Consultative Committee Report

February 2002

Prepared on behalf of:

The Consultative Committee for the Jordan River Water Use Plan

Jordan River Water Use Plan

A Project of BC Hydro

National Library of Canada Cataloguing in Publication Data
Jordan River Water Use Plan Consultative Committee (Canada)
Consultative committee report [electronic resource] :
Jordan River water use plan

"A project of BC Hydro."
Consists of CD ROM.
Issued also in printed form.
ISBN 0-7726-4790-9

1. Water use - British Columbia - Jordan River (Vancouver Island). 2. Water use - British Columbia - Capital - Planning. 3. Water resources development - British Columbia - Jordan River (Vancouver Island). 4. Hydroelectric power plants - British Columbia - Capital. 5. Dams - British Columbia - Jordan River (Vancouver Island). I. B.C. Hydro. II. Title. III. Title: Jordan River water use plan.

TD227.B7J67 2002 333.91'09711'28 C2002-960120-7

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This report was prepared for and by the Jordan 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 Jordan Water Use Plan which was submitted in April 2002 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

The Jordan River Water Use Plan consultative process was initiated in April 2000 and completed in November 2001. The consultative process follows the steps outlined in the 1996 provincial government *Water Use Plan Guidelines*. This report summarizes the consultative process and records the areas of agreement and disagreement arrived at by the Jordan Water Use Plan Consultative Committee. It is the basis for the draft Jordan River Water Use Plan simultaneously submitted by BC Hydro to the provincial government and the Comptroller of Water Rights. A Water Use Plan (WUP) is a technical document that, once reviewed by provincial and federal agencies and accepted by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of a water use planning process is to develop recommendations defining a preferred operating strategy using a public participatory process.

The Jordan River is located within the Capital Regional District, along the southwest coast of Vancouver Island, approximately 72 km from Victoria. The Jordan River hydroelectric project (JOR) is the only major facility on the southwest coast of the island and can contribute up to 35% of the total island hydroelectric generation. The hydroelectric system is comprised of three dams (Bear Creek, Jordan Diversion, and Elliott) and a single turbine powerhouse (170 MW maximum sustained generating capacity) which receives water through a 7.2 km tunnel and penstock from the Elliott Headpond. Bear Creek Dam and Jordan Diversion Dam impound Bear Creek Reservoir and Diversion Reservoir, respectively. Bear Creek Reservoir is not actively managed for power generation and free spills inflow like a natural lake. Diversion Reservoir provides the primary storage for the hydroelectric system and Elliott serves as the headpond for the powerhouse. No water is released past Elliott Dam into the Jordan River with the exception of seasonal spill events (1-2 times/yr).

Informal recreation occurs within the watershed, primarily in the reservoirs and on the coast. Resident fish (rainbow trout) are found throughout the reservoirs and the Jordan River. Prior to 1970, coho, pink, chum, and steelhead used the accessible portion of the lower Jordan River including the tailrace associated with the old powerhouse. Since the 1970's, however, no self-sustaining populations of salmon have been maintained in the river below the natural passage barriers. Industrial activities that may have contributed to their decline include altered flows due to hydroelectric generation, removal of estuary wetlands by forestry operations, and sediment and water quality issues associated with an abandoned copper mine site located in the lower part of the river. The Jordan River is in the traditional use area of the T'Sou-ke Nation, the Pacheedaht First Nation, and the Ditidaht First Nation.

The Jordan River Consultative Committee was comprised of fourteen members representing a variety of interests including: power, recreation, cultural use and heritage sites, fish, wildlife, water quality and socio-economic. The consultative process included numerous committee meetings to work through the steps outlined in the provincial *Water Use Plan Guidelines.*

The Committee explored issues and interests affected by the operations of BC Hydro's facilities and agreed to the following objectives for the Jordan River Water Use Plan:

- Maximize the value of power generation.
- Maintain recreational opportunities in the reservoirs.
- Maximize the quality of surfing.
- Maximize resident fish populations, invertebrates and aquatic life in the reservoirs.
- Maximize resident fish populations in the Jordan River below Elliott Dam.
- Maximize anadromous fish populations in the Jordan River below Elliott Dam.
- Optimize littoral habitat in reservoirs and riparian habitat along streams for wildlife.
- Increase socio-economic welfare of the local community.

Performance measures were identified based on these objectives. Where possible, performance measures were modelled quantitatively. In other cases, they were described qualitatively. Operating alternatives were then generated to meet the various objectives. In total, fifteen alternatives were run through BC Hydro's operations model and then assessed based on the performance measures.

To assess the alternatives and develop an accepted operating strategy for the system, the following components of the Jordan River Project were examined individually:
Bear Creek Reservoir, Diversion Reservoir, Elliott Headpond, flows downstream of Elliott Dam, and turbine discharge. The preferred options for the various components were then combined to form a complete operating strategy.

The majority of committee members, with the exception of two members representing the T'Sou-ke Nation, came to agreement on one operating alternative. The recommended alternative and the operating constraints are outlined in Table 1:

Table 1 Recommended Operating Constraints for the Jordan River Hydroelectric System

System Component	Constraint	Time of Year	Purpose
Bear Creek Reservoir	BC Hydro shall not operate the low level outlet in a manner which drafts the elevation below 411 m, except in emergency situations.[1]	All year	Reservoir productivity; recreation
Diversion Reservoir	Minimum normal elevation of 376 m.	1 Jul-30 Sept	Reservoir productivity and reduced fish stress
	Minimum normal elevation of 372 m.	1 Oct-30 Jun	
	BC Hydro shall not operate the reservoir below the stated minimum elevations except in emergency situations,[1] when undertaking works associated with maintaining the integrity of the dam for dam safety reasons or in low water situations to provide flows downstream. In low water situations, when the reservoir elevation is expected to drop below the normal minimum operating level, BC Hydro shall notify the appropriate federal and provincial agencies. BC Hydro will then proceed with providing a 0.25 m^3/s flow below the Elliott Dam during the 4-year river monitoring program, or reduce flows and reservoir levels according to a flow decision rule[2] when the monitoring program is not in place.		
Elliott Headpond Elevations	No operating constraints. BC Hydro shall seek opportunities to reduce the fluctuation of the headpond levels by further coordinating planned releases from Diversion Reservoir and the operations of the penstock intake.	All year	Reservoir productivity
Elliott Dam Outlet (new infrastructure needed)	Base target flow of at least 0.25 m^3/s with an accepted deviation to 0.225 m^3/s. In low water situations, this flow may need to be reduced (see Diversion Reservoir Section).	All year	River ecosystem health
Turbine Discharge	BC Hydro shall plan to operate the generation with a discharge of not greater than 30 m^3/s from 6:00 a.m. to 6:00 p.m. on a minimum of 4 weekend days during the month of March. Higher releases are permissible when required to manage basin inflow, or emergency situations.[1] A surfing representative may advise BC Hydro of a good weekend day in March and BC Hydro shall make reasonable attempts to apply this constraint on that day.	Up to four weekend days in March	Recreational surfing

[1] Emergency: Emergencies include those required to address dam safety, actual or potential loss of 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.

[2] See Appendix N for proposed decision rule.

In order to implement the operating recommendations stated above, new infrastructure is required to provide a base flow below Elliott Dam. The estimated cost of the new infrastructure was included in the trade-off discussions of the relevant alternatives.

All committee members, with the exception of two representatives from the T'Sou-ke Nation, came to agreement on the final operating recommendations. The level of support for the recommendations varied, particularly with respect to the provision of flows below Elliott Dam. Preferences were documented and additional member statements of values are included in this report. The T'Sou-ke Nation representatives supported the Run-of-River alternative as they felt it is the closest to restoring river flows and the conditions interpreted as the basis for exercising their fish dependent treaty rights.

The expected outcomes of the final recommendation are summarized in Table 2. Once the Water Use Plan is approved by the Comptroller of Water Rights, BC Hydro will be responsible for meeting the operating parameters set out in the Water Use Plan. The outcomes listed in Table 2 are expected to occur as a result of implementing operational changes. BC Hydro will not be responsible for achieving these outcomes.

Table 2: Expected Outcomes of Recommended Operations

Interest	Expected Outcomes
Resident Fish/Recreation (Bear Creek Reservoir)	Maintain as a natural lake (i.e. free spill reservoir): optimum conditions for fish and recreation.
Resident Fish/Biological Productivity (Diversion Reservoir)	Reduce fish stress. Maintaining a higher level is expected to provide better temperature and oxygen conditions.
Resident Fish/Biological Productivity (Jordan River Downstream of Elliott Dam)	Provide an additional (approximately 15 times) amount of rainbow trout rearing habitat expressed as weighted useable area (from 224 to 3163 m^2) in August, the period of expected lowest local inflows. Year round flow is estimated to provide an additional three kilometres of continuously wetted river habitat in the upper reaches all year. A year round base flow provides constant protection (up to 0.25 m^3/s) for the entire lower Jordan River during summer low flows and winter freeze ups, which will benefit resident fish and overall ecosystem health. Although the decision is based on improvements to resident (rainbow trout) populations and riparian productivity, it is recognized there may be ancillary benefits to anadromous species by providing better conditions for their re-establishment in the lower 500 m of the Jordan River.
Power[1]	Costs of $430,000/yr (comprised of forgone power of $330,000/yr and total estimated costs of new infrastructure of $1,000,000 amortized over 20 years for an annual cost of $100,000/yr).
Recreation: Surfing	Enhance quality of surfing by providing a minimum of 4 weekend days in March with minimal disruption from turbine discharge.

1. The total power cost estimate was revised to $483,000/yr based on refined modelling to capture the value of reservoir storage and plant dispatchability. The revised estimate for forgone power is $383,000/yr (or an additional $53,000/yr). Estimates for new infrastructure remain the same.

Sources of uncertainty associated with each expected outcome were discussed by the Consultative Committee.

Key uncertainties will be addressed through the recommended monitoring program. The components of the monitoring program include:

- Validation of local inflow measurements (River): Determines whether inflow data for river below Elliott Dam was accurately estimated from drainage area calculations. This will confirm whether or not a 0.25 m^3/s base flow release will significantly enhance habitat.
- Biological productivity as characterized by fish (River): Demonstrates whether a base flow elicits a response in resident fish condition and abundance.
- Qualitative habitat survey for anadromous salmonids (River): Observes whether a base flow elicits any ancillary responses in anadromous fish rearing and spawning success in the lower Jordan River.
- Biological productivity as characterized by fish (Reservoir): Confirms that the restrictions in reservoir drawdown levels improves conditions for resident fish.
- Surfing monitoring (Estuary): Addresses the extent of additional surfing benefits associated with generation restrictions on weekend days during March.

The annual costs of the recommended package and monitoring plan, including development of detailed terms of references and review of monitoring results, are outlined in Table 3.

Table 3 Annual Cost of Operational Changes and Monitoring Program

Cost Components	**$ Cost '000/Year**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Foregone Power	-	-	330	330	330	330	330	330
New Infrastructure								
• Engineering design	100							
• Infrastructure cost		100	100	100	100	100	100	100
Monitoring Program								
• Develop terms of reference	40							
Recreation								
• Surfing Quality	1	0.5	0.5	0.5	0.5	0.5		
River Fish Monitoring Studies								
• Inflow measurements		6	6	6	6	6		
• Biological productivity (fish)	20	20	20	20	20	20		
• Habitat quality			10	10	10	10		
Reservoir Fish Monitoring Studies								
• Biological productivity (fish)		10	10	10	20			
Review Monitoring Results						35		
TOTAL[3]	161	137	477	477	487	537	430	430

1. The revised estimated cost for forgone power in years 3 to 8 are $383,000/yr (or an additional $53,000/yr) based on refined modelling to capture the value of reservoir storage and plant dispatchability.
2. The numbers reflected in this table are the total costs which the Consultative Committee based their trade-off discussions. The Committee agreed to have the revised estimates reflected as notes to this table. The revised total cost estimates for years 3 to 8 should be revised to capture the additional $53,000/yr explained above. Revisions are as follows: Year 3 = $530,000; Year 4 = $530,000; Year 5 = $540,000; Year 6 = $590,000; and Years 7 and 8 = $483,000.
3. Totals have been rounded to the nearest thousand.
4. Years 1 through 8, in thousands of dollars. Year 6 marks a review of the monitoring program results.

The Consultative Committee did not establish a review period for this Jordan River Water Use Plan. However, the Committee did make the following recommendations for the implementation period:

- Remediation of the mine site in the lower Jordan River will trigger a review of the Water Use Plan.
- A review of the monitoring results will occur after 6 years.
- The review of monitoring results may trigger a review of the Water Use Plan.

In summary, the Jordan River Water Use Plan Consultative Committee members, with the exception of the T'Sou-ke Nation representatives, came to agreement on a recommended operating alternative and associated monitoring program to be submitted by BC Hydro to the Comptroller of Water Rights.

The consultative process provided a forum to share information and promote understanding of various affected interests, perspectives and values, explore alternative ways to operate the facility, and evaluate outcomes of operational changes in a structured way. This facilitated an open and transparent decision-making process. This participatory form of recommendation 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 introduced by the Minister of Employment and Investment (MEI)[1] and the Minister of Environment, Lands and Parks (MELP)[2] in 1996 as an approach to ensuring provincial water management decisions reflect changing public values and environmental priorities. A Water Use Plan (WUP) is a technical document that, once reviewed by provincial and federal agencies and approved by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The purpose of water use planning is to understand public values and develop recommendations defining a preferred operating strategy using a consultative process. This consultative process is outlined in the provincial *Water Use Plan Guidelines* (Province of British Columbia, 1998).

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

The Jordan River consultative process was initiated in April 2000 and completed in November 2001. The purpose of this report is to document the consultative process and present the recommendations of the Jordan River Water Use Plan Consultative Committee. The interests and values expressed in this report will be used by BC Hydro to prepare a draft Water Use Plan for the Jordan River hydroelectric system. This Consultative Report is a record of the water use issues and interests and the analysis of trade-offs associated with operating alternatives. This report ensures the Comptroller of Water Rights has complete information from participants for use in decision-making. Both the Jordan River Water Use Plan Consultative Committee Report and BC Hydro's draft Water Use Plan will be submitted for review and approval.

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[1] The Ministry of Employment and Investment responsible for electricity policy at the reception of the WUP program is now part of the Ministry of Energy and Mines.

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

[3] The focus of a WUP is to determine how water could be allocated to accommodate different uses. However, there may be opportunities to undertake physical works as a substitute for changes in flow.

2 DESCRIPTION OF JORDAN RIVER PROJECT

The Jordan River is located within the Capital Regional District, along the southwest coast of Vancouver Island, approximately 72 km west of Victoria. The 35 km long river flows southwesterly between the Sooke Hills and the Seymour Mountain range into the Juan De Fuca Strait. The Jordan River facility is part of the Bridge River/Coastal Generation Area. It is the only major hydroelectric development on the southwest coast of Vancouver Island and can contribute up to 35% of the island's total hydroelectric generation. A map of the current facilities at Jordan River is provided in Figure 2-1. A history of the Jordan River hydroelectric system is provided in Appendix A.

The current physical structures comprising the Jordan River project include the following:

- **Bear Creek Dam**: The Bear Creek Dam is located on Bear Creek at the upstream end of the reservoir chain. The earthfill dam is 337 m (meters) long and 17.4 m high. Water release facilities consist of a freeflow overflow weir and spillway (411 m) and two low level outlet valves (402.92 m).[1]

- **Jordan Diversion Dam**: The Jordan Diversion Dam is located on the Jordan River approximately 2.8 km downstream from the Bear Creek Dam, and impounds Diversion Reservoir. The concrete buttress dam is 232 m long and 40 m high, has an uncontrolled freeflow overflow weir and spillway (386.18 m), a controlled low level (hollow cone valve) outlet (358.68 m), and an emergency low level outlet (360.0 m).

- **Elliott Dam**: The Elliott Dam is located on the Jordan River approximately 1.6 km downstream of the Jordan Diversion Dam. The concrete dam is 114.6 m long and 27.4 m high, and has an uncontrolled freeflow overflow weir and spillway (335.89 m) and a low level outlet gate (311.51 m). The power intake sill is located at 318.36 m.

- **Jordan River Powerhouse**: The Jordan River powerhouse is located on the west side of the lower end of Jordan River and contains a single 170 MW capacity turbine generator unit. Water is delivered to the powerhouse from Elliott Headpond through a 7.2 km tunnel and penstock. This replaced the old powerhouse and associated tailrace on the east side of the river in 1972.

[1] All datum relative to Geological Survey of Canada (GSC).

Photo 2-1 Jordan River Powerhouse

Relevant current operating aspects of the Jordan River project are as follows:

- **Bear Creek Reservoir:** Bear Creek Reservoir is not actively managed and is operated as run-of-river with all inflow discharged via the spillway at 411 m (the elevation of the Bear Creek Dam overflow weir). As a result, Bear Creek essentially functions as a natural lake. The reservoir is approximately 7.5 km^2.

- **Diversion Reservoir:** Diversion Reservoir has the largest storage capacity of the three reservoirs in the system. The storage capacity of the reservoir provides for approximately 3.5 days operation. Generally, the amount of inflow received in the basin limits the generating ability of the Jordan River project. The normal operating level range is between 367.9 m and 386.2 m. At elevations above 386.2 m water is released from the reservoir overflow weir at Jordan Diversion Dam. The reservoir is approximately 18 km^2.

- **Elliott Headpond:** The Elliott Headpond is the intake for the Jordan River powerhouse. It has the smallest storage capacity and has a normal operating level range between 325.2 m and 335.9 m. At elevations above 335.9 m water is released via the overflow weir at Elliott Dam. The surface area at full pool is approximately 1.6 km^2.

  Water is not normally released past the Elliott Dam into the Jordan River. Occasional uncontrolled spills (1-2 times/yr.) can occur during high inflows after the reservoirs in the system are filled to capacity.

- **Jordan River Powerhouse:** The Jordan River powerhouse is normally operated as a peaking plant. Operation generally follows domestic electricity demand such that the generator may be turned on and off up to twice a day. Maximum turbine discharge is approximately 65 m^3/s.

Photo 2-2 Elliott Dam and Headpond

Photo 2-3 Jordan Diversion Dam

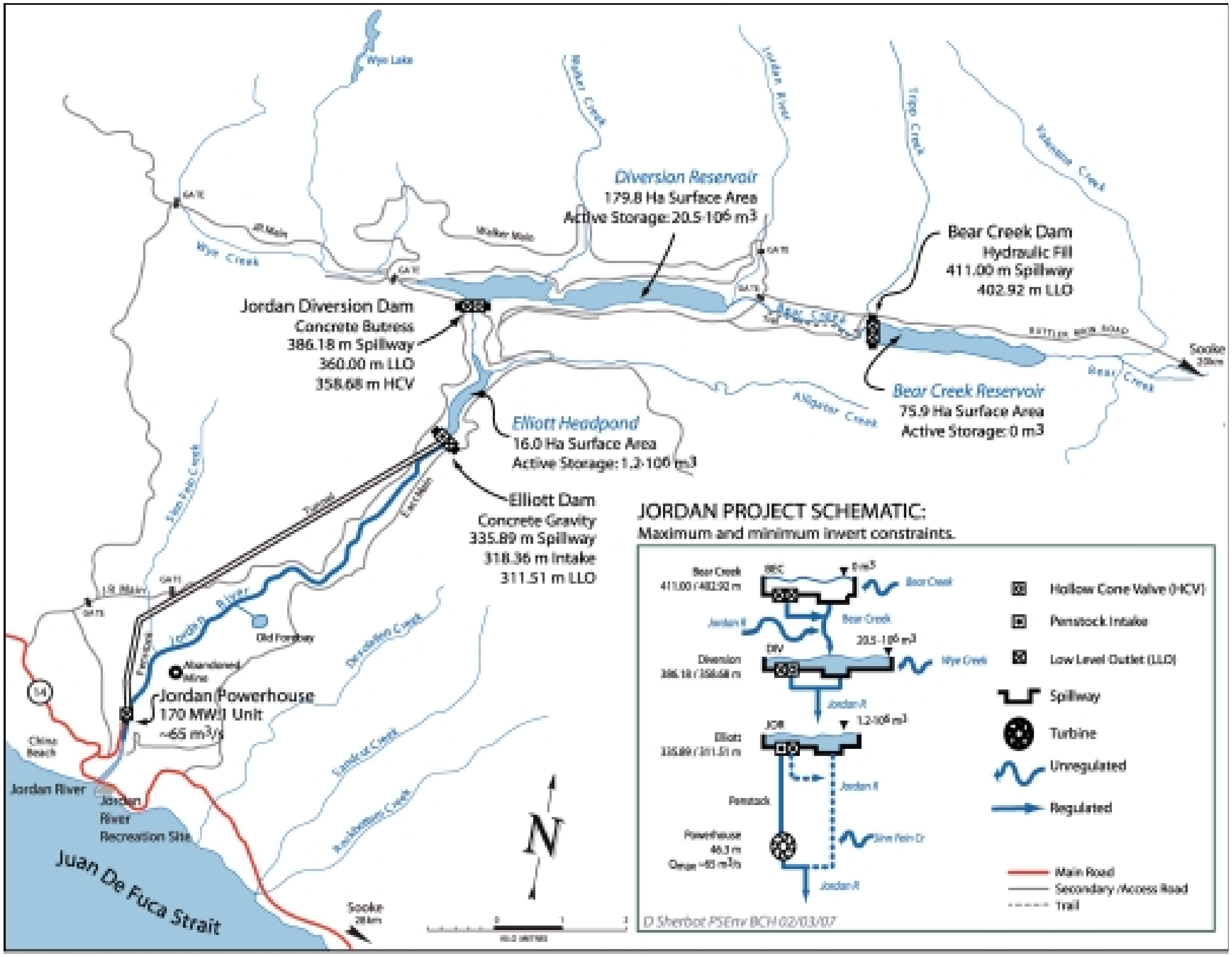

Figure 2-1 Jordan River Project Schematic

3 CONSULTATION PROCESS

The Jordan River Water Use Plan consultation process followed the steps outlined in the provincial government is *Water Use Plan Guidelines* (Province of British Columbia, 1998). These steps provide the framework for a structured approach to decision-making (see Table 3-1).

Table 3-1 Water Use Plan Process

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

3.1 Initiation and Issues Scoping

The Jordan River water use planning process was publicly announced on 6 April 2000. The announcement ad ran in the *Times Colonist* and in the *Sooke Mirror*. BC Hydro contacted agencies, organizations, industries, local governments, and other groups soliciting interest in the Water Use Plan. Those contacted also suggested others in the community who may be interested. BC Hydro also responded to individuals who inquired about the ad or news release. In addition, a questionnaire was distributed to interested parties for input.

A public information and issues identification meeting was held on 6 June 2000. At this meeting, the consolidated information from the questionnaires, informal meetings, meetings with provincial and federal agencies, e-mail and phone conversations, was used to confirm the issues already identified and to provide an opportunity to raise new issues related to facility operations. An *Issues Identification Report* (BC Hydro, 2000) was completed and submitted to the Comptroller of Water Rights to complete Step 2 of the *Water Use Plan Guidelines*. Key interests identified are the following:

- Power
- Fish
- Water Quality
- Recreation
- Cultural Use and Heritage Resources
- Socio-economic
- Wildlife

A detailed list of issues associated with each of the above interests is provided in Appendix B. Additional issues raised that did not fall within the defined scope of water use planning are listed in Appendix C.

Photo 3-1 Future Committee Members and Observers at Bear Creek Reservoir - Site Tour June 2000

3.2 First Nations Involvement

The Jordan River hydroelectric system is in the traditional use areas of three First Nations, including the T'Sou-ke Nation, Pacheedaht First Nation and Ditidaht First Nation. Introductory meetings were held with First Nation representatives from these three nations plus the Te'Mexw Treaty Association and Nuu-chah-nulth Tribal Council in March and May 2000. The representatives from T'Sou-ke Nation and from the Te'Mexw Treaty Association, also representing T'Sou-ke Nation, both participated at the main table of the Consultative Committee and contributed in all discussions. In addition, a T'Sou-ke Nation representative sat on the Fish Technical Committee (FTC).

Early in the process, the representative from Ditidaht First Nation attended meetings and observed the process. As the process continued Ditidaht's representative acknowledged the Jordan River water use planning process was not a priority given the location of Jordan River and its distance from Ditidaht's claimed traditional territory and did not attend subsequent meetings. Throughout the entire process, the Ditidaht representative continued to receive all meeting minutes and Water Use Plan information.

Pacheedaht First Nation did not directly engage in the consultation process. They indicated they were not satisfied with the process being undertaken. They advised that Jordan River is in the traditional territory claimed by Pacheedaht First Nation, that they have rights and title there, and that BC Hydro was not recognizing that. Efforts made to discuss their concerns and explore options to involve Pacheedaht in the process were unsuccessful and they did not attend meetings beyond two introductory sessions. All meeting minutes and Water Use Plan information provided to the Consultative Committee was shared with the Pacheedaht First Nation throughout the process.

3.3 Committee Structure and Process

The Jordan River Water Use Plan Consultative Committee was initially comprised of 20 members. As the process advanced, some members opted to change their status (from member to observer) while others were comfortable with their interests being represented by other committee members. While some members were unable to continue their level of involvement due to other priorities, no member who changed their status expressed unhappiness with the process. Fourteen members actively completed the process (see committee list in Appendix D, along with status changes). In addition to the Water Use Plan Consultative Committee, a Fish Technical Committee (FTC) was formed to address fisheries questions, develop performance measures and coordinate information gathering. Subcommittees were also formed on an as needed basis to discuss interests (water quality, cultural use and heritage resources, recreation and socio-economic), develop performance measures, and determine information requirements.

A Terms of Reference and work plan was developed and agreed to by the Consultative Committee. The Terms of Reference was documented in the *Proposed Consultative Process Report* (BC Hydro, 2000) and submitted to the Comptroller of Water Rights to fulfil Step 3 of the *Guidelines*. The Committee met between June 2000 and November 2001 to move through the steps in the process. Table 3-2 highlights meeting dates and main activities.

Photo 3-2 Jordan River Water Use Plan Consultative Committee

Table 3-2 Consultative Committee Meetings and Activities

Step 1: Initiate Water Use Plan Step 2: Issues Scoping	6 April 2000 ▪ Public announcement 6 June 2000 ▪ Overview of process ▪ Meeting to confirm issues 20 June 2000 ▪ Presentation of Jordan River project operations ▪ Site tour to reservoirs and powerhouse
Step 3: Determine the Consultative Process Step 4: Develop Objectives and Performance Measures	13 July 2000 ▪ Confirmed committee members ▪ Presentation on Structured Decision Making (process steps) ▪ Started objective setting 15 August 2000 ▪ Review committee terms of reference ▪ Continue development of objectives and performance measures 12 September 2000 ▪ Confirmed terms of reference ▪ Presentation on BC Hydro system ▪ Continue development of objectives and performance measures
Step 4: Develop Objectives and Performance Measures Step 5: Additional Information Gathering Step 6: Creating Alternatives	26 September 2000 ▪ Report out on subgroup work to date in developing performance measures ▪ Key fish studies started (anecdotal, presence/absence) ▪ The committee brainstormed alternatives by interest 17 October 2000 ▪ Discussion of preliminary alternatives and impacts ▪ Discussion of studies. Bioassay study started 14 November 2000 ▪ Confirmed remaining studies to be undertaken 28 November 2000 ▪ Reviewed work to date ▪ Site visit to Jordan River mouth to observe surfing
Step 4: Develop Objectives and Performance Measures Step 6: Creating Alternatives Step 7: Assess Trade-Offs	16 January 2001 ▪ Value of Electricity presentation ▪ Update on studies ▪ Discussion of operating scenarios and trade-offs 20 February 2001 ▪ Review of alternatives table ▪ Created new alternatives ▪ Presentation of fish work completed to date 20 March 2001 ▪ Presentation by T'Sou-ke Nation on Douglas Treaties ▪ Update of work
Step 7: Assess Trade-Offs Step 8: Document Areas of Agreement and Disagreement	12 June 2001 ▪ Presentation of surf survey results; fish study results ▪ Agreement on recommendation for Bear Creek ▪ Agreement to focus flow alternatives to 0.5 m^3/s or lower for resident fish species 6 July 2001 ▪ Trade-off discussion and documentation of agreement and disagreement 10 July 2001 ▪ Continue trade-off discussion and documentation 30 October 2001 ▪ Review of recommended monitoring program and specific wording of recommendations 29 November 2001 ▪ Final review of recommendations and wording of the Consultative Committee Report

3.4 Community Awareness and Communication

A public information session was held in Sooke in June 2000 to create better awareness of the water use planning process and to give interested parties an opportunity to tour the facilities at Jordan River. The Consultative Committee members felt that the use of open houses within the area would not be well attended and recommended that newsletters would be a more effective way to communicate with the broader community.

During the water use planning process, three news releases and three newsletters were issued within the Greater Victoria area to keep people informed about the development of the Jordan River Water Use Plan. An update news release and newsletter were issued at the end of the following key consultative milestones - Step 3, 6 and 8.

Materials related to the Jordan River Water Use Plan and the consultative process were made available at the Sooke Library which served as a local resource for those who wanted to find out more about the work of the committee and the water use planning process. The BC Hydro Water Use Plan website was another source of information for those interested in the Jordan River Water Use Plan as well as those interested in other Water Use Plans being undertaken by BC Hydro in other parts of the province.

4 INTERESTS, OBJECTIVES AND PERFORMANCE MEASURES

Step 4 of the provincial water use planning process requires the Consultative Committee to take the issues and interests confirmed by the group and express them in terms of specific objectives and performance measures. In defining the objectives, the participants articulate what they are seeking to achieve through a change in operations while the performance measures provide the means to assess the degree to which those objectives are achieved. This section describes the objectives and performance measures developed for the Jordan River Water Use Plan. Table 4-1 shows the final Jordan River Water Use Plan objectives and performance measures developed by the Consultative Committee. More detail on the performance measures and how they are calculated is provided in Table 4-2. A more detailed description of the interests, objectives and performance measures and how they were calculated can be found in the associated Appendices.

4.1 Power Generation

Vancouver Island is a net importer of electricity from the British Columbia mainland. The Jordan River hydroelectric plant plays an important role in meeting island demand and generally is operated as a peaking[1] plant. This is an important component of its financial and reliability value. Jordan River is the only facility on the south and west coast of Vancouver Island and it can contribute up to 35% of total island hydroelectric generation. It is the highest capacity hydroelectric powerhouse (170 MW) on Vancouver Island.

The power generation **objective** is to ***maximize the value of power***. This includes both the financial value of power generation as well as ensuring electrical reliability of the Vancouver Island hydroelectric system.

Tracking greenhouse gas emissions was also discussed and agreed to under the power interest. Any power generation forgone to accommodate the recommended operating alternative may lead to an increase in provincial greenhouse gas emissions under the current suite of options for replacement technology. The **performance measures** developed were ***financial value ($/yr), reliability index, and greenhouse gas emissions*** (see Appendix E for the Power Generation Information Sheet).

[1] A 'peaking' plant is one that operates during peak hours of electricity demand within the day (and thus can lead to the plant operating at full capacity for a short duration). Peak electricity demand is typically between the hours of 6:00-8:00 a.m. and 4:00-6:00 p.m., Monday through Saturday.

4.2 Recreation (reservoir and river)

There are no formal recreational facilities in the Jordan River watershed, however both reservoirs and the headpond are used to some extent for recreational activities, such as swimming, camping, fishing, boating and picnicking. It was noted that Bear Creek Reservoir is the most popular one, along with the Old Forebay (no longer part of the current hydroelectric system). Bear Creek is not managed and thus the reservoir elevations do not fluctuate beyond natural inflows and outflows. Bear Creek Reservoir provides a convenient alternative recreational area to Diversion Reservoir or Elliott Headpond, whose elevations fluctuate as part of the normal operations of the hydroelectric facility.

The reservoir recreation **objective** is to ***maintain recreational opportunities***. This objective was related to maintaining road access and the ability to continue informal recreational activities associated with the reservoir rather than reservoir elevations. Given this is outside the scope of water use planning, **no performance measure** was required. It was noted that if an operating alternative to manage Bear Creek Reservoir is considered, then reconsideration of a recreation performance measure would be necessary for that reservoir.

Recreation in the Jordan River between Elliott Dam and the powerhouse is extremely limited due to the terrain and difficult access into the river canyon. As a result, the Jordan River Water Use Plan Consultative Committee did not identify a specific recreation objective or performance measure for this section of the river (see Appendix F for the Recreation Information Sheet).

4.3 Coastal Recreation (surfing)

Jordan River is one of the most popular surf locations on Vancouver Island. Board surfing, which extends from October to March, is the primary coastal recreation interest. It is believed that high river discharges associated with turbine operation create a strong seaward flowing current making it difficult to paddle against and hard to catch waves. High river discharges also flatten waves by preventing them from breaking. It is felt that these discharges directly influence surf quality.

While the magnitude of these effects are not well understood, a surfing survey conducted during the water use planning process concluded that when people recognize the effects of discharge, the description of these effects are consistent. In general terms, it was noted that as turbine generation and river discharge increase, there is an effect on surf quality. These effects, however, are noticed more often by experienced surfers.

It was recognized that other factors, independent of river discharges, are also critical to the quality of surfing, including: ocean swells, tides, current direction, and local wind conditions. It was estimated that for approximately 10 days a month the combination of these factors provides good conditions for surfing. Turbine generation and river discharge, therefore, have the potential to impact these estimated 10 days. However, as conditions are variable and weather dependent, there is an inability at this time to predict the specific days that will be impacted.

The coastal recreation **objective** is to ***maximize the quality of surfing***. The **performance measure** developed was ***# potential days surfing impacted, from October to March*** (see Appendix F for the Recreation Information Sheet).

Photo 4-1 Surfing at Jordan River

Photo courtesy of coastalbc.com, taken March 2001 near the mouth of the Jordan River.

4.4 Fish

Jordan River has historically supported a variety of fish including trout, anadromous salmonids and steelhead. Due to a range of industrial activities in the watershed, species diversity and populations have declined. Today the primary fish inhabiting the Jordan River system include rainbow and cutthroat trout, with the occasional occurrence of salmon in the lower reach.[1] Since the habitat conditions for fish vary within the watershed, objectives and performance measures were developed for both reservoir and river fish.

4.4.1 Reservoir Fish

Rainbow trout and, to a lesser extent, cutthroat trout are present in the reservoirs and the headpond. An intermittent stocking program, coordinated by the Ministry of Environment, Lands and Parks,[2] has been in place since 1985 for both rainbow and cutthroat trout. Rainbow trout, however, were considered common to Bear Creek and the Jordan River system prior to 1985.

In general, the numbers of fish observed in Bear Creek and Diversion reservoirs were high and typified a productive interior B.C. lake. High fish densities are likely a function of overstocking over and above natural recruitment rather than a measure of true carrying capacity (Griffith, 1996).

Bear Creek Reservoir is not actively managed as part of the hydroelectric system and functions as a natural lake. This provides optimal habitat for resident fish. It was also noted that rainbows observed in Elliott Headpond, while lower in density, were larger and in better health than rainbows observed in Diversion Reservoir. Increased health is likely attributed to a greater carrying capacity to fish ratio and a more stable drawdown range in comparison with Diversion Reservoir. Diversion Reservoir is the working reservoir and exhibits the greatest annual fluctuation of the three storage areas (approximately 370-386.2 m). Fish condition was noted to be poor during one sampling period in 1995 when the reservoir was drawn down to 372 m, about one quarter of the capacity of the reservoir, during the summer (Griffith, 1996). Fish movement is isolated in Elliott Headpond. However, recent improvements (1995) on Bear Creek allow fish movement between Diversion and Bear Creek reservoirs.

The reservoir fish **objective** is to ***maximize habitat conditions in the reservoirs to maximize resident fish populations, invertebrates and aquatic life.*** The **performance measure** developed for reservoir fish is ***Effective Littoral Zone (ELZ)*** (see Appendix G for the Fish Information Sheet).

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[1] Salmonids are restricted to the lower 500 m of the Jordan River by natural passage barriers.

[2] The Ministry of Environment, Lands and Parks has since been changed to the Ministry of Water, Land and Air Protection.

Photo 4-2 Jordan Dam and Diversion Reservoir

4.4.2 River Fish

Resident rainbow trout were noted throughout the system. Limited opportunity to influence flows in the river between Diversion Reservoir and Elliott Headpond focused efforts on the river below Elliott Dam. As no water is released below the dam, all of the water in the river comes from tributaries entering the river below the dam. The largest inflow comes from Sinn Fein Creek, located approximately 6 km downstream from Elliott Dam. As such, continuous flow (connectivity) through the upper reaches of the system is an issue. This will influence both available habitat and riverine productivity at all trophic levels. It is suggested that the most productive areas of the river are riffle areas, which are shallower, fast flowing stretches of the river.

