Consultative Committee Report

September 2005

Prepared on behalf of:

The Consultative Committee for the Duncan Dam Water Use Plan

Duncan Dam Water Use Plan

A Project of BC Hydro

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This report was prepared on behalf of the Duncan Dam 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 Duncan Dam Water Use Plan that will be submitted to the Comptroller of Water Rights for review under the *Water Act*.

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

Stephan O'Shea, a Consultative Committee member and resident of the Duncan River watershed, presented the following illustration by his wife to the Duncan Dam Water Use Plan Consultative Committee

EXECUTIVE SUMMARY

Introduction

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 multi-stakeholder consultative process.

This report summarizes the consultative process and records the areas of agreement and disagreement arrived at by the Duncan Dam Water Use Plan Consultative Committee. It is the basis for the Duncan Dam Draft Water Use Plan. Both the Duncan Dam Consultative Committee Report and the Draft Water Use Plan will be submitted to the Comptroller of Water Rights.

Duncan Dam Project

The Duncan Dam Project is located within the Regional District of Central Kootenay, and lies within the Duncan River drainage basin that covers 2400 km^2. The Duncan Dam is located immediately upstream of the confluence of the Duncan and Lardeau rivers, approximately 11 km upstream of Kootenay Lake and 42 km north of the Village of Kaslo. The Duncan Reservoir, impounded by the dam, is 45 km long when the reservoir is at full pool. Besides providing storage for downstream hydroelectric generation and flood control, the reservoir also provides for fish flow regulation for the Duncan River between the dam and the mouth of the river at Kootenay Lake. There are no power generation facilities at the dam.

Consultative Committee

The Duncan Dam Water Use Plan Consultative Committee members included BC Hydro, provincial and federal government agencies, municipal government, industry, First Nations, and local stakeholders. The Committee held a total of eight meetings and was supported by numerous technical subcommittee meetings.

The Consultative Committee initially was comprised of 15 members. Over the course of the Duncan Dam water use planning process, some members opted to change their status to observer status or others were reassigned other duties. Those who moved to observer status were comfortable that other Committee members represented their interests. There were 12 Committee members who actively completed the water use planning process.

The Duncan Dam Water Use Plan consultative committee process was initiated in August 2001 and completed in April 2004. The consultative process followed the steps outlined in the 1998 provincial government's *Water Use Plan Guidelines*.

An information session and a public open house were held in September 2001 in Meadow Creek. Site visits to the Duncan Dam facility were held in October 2002 and May 2003. A second public information session was held in October 2003 in Meadow Creek to provide an update to area residents on the Duncan Dam water use planning process.

Structured Decision-Making Process

The Consultative Committee explored issues and interests affected by operation of BC Hydro's Duncan Dam facility and agreed to the following fundamental objectives for the Duncan Dam Water Use Plan:

- *Cultural Resources*
  Protect cultural sites and resources from erosion in the Duncan Reservoir.

  Protect cultural sites and resources from exploitation in the Duncan Reservoir.

  Provide opportunities for archaeological investigation in the Duncan Reservoir.

  Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.

  Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River.

- *Fish*
  Maximize fish abundance and diversity.

- *Flood Management (and Erosion Protection)*
  Minimize the flood damage to people and property on the lower Duncan River.

- *Power Generation*
  Minimize economic impacts to both the Kootenay River and the Columbia River generation system.

- *Quality of Life – Mosquitoes*
  Maximize the quality of life for residents in the Duncan Dam area.

- *Recreation*
  Maximize the quantity and quality of the recreational experience.

- *Wildlife*
  Maximize the quality and quantity of available habitat area for wildlife.

The Consultative Committee developed performance measures for the seven water use planning objectives listed above. Where possible, performance measures were modelled quantitatively. In other cases, they were described qualitatively. The Committee then developed operating alternatives to address the various objectives. The output of the modelling process provided the Committee with a description of the consequences for each alternative based on the performance measures.

Recommendations

At the final Consultative Committee meeting held in April 2004, the Committee reached a conditional consensus on a recommended alternative, physical works in lieu of operational changes, a monitoring program and a review period for the Duncan Dam Water Use Plan. The recommendations were subject to the BC Hydro project team confirming the performance measure results[1] and conditions specified by the Ktunaxa–Kinbasket Tribal Council, Columbia Power Corporation, and Columbia Basin Trust Committee members.

Subsequent to the final Consultative Committee meeting, on 19 May 2004, the Regional District of Central Kootenay Committee member withdrew his support for the Duncan Dam Water Use Plan. Also, on 9 November 2004, the Columbia Power Corporation forwarded a letter to BC Hydro stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, Columbia Power Corporation, on behalf of the Columbia Power Corporation/Columbia Basin Trust ventures, can now accept the preferred Alternative S (73). Refer to Appendix I: Correspondence from Columbia Power Corporation. The BC Hydro project team estimated the performance measures for a new operating Alternative S (73) developed during the final Consultative Committee meeting. Subsequent to this meeting, the BC Hydro project team modelled the recommended alternative and calculated the performance measures. Upon review of the calculated performance measures, Committee members confirmed the same level of support for the recommended alternative as expressed during the final meeting.

Operating Conditions

Table 1 summarizes the recommended operating conditions for the Duncan Dam facility.

[1] The Consultative Committee agreed that if the calculated performance measures under Alternative S (73) were within the uncertainty (MSIC) of the estimated performance measure values, their support for this alternative would remain.

Table 1: Recommended Operating Conditions for the Duncan Dam Facility

System Component	Condition	Purpose
Duncan Reservoir	Reach full pool (576.4 m and 576.7 m) between 1 and 10 August	
	After full pool is reached or after 10 August, decrease reservoir elevation to 575.5 m and maintain within 0.3 m of this level until 5 September[1]	
Duncan Dam Discharge	3 m^3/s minimum year-round	
	283 m^3/s normal maximum year-round	
Lower Duncan River	Minimum target as measured at the Water Survey of Canada gauge: 08NH118, below the Duncan and Lardeau rivers confluence: • 73 m^3/s flow year round[2]	
	Maximum target as measured at the Water Survey of Canada gauge 08NH118, below the Duncan and Lardeau rivers confluence: • 250 m^3/s from 1 August to 24 September • 190 m^3/s from 25 to 27 September • 130 m^3/s from 27 to 30 September • 73 m^3/s flow from 1 to 21 October • 110 m^3/s from 22 October to 21 December • 250 m^3/s from 22 December to 9 April (300 m^3/s, alternate to better meet the Columbia River Treaty Flood Control Rule Curve maximums)[3] • 120 m^3/s from 10 April to 15 May • 400 m^3/s 16 May to 31 July	

Note: From 1 to 21 October, the maximum and minimum target flow in the lower Duncan River are identical at 73 m^3/s.

1 The Duncan Reservoir elevations shall not take priority over maintaining target minimum flows in the lower Duncan River.

2 It is possible that, in some years, this desired minimum flow target in the lower Duncan River cannot be maintained during the March to May period due to inadequate Duncan Reservoir storage on 1 March. While BC Hydro will make best efforts to secure a flood control variance from the U.S. Army Corps of Engineers in order to provide adequate storage on 1 March, the success of these efforts cannot be guaranteed. If a variance were not granted, a lower minimum flow may be implemented. BC Hydro will consult with federal and provincial fisheries agencies and First Nations and seek direction from the Comptroller of Water Rights.

3 In the event that this maximum flow target would not allow BC Hydro to meet the maximum reservoir levels specified by the Columbia River Treaty Flood Control Operating Plan, BC Hydro would request a variance from the U.S. Army Corps of Engineers. If a variance were not granted, this maximum flow limit would increase to 300 m^3/s. BC Hydro will consult with federal and provincial fisheries agencies and First Nations and seek direction from the Comptroller of Water Rights.

Expected Consequences

Table 2 summarizes the expected consequences of the recommended Alternative S (73) for the Duncan Dam facility.

Table 2: Expected Consequences of the Recommended Alternative S (73) – Downstream Fish and Cottonwood Compared to Alternative A – Current Operations

Water Use Interest	Consequences	
Cultural Resources	+	Increase in knowledge and understanding of the characteristics of the cultural sites, and provide opportunities to protect cultural sites and resources and for archaeological investigation through the provision of a monitoring study and erosion protection physical works in the Duncan Reservoir.
Downstream Impacts	o	Maintain nutrient retention in Kootenay Lake with implementation of physical works.
Erosion Protection in Lower Duncan River	+	Improved protection of Argenta Slough and wetlands with implementation of physical works.
Financial Revenue	–	Decrease in the annual average revenue of approximately $1.7 million per year.
Fish in Duncan Reservoir	o	No change.
Fish in Lower Duncan River	+	Increase in overall aquatic productivity with implementation of the Adaptive Stranding/Ramping Protocol, the Flood Control Rule Curve Risk Protocol, and physical works, and a more natural-like hydrograph.
Flood Management	+	Decrease in frequency and duration of local flooding events in lower Duncan River from 1 to 31 August with implementation of target flows.
Quality of Life – Mosquitoes	+	Decrease in the number of events which lead to mosquito breeding opportunities (greater than 350 m^3/s) from 1 to 31 August with implementation of target flows.
Recreation	+	Increase in number of weighted user days the reservoir is at preferred elevations with implementation of a reservoir elevation target and physical works.
	+	Increase in opportunities for water-based recreationalists to access the reservoir on the eastern shore with implementation of reservoir elevation targets.
Wildlife in Duncan Reservoir	–	Decrease in riparian productivity with implementation of reservoir elevation targets due to loss of sedge/grass meadow area.
Wildlife in Lower Duncan River	+	Improved recruitment of cottonwood in the lower Duncan River, which increases the overall riparian productivity in the area with implementation of target flows.

Recommendations developed at the final Consultative Committee meeting in April 2004 were based on estimated costs of:

Power Generation	$2,600,000 per year
Physical Works	$367,600 annualized (not including sidechannel exclusion fencing)
Monitoring	$559,400 per year for 10 years

Subsequent to the final Consultative Committee meeting in April 2004, the BC Hydro project team modelled the recommended alternative and calculated the performance measures. Although some of the performance measure values varied from those used by the Committee at the final, they confirmed their level of support for the recommended alternative. Final modelling of the recommended operating alternative resulted in power generation costs of approximately $1.7 million. The non-operational physical works annualized costs were estimated at $381,100 with the sidechannel exclusion fencing.

Other Water Use Plan Recommendations

The Consultative Committee recommended a number of items that are directly linked to Duncan Dam facility operations and/or decisions considered by the Committee as follows:

- The Adaptive Stranding/Ramping Protocol – The Protocol was initially proposed under a negotiated settlement between BC Hydro and Fisheries and Oceans Canada over a fish stranding incident that occurred in the lower Duncan River in 2001. The agreement (referred to as the *Alternative Measures Agreement*) commits BC Hydro to a number of mitigative measures some of which were linked to the Duncan Dam Water Use Plan.[1] The Protocol is intended to minimize the negative residual impacts of fish stranding in the lower Duncan River caused by planned flow changes from the Duncan Dam.

- Flood Control Rule Curve Risk Protocol – Develop a Risk Protocol in the event the Columbia River Treaty Flood Rule Curve had to be strictly adhered to and BC Hydro was unable to secure a variance from the U.S. Army Corps of Engineers.

- Funding Cultural Resource Monitoring Studies – Government ministries and BC Hydro consider funding these initiatives prior to implementation of the Duncan Dam Water Use Plan. Further, the government ministries and BC Hydro should work with the Ktunaxa–Kinbasket Tribal Council on this issue. Any funds that BC Hydro

[1] Refer to the monitoring program and the Adaptive Stranding Protocol Development. The first two stages (Stages 1 and 2) were committed to by BC Hydro and were not a part of the Duncan Dam Water Use Plan. The remaining components (Stages 3 and 4) were built into and considered during the water use planning process.

spends prior to implementation of the Duncan Dam Water Use Plan on the cultural studies should be reimbursed through the water use planning process.

- Total Gas Pressure Procedure – When Duncan Dam discharges are nearing 285 m^3/s, ensure that flows through one low level outlet are near the maximum flow of 170 m^3/s to restrict spill volumes to 115 m^3/s (in the spillway) and therefore, limit Total Gas Pressure levels downstream.

Non-Water Use Plan Recommendations

The Consultative Committee recommended a number of items that were not directly linked to Duncan Dam facility operations or decisions considered by the Committee as follows:

- BC Hydro continues their debris management program on the Duncan Reservoir.
- A regional Hydroelectric System Review be undertaken.
- Development of a watershed management plan for the upper Duncan River system.

Monitoring Program

The Consultative Committee discussed sources of uncertainty associated with implementing the recommended operating alternative. Throughout the water use planning process and the trade-off analysis process, the Committee discussed monitoring studies to address these uncertainties. The Committee recommended the following monitoring studies for the Duncan Dam Water Use Plan:

- Adaptive Stranding Protocol Development Stages 1 and 2: Develop and Implement Interim Protocol
- Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol Continued
- Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor
- Kokanee Spawning Study
- Bull Trout Passage Studies
- Temperature and Total Gas Pressure Monitoring Studies
- Cottonwood Studies
- Mosquito Management Study
- Stock Assessment and Fish Habitat Utilization Studies

- Burbot Studies
- Archaeology Study
- Erosion Studies
- Reservoir Riparian Studies

Physical Works in Lieu of Operational Changes

During the Duncan Dam water use planning process, the Consultative Committee considered a number of physical works in lieu of operational changes. The Committee recommended the following physical works in lieu of operational changes:

- Argenta Slough Erosion Protection in lieu of operational changes in Duncan Reservoir to address impacts to wildlife and riparian communities.
- Heritage and Cultural Sites Erosion Protection in lieu of operational changes in Duncan Reservoir to address the impacts to identified heritage and cultural sites in the reservoir.
- Boat Launch and Mooring Buoys at Glacier Creek in lieu of operational changes in Duncan Reservoir to address recreation impacts.[1]
- Partial funding for the Columbia Basin Fish and Wildlife Nutrient Loading Program in lieu of operational changes at the Duncan Dam to address the impacts to nutrient retention in the North Arm of Kootenay Lake. Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee and the BC Hydro Committee member met on 16 August 2004 to review the nutrient loading impacts. The subcommittee concluded that operational impacts of this alternative under Alternative S (73) would account for approximately half of the nutrient loading impacts from the Duncan Dam. Therefore, the subcommittee recommended that partial funding of $100,000 be directed to the Columbia Basin Fish and Wildlife Compensation Program’s nutrient loading program on an annual basis as a non-operational physical works for the Duncan Dam Water Use Plan.
- Lower Duncan River sidechannel exclusion fencing in lieu of operational changes in the lower Duncan River to mitigate fish stranding incidents by restricting spawning kokanee from entering the sidechannels from 15 September to 1 October when flows would be reduced to the target flow level of 73 m^3/s. This recommendation was subject to review by the Fish Technical Subcommittee.

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[1] The Consultative Committee agreed to the Glacier Creek Boat Ramp Extension to a funding cap of $126,000 with the caveat that the Regional District of Central Kootenay would be responsible for the boat ramp upon completion of construction.

- Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee recommended that BC Hydro develop, in consultation with federal and provincial fisheries agencies and First Nations, an action plan to minimize the risk of stranding kokanee spawning in Duncan River sidechannels rather than the exclusion fencing. The action plan is in lieu of operational constraints that would maintain a minimum flow in the Duncan River below the facility from 15 September to 30 September. The action plan will include monitoring sidechannel use, assessment of exclusion methods, and implementation of physical works where appropriate.

The Consultative Committee did not recommend the following physical works:

- Partial funding towards the Regional District of Central Kootenay's Mosquito Abatement Program given they felt that the Duncan Dam water use planning process has addressed the mosquito issue by including maximum flood constraints in the lower Duncan River in the operating alternatives. The recommended alternative avoids higher Duncan River flows in August that could potentially lead to increased mosquito breeding opportunities.

- Maintenance at Howser and Glayco creeks recreation sites given the Ministry of Forests Committee member stated that there was three years of funding secured to better maintain these sites in the future.

- Erosion protection works for agricultural lands in the lower Duncan River given the Channel Stability Assessment: Lower Duncan River study conducted during the water use planning process concluded that the construction of the Duncan Dam likely reduced erosion impacts through the reduction in peak flows. Erosion will continue to occur, however the extent is unknown.

Review Period

The Consultative Committee recommended that the Duncan Dam Water Use Plan be reviewed 10 years after implementation of the Plan unless results of the monitoring program suggest that an earlier review is appropriate. The Committee also recommended that a review of the Water Use Plan be undertaken in the event that one of the following events occurs:

- Kootenay River water use planning process being initiated.

- International Joint Commission Order being re-opened.

- Biologically significant trigger.

- Maximum normal dam discharges being changed to above 283 m^3/s (due to Total Gas Pressure issues) with recognition that dam safety would take precedence.

- External factors affecting the ability to deliver the preferred flow regime in the lower Duncan River. For example, changes to the Libby VARQ or the Flood Control Rule Curves, or conflict with the outcome of the Columbia River Water Use Plan or the Ktunaxa–Kinbasket Treaty negotiations.

The Consultative Committee recommended that annual meetings be held in Lardeau or Kaslo to review BC Hydro's compliance with the Duncan Dam Water Use Plan and the monitoring studies results.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

APPENDICES

1 INTRODUCTION TO WATER USE PLANNING

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 ensure provincial water management decisions reflect changing public values and environmental priorities. The purpose of water use planning is to understand public values and to develop a preferred operating strategy through a multi-stakeholder consultative process. The product, a Water Use Plan, is a technical document that, following review by provincial and federal agencies and approval by the provincial Comptroller of Water Rights, defines how water control facilities will be operated. The process for developing a Water Use Plan is described in the provincial government's *Water Use Plan Guidelines* (British Columbia, 1998).

The Water Use Plan is intended to accommodate other water use interests through incremental changes in how existing water control facilities store and release water. While there may be opportunities to undertake physical works as a substitute for changes in flow, water use planning focuses primarily on a better use of water at facilities as they exist today. Water Use Plans are not intended to be comprehensive watershed management plans or address water management issues associated with other activities in the watershed such as forestry or mining. First Nations' rights and title issues and historic grievances arising from the initial construction of the facilities are specifically excluded from Water Use Plans, but can be considered as part of other processes (Province of British Columbia, 2000).

The Duncan Dam Water Use Plan consultative process was initiated in August 2001 and completed in April 2004. The purpose of this report is to document the consultative process and present the recommendations of the Duncan Dam 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 Duncan Dam Project. Both the Duncan Dam Consultative Committee Report and BC Hydro's Draft Water Use Plan will be submitted to the Comptroller of Water Rights.

The remainder of this report is structured in the following manner. The *italicized references to steps* indicate how a given section and topic relates to the provincial government's *Water Use Plan Guidelines*:

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[1] The Ministry of Employment and Investment responsible for electricity policy at the inception of the Water Use Plan Program is now part of the Ministry of Energy and Mines.

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

Section	Description
2 Description of the Duncan Dam Project	Describes the Duncan Dam hydroelectric storage facility.
3 Consultative Process	Describes the Duncan Dam Water Use Plan consultative process, including process initiation, Consultative Committee participants and Committee structure *(Steps 1 and 3)*.
4 Issues, Objectives and Performance Measures	Describes the issues, objectives and performance measures *(Steps 2 and 4)*.
5 Information Collected	Describes the studies that the Committee had undertaken during the water use planning process *(Step 5)*.
6 Operating Alternatives	Describes operating alternatives considered by the Committee and the modelling process *(Step 6)*.
7 Trade-off Analysis	Describes the trade-off analysis process and the package of recommendations developed by the Committee *(Step 7)*.
8 Monitoring Program	Describes the Duncan Dam Water Use Plan monitoring program, and the criteria used to evaluate the proposed studies for eligibility under the Water Use Plan Program.
9 Review Period	Describes the timing and process for future review of the Duncan Dam Water Use Plan.
10 Implementation of Recommendations	Describes the implementation plan for the Duncan Dam Water Use Plan.
11 Summary of Recommendations and Outcomes	Describes the Committee's recommendations and expected outcomes of the Duncan Dam Water use Plan.

2 DESCRIPTION OF THE DUNCAN DAM PROJECT

2.1 Description of Current Facility

The Duncan Dam Project is part of BC Hydro's Columbia Basin Generation area. The Duncan Dam, completed in 1967, was one of three dams built in Canada as a result of the Columbia River Treaty between Canada and the United States. (A fourth dam, Libby, on the U.S. Kootenai River upstream of Kootenay Lake, was authorized under the Treaty and subsequently completed in 1974.) The Duncan Reservoir provides storage to improve hydroelectric generation and flood control downstream in the Kootenay and Columbia river basins.

The Duncan Dam Project is located within the Regional District of Central Kootenay, and lies within the Duncan River drainage basin that covers 2400 km^2. The Duncan Dam is located immediately upstream of the confluence of the Duncan and Lardeau rivers, approximately 11 km upstream of Kootenay Lake and 42 km north of the Village of Kaslo.

The Duncan Reservoir, impounded by the dam, is 45 km long when the reservoir is at full pool. Besides providing storage for downstream hydroelectric generation and flood control, the reservoir also provides for minimum flow regulation for the lower Duncan River between the fish passage provisions at the dam and the mouth of the river at Kootenay Lake.

There are no power generation facilities at the Duncan Dam. The structure consists of an earth-filled dam, two discharge tunnels on the west side of the dam, and a concrete spillway located on the east bank of the dam. During summer, the low-level outlet is operated similarly to a navigation lock to assist the upstream migration of bull trout. Water release facilities at the dam consist of the two discharge tunnels, controlled at the downstream ends by radial gates, and the gated spillway. Refer to Appendix A: Briefing Note on the Duncan Dam Facility.

Figure 2-1 provides a map of the Duncan Dam and surrounding area.

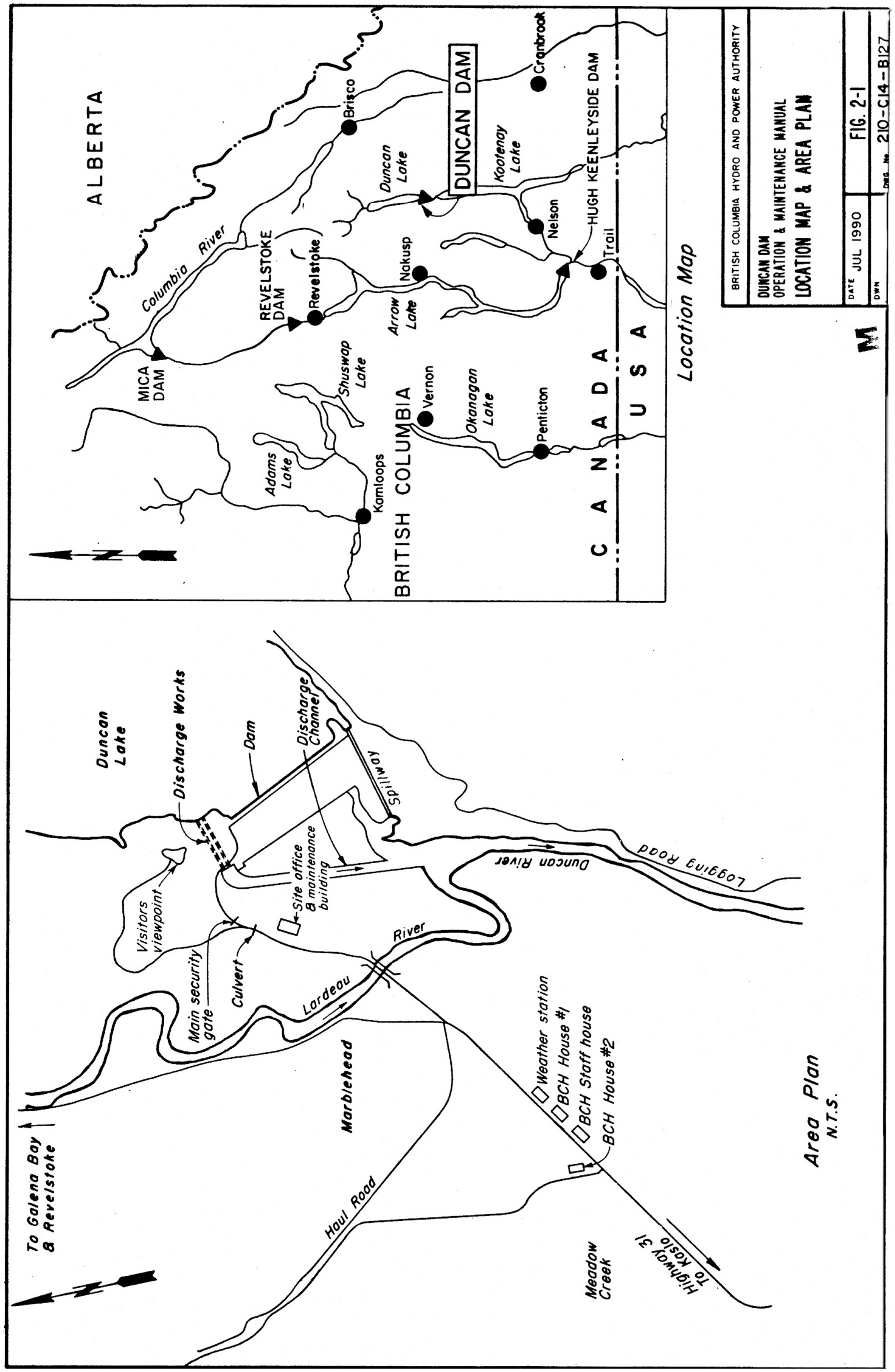


Figure 2-1: Map of the Duncan Dam and Surrounding Area

The physical structures comprising the Duncan Dam Project include:

- **Duncan Reservoir:** Duncan Dam impounds Duncan Reservoir. At full pool, the reservoir covers an area of approximately 7150 ha, and has a usable (live) storage volume of 1730 million m^3. The normal operating range of the reservoir is between 546.87 m and 576.68 m.

- **Duncan Dam:** The dam is earth filled and is 80 m long and 40 m high. The dam crest elevation is 581.5 m. Used for storage only, there are no power generation facilities at this dam (refer to Photo 2-1). Water release facilities consist of two 6.1 m diameter pressure tunnels approximately 333 m long controlled at the downstream ends by radial gates with dimensions 5.9 m wide by 4.8 m high. There is also a gated spillway consisting of two 8.7 m wide by 12.2 m high vertical lift gates.

Photo 2-1: Duncan Dam and Duncan Reservoir

Figure 2-2 illustrates the Duncan Dam project facilities.

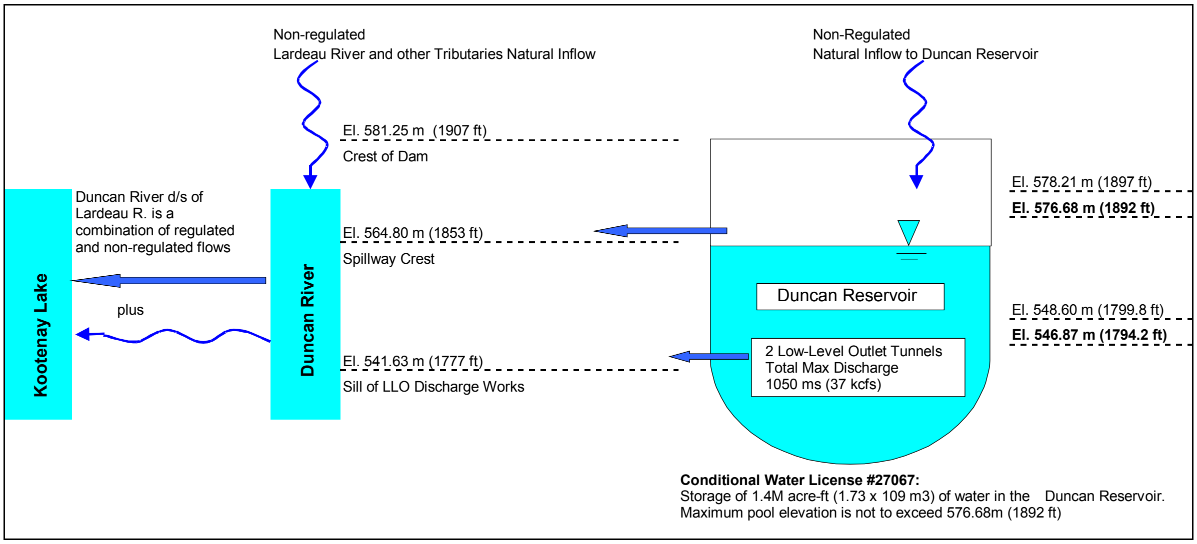


Figure 2-2: Schematic of Duncan Dam Project Facilities

2.2 Description of Current Operations

2.2.1 Water Licences Rights and Obligations

BC Hydro is authorized by Conditional Water Licence No. 27067 to store a maximum of 1.4 million acre-feet (1.73 x $10^9 m^3$) of water in the Duncan Reservoir. The maximum pool elevation is not to exceed 1892 feet (576.68 m).

2.2.2 Water Releases

BC Hydro is responsible for scheduling and implementing Duncan Dam releases under the Columbia River Treaty. Treaty storage releases for Duncan, as well as for Mica and Hugh Keenleyside dams (the other two Treaty projects in Canada), are determined by operating plans designed to maximize power generation and flood control in Canada and the United States. BC Hydro normally has discretion to determine individual releases at each of the three Treaty projects; however, overall Treaty releases must satisfy Treaty operating plans, including requirements for power generation, flood control, and dam safety. From time to time, BC Hydro (the Canadian Entity under the Treaty) and the U.S. Entity may modify Treaty requirements by mutual agreement to improve power generation, fisheries or other non-power operations.

2.2.2.1 Assured Operating Plan

The Columbia River Treaty requires that an Assured Operating Plan (AOP) be prepared and agreed to each year by the Canadian and U.S. Entities for the operation of Treaty storage for the sixth succeeding year of operation. The AOP provides assured rules for Treaty project operation so that proper investment planning can be done for power systems in both British Columbia and the United States Pacific Northwest. The AOP outlines operating rules for each of the Treaty projects that define the draft and refill rights and obligations for the project, and provides a default position from which the Detailed Operating Plan (DOP) is constructed. The AOP is prepared jointly by the Entities and must follow fairly rigid rules related to the provision of flood control space and optimization of generation in both countries. Treaty storage at the three Treaty projects total 15.5 million acre-feet (MAF), of which 1.4 MAF is at Duncan Dam.

2.2.2.2 Detailed Operating Plan

The Columbia River Treaty also allows for a DOP to be prepared and agreed to each year by the Entities for the operation of Treaty storage in the following year. Operating rules established in the appropriate AOP (i.e., for application in the following year), may be updated and/or altered by mutual agreement of the two Entities. If no agreement is reached, then the rules agreed to in the AOP are the default rules. The DOP is prepared jointly by the Entities.

2.2.2.3 Actual Operations

The operating rules documented in the DOP for the current year, along with actual inflows and inflow forecasts, provide the inputs for the "Treaty Storage Regulation" (TSR) study, which is updated by the Columbia River Treaty Entities twice each month. The TSR study results then provide the default monthly targets for actual Treaty storage.

The U.S. Entity makes its request for Treaty storage operations each Friday for the following week (implementation usually begins at 0800 on Saturday). Prior to implementation, BC Hydro verifies that the Treaty storage request is in accordance with the current TSR storage targets and any other agreements between the two Entities. Within the week, actual releases from Duncan Dam may be altered at BC Hydro's discretion for any reason provided that:

1) The Kootenay Lake release is greater than the Duncan Dam release.

2) Project-specific Treaty flood control provisions are maintained.

3) Treaty project hydraulic discharge capabilities meet Treaty requirements.

4) Actual releases from Arrow Lakes Reservoir are altered to comply with the total Treaty discharge requirements from Canadian storage.

Figure 2-3 illustrates historical operation of the Duncan Reservoir from 1984 to 2000.

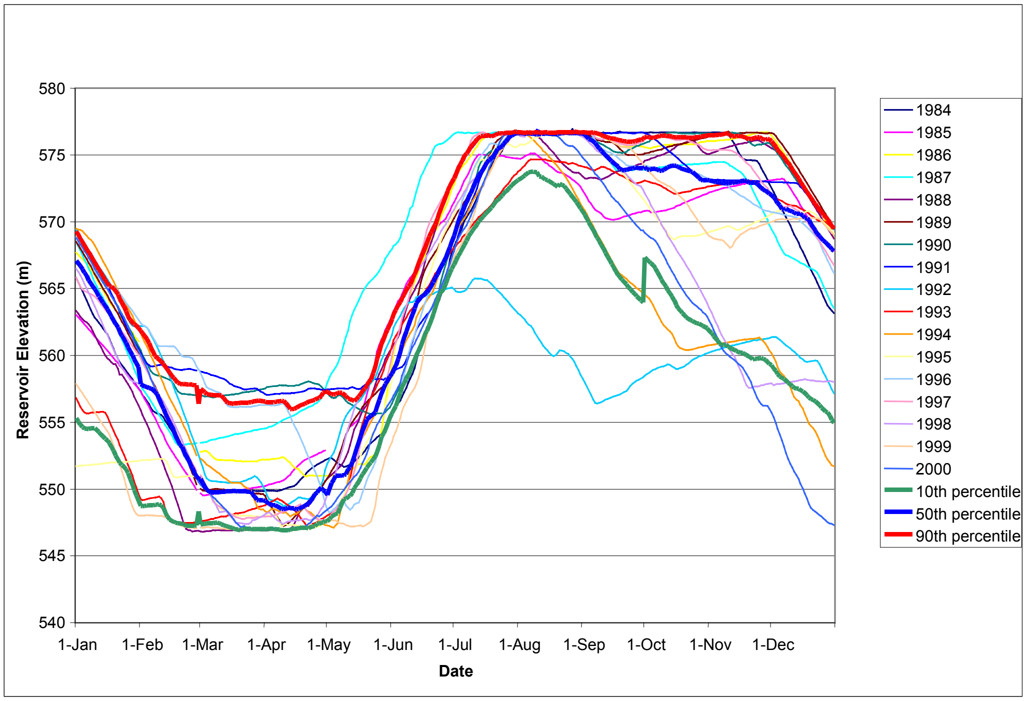


Figure 2-3: Duncan Reservoir Historical Operation (1984–2000)

Figure 2-4 illustrates historical discharge from the Duncan Dam from 1984 to 2000.

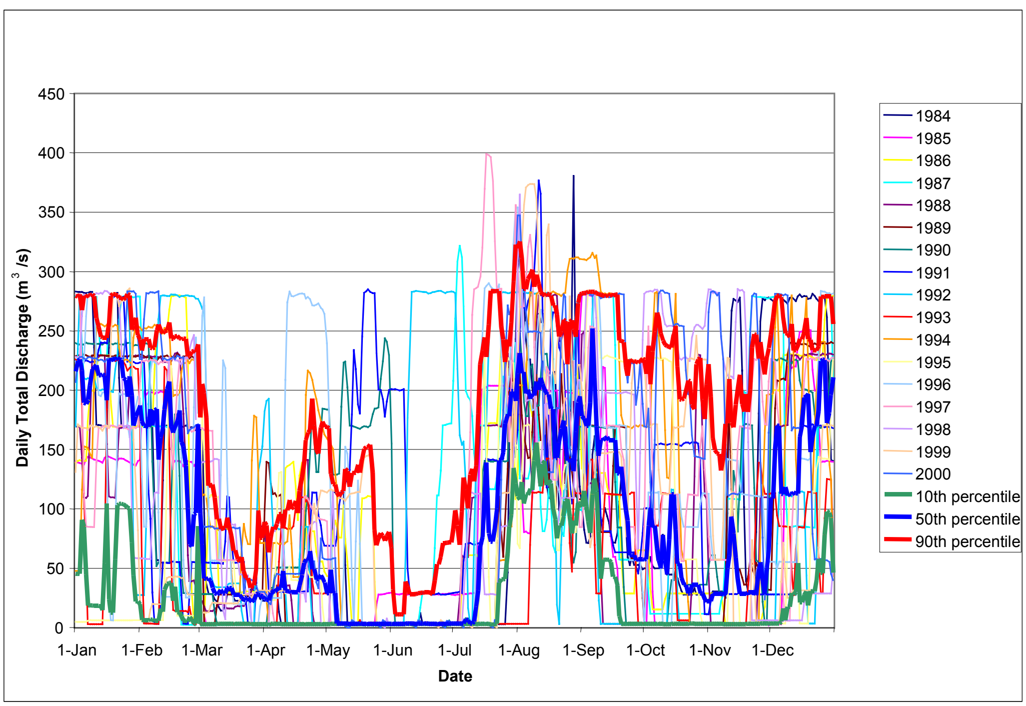


Figure 2-4: Duncan Dam Historical Discharge (1984–2000)

2.2.3 Flood Control

Regulation of the Duncan Reservoir for flood control purposes in Canada and the United States is governed by the Columbia River Treaty Flood Control Operating Plan (FCOP) developed by the U.S. Army Corps of Engineers (the Corps) in consultation with BC Hydro, based on principles laid out in the Treaty. Duncan Reservoir levels must not exceed Flood Control Rule Curves specified in the FCOP except as directed by the Corps to prevent downstream flooding.

The Treaty provides for both system and local flood control objectives, and BC Hydro works closely with the Corps to define these flood control needs. In many cases, system flood control needs are more restrictive to Duncan Reservoir operations than are local flood control needs and the Treaty Flood Control Rule Curves reflect this. If necessary to accommodate a desired project operation, BC Hydro may request that the Corps issue a variance from the Flood Control Rule Curve for one of the Treaty projects. The Corps will consider this request in light of the current and forecast system and local flood potential.

Duncan Reservoir is operated under the terms of the Treaty, which stipulates weekly agreement for storage regulation between the Entities. The DOP prepared under the terms of the Treaty specifies minimum, maximum and rate of change in reservoir discharge.

2.2.4 Duncan Dam Discharge Facilities Operation

The Low-Level Outlet Gates (LLOGs) are the preferred means of discharging water from the Duncan Dam (refer to Photo 2-2). The spillway is only to be used to control the surcharge storage during local flood conditions when the reservoir is full (refer to Photo 2-3) and during bull trout migration operations (refer to Section 2.2.6).

Except under emergency conditions, the total discharge from the LLOGs should not exceed 283 m^3/s (10 kcfs). This may be increased to 566 m^3/s (20 kcfs) if the spillway capacity is not adequate to discharge project requirements. The minimum average weekly allowable discharge from the Duncan Dam is 3 m^3/s (0.1 kcfs). Bull trout transfers in June, July and August require low level outlet flows to be halted for short durations while the gate changes are executed. In such cases, the average flow constraints will be met by increasing instantaneous discharge (e.g., 24 m^3s^{-1} for 3 hours = 3 m^3s^{-1} for 24 hours). The maximum rate of change of outflow is 113 m^3/s (4 kcfs) per day.

When the Duncan Reservoir is filling and the water level reaches elevation 575.8 m, the LLOGs are opened to discharge the lesser of 283 m^3/s (10 kcfs), or a percentage of the calculated inflow as shown below.

Reservoir Elevation (m)	Per Cent of Inflow to be Discharged
575.8	25
576.1	50
576.4	75
576.7	100

Photo 2-2: Duncan Dam Low-Level Outlets

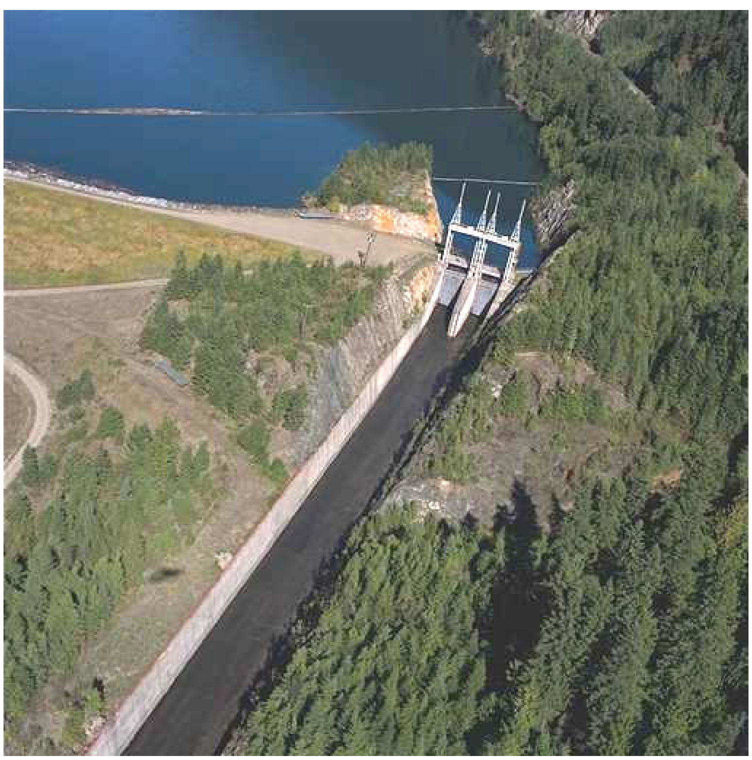


Photo 2-3: Duncan Dam Spillway

2.2.5 Fish Interests

Prior to initiating the Duncan Dam water use planning process, there were no formal agreements, restrictions or obligations for specific fish operations at the Duncan Dam Project. Informal agreements with Fisheries and Oceans Canada and the Ministry of Water, Air and Land Protection included bull trout migration operations and spill control to minimize total gas pressure impacts. During the water use planning process, Fisheries and Oceans Canada and BC Hydro signed an Alternative Measures Agreement to address stranding issues on the lower Duncan River.

2.2.6 Duncan Dam Fish Transfer Procedures

Beginning in late May or early June of each year, some bull trout migrate from Kootenay Lake up the Duncan River to the base of the Duncan Dam. At this time, the project outflows are normally between 3 and 30 m^3/s (100 and 1000 cfs). Duncan Dam operations are modified to allow fish to pass up one of the discharge tunnels in much the same way as a boat is allowed to pass through a navigation lock. Details are as follows:

- Approximately every two weeks, after sufficient fish are spotted congregating in the flip bucket, the LLOG is closed.
- The upstream maintenance gate is then closed to cut off inflow into the tunnel and isolate it from the reservoir.
- The LLOG is then opened to allow fish to go into the tunnel.
- When the fish are in the tunnel, the LLOG is closed and leakage from the maintenance gate gradually primes the tunnel.
- Once the tunnel is filled, the upstream maintenance gate is fully opened to allow the fish to migrate into the Duncan Reservoir.

The trout are not expected to spawn until some time in the fall in Duncan Reservoir tributaries, after which they pass downstream through Duncan Dam in the fall and winter to Kootenay Lake.

A fish weir was constructed at the toe of the outlet of LLOG #2 in June 1994. This makes LLOG #2 the preferred gate for fish transfers. The weir has removable stoplogs and helps fish enter the flip bucket by staggering the jump from the tailwater. In a normal year, this fish transfer operation is repeated 10 to 12 times, transferring hundreds of fish into the Duncan Reservoir. This operation does not affect normal discharges or storage operations at the project since the other tunnel and the spillway are normally available.

2.3 Linkage of the Duncan Dam to the Kootenay and Columbia Rivers

The Kootenay River originates in the Rocky Mountains near the source of the Columbia River at Canal Flats, and flows south into Koocanusa Reservoir formed behind Libby Dam in Montana, United States. From Libby, the Kootenay River turns north and re-enters British Columbia near the community of Creston, flowing into the south arm of Kootenay Lake. Water levels in Kootenay Lake are regulated by the International Joint Commission (Kootenay Board of Control) under the “Kootenay Lake Order.” This Order is held by FortisBC, the water-licence holder for one-half of Kootenay Lake storage, as well as the owner of Corra Linn Dam, which regulates the lake levels. Brilliant Power Corporation, a Columbia Power Corporation/Columbia Basin Trust (CPC/CBT) joint venture that owns the Brilliant Powerplant, is the water-licence holder for the other one-half of Kootenay Lake storage.

CPC/CBT’s Brilliant Powerplant and the Brilliant Expansion Project, which is currently being constructed, are located near Castlegar and use regulated Columbia River Treaty flows. Because of the need to achieve certain Columbia River Treaty flow levels at the Canada–US border, there are cross-system impacts at lower Columbia River facilities, including CPC/CBT’s Arrow Lakes Generating Station (ALGS), associated with the various operating alternatives that were considered during the Duncan Dam water use planning process.

In the northern part of the Kootenay basin, the Duncan River is joined by the Lardeau River just downstream from Duncan Dam, and then flows into the north arm of Kootenay Lake (refer to Figure 2-5). Water from the north and south arms of Kootenay Lake then flows through the west arm of the lake and past Grohman Narrows and the Corra Linn Dam (as well as other dams) en route to the Columbia–Kootenay confluence at Castlegar.

From Castlegar, the Columbia River continues south where it is joined by the Pend d’Oreille River 100 m north of the Canada and United States border. From this confluence, the Columbia River flows into the United States, continues through 11 more reservoirs and dams, and completes its 1942 km long journey at the Pacific Ocean near the city of Astoria, Oregon.

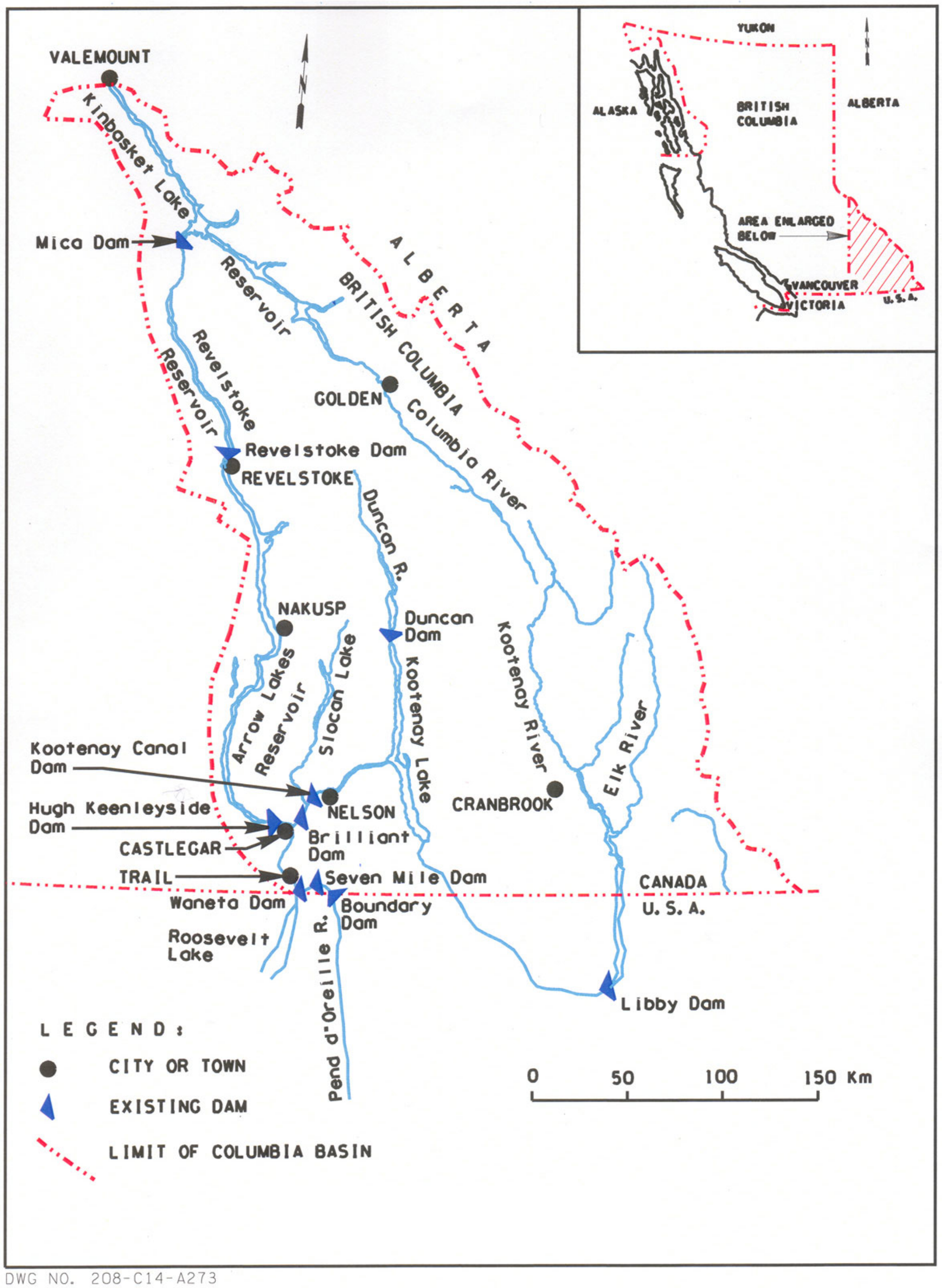


Figure 2-5: Columbia River Basin

3 CONSULTATIVE PROCESS

3.1 Introduction

The Duncan Dam Water Use Plan consultative process followed Steps 3 to 8 of the provincial government's *Water Use Plan Guidelines* (Province of British Columbia, 1998). These steps provide the framework for a structured approach to decision-making.

This section describes the Duncan Dam Water Use Plan consultative process including process initiation, Consultative Committee participants, and Committee structure.

Table 3-1 summarizes the steps in the provincial government's *Water Use Plan Guidelines.*

Table 3-1: Steps in the Water Use Plan Guidelines

Step	Description
1	Initiate water use planning process
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

3.2 Initiation and Issues Scoping

Prior to initiating the Duncan Dam water use planning process, BC Hydro contacted approximately 50 key regional stakeholders including community leaders, elected representatives and interested parties during the summer of 2001. Discussions were also held with the Shuswap Nation Fisheries Commission, Little Shuswap Indian Band, Ktunaxa–Kinbasket Tribal Council, Okanagan Nation Alliance, Spallumcheen Indian Band and Canadian Columbia River Inter-

Tribal Fisheries Commission to discuss their participation in the Duncan Dam water use planning process.

In addition to inviting interested parties to participate, BC Hydro asked a number of questions regarding issues and interests with regard to Hydro's operation of the Duncan Dam. Letters were also mailed to water licence holders along the Duncan Reservoir and the Duncan River to inform them about the Duncan Dam water use planning process and to extend an invitation to participate. In an effort to engage additional participants in the Duncan Dam water use planning process, a letter was sent to a number of local residents, businesses and associations in April 2002.

On 31 August 2001, BC Hydro issued a news release in the West Kootenay area to publicly announce the Duncan Dam water use planning process. A public Open House and Information Session was held on 19 September 2001. A newspaper advertisement followed in the *Kootenay Lake Pennywise*, *Kootenay Express* and the *Nelson Daily News* to support the news release. Information on the Duncan Dam water use planning process is also posted on BC Hydro's Water Use Plan website, www.bchydro.com/wup. A password-protected website was created to enable Consultative Committee members to share information on the water use planning process.

BC Hydro summarized the interests and issues identified by the stakeholders, and submitted an *Issues Identification Report* (BC Hydro, August 2002) to the Comptroller of Water Rights. This report completed Step 2 of the provincial government's *Water Use Plan Guidelines*.

Key interests identified included:

- Cultural Resources and Heritage.
- Fish.
- Flood Management (Erosion Protection).
- Power Generation.
- Quality of Life – Mosquitoes.
- Recreation and Tourism.
- Wildlife.

3.3 Consultative Committee Structure and Process

The Duncan Dam Water Use Plan Consultative Committee consisted of Committee members and observers (refer to Appendix B: Consultative Committee, Observers and Subcommittees). Observers attended on a drop-in basis and provided input, but could not participate in decision-making. The

Committee initially was comprised of 15 members. Over the course of the Duncan Dam water use planning process, some members opted to change their status to observer status or others were reassigned other duties. Those who moved to observer status were comfortable that their interests were represented by other Committee members. There were 12 Committee members who actively completed the water use planning process.

In addition to the Consultative Committee, participants formed several technical subcommittees to focus on specific issues and to provide technical advice to the Committee. These subcommittees included:

- Fish Technical Subcommittee addressed fish and fish habitat issues in the Duncan Reservoir and the Duncan River.
- Cultural Resources and Heritage Technical Subcommittee addressed traditional use and archaeological issues at the Duncan Reservoir and the Duncan River.
- Wildlife Technical Subcommittee addressed wildlife issues at the Duncan Reservoir and along the Duncan River.
- Quality of Life/Recreation Technical Subcommittee addressed recreation concerns, including swimming, mosquitoes, sport fishing and boating, in the Duncan Reservoir and the Duncan River.

In January 2002, the Consultative Committee developed and adopted Terms of Reference and a consultation work plan. The Terms of Reference were included in the *Proposed Consultative Process Report: Duncan Dam Water Use Plan* (BC Hydro, August 2002) and submitted to the Comptroller of Water Rights to fulfil Step 3 of the provincial government's *Water Use Plan Guidelines* (refer to Appendix C: Consultative Committee Terms of Reference).

The Consultative Committee and the technical subcommittees met between November 2001 and April 2004 to complete the Duncan Dam water use planning process. In June and July 2004, the facilitator contacted each Committee member to determine their level of support for the recommended alternative that was modelled subsequent to the final Committee meeting in April 2004.