The first **objective** for fish in the river is ***to maximize resident fish populations in the Jordan River below Elliott Dam.*** The **performance measure** developed was ***Weighted Usable Rearing Area (WURA)***.

Photo 4-3 Section of Lower Jordan River

Photo taken approximately 500 m upstream from the tailrace (first passage barrier).

Currently, no self-sustaining populations of anadromous fish exist in the system. Up until 1971, species present in the river and the old tailrace included pink, chum and coho salmon, sea-run cutthroat trout, and steelhead. In 1971, dam redevelopment decommissioned the old tailrace (used for spawning in addition to the lower river) and construction of Elliott Dam eliminated additional inflow into the Jordan River (see Appendix A for an overview of the system history). Other significant factors that have led to the decline of anadromous species include sediment and water quality issues associated with old copper mines in the Lower Jordan River within the first 500 m above the powerhouse, and the removal of estuarine wetlands by forestry operations.

Large boulders and falls characterize the river. Pink, chum and coho species were unlikely to have migrated above a first set of falls found approximately 500 m above the powerhouse. Steelhead were unlikely to have migrated above a set of seven meter high falls found approximately 1.5 km upstream of the river mouth. The majority of the area between the powerhouse and the first set of falls has sediment and water quality issues from deactivated copper mines, and is currently believed to be unsuitable fish habitat.

The second **objective** for fish in the river is to ***maximize anadromous fish populations in the Jordan River below Elliott Dam.*** The **performance measures** developed were ***Weighted Usable Rearing Area*** and ***Deviation of the Natural Hydrograph.*** For more details on anadromous fish see Appendix G.

Photo 4-4 Lower Jordan River

Photo taken approximately 250 m upstream of the tailrace.

4.5 Water Quality

A review of the reservoirs in August 1995 found reduced water elevations in Diversion Reservoir were associated with high temperatures and low dissolved oxygen levels. This was believed to have a negative impact on aquatic life and to cause fish stress attributing to the low fish condition found in Diversion Reservoir (Griffith, 1996). During the water use planning process, collection of limnological information was undertaken. A general lack of water quality information prevented technical experts, and the group, from being able to develop a performance measure identifying a threshold reservoir elevation level for fish stress.

The water quality **objective** for the reservoirs was combined with the fish objective, to ***maximize habitat conditions in the reservoirs to maximize resident fish populations, invertebrates and aquatic life.*** No performance measure was developed; however, it was noted that the fish effective littoral zone performance measure provides an indication of benefits for aquatic life (see Appendix H for the Water Quality Information Sheet).

Water quality in the Jordan River focused on the contaminated riverbed adjacent to the mine site and the question of whether that habitat was suitable to support anadromous species, a topic addressed within the Fish Technical Committee (see explanation for decision in Appendix G).

4.6 Wildlife

The Jordan River watershed has a variety of habitats including second growth forest, non-forested areas, open water and rock bluffs. A portion of the area adjacent to the reservoirs and the river is mature forest. A wide variety of wildlife species are found in all habitats throughout the Jordan River watershed, and the presence of these species provides hunting, trapping, and wildlife viewing opportunities. Examples of species occurring in the area include dear, bear, cougar, mink, river otter, osprey, and bald eagles (Bianchini and Robertson, 2000).

The wildlife **objective** is ***to optimize littoral habitat in reservoirs and riparian habitat along streams for wildlife***. Following an initial information review, the Committee agreed to use the fish performance measure as a proxy for wildlife with the assumption that what is good for resident fish is also good for wildlife. Increased fish productivity would equate to enhanced conditions for wildlife (see Appendix I for the Wildlife Information Sheet).

4.7 Cultural Use and Heritage Resources

The Jordan River project is in the traditional use area of three First Nations, the T'Sou-ke Nation, the Pacheedaht First Nation and the Ditidaht First Nation. The primary interests of the participating First Nation are related to fish and fish habitat and to restoring fish to the Jordan River. Wildlife, access to hunting and archaeological and cultural resources were raised as interests as well. With respect to fish and wildlife, the fish and wildlife objectives already identified reflect the T'Sou-ke Nation's interests.

With regards to heritage resources, one archaeological site is known to exist at the mouth of the Jordan River. While no known sites have been identified further up the river or in the reservoir system, no formal archaeological studies have been conducted. Discussions with First Nation participants concluded that initiating an archaeological study or formal traditional use study would not be required, but an interview with Elders to collect information on interests and traditional use was preferred. In the absence of information or expected need, no objective or performance measure was developed for cultural use and heritage resources.

The T'Sou-ke Nation holds a Douglas Treaty, and during this Water Use Plan the T'Sou-ke Nation started a process to determine the interpretation of rights stated within the Treaty (see Appendix J for the Cultural Use and Heritage Resources Information Sheet and for a summary of the interview with the T'Sou-ke Nation elders).

4.8 Socio-economic Welfare of the Local Community

There was an interest in examining the potential changes to socio-economic welfare of the local community as a result of changing operations. It was anticipated that changes to socio-economic welfare could occur with a change in water use, particularly if these changes affected commercial fishing and/or local recreation.

The socio-economic **objective** is ***to increase the socio-economic welfare of the local community***. Since there is no direct link between changes in operations and the financial resources allocated to the community by the provincial government, it was agreed that the **performance measure** would be a qualitative statement added to each operating alternative describing the expected changes (see Appendix K for the Socio-Economic Welfare of the Local Community Information Sheet).

4.9 Safety

Safety issues arose with respect to recreation interests in the watershed, particularly surfing and reservoir recreation. With respect to surfing safety, it was noted that inexperienced surfers may be pushed out by the current during high discharges from the Jordan River hydroelectric facility as they may not be familiar with the warning siren or in fact that a powerhouse exists 1 km upstream. Given this is outside the scope of the water use planning process, it was decided to deal with this issue through signage and the appropriate BC Hydro facility department was notified. BC Hydro worked with the surf interests and Western Forest Products to develop signage. These signs were erected at the mouth of the Jordan River in December 2001.

It was noted that spillway booms and the powerhouse intake were not adequately marked at Elliott Headpond and Diversion Reservoir and could affect boater safety or swimmer safety. This issue was forwarded to the BC Hydro facilities manager.

4.10 Flood Management

Flood management is not an issue for the Jordan River project. Therefore, no objectives or performance measures were identified or developed.

4.11 Consumptive Water Use

A very small amount of water is withdrawn from the powerhouse and serves as a domestic water source for 12 houses in the Hilltop area of the Jordan River community. Consumptive water use was determined not to be an issue for the Consultative Committee as alternative ways to operate the facility would not impact consumptive use. BC Hydro is the sole licensee holder that withdraws water from the Jordan River. Other licensees exist around Jordan River but do not withdraw water directly from the river (see Appendix L for the Consumptive Water Use Information Sheet).

Table 4-1 Jordan River Water Use Plan Objectives and Performance Measures (PMs)

Interests	Objectives	Performance Measures
Power	Maximize the value of power	Financial Value ($/year) Reliability Index Greenhouse Gas Emissions
Recreation		
Reservoir	Maintain recreational opportunities (reservoir)	
Coastal	Maximize the quality of surfing	# potential days surfing impacted, from October to March
Fish		
Reservoir	Maximize habitat conditions in the reservoirs to maximize resident fish populations, invertebrates and aquatic life	Effective Littoral Zone (ELZ)
River	Maximize populations of resident fish populations in Jordan River below Elliott Dam	Weighted Usable Rearing Area (WURA)
	▪ Maximize sustainable habitat in the river to enhance existing populations of resident rainbow trout	
	Maximize anadromous fish populations in the Jordan River below Elliott Dam	Deviation of the Natural Hydrograph (DNH)
	▪ Increase riverine ecosystem health by restoring an unregulated flow regime both in shape and magnitude	
Wildlife	Optimize littoral habitat in reservoirs and riparian habitat along streams for wildlife	
Socio-Economic	Increase socio-economic welfare of the local community	Qualitative Statement

1. Objectives and subobjectives, where applicable, are listed.

Table 4-2 Summary of Interests and Description of Performance Measures (PMs)

Interest	PM	Units	Description of Performance Measures
Power	Financial Value	Annual revenue $/yr	This is the total value of the revenue generated from the operation of BC Hydro's Jordan River facility under each operating alternative. For alternatives involving new infrastructure (i.e. providing flows down the Jordan River below Elliott Dam) this cost is included in the total value.
	Reliability Index		The reliability index considers what water is available for use in the event of an emergency. If there is an added discharge from Diversion Reservoir, for example water used for fish flows, then reservoir levels will be slightly lower than if that water was not discharged. Less water is then available in the event of an emergency. The index that will be used as a general guide as follows:
		Index:	
		Minimal positive impact	More water available in the event of an emergency
		Status quo	No change from current operations
		Minimal negative impact	Less water available in the event of an emergency, but not compromising reliability; except in the case of a major and prolonged transmission outage
		Moderate negative impact	Significantly less water available in the event of an emergency, and at times may compromise reliability.
		High negative impact	Insufficient water to operate system in the event of an emergency - Jordan would not be available for electric generation.
	Greenhouse Gas Emissions	Tonnes CO_2e equivalents/yr	In the short term, lost hydroelectric generation will be replaced by thermal based resources (least cost replacement), which will increase CO_2 emissions. This number is the estimated amount that emissions will increase with a decrease in hydroelectric generation.
Surfing	Quality of surf	Potential days of surfing impacted	This is a relative indicator of total potential # of days per month there is any surfing impact where 'impact' is defined as generation exceeding a certain amount (1894 MWh) during high load hours on any given day between October and March. This indicator cannot be used to estimate the actual number of days impacted, but does allow a comparison between alternatives, where by the fewer days impacted represents the better quality of surf.
Fish **(Reservoir)**	ELZ (Effective Littoral Zone)	area.days	This PM reports on the amount of reservoir area which remains wetted and lit, weighted by duration (number of days). Under these conditions it is assumed algae will be able to grow and thus provide a food chain base and nutrient sink for other forms of life (invertebrates, fish). This PM assumes periphyton (algae) growth and not macrophyte (large plant) growth within the littoral zone.

Interest	PM	Units	Description of Performance Measures
Fish **(River)**	Weighted Usable Rearing Area (WURA)	m^2	This PM reports the area estimated to be suitable for summer rearing of rainbow parr (young resident rainbow trout). It measures the area of riffle habitat in the Jordan River below Elliott Dam (approximately 8 km). Riffle habitat was used as a proxy for the habitat type assumed to support the most food production for fish and invertebrates. In general it provides the optimum rearing habitat for rainbow trout parr. The amount of connectivity (continuous flow along the river) will be addressed in a qualifying statement. This PM is calculated for the month of August. This month is considered to be the time when flows are naturally the lowest, and thus when additional flows would provide the most additional benefits for rainbow trout habitat. The primary fish objective is to maximize productive habitat for rainbow trout within the range of flow releases considered. Given current conditions, restoring anadromous species to the system is no longer a primary objective. However, it was concluded that what was good for rainbow trout in the upper 8 km of the Lower Jordan River would also benefit salmon in the lower 500 m. In addition, this PM also provides an indicator of other ecosystem benefits not captured with other discrete PMs. For example, wildlife and other aquatic life will benefit with an increase in this PM for rainbow trout parr.
Fish **(River)**	Deviation from the Natural Hydrograph	Sum of square errors (SSE)	This PM reports on how the shape of the hydrograph for the alternative in question compares with the shape of the hydrograph for the run-of-river alternative. This represents what the system would look like without any regulation or infrastructure.
Socio-economic welfare		Qualitative statement	This PM reports on the expected change over time in socio-economic benefits due to changes in operations. Changes in socio-economic benefits were expected to be due to a return of anadromous fish species, which over time may lead to increased tourism and or fisheries.

5 INFORMATION COLLECTED

During the process of identifying issues, structuring objectives and developing performance measures, a number of questions were raised. In the case of the Jordan River, limited information was available to develop performance measures upon which to base operational decisions. As a result, a number of studies were undertaken to improve the knowledge base on the Jordan River system. A summary of the information collected during the Jordan River water use planning process is provided in Table 5-1.

Table 5-1 Summary of Information Collected

Interest	Information Collected	Description/Rationale
Recreation (Surf)	Formal Surf Users Survey	A survey to provide additional information on the quality, frequency and magnitude of the impact of turbine discharge on surfing
Recreation (Reservoir)	Informal Local Recreation Use Survey	To scope issues
Fish (Reservoir)	Bathymetry Mapping (Bear Creek and Diversion reservoirs and Elliott Headpond)	Used to develop digital elevation models for each reservoir for storage, area, and elevation relations. Elevations were used in estimating the Effective Littoral Zone performance measure.
Fish (River)	Anecdotal Survey of Historical Species and Passage Access	Survey to determine species presence in the river pre-1971 and the extent of migration for salmon and steelhead. Results used to clarify fish river objectives and performance measures based on historical passage.
	Instream Swim Surveys for Spawners (Coho, Pink, Chum, and Steelhead)	Survey to determine whether anadromous salmonids are currently present in the system. Results used to clarify objectives and performance measures.
	Instream Flow Assessments and Channel Survey for the Lower Jordan River	Characterized river reaches, determine riffle width and habitat suitability changes for transects under three flow scenarios. Results used to develop the Weighted Usable Rearing Area (WURA) performance measure.
	Expert Assessment of Passage Barriers	A visual assessment to determine whether steelhead were able to migrate past several passage barriers including the approximately 7 m falls. Used to clarify objectives and performance measures.
	Bioassay and Laboratory Toxicity Tests for Metal Toxicity Assessments	Assessment of whether the sediment and water quality below the mine site is suitable habitat for anadromous salmonids. Used to clarify fish river objectives and performance measures.
	Historical Review of Anadromous Fish and Species Periodicity	Background information on timing of life history stages of anadromous salmonid species. Used to determine fish river performance measures.
	Watershed Models for Regulated and Unregulated Inflows	Necessary to estimate tributary inflow into Jordan River below Elliott Dam for the WURA performance measure.

Interest	Information Collected	Description/Rationale
Fish (Cont'd)	Establishment of a Semi-Permanent Flow Gauge to Assess Flows in the Lower Jordan River	Used to validate flows occurring during the transect work to develop the fish river performance measure.
Water Quality	Water Quality Sampling in Reservoirs (Initiated and funded outside the water use planning process)	Baseline seasonal limnological information and water chemistry.
Wildlife	Review of Existing Wildlife Information	To scope issues
Cultural and Heritage Resources	Interview with Elders	To scope issues, gather background information on the area, and determine priorities

6 OPERATING ALTERNATIVES

In Step 6 of the water use planning process, the Consultative Committee created operating alternatives based on the objectives adopted by the group for each interest. These operating alternatives were then run through BC Hydro's operations model (AMPL - see inset) to determine how the system responds under these new operating regimes. Performance measures were then used to assess the degree to which each operating alternative met the objective laid out by the Consultative Committee. The results generated from these model runs were used in the trade-off discussions and analysis, which are presented in Section 7. As new information was collected over the course of the process, alternatives were refined and modified. All of the alternatives considered during the Jordan River water use planning process are listed below. Appendix M provides a matrix of the alternatives including the operating constraints for each component of the system.

In addition to including a Current Operations scenario and a Run-of-River scenario, the alternatives created consider changing operations for the various components of the hydroelectric system. These system components include:

- Bear Creek Reservoir
- Elliott Dam
- Diversion Reservoir
- Elliott Headpond
- Jordan Powerhouse - Turbine Generation

6.1 Jordan River Project Alternatives

Current Operations (A)

This alternative represents how the system is currently operated. Constraints are defined in the current license, plus a voluntary agreement not to manage Bear Creek Reservoir, which remains full and passes water over the spillway. Diversion Reservoir levels were limited to 375 m year round except 372 m during July to September, inclusive. A drawdown of 372 m for Diversion Reservoir and 325 m for Elliott Headpond prior to annual maintenance outage was modelled. The annual maintenance outage was modelled in September, when the turbine is not running for four weeks. In practice, annual maintenance may be undertaken at anytime and is coordinated with maintenance scheduling on a system-wide basis.

Run-of-River (E)

Modelled as two reservoirs and the headpond as free spill systems (no management). All water is assumed to pass via the Elliott spillway into the Jordan River, no diversion for turbine discharge was used.

6.2 Bear Creek Reservoir Alternatives

Current Operations with Bear Creek (B)

The same as Alternative A, plus the use of active storage associated with the Bear Creek Reservoir. The low level outlet valves (water release valves situated at 405 m) were left open all year round. This option maximizes the production of energy at the Jordan River hydroelectric facility. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Manage Bear Creek at a constant lower level (B2)

The same as Alternative A, plus the use of Bear Creek Reservoir. Bear Creek would be maintained at a constant lower level to provide storage during heavy inflow (rainfall) events.

6.3 Flows Below Elliott Dam Alternatives

Base Flow of 0.5 m^3/s below Elliott Dam year round (C)

A 0.5 m^3/s minimum base flow release from Elliott Dam down the Jordan River year round was modelled. Diversion Reservoir is constrained to a minimum of 375 m year round. Bear Creek was not managed. A September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Conservation Flows (D)

A conservation fish flow release from Elliott Dam down the Jordan River with variable monthly minimum flows was modelled. These flows are intended to provide migration, spawning and rearing flows for several anadromous species. The fish release was modelled such that if the daily inflow exceeds the prescribed release, the prescribed fish flow is released, however, if the daily inflow is less than the prescribed release, then only an amount equal to the inflow is released from Elliott Dam. Diversion Reservoir constrained to a minimum level of 375 m year round. Bear Creek is not managed. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Base Flow of 0.25 m^3/s base below Elliott Dam year round (F)

A 0.25 m^3/s minimum base flow release from Elliott Dam down the Jordan River year round was modelled. Diversion Reservoir is constrained to a minimum level of 375 m year round. Bear Creek is not managed. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Summer Base Flow of 0.25 m^3/s (May to October) below Elliott Dam (H)

A 0.25 m^3/s minimum base flow release from Elliott Dam down the Jordan River from May through October was modelled. Bear Creek is not managed. Diversion Reservoir was constrained to a minimum of 375 m year round. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Summer Base Flow of 0.5 m^3/s (May to October) below Elliott Dam (K)

A 0.5 m^3/s minimum base flow release from Elliott Dam down the Jordan River May through October was modelled. Bear Creek was not managed. Diversion Reservoir constrained to a minimum of 375 m year round. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

6.4 Diversion Reservoir Alternatives

Maintaining Diversion Reservoir level at 375 m (G)

Diversion Reservoir was constrained to a minimum level of 375 m year round. Bear Creek was not managed. September maintenance outage was modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond.

Minimum Elevation Diversion Reservoir at 375 m with October maintenance to 372 m (L)

Diversion Reservoir was constrained to a minimum level of 375 m year round, except drawdown to 372 m prior to maintenance outage. Modelled with an October outage with drawdowns to 372 m for Diversion Reservoir and 325 m Elliott Headpond.

Smaller operating range Diversion Reservoir (376-380 m) (M)

Diversion Reservoir was constrained to a minimum operating level of 376 m and a maximum level of 380 m from May to September, inclusive, and a minimum level of 375 m October to April. This was to provide a band for optimal littoral zone growth. September outage modelled with drawdowns to 376 m for Diversion Reservoir and 325 m for Elliott Headpond. Bear Creek was not managed.

Smaller operating range Diversion Reservoir (376-380 m) with October maintenance drawdown to 372 m (N)

Diversion Reservoir was constrained to a minimum level of 376 m and a maximum level of 380 m from May to September, inclusive, and a minimum level of 375 m November to April. This is to provide a band for optimal littoral zone growth. October outage modelled with drawdowns to 372 m for Diversion Reservoir and 325 m for Elliott Headpond. Bear Creek was not managed.

6.5 Turbine Discharge Alternatives

Shifting generation above 120 MW (50 m^3/s) from high to low load hours (I)

Output of Alternative A was modified to reduce the impact on surfing October through March each winter. This was done by moving discharges and energy production from High Load Hours (HLH - during the day) to Low Load Hours (LLH - night time) when room exists, and is based on a 57/43% HLH/LLH split 7 days a week. The desire is to limit generation to 120 MW (approximately 50 m^3/s) 9 hours per day.

Shifting generation above 90 MW (35 m^3/s) from high to low load hours (J)

Output of Alternative A was modified to reduce the impact on surfing October through March each winter. This was done by moving discharges and energy production from High Load Hours (HLH - during the day) to Low Load Hours (LLH - night time) when room exists, and is based on a 57/43% HLH/LLH split 7 days a week. The desire is to limit generation to 90 MW (approximately 35 m^3/s) 9 hours per day. This alternative was removed, as the surfing interest preferred to use 50 m^3/s as the threshold impact flow.

THE AMPL (OPERATIONS) MODEL

The AMPL model is BC Hydro's operations model used to determine how the system responds to a given set of constraints. Physical and equipment constraints and historic inflow data (32 years in the case of the Jordan Water Use Plan) are invariable inputs to the model. Variable inputs to the model include constraints the Committee has agreed to test, such as providing flows for fish during certain times of the year, or maintaining a minimum reservoir elevation. The AMPL model maximizes for power subject to these constraints. Output from the model for any particular alternative provides daily averages for power production (Megawatts), turbine discharges, reservoir levels, dam releases and spills.

From these "reservoir level" and "flow" outputs, performance measure results were calculated for each alternative. Alternatives were then assessed based on these performance measure results. This assessment of the alternatives based on the output from AMPL is described in the next section.

7 TRADE-OFF ANALYSIS

In order to evaluate the alternatives more easily, they were considered in groups. These groupings were based on key areas of decisions in terms of making operating changes and include: alternatives that consider modification to Bear Creek (B,B2); alternatives that consider minimum flows below Elliott (D,C,F,K,H); alternatives that consider modifications to Diversion Reservoir (G,L,M,N); and an alternative that looks at shifting generation (I).

For each component, the effects of the constraints were evaluated using the performance measures developed by the Consultative Committee. This evaluation formed the basis for the trade-off discussions that lead to the selection of a preferred alternative for each component. These preferences were then combined to create the preferred operating recommendation for the Jordan River system.

The process for determining the preferred operating alternative depended upon which component was being addressed. For Bear Creek Reservoir, a high level assessment of alternatives was undertaken by the Consultative Committee to come up with a recommendation. For the Elliott Headpond, the Consultative Committee discussed Elliott operations and made a recommendation based on how the headpond is currently operated. For the Turbine Discharge, key trade-offs between two alternatives were assessed, and a recommendation was made based on a discussion of the least cost option. For flows below Elliott Dam and for operating elevations for Diversion Reservoir, the process for choosing a preferred alternative from the consequence tables (Table 7-2 and Table 7-7, respectively) was as follows:

- **Narrow Performance Measures:** Performance measures were narrowed by determining whether there were real differences between the range of alternatives being considered. Performance measures that did not show a real difference were set aside. Real differences were defined as differences that were not attributable solely to modelling error or differences not significant enough to play a role in decision-making for the members.

- **Narrow Alternatives:** Alternatives were eliminated by looking at pairs of alternatives and when possible eliminating alternatives which were either dominated or the Committee agreed that one was less preferred than the others. An alternative was assumed to dominate another alternative if it performed at least as good in all performance measures and better in at least one performance measure.

- **Assess Trade-offs:** Key trade-offs were assessed between remaining alternatives.

- **State Preferences:** Preferences on the remaining alternatives were stated by Consultative Committee.
- **Create Recommendation:** Operating recommendations were developed as the final step in the trade-off analysis.

7.1 Bear Creek Reservoir Alternatives

A high level assessment was undertaken to determine whether it was worth reactivating the remaining Bear Creek Reservoir storage (approximately 3.2 M m^3) for enhanced power benefits. It was determined that the use of Bear Creek Reservoir would only be considered as long as there would not be a net loss of fish and recreation values. Under current normal operations, this reservoir is no longer actively managed for power generation and it was believed this provides optimal conditions for fish. A preliminary assessment was undertaken for two alternatives as shown in Table 7-1. Alternative B represents the maximum power benefits possible from operating the remaining storage in the reservoir from 411.0 m to 404.8 m (spillway sill to depth of low level outlet). Alternative B2 considers some recreational and aquatic value by restricting operation to a fixed depth of 409 m, leaving 3 m of storage but reducing power benefits.

These alternatives were subsequently removed from further consideration given the trade-offs between fish productivity and recreational benefits against a marginal increase in power values.

Table 7-1 High Level Impacts of Bear Creek Alternatives

Interest	Alternative B	Alternative B2
	Current operations with the use of Bear Creek Storage lowered to 404.8 m.	Current operations and maintain Bear Creek at a lower level. This permits capture of storage during high inflows.
Power	Increased generation of $80,000/yr.	Something much less than $80,000/yr. Plus additional cost of new infrastructure needed for low level outlet to maintain constant level.
Fish	Elimination of an established littoral zone between 411 m - 404.8 m would significantly reduce productivity.	Partial elimination of the littoral zone would reduce productivity.
Recreation	Large decrease in quality of recreation and access (stump exposure). Bear Creek is cited as the most important reservoir of the three for recreation.	Decrease in quality of recreation and access (stump exposure). Bear Creek is cited as the most important reservoir of the three for recreation.

7.2 Elliott Dam Base Flow Alternatives

One of the primary objectives of the Jordan River Water Use Plan Consultative Committee was to maximize fish populations in the Jordan River. In order to meet this objective, the Consultative Committee explored a number of operating alternatives that would provide flows for fish below Elliott Dam. Under current operations, no base flow is provided below Elliott Dam for the lower 8 km of the Jordan River. Discharge in the lower Jordan River is solely sourced from local tributary inflow and ground water runoff increasing from 0 cubic meters per second (m^3/s) immediately downstream of Elliott Dam to 1.5 m^3/s (mean annual) upstream of the tailrace. Potential mean annual discharge for the system is 13.8 m^3/s. Consideration was given for both anadromous fish and resident rainbow and cutthroat trout. The following section outlines the discussions and decisions made in narrowing and assessing alternatives in terms of their performance measures and expected benefits for both anadromous fish and resident trout.

7.2.1 Flows for Anadromous Fish Species

The Consultative Committee considered Alternative D 'Conservation Flow', which was designed to provide migration and spawning flows for anadromous species. Additional studies were undertaken concurrently to assess the extent and suitability of habitat in the river for anadromous salmonids. Following a habitat assessment the Fish Technical Committee (FTC) recommended, and the Consultative Committee agreed to, the following statements:

- Anadromous species such as coho, pink, and chum were unlikely to migrate above the first set of cascades or falls (approximately 500 m upstream of the tailrace), and steelhead (a more energetic species) were not likely to migrate past the approximately 7 m falls just above Sinn Fein Creek approximately 1500 m upstream of the tailrace (see Figure 7-2).
- Given the information available to date, it was assumed that the habitat area below the copper mine (approximately 250 m of the lower 500 m) is not presently suitable under current flow conditions to sustain anadromous salmonid rearing populations.

Background information leading to this recommendation included *in situ* bioassay results and standard toxicological tests:

- Coho Egg Bioassay (egg to fry stage) results did not show lethal toxicity. Survival comparable to normal survival rates (DFO, 2001). This stage was expected to be the least sensitive to metal toxicity.
- Egg to fry stage (bioassay) is not the most sensitive stage. Literature suggests that the smolt stage is the most sensitive and this stage was not tested.

- Lab LC50 test (lethal concentration at which 50% mortality occurs) showed acute toxicity with rainbow trout fry at a river water dilution factor of 60% (PESC, 2001). This stage was expected to be more sensitive to metal concentrations.
- Currently there are no sustaining anadromous salmonid populations in the Jordan River. This lends weight to the conclusion that under current flow conditions, the habitat is not suitable.

The Consultative Committee agreed to remove Alternative D 'Conservation Flow' from consideration in this Water Use Plan. The Consultative Committee concluded that under current flow conditions the habitat below the mine site is currently not suitable for anadromous salmonid species and that the total amount of habitat available is limited (<250 m linear habitat) considering the estimated costs of providing conservation flows of approximately $2.5 million/yr.

7.2.2 Flows for Resident Fish

Following the removal of the 'Conservation Flow' Alternative and using the consequence table, presented in Table 7-2, the Committee continued to narrow alternatives and performance measures, where applicable, for resident fish in order to facilitate key trade-offs for discussion.

Table 7-2 Consequence Table for Elliott Dam Flow Alternatives

Interest	Performance Measure	A Current (no flows)	E Run-of-River	C 0.5 m^3/s base all year	F 0.25 m^3/s base all year	K 0.5 m^3/s May-Oct	H 0.25 m^3/s May-Oct
Power	Power ($/yr.)[1]	15,060K	0	14,300K	14,630K	14,640K	14,800K
	Gain/loss[1]	0 (base)	-15,060K[2]	-760K	-430K	-420K	-260K
	Reliability Index	status quo	high neg.	moderate neg.	minimal neg.	moderate neg.	minimal neg.
	GHG (tonnes CO_2e/yr)[3]	0 (base)	130 861	5612	2807	2829	1415
Fish	ELZ (area.days)	11.4	37.6	16.0	14.3	16.2	14.3
	WURA m^2 [4]	224	5805	4997	3268	5297	3268
	Additional information for year round vs. seasonal flows			Increases incremental habitat during summer and adds marginal benefits in winter.	Additional 3 km of wetted channel all year round[5]	Increases incremental habitat during summer only.	Additional 3 km of wetted channel during the summer only.
	Natural hydrograph (SSE)[6]	1.0	10.0	2.3	1.6	1.5	1.2
Socio-economic	Socio-economic welfare[7] (qualitative statement)	status quo	neg & pos	status quo	status quo	status quo	status quo
Recreation	Surfing (potential days impacted)[3,8]	54	16	50	50	55	55

[1] Gains/loss calculated from current operations (Alternative A).

[2] This cost does not include decommissioning costs associated with dam removal.

[3] Aside from these two performance measures (GHG and surfing) 'more is better'. With these two performance measures, less is better for the given objective.

[4] The weighted usable rearing area (WURA) performance measure is calculated for August, the time when local water inflows are lowest. Therefore the summer flow (H,K) alternatives have the same results as the year round alternatives (F,C), and thus, do not represent any additional benefits gained by moving to a year round flow.

[5] The year round 0.25 m^3/s flow is estimated to provide an extra 3 km of continuous wetted channel (in the upper reaches which receive tributary inflow <0.04 m^3/s), and to also sustain habitat along the remaining 5 km of river during periods of low flow. This flow provides constant protection (up to 0.25 m^3/s) for the entire lower Jordan River during summer low flows and winter freeze ups.

[6] Deviation from the natural hydrograph (DNH) normalised between a scale from 1 – 10, representing the most and least deviation, respectively. The least amount of deviation is assumed to be best for fisheries values.

[7] Neg & pos = negative and positive - loss of 2 BC Hydro jobs and local payments; potential increased recreational fishing over time.

[8] This measure is not to be confused with 'actual' number of days impacted. It is a relative number and should be considered that less is better.

7.2.2.1 Narrowing Performance Measures

Under a given range of alternatives, as individual performance measures (PM) and/or alternatives became redundant, the opportunity existed to remove some measures in order to simplify trade-off decisions. At this point in the decision analysis, the Consultative Committee was asked to remove Alternative E 'Run-of-River'. Alternative E showed marked differences against all other alternatives due to the extreme nature of the operating changes. Discussion could subsequently focus on performance measure results for the remaining base flow alternatives. It should be noted, however, that the Run-of-River was not removed from overall consideration as the T'Sou-ke Nation wanted it to remain. Subsequently, it was later brought back into the discussion as final preferences were stated.

The following performance measures were removed from the consequence table, as agreed to by the Consultative Committee for the stated reasons:

- **Reliability Index:** Differences were small enough that it did not help make a selection between alternatives.
- **Effective Littoral Zone (ELZ):** PM specifically designed to consider reservoir alternatives not river alternatives (see Diversion Reservoir Section 7.3).
- **Deviation of the Natural Hydrograph (DNH):** Differences were small enough that it did not help to make a selection between alternatives.
- **Socio-economic Welfare:** Given the range of alternatives, this objective was not affected.
- **Potential # days surfing impacted:** Given the range of alternatives, the difference between alternatives was small enough that it did not help to make a selection between alternatives. In addition, a specific surfing alternative is considered under the Turbine Generation Section.

7.2.2.2 Narrowing Alternatives: Annual Base Flow vs. Seasonal Base Flow

The Committee narrowed alternatives by first comparing Alternatives F and K, as they were similar in cost, $430,000/yr vs. $420,000/yr. The question was then asked which provided more value from a fish productivity perspective. The alternative that provides a base flow all year or the alternative that provides higher seasonal flow? Although the performance measures show Alternative K as outperforming Alternative F, ancillary information, not captured in a performance measure, was included in the decision matrix that favoured Alternative F. Table 7-3 lists the outcomes of the two alternatives.

Table 7-3 Narrowing Flow Alternatives: Comparing Alternative F and K

Interest	Performance Measure	Alternative F	Alternative K
		0.25 m^3/s base all year	0.5 m^3/s May-Oct
Power	Gain/loss ($/yr)	- $430K	-$420K
	GHG (tonnes CO_2e/yr)	2807	2829
Fish	WURA (m^2) August	3268	5297
	Additional information on impacts	In upper reaches, provides an additional 3 km of continuously wetted habitat all year round. Provides constant protection (up to 0.25 m^3/s) for the entire lower Jordan River during summer low flows and winter freeze ups.	Provides an additional 3 km of continuously wetted habitat in the summer only. Upper reaches (3 km) subject to complete dewatering during Nov–Apr 25% of the time.

Key Uncertainty

The accuracy of river inflow data (below Elliott Dam) is unknown given that empirical measures were limited to the one field season that the Water Use Plan spanned. River inflow data for decision-making purposes was extrapolated using the inflow data from the upstream watershed (Elliott) and relative drainage area sizes. This means that the incremental gains in habitat from adding 0.25 m^3/s to 0.50 m^3/s are known if the estimated river inflows are correct. Moreover, it assumes a threshold increase in habitat (dry to wetted) based on the assumption that inflows are significantly lower than 0.25 m^3/s for all sections of the lower Jordan River during the summer. Consequently, it was noted that the inflows need to be verified prior to implementation of the base flow release.

Figure 7-1 and Figure 7-2 illustrate the expected impacts of providing flows seasonally and year round. An annual base flow of 0.25 m^3/s provides a substantial flow during the summer months and prevents dewatering of the river during winter cold snaps. Moving from 0.25 m^3/s to 0.50 m^3/s provides incremental improvement in habitat as is shown in the WURA performance measure. Alternatively, while a 0.50 m^3/s base flow during summer months improves rearing habitat, it does not prevent dewatering of habitat in the upper reaches (3 km) or a decrease in base flow in the remaining river below 0.25 m^3/s during the winter. Under these options, members of the Fish Technical Committee agreed that a base flow of 0.25 m^3/s year round would be of greater benefit to fish than a base flow of 0.5 m^3/s during the summer months alone.

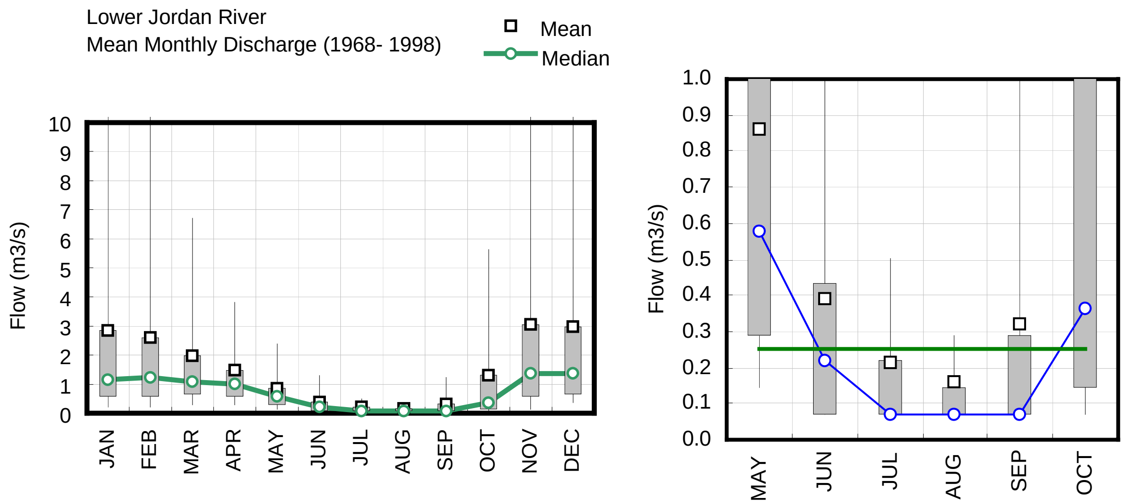

Figure 7-1 Mean Monthly Inflows: Lower Jordan River

Monthly inflows estimated immediately upstream of the tailrace with base flow and no base flow. Mean, median and upper and lower 75% and 95% percentiles depicted. Flow detail (May to October) expanded to illustrate the flow benefits associated with a base flow of 0.25 m^3/s.