The Duncan Water Use Plan consultative process included eight Consultative Committee meetings, 11 Fish Technical Subcommittee meetings, three Quality of Life/Recreation Technical Subcommittee meetings, six Wildlife Technical Subcommittee meetings, and seven informal Cultural and Heritage Technical Subcommittee meetings (refer to Appendix D: Schedule of Consultative Committee Meetings and Activities). The subcommittees also held numerous conference calls and communicated by email or royal mail.

Site visits to the Duncan Dam facility were held on 9 October 2002 and 14 May 2003 (refer to Photo 3-1 and Photo 3-2).

Detailed meeting notes recorded the discussions and decisions made during meetings and conference calls. Refer to Appendix E: Documents Generated by the Duncan Dam Water Use Planning Process for a list of documents, including meeting notes, produced during the Duncan Dam water use planning process.

Photo 3-1: Members of the Consultative Committee and BC Hydro Project Team during the Duncan Dam Project Site Visit

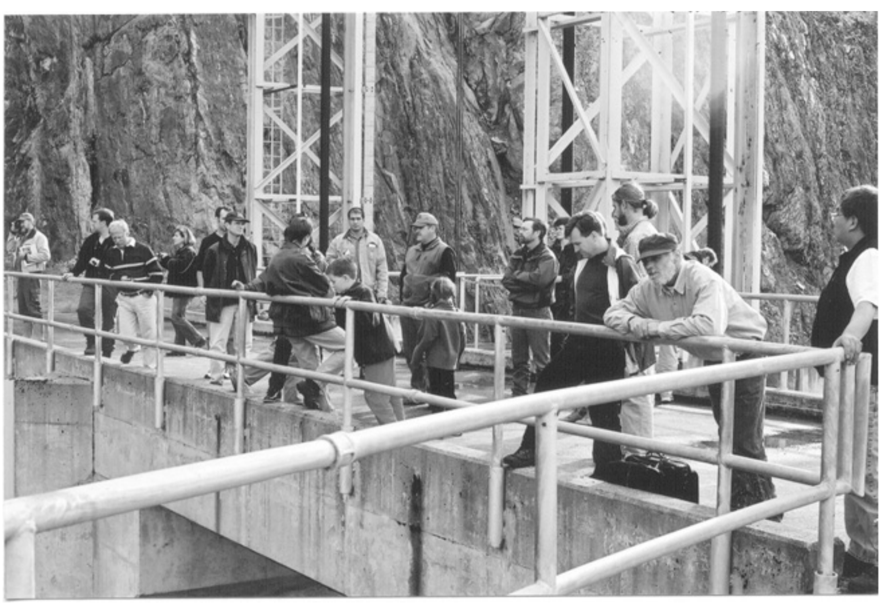


Photo 3-2: Members of the Consultative Committee and BC Hydro Project Team on Spillway at Duncan Dam

3.4 First Nation Involvement

The Duncan Dam Project is in the claimed traditional territory of the Ktunaxa–Kinbasket Tribal Council. The Shuswap Nation Fisheries Commission, Little Shuswap Indian Band, Ktunaxa–Kinbasket Tribal Council, Okanagan Nation Alliance, Spallumcheen Indian Band, and the Canadian Columbia River Inter-Tribal Fisheries Commission were contacted to determine their desired level of participation in the Duncan Dam water use planning process.

The Okanagan Nation Alliance and the Spallumcheen Indian Band declined to participate in the Duncan Dam water use planning process. The Little Shuswap Indian Band and Shuswap Nation Fisheries Commission participated as observers by receiving meeting pre-reading materials, minutes, process updates and news releases.

The Ktunaxa–Kinbasket Tribal Council and their aquatic technical resource advisors, the Canadian Columbia River Inter-Tribal Fisheries Commission, participated in the Duncan Dam water use planning process as Consultative Committee members. A Canadian Columbia River Inter-Tribal Fisheries Commission representative participated on the Fish Technical Subcommittee. Archaeological technical advice was provided by Wayne Choquette Consulting.

The Ktunaxa–Kinbasket Tribal Council represented the St. Mary's, Lower Kootenay, Tobacco Plains, Shuswap and Columbia Lake Indian Bands' interests on traditional territory while the individual Bands represented their interests on-reserve.

The Canadian Columbia River Inter-Tribal Fisheries Commission acts as a technical advisor on aquatic resources to the Ktunaxa–Kinbasket Tribal Council communities, as well as to the Shuswap Nation Fisheries Commission and associated communities. The Commission also helped to articulate the interests of Ktunaxa–Kinbasket Tribal Council communities during the Duncan Dam water use planning process to help build consensus for a "First Nation preferred" operating alternative.

A BC Hydro Aboriginal Relations Task Manager was assigned to the BC Hydro Project Team. During the Duncan Dam water use planning process, the Aboriginal Relations Task Manager worked closely with the Community Relations Task Manager and the Consultative Committee facilitator to:

- Ensure information was provided to First Nations in a timely manner.
- Offer assistance in reviewing the information.
- Determine if resources were required to support First Nations' involvement.
- Determine and arrange for technical assistance to support First Nations in interpreting information.
- Co-ordinate any tasks that involved First Nations.

The BC Hydro Aboriginal Relations Task Manager met with First Nations and their archaeologist to develop cultural and heritage objectives, performance measures and identify appropriate monitoring studies. Communication also included conference calls, emails and phone calls to develop and refine objectives and performance measures.

First Nations representatives participated in two site visits on 9 October 2002 and 14 May 2003 to the Duncan Dam and Reservoir. The BC Hydro Aboriginal Relations Task Manager also participated in an archaeological field reconnaissance of part of the Duncan Reservoir on 2 May 2002.

At the 9 October 2002 Consultative Committee meeting, a Lower Kootenay Indian Band member delivered a cultural awareness presentation to the Consultative Committee. The presentation described the historic relationship between First Nations people and natural resources, and how people traditionally used those resources. The presentation was informative and well received by those in attendance.

3.5 Community Awareness and Communication

On 19 September 2001, BC Hydro held a public Open House and Information Session in Meadow Creek to promote awareness of the Duncan Dam water use planning process, invite potential participants to the Consultative Committee table, and scope potential issues that may be addressed during the Duncan Dam water use planning process. On 8 October 2003, a second public Information Session was held in Meadow Creek to update area residents on the water use planning process and provide an overview of the operating alternatives being considered.

During the Duncan Dam water use planning process, BC Hydro issued four news releases and three newsletters to inform the public in the West Kootenay area about developments in the water use planning process. An update news release and newsletter were issued at the end or near the following key consultative milestones – Steps 3, 6 and 8 of the provincial government's *Water Use Plan Guidelines*.

The BC Hydro Water Use Plan website provided information to those interested in the Duncan Dam Water Use Plan, as well as to those interested in other Water Use Plans for other BC Hydro facilities in the province.

4 ISSUES, OBJECTIVES AND PERFORMANCE MEASURES

4.1 Introduction

In Step 4 of the provincial government's *Water Use Plan Guidelines*, the Consultative Committee stated specific objectives for the desired outcomes in dealing with Duncan Dam water use planning issues described in Section 3. In defining the objectives, the participants articulated what they sought to achieve through incremental changes in BC Hydro operations (e.g., maximize fish abundance and diversity). For each objective, the Committee defined one or more performance measures to quantify how the objective would be measured (e.g., square metres of fish habitat). The Committee then used the performance measures to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility.

This section provides a summary of the issues, objectives, and performance measures developed by the Consultative Committee. The presentation order of issues does not imply any priority or relative importance among the issues.

4.2 Issues

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

As per the provincial government's *Water Use Plan Guidelines*, issues are considered within the scope of the Duncan Dam Water Use Plan if:

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

Not all the issues raised by the Consultative Committee were within the scope of the Duncan Dam Water Use Plan. However, in some cases, provisions were made outside the water use planning process to address these issues through other programs or initiatives.

4.3 Objectives

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

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

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

Example sub-objectives for Duncan Reservoir fish include:

- Maximize littoral productivity.
- Maximize pelagic productivity.
- Minimize fish stranding risk.

The extent to which these sub-objectives are satisfied is indicative of the extent to which the ends objective, "maximize fish abundance and diversity" is satisfied.

4.4 Performance Measures

Performance measures are used to indicate impacts of different operating alternatives on objectives. For example, impacts of an operating alternative on the sub-objective for Duncan Reservoir fish, "minimize fish stranding risk" is measured in units of m^2 of average dewatered area.

Performance measures were typically developed by the following technical subcommittees:

- Fish Technical Subcommittee
- Cultural and Heritage Technical Subcommittee
- Quality of Life/Recreation Technical Subcommittee
- Wildlife Technical Subcommittee

When developing a performance measure, the Consultative Committee or technical subcommittee considered the following:

- Reliability of the measure (are the results understandable?).
- Sensitivity of the measure (is there a difference between alternatives?).
- Assumptions of the measure (is there adequate information to develop the measure?).

Refer to Appendix F: Performance Measure Information Sheets for specific details on how the performance measures were calculated.

In the following section, performance measures presented in italics were assessed by the appropriate technical subcommittee, and information was forwarded to the Committee when deemed appropriate.

4.5 Recreation

4.5.1 Duncan Reservoir

4.5.1.1 Background

The Duncan Dam area is used by a variety of recreationalists and attracts many tourists each year. In general, local residents are the main users and their activities are concentrated in the southern end of the Duncan Reservoir rather than downstream below Duncan Dam. The preferred time for recreation is from 15 July to 30 September when water temperatures are high and the reservoir is near full pool. Activities at the reservoir include swimming, boating, fishing, and activities such as camping near the beach areas. The most utilized beach areas during the summer are Howser Creek (Ministry of Forests) and Glacier Creek (Regional District of Central Kootenay) recreational campsites. According to the Ministry of Forests, the campgrounds receive moderate use.

Around the Duncan Reservoir, there are a number of hiking trails that are easily accessible from the Forest Service road, which runs along the east side of the reservoir.

Figure 4-1 illustrates existing and potential recreation sites along the shore of Duncan Reservoir.

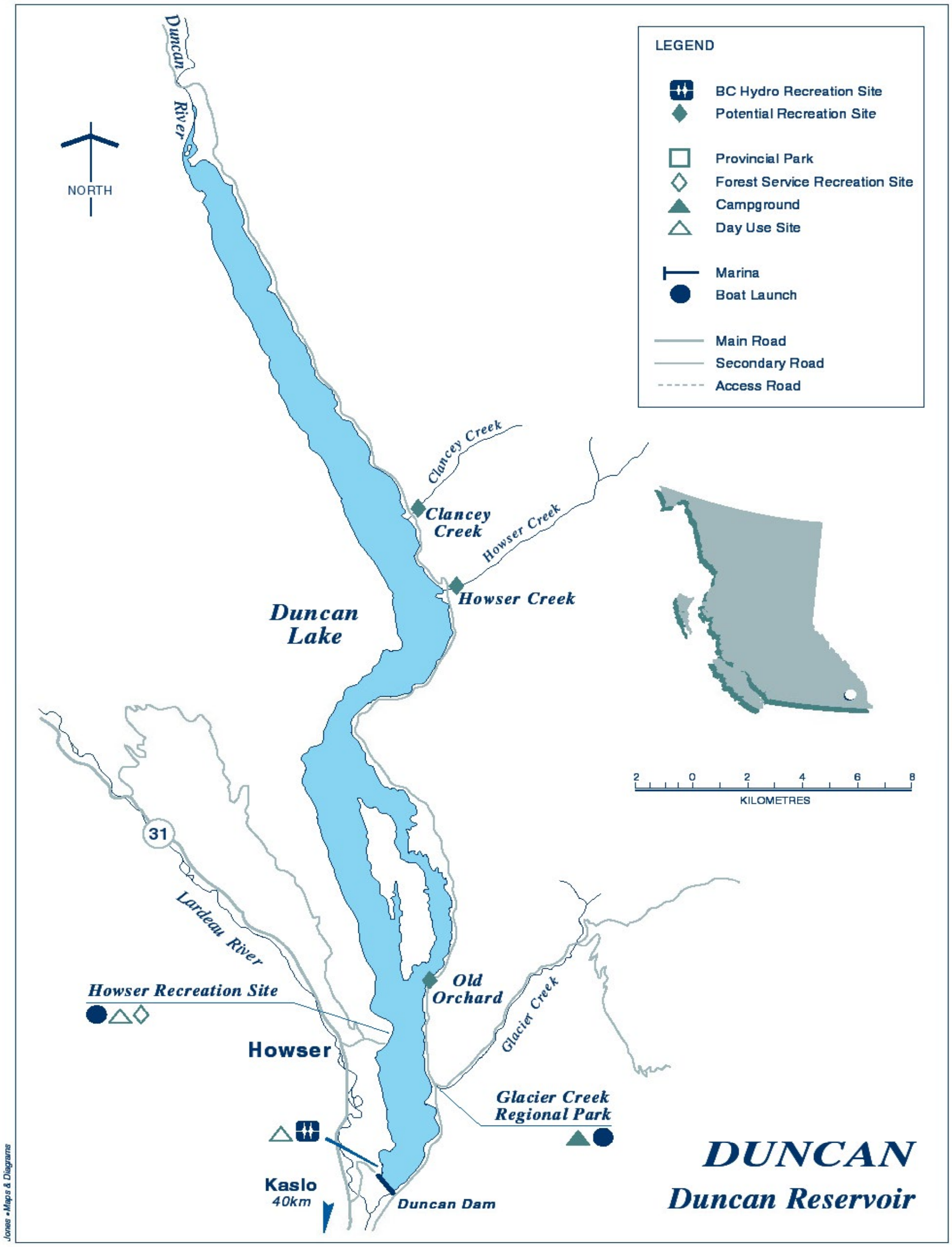


Figure 4-1: Recreation Facilities and Sites along Duncan Reservoir

4.5.1.2 Issues

Table 4-1 summarizes the Duncan Reservoir Recreation issues identified by the Consultative Committee and how each issue was addressed through the Duncan Dam water use planning process.

Table 4-1: Duncan Reservoir Recreation Issues

Issue	Description and Action
Aesthetics	The Duncan Reservoir drawdown zone refers to the zone between full pool and the minimum reservoir elevation. In general, the fuller the reservoir the better the aesthetic values associated with recreation and tourism opportunities. A performance measure was developed to address issues related to aesthetic value.
Exposed Stumps	The Consultative Committee acknowledged that stumps are present throughout the Duncan Reservoir drawdown zone and operational changes would not minimize the degree of risk associated with exposed stumps. It was also acknowledged that stumps in high use areas such as Glacier Creek and Howser Creek recreation sites were bulldozed to lessen any hazards when the Duncan Dam was constructed. A performance measure was not developed to address this issue.
Floating Debris	In the past, debris has been an important issue on the Duncan Reservoir. However, since the debris management program was initiated, this issue has been largely addressed. A debris management program has been conducted on the reservoir since the dam's construction in 1967, by BC Hydro in the south end and by the BC Forest Service in the north end. In 1980, BC Hydro took over debris management for the north end of the reservoir from the Forest Service, and has been actively implementing the program for the entire reservoir since that time. The Recreation Technical Subcommittee was interested in an operation that maintained the reservoir within 1 m of full pool for 6 to 8 weeks after the freshet to maximize the opportunity to undertake an annual debris program. Because the Columbia River Treaty requires the reservoir to be operated in this manner, a performance measure was not developed.
Boat Access	There is limited trailer boat access on the east side of Duncan Reservoir at Glacier Creek except when reservoir water levels are near full pool. This was not considered an important issue for local residents, as the Howser Creek boat ramp is accessible at all reservoir elevations. A performance measure was therefore not developed.
Area of Usable Beach	The preferred Duncan Reservoir water levels for use of beach areas were assessed to be between 0 and 3 feet below full pool for Glacier Creek, and 5 feet below full pool at Howser Creek recreation site. A performance measure was developed to address this issue.

4.5.2 Lower Duncan River

4.5.2.1 Background

Recreation opportunities in the lower Duncan River include bird watching, nature hiking, hunting, fishing and the occasional canoeing and kayaking. Fishing on the lower Duncan River is restricted to a 6-week window starting on 1 March each year for whitefish only.

4.5.2.2 Issues

Table 4-2 summarizes the lower Duncan River Recreation issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-2: Lower Duncan River Recreation Issues

Issue	Description and Action
Wetted Area/Log Jams	Wetted area and log jams refers to their impact on mosquito breeding grounds (discussed in the Quality of Life section). Log jams impact boater safety and water levels. A performance measure was not developed.
Floating Activities	While large flow reductions during the day can strand boaters on bars/islands in the lower Duncan River, there are a limited number of recreationalists who use the lower river for floating activities. Most kayakers, canoeists and/or boaters use the Lardeau River about 11 km upstream from the bridge. Accordingly, this was not considered a significant issue, and a performance measure was not developed.
Sport Fishing Access	The sport fishery on the lower Duncan River is closed, with the exception of whitefish fishery which occurs from 1 March to 15 April. Signs are posted to warn people of rapid water fluctuations on the river. Sport fishing access was therefore not considered an important issue. A performance measure was not developed.

4.5.3 Objective and Sub-objectives

Table 4-3 summarizes the Recreation objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-3: Recreation Objective and Sub-objectives

Objective	Maximize the quantity and quality of the recreational experience
Sub-objectives	Maximize Reservoir Access (boating, shoreline facilities, etc.)
	Minimize mosquitoes[1]
	Maximize visual quality (aesthetics)
	Maximize safety (people stranding, debris and stump hazards)[2]

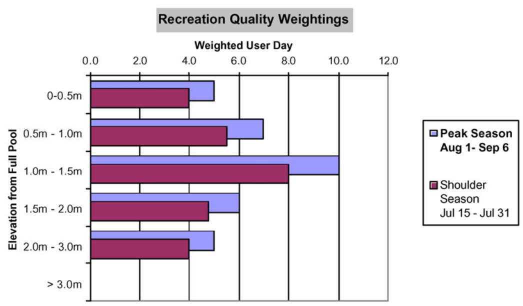
[1] No mosquito-human issues were associated with the reservoir area.

[2] While acknowledging that safety issues are important, it was recognized that none of the identified reservoir issues (in the Issues Report) were known to occur with any regularity and that the debris management program has greatly assisted with minimizing debris hazards.

4.5.4 Performance Measures

Table 4-4 summarizes the Duncan Reservoir Recreation performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility. No performance measures were identified for recreation on the lower Duncan River.

Table 4-4: Duncan Reservoir Recreation Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Recreation Quality	Number of weighted user days the reservoir is at preferred elevations	Weighted usable recreation days based on reservoir levels during the peak recreation season. Where $Weight_{Day}$ is determined from the following table: 	Duncan Reservoir	See dates in description

The ***Recreation Quality*** performance measure is defined as ***the number of weighted user days the Duncan Reservoir is at preferred elevations***. This performance measure estimates the quality of recreation in the reservoir under different operating alternatives.

During the summer of 2003, local BC Hydro operating staff confirmed the preferred Duncan Reservoir elevations for recreation and tourism objectives through site user interviews, direct observations and local phone interviews (BC Hydro 2003, BC Hydro 2003a, Spitler 2003). When reservoir water elevations drop by more than 1.5 m below full pool, the recreation value at Glacier Creek campground is greatly reduced. Elevations more than 3 m below full pool provide little to no water-based recreation value at Glacier Creek or Howser and Glayco Beach and campground areas.

At the final April Consultative Committee meeting, the Regional District of Central Kootenay Committee member expressed that recreation is a real concern because it affects the economics of the area. In addition, the discharge of water for some of the proposed operating alternatives is costly to the public. The Regional District Committee member disagreed with the findings of earlier surveys conducted and reviewed by the Recreation Technical Subcommittee last summer around reservoir levels that are considered desirable for recreation. The Regional District Committee member's alternate attended the Technical Subcommittee meeting, but was not an official representative for the District according to the Committee member. During the final Committee meeting, the Regional District Committee member undertook a telephone survey of local residents of Meadow Creek, Howser, Argenta, Lardeau, Cooper Creek and Kaslo that use Duncan Reservoir most consistently for recreation. The key messages from his survey were that:

- An overwhelming number of individuals surveyed (72 per cent) felt that full pool was most desirable.
- Some wanted the reservoir to be 6 inches to 1 ft below full pool for beach area.
- One individual felt that as much as 1 m below full pool would be most desirable.

The recreation surveys conducted and reviewed by the Recreation Technical Subcommittee last summer indicated that desirable levels were 1 to 2 ft below full pool at Glacier Creek and 5 ft below full pool at Howser. The Technical Subcommittee weighted these two sites equally. These results are not significantly different from the Regional District Committee member's survey. It was also noted that all the preferred operating alternatives have similar Duncan Reservoir elevations near full pool during the first two weeks in August.

4.6 Quality of Life – Mosquitoes

4.6.1 Background

Prior to construction of the Duncan Dam, the lower Duncan River was known as a prime mosquito habitat area and was a pervasive problem for many local residents. There are no known mosquito problems in the Duncan Reservoir area.

Mosquitoes were particularly problematic during high inflow years such as 1973, 1999 and 2002. 1999 was a bad year for mosquitoes where several areas in the floodplain were flooded repeatedly in the spring and summer months. 2002, the year of sampling was also considered a bad year for mosquitoes, according to local residents. The degree to which discharges from Duncan Dam directly affect mosquitoes and their breeding grounds in the lower Duncan River was not fully understood at the initiation of the Duncan Dam water use planning process. Some residents feel that Duncan Dam operations exacerbate the mosquito problem in early August.

The Regional District initiated a mosquito control abatement program in 1997, which has continued to date. The mosquito control season is from about 1 June to 31 August.

Duncan Dam discharges are typically 3 m^3/s until mid-July when the reservoir is nearing full pool and discharge is increased. Therefore, any mosquito issues prior to mid-July are primarily related to freshet flows from the Lardeau River and

Meadow Creek, which typically peak by the beginning of July. Mosquito production can also be influenced by temperature, precipitation, and Kootenay Lake levels (Jackson, 2002). For the Duncan Dam water use planning process, the focus was on mitigating the negative impacts of higher flows in the lower Duncan River to avoid subsequent mosquito hatching events after the reservoir is nearing full pool in mid-July.

During the Duncan Dam water use planning process, the Consultative Committee undertook a study of the impact of Duncan Dam operations on mosquito breeding (Jackson, 2002). The following are key findings of the study:

- Duncan Dam operations do not impact the first hatch of mosquitoes typically after 1 June when dam discharges are typically 3 m^3/s, as this is caused by flows from the Lardeau River natural variables such as inflows from Lardeau River, Meadow Creek, snowmelt, rainfall, etc.

- The primary human nuisance mosquito species in this area are Aedes Vexans and Aedes Sticticus.

- Different vegetation types form mosquito species-specific breeding habitats. There is a link between vegetation types and the water regime. Low bench grasslands accounts for approximately 85 per cent of the total mosquito breeding area, but 95 per cent of the potential breeding area for the Aedes species. The Meadow Creek area was selected as the performance measure index site for the lower Duncan River floodplain because it is most influenced by Duncan Dam operations and it contains one of the largest potential breeding areas for the Aedes species. It was felt that if flows were changed to minimize mosquito breeding opportunities in the Meadow Creek area, then this would have a positive affect on other areas downstream as well.

- High flows in the lower Duncan River above 400 m^3/s can backflood the Meadow Creek area, which is characterized by low bench grasslands as well as infiltrate low-lying hayfields, causing re-flooding and triggering of mosquito hatching.

- Subsequent high flow events have less impact on mosquito breeding as long as flows are at or below previous high flows. Wetted areas suitable for egg hatching can be created within a 24- to 48-hour wetting period, which is assumed to allow completion of the mosquito life cycle.

- The impact of Duncan Dam operations on mosquito breeding is likely exacerbated during high snowpack years, delayed Lardeau River freshet, above average spring or summer temperatures, higher dam discharges, and Kootenay Lake levels.

The primary impact on mosquito breeding occurs when the warmer temperatures arrive and the melt water comes down all at once. This negative impact is increased when the Duncan Dam discharges water earlier (after reaching full pool), inundating grassland areas downstream. It was also noted that the worst mosquito hatch is not necessarily the first hatch of the season when the dam is discharging 3 m^3/s. It is also influenced by the magnitude and timing of dam releases subsequent to the first hatch and water temperatures in the lower Duncan River.

4.6.2 Issues

Table 4-5 summarizes the Quality of Life – Mosquitoes issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-5: Quality of Life – Mosquitoes Issues

Issue	Description and Action
Wetted Area – Grasslands	The impact of Duncan Dam operations on mosquito breeding depends on a number of variables, including the timing of Lardeau River flows, backwater effects from Kootenay Lake, magnitude, duration, and timing of Duncan Dam peak flows, seepage through natural and dike channels, and climatic factors (e.g., snowpack, rain events, temperature and groundwater effects). Jackson (2002) indicates that the area most affected by Duncan Dam operations and thought to be prime breeding grounds for the primary human nuisance mosquito species was the Meadow Creek area. This area has a tendency to backwater independent of dam operations because of a narrow highway crossing and some recent instream work. A performance measure was developed to address the mosquito issue in the lower Duncan River.
High Coliform Levels	High coliform levels are not known to be an issue on the Duncan Reservoir. Consultative Committee members were unaware of any reported cases of giardia. It was assumed that if there was a health risk, it would probably occur during the Rainbow Festival when large groups of people camp near the reservoir. A performance measure was not developed.
West Nile Disease	The West Nile disease, which is carried by mosquitoes, is a concern for local residents as the virus spreads into Western North America. A mosquito study undertaken during Step 5 of the Duncan Dam water use planning process (Acroluxus Wetlands Consultancy, 2002; refer to Section 5), indicates that the mosquito species that transfer the disease from birds to humans are present in the lower Duncan River. A performance measure was not developed.

4.6.3 Objective and Sub-objectives

Table 4-6 summarizes the Quality of Life – Mosquitoes objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-6: Quality of Life – Mosquitoes Objective and Sub-objectives

Objective	Maximize the quality of life for residents in the Duncan Dam area
Sub-objectives	Minimize the nuisance from mosquitoes[1]
	Minimize high coliform bacteria levels in Duncan Reservoir
	Minimize infectious diseases spread by mosquitoes(West Nile)

[1] No mosquito issues were associated with the Duncan Reservoir area.

4.6.4 Performance Measure

Table 4-7 summarizes the Quality of Life – Mosquitoes performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-7: Quality of Life – Mosquitoes Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Mosquito Breeding Habitat[1]	Weighted area-days inundated after Lardeau freshet 1 July to 31 August	Calculates the weighted inundated area based on the following weightings: • 1st Inundation: weight = 1 • 2nd Inundation: weight = 0.5 • 3rd Inundation: weight = 0.05	Lower Duncan River	1 July to 31 August

[1] This performance measure was merged with the Flood Risk performance measure into the Flood/Mosquito Risk performance measure because they behaved identically.

The ***Mosquito Breeding Habitat*** performance measure is defined as ***the weighted area-days re-flooded 1 July to 31 August***. This performance measure estimates the impact of Duncan Dam operations on mosquito breeding habitat in the lower Duncan River floodplain in late summer under different operating alternatives.

According to the assumptions of this performance measure, mosquito breeding habitat is maximized when operations and/or inflows are highly variable through the summer months. The greater degree of flooding and re-flooding, the larger the area of mosquito breeding habitat is created. Although multi-year effects are not calculated, it is assumed that any flooded habitats contained eggs from previous years' mosquito populations.

4.7 Fish

4.7.1 Duncan Reservoir

4.7.1.1 Background

The Duncan Reservoir is located in a steep sided valley with slopes often exceeding 30 per cent. Areas of lesser slope are confined to alluvial fans, terraces and the upper Duncan River floodplain. There are three main catchment areas draining into the reservoir: the upper Duncan River, Howser Creek and Glacier Creek. There are a number of other creeks around the reservoir that are ephemeral or steep in nature, which restrict fish use. Tributaries to the upper Duncan River have moderate to steep gradients, some of which have fish passage barriers.

Limited information exists on the status of fish stocks in the Duncan Reservoir, as well as specific timing of activities such as spawning and migration. Sport fish species identified in the reservoir include bull trout, rainbow trout, burbot, white sturgeon, cutthroat trout, kokanee, mountain whitefish, and pygmy whitefish. Non-sport fish species include lake chub, peamouth chub, longnose dace, finescale and largescale sucker, northern pikeminnow, redside shiner, prickly sculpin, slimy sculpin, and torrent sculpin. Bull trout and rainbow trout are known to use the lower reaches of the main tributaries for spawning and early rearing. Regional timing and general life history characteristics have been used in the absence of site-specific information.

Burbot are a Red-listed species in the Kootenays and of particular interest to First Nations. The status of the Duncan Reservoir burbot population is unknown and there is not strong scientific data to indicate the relative health of this population. One of the hypotheses considered by the Fish Technical Subcommittee was that burbot spawn at the interface of the reservoir and tributary mouths. If this hypothesis in proven correct, stable reservoir water levels during the burbot spawning and incubation period may be required to prevent egg loss through dewatering or suffocation (i.e., sediments from eroding riverbanks).

Bull trout are the primary target of the sport fishery in the Duncan Reservoir. Anglers target bull trout early in the spring when reservoir levels are low. The reservoir also serves as a corridor for Kootenay Lake bull trout that migrate through the Duncan Dam and spawn in the upper Duncan River.

The issue of debris management at tributary mouths and potential blockage of fish access was raised early in the Duncan Dam water use planning process. Debris booming areas (i.e., Cockle Creek) are now managed by BC Hydro to ensure that debris does not affect fish access. Due to Columbia River Treaty restrictions on how the reservoir is managed, this issue was dropped from further consideration.

The Fish Technical Subcommittee hypothesized that when the Duncan Reservoir is low, there is less reservoir volume, which could lead to increased feeding success of top predators.

4.7.1.2 Issues

Table 4-8 summarizes the Duncan Reservoir Fish issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-8: Duncan Reservoir Fish Issues

Issue	Description and Action
Littoral Productivity	Littoral habitat is the portion of the Duncan Reservoir along a shoreline that is penetrated by light. It is related to reservoir productivity in terms of a food source (invertebrates) and rearing habitat for fish. Littoral productivity is a function of water clarity, stability, and temperature (season). It is not known to what degree littoral productivity is limited in the Duncan Reservoir, or its function in terms of fish production. Results of a study (Perrin, 2002) concluded that not enough is known about the fish-littoral interaction to define operational constraints. A performance measure was not developed.
Pelagic Productivity	The pelagic zone is the portion of the Duncan Reservoir outside of the littoral zone that is penetrated by light. Pelagic productivity is a function of residence time of water in the reservoir, water clarity, and temperature. In general, a fuller and more stable reservoir through May to September will lead to higher pelagic productivity. It is not known to what degree pelagic productivity is limited in the reservoir, or its potential for improvement. It may be limited as a consequence of being a fairly glaciated system. Results of a study (Perrin, 2002) concluded that not enough is known about the fish-pelagic interaction to define operational constraints. A performance measure was not developed.
Fish Stranding	It is not known to what degree fish stranding occurs in the Duncan Reservoir, or which periods or elevations are most critical. Stranding is thought to occur at the far northern end of the reservoir when the reservoir is drawn down (i.e., typically in the early fall when dozens of isolated pools and ponds are formed at the confluence of the upper Duncan River). Although the Low Reservoir Impact Study (Golder, 2002) highlighted fish stranding as an issue, it did not quantify the impact of reservoir drawdown on fish stranding. A performance measure was developed to address this issue.
Entrainment	Entrainment refers to fish being injured or killed as they pass downstream over the spillway or through the low-level outlets. It is not known to what degree entrainment occurs or what the critical times are. Further, it is unclear whether there would be any benefit to encouraging fish to use the spillway over the low-level outlets, or if use of the spillway would create additional total gas pressure problems. It was noted that bull trout are surviving downstream migration through the dam. The Fish Technical Subcommittee concluded that a study to address these uncertainties would be complex and could not be completed within the time frame of the Duncan Dam water use planning process. A performance measure was not developed to address the entrainment issue based on the understanding that it would be addressed through a separate process investigating system-wide entrainment issues.

Table 4-8: Duncan Reservoir Fish Issues (cont'd)

Issue	Description and Action
Backwatering Effects	Backwatering effects refer to two potential impacts caused by rising Duncan Reservoir levels: flooding of eggs leading to reduced spawning success, and suffocation of eggs due primarily to intraground flow. It is not known if backwatering effects occur or to what degree. The Low Reservoir Impact Study (Golder, 2002) concluded that rainbow trout spawning was not affected by reservoir operations, but burbot habitat may be affected through erosion of upstream habitats or reduced spawning success due to backwatering or dewatering. A performance measure was initially developed to address effects on burbot spawning, but was subsequently dropped due to lack of substantive data to support the underlying hypothesis.
Burbot Spawning	It is unclear to what degree burbot spawn along the shores of the Duncan Reservoir, in the tributaries or more deeply in the reservoir. If they are shore spawners or use the tributaries in the drawdown zone, then the stability of the banks may play an important role in spawning success. The Low Reservoir Impact Study (Golder, 2002) undertook an assessment of the bank stability along the reservoir and in the drawdown zone of the tributaries and concluded that burbot spawning habitat may be affected through erosion of upstream habitats or reduced spawning success related to backwatering or, alternatively, dewatering. A performance measure was developed, but was not applied to decision analysis in the water use planning process due to uncertainty in the measure's assumptions. It was agreed that burbot would not be considered in the Committee's deliberations provided that a suitable burbot monitoring program would be implemented to address the identified uncertainties.
Tributary Access	Tributary access refers to blockage or passage issues of reservoir fish that cannot access spawning areas on tributaries because reservoir water levels are too low. The Low Reservoir Impact Study (Golder, 2002) concluded that this issue was not significant under Columbia River Treaty operations. A performance measure was not developed.
White Sturgeon Recovery	The Fisheries Technical Subcommittee assumed the position of the Ministry of Water, Land and Air Protection that Duncan Reservoir white sturgeon are part of the Kootenay Lake population and that the Duncan River system cannot sustain a sturgeon population under any operational regime. A performance measure was not developed.

4.7.2 Lower Duncan River

4.7.2.1 Background

The lower Duncan River extends 1 km along a man-made channel between the Duncan Dam and its confluence with the Lardeau River. From there, the river extends another 10 km where it enters the north end of Kootenay Lake.

During the Duncan Dam water use planning process, a geomorphologic assessment was undertaken to determine the impact of Duncan Dam operations on channel characteristics of the lower Duncan River (Miles 2002, Miles 2002a). The results of this assessment were to provide information to assist with discussions on fish and wildlife habitat during the water use planning process.

Results of the study indicate that the lower Duncan River channel is likely to aggrade over time due to regulation of peak flows.

Seventeen species of fish have been documented in the lower Duncan River, including rainbow trout, kokanee, bull trout, white sturgeon, cutthroat trout, mountain whitefish, pygmy whitefish, burbot, peamouth chub, longnose dace, umatilla dace, longnose sucker, largescale sucker, northern pike minnow, redside shiner, and slimy sculpin. Some study of bull trout, kokanee and rainbow trout (gerrard) has occurred in the lower Duncan River. However, there is a lack of information on life stages, times of year they are present, and habitat types utilized (Vonk, 2001). The lower Duncan River contains abundant high quality mainstem and sidechannel habitats for spawning, rearing and overwintering.

The Duncan River system historically represented an important source of spawning habitat for several sport fish species from Kootenay Lake including kokanee, rainbow trout, and bull trout. Fishing in the lower Duncan River is closed to all species except whitefish from 1 March to 15 April. The Duncan–Lardeau rivers system is a migration corridor for bull trout, Gerrard rainbow trout, and home to the largest run of spawning kokanee from Kootenay Lake. Many of these species utilize the river for all or a portion of their life cycle.

In addition to the potential impacts of Duncan Dam operations on fish habitat, the effects of maintenance activities were also discussed. Each year, trashrack maintenance or low-level outlet inspections require the complete shutdown of discharge from the dam for one day. In 2002, this process was observed for potential impacts to fish habitat (dewatering). It was found that a natural invert at the confluence of the Duncan Dam tailrace and Lardeau River maintains water in the tailrace channel and spillway plunge pool, thereby minimizing impacts to fish habitat. This issue was dropped from further consideration.

4.7.2.2 Issues

Table 4-9 summarizes the Duncan River Fish issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-9: Duncan River Fish Issues

Issue	Description and Action
Fish Stranding	Fish stranding refers to fish being trapped or isolated, either in sidechannels or on benched areas near the mainstem of the lower Duncan River, as flows decrease. This issue is related to the stability of sidechannel flows, which are most susceptible to dewatering events. A performance measure was developed to address this issue, and a stranding protocol was adopted.
Habitat Availability	Maximizing fish productivity in the lower Duncan River requires the provision of suitable spawning and rearing habitat through dam releases. Habitat area is a function of depth, velocity, substrate condition and cover. Because of timing issues and budget restrictions, the Duncan Dam water use planning process focused on wetted habitat to represent habitat availability. Several performance measures were developed.

Table 4-9: Duncan River Fish Issues (cont'd)

Issue	Description and Action
Mainstem Passage	Mainstem passage refers to bottlenecks in the mainstem where fish access to upper portions of the river is effectively blocked. The Fish Technical Subcommittee determined that burbot are the most susceptible to passage constraints, and that the other species of interest in the system are not likely to be affected by the range of flows being considered in the Duncan Dam water use planning process. An evaluation comparing velocity profiles to passable widths and a field assessment were completed in the mainstem (van Dishoeck and Gebhart, 2003). Based on study findings, no velocity barriers were identified in the lower river. A performance measure was developed, but subsequently dropped as performance measure outcomes substantiated the field assessment results.
Habitat Suitability	A number of variables influence the suitability and use of fish habitat by different life stages, including nutrients, food, water depth and velocities, temperature, gas pressure, cover, and water quality. It is not known which fish use which habitat types and how healthy their populations are in the lower Duncan River. Several performance measures were developed to address this issue.
Water Temperature	The degree to which water temperature affects fish species downstream of the Duncan Dam is currently unknown. However, information from the provincial government's *Water Quality Guidelines* was used to determine preferred temperature ranges for different fish species and life stages. It is known that there is a temperature differential associated with either discharging flows through the spillway (warmer) or through low-level outlets (colder). During the Duncan Dam water use planning process, a study (BC Hydro, 2003) confirmed that releases in 2002 did not increase water temperatures beyond levels critical to fish survival. A performance measure was not developed.
Total Gas Pressure	Dissolved gases may become supersaturated when air gets trapped in water and submerged to sufficient depth. Total gas pressure (TGP) levels above certain thresholds may subject fish and other organisms to injury or mortality. According to Fisheries and Oceans Canada, TGP levels above 115 per cent can be harmful to fish if they are maintained for a period of 4 to 5 days. It was also noted that TGP levels above 130 per cent could kill fish within hours. Monitoring of spill events at Duncan Dam indicates that spills greater than 114 m^3/s result in TGP levels above 115 per cent. Recent information (Aspen Applied Sciences, 2002) indicates the situation is most prominent during bull trout transfers when less water is passed through the low-level outlets and more water is spilled over the spillway. A performance measure was developed to address the risk of elevated TGP levels.
Tributary Access	As Duncan River water levels decrease, fish access to tributaries may be restricted. The Consultative Committee did not consider tributary access a significant issue for the Duncan Dam water use planning process based on the Fish Technical Subcommittee site visit. A performance measure was therefore not developed.
Kokanee Genetics	Members of the Fish Technical Subcommittee were concerned that the provision of spawning habitat for kokanee in the Duncan River was not adequately satisfied by operation of the Meadow Creek spawning channel. Assuming that a distinct stock of kokanee using the Duncan River mainstem would be best served by the provision of spawning flows, the Subcommittee used performance measures to evaluate habitat and promoted a review of kokanee spawning use in the monitoring period.

4.7.3 Kootenay Lake, Kootenay River and Columbia River Downstream

4.7.3.1 Background

Prior to the third round of trade-off analysis, cross-system power generation impacts were identified with the operating alternatives. Power generation losses at ALGS, owned by Arrow Lakes Power Corporation (a joint venture of Columbia Power Corporation/Columbia Basin Trust) resulted from additional spills during the early fall period to meet Columbia River Treaty flow requirements[1].

The impacts of decreasing and/or time-shifting power generation due to operating alternatives are manifested on both the Kootenay River and United States mainstem Columbia River. Estimating power generation at the United States plants required modelling the integrated operation of the entire Columbia River system. Initially, this was not within the scope of the Duncan Dam Water Use Plan. Therefore, the water use planning process was delayed while the Operations Model was modified, potential issues were identified and new power generation performance measures were developed.

Upon review and discussion by the technical subcommittees and the Consultative Committee, it was agreed that the Duncan Dam Water Use Plan operating alternatives were not significantly affecting Kootenay Lake levels, Kootenay River flows, or environmental interests below Hugh Keeneyside Dam other than power impacts at ALGS. The only new issue identified was the potential impact associated with nutrient transfer effects into the North Arm of Kootenay Lake.

4.7.3.2 Issues

Table 4-10 summarizes the fish-related issues identified by the Consultative Committee for Kootenay Lake, Kootenay River and Columbia River.

Table 4-10: Kootenay Lake, Kootenay River and Columbia River Downstream Fish Issues

Issue	Description and Action
Kootenay Lake Regulation Impacts	It was hypothesized that changes in Duncan Dam operations could impact Kootenay Lake elevations, thereby affecting spawning, stranding, access to tributaries, etc. However, upon review by the Fish Technical Subcommittee (FTC meeting #11), it was apparent that the suite of operating alternatives had little impact on Kootenay Lake. The FTC did not consider this issue further, and no performance measures were developed.

[1] The cause of the cross-system impacts was related to Columbia River Treaty flow requirements, which required certain flow volumes to be met from the combined discharges at Duncan and Hugh Keenleyside dams (including flows through ALGS). In many years, this meant that if flows needed to be reduced from Duncan Dam (in the fall and winter period), more water would have to be discharged through Hugh Keenleyside Dam and this was often beyond the capacity of ALGS. The result was therefore lost generating opportunities (i.e., spilling) and lower reservoir levels (i.e., lower performance of the power generators).

Table 4-10: Kootenay Lake, Kootenay River and Columbia River Downstream Fish Issues (cont'd)

Issue	Description and Action
Kootenay Lake Nutrient Loss (Duncan Reservoir Nutrient Retention)	It was hypothesized that changes in Duncan Dam operations could impact nutrient retention in the Duncan Reservoir, affecting throughput of nutrients to Kootenay Lake. Further review (Perrin and Leake, 2004; FTC meeting #12) estimated that nutrient retention was sensitive to operational alternatives. A performance measure was developed based on information in Perrin (1997).
Kootenay River Brilliant TGP	It was hypothesized that Duncan Dam operations could impact the frequency of total gas pressure (TGP) events in the Kootenay River below Brilliant Dam. Preliminary analysis (FTC meeting #11) indicated that the changes between operating alternatives were not significant. No performance measures were developed.
Kootenay River Lower Bonnington TGP	It was hypothesized that Duncan Dam operations would impact TGP events in the Kootenay River below Lower Bonnington. Preliminary analysis (FTC meeting #11) indicated that the changes between operating alternatives were not significant. No performance measures were developed.
Kootenay River Stranding below Brilliant	It was hypothesized that Duncan Dam operations would impact stranding events below Brilliant. Preliminary analysis (FTC meeting #11) indicated that the differences between operating alternatives were not significant enough to warrant further analysis. No performance measures were developed.
Columbia River Whitefish and Rainbow Trout Flows	A quick review (FTC meeting #11) of the operations requirements indicated that flow provisions for fish below Hugh Keenleyside Dam would not be compromised by Duncan Dam operations. No performance measures were developed.
Columbia River TGP below Hugh Keenleyside Dam	Following a review of the Duncan Dam impact on Hugh Keenleyside Dam TGP (FTC meeting #11), a performance measure was developed to assess the possible TGP risk effects of Duncan Dam operations. Although there were measurable differences particularly with naturalized alternatives, the FTC agreed that the significance of these effects were low in comparison to the reduction in TGP resulting from Arrow Lakes Generation System operations. No performance measures were developed.
Columbia River Entrainment at Hugh Keenleyside Dam	A review of the potential outcomes from an entrainment performance measure resulted in the FTC dropping the issue due to conflicts with the Duncan Dam Water Use Plan environment objectives. No performance measures were developed.

4.7.4 Objective and Sub-objectives

Table 4-11 summarizes the Fish objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-11: Fish Objective and Sub-objectives

Objective	Maximize fish abundance and diversity
Sub-objectives	Duncan Reservoir: • Maximize littoral productivity • Maximize pelagic productivity • Minimize fish stranding • Minimize egg mortality associated with tributary backwatering • Minimize entrainment risk • Maximize white sturgeon populations • Maximize burbot spawning success • Maximize bull trout populations • Maximize tributary access to spawning tributaries • Maximize nutrient loading in the North Arm of Kootenay Lake from Duncan Reservoir Lower Duncan River: • Minimize fish stranding risk • Minimize total gas pressure (TGP) effects • Minimize temperature effects • Maximize tributary access • Maximize habitat suitability • Maximize food availability • Minimize any fish passage issues in the mainstem

4.7.5 Performance Measures

4.7.5.1 Duncan Reservoir

Table 4-12 summarizes the Duncan Reservoir Fish performance measure.

Table 4-12: Duncan Reservoir Fish Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Fish Stranding Risk	*Average Daily Dewatered Area* m^2	*Days where reservoir elevations are decreased, the average dewatered area is calculated and reported for the year.*	*Duncan Reservoir*	*Year-round*

The ***Fish Stranding*** performance measure is defined as ***the average daily dewatered area in the Duncan Reservoir***. This performance measure estimates the relative risk of fish stranding in Duncan Reservoir under different operating alternatives.

Due to the lack of information linking reservoir drawdown with fish stranding, the ***Fish Stranding Risk*** performance measure was not presented to the Consultative Committee. However, the performance measure was reviewed by the Fish Technical Subcommittee throughout the Duncan Dam water use planning process to determine whether there was a stranding risk associated with any of the operating alternatives.

4.7.5.2 Duncan River

The Duncan River Fish performance measures were developed and revised as appropriate throughout the Duncan Dam water use planning process as new information was gained during the data collection phase. Limited data were collected to develop performance measures that were representative of fish habitat and flow relationships, and further data collection is required to validate and improve the performance measures. The Fish Technical Subcommittee recommended several monitoring studies to improve performance measure relationships for future water use planning processes (refer to Section 8).

Table 4-13 summarizes the Duncan River Fish performance measures used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-13: Duncan River Fish Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Kokanee and Whitefish Effective Spawning Habitat	Hectares of effective spawning habitat	HEC modelling results are integrated with instream flow data to determine the amount of spawning habitat that remains effective to the end of incubation.	Lower Duncan River Mainstem and Sidechannels	Kokanee: spawning 7 September to 21 October and incubating to 15 June Whitefish: spawning 21 October to 21 December and incubating to 31 May
Whitefish Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	HEC modelling results are integrated with instream flow data to determine what habitat was available during spawning, but subsequently dewatered during incubation.	Lower Duncan River Mainstem	Whitefish: spawning 21 October to 21 December and incubating to 31 May
Rainbow Effective Rearing Habitat Lost	Hectares of effective rearing habitat lost	HEC modelling results are integrated with instream flow data to determine the amount of rearing habitat that is dewatered over a running 10-day rearing period.	Lower Duncan River Mainstem	Rainbow: rearing 1 April to 31 October
Significant Events (>0.2 m and >0.45 m) Measures	*Number of stranding events*	*Based on HEC modelled overall river stage versus flow relationship, counts the number of times dam operations cause a downstream stage change >0.2 m and 0.45 m*	*Lower Duncan River Mainstem*	*Year-round*

Table 4-13: Duncan River Fish Performance Measures (cont'd)

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Total Gas Pressure Days/Events	*Number of Total Gas Pressure Days and Events*	*Based on an empirical relationship between spill magnitude and TGP concentration, counts the number of days TGP exceeds 115% through spilling and the number of events where consecutive days exceed 115%.*	*Lower Duncan River (spillway plunge pool)*	*Year-round (bull trout transfer set 1 May to 15 September)*
Whitefish and Kokanee Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The amount of habitat available during spawning but subsequently lost over incubation is calculated.	Lower Duncan River Sidechannels	Kokanee: spawning 7 September to 21 October and incubating to 15 June Whitefish: spawning 21 October to 21 December and incubating to 31 May
Rainbow Effective Rearing Habitat	*Hectares of effective rearing habitat*	*HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The minimum amount of habitat available over a running 10-day period is calculated.*	*Lower Duncan River Sidechannels*	*Rainbow: Rearing 1 April to 31 October*
Rainbow and Kokanee Effective Rearing Area Lost	*Hectares of effective rearing habitat lost*	*HEC modelling and field validation is integrated with instream flows to calculate sidechannel-wetted areas. The amount of rearing habitat dewatered over a running 10-day period is calculated.*	*Lower Duncan River Sidechannel*	*Kokanee: emigration 1 April to 31 May* *Rainbow: Rearing 1 April to 31 October*

The ***Kokanee and Whitefish Effective Spawning Habitat*** performance measures are defined as ***the area, in hectares, that has the potential to provide effective spawning mainstem habitat that is successful to the end of the incubation period***. These measures are evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.
- Kokanee: spawning 7 September to 21 October, incubating to 15 June.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is not dewatered over the spawning incubation period for whitefish and kokanee under different operating alternatives.

The ***Whitefish Effective Spawning Habitat Lost*** performance measure is defined as ***the area, in hectares, of effective whitefish mainstem habitat lost over the spawning period*** (i.e., those habitats that are spawned in, but not effective). This measure is evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is dewatered and lost over the spawning incubation period for whitefish under different operating alternatives.

The ***Rainbow Effective Rearing Habitat Lost*** performance measure is defined as ***the area, in hectares, of effective rainbow and kokanee rearing mainstem habitat lost over the rearing period*** (i.e., those habitats that are available for rearing and then dewatered). This measure is evaluated for:

- Rainbow: rearing 1 April to 31 October. The rainbow-rearing period overlaps the kokanee emigration period (1 April to 30 May) and is, therefore, the indicator for both species.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is dewatered and lost over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

The ***Significant Events*** (>0.2 m and >0.45 m) performance measure is defined as ***the number of operational changes annually and seasonally that result in "overall river stage change" greater than 0.2 and 0.45 m respectively.*** This performance measure provides an indication of stranding risk under different operating alternatives. Overall, river stage change is a weighted average of cross sectional relationships between discharge and water surface elevation (stage) for the entire river.

The ***Total Gas Pressure Days/Events*** performance measure is defined as ***the number of days when TPG levels are greater than 115 per cent through spilling and the number of events where consecutive days exceed 115 per cent.*** This performance measure estimates the quantity of TGP under different operating alternatives.

The ***Whitefish and Kokanee Effective Spawning Habitat Lost*** performance measure is defined as ***the area, in hectares, of effective whitefish and kokanee rearing sidechannel habitat lost (i.e., those habitats that are spawned in but not effective).*** This measure is evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.
- Kokanee: spawning 7 September to 21 October, incubating to 15 June.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is dewatered and lost over the spawning incubation period for whitefish and kokanee under different operating alternatives.

The ***Rainbow Effective Rearing Habitat*** performance measure is defined as ***the area, in hectares, of effective rainbow rearing sidechannel habitat available (wetted area stable for 10 days).*** This measure is evaluated for:

- Rainbow: rearing 1 April to 31 October. The rainbow rearing period overlaps the kokanee emigration period (1 April to 30 May), and is therefore the indicator for both species.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is not dewatered over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

The ***Rainbow and Kokanee Effective Rearing Habitat Lost*** performance measure is defined as ***the area, in hectares, of effective rainbow and kokanee rearing sidechannel habitat lost***. This measure is evaluated for:

- Kokanee: emigration period 1 April to 31 May.
- Rainbow: rearing period 1 April to 31 October.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is dewatered and lost over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

4.7.5.3 Kootenay Lake, Kootenay River and Columbia River

Table 4-14 summarizes the fish performance measure for Kootenay Lake, Kootenay River and Columbia River used by the Consultative Committee to evaluate alternatives for the Duncan Dam facility.

Table 4-14: Kootenay Lake, Kootenay River and Columbia River Downstream Fish Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Reservoir Nutrient Retention	*Tonnes of dissolved phosphorus retained annually*	*Compared to an agreed baseline, this calculation is based on the difference between the phosphorous loading (reservoir inflows) and release from the dam.*	*Duncan Reservoir*	*Year-round*

Nutrient Retention is defined as ***the disruption of nutrient flow to Kootenay Lake***. This performance measure estimates the quantity of total dissolved phosphorous (TDP) retained in the Duncan Reservoir, as governed by reservoir elevations, outflow rates and inflow TDP concentrations under different operating alternatives.

The ***Nutrient Retention*** performance measure was used by the Fish Technical Subcommittee to determine the amount of funding required to compensate for the loss of nutrients to Kootenay Lake due to Duncan Dam operations.

4.8 Cultural Resources

4.8.1 Background

The linkages between aboriginal people and the Duncan River system are long and enduring. The mountains provide for spiritual retreats and seasonal gathering areas. The passes, valleys and the lake and river systems provided routes for travel, transportation and associated trade. Further, these valleys and aquatic systems provided fresh water and abundant food supplies. They played an important role in constraining large mammal migration and travel, providing opportunities for efficient harvest.

Historically, the Duncan River system (Duncan Lake, upper and lower Duncan River) was used by aboriginal people possibly as a hunting and/or harvesting area, and seasonal habitation. This habitation is evidenced by artifacts found during the data collection study conducted during the Duncan Dam water use planning process. Typically, where people live, they gather for sustenance, so it is reasonable to speculate that the Duncan River and surrounding areas would have been a source of food and materials. Examples of food would be cranberries or similar berries that would likely have existed in historic times, small game such as birds and rabbits, and deer or other ungulates. Examples of materials collected include roots, grasses, reeds, bark and other plant materials used to create implements such as baskets, spoons, and the well-known sturgeon-nosed canoe. Stone could have also been collected to be fashioned into mortar and pestle and other tools.

4.8.2 Issues

Habitation sites are associated with areas that provide access to resources important to aboriginal people. Wherever suitable land forms existed along travel corridors and particularly where they intersect, past habitation is likely to have occurred. Archaeological artifacts found on three sites located in the Duncan Reservoir (Choquette, 2002) provide evidence of past habitation. The artifacts included stone butchering (chopping) tools as well as many lithic (stone chips) and points (spearheads), which were made from a number of different types of stone. Some of these materials are thought to have been transported to the sites, rather than having originated there.

During the Duncan Dam water use planning process, an archaeological overview study was undertaken and two cultural sites were identified. These sites are extremely rare and have been defined as being globally significant given their age, location, and the condition (intactness of the materials found). The archaeologist speculated that these sites have been just recently exposed because of erosion within the drawdown zone of the reservoir. The archaeologist believed that erosion is causing significant degradation of these sites and will likely destroy them in the next few years if no immediate action is taken.

Given the elevation levels of culturally important sites identified in the Duncan Reservoir drawdown zone within two ranges of reservoir elevations (1) 552 m to 567 m, and (2) above 575 m, modifications to operations may stop the deterioration of the sites. Operational changes to improve riparian habitat for fish, wildlife and other resource interests, coupled with non-operational physical works such as re-vegetation of the drawdown zone, may have indirect positive benefits for cultural resources. For example, improved vegetation complexes in riparian areas help stabilize erodible materials, reducing potential erosion or exposure of cultural materials. Vegetation may also provide sufficient ground cover to mask exposed cultural deposits, minimizing unauthorized collection. Other physical works options such as riprap or non-woven geotextile blankets could also be considered to prevent the degradation of two cultural sites located in the Duncan Reservoir.

4.8.3 Objective and Sub-objectives

Table 4-15 summarizes the Cultural Resources objectives developed by the Heritage and Cultural Subcommittee and presented to the Consultative Committee for the Duncan Dam water use planning process.

Table 4-15: Cultural Resources Objectives

Objectives	Protect cultural sites and resources from erosion in the Duncan Reservoir
	Protect cultural sites and resources from exploitation in the Duncan Reservoir
	Provide opportunities for archaeological investigation in the Duncan Reservoir
	Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites
	Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River (*included in Fish and Wildlife Performance Measures*)

4.8.4 Performance Measures

Two Cultural Resource performance measures were developed based on information gained from Traditional Use and Archaeological studies (Keefer, 2002; Choquette, 2002; refer to Section 5) and discussions with the Ktunaxa–Kinbasket Tribal Council and Canadian Columbia River Inter-Tribal Fisheries Commission representatives. The performance measures indicate the level of potential impacts to cultural sites within the drawdown zone of Duncan Reservoir. The first performance measure relates to erosion impacts caused by wave action and other hydrological effects. The second performance measure relates to exploitation impacts associated with theft or damage by unauthorized collectors and damage by recreationalists. Both performance measures related to the time that the reservoir is at undesirable elevations and then weighting factors are applied to take into account priorities of the sites, time of the year, and whether the reservoir is filling or draining.

Table 4-16 summarizes the Cultural Resources performance measures used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility. The Exploitation Impacts performance measure (presented in italics) was assessed by the Cultural and Heritage Technical Subcommittee, but was not presented to the Consultative Committee, as it was insensitive across operating alternatives.

Table 4-16: Cultural Resources Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Cultural Site Erosion	Number of weighted days reservoir is operated within specified bands	The number of days the reservoir elevation is operated in each band where cultural sites exist multiplied by a weighting factor to consider the impacts of dewatering or inundation.	Duncan Reservoir	Year-round
Exploitation Impacts	*Number of weighted days reservoir is at undesirable elevations*	*The duration of time the reservoir is operated within elevation bands where cultural sites exist by a weighting factor describing site importance.*	*Duncan Reservoir*	*Key times in the spring, summer and fall*

The ***Cultural Site Erosion*** performance measure is defined as ***the number of weighted days the reservoir is operated within specified bands***. This performance measure estimates the impact of Duncan Dam operations on the protection and integrity of cultural sites identified in the Duncan Reservoir drawdown zone within two ranges of reservoir elevations (1) 552 m to 567 m, and (2) above 575 m, under different operating alternatives.

4.9 Wildlife

4.9.1 Duncan Reservoir

4.9.1.1 Background

Wildlife utilize the area around the Duncan Reservoir for feeding, breeding, and living. Ungulates, bear, aquatic mammals, and nesting waterfowl have been identified in the study area (Herbison et al., 2002). Wildlife issues identified include: limited valley bottom habitat, wildlife mortality if ungulates fall through the ice, and influences of reservoir operations on riparian habitat (forage, perching and nesting trees, shrubs). Riparian and herbaceous vegetation in the reservoir drawdown zone is important in that it provides an early spring food source for animals. The primary interest that Wildlife Technical Subcommittee members feel they can impact through water use planning is maximizing the amount of shrub habitat and minimizing impacts on grasses and sedges in the upper drawdown zone.

Naturalists, hunters, trappers, and guides have an interest in wildlife in both the Duncan Reservoir and the lower Duncan River.

4.9.1.2 Issues

Table 4-17 summarizes the Duncan Reservoir Wildlife issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-17: Duncan Reservoir Wildlife Issues

Issue	Description and Action
Devils Creek Wetlands	Located at the head of the Duncan Reservoir, the Devils Creek Wetlands are considered a high priority area for wildlife interests. The area is fed by natural springs and is not affected by Duncan Dam operations. A performance measure was not developed.
Bear Trap Flats and Creek fans	Bear Trap Flats is located within the drawdown zone of the Duncan Reservoir and has very good soil. Both Bear Trap flats and the low gradient portions of creek fans around the reservoir perimeter are viewed as good areas to focus on for improving the reservoir riparian area. In July 2002, an overview assessment of drawdown zone vegetation was undertaken in the Duncan Reservoir (Moody, 2002; refer to Section 5). This study concluded there was limited opportunity to expand the herbaceous community, but potential for significant gains in shrub area. A performance measure was developed to address riparian productivity in the drawdown zone of the reservoir.
Upland Forest (East and West)	The upland forest is considered a high priority area for wildlife interests. However, the area is not affected by Duncan Dam operations. A performance measure was not developed.

4.9.2 Lower Duncan River

4.9.2.1 Background

The Consultative Committee considered the value of riparian and wetland habitat in the lower Duncan River valley very high from a wildlife perspective. Wetlands provide habitat for aquatic insects, vegetation species, beaver, muskrat, painted turtles and various species of birds. The large wetland at the southeast corner of the floodplain (known as Argenta Slough and Wetland) is in danger of succumbing to erosion. The amount and diversity of riparian habitats is not quantified. Wildlife Technical Subcommittee members feel that riparian habitat in the lower Duncan River is the most likely habitat to be affected by changes in water regimes. Multiple species benefit from a diverse riparian community. Cottonwood regeneration was selected as an index species for riparian health as this species is often most affected by water regulation.

Based on information summarized in Herbison (2003), cottonwood forests were chosen as an indicator of riparian success due to the fact that successful cottonwood establishment is extremely sensitive to elements of the natural hydrograph affected by operations. Throughout the water use planning process, the "cottonwood hydrograph" was transformed to fit into alternatives of interest to the Consultative Committee. The elements of the hydrograph that were sought in any alternative were:

- "Natural" reductions in flows during ramp down operations.
- Maximum flows of 250 m^3/s over the fall and early winter period.
- Peak flows in early to mid-summer.
- Disruptive or channel changing flows in the spring/early summer.

While channel forming flows were not appropriate due to conflicts with flooding, it was believed that the natural inflows of Lardeau River would contribute to erosion and depositional areas considered critical to the successful establishment of cottonwood to the lower Duncan River.

4.9.2.2 Issues

Table 4-18 summarizes the lower Duncan River Wildlife issues identified by the Consultative Committee and how each issue was addressed through the process.

It should be made clear, perhaps using a footnoted definition, that "recruitment of cottonwood" in the context of the Duncan WUP is defined specifically as the recruitment of cottonwood from naturally produced and naturally dispersed seed. Recruitment from seed is required in order to maintain genetic diversity and diversity of age-classes.

Table 4-18: Lower Duncan River Wildlife Issues

Issue	Description and Action
Coniferous, Deciduous, Valley Bottom Forests	The coniferous, deciduous, valley bottom forests are considered a high priority area for wildlife interests. However, the area is not influenced by Duncan Dam operations. A performance measure was therefore not developed.
Advanced/Young Shrub Communities and Young Cottonwood[1]	While maintaining a diversity of riparian habitats in the lower Duncan River is a sub-objective within the Duncan Dam water use planning process, it is recognized that measuring each species that comprises the community would be difficult. Therefore, cottonwoods were chosen as an indicator species for riparian health. Factors influencing cottonwood recruitment include presence of exposed mineral soil, peak flows and recession limb suitable for seed germination and growth as well as limiting water levels in the first year of growth which may flush seedlings away. A study undertaken during the Duncan Dam water use planning process indicated that there has been fairly constant recruitment of cottonwoods in the lower Duncan River (Herbison, 2003; refer to Section 5). A performance measure was developed.

Table 4-18: Lower Duncan River Wildlife Issues (cont'd)

Issue	Description and Action
Beach Shoreline	The sand dunes by Kootenay Lake are increasing in size. It is considered important to encourage recruitment of vegetation in this area. The interaction between Kootenay Lake levels and Duncan River flows on the vegetative zones is not well understood. The beach shoreline is susceptible to fluctuating Kootenay Lake levels, of which Duncan River flows are only a minor contributor. A performance measure was not developed.
Marsh Wetlands	Marsh wetlands are considered a high priority area for wildlife. Both Duncan River levels and Kootenay Lake levels play an important role in the water regime needed for the wetland; however, the Duncan Dam water use planning can only partially impact the former. It was noted that if erosion continues along the last meander of the mainstem of the Duncan River before it enters Kootenay Lake, it threatens the entire wetland as it may breach the riverbank and drain the water from it. A performance measure was not developed, but a non-operational physical works was recommended by the Consultative Committee (refer to Appendix H: Non-Operational Physical Works).
Log Jams	Prior to the 1960s, log jams were removed from the lower Duncan River by use of dynamite. The Consultative Committee acknowledged that there were limited opportunities to minimize log jams with changes to Duncan Dam operations, given constraints of the Columbia River Treaty.

[1] Recruitment in the Duncan Dam water use planning process was defined specifically as the recruitment of cottonwood from naturally produced and naturally dispersed seed. Recruitment from seed is required in order to maintain genetic diversity and diversity of age-classes.

4.9.3 Objective and Sub-objectives

Table 4-19 summarizes the Wildlife objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-19: Wildlife Objective and Sub-objectives

Objective	Maximize the quality and quantity of available habitat area for wildlife
Sub-objectives	• Maximize riparian (wetland) production for breeding and migration habitat • *Maintain a diversity (species and age classes) of riparian habitats in the lower Duncan River using cottonwood as an indicator* • *Maximize herbaceous and shrub communities in the Duncan Reservoir*

4.9.4 Performance Measures

4.9.4.1 Duncan Reservoir

Table 4-20 summarizes the Duncan Reservoir Wildlife performance measures used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-20: Duncan Reservoir Wildlife Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Riparian Productivity - Long-term Median	Hectares of herbaceous riparian habitat	Calculates the area between full pool and the long-term median elevation over the growing season that has been shown in other reservoirs to be a good approximation of grassland habitat.	Duncan Reservoir drawdown zone	Growing season 1 April to 31 October
Riparian Productivity - Inundation Tolerance	Hectares of herbaceous (grass/sedge) area Hectares of shrub (sedge/willow) area	Using inundation tolerances based on results in other reservoirs and professional opinion, calculates the area of potential riparian growth divided between shrubs and herbaceous within the drawdown zone.	Duncan Reservoir drawdown zone	Growing season 1 April to 31 October

The ***Riparian Productivity - Long-term Median*** performance measure is defined as ***the area of herbaceous vegetation in the drawdown zone above the long-term median reservoir elevation mark.***

The ***Riparian Productivity - Inundation Tolerance*** performance measures are defined as ***the area of potential grassland and shrub growth areas in the reservoir drawdown zone.***

These performance measures estimate the impact of changes in herbaceous and shrub riparian productivity under different operating alternatives.

4.9.4.2 Lower Duncan River

Table 4-21 summarizes the Wildlife performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-21: Lower Duncan River Wildlife Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Cottonwood hydrograph weighted index	0 to 1 scale where 1 represents an optimal cottonwood hydrograph It was also represented as a percentage	Three criteria define a cottonwood hydrograph: a. Peak flows in July; b. Recession of flows by late August; and c. Lower base flows until the following freshet. The performance measure quantifies the difference between the operation and the cottonwood hydrograph targets.	Lower Duncan River	Year-round

The ***Cottonwood Hydrograph Weighted Index*** performance measure is defined as ***the difference between the operating alternative and the cottonwood hydrograph targets.***

This performance measure estimates the value of a particular flow in comparison to those aspects of the natural hydrograph that contribute to the recruitment of cottonwoods in the lower Duncan River. The measure incorporates the impact of the Lardeau River and information on conditions that may have led to past cottonwood recruitment from seed, including peak discharge, seed dispersal timing, and recession limb characteristics. Because the measuring point of the historic impacts analysis was above the confluence point of Meadow Creek and Cooper Creek, this performance measure does not include their flow magnitudes in the assessment of flooding risk in the lower Duncan River.

4.10 Flood Management

4.10.1 Background

The Duncan Reservoir was constructed under the Columbia River Treaty to mitigate downstream (Canada and United States) flooding and provide additional power generation on the Kootenay River generation system. The Duncan Dam is a storage facility with no generation equipment.

Flood mitigation benefits from the Duncan Reservoir result from the ability of the project to store water during the freshet when peak inflows occur, and release it later in the year when natural flows are lower. Each of the Columbia River Treaty projects is operated to reserve space for flood control by means of a rule curve that specifies the minimum amount of empty storage space that must be provided each month of the year, based on the total volume of inflow that is forecast. These flood operational constraints are designed to mitigate flooding downstream on the Columbia River both in Canada and in the United States. During flood events, reservoir space may be refilled above these rule curves, in accordance with regular operations studies, if necessary to prevent floods greater than the accepted control flow objective.

While some of the Columbia River Treaty projects have Flood Control Rule Curves that are based on total volume forecasts for the entire Columbia River basin, the Duncan Reservoir Flood Control Rule Curve is based only on the volume forecast for the reservoir itself. In particular, the Duncan Reservoir Flood Control Rule Curve begins the annual drawdown at the beginning of December following a fixed curve, and moving to a variable curve on 1 January. The variable curve is based on the April through August total volume forecast. Minimum and maximum rule curves are specified. If the forecast is less than the minimum, the minimum curve is used. Similarly, if it is greater than the maximum, the maximum curve is used. For forecasts between the minimum and the maximum, the rule curve is interpolated based on the actual forecast.

There are two major storage projects on the Kootenay River: Duncan Dam and Libby Dam. Water from both of these projects is discharged into Kootenay Lake, which is a natural lake with outflow controlled by a channel restriction at Grohman Narrows west of Nelson, and also to a limited degree by the Cora Linn Dam downstream of Grohman Narrows. To mitigate flooding on Kootenay Lake, the International Joint Commission (IJC), established by the Boundary Waters Treaty, has established a rule curve that specifies an upper bound on water levels on the lake at the Queens Bay gauge. As with the Columbia River Treaty flood control curves, the Duncan River system operation must adhere to the IJC rules.

The storage capability of the Duncan Reservoir and its operations for flood control under the Columbia River Treaty have mitigated flooding on the Duncan River between Duncan Dam and Kootenay Lake by reducing the level of peak flows during the freshet. As a result, extent of inundation of the Duncan River floodplain has been reduced since the dam was constructed.

4.10.2 Issues

Table 4-22 summarizes the Flood issues identified by the Consultative Committee and how each issue was addressed through the process.

Table 4-22: Flood Issues

Issue	Description and Action
Local Inundation	When high flow events occur on the lower Duncan River, there are a several areas of private property within the floodplain known to have inundation problems. These include Cooper Creek Sawmill, other low lying property and several hay fields including Rempell and Deer farms. Observations of locations and discharge flows at which flooding started to occur was documented during the high flow event in July 2002. Flooding in the lower Duncan River occurs as a result of water table increase and seepage through dikes and natural barriers at combined Lardeau/Duncan rivers discharges of approximately 400 m^3/s. Above this flow, surface water begins to flow over natural barriers and dikes increasing the degree to which low lying areas are being flooded. Three levels of risk were defined based on observed flooding impacts: **400 m^3/s** – No surface water pooling in farmland, **450 m^3/s** – Water overtop banks at Cooper Creek Cedar, low level flooding at Rempell and Jacobs properties, and **500 m^3/s** – Water into electrical shed at Cooper Creek Cedar – mill shut down. Extensive flooding of low lying hayfields. Timing of flooding (after 7 August) could benefit hay farmers; however, timing would not impact flooding impacts at Cooper Creek.

Table 4-22: Flood Issues (cont'd)

Issue	Description and Action
Local Inundation (cont'd)	It is known that localized flooding can and does occur because of uncontrolled discharges of Meadow Creek and the Lardeau River (independently of discharges from the Duncan Dam). The carrying capacity of Meadow Creek channel is currently below that of freshet flows and, therefore, flooding impacts are exacerbated by constrictions associated with culvert and bridge crossings on Highway 21. The Lardeau River is also known to cause flooding events when the Duncan Dam is releasing its minimum flow release. Flooding in the lower portions of the river are also known to be exasperated when Kootenay Lake levels are high (which is typically the case during freshet flows in the late spring). BC Hydro is developing a communication protocol, which would provide advanced notice of potential flooding for farmers and other property owners subject to flooding in the floodplain to assist in proactive response to potential flooding. A performance measure was developed.
Erosion	Erosion was an important issue for some local residents. Erosion was speculated to have increased as a result of higher flows being released in the winter time, which causes scouring behind the frozen face of the banks of the river and sidechannels, and then the outer frozen face of the bank caving in once temperatures increase. Erosion problems are thought to exist adjacent to two properties: (1) owned by Chris von Ruh (formerly owned by Roy Lakes); and (2) referred to as the Wasden farm. M. Miles and Associates (2002) undertook a review of channel stability in the lower Duncan River with an overview assessment of erosion. Erosion is thought to be an ongoing process in the lower Duncan River, which will continue regardless of dam operations and can be influenced by man's activities (cutting of riparian vegetation, land use patterns, etc.) (Miles, 2002b). A performance measure was not developed.

4.10.3 Objective and Sub-objectives

Table 4-23 summarizes the Flood objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-23: Flood Objective and Sub-objectives

Objective	Minimize the flood damage to people and property on the lower Duncan River
Sub-objective	• Minimize flooding on the lower Duncan River • Minimize effects of erosion and sediment deposits • Maximize flexibility of operations to deal with flooding issues • *Minimize log jams in the lower Duncan River*

4.10.4 Performance Measures

Table 4-24 summarizes the Flood Risk performance measure used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-24: Flood Performance Measure

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Flood Risk[1]	Annual average number of days that flows in the lower Duncan River exceed threshold levels	Three threshold levels have been identified as follows: • 400 m^3/s • *450 m^3/s* • *500 m^3/s* These flows include tributary inflows from the Lardeau River.	Lower Duncan River	Year-round

[1] This performance measure was merged with the Mosquito Breeding Habitat performance measure into Flood/Mosquito Risk performance measure because they behaved identically.

The ***Flood Risk*** performance measure is defined as ***the number of days that flows in the lower Duncan River exceeds threshold levels***. This performance measure estimates the quantity of flooding under different operating alternatives.

Performance measure results for >450 m^3/s and >500 m^3/s flood threshold indicated a lack of sensitivity across the range of operating alternatives, and were therefore dropped from further consideration. The >400 m^3/s flood threshold was utilized throughout the Duncan Dam water use planning process.

4.11 Power Generation

4.11.1 Background

The seasonal operation of the Duncan Reservoir to provide flood control also benefits power generation. Since the generating stations on the Kootenay and Columbia rivers do not have the capacity to pass the annual peak inflows through the turbines, excess water is spilled and unavailable for power generation. The full turbine discharge capability varies from project to project, and optimal power generation results when the water is released from storage in such a fashion that no spill occurs at the downstream plant with the minimum turbine capacity.

The power generation benefits of Duncan and Libby storage extend beyond the Kootenay River to the mainstem Columbia River. With the exception of Grand Coulee, the United States projects are effectively run-of-river, and must spill water that can not be used for power generation. The Grand Coulee Reservoir, while large, does not have the storage capacity to regulate flows in the Columbia River, and hence the need for the Columbia River Treaty projects upstream.

Under the terms of the Columbia River Treaty, the combined outflow of the Columbia and Kootenay rivers generating plants is regulated to provide power benefits to both Canada and the United States. Thus the drafting of the Duncan Reservoir is affected by Columbia River Treaty operations.

In a typical water year, operations that are optimal for power generation will draft the Duncan Reservoir lower in the spring, and hold the reservoir higher in the fall than would otherwise be required solely for flood control.

The costs associated with sub-optimal power generation arise from:

- Operations that increase the amount of water that is spilled at one or more downstream generating plants that could otherwise have been used for power generation.
- Operations that increase power generation during time periods when the value of generation is typically lower (i.e., March through June when supply is great and demand low, or within day shifts from higher value daytime generation to lower value night-time generation).
- Operations that decrease power generation during time periods when the value of generation is typically higher (the reverse of the examples noted above).
- Operations that require spilling from Hugh Keenleyside Dam, or curtailed generation from ALGS to meet downstream Columbia River Treaty requirements.

The impacts of decreasing and/or time-shifting power generation due to operating alternatives will be manifested on both the Kootenay River and United States mainstem Columbia River. However, estimating power generation at the United States plants requires modelling the integrated operation of the entire Columbia River system, which was not within the scope of the Duncan Dam Water Use Plan. As such, only the decreased value of generation on the Kootenay River system and at ALGS was modelled and evaluated in the Duncan Dam Water Use Plan alternatives.

4.11.2 Issues

4.11.2.1 Cross-System Impacts

The impacts of decreasing and/or time-shifting power generation due to operating alternatives are manifested on both the Kootenay River and United States mainstem Columbia River. However, estimating power generation at the United States plants requires modelling the integrated operation of the entire Columbia River system. Initially, this was not within the scope of the Duncan Dam Water Use Plan.

Prior to the third round of trade-off analysis, it became apparent that the operating alternatives could affect power interests on the lower Columbia River system. Power generation losses at the ALGS resulted from additional spills during the early fall period to meet Columbia River Treaty flow requirements[1]. The Operations Model used to simulate operating alternatives for the Duncan Dam water use planning process did not account for this cross-system impact. As a result, the BC Hydro Operations Model and the power generation performance measures were modified to incorporate an estimation of the power impacts on the lower Columbia River plants at the outlet of Arrow Lakes Reservoir.

4.11.2.2 Columbia River Treaty Flood Control Rule Curves

Regulation of the Duncan Reservoir for flood control purposes in Canada and the United States is governed by the Columbia River Treaty Flood Control Operating Plan (FCOP), developed by the U.S. Army Corps of Engineers (the Corps), in consultation with BC Hydro, based on principles laid out in the Treaty. Duncan Reservoir levels must not exceed Flood Control Rule Curve levels specified in the FCOP except as directed by the Corps to reduce downstream flooding. The Treaty provides for both system and local flood control objectives, and BC Hydro works closely with the Corps to define these flood control needs. In many cases, system flood control needs are more restrictive to Duncan Reservoir operations than are local flood control needs and the Flood Control Rule Curves reflect this. If necessary to accommodate a desired project operation, BC Hydro may request that the Corps issue a variance from the Flood Control Rule Curve for one of the Treaty projects. The Corps will consider this request in light of the current and forecast system and local flooding potential.

Under most conditions, BC Hydro will have adequate flexibility at the three Treaty reservoirs to allow Duncan Dam Project operations to meet the conditions specified in the Duncan Dam Water Use Plan. However, there are potential circumstances where this flexibility, including any allowable variances to Flood Control Rule Curves, will be inadequate. In such cases, operations to meet Treaty operating plan obligations shall have precedence over the operational conditions outlined in this Water Use Plan.

During the trade-off analysis process, it became evident that in some years, the desired target flows in the lower Duncan River specified in the operating alternatives would not allow BC Hydro to meet the maximum reservoir levels specified by the FCOP. Therefore, BC Hydro would need to request a variance from the Corps. If a variance were not granted, BC Hydro would need to consult with federal and provincial fisheries agencies and First Nations to determine an

[1] The cause of the cross-system impacts was related to Columbia River Treaty flow requirements, which required certain flow volumes to be met from the combined discharges at Duncan and Hugh Keenleyside dams (including flows through Arrow Lakes Generation Station (ALGS)). In many years, this meant that if flows needed to be reduced from Duncan Dam (in the fall and winter period), more water would have to be discharged through Hugh Keenleyside Dam and this was often beyond the capacity of ALGS. The result was therefore, lost generating opportunities (i.e., spilling) and lower reservoir levels (i.e., lower performance of the power generators).

agreeable flow target and seek special direction on operations from the Comptroller of Water Rights.

4.11.3 Objective and Sub-objectives

Table 4-25 summarizes the Power Generation objective and sub-objectives developed by the Consultative Committee for the Duncan Dam water use planning process.

Table 4-25: Power Generation Objective and Sub-objectives

Objective	Minimize economic impacts to both the Kootenay River and the Columbia River generation system.
Sub-objectives	• Maximize revenue from energy sales • Minimize negative impacts to Kootenay Lake (e.g., IJC Order) • Minimize negative impacts on ancillary services

4.11.4 Performance Measures

Table 4-26 summarizes the Power Generation performance measures used by the Consultative Committee to evaluate operating alternatives for the Duncan Dam facility.

Table 4-26: Power Generation Performance Measures

Performance Measure	Unit of Measure	Description	Measured Where?	Measured When?
Operation Flexibility	Number of days that operations are constrained	Impacts to other Columbia River projects (U.S./Canada)	All plants in Canada affected by Duncan operations	Year-round
Power – Kootenay River	*Megawatt-hours (MWh)*	*The average annual power from the combined power generation of the Kootenay River plants*	*Kootenay River plants*	*Year-round*
Financial Revenue - Kootenay River and Lower Columbia River	*Net Annual Average of Generation $/year compared to Alt A – Current Operations*	*The estimated average annual value of electricity (VOE) from the combined power generation of the Kootenay River and lower Columbia River plants.*	*All plants in Canada affected by Duncan operations*	*Year-round*
Financial Revenue – Kootenay River	Net Annual Average of Generation $/year compared to Alt A – Current Operations	The VOE from the combined power generation of the Kootenay River plants.	Kootenay River plants	Year-round
Financial Revenue – Lower Columbia River	Net Annual Average of Generation $/year compared to Alt A – Current Operations	The VOE from the power generation at ALGS on the lower Columbia River.	ALGS	Year-round

The value of power generation on the Kootenay River system and at ALGS were modelled and evaluated in the Duncan Dam water use planning process.

The ***Operation Flexibility*** performance measure is defined as the ***number of days per year that Duncan Dam operations are constrained***. This performance measure estimates the impact to other Columbia River projects (U.S./Canada) from a constrained Duncan Dam operation under different operating alternatives.

The ***Power: Kootenay River*** performance measure is defined as ***the average annual power in megawatts (MWhrs) from the combined power generation of the Kootenay River plants.*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River plants under different operating alternatives.

The ***Financial Revenue: Kootenay River and Lower Columbia River*** performance measure is defined as ***the estimated average annual value of electricity (VOE) in $/year from the combined power generation of the Kootenay River and lower Columbia River plants compared to Alternative A – Current Operations.*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River and lower Columbia River plants under different operating alternatives.

The ***Financial Revenue: Kootenay River*** performance measure is defined as ***the VOE in $/year from the combined power generation of the Kootenay River plants compared to Alternative A – Current Operations.*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River plants under different operating alternatives.

The ***Financial Revenue: Lower Columbia River*** performance measure is defined as ***the VOE in $/year from the power generation at ALGS on the lower Columbia River compared to Alternative A – Current Operations.*** This performance measure estimates the total amount of the power generated from this lower Columbia River plant under different operating alternatives.

The following downstream constraints were incorporated into the BC Hydro power Operations Model for the performance measures calculations:

- Columbia River Treaty requirements downstream of Kootenay and Columbia rivers confluence.
- International Joint Committee (IJC) Flood Rule Curves for Kootenay Lake.
- A completed Brilliant Expansion Project, which is expected to be in commercial operation in September 2006 and will increase the maximum turbine discharge from 582 m^3/s to 1067 m^3/s, including the agreed minimum flow agreement.

- An implemented variable flow regime from Libby Dam (VarQ25kcfs).
- An assumed operation of Revelstoke Dam and Arrow Lakes Reservoir inflows, including limitations on ALGS power generation due to low reservoir elevations.

4.11.4.1 Value of Energy

BC Hydro values the power generated by a power plant using the methodology developed in the Value of Electricity (VOE) Report. The VOE Report provides time-of-generation energy values with adjustments to reflect dispatch and capacity reserve capabilities.

The VOE Report uses the forecast British Columbia/United States border monthly average heavy load hour and light load hour prices, and combines them with incremental transmission cost estimates for the BC Hydro electric system to generate unit value forecasts for the nine Hydro transmission regions.

The VOE Report contains commercially sensitive information and is confidential; however, use of this methodology was reviewed and accepted by the Water Use Plan Program Interagency Management Committee.

4.12 Summary of Performance Measures

During the Duncan Dam water use planning process, a number of performance measures were developed, but subsequently eliminated as they were either insensitive across the operating alternatives or were represented by other measures.

Table 4-27 summarizes the final performance measures used by the Consultative Committee and/or a technical subcommittee to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility. Refer to Appendix F: Performance Measure Information Sheets for additional detail on the performance measures.

Table 4-27: Final Performance Measures

Interest	Location	Performance Measure	Units of Measure	Considered by:
Recreation	*Duncan Reservoir*	Recreation Quality	Number of weighted user days the reservoir is at preferred elevation levels	CC/RTC
Flood Management and Quality of Life - Mosquitoes	*Lower Duncan River Mainstem*	Flood/Mosquito Risk	Number of days flow below Lardeau River > 400 m^3/s	CC
			Weighted area-days inundated after Lardeau River freshet 1 July to 31 August	CC/QOLTC
Fish	*Duncan Reservoir*	Fish Stranding Risk	Average dewatered area	FTC
		Reservoir Nutrient Retention	Tonnes of dissolved phosphorus retained annually	FTC
	Lower Duncan River Sidechannel	Kokanee Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	CC/FTC
		Kokanee Effective Rearing Habitat Lost	Hectares of effective rearing habitat lost	FTC
		Rainbow Effective Rearing Habitat	Hectares of effective rearing habitat	FTC
		Rainbow Effective Rearing Habitat Lost	Hectares of effective rearing habitat lost	FTC
	Lower Duncan River Mainstem	Whitefish Effective Spawning Habitat	Hectares of effective spawning habitat	CC/FTC
		Whitefish Effective Spawning Habitat Lost	Hectares of effective spawning habitat lost	CC/FTC
		Kokanee Effective Spawning Habitat	Hectares of effective spawning habitat	CC/FTC
		Rainbow Effective Rearing Habitat Lost	Hectares of effective spawning habitat lost	CC/FTC
		Total Gas Pressure Days	Number of days TGP > 115%	FTC
		Total Gas Pressure Events	Number of events TGP > 115%	FTC
		Significiant Events	Number of significiant operational changes > 0.20 m	FTC
			Number of significiant operational changes > 0.45 m	FTC
Cultural Resources	*Duncan Reservoir*	Cultural Site Erosion	Number of weighted days reservoir is operated within specific bands	CC/CHTC
Wildlife	*Lower Duncan River*	Cottonwood Hydrograph Weighted Index	Comparison to optimum cottonwood hydrograph	CC/WTC
	Duncan Reservoir	Riparin Productivity - Long-term Median	Hectares of grassland riparian habiat	CC/WTC
		Riparian Productivity - Inundation Tolerance	Hectares of herbaceous (grass/sedge) area	WTC
			Hectares of shrub (sedge/willow) area	CC/WTC
Power Generation	Duncan Dam System	Financial Revenue - Kootenay River	Net annual average of generation $/year compared to current operations	CC
		Financial Revenue - Lower Columbia River	Net annual average of generation $/year compared to current operations	CC

5 INFORMATION COLLECTED

5.1 Introduction

During the process of identifying issues, structuring objectives and developing performance measures, a number of questions were raised by the Consultative Committee. At the conclusion of Step 4 of the provincial government's *Water Use Plan Guidelines*, the technical subcommittees proposed that a number of data collection studies be undertaken during the Duncan Dam water use planning process to address these uncertainties. These proposed studies were evaluated by the Consultative Committee using the eligibility criteria developed by the Water Use Plan Program (refer to Appendix G: Eligibility Criteria for Water Use Planning Studies).

5.2 Water Use Plan Studies

This section describes the studies that the Consultative Committee undertook during the Duncan Dam water use planning process.

Table 5-1 summarizes the Duncan Dam Water Use Plan data collection studies.

Table 5-1: Summary of Duncan Dam Water Use Plan Data Collection Studies

Interest	Information Collected	Reference*	Description/Rationale/ Assessment	Results/Application
Fish – Duncan Reservoir	Low Duncan Reservoir Assessment	Golder Associates (2002)	A field assessment with professional judgment of potential reservoir fish issues to determine how the Duncan Reservoir drawdown affects fish stranding, fish access to tributaries, reproductive success of rainbow trout and burbot.	Informed the Fish Technical Subcommittee on possible Duncan Reservoir burbot spawning and dewatering issue. Removed the issue of tributary access from discussion. Did not provide sufficient information to develop performance measures.
	Duncan Reservoir Digital Elevation Model	BC Hydro (2002a)	A digital elevation model using low reservoir photography for the Duncan Reservoir to assess and calculate reservoir performance measures for recreation, fish and wildlife.	Provided a relationship for north end of Duncan Reservoir between reservoir elevation and inundated surface area. Applied to several performance measures.
	Littoral/Pelagic Productivity Assessment	Perrin (2002); Perrin and Korman (1997)	An expert review of existing information on Duncan Reservoir productivity to determine the degree to which aquatic productivity could be improved with operating changes.	Resulted in elimination of littoral and pelagic productivity as a performance measure due to lack of available information.

Table 5-1: Summary of Duncan Dam Water Use Plan Data Collection Studies (cont'd)

Interest	Information Collected	Reference*	Description/Rationale/ Assessment	Results/Application
Fish – Duncan Reservoir (cont'd)	Historical Burbot Spawning Assessment	Fish Technical Subcommittee Minutes	Hypothesized that decreasing Duncan Reservoir elevations during burbot spawning would disrupt burbot spawning behaviour and reduce spawning success.	Initially provided hypothesis to develop a performance measure which was subsequently eliminated due to lack of information to support hypothesis.
Fish – Lower Duncan River	HEC–RAS Model	Klohn Crippen (2003a, 2003b)	A lower Duncan River sidechannel survey, map analysis, and a conversion of an existing HEC Floodplain model for the river to a HEC–RAS model with added transect data collection on sidechannels for use in assessment of fish performance measures.	Provided the rationale for lower Duncan River sidechannel flow targets, identifying FC1 and FC11 as primary sidechannel targets. Also provided the habitat model for the river mainstem. Both types of information were applied to fish habitat performance measures.
	Sidechannel Ground Truthing Study	Herbison (2003)	Fish Technical Subcommittee Minutes.	Further clarified lower Duncan River sidechannel flow targets, which led to performance measure refinement.
	Lower Duncan River Fish Habitat Suitability	van Dishoeck and Gebhart (2003)	A review of existing information on habitat use (gaps identified) to determine how Duncan Dam discharge affects wetted habitat in the lower Duncan River sidechannels and mainstem for establishing fish performance measures (low flow) and zones where ramping rates should be considered to minimize fish stranding.	Provided information to develop the Adaptive Stranding Protocol Development monitoring study. Also provided rationale for refining spawning timing for whitefish and kokanee.
	Lower Duncan River Access (Mainstem and Tributaries)	Fish Technical Subcommittee (FTC) Minutes	A FTC site visit during low flows to determine if fish access to tributaries or up the mainstem of the lower Duncan River is affected by dam discharges.	Resulted in tributary access issue being dropped, but highlighted lower Duncan River sidechannel stranding as a significant issue.
	Review of proposed operating alternatives	Miles (2003)	A review of operating alternatives for erosion impacts.	The review concluded that erosion impacts would not be distinguishable between alternatives.
	Total Gas Pressure/ Temperature	BC Hydro (2003c, 2003d)	Analysis to determine how operation of the Duncan Dam low-level operating gates and the spillway affect temperature and total gas pressure (TGP) in the lower Duncan River and their potential implications to fish.	Provided spill versus TGP production relationship, indicating that TGP events (115% TGP or greater) occur when spills exceed 115 m^3/s.

Table 5-1: Summary of Duncan Dam Water Use Plan Data Collection Studies (cont'd)

Interest	Information Collected	Reference*	Description/Rationale/ Assessment	Results/Application
Fish – Lower Duncan River (cont'd)	Effects of Maintenance Shutdowns (Dewatering of Power Channel)	FTC Minutes	Site visit in spring when discharge from the Duncan Dam is reduced to 0 m^3/s to determine potential affects on habitat dewatering and fish stranding.	Highlighted lower Duncan River sidechannel stranding as a significant issue.
Wildlife – Duncan Reservoir	Riparian Area Assessment in Duncan Reservoir Drawdown Zone	Moody (2002)	A desktop exercise to identify areas within the Duncan Reservoir drawdown zone which have the highest potential for vegetation establishment and recommend operating alternatives that will facilitate development of this potential.	Provided initial rationale for developing the "long term median" Duncan Reservoir elevation performance measure to describe the limit of grassland riparian production.
Wildlife – Lower Duncan River	Lower Duncan River Black Cottonwood Recruitment	Herbison (2003)	Utilizing Cottonwood as an indicator of riparian habitat diversity, fieldwork and air photo interpretation was undertaken to describe and quantify seed-generated black cottonwood on the lower Duncan River. Based on these findings and a review of literature from other systems performance measures, operating alternatives were recommended and additional data requirements were identified.	Provided the timing and habitat requirements needed to develop a "cottonwood hydrograph" performance measure. Further clarification of actual flow levels and the sensitivity of flow-habitat dynamics gained from further discussion with the author and Dr. Stewart Rood.
Wildlife – General	Wildlife Information Review	Herbison et al. (2002)	A summary of existing wildlife information related to the Duncan Dam operation to develop potential performance measures and identify data gaps related to water regulation.	Highlighted areas and species of interest, but did not provide details for developing performance measures describing the relationship between operations and wildlife values.
Quality of Life – Mosquitoes	Influence of Duncan Dam Operations on Mosquito Populations	Jackson (2002)	A field and literature based study to determine species of mosquito present, key mosquito habitats and how Duncan River levels and external factors relate to mosquito production. Appropriate operation thresholds and performance measures were recommended to minimize nuisance mosquitoes.	Provided the information required to develop an initial Mosquito Habitat performance measure, operational linkages, timing, and habitat mapping.

Table 5-1: Summary of Duncan Dam Water Use Plan Data Collection Studies (cont'd)

Interest	Information Collected	Reference*	Description/Rationale/ Assessment	Results/Application
Recreation – Duncan Reservoir	Recreation Activity and Influence of Reservoir Operations	BC Hydro (2003b) and Spitler (2003)	Interviews with users of Duncan Dam area recreation sites, Recreation Technical Subcommittee members and Duncan Dam staff on recreation usage and implications of reservoir operations on activities to develop performance measures.	Field verified recreation targets towards the refinement of the recreation quality performance measure. Characterized the use and expectations of campers at Glacier Creek and Howser Creek recreation sites.
Flooding – Lower Duncan River	Flooding Threshold	Performance Measure Reference Sheet	A field assessment of the impacts of high Duncan Dam discharges in 2002 was used to develop a flood threshold for the lower Duncan River floodplain and the levels that affected private property.	Aerial flights at different discharges to determine flooding thresholds and establish performance measures.
Erosion/ Flooding – Lower Duncan River	Lower Duncan River Geomorphology Study (in conjunction with BC Hydro, Kootenay Generation)	Miles and Associates (2002)	A review of existing aerial photos and hydrology data in order to understand how the lower Duncan River channel is expected to change over time.	Provided the lower Duncan River reach breaks, sidechannel descriptions, and general habitat descriptions for Fish Technical Subcommittee discussions. Characterized the river as "in transition" to a simpler structure.
Cultural Resources – Duncan Reservoir	Duncan Reservoir Archaeological Survey and Preliminary Impact Assessment	Choquette (2002)	A preliminary survey of the Duncan Reservoir drawdown zone to identify archaeological site elevation ranges, develop performance measures and describe implications of reservoir operations on these sites.	Specified the location (by Duncan Reservoir elevation) of two heritage sites at risk of degradation from exposure and/or erosion due to reservoir operations, and the basis for developing two performance measures.
Traditional Ecological Knowledge – Duncan Reservoir	Duncan Reservoir, River and Kootenay Lake Area Traditional Use Study	Keefer (2002)	Ktunaxa community member interviews, review of Ktunaxa files to identify traditional uses of fish, wildlife, plants and resources. Information contributed to list of plants for use in revegetation, establishing significance of archaeological sites and understanding of First Nations' use of area.	Highlighted the significance of First Nation cultural use and knowledge in the Duncan Dam area. Information was used primarily in the development of wildlife and cultural resources monitoring studies.

* Full citations are provided in Section 12.

6 OPERATING ALTERNATIVES

6.1 Introduction

In Step 6 of the provincial government's *Water Use Plan Guidelines*, the Consultative Committee created and evaluated various operating alternatives for satisfying the Duncan Dam water use planning objectives described in Section 4. The BC Hydro project team simulated these alternatives using computer models of the Duncan River system and the hydroelectric plants on the Kootenay River and lower Columbia River. The Committee used the modelling results and performance measures to compare how well each alternative performed in satisfying the water use planning objectives.

This section describes the specifications of the Duncan Dam Water Use Plan alternatives and the modelling process.

6.2 Modelling Operating Alternatives

Figure 6-1 illustrates the models that were used to predict the impacts of operating alternatives on the performance measures.

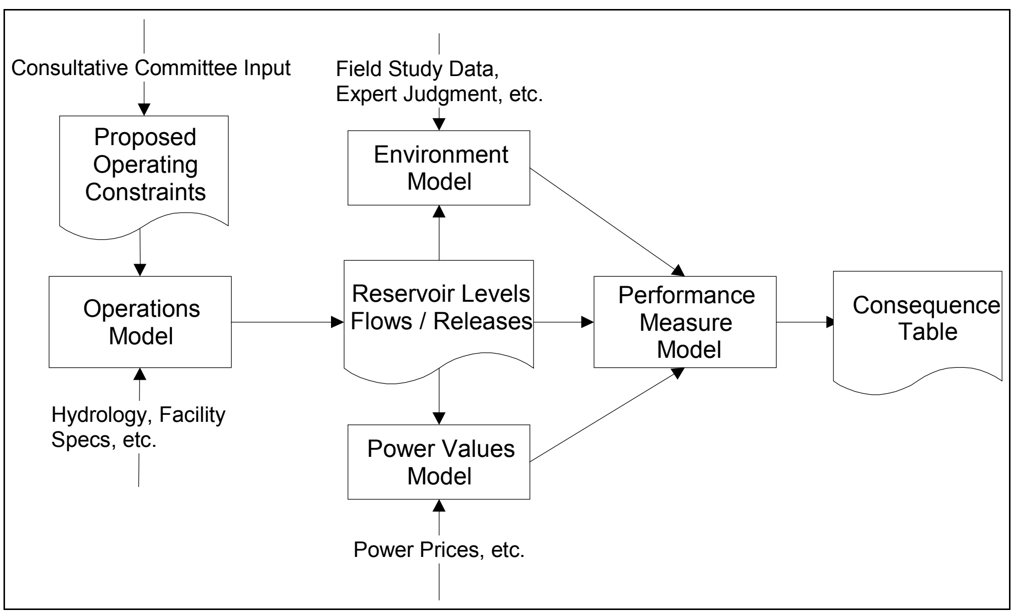


Figure 6-1: Overview of Duncan Dam Water Use Plan Models

Modelling the operating alternatives involved a number of steps and computer programs. Once the Consultative Committee developed an alternative, the modellers used an Operations Model developed for BC Hydro's water use planning process to simulate operations of the Duncan Dam facility according to the specified constraints of each alternative.

While there are no power generating units at the Duncan Dam, flow released from the dam passes through Kootenay Lake and then through FortisBC, City of Nelson, BC Hydro and Brilliant Power Corporation generating stations downstream on the Kootenay River. In total, seven generating plants exist downstream on the Kootenay River including BC Hydro's Kootenay Canal Project and an eighth generating station, the Brilliant Expansion Project, owned by Brilliant Expansion Power Corporation (a joint venture of Columbia Power Corporation/Columbia Basin Trust), which is currently under construction and is scheduled to be in commercial operation in September 2006.

The BC Hydro Operations Model utilizes the A Mathematical Programming Language (AMPL) to describe the project's physical characteristics (model configuration), physical operation limits (hard constraints), preferred ranges of operation for a particular scenario (soft constraints), and objective functions (optimization criteria). The AMPL code is compiled and submitted to a CPLEX solver that determines the optimal mode of project operation for the specified scenario. For each Duncan Dam operating alternative, the model optimizes the power generation that can be achieved on the Kootenay River and lower Columbia River plants, given the operating constraints specified for the particular scenario.

For each operating alternative, the Operations Model provides daily data on Duncan Reservoir elevation, dam discharges, lower Duncan River flows, Kootenay Lake elevations, Kootenay River power, and lower Columbia River power generation for 20 years (1968 to 1987) of simulated flow operation. These outputs serve as inputs to the Environmental Model and the Power Values Model to calculate the performance measures for each alternative.

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

Daily project generation data is routed through a Value of Energy spreadsheet model that uses information about energy prices, dispatchability, and facility characteristics to calculate the annual value of the power generation that will be produced under each operating alternative.

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

6.3 Specifying Operating Alternatives

The operating alternatives specified minimum flow releases from Duncan Dam, target flows in the lower Duncan River (below the confluence of the Lardeau River), and target elevations for Duncan Reservoir. The operating constraints for each alternative were prioritized by the Consultative Committee to inform the modeller of which objectives were the most important to satisfy first. Once these constraints were satisfied, the next priority was to maximize power generation.

6.3.1 Constraints

Two types of constraints were specified for each operating alternative: "hard" and "soft" constraints. A "hard" constraint is typically a physical limitation that cannot be exceeded. For example, you can't store more water than the total volume of the reservoir, or exceed the capacity of the low-level outlets. A "soft" constraint is a desired outcome, which the Operations Model attempts to achieve. For example, minimum flow releases from the dam, and minimum or maximum flows in the lower Duncan River. Where all soft constraints cannot be satisfied, those with higher priority are achieved first.

In addition to the physical capabilities of the facilities, two other factors were considered "hard" constraints during development of operating alternatives: the Columbia River Treaty requirements and the International Joint Commission Order on Kootenay Lake elevations.

6.3.1.1 Columbia River Treaty

The Duncan Dam was one of three dams built to fulfil the obligations of the Columbia River Treaty between Canada and the United States. The primary purpose of the facilities on the Duncan River system is to mitigate downstream (Canada and United States) flooding and provide additional power generation on the Kootenay and Columbia rivers generation systems.

Each of the Columbia River Treaty projects is operated to reserve space for flood control by means of a rule curve that specifies the minimum amount of empty storage space that must be provided each month of the year, based on the total volume of inflow that is forecast. The Duncan Reservoir Flood Control Rule Curves are based on the volume forecast for the Duncan Reservoir. In particular, the Flood Control Rule Curve begins the annual drawdown at the beginning of December following a fixed curve, and moving to a variable curve on 1 January. The variable curve is based on the April through August total volume forecast. Minimum and maximum rule curves are specified. If the forecast is less than the minimum, the minimum curve is used, and if the forecast is greater than the maximum, the maximum curve is used. For forecasts between the minimum and the maximum, the appropriate rule curve is interpolated based on the actual forecast.

Under the terms of the Columbia River Treaty, the Duncan Reservoir draft is controlled to provide power benefits to both Canada and the United States. For example, in low water years, the Treaty requires that all reservoirs in the system draft proportionately to ensure that power generation benefits on both sides of the border can be achieved.

Based on the Columbia River Treaty requirements, the following constraints were included in the Duncan Dam Water Use Plan operating alternatives:

- Current Columbia River Treaty Flood Control Rule Curves:
    - In years with average to above-average snowpack, the Treaty Flood Control Rule Curves cause Duncan Reservoir to be drafted to 551.0 m (1808 ft) or lower by the end of February (1.27 million acre-feet of flood protection).
    - In below-average snowpack years, the Treaty Flood Control Rule Curves may be as high as 564.4 m (1852 ft) at the end of February (0.67 million acre-feet of flood protection).

Figure 6-2 illustrates the current Columbia River Treaty Flood Control Rule Curves for the Duncan Reservoir.

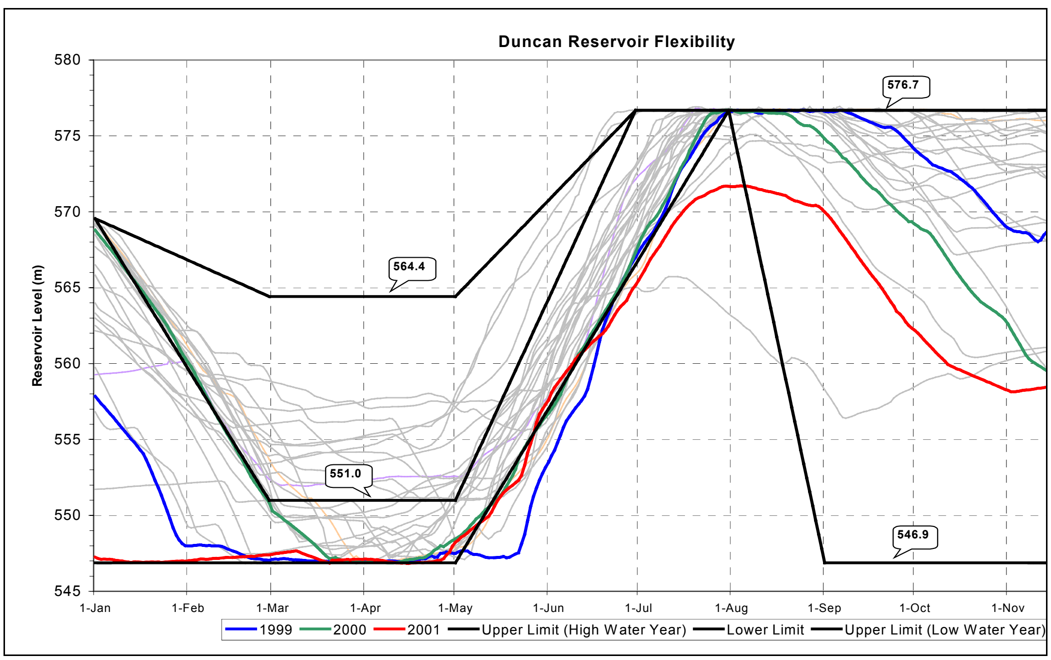


Figure 6-2: Columbia River Treaty Flood Control Rule Curves for the Duncan Reservoir

Adhering to the Columbia River Treaty Flood Control Rule Curves has implications for the Duncan Reservoir as follows:

- Duncan Reservoir must be below elevation 569.8 m on 31 December each year.
- Duncan Reservoir must be targeted to reach full pool (i.e., 576.7 m) by the end of July each year.

Other constraints associated with the Columbia River Treaty requirements are described in Appendix A: Briefing Note on the Duncan Dam Facility.