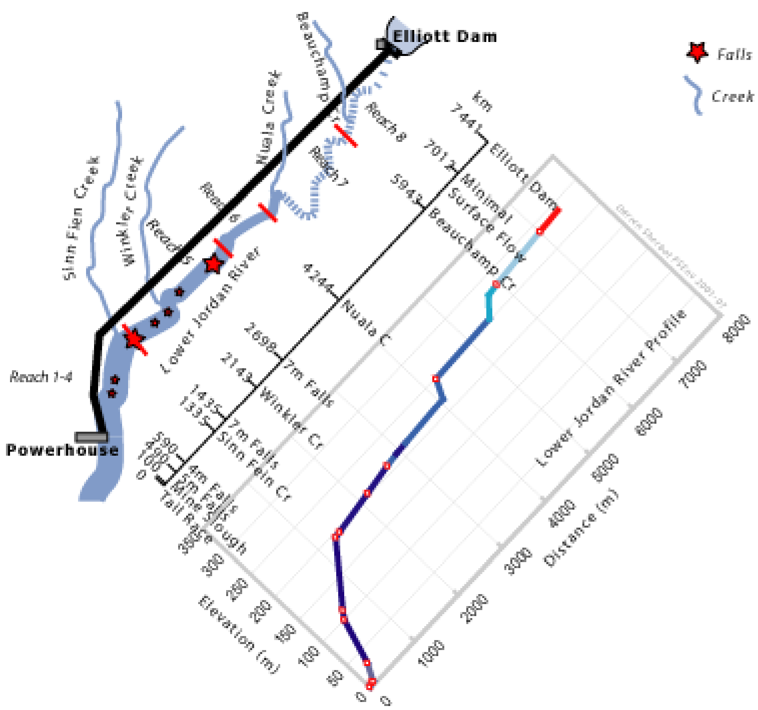

Figure 7-2 Schematic of Lower Jordan River

The figure depicts the various reaches of the Jordan River showing elevation and distance from Elliott Dam to the powerhouse, along with the location falls and tributaries flowing into the mainstem.

Agreement

The Consultative Committee agreed that Alternative F (0.25 m^3/s base flow all year) was better than K (0.5 m^3/s May to October). Subsequently, K was removed from the table. The Consultative Committee also agreed to remove Alternative H (0.25 m^3/s from May to October) from the table. This decision considered the added benefits of moving from a 0.25 m^3/s seasonal flow to a 0.25 m^3/s year round flow.

7.2.2.3 Narrowing Alternatives: Annual Low (0.25) and High (0.50) Base Flows

Once it was established that a year round base flow was preferred over a seasonal flow, the Committee was then asked what were the added fish benefits of moving from an annual base flow of 0.25 m^3/s (Alternative F) to 0.5 m^3/s (Alternative C), Table 7-4 lists the outcomes of the two alternatives.

Table 7-4 Narrowing Flow Alternatives: Comparing Alternative C and F

Interest	Performance Measure	C 0.50 m^3/s base all year	F 0.25 m^3/s base all year
Power	Gain/loss ($/yr)	-760K	-430K
	GHG (tonnes CO_2e/yr)	5612	2807
Fish	WURA (m^2) August	5195	3163
	Additional Information	Provides incremental rearing habitat gains during the summer months. The FTC did not think marginal benefits from additional flow (0.5 m^3/s vs. 0.25 m^3/s) over the winter months would be significant.	

Key Uncertainties

As indicated previously, the accuracy of river inflow data (below Elliott Dam) is unknown. This implies that the incremental gains in habitat from adding 0.25 m^3/s to 0.50 m^3/s is highly uncertain. Again, estimated inflows need to be verified before detailed comparisons between Alternative C and Alternative F can be confirmed.

The WURA measures increases in potential habitat. The working hypothesis with any physical habitat model is that increases in habitat translate into increases in aquatic productivity. For indicator species such as rainbow trout (Rb), increases in productivity are assumed to be manifested at the population level in both condition and numbers. Predicting actual increases in productivity, however, are much more uncertain. Other factors, such as density dependent relations, may significantly confound results. For the Jordan River, the Fish Technical Committee (FTC) agreed that increasing a base flow from 0.00 m^3/s to 0.25 m^3/s would likely have significant gains in habitat, an assumption verified by the WURA modelling. The FTC also hypothesised that this would also significantly increase riverine and riparian productivity, however, whether this translated into measurable gains in rainbow population is unknown.

The Consultative Committee was unable to narrow these alternatives at this point. A new alternative was suggested which was a combination of C and F (Alternative P) which provides a 0.25 m^3/s year round flow with a higher flow of 0.5 m^3/s for some duration. The Committee agreed to consider this alternative, as they moved on to state their preferences for the remaining alternatives.

7.2.2.4 Outcomes of the Final Flow Alternatives

The outcomes of the final set of flow alternatives and their impacts on the objectives is summarized in Table 7-5.

Table 7-5 Consequence Table for Final Elliott Dam Flow Alternatives

		A	**E**	**C**	**F**	**P**
Interest	**Performance Measure**	Current (no flows)	Run-of-River	0.5 m^3/s base all year	0.25 m^3/s base all year	0.25 m^3/s with some time at 0.5 m^3/s
Power	Gain/loss ($/yr)	0 (base)	-15,060K	-760K	-430K	Between –430K and -760 K
	GHG (tonnes CO_2e/yr)	0 (base)	130,861	5,612	2,807	
Fish	WURA (m^2) August	224	5805	4997	3268	(Not calculated)
	Additional information on impacts			Provides incremental rearing habitat gains during the summer months. The FTC did not think marginal benefits from additional flow (0.5 m^3/s vs. 0.25 m^3/s) over the winter months would be significant.	The year round flow is estimated to provide an extra 3 km of channel wetted in the upper reaches which receive less tributary inflow. A year round base flow provides constant protection (up to 0.25 m^3/s) for the entire lower Jordan River during summer low flows and winter freeze ups, which will benefit resident fish and overall ecosystem health.	See Alternatives C and F

As shown in Table 7-5, the key trade-offs are between forgone power and fish benefits. Moving through Alternatives A, F, and C to E shows increasing costs over Alternative A of $430,000/yr to $760,000/yr to $15,000,000/yr, respectively. In addition, fish benefits (and by proxy associated wildlife and ecosystem health) also increase moving through Alternatives A, F, and C to E. This is shown with an increase in habitat measures (in August) over Alternative A of 15 times, 25 times, and 26 times, respectively. Additional fish and associated riparian benefits of the flows include the reduction of seasonal dewatering (winter and summer) and providing continuous wetted area in the upper reaches of the river.

7.2.2.5 Stating Preferences

The Consultative Committee members stated their preferences with respect to the remaining alternatives listed in the consequence table (See Table 7-5). These preferences, presented in Table 7-6, were captured by using a relative scale where:

- **S** = Fully support the alternative;
- **A** = Accept the alternative (I can live with it); and
- **B** = Block the alternative (I do not accept it).

Table 7-6 Preference Table for Elliott Dam Flow Alternatives

Committee Member by Affiliation	A	E	C	F	P
Victoria Chamber of Commerce	A	B			S
Ministry of Energy and Mines[1]	A	B		S	S
West Coast Surfing Associates	B	B			S
South Islands Aquatic Stewardship Society	A			A	S
Fisheries and Oceans Canada	B			A	S
Jordan River Community	A	B		S	S
T'Sou-ke Nation	B	S	-	-	-
BC Hydro	S	B	A	A	A
Te-Mexw Treaty Association	B	S	-	-	-
Ministry of Water Land and Air Protection (MWLAP)[2]	B	B	S	S	S
Ministry of Sustainable Resource Management[3]	A	B	A	A	S

1. Blank spaces exist because at first the committee members were not asked to fill in all of the boxes. As the round table progressed, people filled in the boxes and some obstained (-) from stating a preference.
2. Two interests were not present this day: Veins of Life Watershed Society (who were represented by the South Islands Aquatic Stewardship Society); and Sooke Parks and Recreation. Both interests were present at the next meeting when the final recommendation was confirmed.

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[1] Formerly part of the Ministry of Employment and Investment.

[2] Formerly part of Ministry of Environment, Lands and Parks - Fish and Wildlife.

[3] Formerly part of the Ministry of Environment Lands and Parks - Water Management.

In providing statements about member values in comparing Alternative F ($0.25\ m^3/s$) and Alternative A (no flow), results of the preference table leads to the following conclusions:

- The Victoria Chamber of Commerce, the Ministry of Energy and Mines, and the Jordan River Community felt that the benefits for resident fish (see Table 7-5) were worth the expected losses in power revenue (approximately $430,000/yr) of Alternative F. Although Alternative F was preferred over Alternative A, they would be willing to accept Alternative A.

- South Islands Aquatic Stewardship Society and the Ministry of Sustainable Resource Management felt that the benefits for resident fish (see Table 7-5) along with the losses (approximately $430,000/yr) of Alternative F were generally equally acceptable with Alternative A which exhibited no added fish benefits at no costs.

- Fisheries and Oceans Canada, Ministry of Water Land and Air Protection and West Coast Surfing Associates felt that the benefits for resident fish (see Table 7-5) were worth the expected losses (approximately $430,000/yr) of Alternative F. Alternative F was preferred over Alternative A, and in addition, this group would not accept Alternative A as a viable option. Fisheries and Oceans Canada prefers Alternative F because, as they state, there is a greater chance of re-establishing an anadromous species population if some base flow is provided.

- BC Hydro supported Alternative A (current operations) over Alternative F, however, were willing to accept this alternative if all of the other Committee members recommended a minimum discharge (see "Additional Member Comments").

- The T'Sou-ke Nation were not willing to accept Alternative A, and were not willing to comment on Alternative F given that their fundamental interest is to have the system restored to its natural flows. They preferred the Run-of-River Alternative E. More detailed reasons for their preferences are outlined in Section 7.7, Areas of Disagreement.

At first, Alternative P (0.25 m^3/s base flow with some time at 0.5 m^3/s) was accepted by members of the Consultative Committee as the preferred operating alternative, with the exception of the First Nations representatives who preferred Alternative E (Run-of-River). However, after reflection, Alternative P was modified back to Alternative F (0.25 m^3/s base flow all year) for the following reasons:

- From a fish productivity perspective, it was commented on that it did not make sense to provide higher flows in the summer time and reduce flows during the winter, it was better to provide a base flow through the year. This was also confirmed to be preferred from an operations perspective.
- The uncertainty around additional benefits of providing more flow than 0.25 m^3/s year round at this point was not worth the additional cost. It was suggested that a decrease in productivity in the river with the lower flow could be gained in the reservoir by increasing the minimum level from 375 m to 376 m (see Diversion Reservoir Section).

Agreement

Alternative F (0.25 m^3/s base flow all year) became the agreed-upon flow by the Consultative Committee members with the exception of the First Nations representatives who preferred Alternative E (Run-of-River).

The definition of Alternative F was discussed in terms of reliability and a compliance issue. It was agreed that Alternative F means that the intent is to provide a target flow of 0.25 m^3/s year round with an accepted lower bound of 0.225 m^3/s. Under low water situations, this flow may need to be reduced (see Diversion Reservoir recommendations).

7.2.2.6 Additional Member Comments on Preferences

Committee members were invited to submit additional information on their values and preferences to be included in the report. The following are verbatim responses:

- **Jordan River Community:** I chose to support Alternative F (year round flow) for the reasons mentioned in the consultation report - benefits to the resident fish, increased habitat for other wildlife that use the river. It also seems a balanced trade-off (loss of power revenue) to make a step forward in restoring the river system. I chose to block Alternative E (Run-of-River) because I value the capacity to produce power that Jordan River represents. Given the limited production capabilities on Vancouver Island, removing an entire generating plant would make us even more dependant on power generated on the mainland or on an alternative power generating system that may create unacceptable levels of greenhouse gases.

- **Veins of Life Watershed Society**: My vote would be to support Alternative F. I support a modest flow regime to the lower river, not one which would incur extraordinary costs or create trade-offs with maintaining the desired new regime for Diversion Reservoir. As stated, my interest is largely in enhancing the reservoir fishery and general ecology of the reservoir, as opposed to looking for substantial gains in the compromised outflow below Elliott Dam.

- **South Islands Aquatic Stewardship Society**: I accepted Alternatives A and F and fully supported Alternative P. In addition to the comments already recorded, I chose Alternative F in the final decision because it would allow the Jordan to function more like a natural system by providing a base flow all year round. This year-round flow would also serve to increase the wetted habitat available for fish and other aquatic organisms thereby increasing the overall productivity of Jordan River.

- **Fisheries and Oceans Canada:** It is my position and the position of Fisheries and Oceans Canada that a minimum fisheries flow should be released below the Elliott Dam on the Jordan River. Alternative A does not provide such a flow, therefore I blocked that choice. Information gained by flow/habitat studies during this Water Use Plan indicates that a flow of approximately 0.25 m^3/s produces significantly better habitat conditions in the river below Elliott Dam (roughly 15 times the weighted usable area for invertebrate food production and juvenile rearing). Providing that flow through the winter (Alternative F vs. Alternative H) has the benefit of maintaining wetted conditions and productive capacity in the upper 3 km of river through the winter. I am convinced that Alternative F (0.25 m^3/s year-round) will improve numbers and quality of trout in the river. Alternative P was to provide 0.5 m^3/s at some times and 0.25 through the rest of the year. I was willing to accept this, but thought the incremental benefits over Alternative F (if any), at least for resident trout, would not be worth the cost. The choice I supported was Alternative F.

  Although anadromous salmon production is presently not observed, there is documentation by Fisheries and Oceans Canada, local residents that pink, chum, coho and steelhead returned to the river (at times in fair numbers) until 1970. It is hard to separate mining and hydro impacts since they occurred roughly at the same time, however the drastic changes in flow regime due to the 1971 hydro redevelopment must certainly have precluded the possibility of recovery of habitat and salmon runs after the slide and mine contamination of the 1960's.

  I feel the hydrograph that would result from a year-round 0.25 m^3/s release from Elliott Dam reservoir will make possible the re-establishment of pink salmon in the lower Jordan River. This species will only be present in the river from September to March, avoiding the low flow period where mine contamination is highest.

  The egg bioassay study performed as part of this Water Use Plan demonstrated excellent egg-to-fry survival for coho, and we observed significant pockets of high quality gravel in the 500 m above the powerhouse. If it can be demonstrated experimentally that pink egg-to-fry survival is comparable, and that the fry are able to adapt to salt water and return as adults, there is a good chance that a run could be re-established. This would provide a significant sport fishery at the mouth of the river, and could provide economic and social benefits for the Jordan River community, as well as other parts of Southern Vancouver Island. Without the flow release, low tributary inflows through September and October could prevent or severely limit spawning.

If pink salmon do return to spawn in future, then flow alternatives should be re-visited. Alternative P, where higher flow could be released as required during the spawning and incubation period (i.e. when tributary inflow is low), would be beneficial.

- **Victoria Chamber of Commerce**: I fully support Alternative P because it may promote some additional fish and wildlife in the Jordan River, without unduly compromising power production. From my perspective as a representative of regional commercial interests and concerned about local socio-economic benefits and costs, I think that this option will enhance the local economic tourism benefits without reducing local benefits from the power produced at Jordan River. However, I will accept the option of no-change "Alternative A," as I think that the continued production of power is potentially important for socio-economic benefits.

- **BC Hydro**: I recommended the "status quo" (i.e. no river discharge from Elliott Dam). While I agree that a minimum Elliott discharge would likely have some positive ecological impact (e.g. "connecting the river," allowing fish and nutrients to move up and down the river), I felt that the societal cost of the lost electrical energy was too high to justify the uncertain ecological benefits. In addition, due to access problems, it appears that the Elliott discharge would not significantly improve local recreational values.

  However, all of my Consultative Committee colleagues recommended at least a small discharge from the dam. I understand that other B.C. citizens have different values than I do. In representing BC Hydro's corporate values, I was not prepared to "block" what would otherwise be an agreement on Elliott discharge... so I "accepted" the agreement. I would definitely have blocked a recommendation on a much larger flow, such as the one proposed for steelhead access.

- **Ministry of Sustainable Resource Management:** I trusted the technical information provided by fisheries, that habitat would increase sizeably with Alternative P, and could be accomplished with only a small drop in power value. I did not like having to make a decision on all alternatives, and the vote "accept with reservations" simply meant it is not out of the picture, I'd need strong arguments before agreeing to go that route. However, since the fish expertise moved towards preferring Alternative F, I have no reason to refute that, and the same reasons for selecting P then applied to F.

- **Ministry of Water Land and Air Protection**: (1) The given tools/measurement criteria were followed during the process; (2) there was an 85% gain in riffle (productive) habitat for a very basic minimum flow, and (3) a 'zero' flow in any British Columbia stream that contains fish is unacceptable.

- **Ministry of Energy and Mines:** Although the original preferences identified in the table indicated that the additional benefits of a 0.25 m^3/s minimum flow was "worth" the $430,000/yr lost, subsequent discussions have called this into question. With new information, the Ministry of Energy and Mines concludes that fish benefits from a minimum flow below Elliott Dam are minimal and questionable. Therefore the $430,000/yr costs associated with providing the flow are high given the uncertainty. Although this may be true there appears to be some potential long-term benefits to resident and anadromous fish (i.e., pinks). We will continue to support the minimum flow conclusion reached by the Consultative Committee primarily because there may be some improvements to ecosystem functions. These benefits are largely intangible and likely immeasurable but still important. The decline in power benefits to provide these benefits is of concern from a BC perspective. However, we understand that other Consultative Committee members are considering the costs from a more local viewpoint.

7.3 Diversion Reservoir Alternatives

A total of six operating alternatives were considered in the discussions on Diversion Reservoir. The consequence table, presented in Table 7-7, summarizes how each Diversion Reservoir alternative responds in terms of performance measures.

Table 7-7 Consequence Table for Diversion Reservoir Alternatives[1]

Interest	**Performance Measure**	**A** Current	**E** Run-of-River	**G** min 375 m	**L** G with October outage to 372 m	**M** more stable 376-380 m	**N** M with October outage to 372 m
Power	Power ($/yr)	15,060K	0	15,060K	14,550K	14,950K	14,550K
	Gain/loss per year ($/yr)[2]	Base	-15,060K[3]	0	-510K	-110K	-510K
	Reliability Index	Status quo	high pos	minimal pos	minimal pos	minimal pos	Minimal pos
	GHG (tonnes CO_2e/yr)	Base	130 861	0	5049	861	5064
Fish (reservoir)	ELZ (area.days)	11.4	37.6	13.9	11.8	18.1	15.3
Additional Information		Periodic drawdowns in summer cause fish stress		Expected to reduce fish stress in summer[4]			
Fish (river)	WURA m^2 Aug	224	5805	224	224	224	224
	Natural hydrograph (SSE)	6769	0	6769	5763	6769	5763
Socio-economic	Socio-economic welfare[5]	Status quo	neg & pos	status quo	status quo	status quo	status quo
Recreation	Surfing (potential days impacted)	54	16	53	49	55	49

7.3.1 Narrowing Performance Measures

Given the range of alternatives presented, performance measures were removed if they did not show real differences and/or would not influence the members' decisions. As with the flow alternatives, the Run-of-River Alternative (E) was removed at this time (and brought back later) to allow comparison between alternatives.

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[1] Unless otherwise noted, for all alternatives maintenance outages and drawdowns are modelled in September.

[2] It is suggested that costs are underestimated because the current model is not able to properly evaluate the costs of these restrictions on reservoir levels.

[3] This cost does not include decommissioning costs associated with dam removal.

[4] Having a minimum level of 375 m is expected to reduce fish stress in the summer as a higher elevation provides better oxygen and temperature conditions for fish health. This is compared with current operations where poor fish condition has been noted at summer drawdowns of 372 m (see Fish Section). Insufficient data did not allow this expected impact to be captured in a performance measure, however, it was a significant factor in the decision.

[5] Both negative and positive impacts: loss of 2 BC Hydro jobs and local transfer payments, possible increase in recreational fishery over time.

The following performance measures were removed from the consequence table as agreed to by the Consultative Committee for the stated reasons:

- **Reliability Index:** Differences were small enough that it did not help make a selection between alternatives.
- **GHG:** Differences were small enough that it did not help make a selection between alternatives.
- **WURA (Weighted Usable Rearing Area):** PM specifically designed to consider river alternatives and not reservoir alternatives.
- **Deviation of the Natural Hydrograph (DNH):** PM designed to consider between river alternatives.
- **Socio-economic Welfare:** Given the range of alternatives, this objective was not affected.
- **Potential # days surfing impacted:** Given the range of alternatives, the difference between alternatives was small enough that it did not help in the selection between alternatives. In addition, a surfing alternative is considered in the Turbine Generation Section.

7.3.2 Narrowing Alternatives

Alternatives L (minimum 375 m with October outage at 372 m) and N (range 376-380 m with October outage at 372 m) were removed because they were outperformed by other alternatives. Alternative L is outperformed by G (minimum 375 m); and N is outperformed by M (range 376-380 m). In addition, these alternatives assumed that maintenance drawdowns would be conducted at certain times of the year. Given BC Hydro's need to maintain flexibility for system wide maintenance planning and integration of plant outages, the Committee agreed that the interest is reservoir elevations and once elevations are agreed to, then BC Hydro will determine how and when to implement maintenance while maintaining the agreed to elevation levels. It was also confirmed that maintenance could be undertaken in the summer months as long as the minimum reservoir elevation constraint was met.

At this point it was also agreed by the Consultative Committee to replace the original G (minimum of 375 m year round) with a modified version, G1 (minimum 375 m 1 July to 30 September, and minimum of 372 m for the rest of the year), as G1 was deemed to be no worse from a fish productivity perspective and better from a power perspective.

7.3.3 Outcomes of Final Diversion Reservoir Alternatives

The consequence table for the final set of Diversion Reservoir alternatives is provided in Table 7-8. These alternatives could not be narrowed down further. Additional information was also highlighted, along with key assumptions. The Consultative Committee then stated their preferences with regard to these final alternatives.

Table 7-8 Consequence Table for Final Diversion Reservoir Alternatives

		A	**E**	**G1**	**M**
Interest	**Performance Measures**	Current	Run-of-River	min 375 m for Jul-Sept and a min. of 372 m from Oct-Jun	Operational range 376-380 m
Power	Gain/loss ($/yr)	base	-15M	0[1]	-110K
Fish	ELZ (area.days)	11.4	37.6	13.9 (PM for G)	18.1
	Additional information on impacts			Fish benefits of stress reduction: data collected by Griffith (1996) suggested that drafting the reservoir in the warmer months stressed fish. Maintaining a higher level provides better temperature and oxygen conditions. Alternative G was developed with this in mind. Power concern also applies to this alternative (see adjacent text under Alternative M).	Power concern that this loss does not reflect the true costs as the operations model used currently is not able to capture the value of storage. Currently there is flexibility of 14 m in this reservoir. Holding the reservoir within 4 m would restrict operations. Suggested that this cost is underestimated.

The Fish Technical Committee (FTC) assumed a 20% deviation of the ELZ performance measure as a deviation representing a real difference between alternatives (see assumptions). However, the FTC members noted that Alternative M likely represents a real difference in ELZ over Alternative A as the operations were confined to a band, while Alternative G likely did not represent a real difference from Alternative A, and the Committee focused on the benefit of reducing fish stress rather than on the ELZ performance measure when considering Alternatives G and G1.

[1] Refined modelling estimates including storage value indicated a revised cost of $20K.

Key Assumptions and Uncertainties

ELZ performance measure:

- The littoral zone is a significant productivity driver relative to pelagic (open water) areas.
- This performance measure solely targets periphyton (algae) growth. Benefits from macrophyte growth (large vascular aquatic plants) are not included.
- It is unknown what the fish, water quality, or macrophyte response is to increased ELZ. It is expected increased littoral zone will increase productivity and habitat options.
- Subsequently, it is unknown whether a 20% increase in ELZ is significant.

Defining a minimum level to reduce fish stress:

- Data is very limited to provide the relationship between reservoir levels and fish stress.

As shown in Table 7-8, the key trade-offs are between power (specifically power losses) and fish. Moving from Alternative A (current operations) to M (more stable operating band) shows an increase in cost of $110,000/yr, but also a corresponding enhancement of the effective littoral zone. Moving from Alternative A to Alternative G1 shows no added cost, and no expected change in the effective littoral zone, however, it is expected to reduce fish stress.

7.3.4 Stating Preferences

The Consultative Committee was asked to state their preferences and a summary of these is provided in Table 7-9. These preferences were captured by using a relative scale where:

- **S** = Fully support the alternative;
- **A** = Accept the alternative (I can live with it); and
- **B** = Block the alternative (I do not accept it).

Table 7-9 Preference Table for Diversion Reservoir Alternatives

Committee Member by Affiliation	A	E	G1	M
Victoria Chamber of Commerce	A	B	S	A
Ministry of Energy and Mines[1]	A	B	S	B
West Coast Surfing Associates	A	B	S	A
South Islands Aquatic Stewardship Society	A	A	S	A
Fisheries and Oceans Canada	A	A	S	A
Jordan River Community	A	B	S	A
T'Sou-ke Nation	-	S	-	-
BC Hydro	S	B	S	B
Te-Mexw Treaty Association	-	S	-	-
Ministry of Water Land and Air Protection[2]	B	B	A	A
Ministry of Sustainable Resource Management[3]	A	B	S	A

1. Two interests were not present this day: Veins of Life Watershed Society (who were represented by South Islands Aquatic Stewardship Society) and Sooke Parks and Recreation. Both of these interests were present at the next meeting when the final recommendation was confirmed.

Results of the preference table (Table 7-9) lead to the following conclusions:

- The Victoria Chamber of Commerce, West Coast Surfing Associates, South Islands Aquatic Stewardship Society, Fisheries and Oceans Canada, Jordan River Community, and Ministry Sustainable Resource Management, all rated Alternative G1 more favourably than Alternatives M and A. This means that they felt the potential reduction in fish stress was worth more than the loss in operating flexibility and that providing additional reservoir benefits at a cost of $110,000/yr was less desirable. The scores for all performance measures across the Alternatives A, G1, and M met their minimum needs.

- BC Hydro rated Alternatives A and G1 equal. This means that the loss of operating flexibility is worth roughly the same as potentially reducing fish stress. The scores for performance measures in Alternatives E and M did not meet BC Hydro's minimum needs.

- Ministry of Energy and Mines rated Alternative G1 more favourably than Alternative A. This means that they felt the benefits of potentially reducing fish stress are worth more than the loss in operating flexibility.

1 Formerly part of the Ministry of Employment and Investment.

2 Formerly part of Ministry of Environment, Lands and Parks - Fish and Wildlife.

3 Formerly part of the Ministry of Environment Lands and Parks - Water Management.

- Ministry of Water Lands and Air Protection rated Alternatives G1 and M equally. This means that the potential benefits of reducing fish stress at no cost is roughly equal to providing more benefits in the littoral zone with an additional $110,000/yr cost. The scores for the performance measures in Alternatives A and E did not meet their minimum needs.

- The T'Sou-ke Nation representatives supported the Run-of-River Alternative, and were not willing to comment on other alternatives as they felt this alternative best meets their interests in terms of achieving their treaty rights.

Initially the Consultative Committee, with the exception of the T'Sou-ke Nation representatives, agreed that G1 would be the alternative that goes forward for recommendation. Diversion Reservoir would have a minimum reservoir level of 375 m from 1 July to 30 September, and a minimum level of 372 m for the remainder of the year. BC Hydro would be able to draw down below this level in case of emergencies.

Alternative G1 was modified at the next meeting at the same time modifications were made to the 'flows downstream of Elliott Dam'. Less flow was accepted and, in turn, a bit more productivity gained in the Diversion Reservoir by having a minimum operating level 1 m higher. The extra benefit was expected to manifest as less fish stress in summer months due to more thermal and oxygen capacity.

Agreement

The modified G1 alternative was accepted by Consultative Committee members with the exception of the T'Sou-ke Nation. The Diversion Reservoir will have a minimum level of 376 m from 1 July to 30 September and a minimum level of 372 m for the remainder of the year. This constraint may be violated in the case of emergencies, with appropriate notification.

A discussion ensued over what would take precedence during low water situations maintaining flows downstream or maintaining the minimum reservoir elevation. It was not known how often this conflict would occur, although having a 376 m minimum level instead of a 375 m minimum level increases the risk of this occurrence. It was suggested that bringing the reservoir levels down slightly may be a better trade-off than halting flows downstream. However, if the reservoir level becomes too low (possibly below 372 m) then holding the reservoir level may become more important than providing flows.

To ensure that BC Hydro had direction to make operational decisions during low water situations the Consultative Committee was asked to provide guidance. At that point, it was agreed that a decision rule should be developed to reduce flows and reservoir elevations in tandem until the flow release hit 0.1 m^3/s and then it would be maintained at this level (see Appendix N for Proposed Decision Rule for Determining Flows). It was also agreed that when the reservoir elevation was expected to drop below 376 m, BC Hydro would notify appropriate federal and provincial regulatory agencies.

It was subsequently decided that during the 4-year monitoring program, it is preferred to continue to provide the 0.25 m^3/s flow to ensure the effects of the operational change can be assessed during this period.

Agreement

The Consultative Committee agreed that in low water situations, when the reservoir is expected to drop below the minimum operating level, BC Hydro shall notify the appropriate federal and provincial agencies and proceed with:

- Providing a 0.25 m^3/s flow below Elliott Dam during the 4-year flow monitoring program, or
- Reducing flows and reservoir levels according to a flow decision rule[1] when the monitoring program is not in place.

7.3.5 Additional Member Comments on Preferences

Committee members were invited to submit additional information on their values and preferences to be included in the report. The following are verbatim responses:

- **Jordan River Community**: I supported Alternative G1 (minimum level of 375 m July to September and 372 m October to June) for the fish benefits in the reservoir and also because there was little or no added cost in power loss. I chose to block Alternative E (Run-of-River) because I value the capacity to produce power that Jordan River represents. Given the limited production capabilities on Vancouver Island, removing an entire generating plant would make us even more dependent on power generated on the mainland or on an alternative power generating system that may create unacceptable levels of greenhouse gases.

[1] See Appendix N for proposed decision rule.

- **Veins of Life Watershed Society**: As I was absent from the voting I unfortunately missed some critical discussions. My vote would have been "S" for Alternative M, with its increased Effective Littoral Zone (ELZ). However, I would have given G1 an "A," as a compromise.

  I have been involved with the reservoir through the joint study with BC Hydro and Royal Roads, and have seen first-hand during snorkelling that there is a total absence of marcrophytes or periphyton. I suspect it will be very advantageous to increase the ELZ to the most practical extent we can. I would likely choose reservoir stability and a minimum level of 376 m most often over maintaining river flows.

- **South Islands Aquatic Stewardship Society**: I accepted Alternatives A, E, M and fully supported Alternative G1. In the final decision I chose the modified G1 alternative because the information available suggested that this alternative would provide a reduction in fish stress by not having water drawn down to a low level which results in increased temperature and decreased oxygen. Therefore this alternative would stabilize the reservoir habitat, improve water quality and reduce fish stress.

- **Fisheries and Oceans Canada**: Alternative G1 seemed like the most balanced choice (benefit vs. Hydro operations flexibility) however there was little data to base this decision on. In the case of low water years there may be conflicts between maintaining reservoir levels and providing downstream flows. I support developing a strategy to split the water in such a way as minimum total stress is imposed on both river and reservoir ecosystems. This should be developed by the Fisheries Technical Committee. More information is required to predict the effects of reservoir levels on biological production, and obtaining this information should be part of the monitoring program.

- **Victoria Chamber of Commerce**: I fully support preference G1 and accept preference A, as I think that these options will tend to provide some increased local socio-economic benefits.

- **BC Hydro**: As a former operations planner for coastal hydroelectric projects, I typically would not welcome additional restrictions on reservoir operations. However, in my experience with the Jordan Diversion Reservoir, I felt that it was reasonable to limit the drawdown of Diversion during the hot summer months to improve conditions for reservoir fish. While I believe there is some small expected power cost for this reservoir restriction (higher likelihood of spill), I believe that the reservoir fisheries benefits are worthwhile. Therefore, overall provincial wealth, considering all values, is likely improved with this operating restriction.

- **Ministry of Sustainable Resource Management:** In a similar vein, the G1 alternative was supportable, and I would have expected to hear strong arguments in favour of the others before agreeing to them, though I felt there were acceptable points in each of the ones for which I voted "accept." Again, I felt the gain to fisheries was strong, while nothing else was compromised.

- **Ministry of Water Land and Air Protection:** With nil or very little cost, the fish in Diversion Reservoir are assured better water quality during the summer, which has been shown to stress fish.

7.4 Turbine Generation Alternatives

Turbine generation alternatives deal with the surfing interest. The surfing alternative would primarily affect power values and Table 7-10 below shows the impacts on power and surfing interests moving from current operations to Alternative I.

Table 7-10 Consequence Table for Surfing Alternatives

Interest	Performance Measure	A (current operations)	I (shift generation above 120 MW from high load hours to low load hours Oct-Mar).
Power	Gain/loss ($/yr)	$0	-$50,000/yr
Recreation	Potential # days impact	54	16

The Consultative Committee raised and discussed the following additional points:

- With Alternative I, surfing is still affected when discharge is maintained at 50 m^3/s (or less), although to a lesser extent than 65 m^3/s (current operations) discharge.

- The recommended discharge of 50 m^3/s was not based on the results of the surf survey, but on expert opinion, in conjunction with knowledge of turbine efficiency.

- The surfing performance measure (potential # of days impact) results for Alternative I show about a threefold increase in benefits i.e. amount of time discharge is 50 m^3/s or less.

- Surf quality is variable and other influences may at other times be greater than the effect of generation. Thus, with Alternative I, there will be many times when discharge is curtailed for surfing when surf quality is poor for other reasons (see Appendix F for Surf Quality Influence Diagram).

- The results of the surf survey were inconclusive (not all surfers notice the impact of generation on surf quality).

- It was estimated that of the 54 potential days of impact in Alternative I, 15-40 would be good surf days. Hence, limiting BC Hydro's operations to the 120 MW in high load hours, may be excessive and a more realistic expected improvement would be 3-5 days. Thus, it was estimated that if Alternative I was implemented and it increased prime surf days by five, Alternative I works out to cost about $10,000 per prime surf day.

7.4.1 Exploring Other Surfing Options

Other approaches to address the surfing interests were discussed. It was thought that a voluntary guideline for BC Hydro operations staff would not work and it would be difficult to implement. An option was suggested to reduce generation for special events. It would require considerable coordination as surfing is affected by current, weather, and tide. Generally, there are no coordinated surfing events at this point at Jordan River.

The Consultative Committee discussed reducing discharge to 20-30 m^3/s for up to four weekends in March unless deemed not a good surfing day and discharge could increase if there was heavy rainfall and/or emergency situations.

BC Hydro and the surfing representative refined this recommendation, which was endorsed by the Committee.

Agreement

The Consultative Committee agreed that BC Hydro shall plan to operate the generation with a discharge not greater than 30 m^3/s from 6 a.m. to 6 p.m. on a minimum of 4 weekend days during the month of March. Higher releases are permissible when required to manage basin inflow, or emergency situations. A surfing representative may advise BC Hydro of a good weekend day in March and BC Hydro shall make reasonable efforts to apply this constraint on that day.

7.5 Elliott Headpond

The operation of the Elliott Headpond was not a primary focus of discussion during the water use planning process. The headpond is typically operated within a reduced range to maximize the generating capability of the facility, an operating practice which is also beneficial for fish in Elliott Headpond. There were no alternatives created for the Elliott Headpond nor were any performance measures applied to this part of the facility. There was a task, however, to scope opportunities to enhance the way the hollow cone valve is operated to provide additional benefits to resident fish.

The Elliott Headpond has a relatively small storage volume that is fed by the Diversion Reservoir and natural inflows. Reservoir levels normally fluctuate within a 2-4 m range to maximize head for power generation. At times, however, the operating level can fluctuate by 5 m in less than 2 hours. The headpond may be drafted to lower levels during maintenance and dam safety inspections and to provide a storage buffer when high local inflows are expected.

Rainbow trout are known to reproduce in the various tributaries entering Elliott Headpond, specifically Alligator and Rough Creeks. Additionally, trout populations are healthier in Elliott Headpond than Diversion Reservoir. This may be because Elliott Headpond levels are maintained at a relatively stable level and populations densities are less.

It was agreed that more work needs to go into scoping the possibilities for improving operations, particularly if opportunities exist to benefit headpond productivity at no cost. Any benefits to fish would also provide benefits to recreation. It was suggested that the BC Hydro group responsible for the operations of Elliott Headpond needs to be involved in these discussions.

Agreement

The Consultative Committee agreed that there will be no operating constraints for Elliott Headpond. However, there is a recommendation that BC Hydro seek opportunities to reduce the fluctuation of the headpond levels by further coordinating planned releases from Diversion Reservoir and the operations of the penstock intake. The intent is to look for opportunities to reduce headpond level fluctuations at minimal cost and increase mutual understanding of the system operations. The season of interest extends from May to September.

7.6 Operating Recommendations for the Jordan River Water Use Plan

The recommendation package developed by the Jordan Water Use Plan Consultative Committee, and agreed to by all members except the T'Sou-ke Nation, is outlined in Table 7-11. The T'Sou-ke Nation preference is the Run-of-River Alternative (see Section 7.7, Areas of Disagreement). The specific wording below was reviewed and accepted by the Consultative Committee.

Table 7-11 Recommended Operating Constraints for the Jordan River Hydroelectric System

System Component	Constraint	Time of Year	Purpose
Bear Creek Reservoir	BC Hydro shall not operate the low level outlet in a manner which drafts the elevation below 411 m, except in emergency situations.[1]	All year	Reservoir productivity; recreation
Diversion Reservoir	Minimum normal elevation of 376 m.	1 Jul-30 Sep	Reservoir productivity
	Minimum normal elevation of 372 m.	1 Oct-30 Jun	
	BC Hydro shall not operate the reservoir below the stated minimum elevations except in emergency situations,[1] when undertaking works associated with maintaining the integrity of the dam for dam safety reasons or in low water situations to provide flows downstream. In low water situations, when the reservoir elevation is expected to drop below the normal minimum operating level, BC Hydro shall notify the appropriate federal and provincial agencies. BC Hydro will then proceed with providing a 0.25 m^3/s flow below the Elliott Dam during the 4-year river monitoring program, or reduce flows and reservoir levels according to a flow decision rule[2] when the monitoring program is not in place.		
Elliott Headpond Elevations	No operating constraints. BC Hydro shall seek opportunities to reduce the fluctuation of the headpond levels by further coordinating planned releases from Diversion Reservoir and the operations of the penstock intake.	All year	Reservoir productivity
Elliott Dam Outlet (new infrastructure needed)	Base target flow of at least 0.25 m^3/s with an accepted deviation to 0.225 m^3/s. In low water situations, this flow may need to be reduced (see Diversion Reservoir Section).	All year	Resident fish habitat, river productivity and ecosystem health

[1] Emergency: Emergencies include those required to address dam safety, actual or potential loss of 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.

[2] See Appendix N for proposed decision rule.

System Component	Constraint	Time of Year	Purpose
Turbine Discharge	BC Hydro shall plan to operate the generation with a discharge of not greater than 30 m^3/s from 6:00 a.m. to 6:00 p.m. on a minimum of 4 weekend days during the month of March. Higher releases are permissible when required to manage basin inflow, or emergency situations.[1] A surfing representative may advise BC Hydro of a good weekend day in March and BC Hydro shall make reasonable attempts to apply this constraint on that day.	Up to four weekend days in March	Recreational surfing

7.7 Areas of Disagreement

While the majority of Consultative Committee members supported the agreements made on each segment of the hydroelectric system (see recommendations section above), T'Sou-ke Nation representatives supported the Run-of-River Alternative. The T'Sou-ke people believe current hydroelectric generation on the Jordan River is incompatible with the exercising of their fish dependent treaty rights in the Jordan River and its watershed.

T'Sou-ke Nation contends that under their existing treaty, current and future generations of T'Sou-ke people hold certain rights, including (1) the right to "carry on their fisheries as formerly," and (2) the right to hunt over the unoccupied lands of their traditional territory. The Jordan River watershed is part of the traditional territory claimed by the T'Sou-ke Nation.

T'Sou-ke Nation's primary interest in the water use planning process is to see the restoration of fish populations in the Jordan River as well as the wildlife species which are dependent upon those fish. It is T'Sou-ke Nation's perspective that the Run-of-River Alternative is the closest to restoring river levels and the conditions which are the basis for being able to exercise their fish dependent treaty rights.

8 MONITORING PROGRAM

As part of the operating alternative, the Consultative Committee recommends an associated monitoring program designed to address key uncertainties and answer specific questions that may change future decisions on operations. The key areas of uncertainty focus on the benefits and costs associated with the base flow release from Elliott Dam, modifying the minimum normal operating level of Diversion Reservoir and altering turbine discharge for improved surfing quality for a minimum of four weekend days in March (see Table 7-11).

In developing this monitoring program, the Consultative Committee used the criteria and guidelines being developed by the Water Use Plan Interagency Fish Advisory Team (FAT) and Resource Valuation Advisory Team (RVAT) to ensure the recommendations being tabled are relevant to the changes being proposed. At the time of this program development, these guidelines were still being developed.

8.1 River and Reservoir Monitoring Program

Table 8-1 provides a summary of the recommended monitoring program for Jordan River below Elliott Dam and Diversion Reservoir. A description of each study is included along with the uncertainty being addressed, operational implications, study length, study certainty and total estimated cost. Detailed descriptions of these studies are provided in Appendix O.

For each of the studies listed in these tables, a detailed Terms of Reference will be developed in the first year with a total estimated cost of $40,000. In addition, upon completion of these studies, a review of the monitoring results (data analysis) will be conducted in the sixth year with a total estimated cost of $35,000. These cost items are summarized in Table 8-2.

8.2 Monitoring for Surfing

In addition, a monitoring program is recommended to track the benefits of the turbine discharge constraint in March for surfing. It was agreed that each year, BC Hydro will send a summary of the March weekend day operations to the surfing representative. This will be followed up by an informal, yet documented, discussion between BC Hydro and the surfing representative as to the costs and benefits of the operational change on those four weekend days. The costs associated with assessing the benefits are expected to be minimal, however, $1000 is allocated for the design of the reporting mechanism, and an additional $500/yr is allocated for documentation and reporting in each subsequent year. The summary costs of monitoring surf quality is provided in Table 8-2.

Table 8-1 Recommended Monitoring Program for the Jordan River Water Use Plan

Program	Description	Uncertainty/ Data Gap	Environmental/ Operational Implications	Time (yr) Certainty Cost[1]
Lower Jordan River Discharge and Local Inflow Measurements	Install gauging stations below Sinn Fein Creek and below Elliott Dam. Establish stage discharge relations curves for each station. Monitoring local inflows and accurately estimate the impact of a 0.25 m^3/s base flow on summer and winter minimum flows.	Accuracy of local inflow data used to rationalise a 0.25 m^3/s base flow. Efficacy of a 0.25 m^3/s base flow release into a dry channel to increase downstream habitat.	Local inflows fail or exceed the needs to generate the habitat associated with a 0.25 m^3/s base flow. Revisit necessity of a base flow to generate expected habitat gains.	2 (4) High $30K
Fish Index: Lower Jordan River	Determine direction of rainbow trout standing stock dynamics (fish size and abundance) (±) following 'treatment' with a base flow release.	Relation of habitat increases to actual changes in rainbow trout condition and population.	The base flow release may need to be increased or the efficacy of any base flow not justified for limited or negligible ecological benefits.	2 (4) Baseline $120K
Qualitative Habitat Survey for Salmonids in the Lower Jordan River	Monitor for successful spawning and rearing of anadromous salmonids in the Lower Jordan River below the first passage barrier.	Metal toxicity and/or critical low flows impact success of incubation and rearing. Base flow may mitigate against any or none of these impacts.	Increased anadromous salmonid success associated with a base flow release will influence future water allocation decisions.	6 Baseline $40K
Fish Index: Diversion Reservoir	Gill netting and minnow trapping at end of each growth season to assess indicators of stress. Includes associated water chemistry (dissolved oxygen and temperature). Includes a planned drawdown to elicit response.	Response and level of stress in rainbow trout (if any) associated with drawdowns below 376 m on Diversion Reservoir.	Absence of measurable changes in fish condition would not justify the recommended decrease in reservoir flexibility.	(1) 5 Medium $50K

1 Time as pre and (post) data collection. Certainty measures: (High) Monitoring study will definitely lead to fine, quantitative discrimination among all of the competing hypotheses including measure of effect size. (Medium) Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses and may quantify effect size. (Baseline) Likely to allow only qualitative comparisons among a few competing hypotheses with little or no sensitivity to effect size. Cost estimated cost for the entire program.

Table 8-2 Monitoring Program Total Estimated Costs

Monitoring	Cost $	
Terms of Reference	40,000	(in year 1)
River Fish		
• Inflow measurements	30,000	(over 5 years)
• Biological productivity	120,000	(over 6 years)
• Habitat quality	40,000	(over 6 years)
Reservoir Fish		
• Biological productivity	50,000	(over 4 years)
Recreation		
• Surfing quality	3,500	(over 6 years)
Review of Monitoring	35,000	(in year 6)
TOTAL	$318,500	

8.3 Monitoring Timing and Costs

The total cost of the recommended monitoring program is provided in Table 8-2. The total annual costs of the operational changes and the monitoring program are provided in Table 8-3. As shown on the table, the monitoring program will include 2 years of baseline collection for river monitoring prior to flow releases. Studies will end in year six, and at that point a review of the monitoring results is recommended.

Table 8-3 Annual Cost of Operational Changes and Monitoring Program

Cost Components	$ Cost '000/Year							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Foregone Power	-	-	330	330	330	330	330	330
New Infrastructure								
• Engineering design	100							
• Infrastructure cost		100	100	100	100	100	100	100
Monitoring Program								
• Develop terms of reference	40							
Recreation								
• Surfing Quality	1	0.5	0.5	0.5	0.5	0.5		
River Fish Monitoring Studies								
• Inflow measurements		6	6	6	6	6		
• Biological productivity (fish)	20	20	20	20	20	20		
• Habitat quality			10	10	10	10		
Reservoir Fish Monitoring Studies								
• Biological productivity (fish)		10	10	10	20			
Review Monitoring Results						35		
TOTAL[3]	161	137	477	477	487	537	430	430

1. The revised estimated cost for forgone power in years 3 to 8 are $383,000/yr (or an additional $53,000/yr) based on refined modelling to capture the value of reservoir storage and plant dispatchability.
2. The numbers reflected in this table are the total costs which the Consultative Committee based their trade-off discussions. The Committee agreed to have the revised estimates reflected as notes to this table. The revised total cost estimates for years 3 to 8 should be revised to capture the additional $53,000/yr explained above. Revisions are as follows: Year 3 = $530,000; Year 4 = $530,000; Year 5 = $540,000; Year 6 = $590,000; and Years 7 and 8 = $483,000.
3. Totals have been rounded to the nearest thousand.
4. Years 1 through 8, in thousands of dollars. Year 6 marks a review of the monitoring program results.

8.4 Other Monitoring Recommendations

Given the breadth of information made available to the Fish Technical Committee (FTC) during the course of the Jordan River water use planning process it was inevitable that many important fish issues were outside the scope of Water Use Plans. Consequently, the FTC flagged the following recommendations for consideration:

- Continue baseline water quality and limnological survey information for Diversion and Bear Creek reservoirs to complete an entire seasonal record. The current model for this program is a joint effort between Royal Roads, BC Hydro, and Ministry of Water, Land and Air Protection. A complete year of information would be beneficial for future decisions.

- The potential for increased successful pink spawning (and a recreational beach fishery) may be an ancillary benefit of the decision to establish a base flow down the Jordan River below Elliott Dam. One means of facilitating this process would involve efforts by Fisheries and Oceans Canada to release pink into the Jordan River system over several years, testing the viability of the system to maintain self-supporting populations. Avenues to pursue such an effort are clearly outside the scope of Water Use Plans but may be pursued by Fisheries and Oceans Canada directly or under joint programs, such as the Bridge River Coastal Restoration Program.

- Water and sediment quality associated with the lower 490 m of the Jordan River that could be accessible for pink, chum, and coho is strongly suspected to be either acutely or chronically toxic to juvenile anadromous salmonids. The toxicity source is attributed to metal levels associated with an abandoned copper mine site. Feasibility of remediation and ongoing water and sediment quality surveys should be pursued under the Ministry of Water, Land and Air Protection and other responsible agencies to eliminate this obstacle to usable habitat.

9 IMPLEMENTATION OF RECOMMENDATIONS

The operational changes and the monitoring program that were recommended by the Jordan River Consultative Committee would be implemented once government has approved the Water Use Plan. The monitoring program will take approximately 6 years to complete. A staged approach to implementation will allow for the collection of critical flow information that will help to confirm expected benefits and improve future decision-making. It will also provide time for the design and installation of an appropriate flow release mechanism for Elliott Dam. Figure 9-1 and the following description outlines how these proposed changes to operations and the monitoring program will be undertaken.

Approval of Water Use Plan (approximately 6 to 12 months)

It is anticipated that the review and approval of the Jordan River Water Use Plan will take approximately 6 to 12 months once it is submitted to government. During this time, the Comptroller of Water Rights will review the recommended plan under provisions of the *Water Act* and will involve the federal government - Fisheries and Oceans Canada, other provincial agencies, First Nations and other identified parties.

Initiate Baseline Monitoring Program (approximately 2 years)

The baseline monitoring program requires initiation of engineering and implementation of selected operational changes. Once the Water Use Plan is approved the following activities will be undertaken:

- Develop detailed terms of reference for the monitoring program studies
- Initiate detailed engineering design work for the flow release mechanism
- Commence the collection of 2 years of baseline flow information in the Jordan River below Elliott Dam
- Constrain turbine discharge (power generation) to 30 m^3/s for a total of 4 weekend days in March to address surfing interest
    - Begin monitoring the effects of a change in turbine discharge
- Implement changes to reservoir operations on Diversion Reservoir
    - Begin monitoring the effects of a change in Diversion Reservoir levels

Install Flow Release Mechanism and Assess Response (approximately 4 years)

After collecting 2 years of baseline flow information it is recommended the following be undertaken:

- Install flow release mechanism at Elliott Dam

- Monitor the effects of the flow release for a 4-year period

Review Monitoring Results (at approximately year 6)

After the installation of the flow mechanism at Elliott Dam and the subsequent collection of four years of information, it is recommended that BC Hydro, in consultation with the appropriate federal and provincial agencies, will review the results of the monitoring program. At that point, it will be decided whether or not to trigger a Water Use Plan review or whether to continue the operational changes as recommended by the Jordan River Consultative Committee.

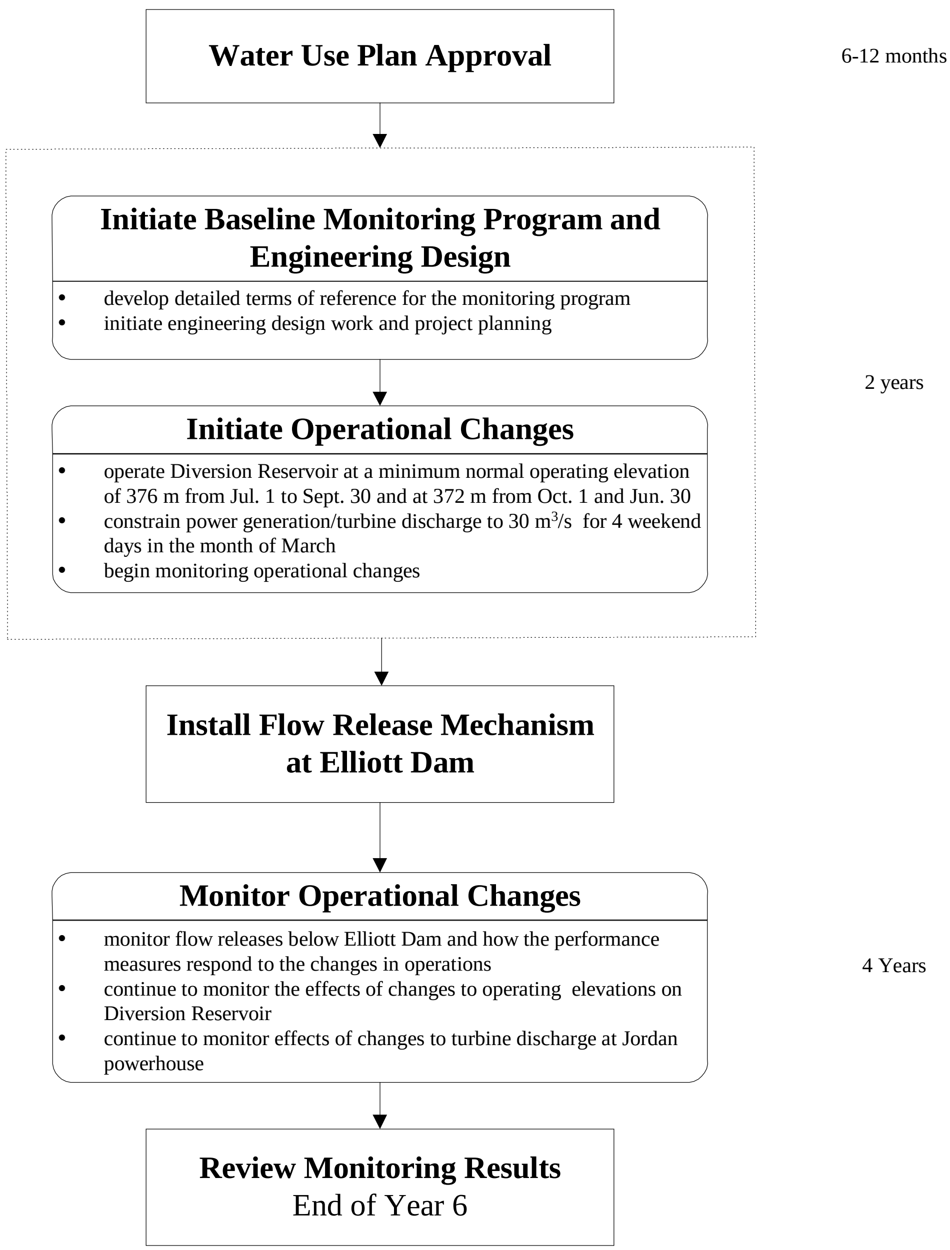

Figure 9-1 Implementation of Recommended Operations and Monitoring

10 REVIEW PERIOD

The Consultative Committee did not recommend a specific review time for the Jordan River Water Use Plan, however they felt that there were a couple of situations that could trigger a review. In particular, the Consultative Committee agreed that if efforts were undertaken to clean-up the old mine site upstream of the current powerhouse, the issue of habitat contamination may be alleviated thereby providing greater potential for the re-establishment of anadromous fish populations in the Jordan River. The Consultative Committee also recognized that the results of the monitoring program might provide opportunity for improved decision-making once additional information has been collected.

Agreement

No review period for the Water Use Plan was specified, however, the Consultative Committee, with the exception of the T'Sou-ke Nation representatives, agreed to the following:

- Remediation of the old mine site would trigger a review of the Water Use Plan.
- A review of the monitoring results would occur in the sixth year and may trigger a review of the Water Use Plan.

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APPENDIX A: HISTORY OF THE JORDAN RIVER FACILITY

Original Jordan Hydroelectric Power Development (1909-1969)

The original power development was initiated in 1909 and completed in 1912. The plant operated from 1912 to 1969. The system consisted of 2 storage reservoirs, Bear Creek and Diversion. Water was diverted from Diversion Reservoir through a 8.5 km wood flume with an initial diversion capacity of approximately 5 m^3/s to the Forebay headpond. The diversion capacity was increased in 1928 to approximately 9 m^3/s when the flume was upgraded. The Forebay headpond had minimal storage and was used to divert water to the original powerhouse on the east side of the river. From the Forebay, water travelled through four 2.8 km penstocks down to the powerplant (26.4 MW) consisting of four Pelton generating units, and then through a 500 m tailrace (an open channel) into the river estuary. The Elliott Dam did not exist at this time (Figure A-1).

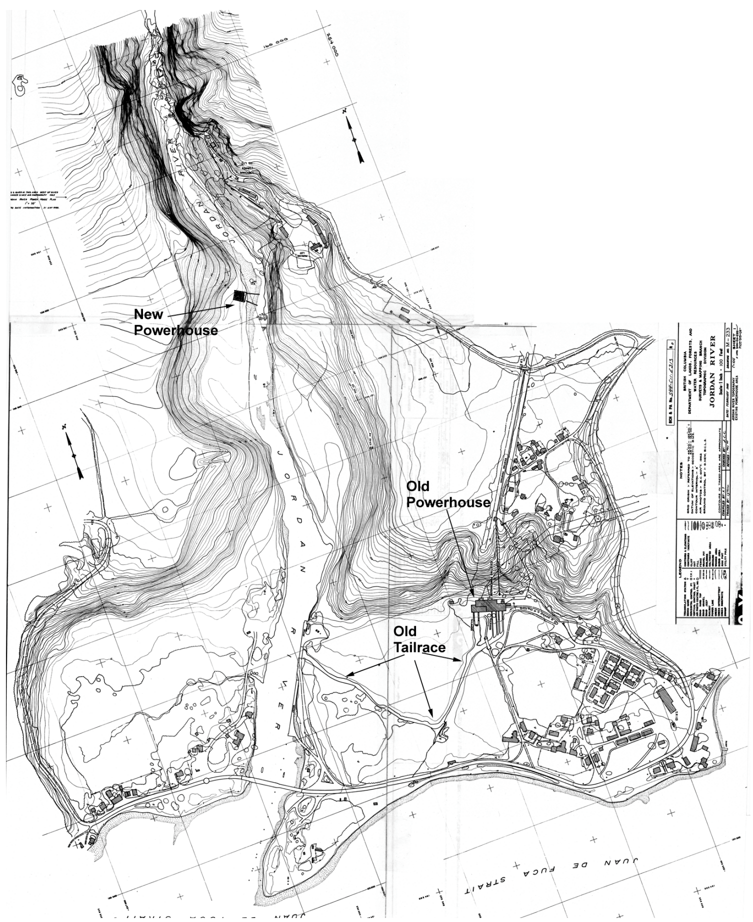


Figure A-1 Jordan River 1912-1971 Powerhouse and Tailrace

Old tailrace approximately 500 m long. Pink and chum spawning in the tailrace noted by DFO annual survey records (1949–1971). Data from BC Hydro 544-C11-E313.

Water flows down the Jordan River

From 1912 to 1969, water entering the Jordan River below Jordan Diversion Dam came from three main sources. The first source was tributaries feeding into the river below Jordan Diversion Dam. These included Rough and Alligator Creeks as Elliott Dam was not yet constructed. The second source was any spill that occurred over the Forebay reservoir, these spills travelled down a spillway in the back of the reservoir and re-entered the lower Jordan River. The third source was any spill that occurred at Jordan Diversion Dam. The actual flows down the Jordan River during this time were not recorded.

Water flows in the original powerplant tailrace

Water passing through the original powerhouse flowed through the 500 m tailrace and out into the River estuary. Turbine discharge was maintained on a regular basis as the plant was 'base loaded' (i.e. run constantly when Diversion and Bear Creek Reservoir levels were sufficient). An informal agreement between DFO and BC Hydro maintained a minimum tailrace flow in the tailrace of approximately 1 m^3/s (35 cfs) between 1964 and 1969. The tailrace was documented to sustain populations of spawning pink and chum salmon. Furthermore, it is indicated that the majority of pink and chum were spawning in the tailrace rather than in the main river channel.

Impacts from other Industrial Activities: Forestry and Mining Operations

The watershed has been actively logged since the 1880's and until 1915 the upper watershed remained characterized by heavy growth of timber. Western Forest Products have managed logging operations and conducted booming and towing operations in the lower Jordan River since 1934. Following a major bank slump from mining operations in 1963, the salt marsh at the river mouth was filled with the slide materials and became the platform for future log sort activities. The gravel bar at the mouth of the river has been frequently dredged to facilitate log boom towing.

Copper mining has occurred intermittently between Elliott Dam and the current powerhouse since the early 1900's. Prior to 1960, mine tailings accumulated along the east bank and occasionally in the river itself. Operations between 1960-1974 permitted a discharge of approximately 450 m^3/d of mine tailings to the nearshore shelf just off the mouth of Jordan River (500 m east of the river mouth, and 500 m out). The line failed at least twice during this period, depositing tailings closer to the shoreline and in the river.

In 1963, a mine shaft under the Jordan River collapsed while the mine was being operated by Cowichan Copper Mine. Additional slumping and sloughing have occurred periodically along the east river bank as abandoned mine shafts became saturated with water. The debris associated with the slide and runoff through the mining tunnels are characterized by high levels of copper.

The Redevelopment (1969-1971)

In 1969, work began to build the new powerplant on the other side of the river. This development is the current project still in operation today. Under the redevelopment program (1969-1971), the dam at Diversion Reservoir was improved, Elliott Dam was created to replace the Forebay headpond, and a single high head Francis turbine (170 MW) was installed in the new powerhouse on the east bank of the Jordan River about 200 m upstream from where it enters the Juan de Fuca Strait. The powerhouse was fed by a new pressure tunnel and penstock (total length 7.2 km) from Elliott Dam and bypassing the original Forebay (now referred to as the Old Forebay).

The Existing Plant (1971 - present)

In 1971 the new plant, as described in the redevelopment above, commenced operation. The Jordan River is diverted at Elliott Headpond into a 7.2 km tunnel and penstock which leads to the powerhouse.

Present water flows in the Jordan River below Elliott

The source of water in the Jordan River mainstem includes the tributary inflow downstream of Elliott Dam (which does not include Alligator and Rough Creeks). In addition, about twice a year, inflows exceed reservoir capacity and spills successively occur at Jordan Diversion Dam and Elliott Dam.

The tailrace from the new powerhouse empties into the lower part of the Jordan River approximately 200 m upstream of the estuary. Water flows are highly variable and may change from 0 to approximately 65 m^3/s twice a day during peaking operations, discharge constantly at 60-70 m^3/s during high inflow periods, or not discharge at all when reservoir levels and inflows are low. Note that the capacity of the new plant is much higher than the old development: 170 MW versus 26.4 MW.

Water flows in the original powerplant tailrace

Water no longer passes through the old tailrace. Parts of the tailrace have been in filled with wood waste and other materials.

Impacts from other Industrial Activities: Forestry and Mining

Western Forest Products have continued to manage logging operations and conducted booming and towing operations in the lower Jordan River.

With respect to mining, as mentioned above, operations between 1960 to 1974 were permitted to discharge mine tailings to the nearshore shelf just off the mouth of Jordan River (500 m east of the river mouth, and 500 m out). The line failed at least twice during this period, depositing tailings closer to the shoreline. The sub-tidal discharge of the copper mine tailing were monitored between 1972 to 1974 by the Ministry of Environment, Lands, and Parks (MELP) Pollution Control Branch.

Mining operations were finally suspended following the depression of copper prices in the 1980's. Most recently, the mine has been purchased in a closed bidding process, however, the future of activity in the area and the new company plans is unknown.

APPENDIX B: PRELIMINARY ISSUES LIST

This section summarizes the interests and issues that were raised during the Jordan River water use planning process. These issues formed the basis for the Consultative Committee's discussions and deliberations.

RECREATION

Diversion Reservoir

- Boat access at Diversion Reservoir may be a problem at low reservoir levels.
- Recreational fishing in Diversion Reservoir may be negatively affected at low levels due to stumps and floating debris.

Mouth of the Jordan River

- Peak releases of water from the generation facility negatively impacts recreational surfers by decreasing the quality of the surfing (with increase in freshwater flow), and in the case of inexperienced surfers, could pose a safety issue with the increased flows creating a current that could carry them further out from shore.
- Opportunities for saltwater fly fishing at the mouth of the Jordan would exist if the river had anadromous salmonid production capability.

FISH

Jordan River

- Insufficient water for fish in lower 8 km of the Jordan River: No minimum flows are currently required below Elliott Dam.
- Records show historic stocks of steelhead, pinks, coho, and chum in the lower river and the old tailrace development.

Reservoirs

- At low reservoir levels, spawning fish may not be able to access tributary streams from the reservoirs and, conversely, may not be able to migrate from the streams back into the reservoirs as fry (young fish). This would primarily affect cutthroat and rainbow trout.

- Low reservoir levels may have negative impacts on fish. At low reservoir levels, fish are squeezed into a smaller area and increased temperatures (in summer) with lower dissolved oxygen (at the higher temperatures) may stress fish and lower survival rates.

- Fish cover in the reservoirs such as stumps provide good protective habitat.

- Fish may be impacted by flows between Diversion Reservoir and Elliott Headpond, with ramping rates (where fish could be stranded if the hollow cone valve closed and water flows are reduced), and generally habitat availability is altered with varying flows.

- Possible impacts of fluctuating reservoir levels on productivity of the littoral zone (the productive zone around the rim of a lake where light penetrates onto the bottom and promotes plant growth), which in turn will impact fish production.

- Nutrient levels in reservoirs may be impacted by operations.

General Fish Issues (throughout system)

- Entrainment (when fish are pulled into the turbine, the pressure change stresses their system and in many cases leads to fatality).

- Total Gas Pressure (when water spills over a dam and increases dissolved gas in the water below which gets absorbed into the fish and causes the 'bends'). It is uncertain if this is an issue at Jordan River.

- Flushing flows - it is not enough to have a steady flow to ensure good quality fish habitat, 'flushing flows' are also needed - this is a periodic high flow to allow removal of sediments that have been deposited. This may occur between Diversion Reservoir and Elliott Headpond, or in the Jordan River.

- Gravel recruitment - water flows in the rivers just below the dams gradually remove gravel by continually moving it downstream. The dam prevents new gravel from being deposited.

WILDLIFE

- Impacts may occur in the littoral/riparian interface (that is, along the edge of the reservoir, and along the edges of the rivers) by fluctuating water levels. This impact is a loss of productive areas. Impacts can occur on species all along the food chain - from terrestrial insects to amphibians, to aquatic mammals to nesting birds and 'dippers' (birds that swim and feed in moving water).

- Generally, there is a lack of knowledge of wildlife in the Jordan River system.

HERITAGE

- Generally there is a lack of knowledge of heritage sites in the area. It is possible that heritage sites exist at the mouth of the river for both the T'Sou-ke Nation and the Ditidaht First Nation.

POWER GENERATION

- A responsibility to maximize the value of the Jordan power plant and reservoir system within agreed upon constraints.
- The Jordan River hydroelectric system provides peaking capability and flexibility for the entire BC Hydro system to meet system load in the most economical way.
- The Jordan River hydroelectric system provides reliability for the Vancouver Island electrical system, especially during periods of peak demand and/or limited transfer capability from Lower Mainland to Vancouver Island.
- At times, Jordan River provides voltage support and/or local support for the southern Vancouver Island area.

FLOODING

Downstream of Generation Station

- No flooding issues arose with respect to property.
- There is a need to understand flooding on recreational safety issues.

APPENDIX C: ISSUES OUTSIDE THE SCOPE OF WATER USE PLANS

Overview

The scope of the water use planning process is to look at how water is used at existing water control facilities and to determine how the use of that water could be altered through operational changes. It was not intended to address issues arising from the construction of the facilities but rather those that could be addressed by changing the way facilities are operated. Throughout the Jordan River water use planning process, a number of issues outside the scope of Water Use Plans were raised by Consultative Committee members and observers. These items are detailed below to recognize that they are of importance to the committee members and the community.

Old Forebay

- A committee member advised that people camp in various areas around the Old Forebay and that this could be a fire hazard to the Hilltop residents. There may also be a potential safety risk of people jumping into the forebay and hitting submerged structures.

- The land around the Old Forebay area belongs to Western Forest Products. At one time the province expressed an interest in taking over the management of the dam and forebay however a number of issues need to be addressed and BC Hydro is reviewing options.

Watershed Planning

- Some participants would like to have seen the water use planning process for BC Hydro facilities take a watershed approach and provide links with mining and forestry activities. Committee members understood that the Jordan River Water Use Plan looks at BC Hydro operations only. Members of the Consultative Committee encouraged others to take this water use planning process on to other watershed initiatives once this process ended.

- Some members of the Consultative Committee would like to have seen full participation from Western Forest Products and the Ministry of Energy and Mines, Minerals Division. Both parties were contacted and chose not to participate in the process as they felt BC Hydro's operations did not impact their interests. Representatives from both organizations followed the process.

Energy Technologies and Sustainability

- Some participants asked if the Consultative Committee could recommend alternative power sources, such as wind and micro-hydro. It was explained that the water use planning process does not give the Consultative Committee, or the Comptroller of Water Rights, the ability or jurisdiction to suggest additional and/or other power sources.

- Demand Side Management (DSM) was asked to be part of the Consultative Committee's approach. There was a real interest in having customers have cheaper energy rates if they consumed energy during off-peak hours. BC Hydro has a long-standing DSM program. The Consultative Committee recognized this was not to be part of their scope.

Economic Benefits from Jordan River Power Generation

- Numerous discussions were held as to who benefits from power generation at Jordan River. Is it Jordan River, Sooke, the Capital Regional District, or the province of British Columbia? School taxes and grants-in-lieu of taxes are paid to the provincial government and allocated to the municipalities and regional districts based on established formulas. The provincial government also receives the profits generated by BC Hydro in the buying and selling of power. How the provincial government allocates this money to local governments and communities is not part of the water use planning process.

Safety Signage at Mouth of Jordan River for Surfers

- It is believed discharges from the Jordan River can push inexperienced surfers away from shore several hundred metres. It was recommended that BC Hydro place a couple signs on either side of the river at the mouth for safety awareness. This issue was forwarded to the facilities manager and signs were posted.

Inactive Copper Mine

- The mine along the Jordan River, just upstream from the current generating station, historically has produced high-grade copper ore. Ore outcrops - resulting from a mine collapse in the mid-1970's - and seepage from previous mines, enter the riverbed despite the mine has being inactive for approximately 20 years. This contamination is suspected to contribute to toxicity of aquatic life.

- BC Hydro has no jurisdiction or influence on the old mine site. Reclamation work to clean up the site is not within the scope of Water Use Plans.

Funding Enhancement Programs in Other Watersheds

- Some interest arose in putting funds into another watershed if it was decided that enhancing habitat for fish in the Jordan River relative to other systems was not cost-effective. The scope of Water Use Plans is limited to the watershed where the facilities exist. This precluded the consideration of more cost-effective habitat enhancement solutions on systems outside of the Jordan River.

Physical Improvements to Existing Facilities

- Physical changes to BC Hydro facilities are not part of the water use planning process. The Bridge Coastal Restoration Program (BCRP) addresses "footprint issues" associated with the construction of BC Hydro's hydroelectric facilities.

- Physical changes to existing facilities can be contemplated if the physical change can provide the same benefits as an operational change but for a lesser cost to the province. For example, in order to provide flows down the Jordan River, the installation of a flow release mechanism at Elliott Dam is more cost-effective than holding the headpond at Elliott at an elevation where it would constantly spill in order to provide flows down the Jordan River.

Reintroduction of Anadromous Fish into the Jordan River

- A suggestion was made that anadromous fish could be re-introduced back into the Jordan River. This was concluded to be not an ongoing operational issue but rather a footprint issue.

Eco-tourism below the Jordan River Powerhouse

- For operations to enhance recreation opportunities, the Juan De Fuca Community Futures had a concept of having a spawning viewing channel below the old generating station. There was some discussion around the objective of tourism and whether it is within the context of this Water Use Plan. It was felt changes to operations would have limited scope in optimizing tourism opportunities specifically associated with this initiative. In addition, the old Jordan River powerhouse, on the other side of the river, is under private ownership and there was no scope within this Water Use Plans to promote the project.

The Douglas Treaty

- Between 1850 and 1854 fourteen treaties were signed with First Nations on Vancouver Island. T'Sou-ke Nation's treaty was signed on 10 May 1850. The T'Sou-ke Nation continue to explore the meaning and implications of this Treaty. It was accepted that this was beyond the scope of the Jordan River Water Use Plan.

APPENDIX D: COMMITTEE MEMBERS AND OBSERVERS

A provincial agency reorganization occurred at the end of the process (in the summer of 2001). The Ministry of Employment and Investment (MEI) is now the Ministry of Energy and Mines (MEM) and the Ministry of Environment, Lands and Parks (MELP) was divided into the Ministry of Water, Land and Air Protection (MWLP) and the Ministry of Sustainable Resources Management (MSRM).