6.3.1.2 International Joint Commission Order

There are two major storage projects on the Kootenay River: Duncan Dam and Libby Dam. Water from both of these projects is discharged into Kootenay Lake, which is a natural reservoir controlled by a channel restriction at Grohman Narrows west of Nelson, and also to a limited degree by the Cora Linn Dam downstream of Grohman Narrows. To mitigate flooding on Kootenay Lake, the International Joint Commission (IJC) established by the Boundary Waters Treaty developed a rule curve for Kootenay Lake that specifies an upper bound on water levels at the Queens Bay gauge. As with the Columbia River Treaty Flood Control Rule Curves, the Duncan River system must adhere to the IJC rules.

While the IJC was considered a "hard" constraint, it did not constrain the Duncan Dam Water Use Plan operating alternatives. Whenever an alternative approached the maximum water levels defined under the IJC, a violation could be avoided by increasing flows through the Kootenay River system (i.e., whatever the desired Duncan Dam discharge, a commensurate volume could be passed down the Kootenay River). Therefore, the IJC was less a "hard" constraint and more a mechanism that would potentially lead to additional power generation impacts.

Figure 6-3 illustrates the IJC Flood Control Rule Curve for Kootenay Lake.

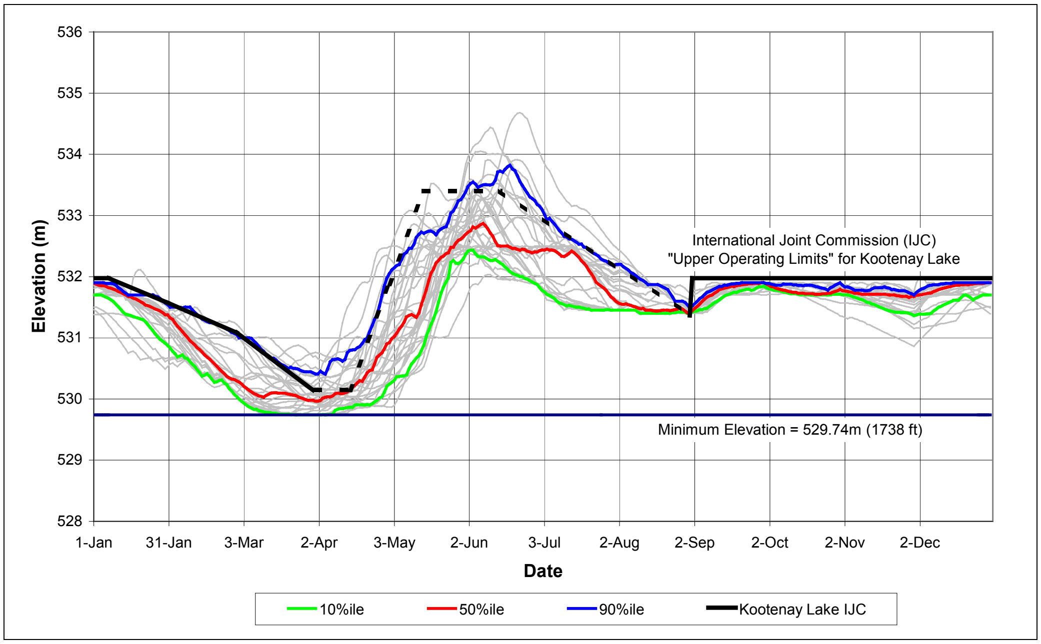


Figure 6-3: International Joint Commission Flood Control Rule Curve for Kootenay Lake

6.3.1.3 Other Agreements

In addition to the Columbia River Treaty and the IJC, the following agreements were considered in the Duncan Dam Water Use Plan operating alternatives:

- Kootenay Canal Plant Agreement.
- Libby Co-ordination Agreement.
- Non-Treaty Storage Agreement.
- Other water licences on the Kootenay system.
- Treaty–Libby and Duncan–Kootenay Storage Swap Agreements.

Similar to the IJC, these agreements did not pose any additional “hard” constraints on operating alternatives.

6.4 Overview of the Operating Alternatives

Creating and evaluating operating alternatives is an iterative process. In all, there were four rounds (or iterations) of alternatives that were created and evaluated during the Duncan Dam water use planning process.

Figure 6-4 illustrates the operating alternatives considered during each round of the development process.

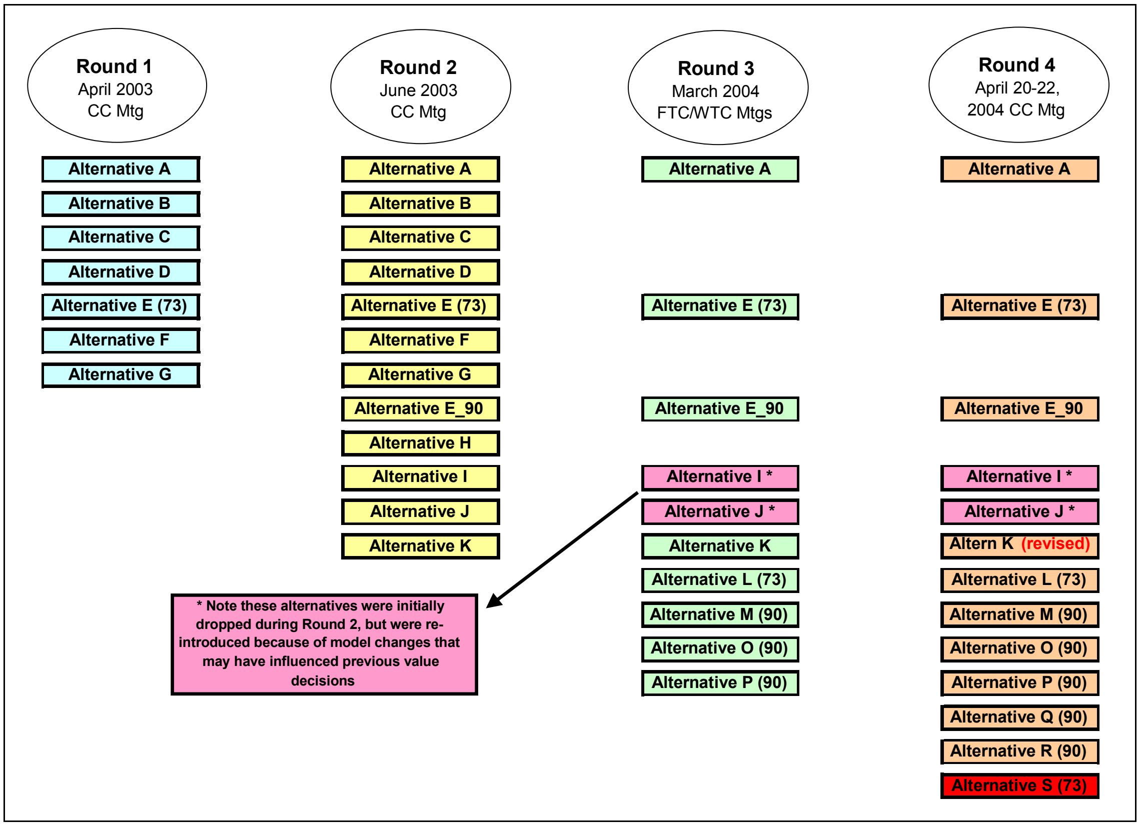


Figure 6-4: Development of Operating Alternatives during the Duncan Dam Water Use Planning Process

The Round 1 operating alternatives demonstrated how the Duncan Dam facility could achieve target flows in the lower Duncan River and target elevations for the Duncan Reservoir within the constraints set out under the Columbia River Treaty. The Round 1 alternatives also demonstrated to the Consultative Committee the process of specifying alternatives and interpreting the resulting model outputs and performance measures.

Based on the learning experience of the Round 1 operating alternatives, the Consultative Committee developed and evaluated alternatives in Rounds 2, 3, and 4. In Round 3, non-operational physical works in lieu of operational changes were introduced. After Round 3, the BC Hydro Operations Model was revised to better take into account identified cross-system impacts on the lower Columbia River system (refer to Section 6.4.3.1).

6.4.1 Round 1 Operating Alternatives

In Round 1, the Consultative Committee developed seven operating alternatives (Alternatives A to G) intended to meet multiple Duncan Dam water use planning objectives. The Committee requested that the Fisheries Technical Subcommittee develop two additional alternatives to meet specific fish interests. Aside from the Current Operations Alternative (Alt A), each alternative attempts to optimize benefits for at least one Duncan Dam water use planning objective. The process for developing alternatives consisted of defining drivers (constraints to meet specific objectives) for each period of the year. The Committee then prioritized the top five drivers, which were used to develop the Round 1 alternatives. Other drivers were then used to complement and build secondary objectives into each alternative.

Table 6-1 summarizes the Round 1 operating alternatives.

Table 6-1: Round 1 Operating Alternatives

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
A Current Operations	Flooding (Columbia River) Power	–	3 m^3/s minimum 283 m^3/s normal maximum	None	Current operations include fish transfer during May to 15 September. This limits flows through one low-level outlet to below 170 m^3/s.
B Downstream Inundation	Local flooding Emigrating kokanee Cultural sites	–	3 m^3/s minimum 283 m^3/s normal maximum	20 m^3/s minimum flow 1 April to 30 May 400 m^3/s maximum	Includes fish transfer May to September.
C Recreation	Recreation (Duncan Reservoir) Local flooding Cultural sites	Target 0 to 3 ft from full pool 15 July to 1 August Target full pool 1 August to 30 August Maintain reservoir elevation above 570 m from 1 to 30 September Increase minimum reservoir elevation to accommodate 15 July target	3 m^3/s minimum 283 m^3/s normal maximum	400 m^3/s maximum	Includes fish transfer May to September.
D Vegetation	Wildlife (Duncan Reservoir) Local flooding Burbot spawning Cultural sites	Stable reservoir 15 February to 30 March Target full pool by 1 August Decrease reservoir elevation to 573.7 m or less after reaching full pool	3 m^3/s minimum 283 m^3/s normal maximum	400 m^3/s maximum	Includes fish transfer May to September.

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

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
E (73) Downstream Fish	Fish (Lower Duncan River) Local flooding	–	3 m^3/s minimum 283 m^3/s normal maximum	73 m^3/s target 15 September to 15 November 73 m^3/s minimum year-round 400 m^3/s maximum	Includes fish transfer May to September.
F Burbot	Burbot spawning (Duncan Reservoir) Local flooding	Stable reservoir 15 February to 15 April 551.1 m minimum reservoir elevation	3 m^3/s minimum 283 m^3/s normal maximum	400 m^3/s maximum	Includes fish transfer May to September.
G Naturalized Hydrograph	Cottonwood recruitment (Lower Duncan River) Local flooding	–	3 m^3/s minimum 283 m^3/s normal maximum	400 m^3/s maximum Refer to target flows in Figure 6-5	Includes fish transfer May to September. This alternative was considered on an opportunistic basis.

The purpose of target flows in the lower Duncan River was to optimize the potential availability of fish habitat for successful spawning and rearing in sidechannels. A target flow was specified with a maximum and minimum level. Given that flows immediately downstream of Duncan Dam are variable as a consequence of the Lardeau River, target flows in the lower Duncan River must be balanced between natural inflows from the Lardeau River and regulated flows from the dam.

Alternative G – Naturalized Hydrograph was distinct from the other operating alternatives. Given the nature of cottonwood recruitment in the lower Duncan River, it was determined that a more natural flow would only need to occur approximately once every five years. The target flows for Alternative G were developed based on expert opinion as to what was considered a more natural flow hydrograph in the lower Duncan River for cottonwood recruitment. Accordingly, Alternative G could be implemented on an opportunistic basis and combined with one of the other alternatives.

All of the operating alternatives developed during Round 1 included the current fish transfer operation (for bull trout), which typically occurs from May to September of each year. During this time, the spillway is used to discharge flows from the Duncan Dam and limit flows released through the low-level outlets (LLOs). This operation is undertaken to allow the LLOs to be used for passage of migrating bull trout.

Figure 6-5 illustrates the target flows in the lower Duncan River under Alternative G – Naturalized Hydrograph.

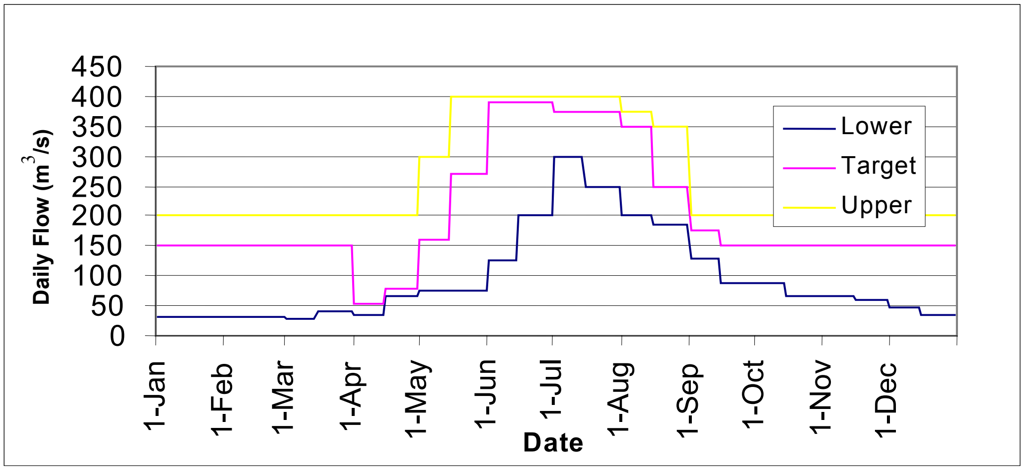


Figure 6-5: Target Flows in the Lower Duncan River for Alternative G – Naturalized Hydrograph

6.4.2 Round 2 Operating Alternatives

In Round 2, the Consultative Committee developed five new operating alternatives that consisted of combined Round 1 alternatives, a new universal discharge constraint, new reservoir elevations and minimum flow constraints. Round 2 alternatives included a maximum Duncan Dam discharge constraint of 255 m^3/s from 1 May to 15 September to mitigate total gas pressure effects on fish in the lower Duncan River by limiting the maximum allowable discharge through the spillway. The incubation period for burbot spawning was revised to 15 February to 15 April and the ***Burbot Spawning*** performance measure introduced an allowance of ±0.25 m variation in the Duncan Reservoir elevations. In addition, a new lower Duncan River minimum flow of 90 m^3/s was proposed, based on new information gained during a field study.

Table 6-2 summarizes the Round 2 operating alternatives.

Table 6-2: Round 2 Operating Alternatives

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
E (90) Downstream Fish	Fish (Lower Duncan River) Local flooding	–	3 m^3/s minimum 283 m^3/s normal maximum 255 m^3/s maximum 1 May to 15 September	90 m^3/s target 15 September to 15 November 90 m^3/s minimum year-round 400 m^3/s maximum year-round	Includes fish transfer May to September. Similar to Alternative E (73) – Downstream Fish except target minimum flows are 90 m^3/s rather than 73 m^3/s. This was based on new survey data.
H (50) Downstream Fish	Fish (Lower Duncan River) Local flooding	Target full pool by 1 August Decrease reservoir elevation to 575.7 m after 1 August	3 m^3/s minimum 283 m^3/s normal maximum 255 m^3/s maximum 1 May to 15 September	50 m^3/s target 15 September to 15 November 50 m^3/s minimum year-round 400 m^3/s maximum year-round	Includes fish transfer May to September. Similar to Alternative E (73*)* except for lower Duncan River target flows of 50 m^3/s rather than 73 m^3/s, and minimum flows of 50 m^3/s rather than 73 m^3/s.
I RCMF	Recreation (Duncan Reservoir) Cultural resources Mosquitoes Flooding	Target full pool by 1 August Decrease reservoir elevation to 576.2 m 1 to 31 August Decrease reservoir elevation to 573.7 m or less after reaching full pool	3 m^3/s minimum 283 m^3/s normal maximum 255 m^3/s maximum 1 May to 15 September	400 m^3/s maximum year-round	Includes fish transfer May to September. Merged Alternative B – Flooding with Alternative C – Recreation. RCMF is an acronym for Recreation, Cultural Resources, Mosquitoes and Flooding.
J Veg-Burbot	Wildlife (Duncan Reservoir) Burbot spawning Cultural sites	Stable reservoir (± 0.25 m) 15 February to 15 April Target full pool by 1 August Decrease reservoir elevation to 573.7 m or less after reaching full pool Maintain reservoir elevation above 570 m 1 August to 30 September	3 m^3/s minimum 283 m^3/s normal maximum 255 m^3/s maximum 1 May to 15 September	400 m^3/s maximum year-round	Includes fish transfer May to September. Merged Alternative D – Vegetation with Alternative F – Burbot.

Table 6-2: Round 2 Operating Alternatives (cont'd)

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
K Cottonwood Hydrograph	Cottonwood recruitment (Lower Duncan River) Local flooding	–	3 m^3/s minimum	400 m^3/s maximum year-round Target: • ≥ 300 m^3/s 15 June to 7 July • >350 m^3/s 8 to 24 July • 325 m^3/s 25 to 31 July • 300 m^3/s 1 to 8 August • 275 m^3/s 9 to 16 August • 250 m^3/s 17 to 23 August • 200 m^3/s 24 to 31 August • below 250 m^3/s 1 September to 14 June	Includes fish transfer May to September. This alternative was considered on an opportunistic basis. Similar to Alternative G except for modified target flows.

6.4.3 Round 3 Operating Alternatives

Four new operating alternatives and six potential non-operational physical works options were developed during Round 3.

At this time, the Consultative Committee decided to consider a flow regime that benefited cottonwood recruitment that could be added to any operating alternative when desired. The rationale was that cottonwood recruitment alternatives would be implemented approximately once every five years. Therefore, the Committee would select a preferred minimum flow alternative for years 1 to 4 then determine whether a cottonwood flow regime was required in year 5. Alternatives G – Naturalized Hydrograph and K – Cottonwood Hydrograph were designated as cottonwood recruitment alternatives.

Four new operating alternatives were developed (L, M, O, and P) as hybrids of the minimum flow alternatives (E73 and E90) to meet the Duncan Dam water use planning objectives as follows:

- New Duncan Reservoir target elevations based on recreation field surveys completed in the summer of 2003.

- Mitigate the large decrease in flows in the lower Duncan River just prior to the desired target flow constraint starting on 15 September of each year.

- Mitigate the sudden drop in lower Duncan River flows that occur at the beginning of August as the flooding risk passes (i.e., dam discharges decrease to reach full pool in the Duncan Reservoir as quickly as possible for recreation interests).

- Minimize the potential re-wetting of mosquito breeding habitats after the main freshet in the Lardeau River passes, typically by 1 August of each year.

- Mitigate the sudden increase in lower Duncan River flows just prior to the official start of the freshet each year (typically the first week in May).

- Based on new information, the total gas pressure (TGP) flow threshold released from the Duncan Dam was revised to 285 m^3/s from 255 m^3/s. This TGP constraint became redundant as the normal maximum flow from the dam was already capped at 283 m^3/s.

These new desired flow parameters were built into each of the new operating alternatives, as follows:

Alternative L (73)	hybrid of Alternative E (73) with a minimum/target flow of 73 m^3/s
Alternative M (90)	hybrid of Alternative E (90) with a minimum/target flow of 90 m^3/s
Alternative O (90)	same as Alternative M (90) with additional target flow constraints in August and September (refer to Table 6-3)

Alternative O (90) was proposed during a Wildlife Technical Subcommittee meeting as a minimum flow alternative that provides more gradual recession flows in the lower Duncan River during the late summer/fall period (beginning in August). The intent of this hybrid alternative was to meet both fish and wildlife interests without the need for a separate infrequent flow regime for cottonwood recruitment (every fifth year as per Alternative K).

6.4.3.1 Cross-System Impacts

During the development of Round 3 alternatives, it became apparent that the Duncan Dam operating alternatives could affect power interests on the lower Columbia River system. This discovery led to modification of the BC Hydro Operations Model to incorporate an estimation of the power impacts on the lower Columbia River plants at the outlet of Arrow Lakes Reservoir. In addition, the Libby VARQ 25 kcfs outflows had been re-simulated by others allowing for the incorporation of this new, longer record into the model. This permitted the period of record for the Operations Model to be extended to 33 years (1967 to 1999).

Alternatives A to M were subsequently re-run to ensure they would be consistent with all future scenarios run with the revised model.

Alternative P was developed by BC Hydro's process team for discussion prior to the final Consultative Committee meeting. This alternative attempted to balance power generation (on the Columbia and Kootenay river systems) and interests in the lower Duncan River defined by the minimum flow alternatives.

Alternative P (90) similar to Alternative M (90) with modified target flows in the early fall to lessen power generation impacts. This meant delaying the implementation of a lower river target flow until 1 October each year (refer to Table 6-3)

In Round 3, the Consultative Committee focused on Alternative K – Cottonwood Hydrograph as the means to address cottonwood interests in the lower Duncan River. Therefore, no further consideration was given to Alternative G – Naturalized Hydrograph[1]. New information was collected during a Wildlife Technical Subcommittee meeting and subsequently from expert opinion, which led to a revision of the minimum flow targets in Alternative K – Cottonwood Hydrograph.

Table 6-3 summarizes the new and revised Round 3 operating alternatives.

Table 6-3: Round 3 Operating Alternatives

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
L (73) Downstream Interests	Fish interests (Lower Duncan River) Local flooding Mosquitoes Recreation	Target full pool by 1 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 300 m^3/s 1 to 31 August • 225 m^3/s 1 to 7 September • 150 m^3/s 8 to 15 September 73 m^3/s target 15 September to 15 November 73 m^3/s minimum year-round 120 m^3/s maximum 10 April to 15 May 400 m^3/s maximum at other times	Includes fish transfer May to September. Hybrid of Alternative E (73).

[1] Refer to *Section 7.0* for more details as to the justification for this.

Table 6-3: Round 3 Operating Alternatives (cont'd)

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
M (90) Downstream Interests	Fish interests (Lower Duncan River) Local flooding Mosquitoes Recreation	Target full pool by 1 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 300 m^3/s 1 to 31 August • 230 m^3/s 1 to 7 September • 160 m^3/s 8 to 15 September 90 m^3/s target 15 September to 15 November 90 m^3/s minimum year-round 140 m^3/s maximum 10 April to 15 May 400 m^3/s maximum at other times	Includes fish transfer May to September. Hybrid of Alternative E (90).
O (90) Downstream Fish and Cottonwood	Fish interests (Lower Duncan River) Cottonwood recruitment (Lower Duncan River) Local flooding Recreation	Target full pool by 1 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	400 m^3/s maximum year-round Target: • 350 to 400 m^3/s 1 to 12 August • 325 to 350 m^3/s 13 to 20 August • 275 to 300 m^3/s 21 to 26 August • 225 to 250 m^3/s 27 August to 1 September • 175 to 200 m^3/s 2 to 8 September • 140 m^3/s 9 to 14 September 90 m^3/s target 15 September to 15 November 90 m^3/s minimum year-round 140 m^3/s maximum 10 April to 15 May	Includes fish transfer May to September. Alternative was considered on an opportunistic basis. Similar to Alternative M (90).

Table 6-3: Round 3 Operating Alternatives (cont'd)

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
P (90) Downstream Interests	Fish interests (Lower Duncan River) Power generation Local flooding Mosquitoes Recreation	Target full pool by 1 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 300 m^3/s 1 August to 14 September • 230 m^3/s 15 to 21 September • 160 m^3/s 22 to 30 September 90 m^3/s target 1 October to 15 November 90 m^3/s minimum year-round 140 m^3/s maximum 10 April to 15 May 400 m^3/s maximum at other times	Includes fish transfer May to September. Similar to Alternative M (90) with modified target flows in the fall to minimize impacts to power generation at ALGS.
K– Cottonwood Hydrograph (Revised)	Cottonwood recruitment (Lower Duncan River) Local flooding	–	3 m^3/s minimum	400 m^3/s maximum Target: • >375 m^3/s 15 to 30 June • >350 m^3/s 1 to 12 July • 325 to 350 m^3/s 13 to 20 July • 275 to 300 m^3/s 21 July to 1 August • 225 to 250 m^3/s 2 to 15 August • 175 to 250 m^3/s 16 August to 15 October Below 200 m^3/s 16 October to 12 April	Includes fish transfer May to September. *Note this alternative is considered to be delivered on an opportunistic basis (1 in 5 years)*

6.4.3.2 Round 3 Non-Operational Physical Works

As specified in the provincial government's *Water Use Plan Guidelines*, the water use planning process is intended to address issues related to the operation of hydroelectric power and other water control facilities in British Columbia as they currently exist, and incremental changes to operations to accommodate other water uses. As per the provincial government's *Creating Water Use Plan Alternatives* information sheet, physical works such as changes to facility physical structures are excluded, except to the extent that they may provide a preferred alternative, in lieu of changes in water flows or reservoir elevations that is both technically feasible and cost effective. A Water Use Plan may combine changes in physical works with changes in flows and reservoir elevations.

In Round 3, the Consultative Committee reviewed a number of non-operational physical works in lieu of operational changes that had been recommended by the technical subcommittees.

Wildlife	1) Argenta Slough erosion protection in the Duncan River
Cultural Resources	2) Identified cultural sites erosion protection options in the Duncan Reservoir
Recreation	Options:
	3(a) Beach re-contouring at Glacier Creek
	3(b) Boat launch/mooring buoys at Glacier Creek
	3(c) Maintenance at Howser and Glayco creeks recreation sites
	3(d) Partial funding towards mosquito abatement program

The Consultative Committee evaluated the non-operational physical works using the following sequential criteria:

1. Assuming existing physical structures, could the issue be addressed, partially or fully, by changes in current operations (i.e., water flows or reservoir levels)?

2. Are the proposed changes permitted by existing legal rights, international agreements and safety standards?

3. Based on an estimate of the benefits, costs and risks, are changes in operations the preferred way to address the specified issue(s)?

4. Based on an estimate of the benefits, costs and risks, is it likely that changes to current physical structures or other changes, either in lieu of or in addition to operational changes, will provide a better way to address the specified issue(s)?

Refer to Appendix H: Non-Operational Physical Works for additional detail on the non-operational physical works options.

Table 6-4 summarizes the Round 3 non-operational physical works options in lieu of operational changes reviewed by the Consultative Committee.

Table 6-4: Round 3 Non-Operational Physical Works Options in Lieu of Operational Changes

Area	Interest	Non-Operational Alternative	Description	Options	Annual Levellized Cost ($K)	Total Cost to Water Use Plans ($K)	YR1	YR2	YR3	YR4	YR5 ($K)	YR6	YR7	YR8	YR9	YR10
Lower Duncan River	Wildlife	Argenta Slough Erosion Protection	To prevent the continued erosion and loss of the Argenta Slough and Wetland, four erosion protection options were identified.	Bio-remediation	$27.5	$275.0	$230.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0
				Armouring	$36.5	$365.0	$325.0	$-	$-	$20.0	$-	$-	$-	$20.0	$-	$-
				Protective Weirs	$11.0	$110.0	$80.0	$-	$-	$15.0	$-	$-	$-	$15.0	$-	$-
				River Re-directions	$15.5	$155.0	$105.0	$-	$-	$25.0	$-	$-	$-	$25.0	$-	$-
Reservoir	Cultural Resources	Erosion Protection for Heritage and Cultural Sites	To prevent the continued erosion and degradation of two cultural sites identified in the Duncan Reservoir, two erosion protection options were identified.	Riprap Blanket	$240.0	$2,400.0	$150.0	$2,250.0	$-	$-	$-	$-	$-	$-	$-	$-
				Non-Woven Geotextile Blanket	$104.0	$1,040.0	$100.0	$860.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
	Recreation	Options for Recreation Non-Ops	The Recreation Technical Subcommittee identified four non-operational physical works to address impacts to recreation on the Duncan Reservoir in lieu of an operational change.	Beach Re-contouring at Glacier Creek	$5.5	$55.0	$10.0	$25.0	$-	$5.0	$-	$5.0	$-	$5.0	$-	$5.0
				Boat Ramp Extension/Mooring Buoys	$12.6	$126.0	$106.0	$-	$-	$-	$10.0	$-	$-	$-	$-	$10.0
				Maintenance at Howser and Glayco creeks recreation sites	$5.0	$50.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0	$5.0
				Partial funding towards mosquito abatement program	$20.0	$200.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0	$20.0

6.4.4 Round 4 Operating Alternatives

In Round 4, the Consultative Committee reviewed the results from four operating alternatives – *three new alternatives and one revised*. Of the three new alternatives, two were developed through recommendations from the Wildlife and Fish Technical subcommittees and the third new alternative was recommended during the final Committee meeting.

The two new operating alternatives recommended by the Wildlife and Fish Technical subcommittees were intended to better meet fish and wildlife objectives and cross-ecosystem benefits. The Fish Technical Subcommittee received new information that suggested that the spawning period for whitefish in the lower Duncan River was different than previously assumed (originally from 15 October to 15 November). Therefore, to achieve similar benefits, the minimum flow alternatives required a longer duration of the fall target flows. A new alternative was recommended that extended target flows in the lower river until the end of December. A target range of 90 to 130 m^3/s was specified to allow more flexibility with a minimum flow of 90 m^3/s year-round.

The Wildlife Technical Subcommittee reviewed Alternatives L, M, O and P and wanted to mitigate the washing and scouring out of new cottonwood seedlings associated with the typical drop in river flows and then sudden increase in flows after reaching full pool each year (referred to as the August trough). At this time, the subcommittee prioritized flows in the lower Duncan River above 250 m^3/s as desirable for encouraging cottonwood recruitment. Accordingly, it was felt that the potential August trough impacts could be mitigated with a flow cap of 250 m^3/s through the first year of the cottonwood growing season.

Based on the target cottonwood recruitment area above 250 m^3/s, the flow constraints for Alternative K were revised to provide additional flexibility with any constraint below 250 m^3/s in the lower Duncan River (refer to Table 6-5).

The alternatives and changes are summarized as follows:

Alternative Q (90)	hybrid of Alternative M (90) except for a change in the desired late fall target flows. A target flow of 90 m^3/s in the lower Duncan River begins on 15 September and continues to 21 October. After this, a variable target range of between 90 to 130 m^3/s is set from 22 October until 31 December.
Alternative R (90)	hybrid of Alternative Q (90) with a maximum lower Duncan River flow of 250 m^3/s from 1 August to 31 August, 190 m^3/s from 1 to 7 September, and 130 m^3/s from 8 to 15 September.

During the final Consultative Committee meeting, the Committee developed Alternative S (73) by combining Alternative R (90) with lower Duncan River flows to minimize negative power generation impacts.

Alternative S (73) hybrid of Alternative R (90) with a minimum/target flow of 73 m^3/s in the lower Duncan River. The start date for the target flow was delayed to 1 October each year.

Table 6-5 summarizes the new and revised Round 4 operating alternatives.

Table 6-5: Round 4 Operating Alternatives

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
Q (90) Downstream Interests	Fish interests (Lower Duncan River) Local flooding Mosquitoes Recreation	Target full pool by 1 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 300 m^3/s 1 to 31 August • 230 m^3/s 1 to 7 September • 160 m^3/s 8 to 15 September 90 m^3/s target 15 September to 21 October Between 90 and 130 m^3/s 22 October to 31 December 90 m^3/s minimum year-round 140 m^3/s maximum 10 April to 15 May 400 m^3/s maximum at other times	Includes fish transfer May to September. Hybrid of Alternative M (90).

Table 6-5: Round 4 Operating Alternatives (cont'd)

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
R (90) Downstream Interests	Fish interests (Lower Duncan River) Local flooding Mosquitoes Recreation	Relax full pool target until 8 August Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 250 m^3/s 1 to 31 August • 190 m^3/s 1 to 7 September • 130 m^3/s 8 to 15 September • 90 m^3/s target 15 September to 21 October Between 90 and 130 m^3/s 22 October to 31 December 90 m^3/s minimum year-round 140 m^3/s maximum 10 April to 15 May 250 m^3/s maximum 1 January to 9 April 400 m^3/s maximum at other times	Includes fish transfer May to September. Hybrid of Alternative M (90).
S (73)	Fish interests (Lower Duncan River) Cottonwood recruitment (Lower Duncan River) Local flooding Mosquitoes Recreation	Reach full pool between 1 and 10 August (to mitigate a drop or trough) Decrease reservoir elevation to 575.5 m after 1 August and maintain until 5 September	3 m^3/s minimum 283 m^3/s normal maximum	Maximum target: • 250 m^3/s 1 August to 24 September • 190 m^3/s 25 to 27 September • 130 m^3/s 27 to 30 September • 73 m^3/s target 1 to 21 October Between 73 and 110 m^3/s 22 October to 21 December 73 m^3/s minimum year-round 120 m^3/s maximum 10 April to 15 May 250 m^3/s maximum 22 December to 9 April (300 m^3/s alternate to meet flood curve) 400 m^3/s maximum at other times	Includes fish transfer May to September. Hybrid of Alternative R (90).

Table 6-5: Round 4 Operating Alternatives (cont'd)

Alternative	Priorities	Duncan Reservoir	Dam Discharge	Lower Duncan River Flows	Notes
K– Cottonwood Hydrograph (Revised)	Cottonwood recruitment (Lower Duncan River) Local flooding	–	3 m^3/s minimum	400 m^3/s maximum Target: • >375 m^3/s 15 to 30 June • >350 m^3/s 1 to 12 July • 325 to 350 m^3/s 13 to 20 July • 275 to 300 m^3/s 21 to 26 July Below 250 m^3/s 27 July to 12 April	Includes fish transfer May to September *Note this alternative is considered to be delivered on an opportunistic basis (1 in 5 years)*

6.4.4.1 Round 4 Non-Operational Physical Works

During the final Consultative Committee meeting, additional non-operational physical works options were added to the list of Round 3 non-operational physical works options (refer to Section 6.4.3.2). Partial funding for the Columbia Basin Fish and Wildlife Compensation's Kootenay Lake Nutrient Loading Program physical works option was proposed in lieu of operational changes in the north arm of Kootenay Lake to address cross-system fish interests. Erosion protection of agricultural lands was proposed in lieu of operational changes in the lower Duncan River.

Fish

1) Partial funding for Columbia Basin Fish and Wildlife Compensation's Kootenay Lake Nutrient Loading Program.

2) Exclusion fencing in affected lower Duncan River sidechannels.

Erosion

3) Erosion protection of agricultural lands.

Table 6-6 summarizes the additional Round 4 non-operational physical works options in lieu of operational changes reviewed by the Consultative Committee.

Table 6-6: Round 4 Non-Operational Physical Works Options in Lieu of Operational Changes

Area	Interest	Non-Operational Alternative	Description	Options	Annual Levellized Cost ($K)	Total Cost to Water Use Plans ($K)	YR1	YR2	YR3	YR4	YR5 ($K)	YR6	YR7	YR8	YR9	YR10
Lower Duncan River	Fish	Annual Sidechannel Exclusion Fencing	To prevent the use of lower Duncan River sidechannels by spawning kokanee proceeding kokanee spawning flows from 1 October through the installation of exclusion fencing at the outlet(s) of affected sidechannel(s) were identified.	Pole fencing	$13.5	$135.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
				Weir	$8.9	$89.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0
				Sandbag Operations	$10.0	$100.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
	Agricultural Lands	Erosion Protection of Agricultural Lands	To prevent the continued erosion and loss of agricultural lands, a number of protective options were identified.	At the final Consultative Committee meeting, a number of options including, riprap armouring deflector, weirs, bioremediation and breaching.	N/A	N/A	-	-	-	-	-	-	-	-	-	-
Downstream (Kootenay Lake)	Ecosystem	Funding towards the Columbia Basin Fish and Wildlife Compensation Program Kootenay Lake Nutrient Loading Program	To retain nutrients in the Duncan Reservoir, partial funding of the Columbia Basin Fish and Wildlife Compensation Program Nutrient Loading Program in Kootenay Lake was identified.	Nutrient retention as a fraction of Total (Alt A Comparison)	$100.0	$1,000.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
				Nutrient retention as a fraction of Total (Optimal Comparison)	$100.0	$1,000.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0
				Nutrient retention as a fraction of 47MT (Alt A Comparison)	$8.9	$89.0	$8.9	$8.9	$8.9	$8.9	$8.9	$8.9	$8.9	$8.9	$8.9	$8.9
				Nutrient retention as a fraction of 47MT (Optimal Comparison)	$17.8	$178.0	$17.8	$17.8	$17.8	$17.8	$17.8	$17.8	$17.8	$17.8	$17.8	$17.8

7 TRADE-OFF ANALYSIS

7.1 Introduction

In Step 7 of the provincial government's *Water Use Plan Guidelines*, the Consultative Committee evaluated the trade-offs associated with the operating alternatives described in Section 6. The alternatives varied in the benefits they provided. Natural rates of inflow and Duncan Reservoir storage capacity imposed limits on how much water was available to satisfy the range of Duncan Dam water use planning objectives. Accordingly, there were trade-offs on what can be achieved with a finite supply of water. For instance, maintaining higher flows for fish utilizing the sidechannels in the lower Duncan River means that, under some conditions, there may be less water available for power generation and operational flexibility.

The trade-off analysis process involved discussions of the relative value among the Duncan Dam water use planning objectives: gaining more of some values in exchange for less of others. The Consultative Committee sought the operating alternative that best balanced the range of water use planning objectives specified in Section 4.

This section describes the trade-off analysis process and values that Consultative Committee members placed on different Duncan Dam water use planning objectives. The structure of this section is organized according to the sequential rounds of the trade-off analysis process.

7.2 Overview of the Trade-off Analysis Process

The Consultative Committee conducted the trade-off analysis process in three Committee meetings during the Duncan Dam water use planning process.

Figure 7-1 illustrates the operating alternatives that were considered in the trade-off analysis process.

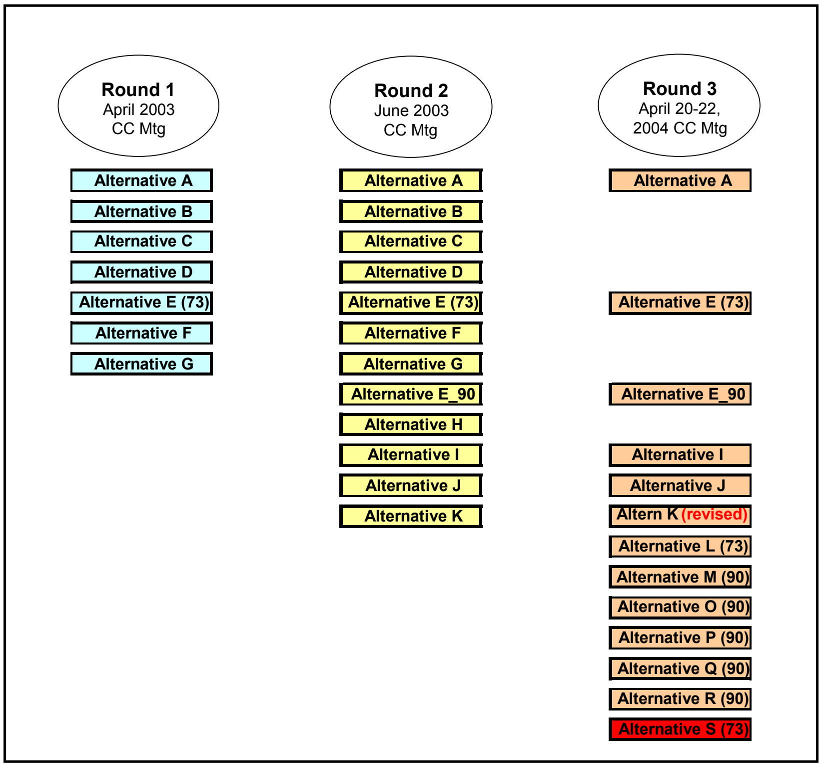


Figure 7-1: Alternatives Considered during the Trade-off Analysis Process

Value-based trade-off techniques and preference analysis were used by the Consultative Committee to select a preferred operating alternative. Numerous techniques were used to assess both the technical and value trade-offs including: interactive consequence tables, direct ranking exercises, swing weighting exercises, and pair-wise comparisons. Alternatives were evaluated and those that were clearly "dominated," or performed worse across performance measures either by direct comparison or agreement by the Committee, were removed from further analysis.

The process for selecting a preferred operating alternative involved the following steps:

1. Assess trade-offs among alternatives with reference to the performance measures;
2. Eliminate performance measures that do not vary across alternatives;
3. Eliminate alternatives that the Consultative Committee agrees are "dominated" by other alternatives;
4. If possible, combine elements of alternatives to design better alternatives and repeat; or
5. Assess the degree of Committee consensus on remaining alternatives; and
6. Ideally, recommend a preferred alternative.

7.3 Understanding the Modelling Results

Technical trade-off analysis consists of analyzing the technical and scientific information presented as performance measures. During the trade-off analysis process, the operating alternative modelling results were presented to the Consultative Committee in a variety of ways. Hydrographs were used to illustrate the hydrological behaviour of Duncan Reservoir, the lower Duncan River, and Kootenay Lake. Consequence tables were used to illustrate the impact of each alternative on objectives through the performance measures.

Table 7-1 summarizes the components included in a consequence table using the Recreation Quality performance measure and five Round 1 alternatives as an example.

Table 7-1: Consequence Table for Recreation

Consequence Table (Median Values)					Alternative Name				
Objective	**Performance Measure**	**Unit**	**Best?**	**MSIC**	**Alt A – Current Operations**	**Alt B – D/S Inundation**	**Alt C – Recreation**	**Alt D – Vegetation**	**Alt E (73) – D/S Fish**
Recreation	Recreation Quality	Weighted User Days (1 July to 30 September)	More	10%	474	228	586	163	357

In the first column, Recreation is the "ends" objective. In the second column, ***Recreation Quality*** is the performance measure. In the third column, Weighted User Days is the unit of measure. In the fourth column, "best" refers to the direction of preferred change. ***Recreation Quality*** is better if the number of weighted user days is more (or higher). In the fifth column, 10% is the Minimum Significant Increment of Change (MSIC). The MSIC indicates the degree of significance to be attributed to the difference between two performance measure values. Subsequent columns of Table 7-1 show the median values for each of the alternatives calculated from the model outputs. In this case, Alternative C – Recreation performs best for ***Recreation Quality*** with 586 weighted user days.

Figure 7-2 illustrates the range of the ***Recreation Quality*** performance measure values, represented by the bold line, due to annual variations in inflows. Comprehensive consequence tables were also used to show median, 10^{th} percentile and 90^{th} percentile values for performance measures based on the 20 years of inflow data. For example, Alternative A – Current Operations scored 474 weighted user days in the median year, 606 in the 90^{th} percentile year (i.e., one year in ten) and 346 in the 10^{th} percentile year (i.e., one year in ten).

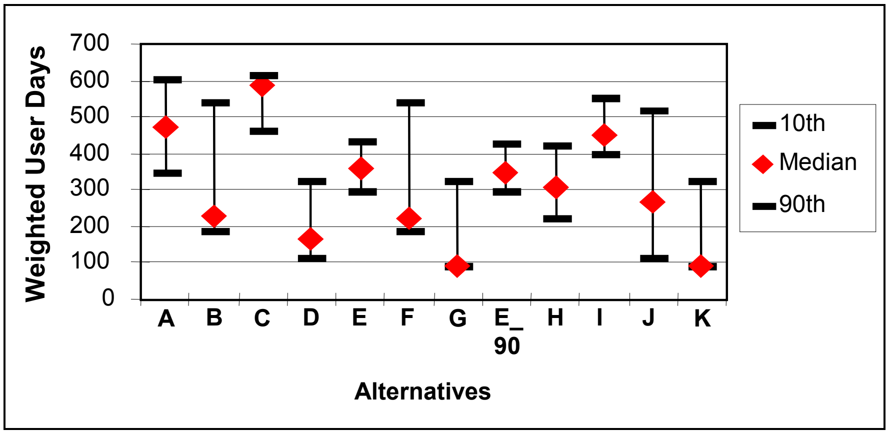


Figure 7-2: Recreation Quality Performance Measure Box Plot

7.3.1 Uncertainties and Limitations

There were a number of uncertainties and limitations associated with the quality of information used during Step 6 – Creating Alternatives and Step 7 – Trade-off Analysis of the provincial government's *Water Use Plan Guidelines*.

- **Inflow data quality:** The BC Hydro Operations Model initially used 20 years and then 32 years of historical inflow data input for the initial rounds of modelling and 33 years of record after the model was revised. The larger the data set, the greater the certainty that the information is adequate to capture the variability associated with extreme events. A 32-year data set was considered adequate for the Duncan Dam water use planning operating alternatives since it included some extreme years, 1972 and 1976 in particular, which were very high inflow years.

- **Inflow variation:** There is variation in the 32 years of historical inflow data for the Duncan Reservoir. Performance measures behave differently when inflows are high compared to when they are relatively low. Performance measures for the operating alternatives were presented for the highest 90th percentile, the lowest 10th percentile, and the average median value.

- **Model configuration accuracy:** During the Duncan Dam water use planning process, an Operations Model called A Mathematical Programming Language (AMPL) was used to model the operating alternatives.

  The AMPL model is configured to meet the constraints specified in an operating alternative. Subsequent to meeting the constraints specified, the alternative was optimized for power generation. In some instances, several iterations of modelling were required for an alternative.

- **Operating alternative specification ambiguity:** Operating alternatives were specified in terms of hard or soft constraints (e.g., minimum flows and minimum reservoir elevations). The Operations Model must meet a hard constraint. Soft constraints are desirable, but can be relaxed should other impacts become excessive in the opinion of BC Hydro modellers. Consequently, several alternatives were remodelled during the trade-off analysis process.

- **Performance measure relationship to objectives:** Most performance measures are not direct measures of the "ends" objective. For example, the number of ***Recreation Quality*** weighted user days can be extracted from modelling data. However, the number of days does not indicate how or to what degree recreation quality will improve.

- **Minimum significant increment of change:** Given the combined uncertainties listed above, the Minimum Significant Increment of Change (MSIC) for each performance measure was developed. Two operating alternatives with a difference in performance measure values equal to or less than the MSIC implies that the difference is not meaningful because of the uncertainty.

  Given the complex nature of the environmental performance measures, the technical subcommittees reviewed the methods of calculation and values derived from the performance measures to define the MSIC values.

7.4 Round 1 Trade-off Analysis

At the first trade-off analysis process meeting, the Consultative Committee considered the seven Round 1 operating alternatives. These trade-off discussions helped the Committee to understand the Duncan Dam system and specify subsequent alternatives. No operating alternatives were dropped during this round of the trade-off analysis process.

The following summarizes the highlights of the first trade-off analysis process meeting:

- Alternative G – Naturalized Hydrograph violated the Columbia River Treaty Flood Control Rule Curves for the Duncan Reservoir in many average or above average inflow years.

- Alternative E (73) – Downstream Fish provided benefits for kokanee spawning and all downstream fish interests because it focuses on the productive capacity of both the mainstem and sidechannel areas of the lower Duncan River.

- **Spawning burbot in the Duncan Reservoir versus fish interests in the lower Duncan River:** There is a large degree of uncertainty as to the timing, location, ideal conditions for spawning, and health of the burbot stock in the Duncan Reservoir; as well as uncertainty related to rearing and spawning habitats in the sidechannels of the lower Duncan River. Given this uncertainty, and based on one of the competing burbot hypotheses for spawning, there is a trade-off in benefits between fish interests in the reservoir versus fish interests in the lower Duncan River. Since winter inflows to the reservoir are not high enough to provide benefits for sidechannel fish habitat in the river, there is a trade-off between desirable reservoir elevations and augmenting river flows. Accordingly, Alternatives A – Current Operations, B – Downstream Inundation, C – Recreation, D – Vegetation, and F – Burbot that perform well for reservoir burbot by maintaining a more stable reservoir, perform poorly for fish utilizing the sidechannels in the lower Duncan River. Conversely, Alternative E (73) – Downstream Fish performs well for sidechannel fish, but performs poorly for reservoir burbot.

- **Total gas pressure versus the operation to allow the passage of bull trout through the low-level outlets of the Duncan Dam:** Operations at Duncan Dam currently allow for the passage of bull trout migrating up into the Duncan Reservoir. This operation is achieved by co-ordinating flows through the two low-level outlets (LLOs) from May to mid-September, restricting flow volumes to 140 m^3/s[1] from the LLOs and using the spillway to release any additional flow. Once spillway flows increase above 115 m^3/s, Total Gas Pressure (TGP) levels are believed to begin adversely affect fish downstream and this risk increases with higher spillway discharges. Therefore, after the reservoir is near full pool and natural inflows are above 255 m^3/s, there is a trade-off between aiding bull trout migrations into the reservoir versus TGP effects on fish downstream. Alternatives that perform well for bull trout migration (C – Recreation, D – Vegetation, E (73) – Downstream Fish, and G – Naturalized Hydrograph) perform poorly for TGP because they involve a fuller reservoir and higher flows in late August and early September. This trade-off was subsequently addressed during the second round of the trade-off analysis process.

- **Recreation quality versus reservoir riparian productivity:** High Duncan Reservoir water levels desired for recreation adversely impact shrub communities in the upper reservoir drawdown zone. Shrubs can withstand a certain amount of flooding throughout their growing season, but will die if the inundation period is too long. There is a trade-off with maintaining a high reservoir elevation level for ***Recreation Quality*** versus maintaining a lower reservoir for high shrub production. Alternatives that perform well for ***Riparian Productivity – Inundation Tolerance*** (B – Downstream Inundation, D – Vegetation, and F – Burbot) perform poorly for ***Recreation Quality***. Conversely, Alternatives A – Current Operations and C – Recreation perform well for ***Recreation Quality,*** but perform poorly for ***Riparian Productivity – Inundation Tolerance***.

[1] Note this flow volume was revised from 140 to 170 m^3/s in Round 2 of developing operating alternatives.

- **Riparian productivity in the reservoir versus cottonwood recruitment in the lower Duncan River:** Alternative G – Naturalized Hydrograph performs best for wildlife interests and cottonwood recruitment in the lower Duncan River, but performs poorly for the riparian community in the upper Duncan Reservoir drawdown zone because minimum inundation periods are not met. There is a trade-off between maintaining high river flows for cottonwood recruitment versus lower reservoir elevations on average through the growing season, which adversely impacts the shrub production. Alternatives A – Current Operations, C – Recreation, and E (73) – Downstream Fish perform poorly for the riparian community in the upper Duncan Reservoir drawdown zone because they involve higher reservoir elevations that exceed the allowable inundation tolerance of shrubs.

- **Recreation quality versus flood protection and mosquito habitat:** Maintaining Duncan Reservoir near full pool during the recreation season (June to September) does not allow a contingency (excess storage space) to mitigate high inflow events that cause higher river flows and sometimes flooding downstream. Higher river flows also increase the risk of mosquito breeding events through the (re) inundation of habitat. There is a trade-off between maintaining a high Duncan Reservoir elevation for recreation interests versus flooding and mosquito interests downstream. Alternatives A – Current Operations and C – Recreation perform well for Recreation Quality, but perform poorly for ***Flood Risk*** and ***Mosquito Breeding Habitat***.

- **Kootenay power generation versus riparian productivity in the lower Duncan River:** To meet high flow targets for cottonwood recruitment in the lower Duncan River, less water on average would be available for power generation during the winter when power values are highest. Since Duncan Dam has to release higher flows during spring freshet when the Kootenay Canal plants are typically spilling, additional financial impacts occur. This spilled water would have otherwise been stored and used for power generation later in the year. There is a trade-off between providing high flows for cottonwood recruitment and power generation. Alternative G – Naturalized Hydrograph performs well for cottonwood recruitment, but performs poorly for power generation.

Table 7-2 summarizes the consequence table for the Round 1 trade-off analysis process.

Table 7-2: Consequence Table for Round 1 Trade-off Analysis Process

					Alternative Name						
Objective	**Performance Measure**	**Unit**	**Best?**	**MSIC**	**Alt A – Power**	**Alt B – Flood**	**Alt C – Recreation**	**Alt D – Veg**	**Alt E – Kokanee**	**Alt F – Burbot**	**Alt G – Naturalized**
Recreation	Recreation Quality	Weighted User Days (1 July – 30 September)	More	10%	474	228	585	163	357	224	92
Quality of Life – Mosquitoes	Mosquito Breeding Habitat	Weighted Hectares of Habitat	Less	10%	48	50	51	51	51	50	49
Fish (Reservoir)	Burbot Spawning	% of time reservoir is stable 15 February – 15 April	More	20%	0.93	0.93	1.00	0.92	0.17	0.87	0.63
Fish (Mainstem)	Kokanee Effective Spawning Habitat	Hectares	More	10%	23.5	23.6	23.6	24.3	42.8	30.3	28.9
	Whitefish Effective Spawning Habitat	Hectares	More	20%	19.9	19.9	20.0	20.3	37.0	29.4	38.9
	Kokanee Effective Rearing Habitat Lost	Hectares	Less	10%	23.2	23.3	18.4	23.1	23.2	22.2	22.6
	Rainbow Effective Rearing Habitat Lost	Hectares	Less	10%	20.3	19.4	20.5	19.2	15.7	18.4	11.9
	Total Gas Pressure (TGP) Risk	TGP Days at or above 115%	Less	10%	4.5	5.5	14.0	14.0	16.5	6.0	14.0
		Average duration for each TGP day	Less	10%	4.5	5.5	14.0	14.0	16.5	6.0	14.0
Fish (Sidechannels)	Kokanee Effective Spawning Habitat	Hectares	More	10%	113.5	113.5	113.5	132.9	541.1	152.2	152.2
	Rainbow Effective Rearing Habitat	Hectares	More	10%	407.2	419.0	398.7	401.2	520.5	433.8	497.0
Cultural Resources	Erosion Protection	Weighted Exposure Days	Less	20%	603	610	663	545	672	627	894
	Exploitation Protection	Weighted Exposure Days	Less	20%	75	75	38	75	74	66	178
Wildlife (Reservoir)	Riparian Productivity – Inundation Tolerance	Hectares of shrub area (willow)	More	20%	86.4	143.6	68.9	128.0	73.6	141.3	75.5
	Riparian Productivity – Long-term Median	Hectares of Herbaceous area using long-term median level	More	20%	314.6	347.8	307.1	341.5	354.0	347.8	456.9

Note: Performance measures are represented as median values.