Table D-1 Committee Members, Observers, and Sub-Committee Members

Member	Affiliation	Interest
Mel Sheng	Fisheries and Oceans Canada	Fish
Marion Lightly (Alternate)		
Doug Lowe	Ministry Water, Land and Air Protection[1]	Fish and Wildlife
Craig Wightman (Moved to Observer status in 2001)	Ministry Water, Land and Air Protection[2]	Fish
Anita Mathur (Moved to Observer status in 2001)	Ministry Sustainable Resource Management[3]	Water Quality
Denise Mullen-Dalmer	Ministry Energy and Mines (formerly Ministry Employment and Investment-Energy Branch)	Power Generation and Economics
Judith Burke (Moved to Observer status in 2001)	Sooke Harbour Chamber of Commerce	Power Generation and Economics
Louise Paterson	Sooke Parks and Recreation	Recreation
Bob Truelson	Veins of Life Watershed Society	Water Quality
Jennifer Sutherst	South Islands Aquatic Stewardship Society	Water Quality and Fish
Glen Varney (Moved to Observer status in 2000)	Sooke Salmon Enhancement Society and Sport Fishing Advisory Board	Fish
Rick Gillie	West Coast Surfing Associates	Recreation
Terrie Poirier	Jordan River Community	Water Quality
John Newcomb	Victoria Chamber of Commerce	Power Generation and Economics
Kevin Jancowski (Moved to Observer status in 2001)	Coastal Enterprise and Resource Cooperative Association (CERCA)	Fish
Denise Purcell	Te-Mexw Treaty Association	Fish and Heritage
Paul Sieber (Moved to observer status in 2001)	Ditidaht First Nation	Fish and Heritage
Dave Lightly	T'Sou-ke Nation	Fish and Heritage
Helen Dunn (Moved to Observer status in 2000)	Pacheedaht First Nation	Fish, Wildlife, and Heritage
Richard Penneway	BC Hydro	Power Generation
Kelvin Ketchum	BC Hydro	Power Generation

[1] Formerly Ministry Environment, Lands and Parks (MELP)
[2] Formerly Ministry Environment, Lands and Parks (MELP)
[3] Formerly Ministry Environment, Lands and Parks-Water Management Branch

Table D-2 Fish Technical Sub-Committee Membership

Member	Affiliation
Mel Sheng	Fisheries and Oceans Canada
Marion Lightly	Fisheries and Oceans Canada
Doug Lowe	Ministry Water, Air and Land Protection
Kevin Conlin	Ministry Sustainable Resource Management[1]
Ron Ptolemy	Ministry Sustainable Resource Management[2]
Bob Truelson	Veins of Life Watershed Society
Dave Lightly	T'Sou-ke Nation
Darren Sherbot	BC Hydro

Table D-3 Water Quality Sub-Group Membership

Member	Affiliation
Jennifer Sutherst	South Islands Aquatic Stewardship Society
Bob Truelson	Veins of Life Stewardship Society
Anita Mathur	Ministry Sustainable Resource Management[3]
Bob Westcott	BC Hydro
Terrie Poirier	Jordan River Community
Judith Burke (moved to observer status)	Sooke Harbour Chamber of Commerce

Table D-4 Socio-Economic Sub-Group Membership

Member	Affiliation
Anita Mathur	Ministry Sustainable Resource Management[4]
Denise Mullen-Dalmer	Ministry Energy and Mines[5]
John Newcomb	Victoria Chamber of Commerce
Richard Penneway	BC Hydro

Table D-5 Surfing Sub-Group Membership

Member	Affiliation
Rick Gillie	West Coast Surfing Associates
Kelvin Ketchum	BC Hydro

[1] Formerly BC Fisheries
[2] Formerly BC Fisheries
[3] Formerly MELP - Water Management
[4] Formerly MELP - Water Management
[5] Formerly Ministry Employment and Investment

Table D-6 Observers Update List

Name	Affiliation	Involvement
Ron Ptolemy	Ministry Sustainable Resource Management[1]	Observer
Neil Banera	Ministry Sustainable Resource Management[2]	Observer
Geoffrey Thornburn	Environment Canada	Observer
Zev Fisher	Graduate Student	Observer
James MacPherson	Calibre Strategic Services	Observer
Dorthe Jakobsen	Ministry of Energy, Mines, and Resources[3]	Observer
Douglas Pollard	Haig Brown Fly Fishing	Observer
Sylvia Bailey	Juan De Fuca Community Futures	Observer
Yogi Carolsfeld	World Fisheries Trust	Observer
Doug Copp	Western Forest Products	WUP Update List
Rick Kasper	MLA	WUP Update List
Brian Hansen	CRD Regional District Area Director	WUP Update List
Ian Montgomery	Haig Brown Fly Fishing	WUP Update List
Wendy Palynchuk	Sooke Works	WUP Update List
Corey Baker	Capital Regional District	WUP Update List
Bob Dick	Western Forest Products and Jordan River resident	WUP Update List
Norma Lajeunesse	Jordan River Resident	Appreciated awareness
Dick Poirier	Jordan River Resident	Appreciated awareness
Chris Paterson	Eagle-Eye Wilderness	Appreciated awareness
Deborah Campbell	Island Outings	Appreciated awareness

[1] Formerly BC Fisheries
[2] Formerly MELP
[3] Formerly Ministry Employment and Investment

APPENDIX E: POWER GENERATION INFORMATION SHEET

The power generation interest encompasses three primary components. These include the Jordan River facility's ability to:

- generate power
- provide power on short notice at times when demand is high (also termed 'peak' demand times)
- provide Vancouver Island system reliability and system support

Generate Power

The Jordan River facilities include the Jordan River Generating Station, Elliott, Jordan Diversion, and Bear Creek dams, Elliott Headpond, and Diversion and Bear Creek reservoirs. The Jordan River power plant contains a single turbine/generator unit, which has a capacity to generate up to 170 MW.

Jordan River is the only major hydro development on the south and west coast of Vancouver Island. It has the capacity to account for up to 35% of total Vancouver Island hydroelectric generation. Although the precipitation along the south coast is high, streamflows vary considerably throughout the year. Compared to the annual volume of inflow, the combined storage capacity of the three reservoirs is small - approximately 3.5 days worth of powerhouse utilization can be stored within the reservoirs.

Provide 'Peaking' Capability

The Jordan River facility provides peaking capability and flexibility for the BC Hydro system to meet system load. Peaking capability refers to the ability to operate the plant up to full generator output during high load demand hours. As demand for electricity increases quickly during certain times of the day, the Jordan River plant can start generating electricity to meet this demand in a very timely fashion.

Provide System Reliability

The Jordan River generating capability also provides necessary 'insurance' to keep the southern Vancouver Island electrical system in tact and stable during two periods each year - winter peak load periods (mid-November to mid-February) and major transmission line maintenance work during two months each summer. In addition, the Jordan River hydroelectric facility is the only generating plant in southern Vancouver Island. Consequently, it is also used to meet local load (Colwood, Sooke, Jordan River, Port Renfrew) during planned or forced line outages.

Objectives and Performance Measures

Table E-1 Power Objectives and Performance Measures

Objective	Performance Measures
To maximize the value of power generation	Financial Value ($/year)
	Reliability Index
	GHG emissions (tonnes of CO_2/year)

Performance Measure Calculations

(i) Financial Value ($ per year):

The financial value ($ per year) of any operating alternative will equal the *value of electricity* for that alternative minus any *new infrastructure costs*. The *value of electricity* is derived through BC Hydro's value of electricity report and is based on long run electricity price forecasts for the electricity market. As electricity cannot be stored and therefore must be supplied at the time of demand, the price of electricity varies considerably by time of day, as well as seasonally. Thus the value of electricity varies with amount generated, the timing of generation, and the flexibility of the plant.

To calculate of the value of electricity, each operating alternative that was modelled produced the number of megawatts generated. This was then converted to an annual financial number using the value of electricity methodology. The methods considers the long run price forecast and price premiums based on plant flexibility.

A few of the alternatives considered include *new infrastructure* which has been given a preliminary annualized estimate of $100,000/yr ($1 Million dollar capital). This cost is incorporated into the final cost of the relevant alternatives. See below for a discussion of new infrastructure.

(ii) Reliability

This index was intended to be a rough indicator of potential changes in reliability in comparing between alternatives. To develop a more accurate index would take considerably more resources then are available in this planning process. At the same time, reliability is important enough to the power interest to warrant mention in the comparison of alternatives. In general, if there is a diversion discharge (water not moving through the turbine), for example water used for fish flows, than reservoir levels will be slightly lower than if that water was not discharged. If that is the case then less water is available in the event of an emergency.

Table E-2 Reliability Index

Reliability Index	General Corresponding Statement
Minimal positive impact	more water available in the event of an emergency
Status quo	
Minimal negative impact	less water available in the event of an emergency, but not compromising reliability; except in the case of a major and prolonged transmission outage
Moderate negative impact	significantly less water available in event of an emergency, and at times may compromise reliability
High negative impact	insufficient water to operate system in event of an emergency - Jordan would not be available for electric generation

(iii) Greenhouse Gas Emissions (GHG) (tonnes of CO_2e/year)

The interest in tracking greenhouse gas (GHG) emissions resulted from the desire to track environmental impacts of a reduction in hydroelectric power generation across the province as Water Use Plans are implemented. GHG emissions result from the burning of fossil fuels, such as coal, gasoline, and natural gas. Based on BC Hydro's Integrated Electricity Plan (January 2000), long term (20 years +) energy reductions at hydroelectric facilities would be replaced by a energy mix which produces greenhouse gases. Similar performance measures have been used on other Water Use Plans.

To provide some context, in 2005 GHG emissions in tonnes of equivalent CO_2 (CO_2e) are expected to be:

- BC Hydro's GHG emissions are forecast to be approximately 4.8 million tonnes CO_2e per year.
- The Province of British Columbia GHG emissions are forecast to be approximately 68 million tonnes CO_2e per year.

These forecasts are based on BC Hydro's 2000 Climate Change report. These numbers do not take into account any action taken under ratification of the Kyoto protocol.

Tonnes of CO_2e/year will be calculated by multiplying the number of net gigawatt hours (GWh) generated above a base case for the year by an emissions factor of 500 equivalent tonnes of CO_2 per gigawatt hour. Equivalent tonnes of CO_2 (i.e. CO_2e) is used because CO_2 is the primary but not the only GHG.

The equation which will be used is:

- GHG contribution = $(A_{base} - A_{option})$ X 500 equivalent tonnes of CO_2.

where A_{base} is the alternative used as a base case and A_{option} is the alternative being considered.

The emissions factor of 500 tonnes/GWh was derived from assessing the GHG contribution from a number of GHG sources which are more and less efficient in terms of emissions (e.g. combined cycle gas turbines, and low efficiency gas used at Burrard Thermal). This number was recommended for use for water use planning.

Alternatives Which Consider New Infrastructure

Some of the operating alternatives suggested by the Consultative Committee included the provision of a controlled flow down the Jordan River below Elliott Dam. The Jordan River system as it presently exists could only provide flows downstream of Elliott Dam by holding the Elliott Headpond high and spilling water. A constant base flow is hypothesized to provide downstream benefits to fish and wildlife. However, when spilling occurs, there is no ability to control the magnitude of the flow over the dam. Thus, it is more effective for both power generation and habitat enhancement to include a modification in infrastructure.

Modifications in infrastructure include the capital costs, any ongoing maintenance and operational costs. A preliminary capital expenditure of $1 million was estimated. Amortized over 20 years at a discount rate of 8%, this capital cost translates to $100,000/yr. That value was then embedded into the financial cost of the relevant alternatives shown on the consequence tables.

In the event that one of the alternatives with a controlled minimum flow was chosen as the preferred alternative and accepted by the Comptroller of Water Rights, a detailed feasibility study would need to be undertaken. This feasibility study would assess the detailed cost of the most suitable design given the particular needs of the facility.

Some components of adding new infrastructure include:

- Conducting a detailed feasibility study.
- Installation of new infrastructure (perhaps a valve which is controlled remotely). This may also include the need for a secure communications link, headpond controller, and flow monitoring. This is dependent on the outcome of the feasibility study.
- Installation of maintenance equipment such as trashracks (to collect debris in front of the valve) and ongoing maintenance and operating costs.

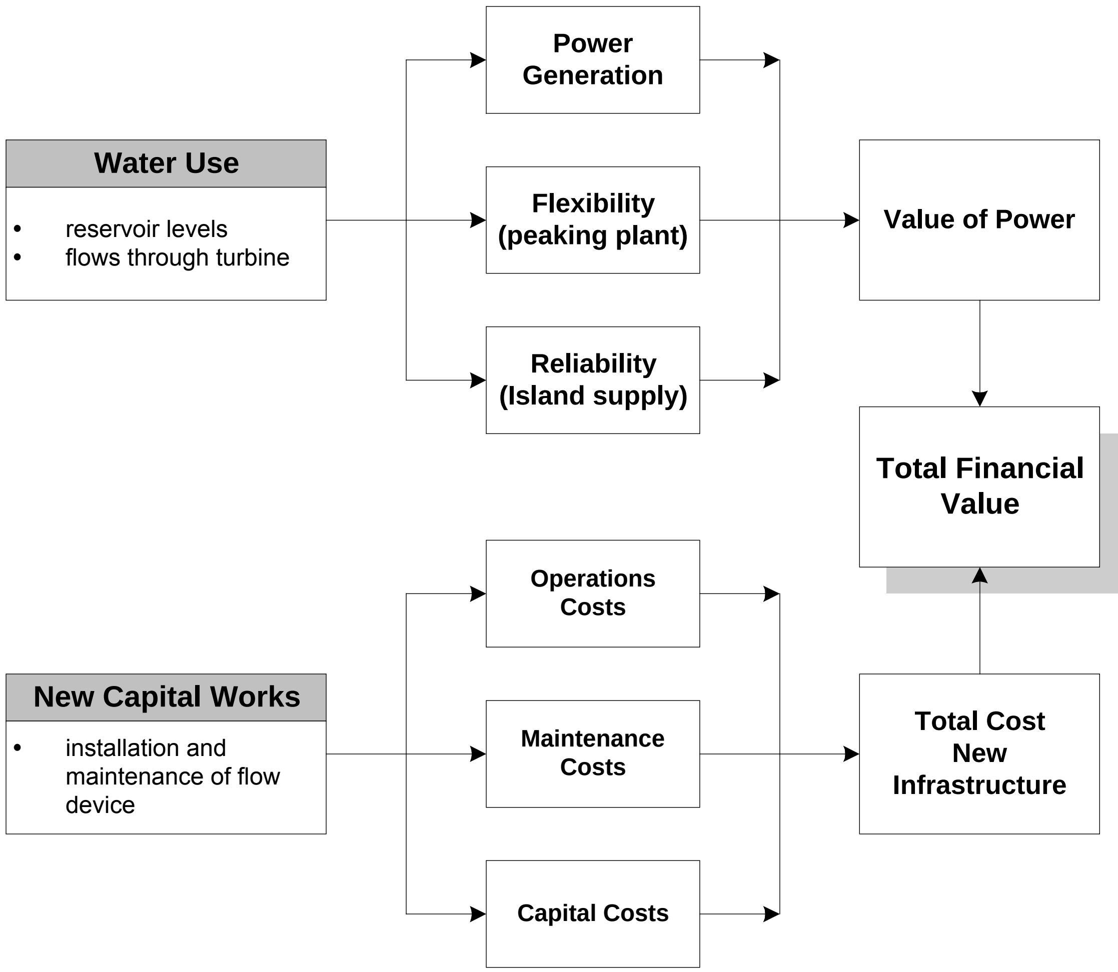


Figure E-1 Financial Value Influence Diagram

Information Collected

Calculation of the value of energy (VOE) and relation to the AMPL (BC Hydro's power model) was conducted prior to all Water Use Plans. No new studies were conducted to address financial estimates specific to the Jordan River Water Use Plan.

APPENDIX F: RECREATION INFORMATION SHEET

The Jordan River Water Use Plan Consultative Committee's interests for recreational activity occur in both the lower river and ocean immediately around the Jordan River mouth and in the upper watershed associated with the reservoirs. The river section between Elliott Dam and the Jordan River powerhouse has limited recreation activities due to difficult access. Activities undertaken in the watershed include: surfing, fishing, camping, picnicking, wildlife viewing, hunting, boating, and swimming.

COASTAL RECREATION - POWERHOUSE TO OCEAN (SURFING)

A primary recreation interest is ocean surfing at the mouth of the Jordan River. Surfing interests encompass windsurfing, kayaking and board surfing. Board surfing is the primary surfing type considered in this planning process and was identified as the activity most affected by powerhouse discharge. Three issues were noted with respect to operations: effects on the quality of surf, surfing safety, and recreational fishing safety issues.

Surf Quality

The prime surfing season is November to March, however it is noted that good surfing can occur outside of the high season, such as September and October. Surfing has become an increasingly popular activity. Influences outside of generating station operations, such as swell from offshore winds and tides, and nearshore wind and wave conditions can influence the quality of surf (Figure F-1). It was estimated that the number of good quality surfing days, where weather dependant influences are optimal, are about ten days a month. As such, it was indicated that during these optimal surfing days, when the power plant starts discharging high volumes of water, the impacts on the quality of surf are particularly noticeable.

A surf survey was completed during the Jordan River water use planning process to provide more insights into surfing in the Jordan River region and the influences of plant operations. The questions and answers below provide a discussion and summary of results.

Does plant discharge affect the quality of surfing? If so, how?

The survey results were not able to draw a clear correlation between respondents observing a negative impact on surfing and flow discharge at the time of surveying. Respondents were able to accurately identify whether there was actual discharge from the generating station 57% of the time. This may be due to influences such as weather and tides, surfing location and knowledge of the surfer. However, respondents were able to state what the negative impacts of flow discharges were when they encountered them.

- The most common impact recorded was that the plant discharge created a strong eastward current that is difficult to paddle against and therefore makes it difficult to catch waves. Individuals also noted that the river can directly effect waves by flattening them or keeping them from breaking. Other effects included the discharge resulting in the change of direction of the waves and decreased buoyancy. Many respondents indicated that the effect of the discharge varied not only with the amount of water discharged from the generating station, but was also dependent on the tides and winds. Also, the surfing area called 'points left', the area in direct line with the river mouth, is most affected by plant discharge.

Is there a threshold discharge volume (using expert judgement) over which surfing becomes negatively affected?

- The surf survey was unable to draw a correlation between negative impact on quality of surf and discharge volume. Using expert judgement it was estimated that negative effects were not that noticeable at a discharge of 20 or 30 cubic meters per second (m^3/s), however, it became noticeable at a discharge of 50 m^3/s.

- A graph compiled for the Consultative Committee compared hourly plant discharges (m^3/s) during the days from November 1999 to March 2000 to get an idea of discharge volumes throughout the day (and thus impact on surfing). The graph shows that under current operations a 50 m^3/s discharge (estimated as the discharge that causes surfing quality problems) is exceeded approximately 30% of the time.

What are the general characteristics of people surfing?

- Additional findings from the surf survey are that board surfers are the primary users of the area. Kayak surfers and boogie boarders were present but fewer in number. At any point in time during the four on-site interviews there were a maximum of 22 people in the water. A total estimate of weekly or monthly surfer numbers was not made. Most surf users are local and regional residents with over 80% of surfers living within 100 km of Jordan River. For each surf day over half of the respondents spend between $10-25.

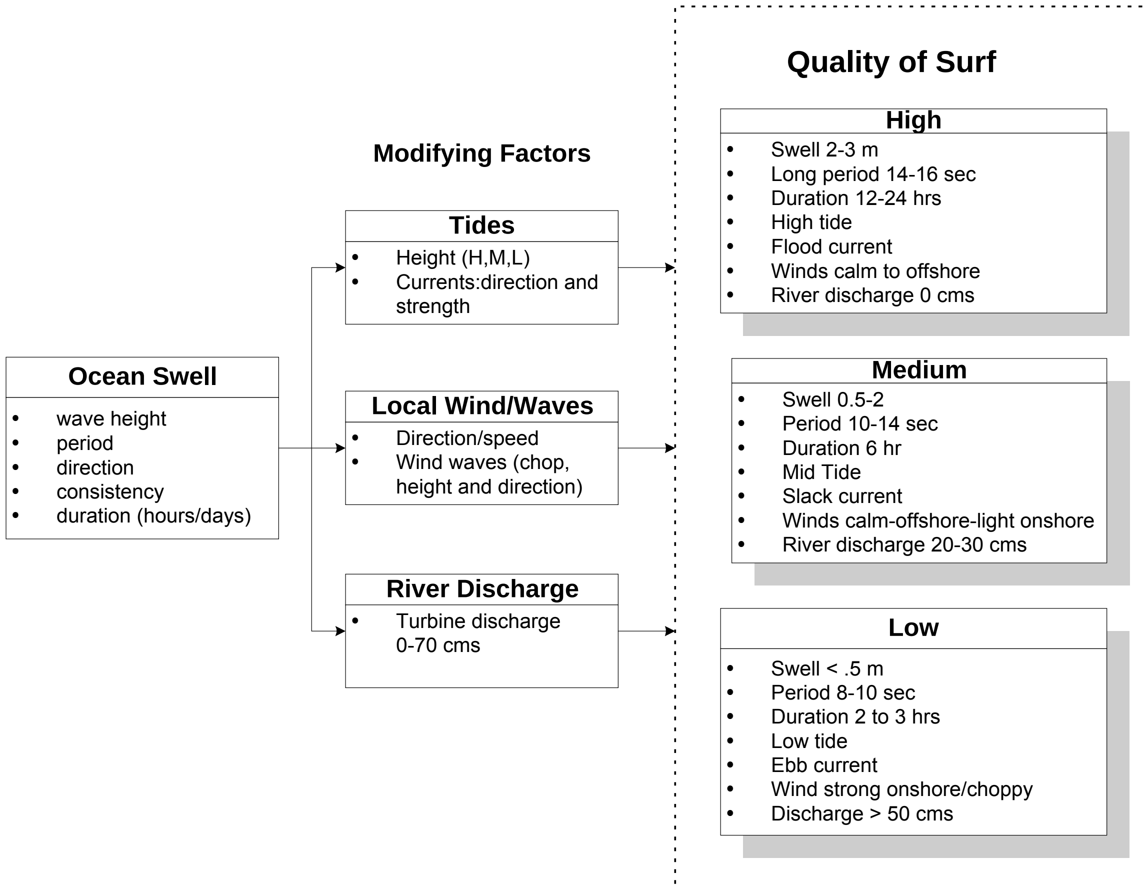


Figure F-1 Surfing Quality Influence Diagram

Surf safety

It was noted that inexperienced surfers may be pushed out by the current during high discharges from the Jordan River. A siren at the powerhouse is used to signal when the generating station starts up, however, inadequate signage and the long distance the sound needs to travel for appropriate warning have both been raised as safety issues. Inexperienced surfers may be particularly affected, as they may not be aware that a powerhouse exists up the river so that the rapid current change would be unexpected.

The recreational interest stated that they would be satisfied to deal with this issue through improved signage and communication on the part of BC Hydro. The safety issue was brought to the attention of the facility manager. Safety signs were placed on either side of the mouth of the Jordan River in December 2001.

Objectives and Performance Measures

Table F-1 Recreation Surfing Objectives and Performance Measures

Objective	Performance Measures
Maximize the quality of surfing	Potential # of days surfing is impacted between October and March

Performance Measure Calculation

Calculation = Total # of days per month there is any surfing impact where 'impact' is defined as generation exceeds 1894 MWh during high load hours on any given day between October and March. The calculation assumes the following:

- Discharges greater than 50 m^3/s significantly affects surfing activities during the hours of 8 a.m. to 5 p.m.
- Operators will optimize generation during high load hours before 8 a.m. and after 5 p.m. and can restrict generation to less than 120 MW output (equivalent to 50 m^3/s discharge) during peak surfing hours.
- Generation demand is during high load hours only.
- The day impacted by generation is a good surf day based on tide, swell, wind and surfers are on-site.
- AMPL output where generation exceeds even a portion of a day (i.e. 1 hour) affects the entire surf day. Modelling at a daily time-step limits ability to refine further.

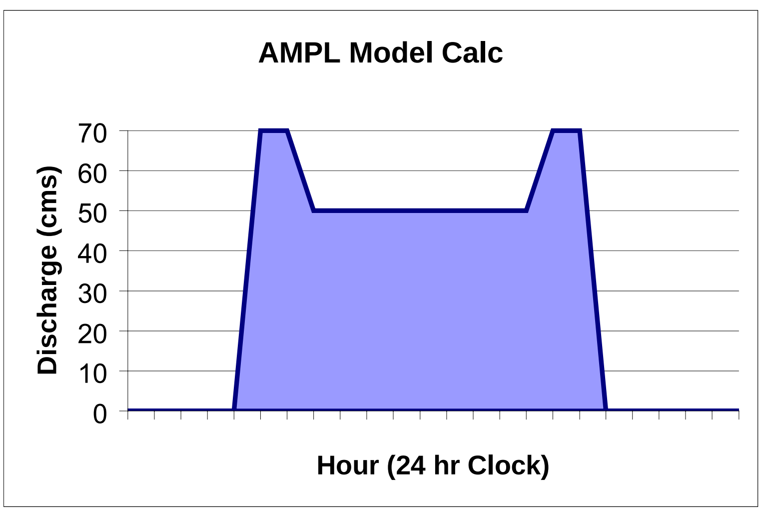


Figure F-2 Power Optimization Model: Surfing Output Requirements

The Power Optimization Model (AMPL), is a program that BC Hydro uses to model various operating alternatives using historical inflow data, optimizes generation based on the alternatives requested by the Consultative Committee. The model assumes that generation will occur only during the high load hours and that if generation is maximized throughout the day, a total of 2367 MWh can be generated. If generation is restricted to 50 MW during surfing hours (between 8 a.m. and 5 p.m.) that reduces the total generating capability to 1894 MWh. Any generation during high load hours in excess of 1894 MWh is counted as impacting a surfer day. Figure F-2 provides a graphical representation of the calculation where generation occurs between 6 a.m. and 5 p.m. and any model outputs where total generation encroaches on the area above 50 m^3/s (between 8 a.m. and 5 p.m.) counts as an impacted surfer day.

Information Collected

Limited information was available on the extent of surfing use and the impacts of varying discharges on ocean recreation activities. A formal survey was undertaken as part of the Water Use Plan process to further define surfing interests and impacts between December 2000 and March 2001 (RRL, 2001).

RIVER RECREATION (FROM ELLIOTT DAM TO OCEAN)

Recreational fishing occurs along the banks of the lower Jordan River and informal launching of boats can occur, both of which could be affected by BC Hydro operations which influences water levels in the river. As there are no existing runs of salmon or steelhead currently in the river, recreational fishing is limited. Western Forest Products owns and operates a log sort in the lower reach of the river below the BC Hydro tailrace. Prior to the decline of these runs, recreational fishing was a popular activity along the lower Jordan River and in the old tailrace prior to 1971 (see Appendix G Fish Information Sheet).

The issue of fisherman safety along the lower river was discussed. It was felt that the current siren was suitable for warning anglers from the tailrace down to the bridge. Improved signage was recommended to indicate that a power plant was located upstream and that fluctuating water levels do occur for both anglers and boaters accessing the lower river from the ocean.

Limited recreation activities occur from Elliott Dam to the powerhouse as the river canyon is difficult to access. There was no recreational fishing highlighted, likely due to remote access and small size rainbow trout (< 6 inches length). Public safety issues associated with recreation in this section of the river were identified including, swimming in the potholes above the powerhouse during summer. During high inflows, spills can occur over the Elliott Dam, leading to high flows down the lower Jordan River in very short notice.

No objective or performance measure was developed for river recreation in this section of the watershed.

RESERVOIR RECREATION

There are no formal recreation facilities in the upper Jordan River. However, the reservoirs are used informally for camping, swimming, hiking, fishing, and boating (non-power boats). Typical impacts on recreation associated with BC Hydro facilities in other systems are the result of fluctuating reservoir levels. Lower levels in Diversion Reservoir or Elliott Headpond may decrease the quality of the user experience (aesthetics, access, and/or fisheries habitat), but does not inhibit use.

In the Jordan River watershed, Bear Creek Reservoir and the Old Forebay are the most popular recreational destinations. Water storage at Bear Creek Reservoir is currently not actively managed for power although it is available for emergency situations, and the Old Forebay is no longer part of the hydroelectric system. It was expressed that if one of the managed reservoirs or headpond (Diversion and Elliott) levels is extremely low, people would use an alternate destination such as Bear Creek Reservoir or the Old Forebay which are not affected by operations.

Safety issues were identified for BC Hydro reservoirs with respect to recreation use. It was noted that spillway booms and the powerhouse intake were not adequately marked at Elliott Headpond and Diversion reservoirs and could affect boater or swimmer safety. This issue was forwarded to the BC Hydro facilities manager for review with the other safety issues.

Objectives and Performance Measures

Table F-2 Recreation Objectives and Performance Measures

Objective	Performance Measure
Maintain current recreational opportunities (related to road access)	No performance measure developed

The objective developed for the upper watershed is *to maintain current recreational opportunities.* This objective is related to road access and maintaining existing recreational opportunities and not water use.

No performance measures were developed for recreation in the reservoirs. The interests expressed by the Consultative Committee were focused on access issues in terms of maintaining current recreation opportunities (not to loose camping/fishing opportunities) and maximize safety around the intakes and spillways. Both of these interests are outside the scope of Water Use Plans and have been referred to BC Hydro's facility manager for the Jordan River and the department in charge of recreation for review and action.

It was further noted that if renewed management of Bear Creek Reservoir was being considered by BC Hydro then the need for a recreation performance measure may be warranted. Lowering the reservoir level would reduce the quality of swimming (with increased stumps), and may also decrease the aesthetic quality for recreation.

Information Collected

An overview of recreation interests/activities was conducted early on in the Water Use Plan process by summarizing available data from BC Hydro and then soliciting local knowledge from members of the Consultative Committee and observers.

APPENDIX G: FISH INFORMATION SHEET

AQUATIC LIFE AND FISHERY INTERESTS

The Fish Technical Committee (FTC) addressed aquatic ecosystem integrity and specific fisheries interests for Bear Creek and Diversion Reservoir, Elliott Headpond, and for the lower Jordan River below Elliott Dam based on an initial framework of impact hypotheses (Figure G-1). Three general aquatic and fishery objectives were initially derived:

- The restoration of anadromous salmonids and steelhead to the lower Jordan River.
- Maximizing fisheries productivity in the lower Jordan River and in the two reservoirs and one headpond.
- Overall improvement to riverine and riparian ecosystem health.

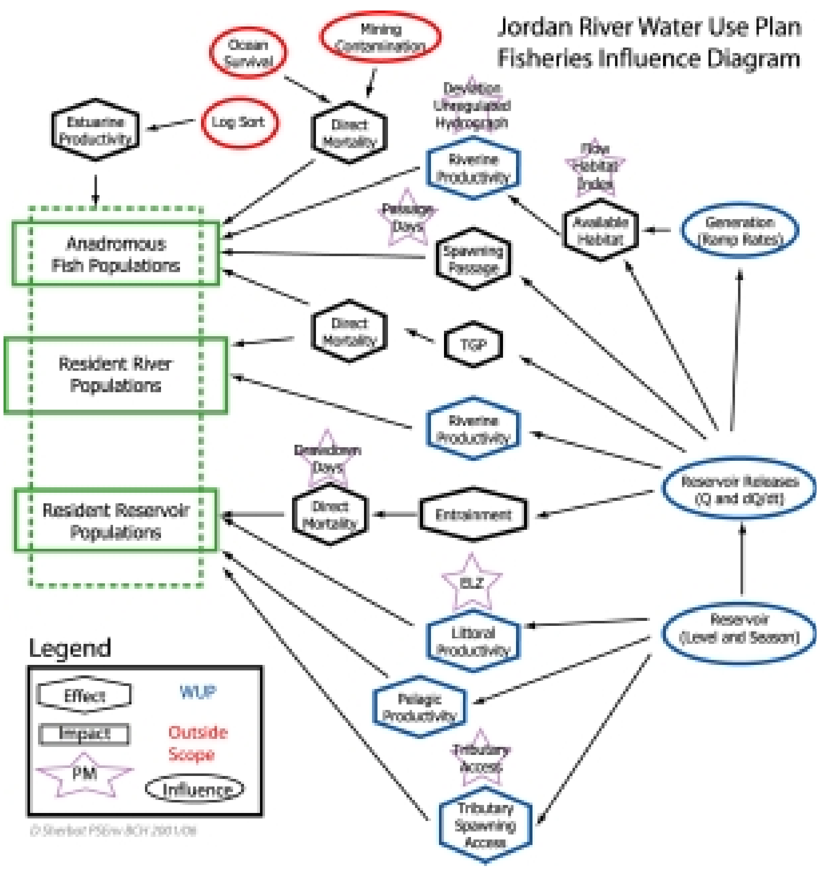


Figure G-1 Jordan River Fisheries Influence Diagram

Causes, effects, and impacts streamlined by FTC. Areas that preliminary PMs directly address are illustrated. Performance measure (PM), flow (Q) and change in flow rate (dQ/dt).

In lieu of general baseline information, objective refinement originally resulted in maximizing habitat for spawning access and rearing fitness for specific indicator species: Steelhead (St), pink (Pk), chum (Cm), and coho (Co) in the lower Jordan River and for rainbow (Rb) in the upper system and the reservoirs (Figure G-2 and Figure G-3). Subsequent literature review and data collection, however, played an important role in refining specific objective and means objectives associated with fisheries performance measures. Three key facts were presented to the Consultative Committee by the FTC prior to finalization of PM development and objective setting:

- It had been established that prior to the powerhouse upgrade and complete diversion of the river in 1971 limited viable populations of pink, chum, coho and steelhead existed in the old BC Hydro tailrace and, to a lesser extent, in the lower river. However, since redevelopment the FTC acknowledged that current populations of anadromous salmonids (Pk, Cm, Co, and St) in the lower Jordan River are presently negligible or non-existent. This is a result of the cumulative impacts from mining, forestry, and hydroelectric practices in the watershed.

- the lower Jordan River is defined as the length of river between the tailrace and Elliott Dam (approximately 8 km). The FTC also noted that the anadromous salmonid habitat for pink, chum, and coho would have been restricted to approximately 500 m upstream of the tailrace because of natural passage barriers even under fully unregulated flows. Furthermore, what limited habitat did exist was likely to be rendered inhospitable by metal contamination associated with an abandoned copper mine site. For steelhead, the first of a series of significant passage barriers (approximately 7 m) were identified approximately 1.5 km upstream of the tailrace. Under river discharge associated with natural inflows solely below Elliott Dam, however, passage would similarly be restricted to the lower 500 m.

- In contrast to former anadromous salmonid populations, evidence presented to the FTC indicated that the reservoirs, specifically Diversion and Bear Creek, currently support self-sustaining populations of rainbow trout. Populations of cutthroat trout are also assumed to remain from previous Ministry Environment, Land and Parks' stocking initiatives. Viable populations of rainbow trout also exist in the river below Elliott Dam, however, these are severely limited by both habitat and in stream productivity.

Under these core assumptions, impact hypotheses and means objectives were developed for both the river and reservoirs to address existing resident fish. Numerous means objectives were considered. Only those within the scope of water use planning, operational control of discharge timing and magnitude, were subsequently evaluated.

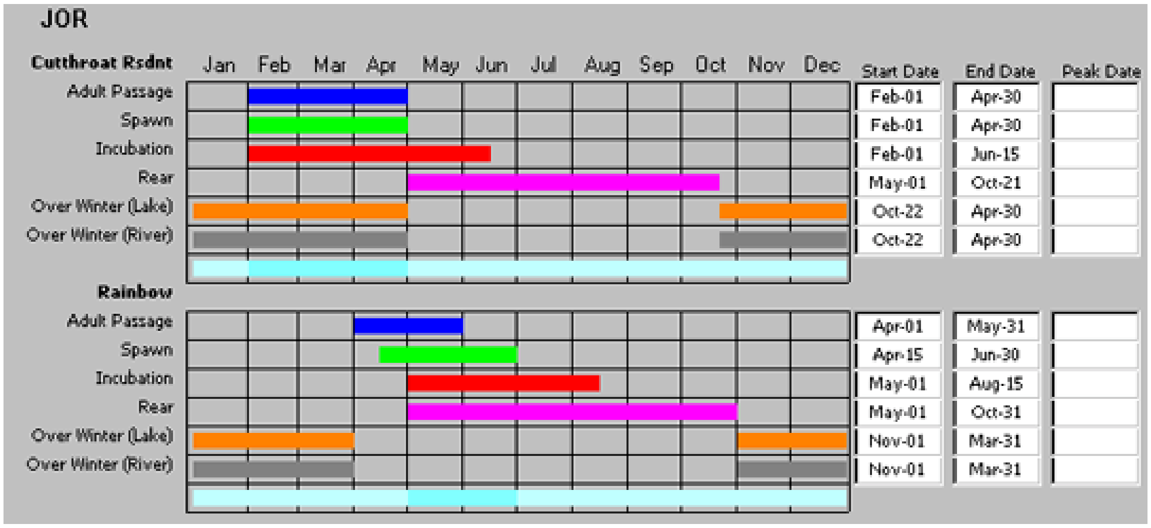


Figure G-2 Resident Fish Periodicity Data

Migration between Diversion and Bear Creek reservoirs is possible. High gradients prevent tributary spawning for resident fish below Elliott Dam: Resident fish in the lower Jordan River are assumed to spawn in the mainstem. Data from Jordan River WUP BCH, MELP, and BCF (2001).

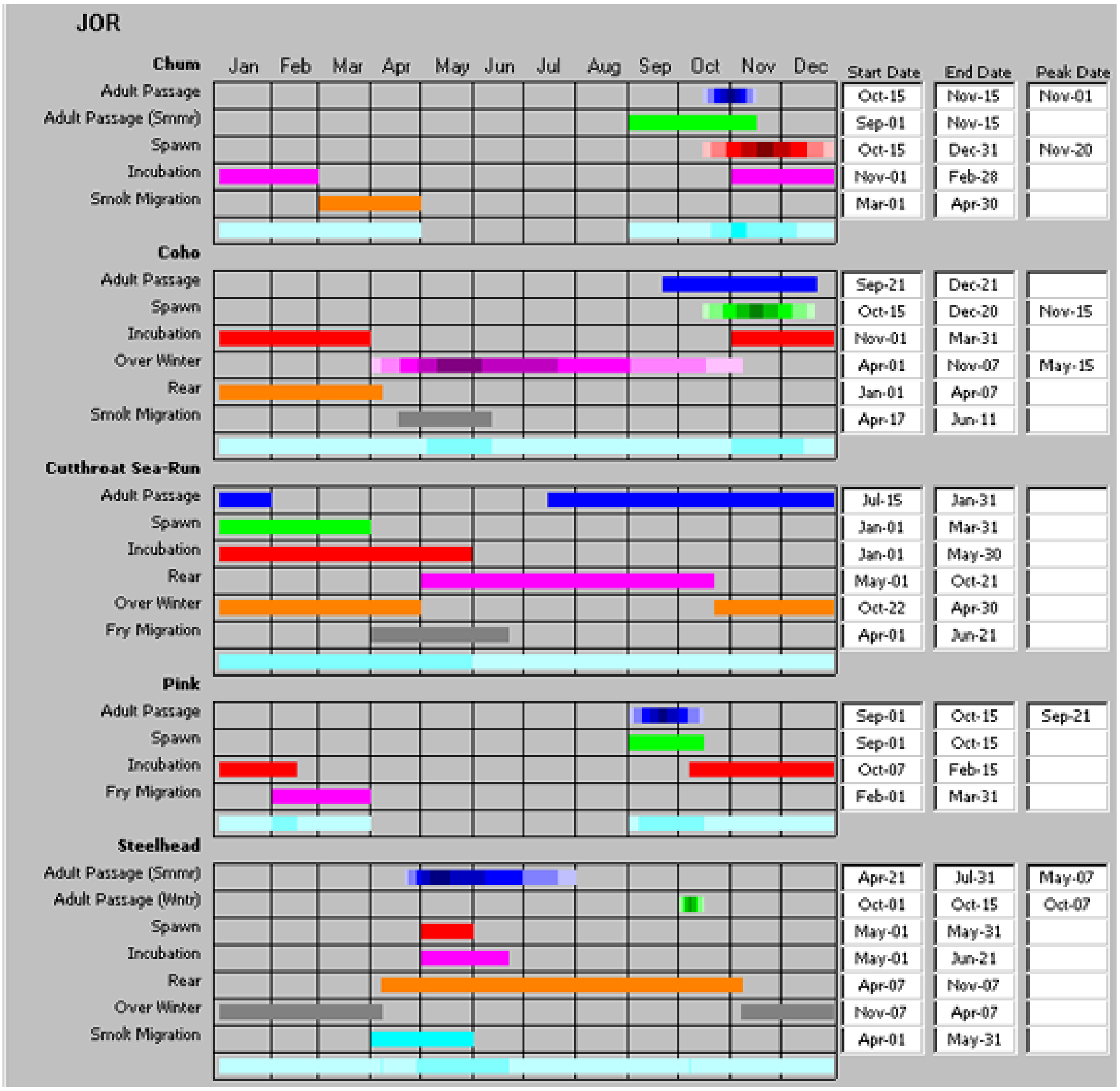


Figure G-3 Salmonid Fish Periodicity Data

No anadromous salmonids presently use the lower Jordan River in significant, if any, numbers. Salmonid habitat is restricted to the lower 490 m. Periodicity data is extrapolated from adjacent systems. Data from Jordan River WUP BCH, MELP, and BCF (2001).

AQUATIC RESERVOIR INTERESTS

Reservoir Objectives and Performance Measures

While digital elevation models (DEMs) were available to calculate an effective littoral zone (ELZ PM) for Bear Creek and Diversion reservoirs and Elliott Headpond (Figure G-4), the FTC decided to apply the ELZ PM solely to Diversion Reservoir (Figure G-5). Several operating alternatives that involved conservation flows, maximizing power generation, and/or stabilizing reservoir levels all significantly influenced Diversion Reservoir levels. No final operating alternatives, however, appreciably influenced either Bear Creek or Elliott reservoirs. It was also noted that as Bear Creek has been operated as a free spill reservoir since 1994 (i.e. as a natural lake), a permanent littoral zone would have been established. Changes in operations that could have affected Bear Creek's littoral zone were removed in the initial scope specifically to avoid this impact.

Impacts associated with reservoir tributary access at Diversion River were not tabled as it was acknowledged that current access was not a problem and any proposed alternatives would not create novel unfavourable conditions. Impacts associated with manipulation of Elliott and Bear Creek reservoirs were also not contemplated. No proposed alternatives duly considered included different management of either Bear Creek or Elliott. Consequently, PM development focused on addressing operational implications and suspected environmental effects coupled with influencing Diversion Reservoir levels.

Performance measures for the reservoir were ultimately pursued to address the environmental implications of operational changes that restricted the seasonal timing of Diversion Reservoir (Table G-1):

- Effective Littoral Zone (ELZ).
- Drawdown depth and seasonal timing.

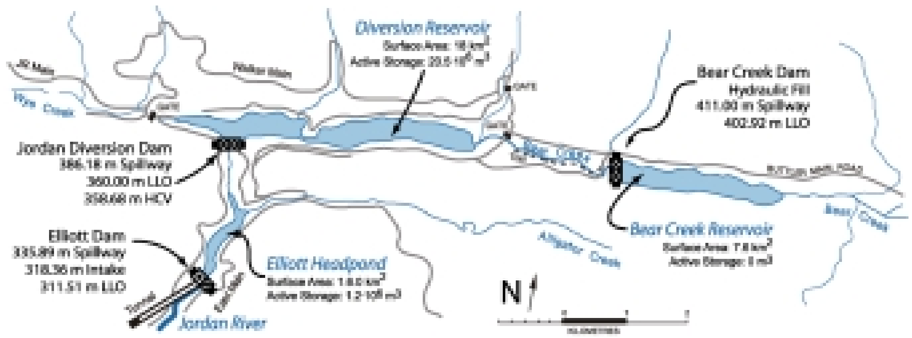


Figure G-4 Schematic: Jordan River WUP Reservoirs

Reservoir operation levels, volumes, and areas are approximate.

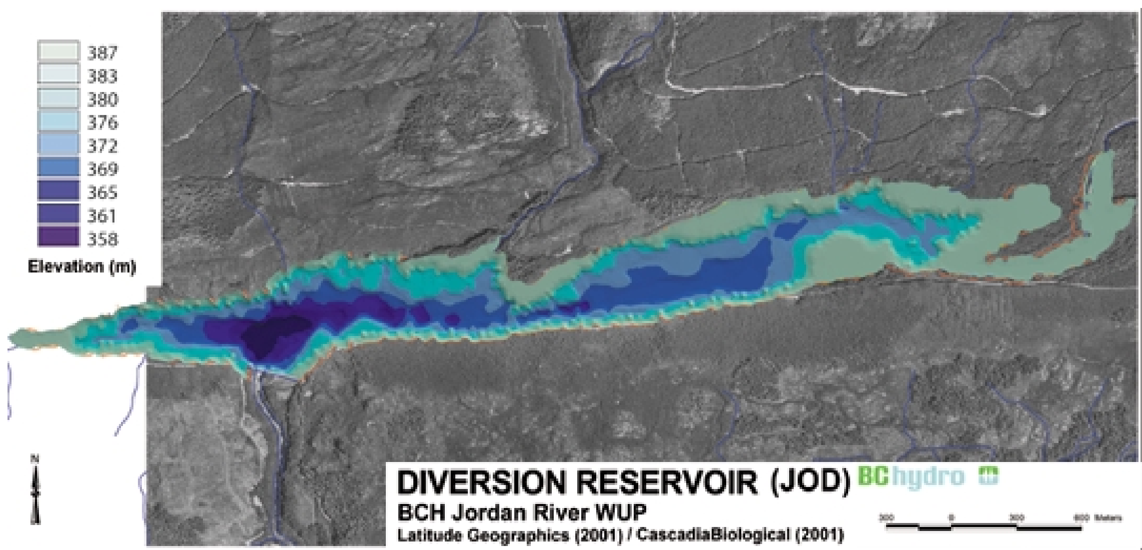


Figure G-5 Diversion Reservoir: Draft Bathymetry

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

Table G-1 Reservoir Fish Objectives and Performance Measures

Broad and specific objectives were created by the FTC and approved by the Consultative Committee. Impact hypotheses and initial performance measures were agreed to by the FTC and adopted by the Consultative Committee. Only bolded performance measures were subsequently developed and used to access alternative trade-offs.

Broad Fisheries Objective	Maximize resident fisheries populations in the Jordan system reservoirs.
Specific Fisheries Objective	Maintain healthy self-sustaining populations of rainbow trout in the reservoirs.
Impact Hypotheses	• Seasonal and daily changes in reservoir levels may preclude the establishment of an effective littoral zone. 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. • In season changes in reservoir levels may limit access to spawning tributaries for rainbow trout. Current operations, however, presently do not limit spawning access. • Seasonal timing of drawdowns for maintenance may stress rainbow trout, if coincidental with high temperatures and low oxygen levels.
Means Objective	• Maximize growing length and area of reservoir littoral zones. • Maximize tributary spawning access for rainbow trout. • Time maintenance drawdowns to minimize fish stress.
Performance Measure	• **Effective Littoral Zone.** • Tributary Access. • Maintenance Drawdowns.
Critical Uncertainties	Importance of littoral to pelagic productivity.

Reservoir Performance Measure Calculation

(a) Effective Littoral Zone PM

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 and littoral 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 than 1 m for lakes with an outlet geometry similar to Diversion or Bear Creek.

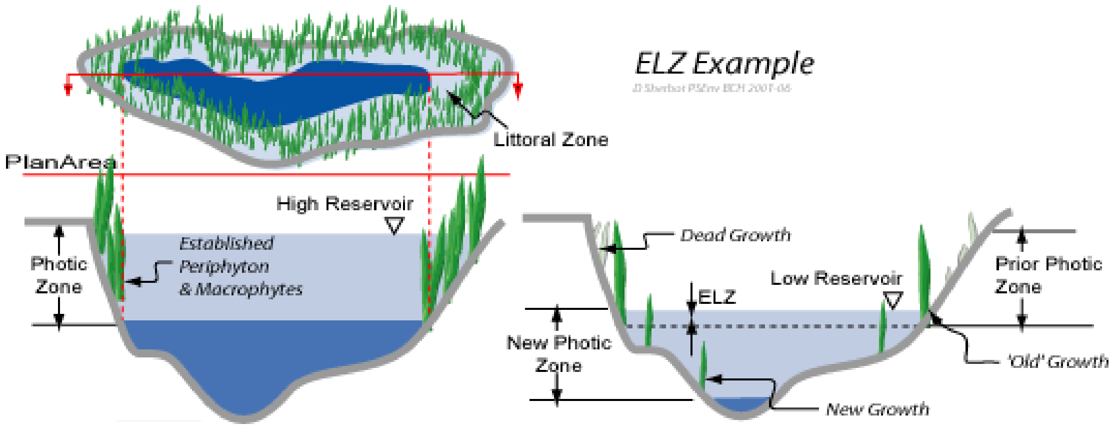


Figure G-6 Littoral Zone and Effective Littoral Zone

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.

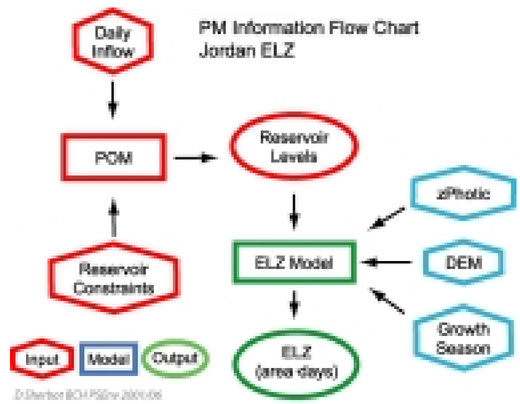
In a reservoir, the establishment of a littoral zone is dependent on the timing and drawdown depth. If sufficient duration of light and wetted area is observed, an effective littoral zone may be established. For the Jordan River Water Use Plan, Effective Littoral Zone (ELZ), was defined as the wetted 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 Water Use Plan and required 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 G-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. POM is the Power Optimization model (also referred to as AMPL). Year (yr), day (d), and alternative (Alt).

Alternative = Alt A, B, C… to N
  Simulation Year = 1967 to 1998
    Day = 1 May to 31 Oct
      ·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



(b) Reservoir Drawdown and Timing PM

It was noted in an earlier biophysical report (Griffith, 1996) that during a summer drawdown (< 372) in Diversion Reservoir, resident rainbow and cutthroat trout were observed to be in poor condition. Adjacent reservoirs not subject to a similar pelagic reduction, however, were characterized by good fish condition factors. Subsequently, it was hypothesized that decreased oxygen levels associated with a reduced pelagic zone and increased temperatures were responsible for the poor fish conditions in Diversion Reservoir.

To attend this issue, the FTC recommended a 'performance index' that tabulated the number and timing of months minimum reservoir level for Diversion was maintained above 372 m. For most alternatives, this simply translated in broad operating constraints such as "*maintain Diversion Reservoir above 376 m for the duration of July through September*." Deviations from these rules for emergency operations and/or system reliability were acknowledged by the FTC as necessary events, but were not expected to be the norm.

Similar performance measure constraint recommendations for Bear Creek Reservoir and Elliott Headpond were not made. As no operational alternatives that would drawdown Bear Creek Reservoir were tabled in the final forum, fisheries stress associated with pelagic reduction was not considered an issue. Similarly, it was made apparent that current operations try to maintain Elliott Headpond at full pool annually to increase powerhouse head. Excluding maintenance requirements and brief drawdowns in anticipation of high local inflows, fish would not be subject to the same stresses as in Diversion Reservoir.

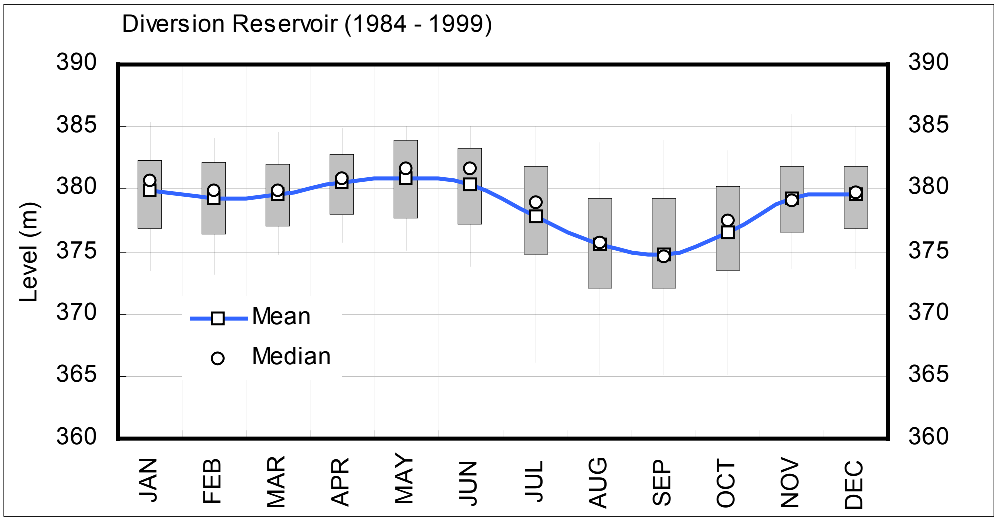


Figure G-7 Historical Reservoir Operations for Diversion (1984-1999)

Mean, median, 75th (box), and 95th (whisker) percentiles. Historical operations have routinely dipped below 372 m during July, August, and September.

Table G-3 Current Reservoir Constraint Summary

Reservoir/ Headpond	Max (m)	Min (m)	Volume (M m^3)	Notes
Bear Creek	411.00	402.92	3.15	Free spill at 411.00. Low level outlet at 404.8.
Diversion	386.18	358.68	20.5	Maintenance drawdown typically June, July, August, or September.
Elliott	335.89	311.51	2.0	Annual maintenance drawdown: August. May be operated ± 1-3 m of sill all other times.

1. Maximum and minimum reservoir sill. Maintenance drawdowns are timed to minimize risk of spilling. Data from BC Hydro System Operating Order (SOO) 4P-34.

Reservoir Information Collected

To quantify the reservoir performance measures, baseline environmental data and information specific for the calculation of selected performance measures were collected for Bear Creek and Diversion reservoirs and Elliott Headpond. These studies and surveys included:

- Bathymetry mapping and digital elevation models of Elliott Headpond (JOR), and Diversion (JOD) and Bear Creek (BCK) reservoirs.
- Summary of drawdown frequency and seasonal timing for Diversion Reservoir and Elliott Headpond.

The digital elevation maps developed for Bear Creek and Diversion reservoirs, and Elliott Headpond were surveyed and post processed at a resolution sufficient to define both change in planimetric area and slope (1:15) as a function of 0.1 m depth intervals.

AQUATIC AND FISHERIES INTERESTS BELOW ELLIOTT DAM

Lower Jordan River Objectives and Performance Measures

The FTC attempted to address 'fisheries' operating alternatives that involved variance between conservation flows, maximizing power generation, and/or stabilizing reservoir levels for the river section below Elliott Dam (Figure G-8 and Table G-4). As no flows are currently released from Elliott Dam, operating alternatives specifically targeted at increasing downstream habitat had to estimate instream flow requirements based on extrapolated benefits. As information became available to the FTC and Consultative Committee during the Water Use Plan, it became apparent that efforts should be focused on addressing the needs of existing resident fish (rainbow trout) rather than on building habitat for anadromous salmonid species that no longer use the system in significant, if any, numbers. This strategy was the conclusion of the following facts:

- Salmonids (Pk, Cm, Co, and St) do not currently use the lower 500 of available upstream of the tailrace and below the first passage barrier (Figure G-8).
- Prior populations of anadromous salmonids, particularly pink, were heavily dependent on the old tailrace, and not the river, after the initial development of the facility in 1912.
- Estimated flows required for potential passage of steelhead (50-100% MAD) for an additional 1000 m of habitat were outside the bookends of determined operational change given the uncertainty associated with historical and potential future use.
- As operational restrictions required to stabilize the approximately 100 m of anadromous salmonid habitat below the tailrace would severely restrict the plant to operate in its designated role (peaking plant 0-70 m^3/s), this was quickly recognized as unachievable alternative by all parties except the First Nations.
- What habitat did remain (approximately 500 m), was suspect to metal toxicity for both rearing and spawning life stages of anadromous salmonids.
- In contrast, resident river fish may benefit from base flow changes that would influence > 7000 m of habitat.

- First Nations interests expressed a desire to restore an unregulated or 'natural' flow regime back to the lower Jordan River. While conceivably possible by running the entire system at full pond and spilling such that inflow = outflow, discharges observed in the lower Jordan River would still remain highly flashy because of extreme logging practices in the upper watershed. 'Naturally' attenuated summer and winter flows would not be possible until the watershed was restored to a mature forest. Until such time, extreme summer and winters low flows would still be observed.

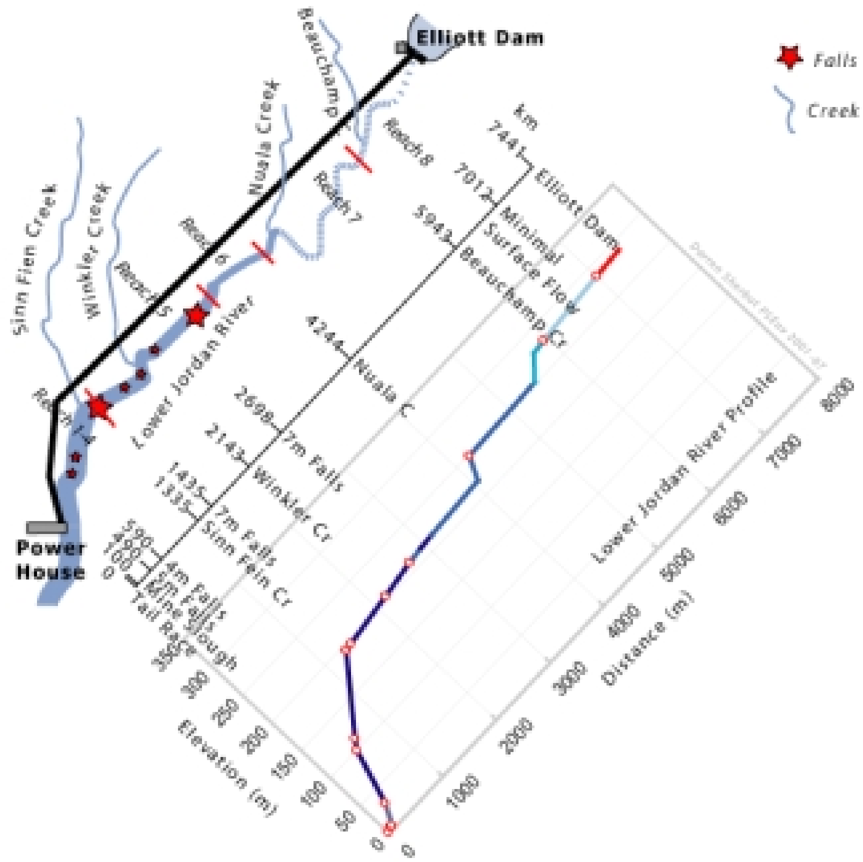


Figure G-8 Schematic: Jordan River below Elliott Dam

Distances and gradients are approximate. Relative proportion of inflow under current operational regime is characterized by thickness.

Resident species were also cited to use the stretch of river between Jordan Diversion Dam and the Elliott Headpond. It was apparent, however, that the minimal length (< 2 km) of the river section and the extreme flow fluctuations (±70 m^3/s) associated with operation of the hollow cone valve at Jordan Diversion Dam did not warrant further investigation until the issues with the lower Jordan mainstem were addressed. The stretch of Bear Creek between Bear Creek Reservoir and Diversion Reservoir was considered as well. Here, however, the river is fed by free spill operations at Bear Creek Reservoir and remains essentially unregulated. As no definitive alternatives scheduled for trade-off analysis changed operations at Bear Creek, this section of the river was also not included in subsequent objective and performance measure exercises.

Eventually performance measures for the lower Jordan River were constructed to exclusively address the incremental change in habitat conditional to a base flow release from Elliott Dam. As an ancillary measure, a second performance measure was used to gauge the relative change in discharge phase and magnitude relative to an unregulated system. Succinctly, performance measures were designed to express incremental gain in resident fish habitat (Rb, St, and Co) under different base flow conditions (0-1.5 m^3/s) and to assess phase and amplitude of different flow scenarios relative to a 'natural' discharge regime:

- Weighted Usable Riffle Area (WURA)
- Deviation from the Natural Hydrograph (DNH)

A summary of specific objectives, means objectives, and performance measures used in the decision making progression for the lower Jordan River are summarized in Table G-4.

Table G-4 River Fish Objectives and Performance Measures

Broad and specific objectives jointly created by the Jordan River FTC and approved by the Consultative Committee. Impact hypotheses and initial performance measures approved by the FTC. Only bolded performance measures were subsequently developed and used to access alternative trade-offs.

Broad Fisheries Objective	• Maximize resident fisheries populations in the Jordan River below Elliott Dam. • Maximize anadromous fish populations in the Jordan River below Elliott Dam.
Specific Fisheries Objective	• Maximize sustainable habitat in the river to restore steelhead populations and historic anadromous fish (pink, chum, coho) populations. • Maximize sustainable habitat in the river to enhance existing populations of resident rainbow trout. • Increase riverine ecosystem health by restoring an unregulated flow regime both in shape and magnitude.
Impact Hypotheses	• The complete diversion of the Jordan River headwaters above Elliott limits successful passage, spawning, and rearing of steelhead, pink, chum, and coho in the lower Jordan River below historic passage barriers. • The complete diversion of the Jordan River headwaters above Elliott limits successful passage, spawning, and rearing of resident rainbow. • The complete diversion of the Jordan River headwaters above Elliott significantly dampens unregulated flow magnitude. Though minor local inflows below Elliott maintain an "unregulated" shape, extensive logging has decreased flow attenuation relative to a "natural" hydrograph in an undisturbed coastal watershed.
Means Objective	• Maximize productive areas (i.e. wetted width of riffle area) in the lower Jordan by increasing (decreasing) flows downstream of Elliott Dam. • Maximize spawning access for steelhead in critical passage areas by increasing flows downstream Elliott Dam. • Restore both the shape and magnitude of a "natural" hydrograph.
Performance Measure	• **Weighted Wetted Width**. • Passage Days. • **Deviation from Natural Hydrograph**.
Critical Uncertainties	• Inflow data for river below Elliott Dam (and thus base flow requirements) was accurately estimated from drainage area calculations. • Baseline flow is sufficient to elicit a response in fish condition. • Baseline flow is sufficient to elicit as response in productivity. • Necessity of winter baseline flows to mitigate as against "winter minimums." • Total increase in linear habitat.

Figure G-9 Passage Barriers on Lower Jordan River

First significant falls approximately 5 m at 490 m upstream the tailrace (left). 7 m falls upstream of Sinn Fein Creek (approximately 1.5 km upstream from the tailrace) (right). 7 m passage barrier photo shot from opposite canyon wall across approximately 10 m deep pool. Note the figure (circled) placed for scale on the rock lip above the falls.

Table G-5 Lower Jordan River Reach Characteristics

Cumulative drainage area (DA), cumulative distance from tailrace (ΣL), reach length (L), gradient (%∇). Approximate reach height (z), cumulative height (Σz), mean reach width (w), hydraulic (Hydr), and substrate (Sbstrt). Riffle (Rf), pool (Pl), cascades (Cs), small (S), large (L), cobble (C), boulder (B), bedrock (BR). Data from Cascadia Biological (2001).

Reach	DA	ΣL	L	%∇	z	Σz	W	Hydrlc	Sbstrt	Note(s)
0.0			-200	1.0	0					U/S estuary boundary.
1.0	17.4	0	100	2.0	2.0	2.0	43.2	Rf/Pl	SB/SC	Tail race @ 0 m.
1.0.1	*17.1*	75	0			*4.3*				Mine Creek @ 75 m.
1.1	*17.0*	100	150	2.0	3.0	5.0	43.2	Rf/Pl	SB/SC	U/S contaminated sediments.
2.0	*16.4*	250	240	10.4	25.0	30.0	37.0	Cs/Pl	LB/SC	Confined canyon.
3.0	*15.5*	490	845	8.3	70.1	100.1	30.7	Cs/Pl	LB/SB	4.6 m falls @ 490 m.
3.0.1	*15.1*	590	0	8.3		*111.3*				4.3 m falls @ 590 m.
4.1	12.2	1335	1602	5.9	94.5	194.6	26.3	Cs/Pl	SB/BR	Sinn Fein at 1335 m. Less confined.
4.1.1	*11.5*	1435	0			*196.3*				6.7 m falls @ 1435 m.
4.1.2	8.1	2183	0			*204.7*				Winkler at 2143 m.
4.1.3	*7.4*	2698	0			*211.3*				7.0 siphon falls @ 2698 m.
4.2	*7.1*	2937	1123	1.7	19.1	213.7	35.6	Rf/Pl	SB/SC	Narrow confined canyon.
4.2.1	*6.8*	3153	0			*214.9*				Another Mine Creek @ 3153 m.
4.3	*5.5*	4060	164	3.7	6.1	219.8	23.4	Cs/Pl	SB/BR	Lower gradient and less confined.
5.1	5.3	4224	1249	2.3	28.7	248.5	25.0	Rf/Pl	SB/SC	Nuala Creek @ 4224 m. Unconfined.
5.2	*3.7*	5473	265	1.5	4.0	252.5	49.0	Rf/Pl	SB/SC	Unconfined.
5.3	*3.3*	5738	1274	2.0	25.5	278.0	28.9	Rf/Pl	SB/SC	Unconfined.
5.3.1	3.0	5943	0			*279.3*				Beauchamp @ ~5943 m.
6.0	*0.9*	7012	429	2.0	8.6	286.5	25.5	Rf/Pl	SB/SC	Minimal or no surface flow.
7.0	0.0	7441	0			*289.4*				Elliott Dam @ 7441 m.

Lower Jordan River Performance Measure Calculation

(a) Weighted Usable Riffle Area (WURA)

Riffles were assumed to be surrogate measures of both lotic productivity and preferred rearing habitat for juvenile trout, steelhead, and certain anadromous salmonids (i.e. coho). The FTC decided that measures of change in riffle habitat would provide an integrated indicator of how different flow alternatives might increase habitat and productivity for resident fish and anadromous salmonids. Multiple transect analyses were completed on each distinct river reach (approximately 8) for three different flow regimes in selected riffle habitats.

Habitat suitability indices (HSI) are data that describe fish preference (prf = 0-1) for a particular parameter range (i.e. velocity and depth) or parameter type (substrate). Generic HSI data developed for the Cheakamus Water Use Plan were used to calculate weighted usable area (WUA) estimates for the Lower Jordan River riffles (WURA). In practice, WUA measures associated with particular species and life history stage are calculated by weighting preference for each variable associated with that area. Weighting used in this application was geometric: WUA = Riffle Area · π (prf_i).

WUA 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) for each sample section (Length) as: Total Area = A(Sctn) · RLength/Length.

The WURA performance measure required the following information for computation (Table G-6):

- For each flow alternative (Alt), daily (d) discharge releases from Elliott into Jordan River from the power optimization model for each year (yr), river reach (rch), and species (Sp).
- Instream flow contribution for each river reach. Calculated from drainage area comparison between Elliott drainage and catchment downstream Elliott.
- Periodicity data for each species to determine if daily flows benefited fry and parr habitat.
- Habitat Suitability Indices (HSI) for each species and lifestage.
- Relative accessible length of system for each species as determined by passage barriers. Steelhead habitat > 490 m was dependent on flow regime selected.

- Mean depth and velocity as a function of flow for each river reach.
- Wetted riffle habitat as a function of flow for each river reach weighted by the linear length of that river reach.

Table G-6 Wetted Width Performance Measure Scope

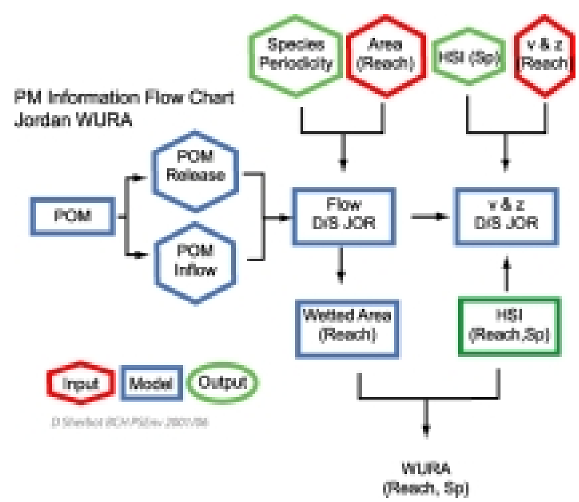
Resident river rainbow trout (Rb), coho (Co), steelhead (Sh). Total length of the river assessable for spawning and rearing. Start relative to tailrace (0 m) and upstream of the mine slough (100 m). All habitat reduced by 100 m in the lower portion to account for mine contamination.

Sp	Start (m)	End (m)	Note
Rb	0 (100)	7441 (7012)	No access above 7012 unless "Run-of-River."
Co	0 (100)	490	Access always limited by 4.6 m falls.
Sh	0 (100)	1435 (490)	Access limited by 4.6 m falls unless "Run-of-River" or "passage flows" provided.

Table G-7 MetaCode for WURA Calculation

Indents represent looping hierarchy. *Italicized data indicates program calculation and/or output*. **Bolded values indicate alternative specific performance measure output.** POM is the Power Optimization model, also referred to as the AMPL model. Year (yr), day (d), species (Sp), reach (Rch), alternative (Alt), median (Mdn), and lower 10th percentile of data (L10).

Alternative = Alt A, B, C… to N
Reach = 1 to 8
Simulation Year = 1967 to 1998
Day = 1 Jun to 30 Sep
·Daily Inflow (Alt, Rch, yr, d)
Species = Rb, Co, and St
·Daily Reach WUA (Alt,Rch,yr,d,Sp)
Next Species
Next Day
·Mdn Annual Rch WUA (Alt,Rch,yr,Sp)
Next Simulation Year
·Median Reach WUA (Alt, Rch, Sp)
·L10 Reach WUA (Alt, Rch, Sp)
Next Reach
·Median River WUA (Alt, Sp)
·L10 River WUA (Alt, Sp)
Next Alternative



(b) Deviation from the Natural Hydrograph (DNH)

The complete diversion of the Jordan River headwaters above Elliott significantly dampens unregulated flow magnitude. In addition, the remaining local inflows are exaggerated from extensive logging that has decreased flow attenuation relative to a "natural" hydrograph in a undisturbed coastal watershed. The intent of the DNH performance measure was to capture both the change in magnitude and alteration of hydrograph shape. As it is assumed that anadromous and resident fish species have evolved to take advantage of system specific hydrograph characteristics for spawning access, rearing, and migration timing, a lower deviation, is synonymous with a better flow regime.

For a given flow alternative, DNH was calculated as the daily sum of square error between flows for the alternative and the natural hydrograph. For the lower Jordan River, the natural hydrograph was calculated by the AMPL as the outflow associated with running the reservoirs at full pool and letting outflow = inflow as the "Run-of-River" alternative. The FTC noted that the "natural" hydrograph observed prior to logging and hydroelectric development (1912) would be slightly different that that provided by an unregulated system with infrastructure still in place. While the creation of a 'new' lake (Elliott) might increase system attenuation, it was assumed, that the deforestation of the upper catchment would overshadow this.

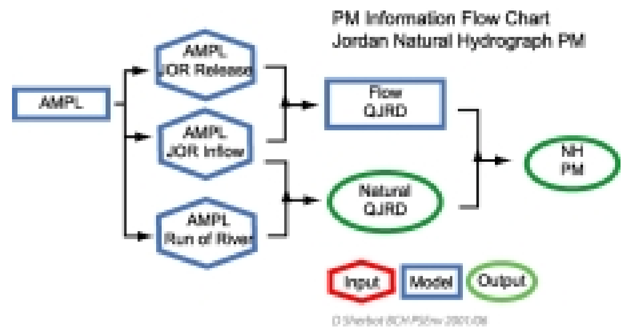
Extreme freshet spikes associated with the natural system would occasionally result in errors 2-4 magnitude orders larger than base flow comparisons. To avoid confounding the data with these events, only the sum of the upper 95% data was used. The number and magnitude of channel forming flows was recorded for separate tabulation.

The following data was required for the DNH PM calculation (Table G-8):

- Run of the river flow, as measured immediately upstream of the tailrace for each day (d) of each simulation year (yr).
- For each flow alternative (Alt), daily (d) discharge from Elliott (spill and release) into Jordan River are required from AMPL for each year (yr).
- Instream flow contribution for river section below Elliott. Calculated from drainage area comparison between Elliott and catchment downstream Elliott.

Table G-8 MetaCode for DNH Calculation

Indents represent looping hierarchy. *Italicized data indicates program calculation and/or output.* **Bolded values indicate alternative specific performance measure output.** POM is the Power Optimization model, also referred to as the AMPL model. Year (yr), day (d), species (Sp), reach (Rch), alternative (Alt), sum of square error (SSE), lower 10th percentile of data (L10), and lower 95th data percentiles.