Table 7-2: Consequence Table for Round 1 Trade-off Analysis Process (cont'd)

					Alternative Name						
Objective	**Performance Measure**	**Unit**	**Best?**	**MSIC**	**Alt A – Power**	**Alt B – Flood**	**Alt C – Recreation**	**Alt D – Veg**	**Alt E – Kokanee**	**Alt F – Burbot**	**Alt G – Naturalized**
Wildlife (Lower Duncan River)	Cottonwood Hydrograph Weighted Index	Weighted Index from the deviation of a naturalized hydrograph	More	10%	46%	49%	55%	49%	52%	54%	85%
Flooding	Annual Flood Risk Days	# of days above 400	Less	10%	5	3	7	4	4	5	3
		# of days above 450	Less	10%	3	0	3	0	0	1	0
		# of days above 500	Less	10%	1	0	1	0	0	0	0
Power	Power Generation (Kootenay River Plants)	Average Annual GWh/yr	More	2	5,777	5,771	5,742	5,764	5,760	5,744	5,700
	Financial Revenue (VOE)	Average Annual Value of Generation ($ in million)	More	$0.1M	298.4	298.1	296.8	298.0	298.2	297.0	294.8
	Operational Flexibility	# of days of constrained operation/yr	Less	10 days	0.0	0.0	35.0	15.0	105.0	15.0	180.0

7.4.1 Trade-off Analysis Techniques

Two trade-off techniques were used during the first round of the trade-off analysis process to inform the Consultative Committee on how the Duncan Dam system operates, and gain insight into how each operating alternative performs according to their values as represented by the performance measures. These techniques were used for discussion purposes and to generate ideas for new alternatives.

7.4.1.1 Interactive Consequence Table

The interactive consequence table was developed as a tool that could be used in the trade-off analysis process to compare two or more operating alternatives and highlight performance measures. A key component of the table was the use of the Minimum Significant Increment of Change, the minimum change in a performance measure, which was meaningful and measurable.

The Consultative Committee used the consequence table to help eliminate non-preferred or practically dominated operating alternatives. During the first round of the trade-off analysis process, no one operating alternative clearly dominated another alternative.

7.4.1.2 Direct Ranking

The Consultative Committee was asked to rank each of the seven operating alternatives in descending order of preference, with 1 being most preferred and 7 being least preferred.

Figure 7-3 illustrates the cumulative results from this exercise using a colour coding scheme of green for most preferred rankings of 1 and 2; beige indicating a neutral ranking for 3, 4 and 5; and red for least preferred rankings of 6 and 7.

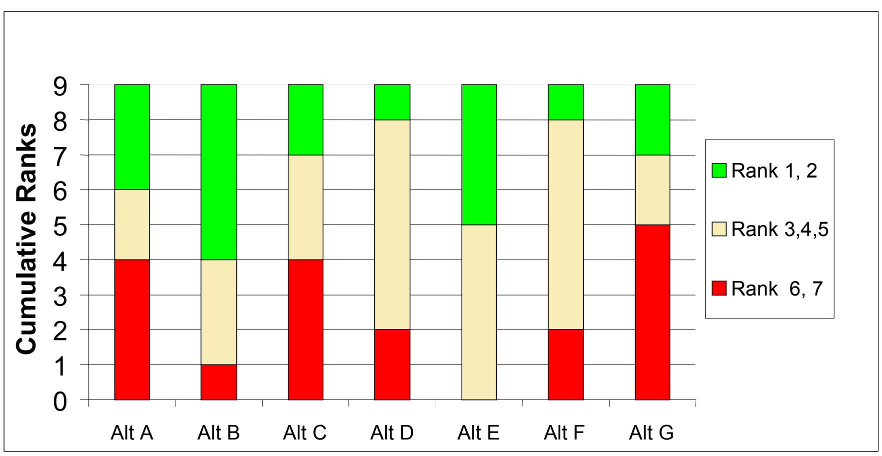


Figure 7-3: Cumulative Consultative Committee Rankings of the Round 1 Operating Alternatives

The cumulative rankings indicate that Alternatives B – Downstream Inundation and E (73) – Downstream Fish were the most favourable to Consultative Committee members. Alternative B had the most number of 1 and 2 rankings, but it was also one of the least favourable alternatives to one Committee member. Alternative E (73) did not have any low rankings, but one less Committee member believed that it performed best for their interests. Alternatives A – Current Operations, C – Recreation, and G – Naturalized Hydrograph were the weakest performers based on the most number of 6 and 7 rankings.

7.4.1.3 Pair-wise Comparison of Value Rankings

The Consultative Committee also reviewed their value rankings according to pair-wise comparisons between any two operating alternatives. For this exercise, Committee members considered pairs of objectives. For each pair, the Committee member decided which objective or performance measure is the more important and indicated whether it is only slightly more important or significantly more important. This exercise provided more insight for members about the degree of support (or popularity) for the alternatives. Figure 7-4 and Figure 7-5 illustrate the results of this exercise.

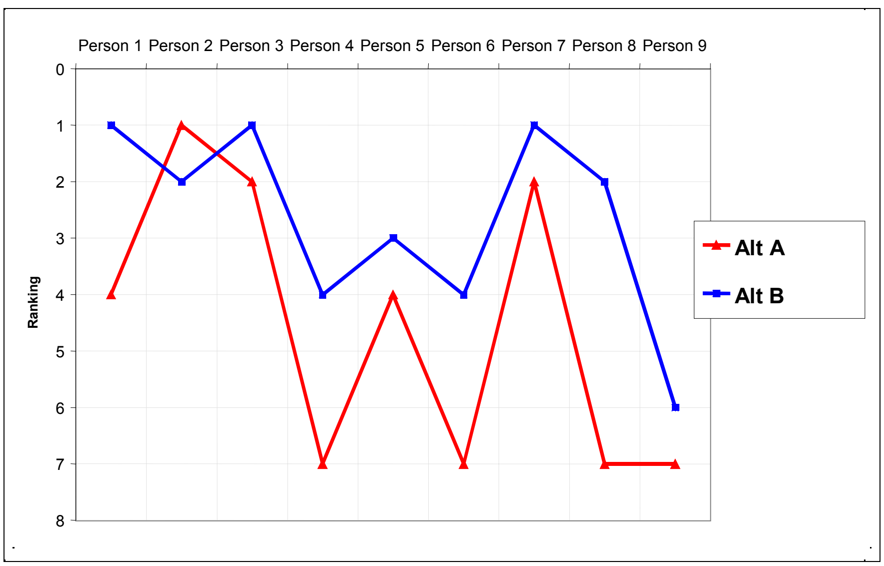


Figure 7-4: Consultative Committee Member Ranking of Alternatives A and B

Figure 7-4 illustrates that, with the exception of one Consultative Committee member, all members preferred Alternative B – Downstream Inundation over Alternative A – Current Operations. Further, if there is little difference between member 2's top two rankings, then effectively Alternative B dominates Alternative A.

Figure 7-5: Consultative Committee Member Ranking of Alternatives E and K

Figure 7-5 illustrates that, with the exception of two Consultative Committee members, all members preferred Alternative E (73) – Downstream Fish to Alternative G – Naturalized Hydrograph.

7.5 Round 2 Trade-off Analysis

During the second round of the trade-off analysis process, the Consultative Committee evaluated the seven Round 1 operating alternatives and five new Round 2 alternatives. These trade-off discussions assisted the Committee in evaluating the alternatives, removing those alternatives that were clearly dominated by other alternatives, highlighting the front-running alternatives, and developing new alternatives for Round 3 that would better meet Committee members' values and balance the competing objectives.

The following summarizes the highlights of the second round of the trade-off analysis process:

- **Spawning burbot in the Duncan Reservoir versus fish interests in the lower Duncan River:** This trade-off was highlighted in the first round of the trade-off analysis process. For the Duncan Reservoir, it is hypothesized that the burbot population is relatively healthy. The Fish Technical Subcommittee hypothesized that burbot spawn at the interface of the reservoir and tributary mouths. Therefore, stable reservoir elevations during the burbot spawning and incubation period would ensure that eggs were not dewatered or suffocated with sediments from eroding riverbanks.

  Figure 7-6 illustrates the historic Duncan Reservoir water levels during the burbot spawning and egg incubation period from 15 February to 15 April.

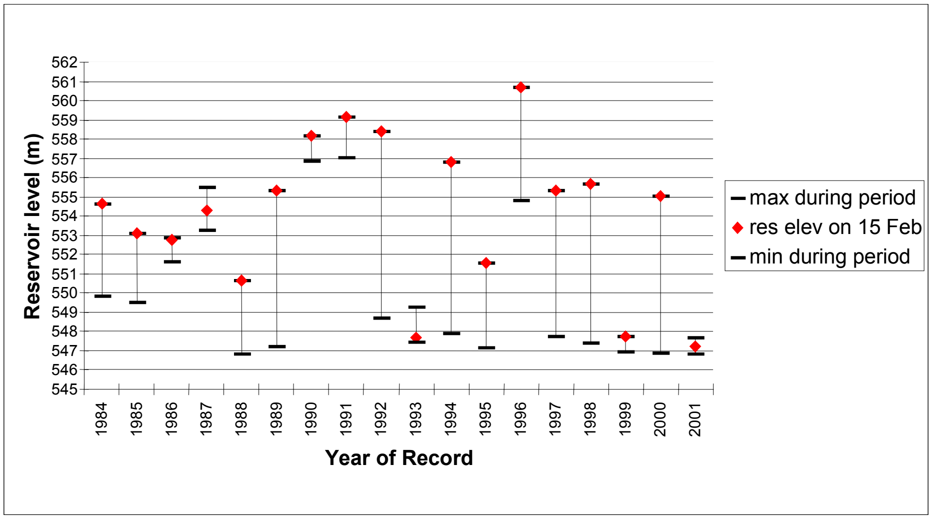


Figure 7-6: Historical Duncan Reservoir Water Levels during the Burbot Spawning and Egg Incubation Period, 15 February to 15 April

Figure 7-6 illustrates that there has been a large variation in historic Duncan Reservoir water levels during the burbot spawning and egg incubation period. This suggests that burbot spawning is insensitive to operations and varying reservoir elevations. However, it was noted that there were years when the reservoir level varied by less than 2 m. Given the lack of any meaningful studies completed on this subject, no conclusions could be drawn between burbot spawning and egg incubation, and reservoir water levels.

Operating alternatives that benefit fish interests in the lower Duncan River include a target minimum flow during the kokanee and whitefish spawning and incubation periods to maximize available sidechannel areas for spawning and limit spawning at higher elevations, which would subsequently become dewatered. Consultative Committee members expressed different values about the significance and importance of providing flows for kokanee spawning.

During large kokanee spawning runs, Meadow Creek[1] is limited by the availability of spawning habitat. When this occurs, the sidechannels and mainstem of the lower Duncan River are important for providing overflow areas for kokanee to spawn. There was uncertainty as to the importance that this overflow spawning area may provide. According to 2002 estimates, the number of kokanee spawning in the lower Duncan River was about one per cent of the total run. However, it was suggested that this one per cent

[1] Meadow Creek is located downstream of Duncan Dam and flows into the lower Duncan River. The Meadow Creek Fish Hatchery was built as a mitigation measure during the construction of the dam to offset lost kokanee spawning areas.

might represent a distinct stock of kokanee, which would increase the importance of providing target flows.

- **Total gas pressure versus operations to allow the passage of bull trout through the Duncan Dam low-level outlets:** A constraint to limit discharges below 255 m^3/s through the Duncan Dam low-level outlets was added to all new operating alternatives to eliminate impacts associated with the bull trout transfer operation on TGP-related fish issues (without affecting other interests).

- **Recreation quality versus reservoir riparian productivity versus kokanee and whitefish spawning target flows:** To provide a minimum flow target at the beginning of the kokanee spawning period, the Duncan Reservoir must be drawn down in preparation to store excess inflows to the reservoir above the desired target flows. Later in the fall as excess inflows continue to enter the reservoir, the elevation level rises and may inundate shrub communities. There is a trade-off between maintaining a high reservoir level for recreation, and maintaining a low reservoir level for shrub production and downstream fish interests.

The minimum flow Alternatives E (73) – Downstream Fish, E (90) – Downstream Fish, and H (50) – Downstream Fish exhibit a similar reservoir hydrograph.

Figure 7-7 illustrates the Duncan Reservoir water levels under Alternative H (50) – Downstream Fish.

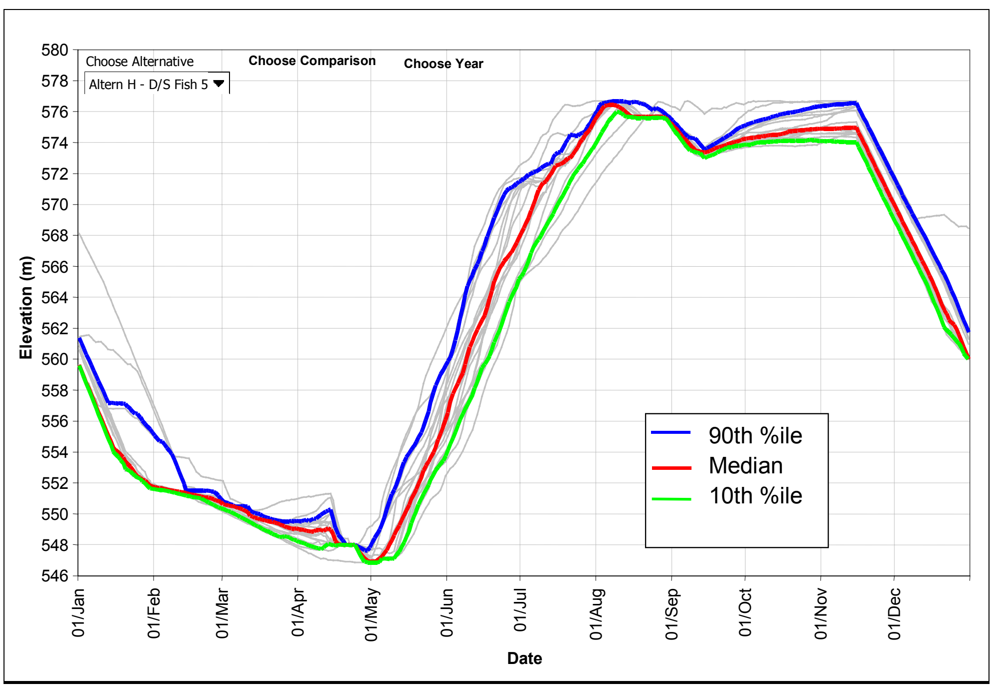


Figure 7-7: Duncan Reservoir Hydrograph for Alternative H

- **Kootenay River power generation versus downstream fish interests in the lower Duncan River:** The delivery of minimum flows throughout the winter period requires additional water above the natural inflows coming into the Duncan Reservoir. Accordingly, the reservoir needs to store sufficient water to augment the natural inflows up to the minimum flow levels until such a time that natural inflows increase these minimum levels, which typically occurs during the pre-freshet as the snow starts to melt. The storage space required for the minimum flows has two direct impacts on financial revenue: less water is available during peak demand times in the winter when the value of electricity is highest; and there is less flexibility to use that water for other reasons (e.g., related to agreements, or to meet other objectives such as swapping water between Columbia River Treaty reservoirs). The lack of flexibility is further increased from 15 September to 15 November when the minimum flow alternatives specify a target flow value (i.e., both a minimum and a maximum river flow restriction). There is a trade-off between the minimum flow alternatives and power generation.

  Table 7-3 summarizes the consequence table for Round 2 of the trade-off analysis process.

7.5.1 Reducing the Number of Performance Measures

During the second round of the trade-off analysis process, the Consultative Committee reviewed the performance measures and concluded that some measures could be removed. Some of the performance measures were insensitive across the operating alternatives. One performance measure was based on limited information and the Committee had concerns with its performance. Some performance measures were similar to other measures across the alternatives.

Table 7-4 summarizes those performance measures that were removed during Round 2 of the trade-off analysis process.

Table 7-3: Consequence Table for Round 2 Trade-off Analysis Process

					Alternative Name											
Objective	Performance Measure	Unit	Best?	MSIC	Altern A - Status Quo	Altern B - D/S Inundation	Altern C - Rec	Altern D - Veg	Altern E - D/S Fish (73)	Altern F - Burbot	Altern G - Naturalized	Altern E_90 D/S Fish	Altern H - D/S Fish (50)	Altern I - RCMF	Altern J - Veg - Burb	Altern K - Ctnwd Hydro
Recreation	Recreation Quality	Weighted User Days (1 Jul - 30 Sep)	More	10%	474	228	586	163	357	225	92	350	305	450	267	92
Fish (Reservoir)	Burbot Spawning	% of time reservoir is stable 15 Feb - 15 Apr	More	20%	0.73	0.72	0.12	0.73	0.07	0.98	0.02	0.03	0.13	0.73	0.98	0.70
Fish (Mainstem)	Kokanee Effective Spawning Habitat	Hectares	More	10%	23.5	23.6	23.6	24.3	39.7	30.3	28.9	38.9	40.4	23.5	31.0	25.7
	Whitefish Effective Spawning Habitat	Hectares	More	20%	23.8	23.9	23.8	24.1	54.0	37.2	38.9	58.3	45.9	23.8	37.2	23.7
	Kokanee Effective Rearing Habitat Lost	Hectares	Less	10%	23.2	23.3	18.4	23.1	22.3	22.2	22.6	24.4	22.7	23.2	22.0	22.8
	Rainbow Effective Rearing Habitat Lost	Hectares	Less	10%	20.3	19.4	20.5	19.2	17.0	18.4	11.9	16.7	16.9	18.7	16.8	11.1
	Total Gas Pressure (TGP) Risk	TGP Days at or above 115%	Less	10%	13.0	9.5	14.0	22.0	16.5	10.5	2.5	15.5	0.0	0.0	0.0	0.0
Fish (Sidechannels)	Kokanee Effective Spawning Habitat	Hectares	More	10%	0.0	0.0	0.0	0.0	293.1	0.2	0.4	315.6	193.9	0.0	22.1	0.0
	Rainbow Effective Rearing Habitat	Hectares	More	10%	253.5	262.7	246.4	251.6	322.0	278.3	345.1	331.9	286.5	261.7	281.7	265.5
Cultural Resources	Erosion Protection	Weighted Exposure Days	Less	20%	603	610	663	545	672	627	837	809	547	610	614	866
	Exploitation Protection	Weighted Exposure Days	Less	20%	168	168	131	168	167	159	271	168	166	168	175	250
Wildlife (Reservoir)	Riparian Productivity - Inundation Tolerance	Hectares of shrub area (willow)	More	20%	60.4	132.2	65.6	54.4	69.1	131.0	63.6	111.0	43.8	131.5	71.1	92.7
	Riparian Productivity - Long-term Median	Hectares of Herbaceous area using long-term median level	More	20%	314.6	347.8	307.1	341.5	347.8	347.8	826.1	363.3	347.8	347.8	347.8	729.9
Wildlife (Lower Duncan River)	Cottonwood Hydrograph Weighted Index	Weighted Index from the deviation of a nat'l hydrograph	More	10%	46%	49%	55%	49%	53%	54%	85%	57%	48%	48%	50%	72%
Flooding/ Mosquitoes	**Flood/Mosquito Risk** Annual Flood Risk Days	# of days above 400	Less	10%	5	3	7	4	4	5	3	4	4	3	2	2
		# of days above 450	Less	10%	3	0	3	0	0	1	0	0	0	0	0	0
		# of days above 500	Less	10%	1	0	1	0	0	0	0	0	0	0	0	0
Power	Power Generation (Kootenay River Plants)	Average Annual GWh/yr	More	2	5,777	5,771	5,742	5,764	5,760	5,744	5,700	5,756	5,761	5,770	5,766	5,714
	Financial Revenue (VOE)	**Net Change from Alt A** in Average Annual Value of Generation ($ in million)	More	$0.1M	0	-0.3	-1.6	-0.4	-0.2	-1.4	-3.6	-0.5	-0.5	-0.3	-0.4	-3.2
	Operational Flexibility	# of days of constrained operation/yr	Less	10 days	0	0	35	15	105	15	180	105	105	0	15	80

Note: Performance measures are represented as median values.

Table 7-4: Performance Measures Removed during Round 2 of the Trade-off Analysis Process

Performance Measure	Rationale for Removal
Burbot Spawning (Duncan Reservoir)	Insensitive, high degree of uncertainty
Kokanee Effective Rearing Habitat Lost (Lower Duncan River Mainstem)	Insensitive
Total Gas Pressure Days/Events (Lower Duncan River Mainstem)	Insensitive and redundant, constraint included in operating alternatives
Cultural Resources - Exploitation Protection	Insensitive
Riparian Productivity – Long-term Median	Insensitive
Flood Risk (>450)	Insensitive and was represented implicitly by Flood Risk (400 m^3/s) measure
Flood Risk (>500)	Insensitive and was represented implicitly by Flood Risk (400 m^3/s) measure
Power Generation	Represented by Financial Revenue measure
Mosquito Breeding Habitat	Represented by Flood Risk (<400 m^3/s) measure, which was renamed Flood/Mosquito Risk
Cottonwood Hydrograph Weighted Index	Not used in operating alternative trade-off analysis process. It was used in the trade-off analysis process for a cottonwood recruitment alternative.

7.5.2 Trade-off Analysis Techniques

Three trade-off techniques were used during Round 2 of the trade-off analysis process. Interactive consequence tables were used for performing pair-wise comparisons between two or more operating alternatives. Direct Ranking and Swing Weighting techniques were used to highlight the preferred alternatives. A Swing Weighting practice session was held prior to the first round of the trade-off analysis process, and then used in the second round of trade-off analysis.

For the swing weighting technique, Consultative Committee members were provided the best and worst median performance measure values across the operating alternatives. For example, in the Round 2 Consequence Table, the best median performance measure value for ***Recreation Quality*** is 586 weighted user days and the worst is 92 days. Consultative Committee members were requested to select the performance measure that was most important to “swing” from its worst to best value. This performance measure was awarded 100 points. The members were then asked to select the second most desirable “swing” of a performance measure and also to weight it relative to their first choice (therefore less than 100). This process was repeated until each performance measure had a rank and a weight.

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

7.5.3 Eliminating Operating Alternatives

The Consultative Committee used an interactive consequence table to eliminate operating alternatives during Round 2 of the trade-off analysis process.

7.5.3.1 Dropping Alternative B – Downstream Inundation and Alternative C – Recreation

Table 7-5 summarizes the performance measure median values for Alternatives B – Downstream Inundation, C – Recreation and I – Comparing Recreation, Cultural Resources, Mosquitoes, Flooding.

Table 7-5: Interactive Consequence Table Comparing Alternatives B, C and I

Performance Measures	Unit of Measure	Alternatives	Downstream Inundation B	Recreation C	Recreation, Cultural Resources, Mosquitoes, Flooding I
Recreation Quality	Weighted User Days		228	586	450
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		23.6	23.6	23.5
Whitefish Effective Spawning Habitat (Lower Duncan River)	Hectares		23.9	23.8	23.8
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		19.4	20.5	18.7
Kokanee Effective Spawning Habitat (Lower Duncan River Sidechannel)	Hectares		0	0	0
Rainbow Effective Rearing Habitat (Lower Duncan River Sidechannel)	Hectares		262.7	246.4	261.7
Erosion Protection	Weighted Exposure Days		610	663	610
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		132.2	65.6	131.5
Flood/Mosquito Risk	# of days above 400 m^3/s		3	7	3
Financial Revenue	Net change from Alternative A in Average Annual Value of Generation ($M's)		-0.3	-1.6	-0.3
Operational Flexibility	# of days of constrained operation per year		0	35	0

During Round 2, Alternative I – RCMF (Recreation, Cultural Resources, Mosquitoes, Flooding) was created by combining Alternatives B – Downstream Inundation and C – Recreation.

The blue numbers in Column I of Table 7-5 highlight that Alternative I – RCMF is the base case alternative. Alternatives B – Downstream Inundation and C – Recreation are the comparative alternatives. The red or green shading indicates that the difference in performance measures is significant. Red indicates that the base case alternative performs better than the comparative alternatives. Green indicates that the comparative alternative performs better than the base case alternative. No shading indicates that there is no significant difference between the two alternatives for that performance measure (i.e., they fall within the MSIC).

Alternative I – RCMF performs better or the same for each performance measure as compared to Alternative B – Downstream Inundation. Therefore, Alternative I dominates Alternative B.

The Consultative Committee agreed to remove Alternative B – Downstream Inundation from further consideration.

Alternative I – RCMF performs better or the same for each performance measure except ***Recreation Quality*** as compared to Alternative C – Recreation. Alternative I results in four more ***Flood/Mosquito Risk*** days compared to Alternative C. There is a direct trade-off between ***Recreation Quality*** and increased ***Flood/Mosquito Risk***. The increased ***Flood/Mosquito Risk*** was unacceptable to Consultative Committee members. Therefore, Alternative I effectively dominates Alternative C.

The Consultative Committee agreed to remove Alternative C – Recreation from further consideration.

7.5.3.2 Dropping Alternative D – Vegetation and Alternative F – Burbot

Table 7-6 summarizes the median values of the performance measures for Alternatives D – Vegetation, F – Burbot and J – Vegetation–Burbot.

Table 7-6: Interactive Consequence Table Comparing Alternatives D, F and J

Performance Measures	Unit of Measure	Alternatives	D Vegetation	F Burbot	J Vegetation-Burbot
Recreation Quality	Weighted User Days		163	225	267
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		24.3	30.3	31
Whitefish Effective Spawning Habitat (Lower Duncan River)	Hectares		24.1	37.2	37.2
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		19.2	18.4	16.8
Kokanee Effective Spawning Habitat (Lower Duncan River Sidechannel)	Hectares		0	0.2	22.1
Rainbow Effective Rearing Habitat (Lower Duncan River Sidechannel)	Hectares		251.6	278.3	281.7
Erosion Protection	Weighted Exposure Days		545	627	614
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		54.4	131	71.1
Flood/Mosquito Risk	# of days above 400 m^3/s		4	5	2
Financial Revenue	Net change from Alternative A in Average Annual Value of Generation ($M's)		-0.4	-1.4	-0.4
Operational Flexibility	# of days of constrained operation per year		15	15	15

During Round 2 development of operating alternatives, Alternative J – Vegetation–Burbot was created by combining Alternatives D – Vegetation and F – Burbot.

Alternative J – Vegetation–Burbot performs better or the same for each performance measure as compared to Alternative D – Vegetation. Therefore, Alternative J dominates Alternative D.

The Consultative Committee agreed to remove Alternative D – Vegetation from further consideration.

Alternative J – Vegetation–Burbot performs better or the same for each performance measure except ***Riparian Productivity – Inundation Tolerance*** as compared to Alternative F – Burbot. Alternative J results in 59.9 fewer hectares of ***Riparian Productivity – Inundation Tolerance*** area than Alternative F. Therefore, Alternative J effectively dominates Alternative F.

The Consultative Committee agreed to remove Alternative F – Burbot from further consideration.

7.5.3.3 Dropping Alternative H (50) – Downstream Fish

Table 7-7 summarizes the median values of performance measures for Alternatives E (73) – Downstream Fish, E (90) – Downstream Fish and H (50) – Downstream Fish.

Table 7-7: Interactive Consequence Table Comparing Alternatives E (73), E (90) and H (50)

Performance Measures	Unit of Measure	Alternatives	Downstream Fish E (73)	Downstream Fish E (90)	Downstream Fish H (50)
Recreation Quality	Weighted User Days		357	350	305
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		39.7	38.9	40.4
Whitefish Effective Spawning Habitat (Lower Duncan River)	Hectares		54	58.3	45.9
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		17	16.7	16.9
Kokanee Effective Spawning Habitat (Lower Duncan River Sidechannel)	Hectares		293.1	315.6	193.9
Rainbow Effective Rearing Habitat (Lower Duncan River Sidechannel)	Hectares		322	331.9	286.5
Erosion Protection	Weighted Exposure Days		672	809	547
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		69.1	111	43.8
Flood/Mosquito Risk	# of days above 400 m^3/s		4	4	4
Financial Revenue	Net change from Alternative A in Average Annual Value of Generation ($M's)		-0.2	-0.5	-0.5
Operational Flexibility	# of days of constrained operation per year		105	105	105

Alternatives E (73), E (90), and H (50) include a target minimum flow in the lower Duncan River for downstream fish interests.

Alternatives E (73) and E (90) perform better or the same for each performance measure except ***Erosion Protection*** as compared to Alternative H (50). Therefore Alternative E (73) and E (90) effectively dominate Alternative H (50).

The Consultative Committee agreed to remove Alternative H (50) – Downstream Fish from further consideration.

7.5.3.4 Dropping Alternative G – Naturalized Hydrograph

Table 7-8 summarizes the median values of performance measures for Alternatives G – Naturalized Hydrograph and K – Cottonwood Hydrograph. There are numerous trade-offs between Alternatives G and K performance measures.

Table 7-8: Interactive Consequence Table Comparing Alternatives G and K

Performance Measures	Unit of Measure	Alternatives: Naturalized Hydrograph G	Cottonwood Hydrograph K
Recreation Quality	Weighted User Days	92	267
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares	28.9	31
Whitefish Effective Spawning Habitat (Lower Duncan River)	Hectares	38.9	37.2
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares	11.9	16.8
Kokanee Effective Spawning Habitat (Lower Duncan River Sidechannel)	Hectares	0.4	22.1
Rainbow Effective Rearing Habitat (Lower Duncan River Sidechannel)	Hectares	345.1	281.7
Erosion Protection	Weighted Exposure Days	837	614
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)	63.6	71.1
Flood/Mosquito Risk	# of days above 400 m^3/s	3	2
Financial Revenue	Net change from Alternative A in Average Annual Value of Generation ($M's)	-3.6	-0.4
Operational Flexibility	# of days of constrained operation per year	180	15

During the first round of the trade-off analysis process, it was determined that Alternative G – Naturalized Hydrograph violated the Columbia River Treaty Flood Control Rule Curves for the Duncan Reservoir in many average or above average inflow years. During the second round of operating alternative development, the Consultative Committee developed Alternative K – Cottonwood Hydrograph to achieve similar cottonwood recruitment benefits as Alternative G and have a higher likelihood of meeting Treaty requirements.

Given the Columbia River Treaty requirement constraints, the Consultative Committee agreed to remove Alternative G – Naturalized Hydrograph from further consideration and to focus on making improvements to Alternative K – Cottonwood Hydrograph.

7.5.4 Identifying Preferred Operating Alternatives

At this point in the second round of the trade-off analysis process, the Consultative Committee used the Swing Weighting and Direct Ranking exercises to identify the remaining operating alternatives that performed best for the Duncan Dam water use planning objectives.

Table 7-9 summarizes the preferred operating alternative of each Consultative Committee member based on the results of the Direct Ranking and Swing Weighting exercises.

Table 7-9: Consultative Committee Member's Alternative Preferences According to the Direct Ranking and Swing Weighting Exercises

Key: Direct Ranking / Swing Weighting

		Alternatives				
	Consultative Committee Member	**Alt A - Current Operations**	**Alt E (73) - Downstream Fish**	**Alt E (90) - Downstream Fish**	**Alt I - RCMF**	**Alt J - Vegetation-Burbot**
1	**1**	5	4	1	3	2
		5	2	1	4	3
2	**2**	5	2	1	4	3
		5	1	2	4	3
3	**3**	5	3	2	4	1
		5	2	1	4	3
4	**4**	2	3	4	1	5
		5	1	2	3	4
5	**5**	5	4	2	3	1
		5	2	1	4	3
6	**6**	5	3	2	1	4
		5	1	2	3	4
7	**7**	5	4	2	1	3
		5	1	2	3	4
8	**8**	5	2	3	4	1
		5	1	2	3	4
9	**9**	1	3	4	2	5
		3	2	5	1	4
10	**10**	5	2	1	4	3
		5	1	2	4	3

Figure 7-8 illustrates the Consultative Committee Member Swing Weighting Rankings according to the number of times each alternative received a 1, 2, 3, 4 or 5 ranking.

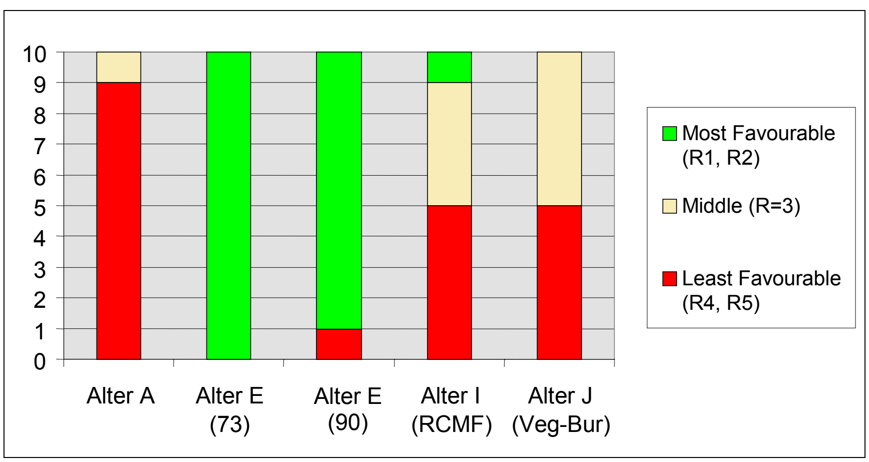


Figure 7-8: Consultative Committee Member Swing Weighting Ranking

Figure 7-9 illustrates the Consultative Committee Member Direct Weighting Rankings according to the number of times each alternative received a 1, 2, 3, 4 or 5 ranking.

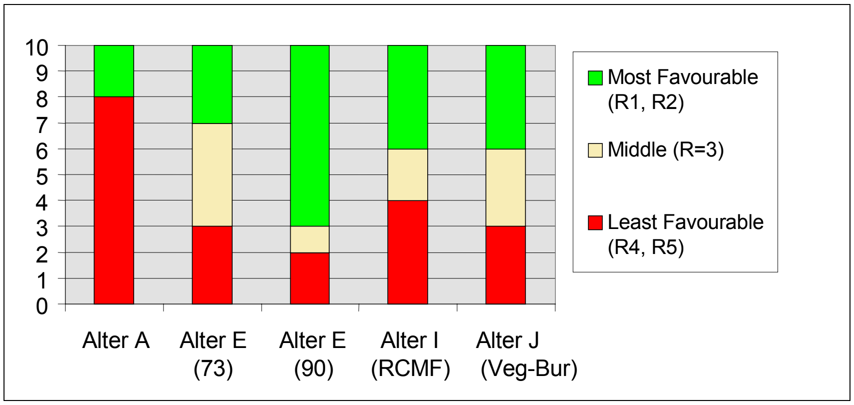


Figure 7-9: Consultative Committee Member Direct Ranking Preferences

The rankings indicate that Alternative E (90) – Downstream Fish was the second most preferred alternative according to the Swing Weighting and the preferred alternative according to the Direct Ranking exercise. While Alternative E (73) – Downstream Fish was the preferred alternative scoring a Rank 1 or 2 from each Consultative Committee member in the Swing Weighting exercise, it was the third or fourth[1] most preferred alternative according to the Direct Ranking exercise.

The Consultative Committee considered Alternatives E (73) – Downstream Fish and E (90) – Downstream Fish performed best at balancing competing Duncan Dam water use planning objectives among the Round 2 operating alternatives.

The Consultative Committee agreed to focus on Alternatives E (73) – Downstream Fish and E (90) – Downstream Fish on the basis that these alternatives have the highest probability of achieving consensus.

Some Consultative Committee members expressed concern about the Swing Weighting exercise. One Committee member mentioned that they felt rushed and needed more time to complete the exercise. Another Committee member commented that the large number of fish performance measures might have disproportionately favoured operating alternatives that were predicated on meeting fish objectives. It was noted that some Committee members took this into account during the ranking and weighting process, while other members did not.

[1] Fourth in terms of number of Rankings of 1 and 2; or third in terms of the fewest number of Rankings of 4 and 5.

7.5.5 Level of Support for Alternatives E (73) and E (90)

At this point, the facilitator requested that each Consultative Committee member verbally state their level of support for Alternatives E (73) – Downstream Fish and E (90) – Downstream Fish and to describe any concerns and how they could be addressed. Committee members were asked to use the following descriptors:

- **Endorse** I fully support this alternative.
- **Accept** I accept this alternative.
- **Accept with reservations** I can live with this alternative, but have concerns *(which I would like addressed)*.
- **Block** I cannot live with this alternative.

Table 7-10 summarizes the level of support for the operating alternatives and specific comments made by each Consultative Committee member.

Table 7-10: Consultative Committee Level of Support for Alternatives E (73) and E (90)

Consultative Committee Member	Organization	Alternative E (73)	Alternative E (90)	Reservations and Comments
Vic Clement	Ktunaxa–Kinbasket Tribal Council	Accept with reservations	Accept with reservations	Downstream fisheries issues (burbot, whitefish, rainbow) need more clarification in terms of the benefits. Like to hear from Anne Moody regarding the riparian zone. Cultural sites – physical works in lieu of operations. Need to do more work in terms of archaeological surveys, monitoring. Burbot in reservoir monitoring.
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	Endorse with reservations	Endorse with reservations	Alternative E (90) provides more benefits for grass and shrubs in reservoir. TGP effects downstream Keenleyside and Kootenay systems. Bank erosion in Duncan River associated with whitefish/kokanee flows. Would like to incorporate cottonwood flows once every five years. Cultural and Heritage physical works in lieu of operational changes. Burbot entrainment to be monitored.

Table 7-10: Consultative Committee Level of Support for Alternatives E (73) and E (90) (cont'd)

Consultative Committee Member	Organization	Alternative E (73)	Alternative E (90)	Reservations and Comments
Steve Macfarlane	Fisheries and Oceans Canada	Endorse with reservations	Endorse with reservations	Alternative E (73) provides significant benefits above status quo. I think recreation interests can be dealt with. Not huge change in flooding events across alternatives. Big difference between Alternative E (73) and Alternative E (90) is riparian shrubs in the reservoir, could be dealt with by physical works. Alternative E (73) with physical works in lieu of operational changes could be a better balance.
Kindy Gosal	Columbia Basin Trust	Almost Block	Almost Block	Flood control/mosquito. Clarify recreation objective/performance measure. Riparian habitat enhancement in the reservoir physical works in lieu of operational changes. Concern regarding system-wide operations flexibility. Nowhere near acceptance.
Gail Spitler	Area Resident	Accept with reservations	Accept with reservations Preference	Try to fix re-wetting issue (begin August). Financial impacts $300,000 difference between Alternative E's is there value? Concern for non-continuous flow for cottonwood.
Llewellyn Matthews	Columbia Power Corporation	Abstain	Abstain	Need to clarify some issues between BC Hydro and CPC. Need to clarify recreation issue.
Stephan O'Shea	Area Resident	Accept with reservations	Accept with reservations	Reservations need to leave margin for flood control. Climate change.
Terry Anderson	Ministry of Water, Land and Air Protection	Endorse	Endorse (prefer)	Concern with cultural and heritage impacts.
Bob Douglas	Regional District of Central Kootenay	Accept	Accept	Was comfortable with both of these alternatives, given the reservations already stated.

Table 7-10: Consultative Committee Level of Support for Alternatives E (73) and E (90) (cont'd)

Consultative Committee Member	Organization	Alternative E (73)	Alternative E (90)	Reservations and Comments
Gordon Boyd	BC Hydro	Accept with reservations	Accept with reservations	Will it result in a second wave of mosquitoes, could mitigate with physical works or high flow. Impact on erosion downstream from high flows in fall. Clarify recreation, end of August and September. If we could have a peak flow for cottonwood would this benefit mosquitoes as well. Burbot and shrubs in the reservoir. Financial impacts $300,000 difference between Alternative E's is there value?

Upon completion of the exercise, a number of Consultative Committee members questioned why the ***Recreation Quality*** performance measure for downstream fish Alternatives E (73) and E (90) had lower values than Alternative A – Current Operations. Committee members expressed concern that the performance measure could be misinterpreted by local residents that recreation conditions might be worse with either one of the minimum flow alternatives.

Two points were emphasized with regards to this issue:

- Alternative A – Current Operations does not represent historic operations. Under Alternative A, the Duncan Reservoir is full throughout the majority of the recreation season. However, a review of historical reservoir water levels indicate that this is not always the case. Over the past 10 years, reservoir levels have not been desirable for recreation because of the need to satisfy other agreements or operating parameters defined by BC Hydro. These additional parameters were not built into the Operations Model because of their variability and inconsistency. Accordingly, it was recognized by the Committee that just because the ***Recreation Quality*** performance measure value was lower for the minimum flow alternatives Alternative E (73) and E (90), it was likely better than current conditions as approximated by Alternative A.

- Concerns were raised by some Consultative Committee members that the ***Recreation Quality*** performance measure may not be representing the full range of recreationalists interests for the Duncan Reservoir. Moreover, it was felt that the timing of the peak recreation season, the preferred reservoir elevations and weightings were inaccurate and, therefore, skewed the performance measure values so that the minimum flow alternatives were performing worse than they really were. This led to a request by the Committee for the Recreation Technical Subcommittee to undertake a review of the ***Recreation Quality*** performance measure and consult with a wider range of recreation stakeholders for their input.

Consultative Committee members expressed concern about how the minimum flow operating alternatives related to the sudden decrease in lower Duncan River flows, which occurred each year at the beginning of August. It was not clear if this was a modelling idiosyncrasy. The concern was that a decrease and then quick increase in lower Duncan River flows may inadvertently cause additional mosquito breeding opportunities as habitat areas are re-wetted. There is a trade-off between reaching full pool rapidly after the flood risk has passed for desirable recreation levels in the reservoir, and a buffering of the sudden decrease in flows to mitigate mosquito hatching events. It was noted that as long as flows are kept below 300 to 350 m^3/s in the lower Duncan River after the decrease in flows, then mosquito hatching events would be limited. This constraint was included in subsequent alternatives.

There was a discussion as to the viability of the minimum flow alternatives. If additional constraints are imposed on the Duncan Dam system, BC Hydro will likely use some of the flexibility from Kootenay Lake to meet these constraints. Therefore, there may be a marginal increase in the fluctuation of Kootenay Lake levels. However, it was noted that any change would be difficult to distinguish from changes currently occurring due to Libby Dam flows under the proposed VARQ flow regime. It was also noted that initiation of a Kootenay Lake Water Use Plan could trigger a review of the Duncan Dam Water Use Plan.

7.5.6 Selecting a Cottonwood Flow Alternative

The Consultative Committee reviewed the performance measures for Alternative K – Cottonwood Hydrograph, which could be combined with a minimum flow alternative if required in Year 5.

Figure 7-10 illustrates historic Duncan Reservoir water levels under Alternative K – Cottonwood Hydrograph for years 1969 to 1988.

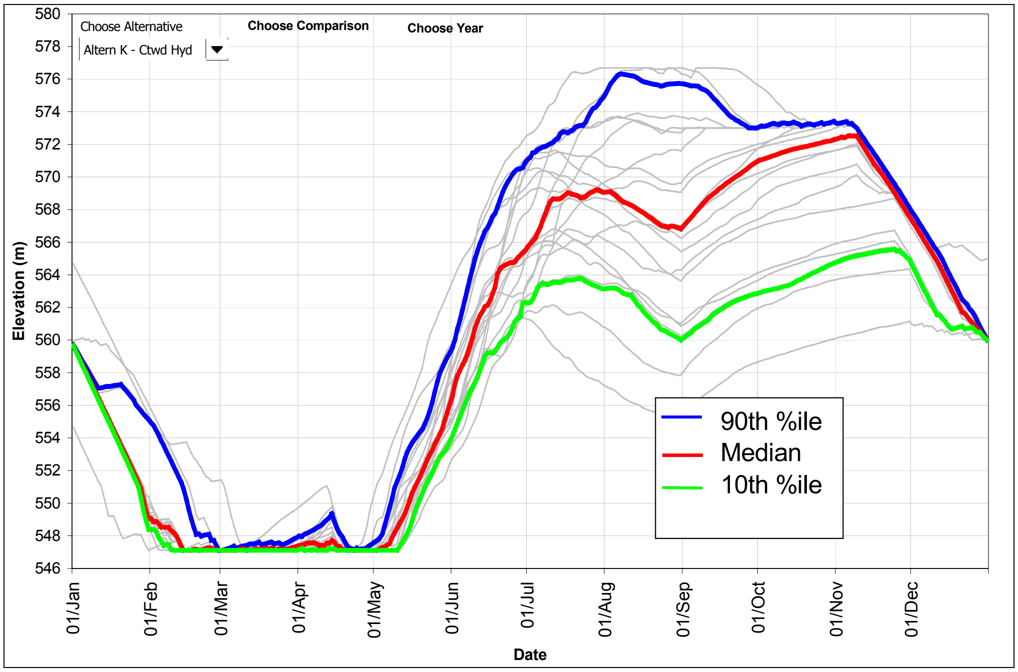


Figure 7-10: Duncan Reservoir Water Levels for Alternative K, 1969–1988

Figure 7-10 illustrates the variability associated with Duncan Reservoir elevations according to natural inflows to deliver the target minimum flow in the lower Duncan River. One of the key issues associated with Alternative K – Cottonwood Hydrograph is determining when it should be implemented.

Opportunistically implementing Alternative K during a high water year (represented by the blue 90th percentile line) will still have significant impacts beyond the MSIC range on recreation values, wildlife interests in the Duncan Reservoir, and Kootenay River power generation. However, if Alternative K is implemented in a low water year (represented by the red median line or the green 10th percentile line), these impacts would increase substantially.

The Consultative Committee recommended that the following actions be undertaken:

- Consult expert opinion regarding a suitable cottonwood recruitment flow regime. There is a high degree of uncertainty regarding the potential cottonwood recruitment benefits that may accrue given the lack of baseline information and poor understanding about suitable flows. Also, the cottonwood habitat area performance measure does not directly quantify the increase in area of cottonwoods, but rather compares flows against a more natural cotton hydrograph.

- Compare the desired cottonwood recruitment flow regime to flows delivered in a high inflow year for Alternative E (73) – Downstream Fish (e.g., inflows in 1981 were 106 per cent of average inflows).

- Ensure that the flow targets for Alternative K – Cottonwood Hydrograph are consistent with the principle of the minimum flow constraints associated with Alternatives E (73) – Downstream Fish and E (90) – Downstream Fish so that fish interests are not significantly adversely affected.
- Other technical issues were directed to the Wildlife Technical Subcommittee to provide feedback and recommendations. For example, are there opportunities to develop an adaptive management experiment to address some of the uncertainties surrounding the potential benefits to cottonwood recruitment.

7.6 System-wide Impacts on the Trade-off Analysis

There were a number of confounding factors that increased the complexity of the Duncan Dam Water Use Plan operating alternatives. As outlined in Section 2, the Duncan Dam system is part of the Columbia River Treaty and at times is further constrained by a number of other agreements. These agreements did not significantly influence the alternatives considered by the Consultative Committee with the exception of Alternative G – Naturalized Hydrograph, which violates the Columbia River Treaty Flood Control Rule Curves. Accordingly, these agreements did not significantly influence the trade-offs in the first two rounds of the trade-off analysis process.

Prior to the third round of trade-off analysis, cross-system power generation impacts were identified with the operating alternatives. Power generation losses at ALGS resulted from additional spills during the early fall period to meet Columbia River Treaty flow requirements[1]. The Operations Model used to simulate operating alternatives for the Duncan Dam water use planning process did not account for this cross-system impact. Therefore, the water use planning process was delayed while the Operations Model was modified and a new ALGS power generation performance measure was developed.

A number of Consultative Committee members felt that cross-system impacts were beyond the scope and mandate of the Duncan Dam Water Use Plan. This issue was discussed at the Water Use Plan Program Interagency Management Committee[2], and it was recommended that Consultative Committee would decide

[1] The cause of the cross-system impacts was related to Columbia River Treaty flow requirements, which required certain flow volumes to be met from the combined discharges at Duncan and Hugh Keenleyside dams (including flows through ALGS). In many years, this meant that if flows needed to be reduced from Duncan Dam (in the fall and winter period), more water would have to be discharged through Hugh Keenleyside Dam and this was often beyond the capacity of ALGS. The result was therefore lost generating opportunities (i.e., spilling) and lower reservoir levels (i.e., lower performance of the power generators).

[2] The Water Use Plan Program Interagency Committee with representation from BC Hydro and federal and provincial regulatory agencies oversaw development and implementation of the facility Water Use Plans.

on where the boundary of interests should be drawn. In preparation of this discussion, the ALGS impacts were quantified along with other cross-system impacts. The Duncan Dam Water Use Plan technical subcommittees were requested to identify any potentially significant cross-system impacts associated with operational changes made at the Duncan Dam facility. In addition, Alternatives I – RCMF, and J – Vegetation–Burbot, which had been previously removed from further consideration by the Committee, were re-introduced in the Round 3 alternatives.

During the preliminary analyses and the scoping of potential issues, it was noted that:

- Duncan Dam releases represent about 10 per cent of the total inflows to the Kootenay River system.
- Kootenay Lake levels are controlled more by outlet flows down Kootenay River rather than inflows into the lake.
- The magnitude of operational changes at Duncan Dam to the Kootenay River system must be weighed against changes with flows at Libby Dam (VARQ) and as a result of new planned minimum flows as a part of the Brilliant Expansion Project.

Upon review and discussion by the technical subcommittees and the Consultative Committee, it was agreed that the Duncan Dam Water Use Plan operating alternatives were not significantly affecting Kootenay Lake levels, Kootenay River flows, or environmental interests below Hugh Keeneyside Dam other than power impacts at ALGS. The only new issue identified was the potential impact associated with nutrient transfer effects into the North Arm of Kootenay Lake (refer to Section 4.7.4).

7.7 Rounds 3 and 4 Final Trade-off Analysis

During the third round of the trade-off analysis process, the Consultative Committee evaluated two Round 1 operating alternatives, four Round 2 alternatives, and seven new Round 3 alternatives[1]. These trade-off discussions assisted the Committee to evaluate the alternatives, remove those alternatives which were clearly dominated by other alternatives, highlight the most preferred alternatives, and select which non-operational physical works would be recommended in the Consultative Committee Report.

The third and fourth rounds of the trade-off analysis process were conducted during the final Consultative Committee meeting held in April of 2004 in Kaslo, two post meeting briefing updates, and a series of separate follow-up discussions

[1] The new Alternative S (73) was developed during the final April 2004 Consultative Committee meeting.

with each Consultative Committee member after the new Alternative S (73) had been modelled to confirm the performance measure values.

In a letter of 19 April 2004 to BC Hydro, Columbia Power Corporation (CPC), as manager of the Columbia Power Corporation/Columbia Basin Trust (CPC/CBT) joint ventures, stated that: CPC's interest in the Duncan Dam Water Use Plan is to ensure that CPC/CBT joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from the implementation of the Duncan Water Use Plan; to protect the important public interests represented by the CPC/CBT joint ventures, CPC must object to any WUP alternative that impairs the rights of the CPC/CBT joint ventures; accordingly, CPC cannot support any of the current alternatives being considered for the Duncan WUP and may object to them before the Comptroller of Water Rights; however, CPC are willing to consider other alternatives that protect the interests of the CPC/CBT joint ventures.

The CBT Consultative Committee member indicated that the water use planning process needs to account for any potential negative impacts on all interests and values that result from an alternative operating regime, and that appropriate compensation or mitigation measures should be implemented. As such, the CBT cannot support any Water Use Plan alternative that may have negative financial impacts on the CBTE/CPC joint venture projects. It was also noted that financial impacts to these joint venture projects could impact the benefits CBT delivers to Basin residents, the very residents who were most directly impacted by the creation of the Columbia River Treaty Dams. Should the CBTE/CPC joint venture power assets not be kept whole through the water use planning process, the Province of BC and BC Hydro could be unduly burdening the people of the basin with the financial costs associated with improved operations at the BC Hydro facilities. The Columbia Basin Trust would then need to consult with its constituents prior to indicating support for any such alternatives. CBT's views on this issue would be similar should impacts be identified for any other interest or value.