<table>
<tr>
<td>Alternative = Alt A,B,C… to N
  Simulation Year = 1967 to 1998
    Day = 1 to 365
      ·Natural Hydrograph (Alt, yr, d)
      ·Daily Inflow (Alt, Rch, yr, d)
      ·Daily Deviation (Alt, Rch, yr, d)
    Next Day
      ·SSE(L75) DHG (Alt, yr)
  Next Simulation Year
      ·Median SSE(L95) DHG(Alt)
      ·L10 SSE(L95) DHG(Alt)
Next Alternative</td>
<td>
</td>
</tr>
</table>

(c) River Information Collected

To quantify the river performance measures, baseline environmental data and information specific for the calculation of selected performance measures were collected for the lower Jordan River. These studies and surveys included:

- Establish resident and expected anadromous lifestage periodicity.
- Water and sediment quality summary and current chemical equilibrium for metal toxicity.
- Anecdotal survey of historical species presence and passage access.
- Instream swim surveys for potential presence of anadromous spawners (coho, pink, chum, and steelhead).
- Instream flow assessments and channel survey for the Lower Jordan River that related wetted width of riffle habitat to flow.
- Expert assessment of passage barriers.
- Bioassay and laboratory toxicity tests for metal toxicity assessments.
- Watershed models to estimate regulated and unregulated inflows to the lower Jordan River.

An anecdotal survey was undertaken to determine and document historical use of the river by fish species. It was also used to determine how far up the river some species, particularly steelhead, were suspected to have travelled prior to project redevelopment in 1971. Thirty-nine individuals were contacted. Of these, eighteen had information specifically about the Jordan River and twelve were quite familiar with the river (RRL 2001). Consensus was not unanimous, however, the majority of references placed anadromous fish in the lower 1 km of the Jordan and/or in the old tailrace.

Instream swim surveys during hypothesized spawner arrivals were conducted to determine what fish species were currently utilizing the system (Benvar, 2000). No chum or pink were observed in the system. Coho (< 15) and steelhead were observed, however, the high proportion of marked fish strongly suggests that these were strays and not local spawners.

Instream flow assessments and a comprehensive channel survey for the lower Jordan River below Elliott Dam was carried out over the fall of 2000 and spring of 2001 (Cascadia, 2001). The river was surveyed and divided into 8 distinct reaches from the mouth up to Elliott Dam to the tailrace. Reach characteristics were documented and transects were taken in selected reaches to quantify riffle areas as a function of flow. Critical passage barriers were assessed for the potential for migration and tributary access potential (minimal) was documented. Assessment of critical barriers was made in conjunction with BC Fisheries, Ministry Environment, Land and Parks, and BC Hydro staff.

Metal toxicity assessments for the lower river were conducted in situ and using Environmental Canada Standard $_{96}LC_{50}$ tests for rainbow trout. An in situ bioassay conducted using coho eggs indicated negligible toxicity associated with fertilization, subsequent incubation, and alevin stages, however, no survival data was collected on the most sensitive stage (smolt) (DFO, 2001). In contrast, standardized LC50 tests indicated acute toxicity to Rb fry (PESC, 2001). The suitability of the lower Jordan River where the abandoned copper mine slough exists remains suspect.

Watershed models to estimate regulated and unregulated inflows to discrete sections of the Jordan River were developed by BC Hydro for use with the power optimization model. A standardized inflow dataset (1967-1998) was developed. An equivalent inflow dataset for the lower Jordan River below Elliott Dam was extrapolated based on known inflows and relative drainage areas. Inflow below Elliott Dam is currently being validated with a new discharge gauge located upstream of the tailrace.

APPENDIX H: WATER QUALITY INFORMATION SHEET

Water quality interests in the Jordan River watershed are related to both quality of habitat for fish and aquatic life as well as for consumptive use in the community of Jordan River. Water quality interests were separated into two areas, reservoirs and downstream Elliott Dam. A water quality sub-group was tasked with leading the reservoir interests and the Fish Technical Committee (FTC) discussed water quality issues in the lower Jordan River.

WATER QUALITY IN RESERVOIRS

There was a lack of water quality information for the Jordan River watershed. Griffith (1996) and BC Hydro, Ministry of Environment, Lands and Parks, and Fisheries and Oceans Canada (2000/01) have collected and reviewed available water quality information. No information exists for suspended sediment and total gas pressure (TGP) and limited information is present on nutrients, oxygen and temperature. Possible influences of dam and reservoir operations included impacts on suspended sediment, nutrients, oxygen, temperature, metals/hydrogen sulphide and total gas pressure (see Figure H-1).

A reservoir review in 1995, (Griffith, 1996) found low water levels in Diversion Reservoir were associated with high temperatures and low dissolved oxygen levels. While not quantified, it was suspected that these environmental conditions may have had a negative impact on aquatic life in the reservoir.

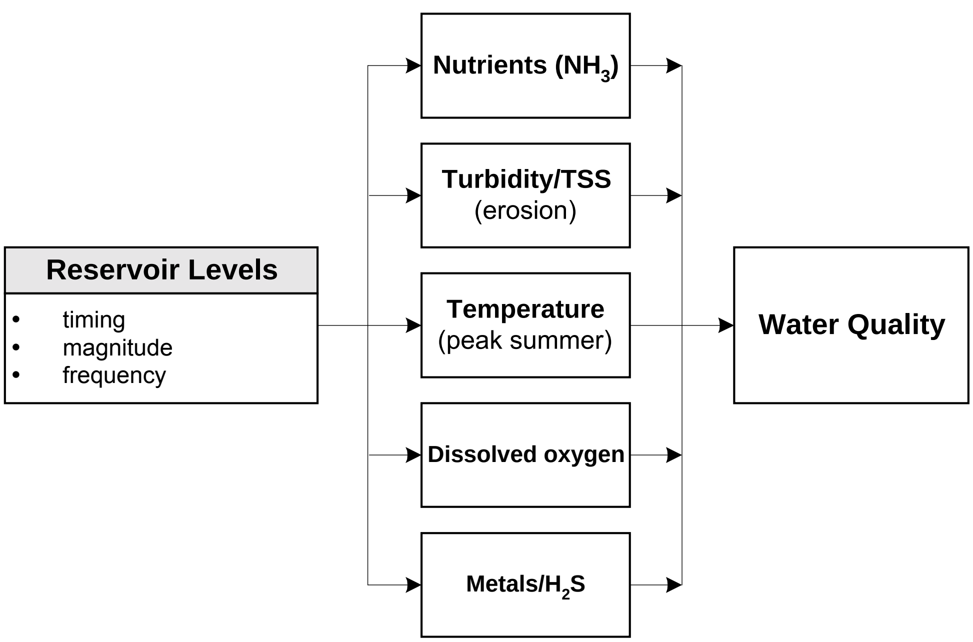


Figure H-1 Water Quality Influence Diagram in Reservoir

Shows variables influenced by changing water use on water quality in reservoirs.

Elevated concentrations of iron, suspected to come from the Bear Creek outlet, were measured in Diversion Reservoir. Strategies to address this were not part of Water Use Plan as they could not be impacted by changes in operations (currently no release from Bear Creek low level outlet).

Objectives and Performance Measures

The water quality group considered objectives and possible performance measures independently and also reviewed measures generated by the FTC. The water quality sub-group members recommended that the fish objectives would satisfy their interests if invertebrates and aquatic life were added to the original objective of maximizing rainbow trout habitat conditions.

For reservoirs, limited baseline data prevented the development of quantitative performance measure during the period of the Water Use Plan project. This resulted from insufficient information to determine the drivers affecting water quality and how operations may influence these drivers. This was particularly the case for drawdown effects on water quality and so no 'minimum level threshold' was determined for Diversion Reservoir. Moreover, it was the opinion of the FTC that the influence on water quality from reservoir operations was likely to be a relatively minor issue.

Water quality information was reviewed by limnologists John Stockner and Rick Nordin for identification of key parameters which would be needed for future decisions on operational effects on water quality. These water quality experts would not offer immediate recommendations for use by the Consultative Committee due to insufficient information.

Table H-1 Water Quality Objectives and Performance Measures

Objective	Performance Measures
To maximize habitat conditions in the Jordan Reservoirs (Bear Creek, Diversion, and Elliott) to maximize populations of rainbow trout, invertebrates and aquatic life.	Performance measure for minimal level threshold could not be established due to limited data available. Effective Littoral Zone (see fish interest).

Information Collected

A study was initiated during this water use planning process to collect water quality information in the reservoirs. This study was conducted through Royal Roads University and was jointly sponsored by Royal Roads, Ministry Environment, Lands and Parks, and BC Hydro. This program will monitor the oxygen, temperature, metals, and sediment issues identified during the water use planning process over a 12 month period. This information will assist BC Hydro when undertaking future operations reviews.

WATER QUALITY IN THE JORDAN RIVER BELOW ELLIOTT DAM

Water quality interests linked to fish production in the lower river were discussed. Issues identified included limited flows and affects on temperatures below Elliott Dam, metals contamination of sediment and water in the lower river associated with a historic mining activities, and total gas pressure resulting from powerhouse discharge. An influence diagram is provided in Figure H-2.

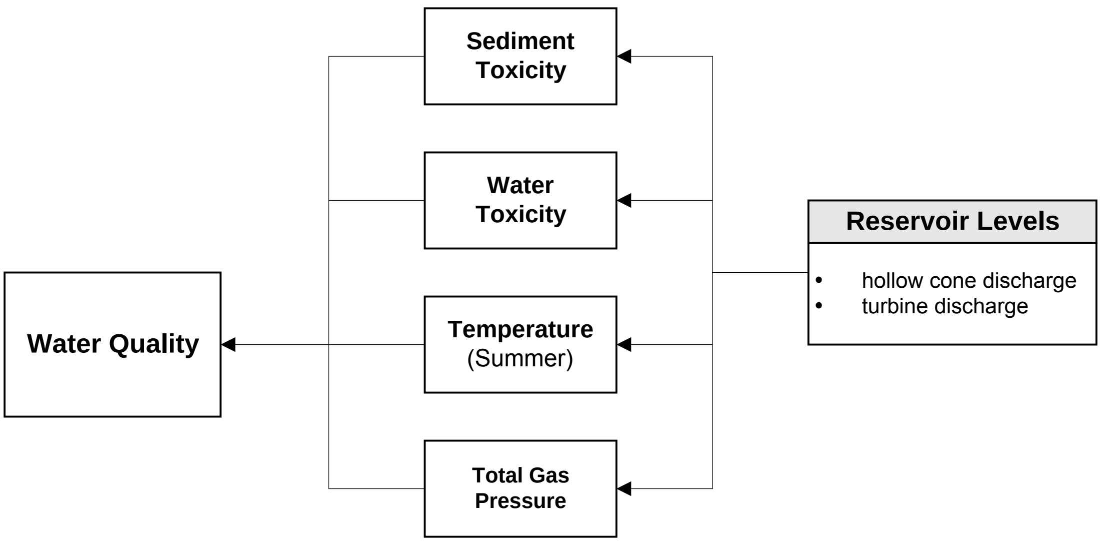


Figure H-2 Water Quality Influence Diagram in Lower Jordan River

Shows variables influenced by changing water use on water quality in the lower Jordan River.

The FTC focused on questions related to metals contamination from historic mine operations to determine the suitability of the habitat for anadromous salmonid production. Sediment metals concentrations in the lower Jordan River are above CCME guidelines for the protection of aquatic life. See fish interest overview for a full discussion of these efforts.

Objectives and Performance Measures

There were no specific objectives developed for water quality in the lower river. Efforts focused on determining the level of suitable habitat in the lower Jordan River, the outcome of which would impact the objective to be achieved (see Appendix G Fish Information Sheet).

Information Collected

Additional sampling of the lower river water and sediment quality occurred during the Water Use Plan and an in situ bioassay of fish (Coho) survival in the lower river was undertaken to determine the suitability of the lower river as fish habitat in conjunction with standard LC50 tests for rainbow trout fry survival (see Appendix G Fish Information Sheet).

WATER QUALITY AND DOMESTIC USE

Water quality issues with respect to domestic use were discussed. A local resident on the Consultative Committee indicated that the water colour turns brown (minimal sediment) in the fall during rain events. Water is drawn from the penstock and pumped for use by a number of houses in the area. A change in water use would not affect domestic water supply, and in addition, the range of changes in operations being contemplated are unlikely to influence the source of water colour. No other water is drawn from the river for domestic use, as the rest of Jordan River community uses various deep wells. Please refer to section on Consumptive Use for more information.

APPENDIX I: WILDLIFE INFORMATION SHEET

Little documented information exists with respect to wildlife and effects of BC Hydro operations on wildlife in the Jordan River watershed. To assist in scoping wildlife issues and developing objectives and performance measures, a review of available information was completed. In addition, anecdotal information with respect to species presence and potential operational impacts on wildlife impacts was gathered from the Jordan River Water Use Plan Consultative Committee.

The Jordan River watershed has a variety of wildlife habitats including old growth forests, second growth forest, non-forested areas, open water habitat (reservoirs, rivers) and rock bluffs. A wide variety of wildlife species are found in all habitats throughout the Jordan River watershed. The presence of these species provides numerous hunting, trapping and wildlife viewing opportunities.

A review of known and potential wildlife species located in the watershed was undertaken. Five red and 11 blue listed species (Conservation Data Centre) have been identified in the watershed (either known or suspected to occur) which may or may not be impacted by BC Hydro operations. Some listed species such as the red-legged frog may be more susceptible to impact while others such as the Roosevelt elk are unlikely to be affected.

Some notable (and speculated) impacts on wildlife gathered from committee members include: dippers impacted by lack of flow in river, and perhaps harlequin ducks; loss of nesting habitat in reservoirs with reservoir drawdown (e.g. loons); influence of operations on fish populations in the lower river that would have a subsequent effect on eagles, bears, and otters. Limited detailed information exists for this watershed. Wildlife habitats in the immediate vicinity of the reservoirs and river are unlikely to be significantly influenced by potential operational changes.

Objectives and Performance Measures

Table I-1 Wildlife Objectives and Performance Measures

Objective	Performance Measure
To optimize littoral habitat in reservoirs and riparian habitat along streams for wildlife.	No performance measure. Fish performance measure to be used as proxy for wildlife.

Information Collected

As part of the water use planning process, the Jordan River Water Use Plan Consultative Committee requested a brief review of wildlife resources of the project area and potential impacts of BC Hydro operations (Bianchini and Robertson, 2000). This review of those habitats immediately adjacent to the reservoir and river, as well as the wildlife of the reservoir and river extending as far downstream as the estuary, involved a summarizing previous wildlife and wildlife habitat studies done in the Jordan River area, and included consultation with knowledgeable individuals.

APPENDIX J: CULTURAL USE AND HERITAGE RESOURCES

The Jordan River hydroelectric system is in the traditional use areas for three First Nations. These include T'Sou-ke Nation, Pacheedaht First Nation and Ditidaht First Nation. Historically, Jordan River was a popular fishing and hunting area for First Nations travelling along the coast. A T'Sou-ke village site was established at the mouth of the Jordan River that was shared by a number of First Nations.

The primary interests of the participating First Nations with respect to Jordan are related to fish and fish habitat and to restoring fish to the Jordan River. Wildlife, access to hunting and archaeological and cultural resources were raised as interests as well.

In particular, T'Sou-ke Nation were interested in how their asserted treaty rights, under the Douglas Treaties, to "carry on the fisheries as formerly" and the "liberty to hunt over unoccupied lands" was to be reflected in this water use planning process.

Regarding cultural use and heritage resources, one archeological site is known to exist at the mouth of the Jordan River. While no known archeological sites have been identified further up the river or in the reservoir system, no formal archeological studies have been conducted in the area.

Discussions with First Nation participants in the process concluded that initiating an archeological study or formal traditional use study would be premature and not an effective use of resources given the limited scope of the water use planning. Instead, it was suggested that meeting with Elders from T'Sou-ke Nation would provide information about Jordan River, how it was and is used and its significance in general. It was expected these discussions would also identify if there were areas in or along the river that might require a closer look from an archeological/heritage perspective.

Objectives and Performance Measures

Table J-1 Cultural Use and Heritage Objectives and Performance Measures

Objectives	Performance Measures
Interests of fish and fish habitat, and wildlife are being addressed through the fisheries and wildlife objectives (see fish interest overview and wildlife interest overview).	Refer to fish performance measures.
In the absence of information, no objective has been established for cultural use and heritage resources.	In the absence of information, no performance measures have been established for cultural use and heritage resources.

Information Collected

Three Elders from T'Sou-ke Nation met with Water Use Plan representatives to share their knowledge of and experiences on the Jordan River, its uses and their perspective on its significance. A summary of this session is found attached as part of this information sheet.

The specific information provided was applied to various objectives and performance measures where appropriate; e.g. fish. The discussions with the Elders did not identify specific heritage concerns or archaeological sites requiring further investigation.

In general, the Elders felt the overall effects of industrial impacts (mining, hydro and logging) on the Jordan River could not be pinpointed to one industry. All three industries played a part in the destruction of the river system. Over the years, the Elders saw how the Jordan River died. The end result was either depletion or destruction of fish, wildlife and habitat that the First Nations used. The Elders saw many companies come into the Jordan and take valuable resources only to leave the environmental clean up for someone else to do. Also, the Elders were frustrated at telling the history repeatedly without any action being taken.

The Elders are interested in seeing the Jordan River restored to its original flows to teach their youth and future generations how to care for and live off the land. The Elders are interested in the reestablishment of fish in the river. While the Elders understand many things contributed to the death of the Jordan River, they believe it would be a good opportunity, through the Water Use Planing process, for the province something about it.

The Elders note they have a right to fish and hunt as formerly (in reference to the Douglas Treaties) but questioned how they might do so if there is not anything there to hunt or fish.

A letter was sent by the T'Sou-ke Nation to the BC Hydro Jordan River WUP project manager on 7 February 2001. The letter stated that it is the perspective of T'Sou-ke Nation that since the Elliott Dam was built in 1971, flows down the Jordan River have been altered to an extent where fish species no longer flourish, to an extent that their treaty rights to fish as formerly has been 'rendered meaningless and illusory'. In the context of the Jordan River WUP it was T'Sou-ke Nation's wish "to have fish supporting water flows restored and their treaty rights respected."

The issue of compensation was not something discussed within the scope of water use planning. This was, however, never clear to them "how they are supposed to consider trading off the exercising of their constitutional rights in favour of interests such as power generation and surfing when they have no information as to what compensation is available to them for doing so."

SUMMARY OF ELDERS INTERVIEW

Overview of Interest

The T'Sou-ke Nation and BC Hydro invited T'Sou-ke Elders to share their experiences and recollections of the Jordan River in order to gain a better perspective on the uses and importance of the Jordan River. In First Nation communities, Elders are important members in the social structure. Elders are leaders, teachers, guides, counsellors and spiritual leaders. Much can be learned from Elders because they are the "keepers of the past."

This meeting was held on 11 December 2000 at the Te'mexw Treaty Association office in Sooke. The Elders present were Frank Planes, Jack Planes and Jim Cooper. Also attending were Denise Purcell (T'Sou-ke Nation Treaty Negotiator) and David Lightly (T'Sou-ke Nation Fisheries Biologist) and Janie Hutchings and Anne Wilson (BC Hydro). Michelle Sprinkling recorded the minutes.

The Jordan River Water Use Plan Consultative Committee approved the meeting with the Elders to gather anecdotal information regarding the history of the Jordan River, as there is virtually no information archived. The objective from a WUP context is to use the information to help clarify objectives, and develop and refine performance measures to serve those objectives.

The transcript of the Elders meeting identified historical and current uses and industry impacts in the Jordan River.

Information Collected

There were three general areas of discussion. First, fish and wildlife emerged as the most important issues - which included references to the Douglas Treaty. Second, the background information on historical sites and uses was provided. Lastly, information regarding the magnitude of industrial impacts by logging, hydroelectric generation and mining were expressed.

(a) Fish and Wildlife

The animals hunted and trapped for food and income were ducks (including mallards), seals, deer, racoons, minks, otters and cougars. The fish included salmon, sea-run cutthroat trout and halibut. There were abundant runs of four salmon species which included the largest run of pink, then coho, and chum with a possibility of a few spring. Steelhead were also abundant.

The Elders indicated that the fish used the entire river which included areas above the large boulders and small falls. In 1932, there were no roads or walkways and fish could usually be caught within the first 200 yards from the mouth of the river. Also, the gravel at the bottom of the canyon was plentiful and provided excellent spawning grounds.

In the mid 1940's, there was still an abundant salmon run where First Nation people would stand on logs and carry out spear fishing. Fishing locations were situated in the old tailrace and spillway prior to the dam. After the dam, coho fishing occurred in the spillway and in the flumes until about 15 years ago. The Elders stated that most of the salmon disappeared during the 50's.

There was a question on the Douglas Treaty and what role it played in the Jordan River area. The Douglas Treaty states that signatories and their descendants retained existing village sites and fields for their continued use, the "liberty to hunt over unoccupied land" and the right to "carry on their fisheries as formerly."[1]

The Elders responded by stating the following verbatim response: "That's our hunting and fishing stations to begin with, to fish and hunt as formerly. So that still stands if we wanted to hunt and fish out there, we still have rights. It is a fishing station, it's an old fishing station, registered for the T'Sou-ke territory. So I don't know if anyone could stop us if they wanted. But is there anything there to hunt and fish anymore?"

The question was then posed if you can fish "as formerly" and the habitat supporting the fish has been destroyed, where does that leave the treaty? Again, the verbatim response was: "Well, that's a violation of our treaty right then. Isn't it? They took that anyway from us." Another Elder voiced his opinion; "The government is responsible for ensuring that these rights are protected…".

(b) Historical Sites and Uses

Prior to European contact, there existed a T'Sou-ke fishing village at the mouth of the Jordan River. The village consisted of cabins, canoe pullouts, campgrounds, smoked salmon houses as well as shacks along the river. The village was based mostly on fishing but the campgrounds could be used all year round. The only transportation at the time was by canoe so there were many different First Nations that used the village. Some of the uses were as a rest stop on the way up to Nit Nat or San Juan, to avoid bad weather in the Straits of Juan de Fuca, and to find food sources by hunting and fishing.

(c) Industrial Impacts

The following points summarize what the Elders recall over the years with regard to industrial activities on the Jordan River. Specific information on dates and which industry was responsible were not always specified by the Elders. There were many industrial impacts over the years on the Jordan River Project. Mining. logging and hydroelectric facilities were identified as the industries that caused the impacts.

[1] Ministry of Aboriginal Affairs, Historical References - Douglas Treaties: 1850-1854, http://www.aaf.gov.bc.ca/douglas.stm

- Most of the fishing village artefacts located at the mouth of the Jordan River were covered up.

- After the flooding, a company brought in a huge machine to drag the bottom of the river. When the river was clean, there was a gravel pile 100 feet high and 400-500 feet long. The gravel was deposited into a nearby pond. This destroyed habitat of ducks, spawning salmon, herring, crab apple and other wildlife. Wetland essentially became dry land for approximately 9-12 acres.

- In the 1960's, the mining company had to wash the ore so they pumped water from the Forebay Reservoir. The tailings from the mine would go into the Bay. It killed the seafood, made the water brown, changed the lower Jordan system and washed away the fine gravel bottom. The ore was washed with cyanide which destroyed wildlife habitat for 2 mile on either side of the piping.

- The mining company put hundreds of cars down a tunnel of the mine shaft to try to stop flooding. When the mine did flood, the Forebay Reservoir must have crashed through the tunnel.

- Two mining companies had environmental impacts when building a tunnel. The tunnel rock was put on a barge by a crawler shovel that had a 10-yard bucket. The tunnel was 10-12 feet and the engineers were off by one inch. The tunnel, which was four miles long, broke through.

- Workers found burial trees which were coffins buried in tree limbs so the animals could not reach them. The superintendent waited until the Elder went on a month holiday. Then, he had the trees logged and remains were hauled out of the trees.

- Up in the Jordan River, above the Sambrio River, workers found an old big cedar log without any bark. It must have been chopped down prior to contact. There was not evidence that a machine was used - it was most likely a chisel. An Elder wanted to take the logs to a museum because his ancestors cut the tree down to use it for a canoe. When on holidays, the Elder asked someone to look after the logs. Upon his return, the logs had been sent to the shake cutters.

- Clear cutting occurred in pristine places, which destroy the habitat. The logs would be dragged into the water and cause logs jams in the river.

- "After the river died," smelts and oolichans could be found in the river above the bridge. Bright lights were brought in to work the booms at night during high tide. The lights would attract the smelts and trap them when the tides went out during the day.

- A logging company, two miles outside Sooke cleared a burial ground in the 1950's. They loaded the gravel and skeletal remains and dumped it into Kemp Lake. The company did not notify anyone so the area would not be shutdown. Non-native workers collected and saved the artefacts to keep for their personal collection.
- Loggers clear-cut much of the Sooke area.
- Cyanide was used to wash away tailings from the mine. It killed the whole area and turned the beach into sand.
- In 1969, BC Hydro started building Elliott Dam and dug a 4-mile tunnel to the new powerhouse.
- BC Hydro had to log the area in order to flood the old dam. The trees were logged with a machine to pull off the limbs; leaving the stumps.
- The mine tailings flooded into the river and destroyed the fish habitat.
- You could see the Elliott reservoir go down when the power was turned on. During the big rains, it used to spill one or two feet over the top of the Elliott.
- When the dam was shut-off at Camp 5, there was not any water running down the river.
- The old dam used a 5-mile flume to release water through the generating plant. The water did not go back into the river but into a side channel. So, there was no steelhead unless the tidal water came up about a half mile. The steelhead disappeared when the new dam was built in 1969.
- When the new powerhouse was being tested, thousands of gallons of clear hydraulic oil poured into the whole river. It lasted about a week until it was flushed clean and disappeared into the beaches.

(d) Summary

The Elders felt the overall effects of industrial impacts on the Jordan River could not be pinpointed to one industry. All three industries played a part in the destruction of the river system. Over the years, the Elders saw how the Jordan River died. The end result was either depletion or destruction of fish, wildlife and habitat that the First Nations used. The Elders saw many companies come into the Jordan and take valuable resources only to leave the environmental clean up for someone else to do. Also, the Elders are frustrated at telling the history repeatedly without any action been taken.

Today, the Elders are interested in seeing the Jordan River restored to its original beauty to teach their youth and future generations to care for and live off the land. The Elders are interested in the reestablishment of fish in the river, particularly pink and chums. While the Elders understand many things contributed to the death of the Jordan River, they believe it would be a good opportunity for BC Hydro to do something about it.

APPENDIX K: SOCIO-ECONOMIC WELFARE OF THE LOCAL COMMUNITY INFORMATION SHEET

There was an interest in examining potential changes to the socio-economic welfare of the local community as a result of changes to operations. Local community is defined as Jordan River and Sooke communities including First Nations and to a lesser extent, Victoria. The term 'socio-economic welfare' is defined as the infusion of money into the local economy through stable local business development and jobs. It is recognized that this, in turn, affects social indicators such as crime rates.

Changes in water use may affect changes in fish habitat (and thus fish populations) which could affect recreational fishing, commercial fishing, and tourism which ultimately could affect the infusion of dollars into the local economy and potential jobs. Changes in water use also have the potential to affect the quality of surfing which may have implications to infusion of dollars to the local economy through increased recreation and tourism (see Figure K-1, below).

The existence of the Jordan River hydroelectric facility provides benefits in the way of two jobs and infusion of dollars into the community by way of grants-in-lieu of taxes. These benefits to the local economy will not change with incremental changes in water use (i.e. power generation). A separate information sheet was developed which illustrates these benefits. A discussion of power benefits to the local community through ensuring reliable service is discussed within the power objective.

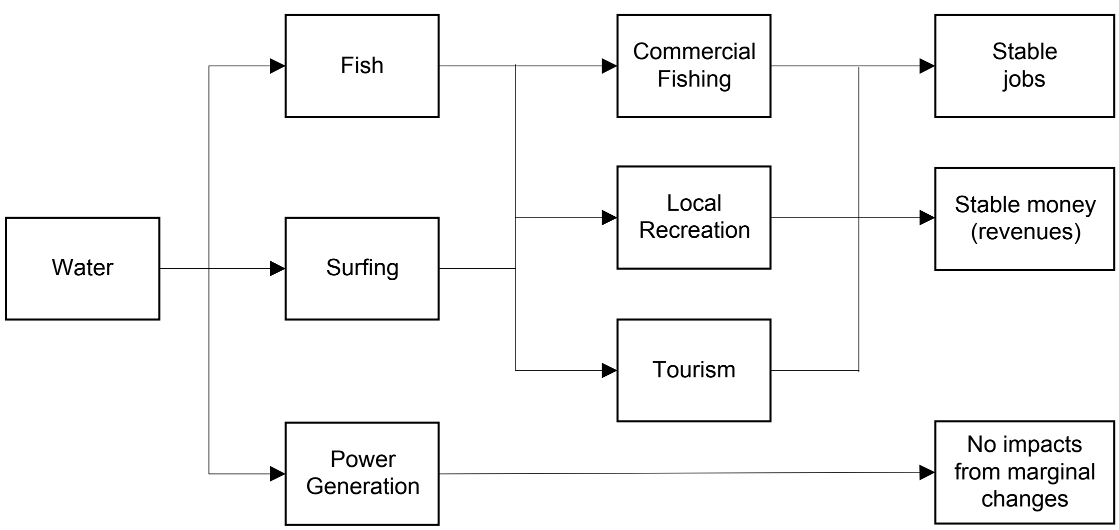


Figure K-1 Socio-Economic Influence Diagram

Shows potential variables influenced by changing water use on objectives related to increasing socio-economic welfare.

Objectives and Performance Measures

Table K-1 Socio-Economic Objectives and Performance Measures

Objective	Performance Measure
Increase Socio-Economic Welfare of the Local Community	A qualitative statement will be made

When assessing choices between alternatives, it was noted to describe qualitatively that the potential impacts of changes to the stated objective may include additional longer term impacts the socio-economic welfare of the local community. This approach ensured that committee members are aware, as they made trade-offs, that potential impacts changing operations have on objectives such as fish and recreation (surfing) may also translate into impacts to local socio-economic welfare in terms of infusion of dollars and jobs. Along with a qualifying statement, the Consultative Committee may wish to use the term status quo, improvement, and/or deterioration to describe potential impacts. The specific weights people applied to any potential changes were their own.

Information Collected

Information was collected on the current benefits to the local economy in terms of jobs and infusion of dollars (through grants-in-lieu of taxes) that BC Hydro provides (not dependent on water use). In addition, the surfing survey has included a socio-economic question which will provide an indication of how much money a surfer spends during a trip to Jordan River.

Jordan River Socio-Economic Information

- The Jordan River hydroelectric facility encompasses the Bear Creek, and Diversion reservoirs, and Elliott Headpond, and the 170 MW powerhouse located one km from the mouth of the river.
- The total MWh of power generation from this facility:
  - 1998 - 253 503 MWh
  - 1999 - 333 200 MWh
  - 2000 - 181 406 MWh
- Province-wide, BC Hydro paid approximately $138.3 million in taxes and grants-in-lieu of taxes for 2000. The following are school taxes and grants-in-lieu paid to the communities within the Capital Regional District:
  - District of Sooke $87,336
  - Colwood $80,878
  - District of Esquimalt $372,624
  - Victoria $1,071,343
  - Capital Regional District $80,280
  - Total $1,692,461
- Water rentals are charged by the Province of British Columbia, pursuant to the *Water Act*, on hydroelectric generating capacity and the use of water in the generation of electricity. In 1999, BC Hydro paid $267 million in water rental fees, with Jordan contributing $2,205,500.00.
- There are 2 BC Hydro employees working at the powerhouse full-time.
- During annual maintenance of the generator, a number of other employees are brought into the area (from Victoria, Port Alberni, and Campbell River) for about a three to 4-week period. This creates some increased revenues for local businesses.
- The Jordan River facility is an important part of BC Hydro's Vancouver Island generation and reliability. The area it serves is the Port Renfrew to Sooke corridor (particularly during power outages caused between Sooke and Colwood) and Victoria during peak demand in the morning and evening. It also serves as an emergency generation contingency in the event of outages from the Lower Mainland caused by problems with the undersea cables, and when conditions allow, generation sales to out-of-province markets.
- Domestic water is supplied from the powerhouse to residents in the Hilltop area (about 10 homes).
- Western Forest Products operates a log sorting operation at the mouth of the Jordan River.
- Diversion and, particularly, Bear Creek reservoirs provide a variety of lake-oriented activities (e.g., swimming, fishing, canoeing). This area attracts residents from mainly Southern Vancouver Island.

APPENDIX L: CONSUMPTIVE WATER USE INFORMATION SHEET

Consumptive water use was determined to be not an issue for the Consultative Committee. BC Hydro is the sole licensee holder that withdraws water from the Jordan River. Other water licenses exist around Jordan River but do not withdraw water from the river. A very small amount of water is withdrawn from the powerhouse for houses in the Hilltop area of the Jordan River community.

Domestic Water Use - The Hilltop Water System

Water for domestic use has been piped from the powerhouse to nearby houses on Hilltop for many years. Historically, water was pumped from the old powerhouse to a wooden tank. It supplied 15 houses on the Hilltop as well as about 12 BC Hydro houses down the hill near the old powerhouse and school. Occasionally it supplied water to the forest company houses. When the new powerhouse was built from 1969 to 1971, BC Hydro installed the current piping system across the Jordan River to the old wooden tank at Hilltop. The water tank was replaced in 1992 with the new 5000-gallon (US) fibreglass tank that is still in use today. The tank, which sits on a metal platform on Dick Poirier's property, serves as the domestic water source for 12 house in the Hilltop area.

The water is piped from the powerhouse (penstock) up to Hilltop by a 2-inch PVC buried pipe. There are two shutoff valves on this line: on the outside of the powerhouse, which was installed in preparation for a usage meter, and on the east side of the river. The water is piped in at a continual flow into the water tank. An overflow outlet on the tank spills excess water continually unless the holding tank is filling. Water is pumped from the powerhouse at a rate of 100 pounds per square inch (psi). This was reduced from 120 psi a few years ago to lessen the amount of water spilled from the overflow outlet.

From the main tank, the water is gravity fed into a 2000-gallon holding tank where it is treated by a chlorine injection system. The chlorine system was set up based on a system flow of 10 gallons per minute, 600 gallons per hour with an injection rate of 1.0 gal/hour, to give a solution of 0.5 parts per million (ppm) of 12% chlorine.

There is a 0.5 horsepower pump pressurizing the system, keeping the water pressure at 40 psi to the 12 remaining houses. This system was put in place in 1992 as a result of a two issues: the previous treatment system using UV lights was deemed ineffective by the Capital Region District (CRD) water testers, who then recommended the chlorination system; and the support structure holding the old tank was unstable so was decided to replace the tank and treatment system.

BC Hydro continues to work with the Hilltop residents on domestic water usage**.**

Other Water Licenses on the Jordan River

No licensee, other than BC Hydro, withdraws water off the Jordan River. Western Forest Products has a log sort operation at the mouth of the river. There are water licensees on either side of the Jordan River however, this water is drawn from wells.