At the beginning of the final Consultative Committee meeting, the Committee members from CPC and CBT stated that since this issue was beyond the scope of the Consultative Committee's ability to resolve, the CPC and CBT Committee members agreed to continue to participate in the water use planning process conditional on the following:

Columbia Power Corporation and Columbia Basin Trust Condition:
Columbia Power Corporation (CPC) and Columbia Basin Trust (CBT) agreed to continue to participate in the selection of a preferred alternative for the Duncan Dam Water Use Plan, on a non-prejudicial basis, on the condition that there would be no adverse impacts borne by any CPC and CBT Joint Ventures. In other words, CPC and CBT Joint Ventures would be saved harmless or appropriately compensated for adverse impacts arising, directly or indirectly, from the implementation of the Duncan Dam Water Use Plan. If this did not occur, CPC would block all alternatives except Alternative A – Current Operations. CBT may block all alternatives except Power Optimal Operations, and may object to them before the Comptroller of Water Rights, but would make a determination after they had all the information.

Subsequent to the final Consultative Committee meeting, on 9 November 2004, CPC forwarded a letter to BC Hydro stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, Columbia Power Corporation, on behalf of the Columbia Power Corporation/Columbia Basin Trust joint ventures, can now accept the preferred Alternative S (73). Refer to Appendix I: Correspondence from Columbia Power Corporation.

The following summarizes the highlights of the third and final trade-off analysis process:

- Alternatives L (73) – Downstream Interests and M (90) – Downstream Interests were both conditionally accepted by the Consultative Committee initially at the final Committee meeting in April 2004. Subsequent to this meeting, the Regional District of Central Kootenay Committee member withdrew his support for outcomes of the Duncan Dam Water Use Plan (refer to Appendix J: Correspondence with the Regional District of Central Kootenay).
- The new Alternative S (73) - Downstream Fish and Cottonwood, developed by the Consultative Committee during the final Committee meeting, was conditionally recommended by the Committee as their preferred operating alternative for the Duncan Dam facility. The Committee's preference for Alternative S (73) was confirmed after the BC Hydro project team completed the modelling and the performance measures calculations (refer to Sections 7.7.8 and 7.7.9).
- The Consultative Committee recommended a number of non-operational physical works in lieu of operational changes, non-Water Use Plan recommendations, a monitoring program and a review period for the Duncan Dam facility.

- As agreed to during the second round of the trade-off analysis process, the Consultative Committee continued to consider Alternative K – Cottonwood Hydrograph separate from the other operating alternatives (refer to Section 7.7.10). This was in recognition that to achieve the intended benefits for cottonwood recruitment in the lower Duncan River, a flow regime similar to Alternative K would be required about every fifth year on average. After the Committee selected Alternative S (73) – Downstream Fish and Cottonwood, they agreed to drop Alternative K from further consideration.

7.7.1 Key Trade-offs and Highlights

During the final Consultative Committee meeting, the key trade-offs were similar to those identified during Round 2 of the trade-off analysis process. However, the ***Financial Revenue*** performance measure was significantly affected by inclusion of cross-system impacts. The key trade-offs and issues that influenced the Committee's decisions are summarized below:

- **Financial Revenue:** Power generation impacts significantly increased across the operating alternatives with the quantification and inclusion of lower Columbia River (ALGS). These impacts were greatest for alternatives[1] that capped Duncan River flows in the early fall, thus requiring an increase in flows from Hugh Keenleyside Dam to meet the Columbia River Treaty target flows in the lower Columbia River. The changes to the performance measure(s) highlighted the fundamental trade-off between financial impacts and meeting fish flows in the lower Duncan River.

- **Recreation quality versus reservoir riparian productivity:** While the latest operating alternatives were better able to meet the desired Duncan Reservoir water levels for recreation in the summer, there was still a trade-off with wildlife interests. Generally, higher reservoir levels (after reaching full pool in the summer) that benefited recreation interests were worse for riparian communities in the reservoir (refer to Section 7.4 and 7.5).

- **Kootenay River power generation versus riparian productivity in the lower Duncan River (refer to Section 7.4).**

- **Reservoir riparian community**: New information received by the Wildlife Technical Subcommittee suggested that almost all the operating alternatives would be worse for riparian habitat (shrubs and grasses) as compared to historic operations.

- A comparison of the alternatives for downstream interests – Alternatives E (73) and L (73), or E (90) and M (90) indicated that the approximate cost to more gradually smooth out fall recession flows in the lower Duncan River

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[1] Alternatives E (73), E (90), L (73), M (90), O (90), P (90), Q (90), and R (90).

would range from \$300,000 to \$500,000 per year. There is no significant difference in the ***Cottonwood Hydrograph Weighted Index*** performance measure associated with the gradual recession flows; however, expert opinion suggests an improvement from "poor" to "fair" in cottonwood performance (Stewart Rood, pers. comm.).

- A comparison of Alternative M (90) with Q (90) indicated that the approximate cost to extend the fall lower Duncan River target flow until the end of December for whitefish spawning would be \$300,000 per year. However, there is a trade-off with ***Whitefish Effective Spawning Habitat Lost*** of approximately 6.9 ha (a difference of 11.6 to 4.7 ha).

- A comparison of Alternatives P (90) and M (90) indicated that the financial benefit of delaying the 15 September target flow in lower Duncan River (for the minimum flow alternatives by two weeks until 1 October) is approximately \$400,000 per year. While there is no significant difference in most fish performance measures, there is a decrease in ***Kokanee Effective Spawning Habitat Lost (Sidechannels)*** of approximately 36.3 ha, which is subsequently dewatered after spawning.

- There is little difference in the environmental performance measures between providing either a 73 m^3/s or 90 m^3/s minimum/target flow in the lower Duncan River. However, the approximate total financial revenue impacts to provide the higher 90 m^3/s flow were between \$300,000 per year (Alternative E (73) versus E (90)) and \$400,000 per year (Alternative L versus M).

- A comparison of Alternatives L (73) – Downstream Interests and M (90) – Downstream Interests indicated that L (73) has a higher probability of meeting the Columbia River Treaty 1 March Flood Rule Curve (FRC) each year. Therefore, Alternative L (73) would cause less fish impacts if the FRC has to be met and there is a late freshet given limited storage in the reservoir that is available to augment and provide the minimum flow in the lower Duncan River. Alternative L (73) would also cause less financial revenue impacts on both the Kootenay and lower Columbia river systems. Alternative L (73) does not perform as well as Alternative M (90) for ***Kokanee Effective Spawning Habitat Lost (Sidechannels)*** or the ***Whitefish Effective Spawning Habitat Lost (Mainstem)***.

Table 7-11 summarizes the consequence table for Round 3 of the trade-off analysis process.

Table 7-11: Consequence Table for Round 3 Trade-off Analysis Process

					Alternative Name											
Objective	Performance Measure	Unit	Best?	MSIC	Alt A - Power	Alt E (73)	Alt E_90	Alt I - RCMF	Alt J - Veg/Burb	Alt L (73)	Alt M (90)	Alt O (90)	Alt P (90)	Alt Q (90)	Alt R (90)	Alt S (73)
Recreation	Recreation Quality	Weighted User Days (15 Jul - 6 Sep)	More	10%	244	234	235	260	225	313	314	174	315	316	318	303
Fish (Mainstem)	Kokanee Effective Spawning Habitat	Hectares	More	10%	24.0	41.9	41.4	24.5	32.3	42.3	41.8	42.1	37.7	41.8	42.4	38.1
	Whitefish Effective Spawning Habitat	Hectares	More	20%	26.2	55.9	60.0	28.7	37.6	55.9	60.1	60.0	60.0	61.5	61.5	57.3
	Whitefish Effective Spawning Habitat Lost	Hectares	More	20%	42.3	14.1	11.7	41.2	34.2	14.0	11.6	11.7	11.8	4.7	4.7	6.1
	Rainbow Effective Rearing Habitat Lost	Hectares	Less	10%	16.0	16.3	16.5	18.6	17.1	16.7	16.1	13.4	16.8	16.3	14.9	16.0
Fish (Sidechannels)	Kokanee Effective Spawning Habitat	Hectares	More	10%	44.7	306.2	322.6	44.7	124.2	306.2	322.6	322.6	322.6	322.6	322.6	306.2
	Kokanee Effective Spawning Habitat Lost	Hectares	Less	10%	231.2	32.3	30.5	228.9	143.0	22.6	13.7	15.9	50.0	12.1	9.5	56.4
Cultural Resources	Erosion Impacts	Weighted Exposure Days	Less	20%	674	687	820	563	609	613	730	765	790	674	671	657
Wildlife (Reservoir)	Riparian Productivity - Inundation Tolerance	Hectares of shrub area (willow)	More	20%	406.3	338.3	360.2	299.4	420.6	132.3	146.1	233.5	299.4	146.1	129.4	260.1
	Riparian Productivity - Long-term Median	Hectares of Herbaceous area using long-term median level	More	20%	407.6	223.8	242.7	275.4	146.5	289.1	288.0	419.1	204.3	288.0	284.4	222.0
Wildlife (Lower Duncan River)	Cottonwood Hydrograph Weighted Index	Weighted Index from the deviation of a nat'l hydrograph	More	10%	47%	50%	54%	43%	48%	50%	55%	60%	56%	58%	62%	59%
Flooding/ Mosquitoes	**Flood/Mosquito Risk** Annual Flood Risk Days	# of days above 400	Less	10%	6	5	5	5	4	6	6	5	6	6	7	6
		# of days above 450	Less	10%	3	1	0	1	0	1	1	1	1	1	1	1
		# of days above 500	Less	10%	0	0	0	0	0	0	0	0	0	0	0	0
Power	Financial Revenue (VOE) - Kootenay River System	**Net Change from Alt A** in Average Annual Value of Generation ($ in million)	More	$0.1M	0.0	-0.6	-0.8	0.0	-0.3	-0.3	-0.5	-1.0	-0.6	-0.8	-0.9	-0.3
	Financial Revenue (VOE) - Lower Columbia River System	**Net Change from Alt A** in Average Annual Value of Generation ($ in million)	More	$0.1M	0.0	-1.2	-1.3	-0.9	-0.8	-1.9	-2.1	-1.5	-1.5	-2.1	-2.4	-1.4

Note: Performance measures are represented as median values.

7.7.2 Reducing the Number of Performance Measures

During Round 3 of the trade-off analysis process, the Consultative Committee reviewed the performance measures[1]: a number of performance measures were dropped because they were insensitive across the operating alternatives; a new performance was added; and a performance measure that had been dropped in Round 2 of the trade-off analysis process was re-introduced.

Table 7-12 summarizes the performance measure changes in Round 3 of the trade-off analysis process during the final Consultative Committee meeting in April 2004.

Table 7-12: Performance Measures Changes in Round 3 of the Trade-off Analysis Process

Performance Measure	Status	Rationale for Removal
Whitefish Effective Spawning Habitat (Lower Duncan River Mainstem)	Dropped	Redundant because it mirrored the performance of the Kokanee Effective Spawning Habitat performance measure across the alternatives (i.e., the Kokanee Effective Spawning Habitat performance measure was used to also represent Whitefish Effective Spawning habitat areas in the mainstem).
Whitefish Effective Spawning Habitat Lost (Lower Duncan River Mainstem)	Added	Added during the final Consultative Committee on the recommendation of the Fish Technical Subcommittee.
Kokanee Effective Spawning Habitat (Lower Duncan River Sidechannel)	Dropped	Redundant since it mirrored the performance of the Kokanee Effective Spawning Habitat Lost performance measure across the alternatives (i.e., the Kokanee Effective Spawning Habitat Lost performance measure was used to represent all fish interests in the sidechannels).
Rainbow Effective Rearing Habitat (Lower Duncan River Sidechannel)	Dropped	Insensitive across the alternatives.
Flood/Mosquito Risk	Dropped	Insensitive across the new alternatives because they all attempted to limit flows in the lower Duncan River below the thresholds for inundation and flooding and wetting of mosquito habitat below 400 m^3/s (note that significant inundation and flooding does not typically begin to appear until flows go above 450 m^3/s).
Power Generation - Operational Flexibility	Dropped	Considered redundant with the addition of the new Financial Revenue performance measure for the lower Columbia River System.
Riparian Productivity – Long-term Median	Re-introduced	Re-introduced because it showed some sensitivity with the modelling changes.

[1] This included a review of all those performance measures dropped during Round 2 (see Section 7.5.1) in case the modelling changes affected decisions.

7.7.3 Trade-off Analysis Techniques

Three trade-off techniques were used by the Consultative Committee during Rounds 3 and 4 of the trade-off analysis process. Interactive consequence tables were used for performing pair-wise comparisons between two or more operating alternatives. Direct Ranking and Swing Weighting techniques[1] were used to highlight which alternatives were preferred based on their ability to satisfy Committee members' interests and better balance the Duncan Dam water use planning objectives.

7.7.4 Eliminating Operating Alternatives

The Consultative Committee eliminated three operating alternatives using the interactive consequence table.

7.7.4.1 Dropping Alternative I – Recreation, Cultural Resources, Mosquitoes and Flooding (RCMF)

While Alternative I – Recreation, Cultural Resources, Mosquitoes and Flooding (RCMF) was initially dropped during Round 2 of the trade-off analysis process, this alternative was re-introduced in the event that changes to the BC Hydro Operations Model showed a significant improvement in its overall performance.

Table 7-13 summarizes the median values of the performance measures for Alternatives A – Current Operations and I – RCMF.

[1] Refer to Section 7.5.2 for additional background on the Direct Ranking and Swing Weighting techniques.

Table 7-13: Interactive Consequence Table Comparing Alternatives A and I

Performance Measures	Unit of Measure	Alternatives	Current Operations A	Recreation, Cultural Resources, Mosquitoes, Flooding I
Recreation Quality	Weighted User Days		244	260
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		24	25
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		16	19
Kokanee Effective Spawning Habitat Lost (Lower Duncan River Sidechannel)	Hectares		231	229
Erosion Protection	Weighted Exposure Days		674	563
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		406	299
Riparian Productivity - Long-term Median (Reservoir)	Hectares of grassland riparian habitat		408	275
Cottonwood Hydrograph Weighted Index (Lower Duncan River)	Comparison to optimum cottonwood hydrograph		0.47	0.43
Financial Revenue - Kootenay River	Net annual average of generation $/year compared to power operations		0	0
Financial Revenue - Lower Columbia River	Net annual average of generation $/year compared to power operations		0	-0.9

Alternative A – Current Operations performs better or the same for each performance measure as compared to Alternative I – RCMF. Therefore, Alternative A effectively dominates Alternative I.

The Consultative Committee agreed to remove Alternative I from further consideration.

7.7.4.2 Dropping Alternative E (90) – Downstream Fish

Table 7-14 summarizes the media values of the performance measures for Alternatives E (90) – Downstream Fish, E (73) – Downstream Fish and P (90) – Downstream Interests.

Table 7-14: Interactive Consequence Table Comparing Alternatives E (90), E (73) and P (90)

Performance Measures	Unit of Measure	Alternatives	Downstream Fish E (73)	Downstream Fish E (90)	Downstream Interests P (90)
Recreation Quality	Weighted User Days		234	235	315
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		42	41	38
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		16	16	17
Kokanee Effective Spawning Habitat Lost (Lower Duncan River Sidechannel)	Hectares		32	30	50
Erosion Protection	Weighted Exposure Days		687	820	790
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		338	360	299
Riparian Productivity - Long-term Median (Reservoir)	Hectares of grassland riparian habitat		224	243	204
Cottonwood Hydrograph Weighted Index (Lower Duncan River)	Comparison to optimum cottonwood hydrograph		0.50	0.54	0.56
Financial Revenue - Kootenay River	Net annual average of generation $/year compared to power operations		-0.6	-0.8	-0.6
Financial Revenue - Lower Columbia River	Net annual average of generation $/year compared to power operations		-1.2	-1.3	-1.5

Alternative E (73) performs better or the same for each performance measure as compared to Alternative E (90). Alternative E (73) also performs better or the same for each performance measure as compared to Alternative P (90) except for the ***Recreation Quality*** and the ***Cottonwood Hydrograph Weighted Index (Lower Duncan River)*** performance measures. Therefore, Alternative E (73) effectively dominates Alternative E (90).

The Consultative Committee agreed to remove Alternative E (90) from further consideration.

7.7.4.3 Dropping Alternative A – Current Operations

The Consultative Committee felt that Alternative A – Current Operations did not adequately satisfy their interests and would not lead to a consensus decision. Alternative A was included in subsequent ranking exercises as a reference point for comparison.

The Consultative Committee agreed to remove Alternative A – Current Operations from further consideration.

7.7.5 Identifying Preferred Operating Alternatives

For the remaining operating alternatives, the Consultative Committee[1] used Swing Weighting and two Direct Ranking exercises to select the operating alternatives that best met the Duncan Dam water use planning objectives. For the Direct Ranking exercises, Committee members were asked to (1) rank each of the nine remaining operating alternatives in descending order of preference (i.e., 1 – most preferred, 9 – least preferred); and (2) rank the alternatives according to endorse, accept or block.

Table 7-15 summarizes the preferred operating alternatives of each Consultative Committee member based on results of the Direct Ranking and Swing Weighting exercises. The results were categorized according to most and least preferred. The most favourable alternatives were those with a ranking of 1 to 3, while the least favourable alternatives were those with a ranking of 7 to 9.

Table 7-15: Consultative Committee Member's Alternative Preferences According to the Direct Ranking and Swing Weighting Exercises[2]

Key: Direct Ranking (upper row) / Swing Weighting (lower row)

Consultative Committee Member	Organization	Alt A Current Operations	Alt E (73) Downstream Fish	Alt J Vegetation-Burbot	Alt L (73) Downstream Interests	Alt M (90) Downstream Interests	Alt O (90) Downstream Fish and Cottonwood	Alt P (90) Downstream Interests	Alt Q (90) Downstream Interests	Alt R (90) Downstream Interests
Gail Spitler	Area Resident	9	6	8	7	5	2	4	3	1
		9	6	8	5	4	2	7	3	1
Steve Macfarlane	Fisheries and Oceans Canada	9	4	8	6	1	5	7	3	2
		9	6	8	4	5	1	7	3	2
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	9	8	5	3	4	7	6	2	1
		7	5	8	4	6	1	9	3	2
Gordon Boyd	BC Hydro	9	1	8	2	4	5	3	6	7
		3	7	9	1	5	4	8	6	2
Stephan O'Shea	Area Resident	1	3	2	7	6	4	9	5	8
		4	7	8	3	6	1	9	5	2
Fred Thiessen	Ministry of Forests	8	6	7	5	4	9	2	3	1
		8	6	9	4	5	2	7	3	1
Terry Anderson	Ministry of Water, Land and Air Protection	9	7	8	4	2	6	5	3	1
		8	6	9	4	5	1	7	3	2
Vic Clement	Ktunaxa-Kinbasket Tribal Council	2	-	1	-	-	-	-	-	-
		6	7	4	3	8	5	9	2	1
Llewellyn Matthews	Columbia Power Corporation	1	5	2	4	3	7	6	8	9
		1	4	6	2	3	7	5	9	8
Kindy Gosal	Columbia Basin Trust	6	7	5	1	2	4	3	8	9
		-	-	-	-	-	-	-	-	-
Gene Anderson	FortisBC	1	2	5	6	7	3	8	9	4
		-	-	-	-	-	-	-	-	-
Larry Greenlaw	Regional District of Central Kootenay	1	-	4	-	3	-	-	-	-
		-	-	-	-	-	-	-	-	-

[1] Note that not every Consultative Committee member completed each exercise and others did not include every alternative in their rankings.

[2] Note that Alternative S (73) had not been proposed at the time that these exercises were conducted.

Figure 7-11 illustrates the Consultative Committee member's Swing Weighting Rankings. Based on this exercise Alternatives O(90) – Downstream Fish and Cottonwood, Q (90) – Downstream Interests and R (90) – Downstream Interests were the most favourable to Committee members while Alternatives J – Vegetation-Burbot and P (90) – Downstream Interests were the least favourable.

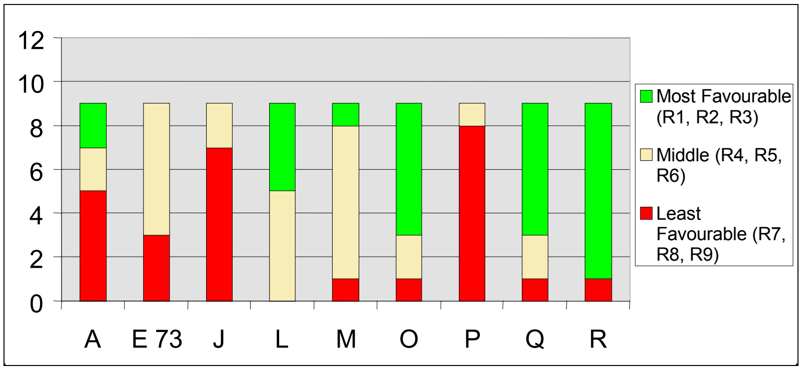

Figure 7-11: Swing Weighting Ranking Preferences of the Consultative Committee

Figure 7-12 illustrates the Consultative Committee member's Direct Rankings. Based on this exercise, Alternatives A – Current Operations, M (90) – Downstream Interests Q (90) – Downstream Interests and R (90) – Downstream Interests were the most favourable to Committee members, while Alternatives A – Current Operations, J – Vegetation-Burbot and R (90)– Downstream Interests were the least favourable.

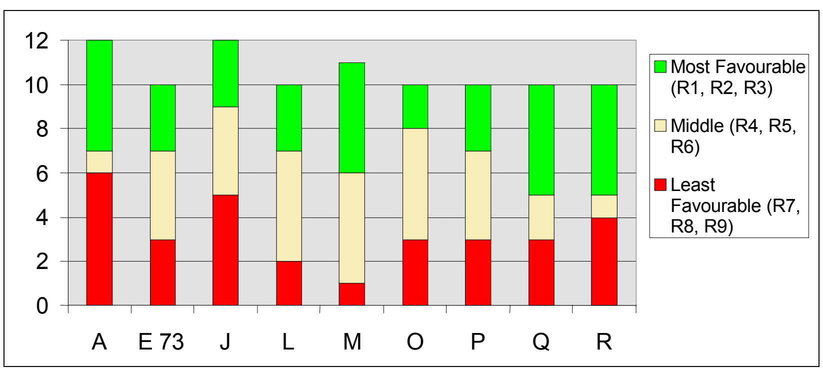

Figure 7-12: Direct Ranking Preferences of the Consultative Committee

Figure 7-13 illustrates the Consultative Committee member's level of support for the alternatives according to their rankings of either endorse, accept or block.

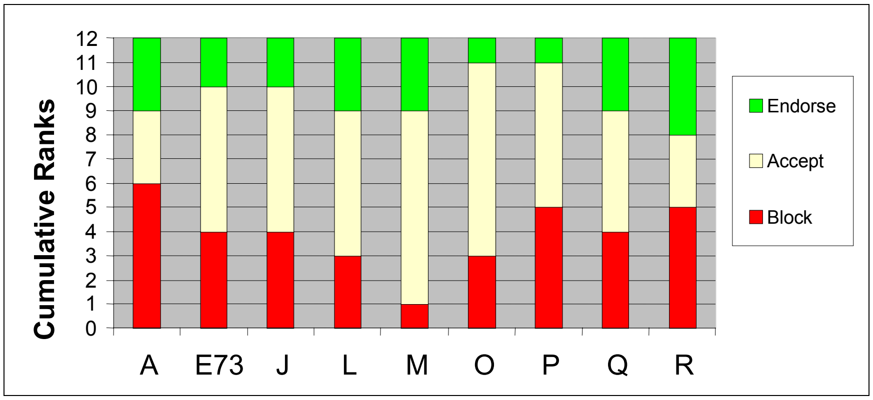

Figure 7-13: Consultative Committee Member Preferences for the Alternatives According to Endorse, Accept or Block

Based on this exercise and subsequent discussions related to cottonwood flows and the new ***Whitefish Effective Spawning Habitat Lost (Mainstem)*** performance measure, the Consultative Committee concluded that:

1. Alternatives L (73) or M (90) had the best opportunity for achieving a consensus recommendation, and
2. If Alternative R (90) could be amended, it had the best possibility of meeting the Committee members' interests.

7.7.6 Level of Support for Alternatives L (73) and M (90)

During Round 3 of the trade-off analysis process, the Consultative Committee members were asked to state their level of support for Alternatives L (73) – Downstream Interests and M (90) – Downstream Interests assuming that these alternatives would likely result in a consensus recommendation for the Duncan Dam Water Use Plan.

Table 7-16 and Table 7-17 summarize the level of support for the operating alternatives and the specific comments made by each Consultative Committee member.

At this point during the Consultative Committee meeting, the Committee member from Ktunaxa–Kinbasket Tribal Council (KKTC) commented that he had a concern with the Duncan Dam water use planning process. He stated that he was unhappy that footprint issues associated with original construction of the Duncan Dam were not being addressed through this process and wanted to ensure that this process would not interfere with the ongoing Treaty process. He also expressed concerns about the protection of cultural resources identified in the Duncan Reservoir, and the role and involvement of First Nations in implementing the monitoring studies. It was noted that some of these isssues were beyond the mandate of the Consultative Committee and the scope of the Duncan Dam Water Use Plan. The KKTC Committee member agreed to continue his participation in the water use planning porocess, if the following conditions were met:

Ktunaxa–Kinbasket Tribal Council (KKTC) Conditions

- *BC Hydro to engage in a grievance process to address footprint issues when the Duncan Dam was first built;*
- *Cultural resource issues need to be addressed;*
- *KKTC is currently involved in the Treaty process. Therefore, the Duncan Dam Water Use Plan needs to include a trigger to re-open the Water Use Plan if it is affected by a Treaty settlement issue; and*
- *First Nations to be involved in the implementation of the monitoring studies.*

Accordingly, these conditions along with those stated earlier by the Consultative Committee members from Columbia Power Corporation and Columbia Basin Trust (refer to Section 7.7) were assumed to be satisfied in order to proceed with the Duncan Dam water use planning process.

Prior to stating their level of support for the alternatives, the Consultative Committee discussed Alternatives L (73) – Downstream Interests and M (90) – Downstream Interests. Alternative L (73) was associated with a higher probability that it could be operationalized every year without violating any Columbia River Treaty requirements associated with the 1 March Flood Rule Curve (FRC). This also translated into fewer fish impacts under Alternative L (73) if the FRC had to be met and there was a late freshet because there is limited storage in the Duncan Reservoir that would be available to augment and provide the desired minimum flows in the lower Duncan River. Alternative L (73) also would cause less financial revenue impacts on both the Kootenay and lower Columbia river systems, but did not perform as well as Alternative M (90) for the ***Kokanee Effective Spawning Habitat Lost (Sidechannels)*** or the ***Whitefish Effective Spawning Habitat Lost (Mainstem)*** performance measures.

Table 7-16 summarizes the Consultative Committee member’s level of support for Alternative L (73) – Downstream Interests.

Table 7-16: Consultative Committee Level of Support for Alternative L (73) – Downstream Interests

Consultative Committee Member	Organization	Alternative L (73)	Comments and Conditions
Kindy Gosal	Columbia Basin Trust	**Accept**	At this point in the process, I would accept with the conditions already mentioned (and described in Section 7.7).
Stephan O’Shea	Area Resident	**Accept**	Confused, swing weightings are out of balance; recreational interests are out of balance. Will accept Alternative L. Need to keep the reservoir lower in spring for grasses; neither Alternatives M nor L has this.
Gail Spitler	Area Resident	**Accept**	Acceptable conditional on downstream monitoring programs; absolute bottom line is that we need more data.
Llewellyn Matthews	Columbia Power Corporation	**Accept**	With conditions tabled (in Section 7.7), Alternative L is acceptable.

Table 7-16: Consultative Committee Level of Support for Alternative L (73) – Downstream Interests (cont'd)

Consultative Committee Member	Organization	Alternative L (73)	Comments and Conditions
Gene Anderson	FortisBC	**Accept**	Acceptable if there are ways to minimize impacts on downstream power without adversely affecting the other performance measures (soft condition).
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	**Accept**	Agrees with Gail. Will accept but need to monitor to ensure that we are not affecting the lower river. There is substantial kokanee sidechannel spawning. Need to monitor this as well. Would want to see a detailed assessment around the need to protect Argenta Slough. Need good data on this to compensate for loss of cottonwood under Alternative L.
Fred Thiessen	Ministry of Forests	**Accept**	
Gordon Boyd	BC Hydro	**Accept**	Acceptance pending overall package. Would be interested in determining if there is some way to get costs down by delaying dam discharges later in the fall to get more water through system. Moving to 1 October would make it more acceptable. But still acceptable (soft conditions).
Vic Clement	Ktunaxa–Kinbasket Tribal Council	**Accept**	Accept with conditions already tabled including attention to cultural sites.
Steve Macfarlane	Fisheries and Oceans Canada	**Accept**	Acceptance with the new performance measures is marginal but will continue to accept. Losses of whitefish are high. This is not best option but could live with it. Obviously monitoring is critical. I would like to see the cultural work done in the reservoir and would be interested in anything to enhance cottonwood in addition to flows.
Terry Anderson	Ministry of Water, Land and Air Protection	**Accept**	Would like to see if we can tweak to address the whitefish issue (soft condition), and possibly look for a more natural hydrograph during the growing season. Median line will never really occur. There are two patterns that could occur under Alternative L (really high and then drop down or high and drop down).
Larry Greenlaw	Regional District of Central Kootenay	**Removed Support**[1]	Larry initially accepted Alternative 73 during the April 2004 Consultative Committee meeting, but subsequently the Regional District removed their support for the Duncan Dam water use planning process (Resolution 605/04) at their 24 April 2004 Board meeting.

Table 7-17 summarizes the Consultative Committee members' level of support for Alternative M (90) – Downstream Interests.

[1] Refer to Appendix J: Correspondence with the Regional District of Central Kootenay for correspondence from the Regional District of Central Kootenay removing their support for the Duncan Dam water use planning process.

Table 7-17: Consultative Committee Level of Support for Alternative M (90) – Downstream Interests

Consultative Committee Member	Organization	Alternative M (90)	Comments and Conditions
Kindy Gosal	Columbia Basin Trust	**Accept**	Accept with same provisions as Alternative L.
Stephan O'Shea	Area Resident	**Accept**	Alternative M is hard on erosion relative to Alternative L and costs more money. Will accept, but still likes Alternative A.
Gail Spitler	Area Resident	**Accept**	Acceptable with same conditions and that we study Argenta Slough.
Llewellyn Matthews	Columbia Power Corporation	**Accept**	With conditions already tabled. Alternative M is acceptable. Alternative L is preferable to Alternative M.
Gene Anderson	FortisBC	**Accept**	Acceptable but conditions are less soft.
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	**Accept**	Agree with Gail. Will accept but with the same conditions. Reduces stranding. Prefers Alternative M for cottonwood recruitment.
Fred Thiessen	Ministry of Forests	**Accept**	
Gordon Boyd	BC Hydro	**Accept**	Prefers Alternative L to Alternative M. Need to see overall package. Accept but not as happily.
Vic Clement	Ktunaxa–Kinbasket Tribal Council	**Accept**	Accept with conditions already tabled including attention to cultural sites.
Steve Macfarlane	Fisheries and Oceans Canada	**Endorse**	Subject to meeting the same conditions.
Terry Anderson	Ministry of Water, Land and Air Protection	**Accept**	Acceptance with the same condition. Would like to see cultural work done. Prefers Alternative M over Alternative L.
Larry Greenlaw	Regional District of Central Kootenay	**Removed Support**[1]	Larry initially accepted Alternative M during the April 2004 Consultative Committee meeting, but subsequently the Regional District removed their support for the Duncan Dam water use planning process (Resolution 605/04) at their 24 April, 2004 Board meeting.

[1] Refer to Appendix J: Correspondence with the Regional District of Central Kootenay for correspondence the Regional District of Central Kootenay removing their support for the Duncan Dam water use planning process.

After articulating their conditional support for Alternatives L (73) – Downstream Interests and M (90) – Downstream Interests, the Consultative Committee felt that their interests would be better met with the development of a new alternative.

A review of the Consultative Committee's Swing Weighting rankings (refer to Figure 7-11) indicated that Alternative R (90) – Downstream Interests would better meet Committee member interests except for the high financial revenue impacts. It was speculated that an operating alternative similar to Alternative R (90) with a delayed lower minimum would provide a better balance of environmental, social and economic interests over Alternatives L (73) and M (90).

7.7.7 Preliminary Consultative Committee Support for the New Alternative S (73) – Downstream Fish and Cottonwood

Alternative S (73) – Downstream Fish and Cottonwood was proposed and evaluated during the final Consultative Committee meeting in April 2004. The Committee recognized that Alternative S (73) was intended to provide benefits to interests other than downstream fish and cottonwood. The performance measures used during the meeting were estimated by the BC Hydro project team (refer to Table 7-18 below). Subsequent to the April meeting, the BC Hydro project team modelled the new operating alternative and calculated the performance measures.

This section summarizes the Consultative Committee deliberations for Alternative S (73) at their final Committee meeting in April 2004.

Table 7-18 summarizes the estimated median values of the performance measures under Alternatives L (73), M (90), R (90) and S (73).

Table 7-18: Interactive Consequence Table Comparing Alternatives L (73), M (90), and R (90) to Alternative S (73)

Performance Measures	Unit of Measure	Alternatives	Downstream Interests L (73)	Downstream Interests M (90)	Downstream Interests R (90)	Downstream Fish and Cottonwood S (73)
Recreation Quality	Weighted User Days		313	314	318	315
Kokanee Effective Spawning Habitat (Lower Duncan River)	Hectares		42	42	42	37
Whitefish Effective Spawning Habitat Lost (Lower Duncan River)	Hectares		14	12	5	6
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	Hectares		17	16	15	17
Kokanee Effective Spawning Habitat Lost (Lower Duncan River Sidechannel)	Hectares		23	14	10	42
Erosion Impacts	Weighted Exposure Days		613	730	671	700
Riparian Productivity - Inundation Tolerance (Reservoir)	Hectares of shrub area (willow)		132	146	129	250
Riparian Productivity - Long-term Median (Reservoir)	Hectares of grassland riparian habitat		289	288	284	154
Cottonwood Hydrograph Weighted Index (Lower Duncan River)	Comparison to optimum cottonwood hydrograph		0.50	0.55	0.62	0.71
Financial Revenue - Kootenay River	Net annual average of generation $/year compared to power operations		-0.3	-0.5	-0.9	-0.7
Financial Revenue - Lower Columbia River	Net annual average of generation $/year compared to power operations		-1.9	-2.1	-2.4	-1.9

At the final Consultative Committee meeting, Committee members were requested to indicate their level of support for Alternative S (73) compared to Alternatives L (73) and M (90).

Table 7-19 summarizes the Consultative Committee members' preliminary level of support for Alternative S (73).

Table 7-19: Preliminary Consultative Committee Level of Support for Alternatives S (73) Compared to Alternatives L (73) and M (90)

Consultative Committee Member	Organization	Preference of Alternative S (73)	Comments and Conditions
Kindy Gosal	Columbia Basin Trust	Prefer	CBT's stance is that costs should not be borne by residents of the basin. Based on conditions stated previously (Section 7.7), I would accept/prefer this alternative. However, I am still concerned over system-wide flexibility issues that need to be discussed. I also echo Stephan's concern around the need for local involvement in monitoring. This is a recommendation as opposed to condition to acceptance.
Stephan O'Shea	Area Resident	Prefer	Recreation is still coming out with lots of days. 288 days from Alternative M to 154 days Alternative S represents a loss of grasses for ungulate habitat. I would accept/prefer Alternative S with monitoring. It is not better for my interests, but recognize that this alternative is better for other people's interests. There is a need more hunters rather than scientists involved in monitoring (more local involvement).
Gail Spitler	Area Resident	Prefer	I prefer this alternative, assuming that all conditions placed on Alternatives L and M also apply to Alternative S.
Llewellyn Matthews	Columbia Power Corporation	Accept	Not sure I prefer Alternative S to Alternative L (additional costs for benefits). My preference is with Alternative L, but would accept Alternative S subject to conditions of CPC stated earlier (Section 7.7)[1]. There should be exclusion fencing to keep kokanee out of sidechannel during the 2-week (15 September to 1 October) period under Alternative S.
Gene Anderson	FortisBC	Prefer	Prefer this alternative over Alternatives L and M.
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	Prefer	Prefer, provided the rationale for violation of the 250 m^3/s constraint is given by BC Hydro should it occur.
Fred Thiessen	Ministry of Forests	Prefer	
Gordon Boyd	BC Hydro	Prefer	We will be helping the system and are tweaking at top end. A $2.6 million cost is getting up there. I like this alternative but what else is coming with the package. I will accept based on the total cost of package.
Vic Clement	Ktunaxa–Kinbasket Tribal Council	Prefer	With the same conditions as noted earlier (Section 7.7.6) for Alternatives L and M.

Table 7-19: Preliminary Consultative Committee Level of Support for Alternatives S (73) Compared to Alternatives L (73) and M (90) (cont'd)

Consultative Committee Member	Organization	Preference of Alternative S (73)	Comments and Conditions
Steve Macfarlane	Fisheries and Oceans Canada	Prefer	This alternative is not the best alternative for fish alone but we should be trying to implement an alternative for all other interests. I would reinforce that my preference for Alternative S is conditional on exclusion fencing.
Terry Anderson	Ministry of Water, Land and Air Protection	Prefer	I accept Alternative S as my preferred alternative. It provides for a more natural hydrograph through the fall. I would like to see cultural sites identified. There is still a nutrient issue – we could be losing more nutrients than originally thought. This needs more work.
Larry Greenlaw	Regional District of Central Kootenay	Removed Acceptance[2]	At the meeting, Larry initially accepted this alternative, but preferred Alternatives L and M because of their August reservoir levels. Subsequent to the April 2004 Consultative Committee meeting, the Regional District removed their support for the Duncan Dam water use planning process (Resolution 605/04) at their 24 April 2004 Board meeting.

[1] Refer to Appendix I: Correspondence from Columbia Power Corporation for correspondence from the CPC outlining their conditions for acceptance of operating alternatives.

[2] Refer to Appendix J: Correspondence with the Regional District of Central Kootenay for correspondence from the Regional District of Central Kootenay removing their support for the Duncan Dam water use planning process.

At the final Consultative Committee meeting, the Committee conditionally agreed to recommend Alternative S (73) as their preferred operating alternative subject to the BC Hydro project team confirming the performance measures[1] and the conditions previously noted by the KKTC, CPC and CBT Committee members.

7.7.8 Modelled Results for the New Alternative S (73)

Subsequent to the final Consultative Committee meeting, the BC Hydro project team modelled the new Alternative S (73) and calculated the performance measures (refer to Appendix K: Hydrographs and Reservoir Elevations for Current Operations and the Recommended Operating Alternative). Upon review, some of the calculated performance measure values varied from those used by the Consultative Committee. This section provides a summary of the results.

The modelled Alternative S (73) released slightly more water from 15 to 30 September and from 22 to 31 December each year to better meet the Columbia River Treaty Flood Control Rule Curve. This resulted in a net

[1] The Consultative Committee agreed that if the actual calculated performance measure values were within the uncertainty (MSIC) of the estimated performance measure values, then their conditional support for Alternative S (73) would remain.

improvement for both ***Financial Revenue*** and ***Riparian Productivity – Long-term Median (Reservoir)***[1]. However, these changes also resulted in an increase in ***Kokanee Effective Spawning Habitat Lost (Sidechannel)*** performance measure and negatively affected the ***Cottonwood Hydrograph Weighted Index (Lower Duncan River)*** performance measure.

Table 7-20 summarizes the estimated median values of the performance measures under Alternative S (73) used at the Consultative Committee meeting, as well as the actual calculated values.

Table 7-20: Comparison of Performance Measures and their Significance for Alternative S (73) between the Estimated Value and the Actual Calculated Value

Performance Measures	Estimated Values (used at final Consultative Committee meeting)	Actual Calculated Values	Significance: Same Worse Better (based on MSIC)
Recreation Quality	315	303	Same
Kokanee Effective Spawning Habitat (Lower Duncan River)	37	38.1	Same
Whitefish Effective Spawning Habitat (Lower Duncan River)	6	6.1	Same
Rainbow Effective Rearing Habitat Lost (Lower Duncan River)	17	16.0	Same
Kokanee Effective Spawning Habitat Lost (Lower Duncan River Sidechannel)	42	**56.4**	**Worse**
Erosion Protection	700	657	Same
Riparian Productivity – Inundation Tolerance (Reservoir)	250	260.1	Same
Riparian Productivity – Long-term Median (Reservoir)	154	**222.0**	**Better**
Cottonwood Hydrograph Weighted Index	0.71	**0.59**	**Worse**
Financial Revenue – Kootenay River	-0.7	**-0.3**	**Better**
Financial Revenue – Lower Columbia River	-1.9	**-1.4**	**Better**

Overall, five performance measure values changed significantly from those estimated by the BC Hydro project team at the final Consultative Committee meeting. Two performance measures performed significantly worse: ***Kokanee Effective Spawning Habitat Lost (Sidechannel)*** and ***Cottonwood Hydrograph Weighted Index (Lower Duncan River)***.

[1] This was a result of lower Duncan Reservoir water levels late in the growing season, and higher flow releases from the Duncan Dam in late September, causing less spilling and more generation at Arrow Lakes Generation Station.

Kokanee Effective Spawning Habitat Lost (Sidechannel)	The actual calculated performance measure value performed worse with 56 ha lost (negative change of 14 ha). This was a result of the later start date for the target flow of 73 m^3/s on 1 October and the steeper recession flow. However, the Consultative Committee observed that the significance of this impact would be mitigated with the recommendation for a non-operational physical work to fence (net) off and prevent kokanee from entering the sidechannels during the last two weeks in September.
Cottonwood Hydrograph Weighted Index (Lower Duncan River)	The estimated performance measure value was 71 per cent, but the actual calculated performance measure performed worse at 59 per cent. This value was an improvement over Alternative L (50 per cent) and the same as Alternative M (55 per cent), which were initially acceptable to the Consultative Committee.

Two actual calculated performance measures performed significantly better than the estimated values: ***Riparian Productivity – Long-term Median***, and the ***Financial Revenue (Kootenay and Lower Columbia Rivers).*** The reasons for the changes were as follows:

Riparian Productivity – Long-term Median (Duncan Reservoir)	The estimated performance measure value was 154 ha of grassland area for Alternative S (73), but the actual calculated performance measure performed significantly better with 222 ha. This was a result of a slightly lower Duncan Reservoir during the fall growing period.
Financial Revenue– Kootenay and Lower Columbia Rivers	The Consultative Committee conditionally accepted combined financial revenue impacts of approximately \$2.6 million per year for Alternative S (73) (relative to Alternative A – Current Operations) during the final Committee meeting in April 2004. The actual calculated ***Financial Revenue*** performance measure performed better at \$1.7 million per year on average. This was a result of better information with the modelled data and changes to meet the 1 January Columbia River Treaty Flood Control Rule Curve target for the Duncan Reservoir each year (i.e., drawing down the reservoir slightly more to create a buffer in the 15 to 30 September and 22 to 31 December periods).

7.7.9 Final Consultative Committee Support for the New Alternative S (73)

On 8 June 2004, Consultative Committee members were sent the results of the newly modelled Alternative S (73) including the calculated actual performance measures values. The facilitator contacted each Committee member directly and asked whether there was a change in their level of support for Alternative S (73) as expressed during the final Committee meeting.

Table 7-21 summarizes the Consultative Committee's final level of support for Alternative S (73).

Table 7-21: Final Consultative Committee Level of Support for Alternative S (73)

Consultative Committee Member	Organization	Support for Alternative S (73)	Comments and Conditions
Kindy Gosal	Columbia Basin Trust	**No Comment**	As stated, "Until such time as we receive sufficient assurance from BC Hydro that our Joint Venture Projects will be kept whole through the water use planning process, I cannot comment any further".
Stephan O'Shea	Area Resident	**Still Supports**	No additional comments.
Gail Spitler	Area Resident	**Still Supports**	Mentioned that money is being directed to mitigating mosquitoes through the capping of flows in August and September. Did not want to see any compromising on the monitoring studies.
Bruce Duncan	Columbia Power Corporation	**Accepts as per CPC condition (refer to Section 7.7 and Appendix I)**	Commented that initial wording of condition should be 'saved harmless or appropriately compensated'. BC Hydro needs to provide assurances before removing conditions. Also wanted feedback on cross-system impacts.
Sue Dyer	FortisBC	**Accepts**	No changes or additional concerns.
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	**Still Supports**	Commented that the decrease in the cottonwood recruitment performance measure is offset with the increase from the grass performance measure. And still better than status quo.
Fred Thiessen	Ministry of Forests	**Still Supports**	Okay with the modelled Alternative S (73) results, as the changes from a forests / recreation perspective are negligible.
Gordon Boyd	BC Hydro	**Still Supports**	Would still support the boat ramp extension at Glacier Creek as long as an acceptable management plan could be arranged with the Ministry of Forests and the Regional District of Central Kootenay. He also wanted to ensure that this option would not infringe on new forestry recreation initiatives. He had a few questions related to the sequencing of the studies in the monitoring program to see if there were any efficiencies to be gained.
Vic Clement	Ktunaxa–Kinbasket Tribal Council	**Still Supports as per KKTC's conditions (Section 7.7.6)**	No additional comments.
Steve Macfarlane	Fisheries and Oceans Canada	**Still Supports**	Conditions apply as they did during the final meeting (e.g., sidechannels to be fenced off during 15 to 30 September). Refer to Table 7-16, Table 7-17 and Table 7-18.

Table 7-21: Final Consultative Committee Level of Support for Alternative S (73) (cont'd)

Consultative Committee Member	Organization	Support for Alternative S (73)	Comments and Conditions
Terry Anderson	Ministry of Water, Land and Air Protection	**Still Supports**	No further comments.
Larry Greenlaw	Regional District of Central Kootenay	**Does Not Support**	Commented that the questions asked during the water use planning process were designed to come up with the answers and he was unhappy with this. Commented that the Regional District would do the maintenance for a boat ramp extension, but not be responsible for it. Part of the mandate for the Glacier Creek recreation site was for it to remain rustic in nature. A new extension to the boat ramp might change this. Therefore, he would need to check with the Regional District to see if they would support the proposed extension. He also felt that the extension might be overkill and only be used for 5 to 6 weeks per year.

The Consultative Committee members confirmed the same level of support for Alternative S (73) as expressed during the final Committee meeting in April 2004.

Therefore, the outcome of the Duncan Dam water use planning process was a conditionally supported non-consensus recommendation for Alternative S (73) with:

- The Regional District of Central Kootenay removing support for outcomes of the Duncan Dam Water Use Plan;
- The Columbia Basin Trust Committee member providing no further comment on the alternatives until more assurances were forthcoming from BC Hydro related to their conditions (refer to Section 7.7 and Appendix I);
- The Columbia Power Corporation Committee member accepting Alternative S (73) as long as their conditions were met (refer to Section 7.7); and
- The KKTC Committee member preferring Alternative S (73) as long as their conditions were met (refer to Section 7.7.6).

7.7.10 Consultative Committee Support for Alternative K - Cottonwood Hydrograph

The Consultative Committee agreed to treat Alternative K – Cottonwood Hydrograph independently from the other operating alternatives, given it would be required on an infrequent basis (about every fifth year on average) to achieve the desired cottonwood recruitment benefits in the lower Duncan River.

Throughout the Duncan Dam water use planning process, Alternative K was modified as new information became available. During a March 2004 Wildlife Technical Subcommittee meeting, the members agreed to the following:

- To achieve the desirable benefits for cottonwood recruitment in the lower Duncan River, Alternative K needs to be implemented approximately once in every five years (an average of one in every four or seven years);
- The target flow for encouraging recruitment of cottonwoods is above 250 m^3/s in the lower Duncan River. This target flow was based on advice from Stewart Rood that flows below this level would likely scour the cottonwoods on a regular basis.
- Slowly receding river flows to meet cottonwood root growth criteria in the early fall (September onwards) was probably not a driving factor because of the high ground water table in the area.
- The combination of target flows above 250 m^3/s and relaxed recession constraints for cottonwood root development allowed the initial constraints for Alternative K to be reduced, providing more flexibility at other times of the year.
- In the early fall period and throughout the winter, cottonwood recruitment benefits were expected to be met provided that flows do not exceed 250 m^3/s.

Figure 7-14 illustrates the Alternative K hydrograph that highlights the key times and flows that are expected to promote cottonwood recruitment.

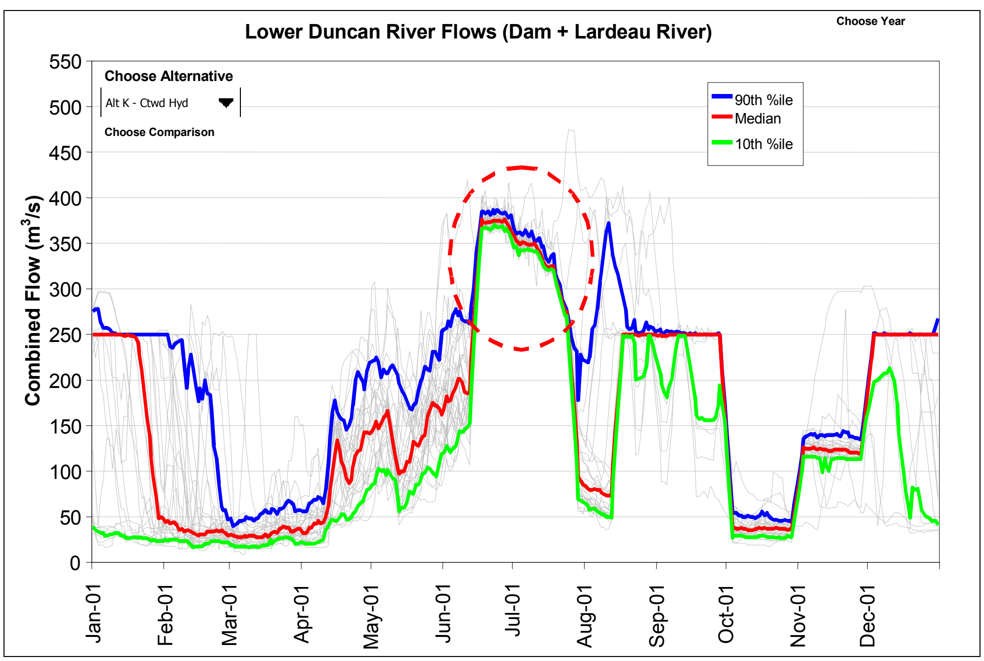

Figure 7-14: Alternative K Hydrograph Identifying the Key Times and Flow Levels (Red Circle) to Promote Cottonwood Recruitment

The Consultative Committee reviewed the trade-offs associated with implementing Alternative K – Cottonwood Hydrograph. However, it was difficult to compare Alternative K with the other alternatives using the performance measures given the alternative would be implemented on an opportunistic or infrequent basis.

Given that the significant impacts of Alternative K – Cottonwood Hydrograph were associated with high spring and summer river flows and receding flows to the beginning of August, the Consultative Committee focused on those performance measure that would be affected during this period as follows:

- Recreation Quality
- Cultural Site Erosion
- Riparian Productivity – Inundation Tolerance
- Cottonwood Hydrograph Weighted Index
- Mosquito Breeding Habitat
- Financial Revenue

During Round 2 of the trade-off analysis process, the Consultative Committee agreed that Alternative K – Cottonwood Hydrograph could only be implemented during relatively high inflow years. In higher than average inflow years, the resulting Duncan Reservoir water levels in the spring and summer would not impact other performance measures including ***Recreation Quality, Cultural Resources Erosion***, and ***Riparian Productivity*.** In addition, since Alternative K tries to avoid flows above 400 m^3/s in the lower Duncan River, there would not be any significant impact to the ***Mosquito Breeding Habitat*** performance measure.

Therefore, the main trade-off for with implementing Alternative K – Cottonwood Hydrograph is the ***Cottonwood Hydrograph Weighted Index*** performance measure in the lower Duncan River (cottonwoods were a proxy for the riparian community and wildlife interests) and the ***Financial Revenue*** performance measure for the Kootenay and lower Columbia river systems. The average reduction in financial revenue was estimated between $5 to $7 million per implementation of Alternative K. The cottonwood benefits associated with implementing Alternative K were more qualitative and based on the ***Cottonwood Hydrograph Weighted Index*** performance measure and expert opinion.

Subsequent analysis indicated that there were only four years in the 33-year period of record where inflows were high enough to avoid negative impacts on other performance measures and yet not so high that the desired cottonwood recession limb could not be achieved. Thus, the desire to implement the scenario every five years could not be achieved without some significant impact on other performance measures. In addition, the average lost generation revenue associated with implementing Alternative K in suitable inflow years exceeded $10 million per year.

During the final Consultative Committee meeting, the Consultative Committee agreed to drop Alternative K from further consideration. This was primarily based on the Committee's preference for Alternative S (73), which performed relatively well for the cottonwood interests in the lower Duncan River. The Committee recognized that implementing Alternative K would negatively impact the ***Recreation Quality*** and the ***Financial Revenue*** performance measures.