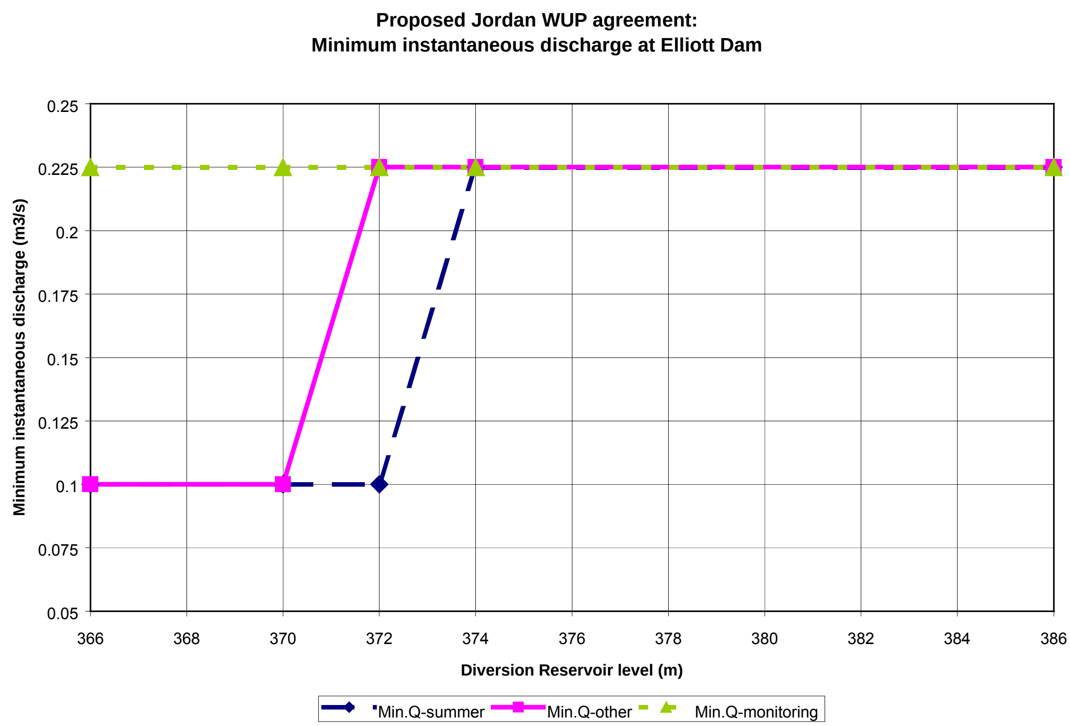
APPENDIX M: MATRIX OF OPERATING ALTERNATIVES

	Alternative	Turbine	Flows below Elliott	Elliott Headpond	HC valve	Diversion Reservoir	Bear Creek Reservoir
A	Close to current operations	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m October-June; 372 m July-September	not managed
B	Current operations + Bear Creek	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m October-June; 372 m July-September	min. 405 m - constantly drafting to 405
C	minimum flow 0.5 m^3/s or inflow	no constraints	0.5 m^3/s - and spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed
D	conservation flow 1.5 m^3/s (varies) or inflow	no constraints	conservation flows' varied 1.5 m^3/s or inflow - and spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed
E	Run of River	no turbine discharge	All flows (no turbine discharge)	not managed	not managed	not managed	not managed
F	minimum flow 0.25 m^3/s, diversion min. 375 m	no constraints	0.25 m^3/s all year - and spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed
G	Reservoir only. Minimum diversion reservoir 375 m	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed

	Alternative	Turbine	Flows below Elliott	Elliott Reservoir.	HC valve	Diversion Reservoir	Bear Creek Reservoir
H	Minimum flow 0.25 m^3/s from May-October, diversion min. 375 m all year	no constraints	0.25 m^3/s May - October - and spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed
I	Surfing	Shift generation above 50 m^3/s October to March from HLH to LLH	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	Alt. A: min. 375 m October-June; 372 m July-September	not managed
J	Surfing	Shift generation above 35 m^3/s October to March from HLH to LLH	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	Alt. A: min. 375 m October-June; 372 m July-September	not managed
K	Minimum flow 0.5 m^3/s from May-October, diversion min. 375 m	no constraints	0.5 m^3/s or inflow May - October - and spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed
L	Alternative G with maintenance drawdown in October	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	min. 375 m all year	not managed

	Alternative	Turbine	Flows below Elliott	Elliott Reservoir	HC valve	Diversion Reservoir	Bear Creek Reservoir
M	Reservoir only. More stable reservoir	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	Restrict reservoir between 376 m-380 m June to August, min. 375 m remainder of year (380 m is a soft constraint, when exceeded the reservoir will be pulled back to 380 m as soon as possible.)	not managed
N	Alternative M with maintenance drawdown in October	no constraints	No flows - other than spills	between 330 m-336, except September maintenance to 325 m	no constraints	Restrict reservoir between 376 m-380 m June to August, min. 375 m remainder of year (380 m is a soft constraint, when exceeded the reservoir will be pulled back to 380 m as soon as possible.)	not managed

APPENDIX N: PROPOSED DECISION RULE FOR DETERMINING FLOWS



The proposed decision rule will be used to determine an appropriate trade-off between reservoir elevations at Diversion Reservoir and the provision of flows below Elliott Dam during low water situations. It is expected this decision rule would not be put into use until all operational changes have been implemented and monitoring results reviewed (a minimum of 6 years post Water Use Plan approval).

APPENDIX O: JORDAN RIVER FISHERIES MONITORING PROPOSALS

Where operational changes are expected to change fisheries values, monitoring program recommendations must address both the direction of the change and the effect size. The necessity and cost of the associated monitoring program should be deliberated against:

The uncertainty associated with the performance measures used to address the impact hypotheses.

- The environmental implication(s) of making a wrong decision.
- The costs associated with the operational change(s).
- The costs associated with the monitoring program.
- The time required to collect the data in a fashion timely enough to be useful for the next WUP review.

A monitoring program may also be implemented to address data gaps that prevented the consideration of reasonable operating alternatives solely on the basis of critical uncertainties. Data collection to address critical uncertainties would then be available for assimilation by interested parities during the next WUP review. Four fisheries monitoring studies (Table O-1) were recommended by the Jordan River Water Use Plan Consultative Committee.

Table O-1 Recommended Monitoring Program for the Jordan River Water Use Plan

Program	Description	Uncertainty/ Data Gap	Environmental/ Operational Implications	Time (yr) Certainty Cost[1]
Lower Jordan River Discharge and Local Inflow Measurements	Install gauging stations below Sinn Fein Creek and below Elliott Dam. Establish stage discharge relations curves for each station. Monitoring local inflows and accurately estimate the impact of a 0.25 m^3/s base flow on summer and winter minimum flows.	Accuracy of local inflow data used to rationalise a 0.25 m^3/s base flow. Efficacy of a 0.25 m^3/s base flow release into a dry channel to increase downstream habitat.	Local inflows fail or exceed the needs to generate the habitat associated with a 0.25 m^3/s base flow. Revisit necessity of a base flow to generate expected habitat gains.	2 (4) High $30K
Fish Index: Lower Jordan River	Determine direction of rainbow trout standing stock dynamics (fish size and abundance) (±) following 'treatment' with a base flow release.	Relation of habitat increases to actual changes in rainbow trout condition and population.	The base flow release may need to be increased or the efficacy of any base flow not justified for limited or negligible ecological benefits.	2 (4) Baseline $120K
Qualitative Habitat Survey for Salmonids in the Lower Jordan River	Monitor for successful spawning and rearing of anadromous salmonids in the Lower Jordan River below the first passage barrier.	Metal toxicity and/or critical low flows impact success of incubation and rearing. Base flow may mitigate against any or none of these impacts.	Increased anadromous salmonid success associated with a base flow release will influence future water allocation decisions.	6 Baseline $40K
Fish Index: Diversion Reservoir	Gill netting and minnow trapping at end of each growth season to assess indicators of stress. Includes associated water chemistry (dissolved oxygen and temperature). Includes a planned drawdown to elicit response.	Response and level of stress in rainbow trout (if any) associated with drawdowns below 376 m on Diversion Reservoir.	Absence of measurable changes in fish condition would not justify the recommended decrease in reservoir flexibility.	(1) 5 Medium $50K

[1] Time as pre and (post) data collection. Certainty measures: (High) Monitoring study will definitely lead to fine, quantitative discrimination among all of the competing hypotheses including measure of effect size. (Medium) Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses and may quantify effect size. (Baseline) Likely to allow only qualitative comparisons among a few competing hypotheses with little or no sensitivity to effect size. Cost estimated cost for the entire program.

Lower Jordan River Fisheries Background

The Lower Jordan River is defined as the approximately 8 km section of the Jordan River between Elliott Dam and the junction of the Jordan River Powerhouse tailrace with the Jordan River (Figure O-1). Under present operating conditions, inflow to this section is limited to local tributary contributions. The largest inflow comes from Sinn Fein Creek, located approximately 6 km downstream Elliott Dam. No flows are released from Elliott Dam with the exception of short (< 1 day) intermittent spills ($\leq 2.yr^{-1}$). As such, flow connectivity in the upper reaches is highly dependent on local precipitation. The Jordan River had historically supported a variety of fish including rainbow trout, several anadromous salmonids (coho, chum, and pink) and steelhead. Due to a range of industrial activities in the watershed, species diversity and populations have declined to the point where only populations of rainbow trout represent sport fish in the Lower Jordan River.

Figure O-1 Lower Jordan River

River profile and approximate distances of significant reach breaks relative to the tailrace. Flow continuity stylised as line thickness.

The following objectives were defined by the Jordan River Fish Technical Committee (FTC) and adopted by the Consultative Committee (CC) to address fisheries interests in Lower Jordan River:

- Maximize resident fish populations in the Jordan River below Elliott Dam.

- Maximize anadromous fish populations in the Jordan River below Elliott Dam.

The Jordan River Consultative Committee recommended an operational change that was hypothesised to elicit significant measurable responses in the Lower Jordan River. Specifically, this operational change included establishing a base flow of 0.25 m^3/s from Elliott Dam to increase resident fish population, condition and increase overall ecosystem integrity by promoting primary and secondary production. This is expected to occur by increasing the wetted area downstream of Elliot Dam and by providing stable summer and winter flows for the entire length of the Lower Jordan River during low inflow periods where local inflow $\leq 0.25\ m^3/s$. To accommodate the qualitative assessment of the benefits associated with a base flow release, the Jordan River Consultative Committee recommended a pre and post implementation of 2 and 4 years, respectively. Delaying the base flow release for 2 years was mediated as a compromise between the Consultative Committee desire to immediately release the water and the Fish Technical Committee's recommendation to acquire baseline data for a meaningful comparison.

It was the FTC's opinion that the recommended flow release would increase resident fish (rainbow trout) populations and improve primary productivity. Hypothesized benefits to anadromous fish (improved rearing an/or spawning habitat), where ancillary and not directly used in the decision to release 0.25 m^3/s. If salmon were to re-populate the lower Jordan River in significant numbers, the amount and timing of the base flow release may need revisiting.

LOWER JORDAN RIVER DISCHARGE AND LOCAL INFLOW MEASUREMENTS

Background

The Jordan River CC's recommendation to release a base flow was based, in part, on estimates of weighted usable rearing area (WURA). For a given section of the river (x), WURA was based both on assumed local inflow, $Q_{Local(x)}$, and the base flow release ($Q_{BaseFlow}$):

$$WURA_{(x)} = f(Q_{Local(x)} + Q_{BaseFlow})$$

The combination of local inflow and the base flow selected by the CC was determined to yield approximately 3 km of additional wetted habitat in the upper reaches and provide a constant flow $\geq 0.25\ m^3/s$ through all reaches in the Lower Jordan River.

The Jordan River CC has recommended that more accurate river discharge and local inflow contributions be assessed. This information is required to confirm resident fish habitat benefits in the Lower Jordan River that were calculated using an assumed local inflow and with the addition of a 0.25 m^3/s base flow release. The information will also be used, once a base flow release is implemented, to estimate the efficacy of the base flow release to actually increase downstream flows in the channel.

Uncertainties and Data Gaps

(a) Description of Uncertainties

No real time series data for local inflow below Elliott Dam was available for purposes of calculating the WURA during the Jordan River WUP. Total local inflow for the river below Elliott Dam was calculated based on the proportional contribution of daily surface and tributary inflows for the next upstream catchment area, the drainage area for Elliott Headpond. Similarly, contribution of flow along the linear length of the river below Elliott Dam was determined as a proportion of discrete drainage area to total drainage area. It should also be noted that the daily inflow to the Elliott Dam catchment, the reference watershed, was also not directly measured. Daily inflow to the Elliott Dam catchment was back calculated from changes in reservoir levels, spill, and turbine discharge for the entire system. The culmination of these factors, required the FTC to acknowledge the high degree of uncertainty associated with the local inflow data set.

Secondly, base flow releases were modelled in the WURA estimate assuming all base flow contributes to the downstream water course. It is possible, however, that subsurface conveyance losses in the dry section of the channel immediately below Elliott Dam may negate any benefits associated with the base flow release from Elliott Dam in providing additional wetted habitat. Following the collection of these data, if estimates of local inflow contribution are not underestimated and a base flow release is implemented, the stations will subsequently monitor the efficacy of the base flow release at both downstream sites.

(b) Summary of Competing Hypotheses

(i) Local discharge into the Lower Jordan River:

- Ho: Estimated inflow is representative of actual inflow.
- H1: Estimated inflow underestimates actual inflow.
- H2: Estimated inflow overestimates actual inflow.

(ii) Efficacy of a base flow release to increase downstream flows:

- Ho: Subsurface losses in the channel exceed the capability of a base flow to increase WURA.
- H1: Base flow is effective increasing WURA.

(c) Operational/Environmental Implications

The decision to release 0.25 m^3/s from Elliott Dam was predicated on the contribution of local inflow and an effective base flow release to provide an additional 3 km of habitat immediately downstream of Elliott Dam and to preserve flows ≥ 0.25 m^3/s for the length the Lower Jordan River. If, however, the assumption of local inflow based on drainage area calculations were underestimated, the necessity to provide a 0.25 m^3/s base flow may be reduced or made redundant as flows may already exceed the recommended levels by the Jordan River CC for maintaining flow continuity and the recommended WURA habitat target (Figure O-2).

If validation of the local inflow contribution supports the release of a base flow, the efficacy of the release will be subsequently monitored. These data will ensure that the water released into the dry upstream channel immediately below Elliott Dam significantly contributes to improving wetted habitat in the upper 3 km of the channel and in maintaining base flows ≥ 0.25 m^3/s for the remaining length of the river. If subsurface conveyance losses are significant and the base flow neither contributes to the predicted gains in continuous wetted habitat in the upper reaches nor improves WURA based on modelling results, the amount or necessity for continued base flow releases should be revisited.

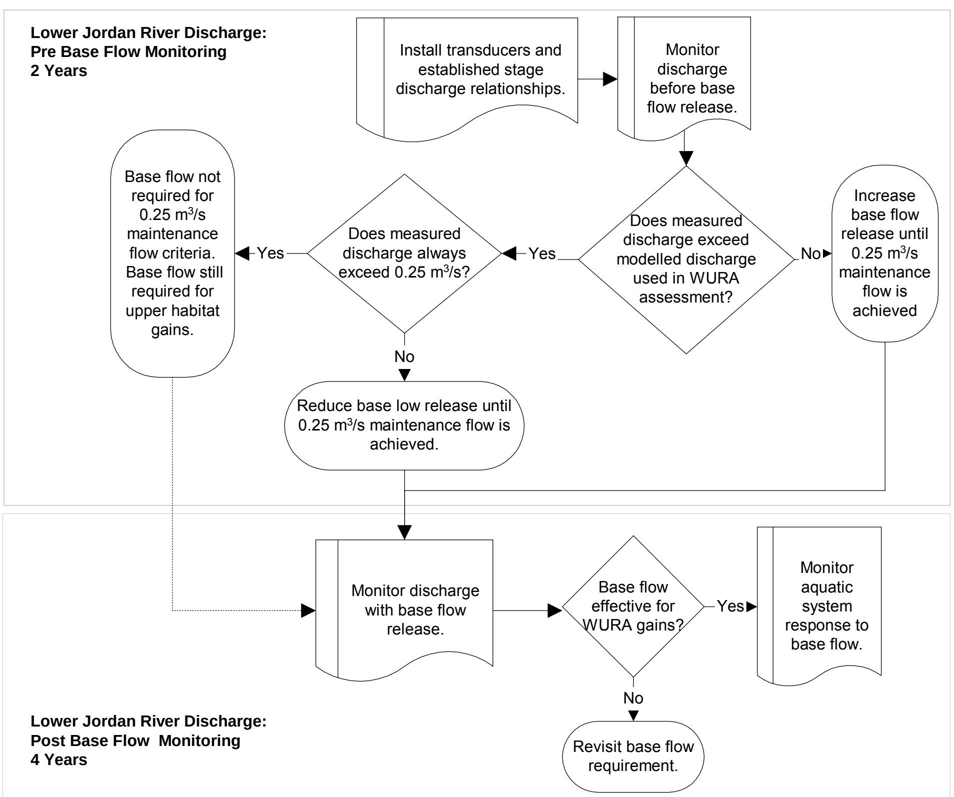


Figure O-2 Operational and Environmental Implications of Accurate Local Inflow Data

Monitoring Program Proposal

(a) Methods

The monitoring program has two components:

- Installation of water level transducers and stage discharge calibration.
- Collection and analysis of real time discharge data for comparison with data generated from drainage area estimates and calculated inflow into the Elliott catchment. This will be conducted both pre and post base flow release.

Local discharge into the Lower Jordan River will be collected initially for 2 years prior to implementation of a base flow release. If local inflow estimates were not grossly underestimated, discharge data will continue to be collected during the period following the base flow release for 4 years. Post base flow release discharge data will provide information on both the efficacy to augment downstream flows and as real time measure of flow to assist in validating the linkages between habitat and fish population and condition in the other proposed monitoring programs. Total possible length of the monitoring program is 6 years, however, following the installation and calibration of stage discharge relationships actual time required to retrieve and analyse the real-time flow data is minimal.

Two sites suitable for estimating the relation between stage and instream discharge and for installation of remote stage logging equipment will be selected. These will be located within physical limitations below Sinn Fein Creek and approximately 1.5 km below Elliott. Stage data can be immediately collected (hourly resolution) upon installation and interpreted later once the stage discharge relationships have been established.

The relationship between stage and discharge relations requires a series of instream flow measures at each transducer transect for the range of seasonal flows. Limited access to the confined channel in the Lower Jordan River may prohibit discharge measurement at higher flows. However, since the CC recommendation for a base flow is designed to augment low flows, the necessity to established the stage discharge relationship at higher flows ($> 5\ m^3/s$) is not crucial.

(b) Monitoring Certainty

Collection of real-time discharge data over the duration of the monitoring program will provide a high level certainty for comparing the local inflow to the Lower Jordan River. Statistical power for comparison can be further increased by comparing the modelled discharge data set and the actual measured data with stream gauges on adjacent systems.

(c) Schedule

Stage gauges will be installed immediately following approval of the Water Use Plan. The program will be conducted over 6 years: 2 years of pre base flow release local discharge data and 4 years of post base flow release data.

(c) Reporting

A detailed technical report will be prepared prior to the review of the base flow implementation that validates the local inflow assumptions used for the Jordan River WUP CC decision making process. If the base flow is subsequently implemented, a second report demonstrating the efficacy of the base flow release to augment downstream flows and increase WURA will be prepared prior to the review of the Water Use Plan.

(d) Estimated Budget

Installation and equipment purchase for the stage gauges are estimated to cost \$15K. Data acquisition and analysis are not expected to exceed \$2K.yr^{-1} for the 6 year period. Total program cost is budgeted at \$30K.

FISH INDEX: LOWER JORDAN RIVER

Background

The Jordan River WUP CC recommendation to release a base flow was based, in part, on estimates of increasing weighted usable rearing area (WURA) for rainbow trout. The combination of local inflow and the base flow selected by the CC (0.25 m^3/s) was determined to yield approximately 3 km of additional wetted habitat in the upper reaches and provide a constant flow $\geq$ 0.25 m^3/s through all reaches in the Lower Jordan River. This decision was predicated on the assumption that increases in rearing area for rainbow trout would translate into improving both fish condition factors and increase standing stock. To address this decision, the Jordan River CC recommended a monitoring program to detect an increase in the standing stock of rainbow trout. A secondary measure of condition factor was also proposed.

Uncertainties and Data Gaps

(a) Description of Uncertainties

Habitat measures (i.e. WURA) for the instream flow assessment in the Lower Jordan River were based on a function of flow and empirical relations that define habitat preferences for velocity, depth, and substrate for rainbow trout. The FTC placed sufficient confidence both in the flow relationships collected during the Jordan River WUP and the habitat preferences to interpret the WURA results for decision making. Excluding the local inflow data set, the FTC subsequently identified the relation between increased habitat and actual population effects as the next largest area of uncertainty. While it was assumed that any increase in WURA habitat would benefit the resident populations of rainbow trout in the Lower Jordan River, the amount of increase (e.g. the effect size) remains unknown. Subsequently, the Jordan River CC recommended that the success associated with a base flow release be measured. The primary metric proposed was rainbow trout standing stock. A secondary metric of rainbow trout size characteristics (length, weight, and coefficient of condition) was also proposed.

(b) Summary of Competing Hypotheses

Relationship between habitat (WURA) and rainbow trout condition and population response:

- Ho: Base flow does not provide any significant (≥ 100%) increase in standing stock.
- H_1: Base flow significantly increases fish standing stock.
- H_2: Base flow decreases fish standing stock (Unlikely).
- Ho: Base flow does not provide any significant (≥ 100%) increase in coefficient of condition.
- H_1: Base flow significantly increases fish standing stock in coefficient of condition.
- H_2: Base flow decreases fish standing stock (Unlikely) in coefficient of condition.

Operational/Environmental Implications

If a significant measurable ecological response does not occur over the monitoring period, relationship between habitat and population responses may need to be revisited. This has two potential operational/environmental implications. The minimum base flow release may need to be increased or the efficacy of any base flow within the operating constraints of the plant may not be justified for limited or negligible ecological benefits for resident fish in the 8 km section of the Lower Jordan River (Figure O-3).

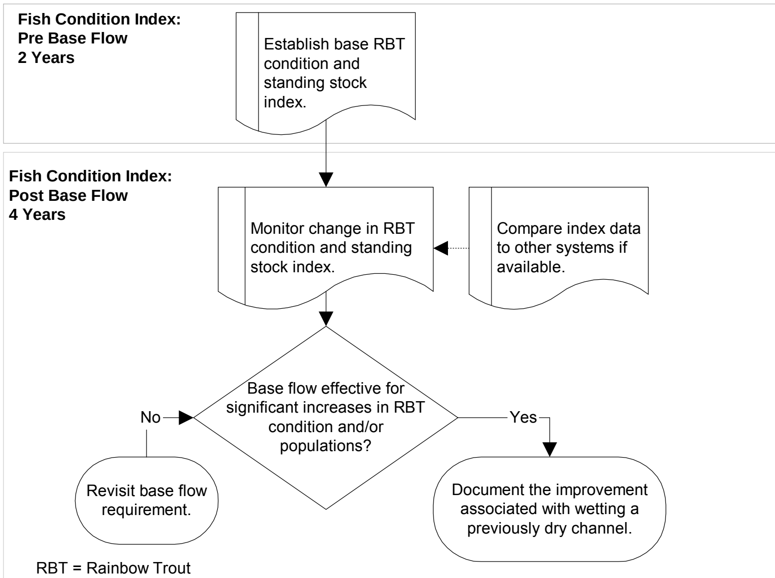


Figure O-3 Operational and Environmental Implications of Rainbow Trout Condition and Population Index

Monitoring Program Proposal

(a) Methods

The monitoring program has three components:

- Establish sampling protocol expected to provide sufficient power (ß=0.50) to detect changes in standing stock ($\Delta \geq 100\%$). Size and condition factor can be calculated as an ancillary measure.
- Collect initial estimates of standing stock and fish size and condition for rainbow trout. Collect time series of standing stock and rainbow trout condition during pre (2 years) and post (4 years) base flow release conditions.
- Analyse data to compare changes (±) in size and condition and standing stock between pre and post base flow release.

Fish sampling techniques employed for the Lower Jordan River will employ a combination of electrofishing and seine netting to provide catch per unit effort estimates. Given the limited size of the system and existing rainbow trout populations, site specific mark recapture estimates are likely to require ≥ 2 pass capture removal method (Griffith, 1996). Ancillary measures of length, weight, and age class will be taken to assist in estimating trends in fish condition along with representative measures of hydraulic suitability assessed at the time of sampling. Preliminary estimates of experimental power assume effect size changes ≥ 100 based on a coefficient of variance for abundance of 150%.

Sites (> 10) selected for indexing should reflect a representative range of different habitat types and should, if possible, overlap with sites used in the Griffith biophysical (1996). Sampling intensity and frequency will account for potential impacts on the total population, itself, given the suspected low densities of existing standing stock.

(b) Monitoring Certainty

The application of the monitoring data to estimate significant changes in condition and/or population for a predetermined effect size (i.e. ≥ 100% change relative to baseline) will likely have moderate certainty. As the system has presently been in an 'equilibrium' flow regime for the last 31 years, the FTC surmised that 2-year baseline data should provide a fairly representative estimate of existing standing stock. Moreover, the flow regime during the post base flow release environment will also be relatively 'static' as the majority of extreme low flows will be superimposed by a constant base flow. Uncontrollable environmental confounding factors will be limited to temperature and the temporal ability of the existing standing stock to exploit the novel habitat under the base flow. A formal power analysis to optimise sampling intensity and frequency will be conducted prior to implementation.

(c) Schedule

Pre base flow release data will be collected in the first two field seasons following the approval of the Water Use Plan. 4 years of post base flow release data will be subsequently collected pending engineering completion of the release mechanism and establishing a stable operating regime. The FTC acknowledged that the first year following the implementation of a release mechanism would likely represent a learning period before a stable operating regime could be implemented.

(d) Reporting

A technical report will be prepared prior to the review of the base flow implementation that details the existing fish condition and standing stock estimates for the Lower Jordan River rainbow trout. A similar report will be prepared following the collection of the post base flow release data, however, the focus of the second report will be to document the success and/or failure of the base flow to improve fish condition and/or standing stock size for rainbow trout. This information may be used to the revisit the existing Water Use Plan recommendation to release water from Elliott Dam.

(e) Estimated Budget

Formal terms of reference and initial study scoping are not expected to exceed $10K. Actual monitoring and contingent data analysis are assessed at approximately $20K.yr^{-1} for 6 years based on estimates from similar work down on the Jordan system previously. Interim reports and final data analysis has been budgeted at an additional $10K. Total monitoring cost is $140K.

QUALITATIVE HABITAT SURVEY FOR SALMONIDS IN THE LOWER JORDAN RIVER

Background

The portion of the Lower Jordan River upstream of the tailrace and below the first significant passage barrier (approximately 490 total length) was observed to have suitable physical spawning and rearing habitat for coho, chum, pink, and steelhead. This area of the river, however, is adjacent to historical copper mining operations and a significant section is immediately impacted from a slough in the bank associated with high levels of metals. Only 100 m of the river remains upstream of the impacted area. Given the cumulative impacts of flow reductions, mine operations, and log sort operations in the Lower Jordan River, the Jordan River WUP CC recognised both the limited opportunity to improve habitat conditions for anadromous salmonids with a base flow release and the fact that the habitat, even if improved, would only affect approximately 490 m of the 8 km river length below Elliott Dam.

Fisheries and Ocean Canada (DFO) and some members of the CC, however, hypothesised that improvements to the base flow in the lower reaches may be adequate to A) improve effective incubation habitat and B) dilute dissolved metal levels (Cu) sufficiently to reduce chronic toxicity. As the likelihood of this scenario was assumed to be minimal, these hypotheses were not actively used in the decision that recommended the base flow release. Nevertheless, to address this hypothesis the Jordan River CC recommended a program to monitor for successful signs of spawning and rearing in the Lower Jordan River following the base flow release. It was agreed to by the FTC that signs of improving habitat conditions for anadromous salmonids would subsequently weigh importantly in future water allocation decisions.

Uncertainties and Data Gaps

(a) Description of Uncertainties

Recent data enumerating returning spawners and rearing anadromous salmonids remains limited to that collected under the Jordan River WUP. These data support the current hypothesis that no self sustaining populations of salmon currently use the bottom 490 m of the Lower Jordan River. While some spawners (< 8 coho) were observed to return to the system, these were suspected to be strays from other systems because a high percentage of these were marked (Benvar, 2001). The fact that strays may enter the system support the notion that salmon could take advantage of suitable habitat and re-establish given the opportunity. What remains uncertain is why no self sustaining populations are currently observed. The leading hypotheses for these questions include 1) metal toxicity preventing successful rearing and/or 2) smoltification and the lack of base flows to maintain critical water levels in the summer and perhaps during the winter.

(b) Summary of Competing Hypotheses

Changes to anadromous salmonid population success in the Lower Jordan River:

- Ho: Base flow does not affect anadromous salmonid spawning/rearing success.
- *H_1: Metal toxicity prevents effective incubation or rearing and is mitigated by a base flow increase.*
- *H_2: Critical summer and/or winter minimum flows prevent effective incubation or rearing and is mitigated by a base flow increase.*
- *H_3: Both metal toxicity and critical summer and/or winter minimum flows prevent effective incubation or rearing and is mitigated by a base flow increase*

* Alternate hypotheses to be investigated in future water allocation decisions.

Operational/Environmental Implications

The decision to release 0.25 m^3/s from Elliott Dam was predicated on the assumption that increases in modelled habitat (WURA) would effectively increase both condition and/or standing stock for resident fish. It was not made on its highly uncertain and assumed limited improvement for anadromous salmonids. If a significant measurable ecological response occurs following a base flow release, this information will become an important new decision making factor in future water allocation plans. If no change is observed, the perceived benefits for anadromous salmonids from a base flow will be demonstrated as unfounded.

Monitoring Program Proposal

(a) Methods

The monitoring program has two components:

- Instream spawner enumeration during periods when coho, chum, pink and/or steelhead are expected to return.
- Presence or absence of rearing anadromous salmonids (steelhead and coho).

Spawner surveys will be conducted during the expected life history timing according the protocol used during a similar survey used previously for the Jordan River WUP (Benvar, 2000). This program conducted snorkel surveys of the river below the first passage barrier once every 2 weeks during the months when spawners were expected to return. *In situ* assessment of rearing success will be contingent on observing significant spawning success and effective incubation. The study will be restricted to the Lower Jordan River from the tailrace to approximately 490 upstream at the first significant passage barrier.

(b) Monitoring Certainty

It is not the intent of this program to accurately estimate response changes in anadromous salmonid condition and/or populations. Rather, the monitoring should address the general data gap of what species (if any) currently use the system and at what life stage recruitment fails. The program may also demonstrate the positive response for anadromous salmonids given an increase in a base flow release. This observation will have limited statistical power, however, it would flag the necessity for a more detailed study under the Water Use Plan review.

(c) Schedule

Pre and post base flow release data will be collected during the first 2 and 4 years respectively, pending the approval of the of the Water Use Plan. This study has less priority with respect to the other river monitoring plans and failure to capture to an initial year of pre base flow release data because of implementation timing and life history constraints should not delay the schedule for the other 2/4 year monitoring program itinerary.

(d) Reporting

A detailed technical report will be prepared prior to the review of the Water Use Plan. The intent of this information is to improve the general uncertainty surrounding anadromous salmonid issues.

(e) Estimated Budget

Formal terms of reference and instream surveys are not expected exceed \$6K.yr^{-1}. An additional \$14K is reserved for contingent studies depending on spawning success.

Diversion Reservoir Background

The Diversion Reservoir has a surface area of 1.8 km^2 at full pool and a maximum depth of 40 m. Controlled by a free crest weir spillway and Howell Bunger Valve (hollow cone valve), the normal operating range for Diversion Reservoir is between 386.18 m and 367.89 m. The maximum active storage is 20.5 x 10^6 m^3 (BC Hydro, 1997). The Diversion Reservoir is the main storage and operating reservoir in the Jordan River system and releases from the hollow cone valve are used to maintain elevation in the Elliott Headpond during power generation. Consequently, storage fluctuations are dependent on operational demands balanced against seasonal inflows. Mean reservoir levels are typically drawn down approximately 5 m between higher inflow winter months (approximately 380 m) and the low flows between July and September (approximately 375 m). The littoral zone in Diversion Reservoir is also subject to more frequent and deeper drawdown than Elliott Headpond. While Elliott is generally maintained at approximately 333 m, Diversion may fluctuate on a daily basis to provide water for daily and weekly operational demands. The added littoral instability and drawdowns that significantly reduce reservoir volume were suspected to play a role in the decreased vitality of fish populations in Diversion Reservoir and contribute directly to the poorer water quality suggested during a single sampling period by Griffith (1996).

Rainbow trout and, to a lesser extent, cutthroat trout are present in the reservoirs and the headpond. An intermittent stocking program, co-ordinated by the Ministry of Environment, Lands and Parks, has been in place since 1985 for both rainbow and cutthroat trout. Rainbow trout, however, were considered common to Bear Creek and the Jordan River system prior to 1985. In general, the numbers of fish observed in Bear Creek and Diversion reservoirs were high and typified a productive interior B.C. lake. High fish densities are likely a function of overstocking and natural recruitment rather than a measure of true carrying capacity (Griffith, 1996).

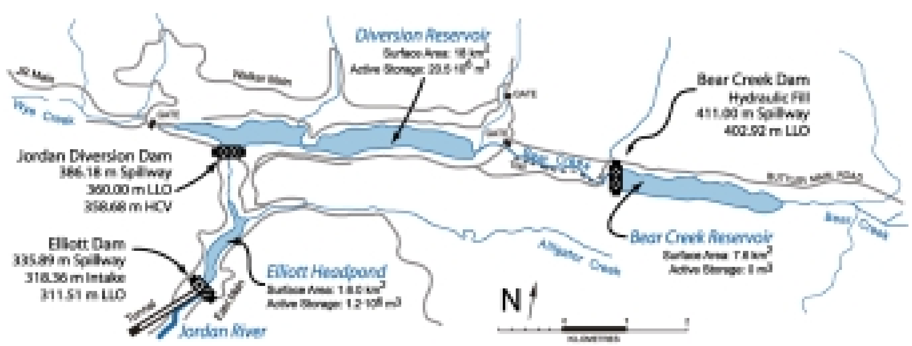


Figure O-4 Diversion Reservoir Detail

Maximum and minimum sill levels under current operating conditions. Approximate surface area at full pool. Bear Creek Reservoir is not currently (free spill system).

The following objective was defined by the Jordan River WUP CC to address fisheries interests in Diversion Reservoir:

Maximise habitat conditions in the reservoirs to maximise resident fish populations, invertebrates and aquatic life.

FISH INDEX: DIVERSION RESERVOIR

Background

The Jordan River WUP CC recommended an operational change that was hypothesised to elicit significant measurable responses in the resident fish populations in Diversion Reservoir. Specifically, this operational change included limiting reservoir drawdown flexibility (and ultimately net storage) by imposing the following operational constraints:

- Minimum normal elevation of 376 m: 1 July - 30 September.
- Minimum normal elevation of 372 m: 1 October - 30 June.

It was hypothesised that the decrease in seasonal and daily reservoir fluctuation and bulk decrease in pelagic volume would increase both the establishment of an effective littoral zone and mitigate against increasing stress in rainbow trout. Stress in rainbow trout was assumed to be coincidental with drawing down the reservoir and associated exposure to high temperatures and low oxygen levels during summer months.

Uncertainties and Data Gaps

(a) Description of Uncertainties

The FTC recognised that 'stress' in reservoir rainbow trout associated with elevations below 376 m was based on a single biophysical conducted by Griffith (1996). As reduced flexibility seemed to have only a minor impact on BC Hydro operations, the CC recommended a risk adverse scenario by introducing the aforementioned reservoir level constraints. Both BC Hydro and the CC, however, wanted to address the level of uncertainty associated both with the existing population size of rainbow trout in Diversion Reservoir and the impact of reservoir drawdowns below 376 on fish condition during the summer months.

(b) Summary of Competing Hypotheses

Diversion Reservoir level constraints:

- Ho: Reservoir constraints do not change rainbow trout condition.
- H_1: Reservoir constraints increase rainbow trout condition.
- H_3: Reservoir constraints decrease rainbow trout condition (unlikely).

(c) Operational/Environmental Implications

It was assumed that drawdowns below 376 m during summer months would negatively impact fish condition. Should the monitoring program suggest that no increased benefits to fish were observed by introduction of reservoir constraints, the recommendations could be revisited for more flexible operating options.

Monitoring Program Proposal

(a) Methods

The monitoring program has three components:

- Mark recapture program to assess fish populations during the first season.
- Catch per unit effort estimates and condition factor at the end of each growth season for subsequent years.
- Measures of condition factor and, perhaps, biochemical measures of fish stress pre and post a drawdown that significantly violates the 376 m constraint (i.e. ≤ 370) over the summer months.

Mark recapture programs for population indexing is recommended to be a combination of mulitple-census (Schumacher-Eshmeyer) and bi-census (Chapman) for the first year. Level of effort required for this exercise will be dependent on recapture rate for the reservoir. For subsequent years, monitoring will be restricted to sufficient random sampling to quantify fish condition factor at the end of the growth season (September) for a 6-year period.

One of these years must include an extended event (> 2 weeks) during the summer months where reservoir levels are drawn down below 372 m. If, by the 6th year of the program, operational events have precluded such an event, the CC recommended affecting a planned drawdown to collect the data if the opportunity arises for BC Hydro. If such an opportunity does not arise, it was agreed that it would be BC Hydro's initiative to collect such data in the future when an event arises if the value of increased flexibility is still a management goal. Exact measures of fish 'condition' (length/weight ratios, gut contents, biochemical markers…etc.) will be determined prior to the program implementation. To avoid confounding population influences, WLAP agreed not to stock the system during the implementation of the monitoring program.

(b) Monitoring Certainty

The FTC suggested that this program would likely provide a medium level of certainty for further decision making. Significant uncontrollable environmental confounding factors include annual inflow timing and seasonal temperature variation. However, by inducing a significant environmental change (i.e. a planned drawdown) effects, if any, should be realised and measurable. A formal power analysis to optimise sampling intensity and frequency will be conducted prior to implementation.

(c) Schedule

Data will be collected over a 6-year period, pending the approval of the of the Water Use Plan. One of these years should opportunistically provide a drawdown that significantly violates the 376 m constraint during summer months. If such an opportunity does not present itself during the monitoring, BC Hydro would complete the study when convenient at a later date.

(d) Reporting

A detailed technical report will be prepared prior to the review of the Water Use Plan. The intent of this information is to improve the general uncertainty surrounding reservoir issues.

(e) Estimated Budget

Formal terms of reference and actual surveys are not expected exceed $\$10K.yr^{-1}$. Total monitoring cost is expected to be less than $60K.