7.7.11 Consultative Committee Support for the Non-Operational Physical Works

At the final Consultative Committee meeting in April 2004, the Committee reviewed three proposed non-operational physical works[1] that were discussed at the conclusion of the Round 2 trade-off analysis process and three new proposed non-operational physical works that were introduced at the final Committee meeting as follows:

Wildlife	1)	Argenta Slough erosion protection in the Duncan River
Cultural Resources	2)	Identified cultural sites erosion protection in the Duncan Reservoir
Recreation	Options:	
	3(a)	Beach re-contouring at Glacier Creek
	3(b)	Boat launch and mooring buoys at Glacier Creek
	3(c)	Maintenance at Howser and Glayco creeks recreation sites
	3(d)	Partial funding towards the Regional District of Central Kootenay's Mosquito Abatement Program
Fish	4)	Partial funding for Columbia Basin Fish and Wildlife Compensation's Kootenay Lake Nutrient Loading Program
	5)	Exclusion fencing in affected lower Duncan River sidechannels
Agriculture Lands	6)	Erosion protection of agricultural lands

[1] By definition, non-operational physical works are another means to create a benefit without manipulating water differently through the control structures. These non-operational options usually refer to some form of a physical works project such as an engineered spawning channel, a planting program for vegetation, or protection measures to mitigate erosion.

The facilitator reviewed the criteria by which non-operational physical works could be considered in lieu of operational changes according to the Province's document titled, *Creating Water Use Plan Alternatives.* The document outlines four decision rules, of which the first three decision rules must be met before a non-operational physical work can be considered in lieu of an operational change.

Figure 7-15 illustrates the provincial guidelines on decision rules for creating non-operational alternatives for water use planning.

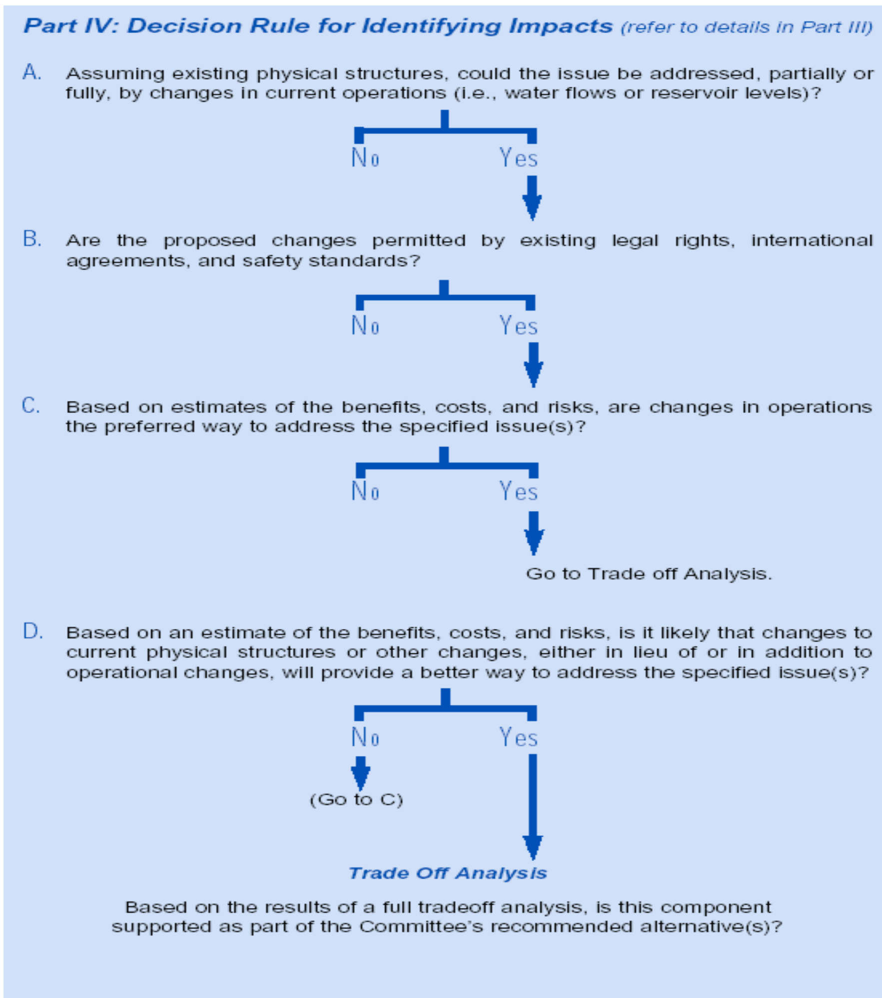

Figure 7-15: Provincial Guidelines on Decision Rules for Creating Non-Operational Alternatives for Water Use Planning

The Consultative Committee considered each of the non-operating alternatives after they selected their preferred operating alternative – *Alternative S (73).* For some Committee members, their level of support for Alternative S (73) was linked to implementation of a non-operational physical work (refer to Appendix H: Non-Operational Physical Works for detailed information).

7.7.11.1 Argenta Slough Erosion Protection

An Argenta Slough Erosion Protection physical work was initially proposed during Round 2 of the trade-off analysis process to address impacts to wildlife and riparian communities in the Duncan Reservoir in lieu of an operational change. While specific non-operational physical works were considered in the reservoir area, the costs of these works were considered high compared to the benefits. Therefore, the Wildlife Technical Subcommittee recommended four Argenta Slough and Wetland protection options downstream from the Duncan Dam given its overall importance to wildlife in the area.

The Consultative Committee agreed to undertake a risk assessment of the erosion protection non-operational physical works and implement a preferred option to a maximum capital cost of $150,000. Committee members also commented that they would not support the use of riprap as the erosion protection measure for the riverbank.

7.7.11.2 Identified Heritage and Cultural Sites Erosion Protection

A Heritage and Cultural Sites Erosion Protection physical work was proposed to address operational impacts on identified heritage and cultural sites in the Duncan Reservoir in lieu of an operational change. When reservoir water levels are above the cultural sites, erosion caused by wave action may be occurring up to 10 m below the surface. As the reservoir levels rise or fall through the elevation zone of the cultural sites, erosion is likely greater as a result of direct wave action. When reservoir levels are below the cultural sites, other erosion processes such as wind scour and surface run-off are likely having a negative impact on the sites.

The Consultative Committee reviewed two erosion protection options for the identified heritage and cultural sites. The Committee acknowledged the uncertainty associated with protecting the cultural sites with a non-operational physical work. The Committee also acknowledged that erosion is caused by both footprint issues such as the Columbia River Treaty that requires the reservoir to be emptied and filled each year and by changes to reservoir elevation. Wayne Choquette noted that these sites are deteriorating and there may be nothing left to protect in a few years time.

A number of Consultative Committee members made protection of these identified cultural sites a condition of their support for Alternative S (73). The Committee also emphasized that timing is critical and that consideration should be given to implementing physical works to protect the sites prior to implementation of the Duncan Dam Water Use Plan.

The Consultative Committee also agreed to support the necessary monitoring studies (erosion monitoring of the sites, conservation excavations, traditional use and cultural assessments) for the cultural sites (refer to Section 8).

Based on further discussions during the April 2004 Consultative Committee meeting, the Committee was asked to express their level of support for a funding envelope of up to $2.4 million to protect the identified cultural sites (and any others found during the field work)[1].

The Consultative Committee agreed, with the exception of the Regional District of Central Kootenay Committee member[2], to a funding cap of $2.4 million for any cultural site protection works deemed necessary through (a) the study results and (b) discussions between KKTC, BC Hydro and the appropriate government regulatory agencies.

7.7.11.3 Beach Re-contouring at Glacier Creek

Beach re-contouring at Glacier Creek was one of four non-operational physical works proposed to address the impacts to recreation on the Duncan Reservoir in lieu of an operational change. Reservoir elevations during the peak recreation season 1 August to 6 September directly impacts the quality and accessibility of recreation opportunities. Beach use is affected when reservoir water levels are too high, while beach and boat ramp access is affected when they are low. The Regional District of Central Kootenay Committee member stated that this option was not feasible given the high costs and the rocky nature of the site.

The Consultative Committee agreed to drop beach re-contouring at Glacier Creek physical works from further consideration.

7.7.11.4 Boat Launch and Mooring Buoys at Glacier Creek

Boat Launch and Mooring Buoys at Glacier Creek was one of four non-operational physical works proposed to address the impacts to recreation on the Duncan Reservoir in lieu of an operational change. Alternative S (73) maintains the Duncan Reservoir water levels approximately 1 m below full pool from mid-August until the Labour Day weekend, and may reduce recreation opportunities at the Glacier Creek recreation facilities. The proposed boat ramp would provide better access and more flexibility to launch boats when reservoir levels are up to 8 ft below full pool from mid-July to mid-September on average.

The Consultative Committee agreed to the Glacier Creek Boat Ramp Extension to a funding cap of $126,000 with the caveat that the Regional District of Central Kootenay would be responsible for maintenance of the

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[1] If additional significant sites are found and they require protection works that cannot be met through the proposed $2.4 million cap, then this will be left up to the regulators, BC Hydro, and First Nations to reconsider.

[2] The Regional District representative could "not rationalize spending large amounts of money for cultural sites, and pinching in other areas that deal with present people."

boat ramp upon completion of construction[1]**.** The option to build the boat ramp at a nearby site was also supported if it made more sense to do so (e.g., steeper terrain, less costly, better access).

7.7.11.5 Maintenance at Howser and Glayco Creeks Recreation Sites

Maintenance at Howser and Glayco Creeks recreation sites was one of four non-operational physical works proposed to address the impacts to recreation on the Duncan Reservoir in lieu of an operational change.

The Ministry of Forests Committee member stated that there was three years of funding secured to better maintain these sites in the future, since it is the Ministry's responsibility.

The Consultative Committee agreed to drop maintenance at Howser and Glayco Creeks recreation sites from further consideration.

7.7.11.6 Partial Funding Towards the Regional District's Mosquito Abatement Program

Partial funding towards the Regional District of Central Kootenay's Mosquito Abatement Program was one of four non-operational physical works proposed to address the impacts to recreation on the Duncan Reservoir in lieu of an operational change.

While closely related to the Quality of Life objective area, mosquitoes were identified as one of the largest deterrents for locals to be able to recreate and enjoy the outdoors. The Recreation/Quality of Life Technical Subcommittee supported partial funding towards the Regional District's Mosquito Abatement Program. The formula for calculating how much of the program should be funded as a recreation non-operating alternative was based on an assessment of historical costs (post Lardeau River freshet effects).

The Consultative Committee reviewed partial funding towards the Regional District's Mosquito Abatement Program after they had agreed to recommend the Boat Launch at Glacier Creek in lieu of operational changes.

The Regional District Committee member felt that the proposed $20,000 annual funding to the mosquito abatement program would benefit recreation more than the boat ramp extension. Furthermore, he stated that he had been given assurances from a Minister that the Regional District would receive funding if they participated in the Duncan Dam water use planning process.

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[1] After the April 2004 Consultative Committee meeting, the Regional District representative commented that the district would not be responsible for the ramp after it was built. They were also not clear if a ramp extension would be in line with their desire to keep the Glacier Creek facilities rustic in nature.

Other Consultative Committee members commented that the Duncan Dam water use planning process has addressed the mosquito issue by including maximum flood constraints in the lower Duncan River recommended for the preferred alternative. Alternative S (73) avoids higher Duncan River flows in August that could potentially lead to increased mosquito breeding habitat. Therefore, many Committee members found it difficult to support partial funding of the Regional District's Mosquito Abatement Program.

Table 7-22 summarizes the Consultative Committee members' level of support for the partial funding of the Regional District's Mosquito Abatement Program.

Table 7-22: Consultative Committee Level of Support for the Partial Funding of the Mosquito Abatement Program

Consultative Committee Member	Organization	Support for Partial Funding of the Mosquito Abatement Program	Comments / Conditions
Kindy Gosal	Columbia Basin Trust	**Abstain**	
Stephan O'Shea	Area Resident	**Not present**	
Gail Spitler	Area Resident	**Cannot Support**	
Llewellyn Matthews	Columbia Power Corporation	**Abstain**	
Gene Anderson	FortisBC	**Do Not Support**	
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	**Abstain**	
Fred Thiessen	Ministry of Forests	**Do Not Support**	Have tried to reduce the risk operationally (for mosquitoes).
Gordon Boyd	BC Hydro	**Do Not Support**	Will be much better operationally. Cannot justify.
Vic Clement	Ktunaxa–Kinbasket Tribal Council	**Abstain**	
Steve Macfarlane	Fisheries and Oceans Canada	**Do Not Support**	Has been addressed operationally.
Terry Anderson	Ministry of Water, Land and Air Protection	**Do Not Support**	The mosquito issue has been addressed through the operating alternative.
Larry Greenlaw	Regional District of Central Kootenay		The government has told the Regional District to participate in the process to enable getting funding for the abatement program. So I have spent 4 years in the process and now have to go back to the public with nothing.

The Consultative Committee, with the exception of the Regional District of Central Kootenay Committee member, agreed to drop partial funding of the Regional District's Mosquito Abatement Program works from further consideration.

7.7.11.7 Partial funding of the Columbia Basin Fish and Wildlife Compensation Program's Nutrient Loading Program

Partial funding of the Columbia Basin Fish and Wildlife Compensation Program's (CBFWCP) Nutrient Loading Program in Kootenay Lake was proposed to address the impacts to nutrient retention in the North Arm of Kootenay Lake in lieu of changing flows from Duncan Dam. This non-operational physical work was proposed during the scoping exercise to identify additional cross-system impacts. The nutrient impacts on Kootenay Lake were recognized to be a combination of footprint issues resulting from the Columbia River Treaty and operational issues.

Some Consultative Committee members felt that this was a bookkeeping exercise since BC Hydro was already providing funding towards nutrient level impacts through the CBFWCP. However, the Committee recognized that the CBFWCP program was designed to compensate for footprint issues associated with construction of the Duncan Dam and was not intended to address operational-related impacts.

The Consultative Committee's discussion of this non-operational physical works was complicated by two key uncertainties: (1) no clear analysis delineating the contribution of footprint versus operational impacts; and (2) no agreement on the base case to determine the operations-related impact for Alternative S (73).

The Consultative Committee was requested to express their level of support for partial funding of the CBFWCP's Nutrient Loading Program up to a maximum of $100,000 per year, if further analysis indicated that there is a nutrient loading impact under Alternative S (73).

Table 7-23 summarizes the Consultative Committee members' level of support for partial funding of the CBFWCP's Nutrient Loading Program.

Table 7-23: Consultative Committee Support for Partial Funding of the CBFWCP's Nutrient Loading Program

Consultative Committee Member	Organization	Support for Partial Funding of CBFWCP's Nutrient Loading Program	Comments / Conditions
Kindy Gosal	Columbia Basin Trust	**Abstain**	It is an existing program, and out of the purview of this committee. Should be focusing on operational changes or works in lieu. Seems bizarre. This is an accounting issue.
Stephan O'Shea	Area Resident	**Do Not Support**	Can't support a fertilizer program that involves the use of chemicals. Will not support this unless the current program is re-evaluated.
Gail Spitler	Area Resident	**Accept**	But calculations seem bizarre
Llewellyn Matthews	Columbia Power Corporation	**Do Not Support**	Agree with undertaking the study on Duncan, but do not support providing funding for the fertilization program. It is being done already with contributions from BC Hydro.

Table 7-23: Consultative Committee Support for Partial Funding of the CBFWCP's Nutrient Loading Program (cont'd)

Consultative Committee Member	Organization	Support for Partial Funding of CBFWCP's Nutrient Loading Program	Comments / Conditions
Gene Anderson	FortisBC	**Accept**	
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	**Accept**	Will there be an assessment of how the 2 fertilization programs holistically affect Kootenay Lake? *It was noted that there is a major study being undertaken on the lake.* If the US is going to add significant nutrition to lake and we don't know how nutrients are going to circulate within the lake, there is a risk of over fertilizing. Could we look at this as part of the study? The contribution shouldn't be made until this uncertainty is addressed.
Fred Thiessen	Ministry of Forests	**Accept**	
Gordon Boyd	BC Hydro	**Accept only from Baseline**	Don't believe the calculations are correct. It should be calculated from baseline condition.
Vic Clement	Ktunaxa–Kinbasket Tribal Council	**Abstain**	
Steve Macfarlane	Fisheries and Oceans Canada	**Accept from Baseline**	Accepts but needs to be measured from a base case as opposed to a hypothetical scenario that would never happen (i.e., Alternative A).
Terry Anderson	Ministry of Water, Land and Air Protection	**Accept**	This is an operational issue.
Larry Greenlaw	Regional District of Central Kootenay	**Left Meeting**	

At the final Consultative Committee meeting, there was no agreement by the Committee for this non-operational physical works. The Committee requested that the Fish Technical Subcommittee review the recent analyses and make a recommendation as to the degree to which Alternative S (73) may adversely impact nutrient loading in the North Arm of Kootenay Lake and the funding amount to the CBFWCP's nutrient loading program.

Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee and the BC Hydro Committee member met on 16 August 2004 to review the nutrient loading impacts. The subcommittee concluded that operational impacts of this alternative under Alternative S (73) would account for approximately half of the nutrient loading impacts from the Duncan Dam. **Therefore, the subcommittee recommended that the partial funding of $100,000 be directed to CBFWCP's nutrient loading program on an annual basis as a non-operational physical works for the Duncan Dam Water Use Plan.**

7.7.11.8 Erosion Protection Measures of Agricultural Lands in the Lower Duncan River

At the final Consultative Committee meeting, during discussion of the Argenta Slough Erosion Protection, the Regional District of Central Kootenay Committee member suggested that consideration be given to erosion protection measures for agricultural lands in the lower Duncan River, which are currently being damaged.

Erosion in the lower Duncan River was discussed early in the Duncan Dam water use planning process. The Channel Stability Assessment: Lower Duncan River (Miles 2002b) conducted during the water use planning process concluded that construction of the Duncan Dam has reduced erosion impacts through the reduction of peak flows downstream of the Lardeau River confluence of 900 cms pre-dam to less than 550 cms post-dam.

While the Regional District Committee member acknowledged that there was not an erosion impact associated with the operating alternatives, he supported erosion protection works for farmers fields on the lower Duncan River because of public perception. He felt that working people in the area would be upset if funds are spent for protecting wildlife areas (i.e., Argenta Slough) and not people areas (i.e., farmland).

The Consultative Committee did not support erosion protection measures of agricultural lands as a non-operational physical works.

The Committee did want to address the uncertainty (for potential future decisions) regarding a linkage between the Duncan Dam operations and erosion effects of agricultural areas on the lower Duncan River and/or whether operations could be changed to benefit and slow down erosion effects. This data gap was built into one of the monitoring studies. A Committee member also noted that funding sources are currently available to farmers for erosion protection measures of agricultural lands.

The Consultative Committee, with the exception of the Regional District of Central Kootenay Committee member, agreed to drop erosion protection measures of agricultural lands in the lower Duncan River.

7.7.11.9 Lower Duncan River Sidechannel Exclusion Fencing

At the final Consultative Committee meeting, the Committee agreed to a fall target flow regime to be implemented 1 October, which could impact kokanee spawning in sidechannels prior to the implementation of target flows. Therefore, the Committee proposed implementation of lower Duncan River sidechannel exclusion fencing from 15 to 30 September, in lieu of operational changes to mitigate stranding of spawning areas by restricting spawning kokanee from entering the sidechannels until after 1 October when flows would be reduced to the target flow level of 73 m^3/s. The sidechannel exclusion fencing enables higher Duncan Dam discharges in the last two weeks of September on average and reduces Duncan Reservoir water levels. Sidechannel exclusion fencing provides a net benefit to ***Flood/Mosquito Risk*** in the fall, ***Riparian Productivity*** in the reservoir, and increases ***Financial Revenue*** by approximately $400,000 per year.

For several Committee members, their level of support for Alternative S (73) – Downstream Fish and Cottonwood was conditional agreement to the sidechannel exclusion fencing non-operational physical work.

The Consultative Committee agreed to lower Duncan River sidechannel exclusion fencing from 15 to 30 September.

After discussing several options for implementing the exclusion fencing physical works at the final Consultative Committee meeting, the Committee requested that the Fish Technical Subcommittee review the options available and make a recommendation. On 16 August 2004, the Subcommittee discussed the sidechannel exclusion fencing options and costs and agreed to defer the decision to BC Hydro for final design and implementation of an option that would be both practical and effective. On 26 November 2004, the Subcommittee recommended that BC Hydro develop, in consultation with federal and provincial fisheries agencies and First Nations, an action plan to minimize the risk of stranding kokanee spawning in Duncan River sidechannels rather than the exclusion fencing. The action plan is in lieu of operational constraints that would maintain a minimum flow in the Duncan River below the facility from 15 to 30 September. The action plan will include monitoring sidechannel use, assessment of exclusion methods, and implementation of physical works where appropriate to a cost of $13,500 per year for the 10 year review period. Flood/Mosquito Risk improvements, Reservoir Riparian Productivity improvements, and Financial Revenue increases of approximately $400,000 per year are realized by deferring implementation of the target flow operations until 1 October (refer to Appendix O: Fish Technical Subcommittee Meeting Minutes, 16 August 2004 and 26 November 2004).

7.7.11.10 Recommended Non-Operational Physical Works

Table 7-24 summarizes the non-operating physical works recommended by the Consultative Committee.

7.7.12 Summary of Recommendations

During the Duncan Dam water use planning process, the Consultative Committee made a number of Water Use Plan and non-Water Use Plan recommendations. Duncan Dam Water Use Plan recommendations are directly linked to operations and/or decisions considered by the Committee. Non-Water Use Plan recommendations are not directly linked to operations and are outside the scope of the Duncan Dam Water Use Plan. Support for a non-Water Use Plan recommendation does not require a commitment from individual Committee members.

7.7.12.1 Water Use Plan Recommendations

At the Consultative Committee's final meeting in April 2004, five Duncan Dam Water Use Plan recommendations were discussed:

1. Adaptive Stranding/Ramping Protocol.

2. Flood Control Rule Curve Risk Protocol.

3. Cultural Resource Monitoring Studies.

4. Total Gas Pressure Procedure.

5. Communications and follow-up during the Review Period.

The Consultative Committee's level of support for these recommendations is outlined below.

Adaptive Stranding/Ramping Protocol

The Adaptive Stranding/Ramping Protocol was initially proposed under a negotiated settlement between BC Hydro and Fisheries and Oceans Canada over a fish stranding incident that occurred in the lower Duncan River in 2001. The agreement (referred to as the *Alternative Measures Agreement*) committed BC Hydro to a number of mitigative measures, some of which were linked to the Duncan Dam Water Use Plan[1]. The Fish Technical Subcommittee reviewed the protocol and recommended that the Consultative Committee endorse it.

The Ramping Protocol is intended to minimize the negative residual impacts of fish stranding in the lower Duncan River caused by planned flow changes from the Duncan Dam. The protocol is designed to be a comprehensive strategy that

[1] Refer to the monitoring program and the Adaptive Stranding Protocol Development. The first two stages (Stages 1 and 2) were committed to by BC Hydro and were not a part of the Duncan Dam Water Use Plan. The remaining components (Stages 3 and 4) were built into and considered during the water use planning process.

identifies longer-term solutions through the identification of better flow alternatives, suitable ramping rates, and possible mitigation works, if required. The results of the monitoring studies in the protocol will be used to inform future water use planning process.

The Consultative Committee was requested to state their level of support according to support, disapprove or indifferent for the entire Adaptive Stranding/Ramping Protocol including the portion already committed to by BC Hydro.

The Consultative Committee supported the Adaptive Stranding/Ramping Protocol with the Columbia Basin Trust Committee member abstaining and deferring to the technical subcommittees because he felt he didn't have sufficient information.

Flood Control Rule Curve Risk Protocol

During the Duncan Dam water use planning process, it was evident that many of the operating alternatives did not meet the Columbia River Treaty Flood Control Rule Curve for the Duncan Dam in every year. The beginning of January and March time periods were of particular concern. Therefore, there was a risk of not achieving some of the desired fish benefits[1] under Alternative S (73), if the U.S. Army Corp of Engineers (the Corps) did not allow a variance to the Flood Control Rule Curve in some years.

The Consultative Committee recommended that a Risk Protocol should be developed in the event the Flood Control Rule Curve had to be strictly adhered to and BC Hydro was unable to secure a variance from the Corps. The intent of the Risk Protocol was to buffer potential fish impacts associated with limited storage in some years to provide the minimum flows in the lower Duncan River.

Figure 7-16 illustrates the Alternative S (73) hydrograph with potential risk areas of not meeting the Columbia River Treaty Flood Control Rule Curve for the Duncan Dam.

[1] If the U.S. Army Corp of Engineers does not permit a variance to the 1 March Flood Control Rule Curve, there is the possibility that there would not be adequate storage in Duncan Reservoir to provide the desired minimum flow under Alternative S (73).

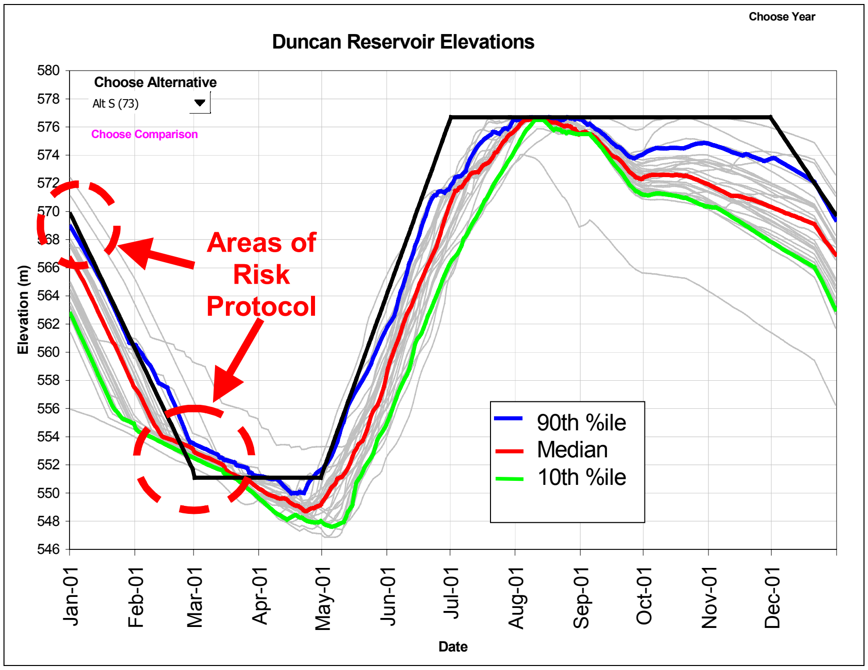

Figure 7-16: Alternative S (73) Hydrograph with Potential Risk Areas for Meeting the Columbia River Flood Control Rule Curve

The January period of concern was addressed by allowing a steeper stepped recession to the target flow of 73 m^3/s in the lower Duncan River on 1 October, and relaxing the flow of 250 to 300 m^3/s starting on 22 December. These constraints were included in Alternative S (73).

The Consultative Committee was requested to state their level of support according to support, disapprove or indifferent for developing and implementing a Risk Protocol.

With the exception of the Columbia Basin Trust Committee member who abstained, the Consultative Committee supported development of a Flood Control Rule Curve Risk Protocol.

Subsequent to the final Consultative Committee meeting in April 2004, the Fish Technical Subcommittee met in August 2004 to discuss various options to mitigate fish impacts associated with the Flood Control Rule Curve variance on 1 March. The subcommittee recommended that, in years when a variance was not granted by the U.S. Army Corp of Engineers, the following be undertaken:

- Revise the minimum flow to 60 m^3/s starting on 1 March to better ensure adequate reservoir storage until the freshet begins;
- Perform an assessment of the 60 m^3/s minimum flow on 1 March to determine if a higher flow (up to 73 m^3/s) would be possible with the available reservoir storage; and
- Revise the implementation of minimum flow according to the assessment.

Cultural Resource Monitoring Studies

At the final Consultative Committee meeting, the Committee supported two additional recommendations related to cultural non-operational physical works and monitoring studies. The Committee agreed that it was important that the proposed cultural monitoring studies be undertaken in the Duncan Reservoir, but recognized vulnerability of the sites to degradation if no immediate protection were undertaken.

Therefore, the Consultative Committee strongly recommends that the government ministries and BC Hydro consider funding these cultural monitoring studies prior to implementation of the Duncan Dam Water Use Plan. Further, the government ministries and BC Hydro should work with the Ktunaxa–Kinbasket Tribal Council on this issue.

Due to the urgency of this situation, the Consultative Committee also recommends that any funds spent by BC Hydro on the cultural monitoring studies prior to implementation of the Duncan Dam Water Use Plan be reimbursed through the Duncan Dam water use planning process.

Total Gas Pressure Procedure

At the final Consultative Committee meeting, the Committee reviewed a recommendation from the Fish Technical Subcommittee related to how flows are discharged through the Duncan Dam spillway to allow bull trout passage into the Duncan Reservoir.

During the summer bull trout passage operation, flows through the Duncan Dam low-level outlets are generally restricted to 170 m^3/s. Any supplemental flows are discharged using the spillway. When flows in the spillway are above 115 m^3/s, there are potentially harmful impacts to fish from increased total gas pressure (TGP) effects.

The Fish Technical Subcommittee recommended the following for the Consultative Committee's consideration:

- When Duncan Dam discharges are nearing 285 m^3/s, ensure that flows through one low-level outlet are near the maximum flow of 170 m^3/s to restrict spill volumes to 115 m^3/s (in the spillway) and therefore limit TGP levels downstream.

The Consultative Committee was requested to state their level of support according to support, disapprove or indifferent for the TGP recommendation.

The Consultative Committee supported the TGP recommendation, with the representative from Columbia Basin Trust abstaining because he felt he didn't have sufficient information.

Communications and Follow-up during the Review Period

During the final meeting, the Consultative Committee was asked how they would like to be informed or updated during the review period of the Duncan Dam Water Use Plan. **The Committee expressed a desire for annual meetings to be held in Lardeau or Kaslo to review BC Hydro's compliance with the Duncan Dam Water Use Plan and the monitoring study results.**

7.7.12.2 Non-Water Use Plan Recommendations

At the Consultative Committee's final meeting in April 2004, three non-Duncan Dam Water Use Plan recommendations were discussed:

1. BC Hydro's Reservoir Debris Management Program.

2. Regional Hydro-Electric System Review.

3. Watershed Management Plan for upper Duncan River system.

> The Consultative Committee agreed to a definition for a Non-Water Use Plan recommendation. A Committee supported Non-Water Use Plan recommendation, did not imply responsibility on any organization, stakeholder, or Committee member. Furthermore, support for a Non-Water Use Plan recommendation only implied that the Committee thought it was a good idea, but there was no expectation of action, commitment or follow-up on the part of any Committee member unless agreed to or volunteered.

The Consultative Committee's level of support for these recommendations is outlined below.

Reservoir Debris Management Program

Early in the Duncan water use planning process, the Recreation/Quality of Life Subcommittee identified floating debris as an important issue on the Duncan Reservoir. However, the Committee recognized that this issue had been largely addressed through BC Hydro's debris management program. The Committee expressed continued support and funding for this, which led to the following recommendation for consideration by the Committee:

- The Duncan Dam Water Use Plan Consultative Committee recommends that BC Hydro continue their debris management program on the Duncan Reservoir.

The Consultative Committee supported the continuation of the Debris Management Program with the Committee members from Fisheries and Oceans Canada and the Ministry of Water, Land and Air Protection conditionally supporting it subject to the material collected being used for ecological purposes (i.e., large debris made available for downstream habitat

complexing or watershed restoration projects). The MWLAP Committee member commented that he did not want burning of the collected debris. The BC Hydro Committee member mentioned that the level of effort that can be expended is subject to the budget allocated for the program.

Regional Hydroelectric System Review

At the final Consultative Committee meeting, the Columbia Basin Trust (CBT) Committee member mentioned that he would like to see BC Hydro, along with other agencies and local communities, review the hydroelectric system flexibility in the future. The CBT representative presented the following recommendation for the Committee's consideration:

System-Wide Operations Review

Background:

Once the Duncan Dam and Columbia River Water Use Plans have been completed and operational alternatives implemented, there may be cross-system impacts and/or operational flexibility issues that occur.

These impacts include unexpected negative (or positive) impacts to values on other parts of the hydro system as a result of implementing the Water Use Plan operating alternative or trying to achieve the performance measure objectives set therein.

These impacts will need to be identified and verified through a number of mechanisms, including the monitoring program implemented under the two Water Use Plans.

Recommendation:

In conjunction with the Duncan Dam and Columbia River Water Use Plan review process, it is recommended that the consultative committees struck for these processes should participate in a review of system-wide operations.

The objective of this review is to:

- Provide recommendations to BC Hydro on addressing any operational flexibility issues.
- Provide BC Hydro with recommendations in dealing with cross-system and/or system-wide impacts that may occur.
- Provide a variety of interest groups with an opportunity to better understanding how system-wide operations are interlinked and function, and provide input to BC Hydro.

The make up of this committee should reflect the diversity of interest currently participating in the water use planning process.

The Consultative Committee was asked for their level of support for a system-wide operations review (according to support, indifferent or abstain).

The Consultative Committee supported a regional hydroelectric system review be undertaken with the Fisheries and Oceans Canada Committee member being indifferent and the BC Hydro member abstaining.

Watershed Management Plan for Duncan Reservoir

At the final Consultative Committee meeting, the Committee reviewed a recommendation for the development of a watershed management plan for the upper Duncan River system (i.e., for the Duncan Reservoir). A local resident on the Committee commented that there should be a 100 m creek reserve and a 500 m reservoir reserve included in such a plan.

The Consultative Committee was asked for their level of support according to support, indifferent or abstain for the development of a watershed management plan for the upper Duncan River system.

The Consultative Committee supported the development of a watershed management plan for the upper Duncan River system. The BC Hydro Committee member abstained. The Ministry of Forests Committee member disapproved of the recommendation because there is a Land Use Plan requirement to co-ordinate by the Ministry of Sustainable Development and this has already been done for the region.

8 MONITORING PROGRAM

8.1 Introduction

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

8.2 Proposed Monitoring Studies

The Consultative Committee conducted three steps to reach its recommendations for the Duncan Dam Water Use Plan Monitoring Program:

1. The technical subcommittees developed a list and rationale for the proposed monitoring studies. Each proposed study was initially screened to exclude studies which were unlikely to contribute useful data for assessing the effectiveness of operational changes or provide a basis for better decisions in the future.

2. Monitoring study proposals were evaluated by the technical subcommittee using a qualitative ranking system to determine the overall value they would provide as follows:

    - Learning Expected:
        - High: Monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.
        - Medium: Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses.
        - Low: Likely to allow only qualitative comparisons among a few competing hypotheses.
    - Willingness to Change:
        - High Importance: It is clear that the Consultative Committee will change its final choice if one of the alternative hypotheses prevails. This change includes a shift in support away from the original choice made and the convergence of the Committee's support on another, existing alternative.
        - Medium Importance: A large shift in support away from the final choice of the Consultative Committee takes place under one of the

competing hypotheses. This shift in support may include some people preferring to block the original choice of the Committee. However, it is not clear that another, existing alternative would be chosen by the Committee under this competing hypothesis.

- Low Importance: A shift in support away from the final choice of the Consultative Committee may occur. However, it is clear that the final choice of the Committee will not be changed to another, existing alternative. This decision may be a non-consensus Water Use Plan.

- Overall Study:
  - High Importance: There is a clear consensus, or close to consensus that this monitoring study should be included as a request within the consultative report.
  - Medium Importance: There is no clear consensus within the group as to whether this monitoring study should be included as a request within the consultative report.
  - Low Importance: There is a consensus, or close to a consensus, agreement that this monitoring proposal should not be included as a request within the consultative report.

3. The Consultative Committee evaluated the proposed monitoring studies.

   At the final Consultative Committee meeting in April 2004, the Committee discussed the following proposed monitoring studies:

   - Adaptive Stranding Protocol Development Stages 1 and 2: Develop and Implement Interim Protocol.
   - Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol.
   - Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor.
   - Kokanee Spawning Study.
   - Bull Trout Passage Studies.
   - Temperature and Total Gas Pressure Monitoring Studies.
   - Cottonwood Studies.
   - Mosquito Management Study.
   - Stock Assessment and Fish Habitat Utilization Studies.
   - Burbot Studies.

- Archaeology Study.
- Erosion Studies.
- Reservoir Riparian Studies.

Table 8-1 summarizes the monitoring studies evaluated by the Consultative Committee. A description of each monitoring study is included, along with the uncertainty being addressed, operational implications, study length, study certainty and total estimated cost. Further details on these monitoring studies are found in Appendix L: Monitoring Program.

8.3 Purpose of Eligibility Criteria

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

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

In the Duncan Dam water use planning process, the expected biological response in Duncan River under the preferred operating alternative represents the best judgment of Consultative Committee members based on the available information. For instance, the final operating alternative specifies minimum and maximum flows in the lower Duncan River. A monitoring study provides the opportunity to access how well the preferred operating alternative achieves the desired objective of maximizing fish abundance and diversity. Therefore, a monitoring study can provide better data for future decision making and reduce the uncertainty around the biological response to changes in operations.

Table 8-1: Monitoring Studies Evaluated by the Consultative Committee

Area	Interest	Study	Description	Components	Key Uncertainties Addressed	Learning Expected (L/M/H)	Results Implemented When	Willingness to Change (L/M/H)	Overall Study Rating	Annual Levellized Cost ($K)	Total Cost to WUPs	FY04/05 (CGA Funding)	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Lower Duncan River	Fish	Adaptive Stranding Protocol Development Stages 1 and 2: Develop and Implement Interim Protocol (CGA Funding)	Develop and implement an interim ramping rate to minimize fish stranding based on best available and current and presently collected information.	Develop Protocol and Ramping Rate Experiments	What is the initial ramping rate and operational protocol to be tested in future studies?	H	FY04/05	H	H	$-	$-	$15.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
				Ramping Rate Experiments	What are the impacts associated with the timing, magnitude and rate of operational changes in the lower Duncan River?	H	YR 3	H	H	$-	$-	$130.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
				Seasonal Habitat Use Study – Rainbow trout migration, rainbow trout adult, and juvenile rainbow trout and bull trout rearing use	What are the predominant habitat use preferences of rainbow and bull trout in the lower Duncan River?	H	YR 3	H	H	$-	$-	$60.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
				Diel Habitat Use Study - Day vs. night habitat use for residents	Can impacts of operational change be mitigated through time of day operations?	H	YR 3	H	H	$-	$-	$25.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
				Whitefish/Rainbow Trout Spawning Life history Timing	What are the spawning timing of whitefish and rainbow adults in the lower Duncan River?	H	YR 3	H	H	$-	$-	$25.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-
		Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol Continued (Water Use Plan Funding)	Develop and implement an interim ramping rate to minimize fish stranding based on best available and current and presently collected information.	Ramping Rate Experiments	What are the impacts associated with the timing, magnitude and rate of operational changes in the lower Duncan River?	H	YR 3	H	H	$18.8	$188.0	$-	$94.0	$94.0	$-	$-	$-	$-	$-	$-	$-	$-
				Seasonal Habitat Use Study – Rainbow trout migration, rainbow trout adult, and juvenile rainbow trout and bull trout rearing use	What are the predominant habitat use preferences of rainbow and bull trout in the lower Duncan River?	H	YR 3	H	H	$20.0	$200.0	$-	$50.0	$50.0	$50.0	$50.0	$-	$-	$-	$-	$-	$-
				Diel Habitat Use Study - Day vs. night habitat use for residents	Can impacts of operational change be mitigated through time of day operations?	H	YR 3	H	H	$7.0	$70.0	$-	$17.5	$17.5	$17.5	$17.5	$-	$-	$-	$-	$-	$-
				Whitefish/Rainbow Trout Spawning Life history Timing	What are the spawning timing of whitefish and rainbow adults in the lower Duncan River?	H	YR 3	H	H	$18.0	$180.0	$-	$45.0	$45.0	$45.0	$45.0	$-	$-	$-	$-	$-	$-
				Mapping, Bathymetric Data Collection and DEM Analysis	What is the current morphology of the lower Duncan River floodplain?	H	YR 3	H	H	$27.6	$276.0	$-	$138.0	$138.0	$-	$-	$-	$-	$-	$-	$-	$-
				Hydraulic Modelling, Calibration and habitat modelling	What are the habitat values associated with flows modelled on the lower Duncan River?	H	YR 3	H	H	$13.8	$138.0	$-	$61.0	$77.0	$-	$-	$-	$-	$-	$-	$-	$-
				Develop/Adapt Protocol	What is the stranding protocol to be implemented over the remainder of the review period?	H	YR 3	H	H	$3.4	$34.0	$-	$-	$-	$17.0	$17.0	$-	$-	$-	$-	$-	$-
				Performance Measure Redevelopment and Reporting	How do the performance measures change as a result of this new information?	H	After Review Period	H	H	$14.4	$144.0	$-	$11.0	$11.0	$28.0	$28.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0
		Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor (Water Use Plan Funding)	The protocol will be finalized and a ramping rate and operating protocol will be implemented. The remaining years in the review period will be dedicated to monitoring effectiveness of protocol and recalibrating model assumptions.	Document fish stranding at key index sites	What are the incidents of stranding associated with the revised stranding protocol?	H	After Review Period	H	H	$12.0	$120.0	$-	$-	$-	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0
				Evaluate residual impacts of stranding through index studies	What are the site level impacts of changing operations based on an opportunistic assessment of various ramping scenarios?	H	After Review Period	H	H	$32.0	$320.0	$-	$-	$-	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0
				Develop recommendations for mitigation including physical works or site salvage	What are the mitigative options available to reduce the impact of operational changes from the Duncan Dam?	H	After YR 3	H	H	$1.6	$16.0	$-	$-	$-	$2.0	$2.0	$2.0	$2.0	$2.0	$2.0	$2.0	$2.0
				Finalize ramping protocol	What is the stranding protocol to be recommended for the future WUP deliberations?	H	After Review Period	H	H	$1.7	$17.0	$-	$-	$-	$-	$-	$-	$-	$-	$-	$-	$17.0
				Monitor Mainstem Channel Changes	What are the changes to the hydraulic model that have occurred as a result of WUP operations?	H	After Review Period	H	H	$12.1	$121.0	$-	$-	$-	$-	$-	$55.0	$-	$-	$-	$-	$66.0
				Monitor Sidechannel Changes						$4.5	$45.0	$-	$-	$-	$-	$-	$28.0	$-	$-	$-	$-	$17.0
		Kokanee Spawning Study	To assess the relative importance of kokanee spawning in the lower Duncan River on overall run strength (Lardeau/Meadow/Duncan) and develop appropriate flow options to protect as required.	Stock Abundance Monitoring A: Intensive study to determine timing of Meadow/Lardeau/Duncan runs	What is the run timing of the kokanee populations in the three systems of interest?	H	After Review Period	H	H	$24.0	$240.0	$-	$60.0	$60.0	$60.0	$60.0	$-	$-	$-	$-	$-	$-
				Stock Abundance Monitoring B: Low intensity study to monitor escapement in each system. Assumes partnership with Ministry of Water Land and Air Protection surveys	What are the annual escapement estimates from the three systems of interest?	M	After Review Period	H	H	$9.0	$90.0	$-	$-	$-	$-	$-	$15.0	$15.0	$15.0	$15.0	$15.0	$15.0
		Bull Trout Passage Study	Develop understanding of bull trout migration importance to Duncan/Kootenay system and determine best management practice.	Juvenile enumeration of upper Duncan River outmigrants into lower Duncan River	What proportion of juveniles emigrating from upper Duncan River return to the Kootenay Lake?	M	After Review Period	M	M	$33.0	$330.0	$-	$165.0	$165.0	$-	$-	$-	$-	$-	$-	$-	$-
				Evaluation of Weir efficacy (or works in lieu)	What is the effectiveness of the bull trout weir in aiding passage to the flip bucket?	H	After Review Period	M	H	$11.0	$110.0	$25.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0	$11.0
		Temperature and Total Gas Pressure Monitoring	Collect baseline temperature/TGP monitoring to further refine TGP performance measure and determine if temperature is an issue.	Temperature Monitoring	What is the general instream temperature regime in the lower Duncan River?	H	After Review Period	M	H	$1.2	$12.0	$-	$6.0	$6.0	$-	$-	$-	$-	$-	$-	$-	$-
				TGP Monitoring and Performance Measure Changes	What are the changes to the TGP-spill relationship and what are the associated changes require for the TGP performance measure?	M	After Review Period	H	H	$5.6	$56.0	$-	$28.0	$28.0	$-	$-	$-	$-	$-	$-	$-	$-
	Wildlife	Cottonwood Study	To monitor the influence of the Duncan WUP alternative on Cottonwood Recruitment and other riparian communities in the lower Duncan floodplain.	Cottonwood Recruitment Study	What is the relationship between hydrology and cottonwood recruitment success on the lower Duncan River?	H	After Review Period	H	H	$58.2	$582.0	$-	$127.0	$44.0	$91.0	$22.0	$22.0	$91.0	$22.0	$22.0	$22.0	$119.0
				Wildlife habitat use study	What is the wildlife use associated with riparian species affected by instream flows?	M	After Review Period	H	H	$17.6	$176.0	$-	$44.0	$-	$44.0	$-	$-	$44.0	$-	$-	$-	$44.0
	Quality of Life	Mosquito Management Study	To determine if the mosquito performance measure and index site are appropriate for other sites in the lower Duncan River.	Resurvey of Mosquito areas and Performance Measure calibration	What is the relationship between hydrology and mosquito reproduction in the lower Duncan River floodplain?	H	YR 2	H	H	$6.6	$66.0	$-	$66.0	$-	$-	$-	$-	$-	$-	$-	$-	$-
				Develop Mosquito Management Plan and Monitor	What are the management options available to mitigate mosquito production in the lower Duncan River floodplain?	H	After YR 1	H	H	$22.6	$225.5	$-	$27.5	$22.0	$22.0	$22.0	$22.0	$22.0	$22.0	$22.0	$22.0	$22.0
Reservoir	Fish	Stock Assessment and Fish Habitat Utilization Study	Stock assessment program to verify the relative abundance and distribution of indicator species to ensure there is not a negative trend in abundance associated with deep drawdown.	Seasonal Habitat Use Assessment	What is the seasonal habitat use of kokanee and rainbow in Duncan Reservoir (tributary/littoral/pelagic)?	M	After Review Period	M	M	$19.8	$198.0	$-	$66.0	$66.0	$66.0	$-	$-	$-	$-	$-	$-	$-
				Kokanee Hydroaccoustic Work	What is the annual kokanee population level in Duncan Reservoir?	M	After Review Period	M	M	$8.4	$84.0	$-	$-	$-	$-	$-	$-	$-	$-	$28.0	$28.0	$28.0
				Tributary spawning assessment	What are the annual kokanee and rainbow spawner escapements for key tributaries to the Duncan Reservoir?	M	After Review Period	M	M	$17.5	$175.0	$-	$-	$35.0	$-	$35.0	$-	$35.0	$-	$35.0	$-	$35.0
		Burbot Study	To define spawning locations of Duncan Reservoir burbot population and assess the implications of reservoir operations.	Telemetry study and spawning observations	What are the spawning and incubation requirements of burbot in Duncan Reservoir tributaries?	M	After Review Period	M	M	$32.0	$320.0		$60.0	$60.0	$100.0	$100.0	$-	$-	$-	$-	$-	$-
				Burbot response monitoring	What are the size at age distribution changes to burbot over the review period ? What are the operational linkages to these changes?	M	After Review Period	M	M	$48.0	$480.0	$-	$-	$-	$60.0	$60.0	$60.0	$60.0	$60.0	$60.0	$60.0	$60.0
	Cultural Resources	Archaeology Study	Thorough reservoir basin survey of heritage and cultural sites, including examination of the rock bluffs and alluvial fan cutbanks found around the reservoir.	Archaeological survey of the Reservoir Basin	Identify all cultural resources in the drawdown zone.	H	After Review Period	M	H	$4.0	$40.0	$-	$40.0	$-	$-	$-	$-	$-	$-	$-	$-	$-
		Erosion Study	On-site FN interviews to collect site-specific knowledge and preferences for disposition of cultural sites.	Traditional use and cultural preference information collection	What are the cultural preferences for cultural resource protection?	M	YR 2	H	H	$3.0	$30.0	$-	$30.0	$-	$-	$-	$-	$-	$-	$-	$-	$-
			Characterization of the sites and the information they contain.	Conservation Excavation	Which areas being eroded are the highest priority and how important are they?	H	YR 2	H	H	$15.0	$150.0		$150.0	$-	$-	$-	$-	$-	$-	$-	$-	$-
			ID factors contributing to the disruption of protected and unprotected sites.	Install monitoring system and monitor rate of disruption of cultural sites in Duncan Reservoir	What factors are contributing to the disruption/erosion of cultural sites?	M	After Review Period	M	M	$5.0	$50.0	$-	$14.0	$9.0	$9.0	$9.0	$9.0	$-	$-	$-	$-	$-
	Wildlife	Reservoir Riparian Study	Determine the pre-alteration distribution of wetland and riparian vegetation and monitor changes in the areal coverage and plant species composition of vegetated communities within the drawdown zone of Duncan Reservoir.	Vegetation Monitoring	What is the riparian response to operational changes on Duncan Reservoir?	M	After Review Period	M	M	$17.8	$178.0	$-	$50.0	$-	$39.0	$-	$-	$39.0	$-	$-	$-	$50.0
				Wildlife habitat use study	What is the wildlife use associated with riparian species affected by reservoir operations?	H	After Review Period	M	M	$13.2	$132.0	$-	$33.0	$-	$33.0	$-	$-	$33.0	$-	$-	$-	$33.0
Total Monitoring Costs (not including CGA costs)										$559.4	$5,593.5	$280.0	$1,394.0	$938.5	$749.5	$533.5	$290.0	$418.0	$198.0	$261.0	$226.0	$585.0

8.4 Eligibility of Monitoring Studies

The Consultative Committee evaluated the monitoring studies listed above for eligibility under the Water Use Plan Program using the criteria for Water Use Plan Monitoring Studies (refer to Appendix M: Eligibility Criteria for Water Use Plan Monitoring Studies).

The eligibility criteria state that a monitoring program should:

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

These criteria can be summed up as efficacy, sensitivity, timeliness, and cost effectiveness. Monitoring studies satisfying these criteria are eligible under the Duncan Dam Water Use Plan. The Consultative Committee determined that the 11 proposed monitoring studies met the criteria.

8.5 Recommended Monitoring Studies

At the final April 2004 Consultative Committee meeting, the facilitator requested that individual members indicate their level of support for the proposed monitoring studies. This information was compiled subsequent to the Committee meeting. In July 2004, the facilitator contacted individual Committee members to confirm their level of support for the proposed monitoring studies. The Committee members confirmed that they wished to recommend the 11 proposed monitoring studies in the Duncan Dam Water Use Plan.

Table 8-2 summarizes individual Consultative Committee member's level of support for the proposed monitoring studies.

For each of the recommended monitoring studies, a detailed Terms of Reference will be developed once the Comptroller of Water Rights directs BC Hydro to implement the Duncan Dam Water Use Plan.

8.6 Review of Monitoring Program Results

The Consultative Committee recommended that a technical review of the monitoring program be conducted five years after implementation of the Duncan Dam Water Use Plan. The Committee also recommended that annual public meetings be held in Lardeau or Kaslo to review monitoring program results and BC Hydro's compliance with their water licence.

Table 7-24: Non-Operational Physical Works Recommended by the Consultative Committee

Area	Interest	Non-Operational Alternative	Annual Levellized Cost ($K)	Total Cost to Water Use Plans ($K)	YR1	YR2	YR3	YR4	YR5 ($K)	YR6	YR7	YR8	YR9	YR10
Lower Duncan River	Wildlife	Argenta Slough Erosion Protection	$15.0	$150.0	$100.0	-	-	-	-	$25.0	-	-	-	$25.0
	Fish	Annual Sidechannel Exclusion Fencing 15 to 30 September	$13.5	$135.0	$45.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
Reservoir	Cultural Resources	Erosion Protection for Heritage and Cultural Sites	$240.0	$2,400.0	$150.0	$2,250.0	-	-	-	-	-	-	-	-
	Recreation	Glacier Creek Boat Ramp Extension [1]	$12.6	$126.0	$106.0	-	-	-	$10.0	-	-	-	-	$10.0
Downstream (Kootenay Lake)	Ecosystem	Funding towards the Columbia Basin Fish and Wildlife Compensation Program Kootenay Lake Nutrient Loading Program	$100.0	$1,000.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0	$100.0

1. The Consultative Committee agreed to the Glacier Creek Boat Ramp Extension to a funding cap of $126,000 with the caveat that the Regional District of Central Kootenay would be responsible for maintenance of the boat ramp upon completion of construction.

Table 8-2: Consultative Committee Level of Support for Proposed Monitoring Studies

Area	Objective Area	Study	Components	Overall CC Rating of Study (High, Medium, Low, Abstain)										
				Vic Clement Ktunaxa-Kinbasket Tribal Council	**Kindy Gosal** Columbia Basin Trust	**Steve Macfarlane** Fisheries and Oceans Canada	**Terry Anderson** Ministry of Water, Land and Air Protection	**Gene Anderson** FortisBC	**Llewellyn Matthews** Columbia Power Corp	**Gail Spitler** Area Resident	**Mark Tiley** Canadian Columbia River Inter-Tribal Fisheries Commission	**Fred Thiessen** Ministry of Forests	**Gordon Boyd** BC Hydro	**Stephan O'Shea** Area Resident
Lower Duncan River	**Fish**	Adaptive Stranding Protocol Development Stage 1 and 2: Develop and Implement Interim Protocol (CGA Funding)	Ramping experiments, habitat use, life history, etc.	H	A	H					H	H		H
		Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol Continued (WUP Funding)	Ramping experiments, habitat use, life history, mapping, hydraulic modelling, adapt protocol	H	A	H	H	H	H	H	H	H	H	H
			PM Redevelopment and Reporting	H	A	H	H	H	L	H	H	H	H	H
		Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor (WUP Funding)	Document fish stranding at key index sites	H	A	H	H	H	H	H	H	H	H	H
			Evaluate residual impacts of stranding through index studies	H	A	H	H	H	M	H	H	H	H	H
			Develop recommendations for mitigation including physical works or site salvage	H	A	H	H	H	M	H	H	H	H	H
			Finalize ramping protocol	H	A	H	H	H	H	H	H	H	H	H
			Monitor Mainstem Channel Changes	H	A	H	H	H	H	H	H	H	H	H
			Monitor Sidechannel Changes	H	A	H	H	H	H	H	H	H	H	H
		Kokanee Spawning Study	Stock Abundance Monitoring A & B	H	A	H	H	H	H	H	H	H	H	H
		Bull Trout Passage Study	Juvenile enumeration of upper Duncan River outmigrants into lower Duncan River	H	A	H	H	M	H	H	H	M	M	H
			Evaluation of Weir efficacy	H	A	M	H	L	M	H	H	M	M	H
		Temperature and TGP Monitoring	Temperature Monitoring	H	A	L	H	M	L	M	H	M	M	H
			TGP Monitoring and Performance Measure Changes	H	A	M	M	M	L	M	H	H	M	H
	Wildlife	Cottonwood Study	Cottonwood Recruitment Study	H	A	H	H	H	H	H	H	H	H	H
			Wildlife habitat use study	H	A	M	M	H	H	H	H	L	L	H
	Quality of Life	Mosquito Management Study	Resurvey of Mosquito areas and performance measure calibration	H	A	H	H	L	L	H	H	H	M	H
Reservoir	**Fish**	Stock Assessment and Fish Habitat Utilization Study	Seasonal Habitat Use Assessment	H	A	H	H	M	L	H	H	M	M	H
			Kokanee Hydroaccoustic Work	H	A	M	M	M	L	H	H	M	M	H
			Tributary spawning assessment	H	A	M	M	M	M	H	H	M	M	H
		Burbot Study	Telemetry study	H	A	H	H	L	M	A	H	M	M	H
			Burbot response monitoring	H	A	H	M-L	L	M	A	H	M	L	H
	Cultural Resources	Archaeology Study	Archaeology Study	H	A	H	H	H	H	H	H	H	H	H
		Erosion Study	Erosion Monitoring Study	H	A	H	H	H	H	H	H	H	H	H
			Conservation Excavations	H	A	H	H	H	H	H	H	H	H	H
			Traditional Use and Cultural Assessment	H	A	H	H	H	H	H	H	H	H	H
	Wildlife	Reservoir Riparian Study	Vegetation Monitoring	H	A	H	H	H	M	H	H	H	H	H
			Wildlife habitat use study	H	A	H	M	H	H	H	H	M	M	H

9 REVIEW PERIOD

The Consultative Committee recommended that the Duncan Dam Water Use Plan be reviewed 10 years after implementation of the Plan unless results of the monitoring program suggest that an earlier review is appropriate. The Committee also recommended that a review of the Water Use Plan be undertaken in the event that one of the following events occur:

- Kootenay River water use planning process being initiated.
- International Joint Commission Order being re-opened.
- Biologically significant trigger.
- Maximum normal dam discharges being changed to above 283 m^3/s (due to Total Gas Pressure issues) with recognition that dam safety would take precedence.
- External factors affecting the ability to deliver the preferred flow regime in the lower Duncan River. For example, changes to the Libby VARQ or the Flood Control Rule Curves, or conflict with the outcome of the Columbia River Water Use Plan or the Ktunaxa–Kinbasket Treaty negotiations.

The Consultative Committee expressed a desire for annual meetings to be held in Lardeau or Kaslo to review BC Hydro’s compliance with the Duncan Dam Water Use Plan and the monitoring studies results.

10 IMPLEMENTATION OF RECOMMENDATIONS

The operational changes and non-operational projects recommended by the Duncan Dam Water Use Plan Consultative Committee will be implemented once the Comptroller of Water Rights and government approve the Duncan Dam Water Use Plan. The Comptroller of Water Rights will review the recommended Water Use Plan under provisions of the *Water Act* and will involve Fisheries and Oceans Canada, other provincial agencies, First Nations and holders of water licences who might be affected by the change. In the interim, BC Hydro will continue planning and operating based on the constraints specified under current permitted operations.

Figure 10-1 illustrates the next steps in the Duncan Dam water use planning process.

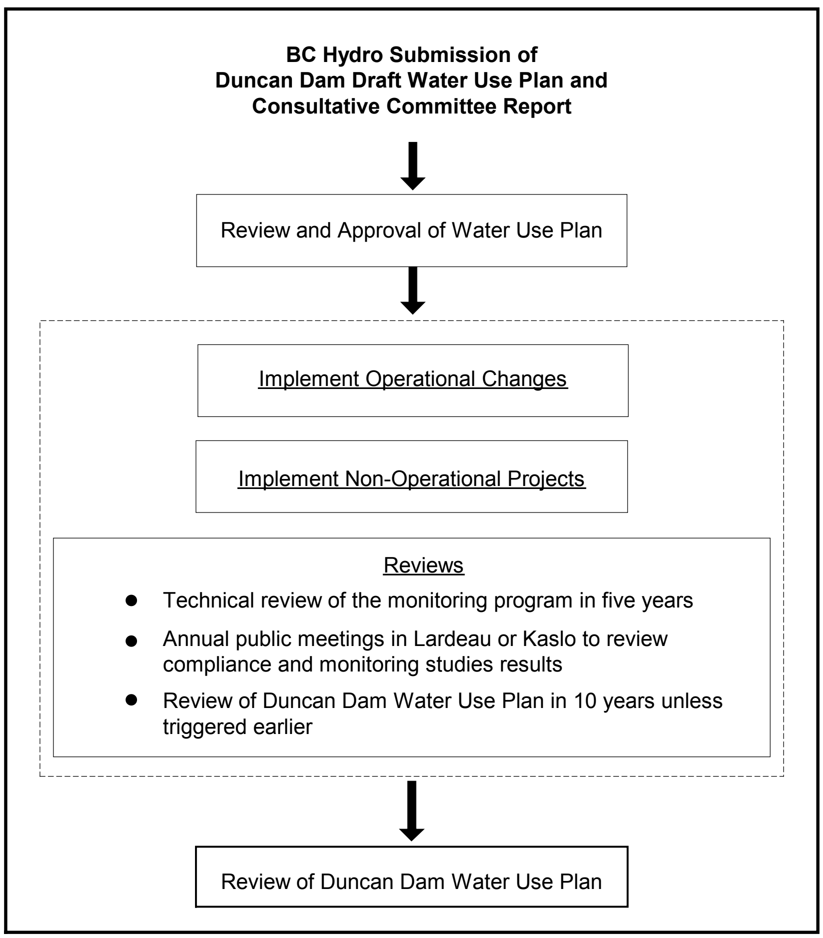

Figure 10-1: Next Steps in the Duncan Dam Water Use Planning Process

The following is a summary of the review, approval and implementation process for the Duncan Dam Water Use Plan:

- BC Hydro will submit two documents to the provincial Comptroller of Water Rights for review and approval:

    1. The Duncan Dam Water Use Plan Consultative Committee Report.

    2. Duncan Dam Draft Water Use Plan.

- Review and Approval of the Water Use Plan: As described for Step 10 of the provincial government's *Water Use Plan Guidelines*, the government will review and issue a decision on the Duncan Dam Draft Water Use Plan under provisions of the *Water Act*. This process involves referring the draft Plan for review and comment to Fisheries and Oceans Canada, other provincial agencies, First Nations, and holders of water licences who might be affected by the changes. This review and approval process is anticipated to take approximately 6 to 12 months once the draft Plan is submitted to government. As part of the review, the government may require modifications to the draft Plan. The outcome of the review process will be a final plan authorized by the Comptroller of Water Rights.

- Implement Operational Changes: Once the government has approved the Duncan Dam Water Use Plan and the Comptroller of Water Rights has provided BC Hydro with direction, Hydro will implement the approved operational changes.

- Implement Non-Operational (Monitoring and Physical Works) Projects: Once the Comptroller of Water Rights has provided BC Hydro with direction on the Duncan Dam Water Use Plan, BC Hydro will:

    1. Develop detailed terms of reference for all approved non-operational projects.

    2. Begin implementation of the projects. The detailed terms of reference will be developed in consultation with appropriate government agencies, First Nations, and interested parties.

- Review of the Duncan Dam Water Use Plan: The Water Use Plan will be reviewed 10 years after the implementation of the Plan unless triggered earlier.

11 SUMMARY OF RECOMMENDATIONS AND OUTCOMES

11.1 Introduction

The Duncan Dam Water Use Plan Consultative Committee, made up of representatives of First Nations, federal and provincial agencies, municipal representatives, industry representatives (FortisBC, Columbia Power Corporation), Columbia Basin Trust, local residents and BC Hydro explored a wide range of operating alternatives for the Duncan Dam facility. They explored impacts to heritage and culture, fish, flooding, mosquito production, power generation, recreation and wildlife across the Duncan River system, as well as relative values.

At the final Consultative Committee meeting in April 2004, the Committee reached a conditional consensus on a recommended operating alternative, physical works in lieu of operations, a monitoring program and a review period for the Duncan Dam Water Use Plan (refer to Appendix N: Duncan Dam Water Use Plan Consultative Committee Meeting #8, Final Meeting Minutes). Subsequent to the final Committee meeting, the Regional District of Central Kootenay Committee member withdrew his support for the Duncan Dam water use planning process. Also, on 9 November 2004, CPC forwarded a letter to BC Hydro stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, Columbia Power Corporation, on behalf of the Columbia Power Corporation/Columbia Basin Trust ventures, can now accept the preferred Alternative S (73). Refer to Appendix I: Correspondence from Columbia Power Corporation.

On completion of the consultative process, a draft Consultative Committee report was prepared to document the process and present the recommendations of the Committee. Copies of the draft report were distributed to members for their review and comment (refer to Appendix P: Consultative Committee Comments on Draft Consultative Committee Report).

Based on the Consultative Committee's recommendations, BC Hydro will prepare a Water Use Plan for the Duncan Dam facility and submit it to the Comptroller of Water Rights for review and approval.

11.2 Recommendations

Table 11-1 summarizes the Consultative Committee's recommendations for the Duncan Dam Water Use Plan.

Table 11-1: Consultative Committee's Recommendations for the Duncan Dam Water Use Plan

Item	Description	Estimated Cost
Operating Alternative	Alternative S (73) – Downstream Fish and Cottonwood	$1.7 million per year compared to current operations
Water Use Plan Recommendations	• Adaptive Stranding/Ramping Protocol • Flood Control Rule Curve Risk Protocol • Funding Cultural Resource Monitoring Studies prior to the Duncan Dam Water Use Plan implementation • Total Gas Pressure Procedure • Annual meetings in Lardeau or Kaslo to review compliance and monitoring study results	N/A N/A TBD N/A TBD
Physical works in lieu of operations		Maximum Funding Cap
	• Argenta Slough Erosion Protection	$150,000
	• Identified Heritage and Cultural Sites Erosion Protection	$2.4 million
	• Boat Launch and Mooring Buoys at Glacier Creek[1]	$126,000
	• Partial funding for the Columbia Basin Fish and Wildlife Nutrient Loading Program[2]	$100,000 per year
	• Lower Duncan River side-channel exclusion fencing[3]	$135,000
Non-Water Use Plan Recommendations	• BC Hydro's Reservoir Debris Management Program • Regional Hydro-Electric System Review • Watershed Management Plan for the upper Duncan River system	N/A
Monitoring Program		Annual Cost
	• Adaptive Stranding Protocol Development Stages 1 and 2: Develop and Implement Interim Protocol	$0
	• Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol	$123,000
	• Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor	$63,900
	• Kokanee Spawning Study	$33,000
	• Bull Trout Passage Studies	$44,000
	• Temperature and Total Gas Pressure Monitoring Studies	$6,800
	• Cottonwood Studies	$75,800
	• Mosquito Management Study	$29,200
	• Stock Assessment and Fish Habitat Utilization Studies	$45,700
	• Burbot Studies	$80,000
	• Archaeology Study	$4,000
	• Erosion Studies	$23,000
	• Reservoir Riparian Studies	$31,000
Review Period	10 years after the implementation of the Duncan Dam Water Use Plan unless triggered earlier	N/A

Table 11-1: Consultative Committee's Recommendations for the Duncan Dam Water Use Plan (cont'd)

Item	Description	Estimated Cost
Triggers	• Kootenay River water use planning process being initiated. • International Joint Commission Order being re-opened. • Biologically significant trigger. • Maximum normal dam discharges being changed to above 283 m^3/s (due to Total Gas Pressure issues) with recognition that dam safety would take precedence. • External factors affecting the ability to deliver the preferred flow regime in the lower Duncan River. For example, changes to the Libby VARQ or the Flood Control Rule Curves, or conflict with the outcome of the Columbia River Water Use Plan or the Ktunaxa–Kinbasket Treaty negotiations.	N/A

[1] The Consultative Committee agreed to the Glacier Creek Boat Ramp Extension to a funding cap of $126,000 with the caveat that the Regional District of Central Kootenay would be responsible for the boat ramp upon completion of construction.

[2] Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee and the BC Hydro Committee member met on 16 August 2004 to review the nutrient loading impacts. The subcommittee concluded that operational impacts of this alternative under Alternative S (73) would account for approximately half of the nutrient loading impacts from the Duncan Dam. Therefore, the subcommittee recommended that the partial funding of $100,000 be directed to CBFWCP's nutrient loading program on an annual basis as a non-operational physical works for the Duncan Dam Water Use Plan.

[3] This recommendation was subject to review by the Fish Technical Subcommittee. Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee recommended that BC Hydro develop in consultation with federal and provincial fisheries agencies and First Nations an action plan to minimize the risk of stranding kokanee spawning in Duncan River sidechannels rather than the exclusion fencing. The action plan is in lieu of operational constraints that would maintain a minimum flow in the Duncan River below the facility from 15 September to 30 September. The action plan will include monitoring sidechannel use, assessment of exclusion methods, and implementation of physical works where appropriate.

11.3 Operating Conditions

Table 11-2 summarizes the operating conditions for the recommended Alternative S (73) – Downstream Fish and Cottonwood.

Table 11-2: Operating Conditions for Alternative S (73) – Downstream Fish and Cottonwood

System Component	Condition	Purpose
Duncan Reservoir	Reach full pool (576.4 m and 576.7 m) between 1 and 10 August After full pool is reached or after 10 August, decrease reservoir elevation to 575.5 m and maintain within 0.3 m of this level until 5 September[1]	
Duncan Dam Discharge	3 m^3/s minimum year-round 283 m^3/s normal maximum year-round	
Lower Duncan River	Minimum target as measured at the Water Survey of Canada gauge: 08NH118, below the Duncan and Lardeau rivers confluence: • 73 m^3/s flow year-round[2] Maximum target as measured at the Water Survey of Canada gauge 08NH118, below the Duncan and Lardeau rivers confluence: • 250 m^3/s from 1 August to 24 September • 190 m^3/s from 25 to 27 September • 130 m^3/s from 27 to 30 September • 73 m^3/s flow from 1 to 21 October • 110 m^3/s from 22 October to 21 December • 250 m^3/s from 22 December to 9 April (300 m^3/s, alternate to better meet Columbia River Treaty Flood Control Rule Curve maximums)[3] • 120 m^3/s from 10 April to 15 May • 400 m^3/s 16 May to 31 July	

Note: From 1 October to 21 October, the maximum and minimum target flow in the lower Duncan River are identical at 73 m^3/s.

[1] The Duncan Reservoir elevations shall not take priority over maintaining target minimum flows in the lower Duncan River.

[2] It is possible that, in some years, this desired minimum flow cannot be maintained during the March to May period due to inadequate Duncan Reservoir storage on 1 March. While BC Hydro will make best efforts to secure a flood control variance from the U.S. Army Corps of Engineers in order to provide adequate storage on 1 March, the success of these efforts cannot be guaranteed. If a variance were not granted, a lower minimum flow may be implemented. BC Hydro will consult with federal and provincial fisheries agencies and First Nations and seek direction from the Comptroller of Water Rights.

[3] In the event that this maximum flow limit would not allow BC Hydro to meet the maximum reservoir levels specified by the Columbia River Treaty Flood Control Operating Plan, BC Hydro would request a variance from the U.S. Army Corps of Engineers. If a variance were not granted, this maximum flow limit would increase to 300 m^3/s. BC Hydro will consult with federal and provincial fisheries agencies and First Nations and seek direction from the Comptroller of Water Rights.

11.4 Expected Consequences

Table 11-3 summarizes the expected consequences of the recommended Alternative S (73), the monitoring program and the physical works for the Duncan Dam facility.

Table 11-3: Expected Consequences of the Recommended Alternative S (73) – Downstream Fish and Cottonwood Compared to Alternative A – Current Operations

Water Use Interest	Consequences	
Cultural Resources	+	Increase in knowledge and understanding of the characteristics of the cultural sites, and provide opportunities to protect cultural sites and resources and for archaeological investigation through the provision of a monitoring study and erosion protection physical works in the Duncan Reservoir.
Downstream Impacts	o	Maintain nutrient retention in Kootenay Lake with implementation of physical works.
Erosion Protection in Lower Duncan River	+	Improved protection of Argenta Slough and wetlands with implementation of physical works.
Financial Revenue	–	Decrease in the annual average revenue of approximately $1.7 million per year.
Fish in Duncan Reservoir	o	No change.
Fish in Lower Duncan River	+	Increase in overall aquatic productivity with implementation of the Adaptive Stranding/Ramping Protocol, the Flood Control Rule Curve Risk Protocol, and physical works, and a more natural-like hydrograph.
Flood Management	+	Decrease in frequency and duration of local flooding events in lower Duncan River from 1 to 31 August with implementation of target flows.
Quality of Life – Mosquitoes	+	Decrease in the number of events which lead to mosquito breeding opportunities (greater than 350 m^3/s) from 1 to 31 August with implementation of target flows.
Recreation	+	Increase in number of weighted user days the reservoir is at preferred elevations with implementation of a reservoir elevation target and physical works.
	+	Increase in opportunities for water-based recreationalists to access the reservoir on the eastern shore with implementation of reservoir elevation targets.
Wildlife in Duncan Reservoir	–	Decrease in riparian productivity with implementation of reservoir elevation targets due to loss of sedge/grass meadow area.
Wildlife in Lower Duncan River	+	Improved recruitment of cottonwood in the lower Duncan River, which increases the overall riparian productivity in the area with implementation of target flows.

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APPENDIX A: BRIEFING NOTE ON THE DUNCAN DAM FACILITY

This document serves as a primer to help familiarize Consultative Committee members with the operations and operating constraints (physical and Columbia River Treaty) on the Duncan Dam facility.

1.0 FACILITIES

1. Earthfill Dam
   - Crest Length = 792 m (2600 ft)
   - Elevation of Top of Dam = 581.25 m (1907 ft)
   - Height of Dam above Lowest Foundation = 38.7 m (127 ft)
2. Reservoir
   - Normal Maximum Operating Elevation (Full Pool) = 576.68 m (1892 ft)
   - Minimum Operating Elevation = 546.87 m (1794.2 ft)
   - Maximum Flood Operating Elevation = 578.21 m (1897 ft)
   - Storage Capacity between 546.87 m and 576.68 m = $1.73*10^9$ m^3 (1.4 MAF)[1]
   - Area at Full Pool = 71.5 km^2 (27.6 sq.mi.)
3. Low Level Outlets
   - 2 Gated Tunnels = 6.1 m (20 ft) Diameter x 332.8 m (1092 ft) Length
   - Inlet Sill Elevation = 541.63 m (1777 ft)
   - Discharge Capacity at 576.68 m = 525 m^3/s (18 500 cfs) Each Tunnel
4. Spillway
   - 2 Vertical Control Gates = 8.08 m (26.5 ft) Wide x 12.19 m (40 ft) High
   - Inlet Gate Sill Elevation 564.79 m (1853 ft)
   - Discharge Capacity at 576.68 m = 1190 m^3/s (42 000 cfs) Both Gates

[1] 1.4 MAF (million acre-feet) is equivalent to 705 800 cfs-days

2.0 OPERATIONAL CONSTRAINTS

1. Storage

- Water licence storage = 1.73×10^9 m^3 (1.4 MAF) between the normal maximum operating level of 576.7 m (1892 ft) and the minimum operating level of 546.9 m (1794.2 ft).
- In years with average to above-average snowpack, the Columbia River Treaty Flood Control Rule Curves cause Duncan Reservoir to be drafted to 551.0 m (1808 ft) or lower by the end of February (1.27 MAF of flood protection).
- In below-average snowpack years, the Treaty Flood Control Rule Curve may be as high as 564.4 m (1852 ft) at the end of February (0.67 MAF of flood protection).
- Except for an "on-call" situation (described below), any additional draft below the Flood Control Rule Curve is for the purpose of maximizing energy production either under Treaty rules (for generation at downstream U.S. plants, which is shared with Canada as Entitlement Energy) or at BC Hydro's discretion for the Kootenay River power plants.
- In a very high snowpack year, the U.S. Army Corps of Engineers may use the "on-call" flood control draft provision of the Treaty and direct Canada to evacuate all possible Columbia River basin storage for downstream flood control – in this case, the Corps may direct that Duncan Reservoir be emptied to 546.9 m (1794.2 ft) by the end of February to provide the full 1.4 MAF of storage for flood protection.

2. Discharge

- Normal Maximum Discharge = 283 m^3/s (10 000 cfs)
- Emergency[1] Maximum Discharge = 566 m^3/s (20 000 cfs)
- Maximum Daily Rate Change in Discharge = 113 m^3/s (4 000 cfs)
- Minimum Average Weekly Discharge = 3 m^3/s (100 cfs)
- Minimum Discharge when the Reservoir is filling and reaches 575.8 m are the lesser of:

  a) 283 m^3/s (10 000 cfs)
  b) A percentage of the calculated inflows (based on reservoir elev.):
     - 575.8 m 25 %
     - 576.1 m 50 %
     - 576.4 m 75 %
     - 576.7 m 100 %

[1] During flood events.

3.0 NORMAL SEASONAL OPERATIONS

1. 1 January to 31 March
   - During this period of high winter loads, the intent is to draft water out of Duncan Reservoir to increase generation at plants downstream of Kootenay Lake.
   - Any water that remains in Duncan Reservoir by the end of March will normally be "trapped" and the water will spill past Kootenay River plants later in the year.
   - Although the minimum Treaty draft level is between 551.0 m (1808 ft) and 564.4 m (1852 ft), depending on the forecast inflow volume, the reservoir is typically drafted to its minimum operating level of 546.9 m (1794.2 ft) by the end of this period.
2. 1 April to 30 April
   - During April and early May, before the start of the freshet, Duncan Dam outflows are approximately equal to inflows since the reservoir is usually passing inflows.
3. 1 May to 31 July
   - Once the freshet starts, the Duncan Dam discharge is normally reduced to minimum to minimize spill out of Kootenay Lake at the Kootenay River plants and refill the Duncan Reservoir.
   - Typically, the Duncan Dam discharge is kept at minimum 3 m^3/s (100 cfs) until early July when the Duncan Reservoir is nearing full-pool at 576.7 m (1892 ft) (depending on water availability[1]), at which time the Duncan Dam discharge is increased to slow the rate of reservoir refill, with the goal to reach full-pool before the Kootenay Lake spill terminates.
4. 1 August to 31 August
   - In August, the Duncan Reservoir typically passes inflow, especially in average and above-average water years when Kootenay Lake is in the "freshet" part of the IJC curve, since there will typically be more than enough water to keep Kootenay River power plant turbines heavily loaded.
   - In a low water year, should the Kootenay Lake level at Nelson drop below 531.4 m (1743.32 ft), additional Duncan Dam releases may be desirable to support Kootenay Lake levels and increase the head at plants on the Kootenay River.

[1] For example, during the summer of 2001, there were insufficient inflows to fill the top 12 ft of the reservoir.

- Additional Duncan Dam releases may also be desirable during August to balance the Duncan Reservoir with the Arrow, Mica, or Libby reservoirs (the latter can only be accomplished through a Treaty-Libby swap agreement with U.S. Agencies that control Libby Dam).

5. 1 September to 30 November

   - Duncan Reservoir typically starts off September at nearly full pool and discharges at maximum of 283 m^3/s (10 000 cfs) in order to increase the head for power generation at plants downstream of Kootenay Lake.
   - The Kootenay Lake IJC maximum level increases 0.6 m on 1 September.
   - As the Kootenay Lake level gets closer to the IJC curve, then Duncan Dam discharges are adjusted to keep the lake level close to the IJC curve.
   - The desire for higher or lower Duncan Dam discharges throughout the September to December period depends primarily on the level of Kootenay Lake, which, in turn, depends on the Libby Dam discharge and the system need for Kootenay River plant generation. Kootenay Lake levels that are significantly lower than the IJC curve result in head losses.

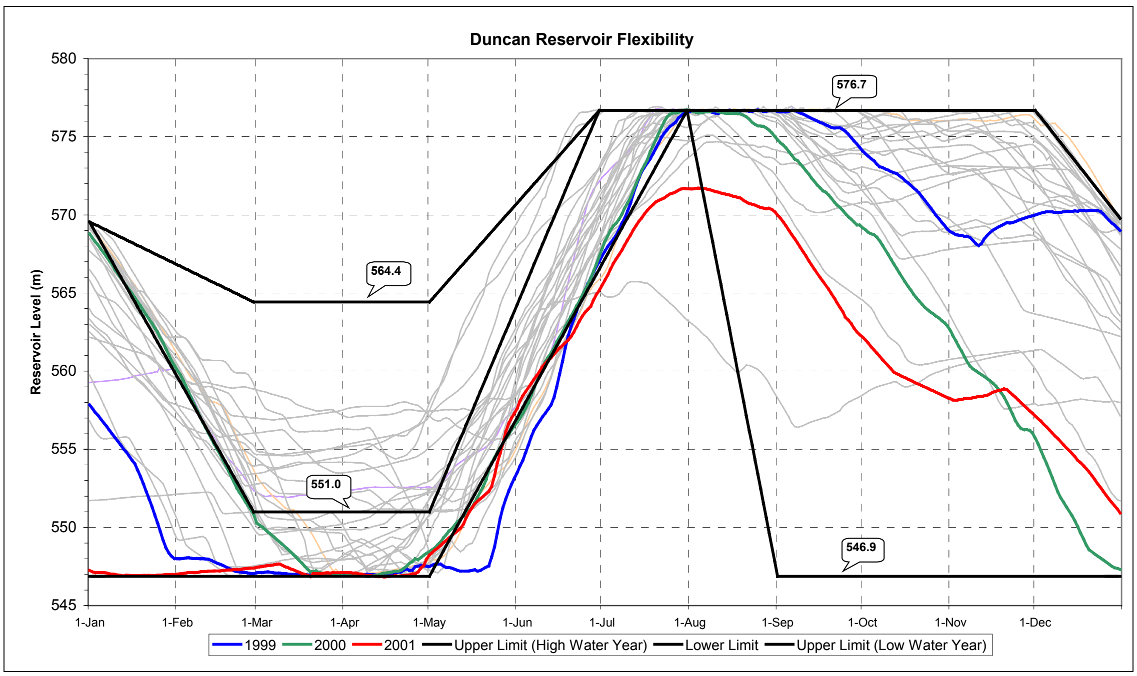
6. 1 December to 31 December

   - By 31 December the Duncan Reservoir must be drawn down to be at or below the Treaty flood control draft point of 569.8 m (1869 ft). In most years, the Duncan draft for energy purposes causes a deeper draft than that required for flood control.
   - Unlike the Treaty Flood Control Curve draft points in January through April, the 31 December draft point is fixed and does not depend on the inflow volume forecast.
   - As the end of December approaches, the Duncan Reservoir level is normally positioned to be in about mid-range (or perhaps slightly below mid-range).
   - If the 1 January runoff forecast for Libby is very low, then Libby will have low discharges in the January to April period, and any water remaining in Duncan Reservoir will be very precious in terms of supplying the Kootenay River plants with water through this period (maintaining the HLH and peak generation).
   - However, if the 1 January runoff forecast for Libby is high, then water remaining in Duncan Reservoir may be spilled at the Kootenay River plants or may result only in additional LLH generation (which is less valuable).

4.0 OTHER CONSTRAINTS

Besides the Columbia River Treaty and other flood management procedures, there are a number of other agreements or operations which influence Duncan operations (on a daily, weekly and monthly basis):

- 1938 International Joint Commission (IJC) Order for Kootenay Lake
- Kootenay Canal Plant Agreement
- Libby Coordination Agreement
- Non Treaty Storage Agreement
- Other water licences on the Kootenay system
- Treaty-Libby and Duncan-Kootenay Storage Swap Agreements



APPENDIX B: CONSULTATIVE COMMITTEE, OBSERVERS AND SUBCOMMITTEES

Table B-1: Duncan Dam Water Use Plan Consultative Committee

Member	Affiliation	Notes
Terry Anderson	Ministry of Water, Land and Air Protection	
Gordon Boyd	BC Hydro	
Vic Clement	Ktunaxa–Kinbasket Tribal Council	
Kevin Conlin	Ministry of Sustainable Resource Management	Stepped down from Committee in 2002
Tola Coopper	Fisheries and Oceans Canada	Replaced by Dan Sneep in 2001
Bruce Duncan	Columbia Power Corporation	
Sue Dyer	FortisBC (formerly Aquila Networks Canada)	
Kindy Gosal	Columbia Basin Trust	Replaced Josh Smienk in 2002
Larry Greenlaw	Area "D" Director, Regional District of Central Kootenay	
Jay Hammond	Ministry of Environment, Lands and Parks Ministry of Water, Land and Air Protection	Replaced by Kevin Conlin in 2001
Steve Macfarlane	Fisheries and Oceans Canada	Replaced Dan Sneep in 2002
Stephan O'Shea	Area Resident	
Josh Smienk	Columbia Basin Trust	Replaced by Kindy Gosal in 2002
Dan Sneep	Fisheries and Oceans Canada	Replaced by Steve Macfarlane in 2002
Gail Spitler	Area Resident	
Fred Thiessen	Ministry of Forests	
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	
Robert Williams	St. Mary's Band	Changed to Observer in December 2001

Table B-2: Duncan Dam Water Use Plan Alternates

Name	Alternate for	Affiliation
Gene Anderson	Sue Dyer	FortisBC
Robert Douglas	Larry Greenlaw	Alternate Area "D" Director, Regional District of Central Kootenay
Bill Green	Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission
Jayson Kurtz	Steve Macfarlane	Fisheries and Oceans Canada
Llewellyn Matthews	Bruce Duncan	Columbia Power Corporation
Steve McAdam	Terry Anderson	Ministry of Water, Land and Air Protection

Table B-3: Duncan Dam Water Use Plan Observers

Registered Observer	Affiliation	Notes
Jamie Alley	Living Rivers Strategy, Ministry of Water, Land and Air Protection	
Amy Ambrosone	Columbia Basin Trust	
Steve Arndt	Columbia Basin Fish and Wildlife Compensation Program	
Andreas Artz	Little Shuswap Indian Band	
Vern Clapper	Area Business Owner	
Brenda Drury	Area Resident	
Rowena Eloise	Area Resident	
Fred Fortier	Secwepemc Fisheries Commission	
Mary Hallam	Area Resident	
Brenda Herbison	Area Resident	
Steven Hureau	Canadian Wildlife Services	
Michael Keefer	Ktunaxa–Kinbasket Tribal Council	Requested to be removed in 2003
Jane Lynch	Area Resident	
Bruce MacDonald	Fisheries and Oceans Canada	
Anita Mathur	Land and Water BC Inc. (formerly Ministry of Sustainable Resource Management)	
Judy Mcquary	Columbia Power Corporation	
Robert Williams	St. Mary's Band	
Marty Williams	Canadian Columbia River Inter-Tribal Fisheries Commission	

Table B-4: Duncan Dam Water Use Plan Subcommittees

Member	Affiliation	Fish Technical Committee	First Nation Archaeology and Heritage	Wildlife Technical Committee	Recreation/ Quality of Life
Terry Anderson	Ministry of Water, Land and Air Protection	✓			
James Baxter	BC Hydro	✓ attended 2 meetings as a resource			
Gary Birch	BC Hydro	✓			
Gordon Boyd	BC Hydro	✓ attended last meeting			
Wayne Choquette	Consultant		✓		
Vic Clement	Ktunaxa–Kinbasket Tribal Council	✓	✓		
Kindy Gosal	Columbia Basin Trust				✓
Larry Greenlaw	Area ‘D’ Director, Regional District of Central Kootenay				✓
Mary Hallam	Area Resident				✓attended 2 meetings
Brenda Herbison	Consultant			✓	
Jayson Kurtz	Fisheries and Oceans Canada	✓			
Steve Macfarlane	Fisheries and Oceans Canada	✓			
Llewellyn Matthews	Columbia Power Corporation	✓			
Steve McAdam	Ministry of Water, Land and Air Protection	✓			
Leloni Needlay	Canadian Columbia River Inter-Tribal Fisheries Commission	✓ attended last meeting		✓ attended last meeting	
Stephan O’Shea	Area Resident			✓	
Dan Sneep (replaced by Jason Kurtz)	Fisheries and Oceans Canada	✓			
Gail Spitler	Area Resident			✓	✓
Fred Thiessen	Ministry of Forests				✓
Mark Tiley	Canadian Columbia River Inter-Tribal Fisheries Commission	✓	✓	✓	
Margaret Trenn	FortisBC	✓			

APPENDIX C: CONSULTATIVE COMMITTEE TERMS OF REFERENCE

The following Terms of Reference are based on those developed by previous water use planning Consultative Committees and the provincial government's *Water Use Plan Guidelines*. These Terms of Reference were accepted at the Duncan Dam Water Use Plan Consultative Committee Meetings held on 31 January and 1 February 2002.

1.0 INTRODUCTION

The purpose of the Terms of Reference is to ensure that participants of the Duncan Dam water use planning process have a clear understanding of their purpose and responsibilities, to provide assurance that public values will be integrated into resource management decisions, and enhance the smooth functioning of the Consultative Committee work.

2.0 CONSULTATIVE COMMITTEE PURPOSE

The broad consultative purpose is to integrate public values into water flow management decisions related to BC Hydro operations. The specific Consultative Committee purpose is to provide clearly documented value-based recommendations for consideration by BC Hydro when preparing their Water Use Plan for the Duncan Dam facility. The objective of the Committee will be to recommend:

- A preferred operating regime (or range of regimes) for the facilities, considering allocation of water to different water uses (e.g., flood control, fisheries, power generation, traditional use, aquatic ecosystem "health," recreation, etc.).
- Criteria for a monitoring and assessment program.
- Timing for periodic review of the Duncan Dam Water Use Plan.

Consensus is a goal, but not a requirement of the water use planning process. Consensus is defined in the provincial government's *Water Use Plan Guidelines* as a decision in which the participants can accept, without having to agree to all the details of the operating regime. Where the process identifies a preferred operating alternative (consensus), documentation will include areas of agreement, as well as areas of contention, and the underlying trade-offs between alternative water uses. Where no preferred operating alternative is identified (non-consensus), documentation will record that agreement was not reached, and indicate differences of opinion and reasons for disagreement.

3.0 CODE OF CONDUCT

All participants of the Duncan Dam Water Use Plan Consultative Committee will endeavour to:

- Support an open and inclusive process.
- Treat others with courtesy and respect.
- Listen attentively with an aim to understand.
- Be concise in making your point.
- Speak in terms of interests instead of positions.
- Be open to outcomes, not attached to outcomes.
- Challenge ideas, not people.
- Let opposing views co-exist.
- Avoid disruption of meetings (e.g., cell phones, caucusing at the table, etc.).
- Use the "parking lot" for issues that fall outside the day's agenda.
- Aim to achieve consensus on issues being addressed.

The facilitator will ensure that the code of conduct is followed by Committee members.

4.0 PROCESS

4.1 Committee Tasks

The Consultative Committee will achieve its purpose by undertaking Steps 4 to 8 of the provincial government's *Water Use Plan Guidelines*. In summary these include:

- Confirm issues and interests in terms of specific water use objectives along with quantitative and/or descriptive measures for assessing their achievement.
- Identify existing information and information gaps related to the impacts of water flows, and their timing, on each objective.
- Create alternative operating regimes to compare impacts on water use objectives.
- Assess the trade-offs between alternative operating regimes in terms of objectives.
- Determine and document areas of agreement and disagreement.

4.2 Procedure in the Event of Disagreement

The following interest-based negotiation steps will be used as a tool for resolving issues:

- Define the issue.
- Identify interests.
- Brainstorm options.
- Evaluate options.
- Choose an option.

Interests are defined as the needs, wants, fears and concerns that are connected to an issue. Positions are defined as a predetermined solution to a problem without consideration for the interests of others.

5.0 DELIVERABLE

A Duncan Dam Water Use Plan Consultative Committee Report, signed off by the participants, documenting the overall process; water use interests, objectives and performance measures; information collected, operating alternatives reviewed, trade-off assessment, and areas of final agreement and disagreement.

The target date for the delivery of this report is Fall 2003.

6.0 WATER USE PLAN PREPARATION, REVIEW, AND APPROVAL

Recommendations in the Consultative Committee Report will be fully considered by BC Hydro as they prepare the Draft Water Use Plan for the Duncan Dam facility. A copy of the draft Water Use Plan, prepared by BC Hydro, will be distributed to the Consultative Committee.

The draft Water Use Plan and the Consultative Committee Report will be submitted to the BC Comptroller of Water Rights. The Comptroller will co-ordinate a final regulatory review and approval as outlined in the provincial government's *Water Use Plan Guidelines*.

The target date for the delivery of this report is fall 2003.

7.0 MEMBERSHIP

7.1 Committee Membership

The Duncan Dam Water Use Plan Consultative Committee has been established in accordance with Steps 2 and 3 of the provincial government's *Water Use Plan Guidelines*. Committee members represent a broad range of interests affected by Duncan Dam facility operations.

7.2 Alternates

Consultative Committee members can designate alternates (either a non-Committee member or another Committee member) to represent them when they are unable to attend a meeting or on issues where an alternate has more relevant knowledge or experience.

Committee members should ensure that their alternate is familiar with these Terms of Reference, the provincial government's *Water Use Plan Guidelines* and is up-to-date on issues being discussed. Alternates who attend meetings should ensure that the Committee member is updated on all issues that were discussed.

7.3 New Members

Individuals or organizations may apply to become Consultative Committee members by:

- Submitting a request for Committee membership to the BC Hydro process co-ordinator. The process co-ordinator will then schedule the membership request as an agenda topic for the next Committee meeting.
- Applicants must be present at the meeting where the application is considered and be prepared to describe the interests they represent and the reasons why they believe those interests are not adequately represented in the process.
- Committee members will consider new applications based on the principle of a fair, open and inclusive process.

New Committee members will be required to:

- Abide by the terms of reference.
- Become familiar with past work completed by the Committee.
- Accept agreements previously made by the Committee.

7.4 Observers and Guests

Water Use Plan observers are included in the communications distribution list, receiving all communications including meeting notices, information packages, agendas and minutes. Observers are not full Consultative Committee members and thus do not participate fully in discussions, do not sit at the main table, and do not participate in the trade-off and decision activities. Observers may, by decision of the Committee, be given opportunity to provide input into the discussions of the Committee.

Guests may be invited to attend meetings to provide a technical presentation or respond to questions on a subject that is relevant to the development of the

Duncan Dam Water Use Plan. Such presentations must be pre-arranged as an agenda item with the Facilitator and/or the BC Hydro Communications representative.

Observers and guests will not participate in making Committee decisions.

8.0 ROLES AND RESPONSIBILITIES

8.1 Committee Members

In addition to following the code of conduct, participants in the Duncan Dam Water Use Plan Consultative Committee are responsible for:

- Attending and openly participating in Consultative Committee meetings. Committee members who miss two consecutive meetings (and/or a total of three Committee meetings), without providing an alternate, may be moved into the observer role.
- Articulating their interests with respect to water use.
- Reviewing relevant information and coming to meetings prepared.
- Making recommendations concerning study/research work.
- Exploring the implications of a range of operating alternatives.
- Seeking areas of agreement.
- Ensuring continuity in representation, through the use of a designated alternate and/or provision of advance comments or information to the facilitator in the event of an expected absence.
- Being accountable to constituents, other Committee members and the general public.
- Keeping constituents current on progress and decisions of the Committee.
- Signing off on the final Consultative Committee Report provided is a true and accurate record of the Duncan Dam water use planning process, documenting decisions and all areas of agreement and disagreement.

8.2 Facilitator

In addition to following the code of conduct, the Facilitator of the Duncan Dam water use planning process is responsible for:

- Aiding the Consultative Committee in achieving its purpose and associated tasks (i.e., undertaking Steps 4 to 8 of the provincial government's *Water Use Plan Guidelines*).

- Making every endeavour to ensure that all parties are heard and that all differences are resolved fairly, without unnecessary delay or expense.

- Making every endeavour to be, and remain, completely impartial between the parties, according equal attention and courtesy to all persons involved.

- Producing the Consultative Committee Report for review and sign off by the Committee.

8.3 BC Hydro Project Team

A BC Hydro Project Team has been established to assist with the work of the Consultative Committee. In addition to following the code of conduct, the BC Hydro Project Team is responsible for assisting and taking the lead role in technical support for the Committee. This includes working with the entire Committee, internal BC Hydro resources and external resources including the regulatory agencies, local resources and experts in:

- Managing and resourcing the process to maintain an acceptable time schedule.

- Compiling and providing existing data and information.

- Establishing the scope, limits and boundaries for proposed studies.

- Arranging and managing studies for collection of new data and information.

The BC Hydro Project Team is also responsible for assisting with administrative tasks, which include:

- Arranging meetings.

- Preparing and distributing the meeting minutes of Committee meetings or any subcommittee, working table or technical work group meetings. Meeting minutes shall focus on content, not people. All such notes will be distributed directly to each Committee member, designated alternates and observers and guests. Committee members may distribute minutes and materials to their constituents.

- Arranging for facilitation services (as necessary).

- Maintaining a database of interested parties who are to receive copies of meeting notes and other written materials.

- Distributing meeting notes and supporting materials.

- Developing and maintaining communication links with interested parties.

- Producing and issuing all communications materials.

- Supporting report and document preparation and copying.
- Assisting with preparation and presentation of the Consultative Committee Report.
- Presenting the Draft Duncan Dam Water Use Plan to the Committee.

9.0 WORKING GROUPS

To expedite the completion of tasks identified by the Consultative Committee, working groups may be established to undertake work between Committee meetings.

Working groups will:

- Be open to all members, who will be notified in advance of any meeting.
- Schedule meetings to optimize opportunities for attendance.
- Offer opportunity for input from members who cannot make a scheduled meeting.
- Include non-committee members, such as technical or scientific experts, as appropriate.
- Include a facilitator as required.
- Prepare options and/or recommendations for consideration by the Committee.

Working groups will not make decisions on behalf of the Committee.

10.0 PUBLIC COMMUNICATION

The following procedure will be followed with respect to public communication:

- Consultative Committee meetings will be open to the public and the media.
- Newsletters, press releases or media updates describing the water use planning process and its progress will be prepared on a periodic basis by BC Hydro.
- Committee members will describe their points of view as interests rather than positions and will not criticize or discredit the process or the views of others when communicating with the broader public with respect to the process.
- Where needed, the Committee will select an appropriate spokesperson, such as the facilitator or BC Hydro communications, to represent the Committee.

APPENDIX D: SCHEDULE OF CONSULTATIVE COMMITTEE MEETINGS AND ACTIVITIES

Step 1: Initiate Water Use Plan Step 2: Issues Scoping	**31 August 2001** • Public announcement **19 September 2001** • Open House and Information Session **28 November 2001** • Present the water use planning process • Review Duncan Dam Project • Introduce terms of reference and workplan • Introduce and discuss the issues list
Step 3: Determine the Consultative Process Step 4: Develop Objectives and Performance Measures	**28 November 2001** • Review issues list and introduce objectives • Present the value-based decision making process **31 January 2002 and 1 February 2002** • Confirm Consultative Committee members, terms of reference, and workplan • Confirm issues list, continue work on objectives and introduced performance measures • Develop bookmark operating alternatives
Step 5: Additional Information Gathering Step 6: Creating Alternatives	**31 January 2002 and 1 February 2002** • Identify and select expedited data collection studies **23–24 May 2002** • Review bookmark operating alternatives • Continue work on objectives and introduce performance measures • Confirm studies to fill in information gaps **9–10 October 2002** • Site visit • Cultural Awareness session • Review study findings • Continue review of objectives and performance measures • Conduct mock trade-off analysis exercises **16–17 January 2003** • Confirm performance measures • Identify round 1 operating alternatives for modelling

	9–10 April 2003 • Review and confirm objectives and performance measures • Review Round 1 operating alternatives • Identify Round 2 operating alternatives for modelling • Review water use planning monitoring principles
Step 7: Assess Trade-offs Step 8: Document Areas of Agreement and Disagreement	**18–19 June 2003** • Review Round 2 operating alternatives • Discuss trade-offs and document areas of agreement and disagreement • Identify Round 3 operating alternatives • Discuss monitoring studies and physical works in lieu of operational changes **20–22 April 2004** • Review Rounds 3 and 4 operating alternatives • Discuss trade-offs and document areas of agreement and disagreement • Review recommended monitoring studies and physical works in lieu of operational changes **June – July 2004** • Facilitator contacted individual Consultative Committee members to confirm level of support for recommended Alternative S(73).

APPENDIX E: DOCUMENTS GENERATED BY THE DUNCAN DAM WATER USE PLANNING PROCESS

This appendix summarizes the documents generated by the 2001 to 2004 Duncan Dam water use planning process. The format of the documents is as indicated, either hard copies or digital files.

1.0 Meeting Notes

Meeting notes summarizing presentations, discussions, and agreements at Duncan Dam Water Use Plan Consultative Committee and Subcommittee Meetings are posted on the BC Hydro Duncan Dam Water Use Plan website and are delivered through Royal mail as required. In most cases, draft notes were circulated for review to the relevant committee members followed by notes marked "final." Meeting notes were distributed as digital files and hard copies.

Committee or Subcommittee	Meeting Notes
Duncan Dam Consultative Committee	19 September 2001 28 October 2001 31 January – 1 February 2002 23–24 May 2002 9–10 October 2002 9–10 April 2003 18–19 June 2003 20–22 April 2004
Quality of Life/Recreation Subcommittee	21 March 2002 28 November 2002 21 August 2003
Wildlife Subcommittee	03 May 2002 12 December 2002 23 March 2003 19–20 August 2003 11 March 2004 14 May, 2004 (site visit)
Cultural Resources and Heritage Subcommittee	No formal meeting notes Three teleconferences February 2004
Fish Technical Subcommittee	02 May 2002 There were 3 other FTC meetings where no formal minutes were produced. 27 September 2002 21–22 November 2002 07 February 2003 17 March 2003 20 May 2003 10–11 September 2003 9–10 March 2004 August 16, 2004 November 26, 2004

2.0 BC Hydro Duncan Dam River Water Use Plan – Interim Reports

These reports are in bound and digital formats.

BC Hydro. (2002). *Issues Identification Report: Duncan Dam Water Use Plan*. November 2001

BC Hydro. (2002). *Proposed Consultation Process Report: Duncan Dam Water Use Plan.* August 2002

3.0 Key reports, literature reviews, and memos generated by the Duncan Dam water use planning process. These reports exist in various forms, either as bound publications or digital in digital MS-Word or Adobe Acrobat pdf form.

Acroloxus Wetlands Consultancy. (2002). *The Influence of the Duncan Dam on the Mosquito Populations of the Lower Duncan River Floodplain.* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

AIM Ecological Consultants. (2002*). Duncan Water Use Plan: Potential Areas for Vegetation Establishment in Duncan Reservoir.* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

AIM Ecological Consultants. (2003). *Duncan Reservoir – Potential Riparian Enhancement Sites, Treatment Options, Preliminary Planting Costs and Monitoring Requirements (Draft).* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

BC Hydro. (2002). *Performance Measure Reference Sheet. Flooding Threshold*. Prepared by BC Hydro Generation Operations Department.

BC Hydro. (2002a). *Digital Elevation Model for Duncan Reservoir.* Prepared by BC Hydro Survey and Photogrammetry Department.

BC Hydro. (2002d). *Total Gas Pressure Data for Lower Duncan River Associated with 2002 Spill.* Unpublished data.

BC Hydro. (2003a). *Duncan Dam Water Use Plan Quality of Life Technical Committee Minutes Meeting #3.* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

BC Hydro. (2003b). *Duncan Dam Water Use Plan Recreation Technical Paper: Recreation Quality Performance Measure – Summary of Responses to Questionnaire.* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

BC Hydro. (2003c). *Total Gas Pressure Data for the Lower Duncan River 1999 and 2002.*

BC Hydro. (2004). *Duncan Water Use Plan, Hydro Operations Study*. Engineering Report #E325.

Choquette, W.T. (2002). *Archaeological Component of Duncan Reservoir Water Use Planning Process, 2002.* Prepared for BC Hydro Duncan Dam Water Use Plan, Burnaby, B.C.

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APPENDIX F: PERFORMANCE MEASURE INFORMATION SHEETS

1.0 Recreation Performance Measure

1.1 Recreation Quality

What is the Recreation Quality performance measure?

Recreation Quality is defined as ***the number of weighted user days the Duncan Reservoir is at preferred elevation levels***. This performance measure estimates the quality and quantity of water-based recreation opportunities in the reservoir under different operating alternatives.

Where is this performance measure relevant?

In the Duncan Reservoir. Two of the principal camping recreation camp sites located on the southern portion of the reservoir, Howser and Glacier creeks, were used as indicators for recreational use in the entire reservoir area.

Why is this performance measure important?

The Duncan Dam area is used by a variety of recreationalists and attracts many tourists each year. In general, local residents are the main users and their activities are concentrated in the southern end of the Duncan Reservoir rather than downstream of Duncan Dam. Activities at the reservoir include swimming, boating, fishing, and activities such as camping near the beach areas.

The quality of the recreational experience is directly related to tourism opportunities for local operators who rely on the Duncan Reservoir as a principal attraction during the summer months.

How does this performance measure affect (or is related to) the objective?

The ***Recreation*** objective is to ***maximize the quantity and quality of the recreational experience***. The recreation performance measure estimates the recreation quality and is therefore related to the recreation objective. The preferred time for recreation is from 15 July to 30 September when water temperatures are high and the Duncan Reservoir is near full pool. Reservoir water levels affect the following recreation issues:

- Foot access and boat access to the water.
- Area of usable beaches.
- Visual quality (appearance of the reservoir, adjacent beaches, mudflats and stumped areas).

How can this performance measure be affected by operational changes?

The impact of the Duncan Dam operations on recreation quality is directly linked to Duncan Reservoir elevations. In general, the fuller the reservoir the better the aesthetic values associated with recreation and tourism opportunities. The preferred reservoir elevation for beach use is assumed to be between 1.0 and 1.5 m below full pool for the Glacier Creek and Howser Creek recreation sites. Reservoir elevations due to the low sloping shoreline particularly impact Glacier Creek.

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

Key assumptions and uncertainties include:

- Minimal recreation use outside the preferred time for recreation and the preferred Duncan Reservoir elevations.
- If the reservoir is managed for recreation quality, non-regulated sites will also benefit.
- Preferred time for recreation and reservoir elevations.

This performance measure does not take into account other variables that impact recreation quality and are outside the effects of reservoir elevations, including:

- Weather – warm weather results in increased recreation use.
- Water temperatures in Duncan Reservoir and Kootenay Lake and other surrounding lakes.
- Day of the week; increased recreation use on weekends and holidays.

How is this performance measure calculated?

The BC Hydro Operations Model provides Duncan Reservoir elevations from specified operating alternatives.

The ***Recreation Quality*** performance measure reports the number of days the reservoir is at ideal levels for recreation interests during the primary recreation period of interest from 15 July to 30 September. Each user day is weighted by a factor depending on the reservoir elevation. The resulting performance measure is the sum total of each weighted user day within the defined recreation season for each year.

Figure F-1 illustrates the recreation quality weightings defined by the Quality of Life/Recreation Technical Subcommittee.

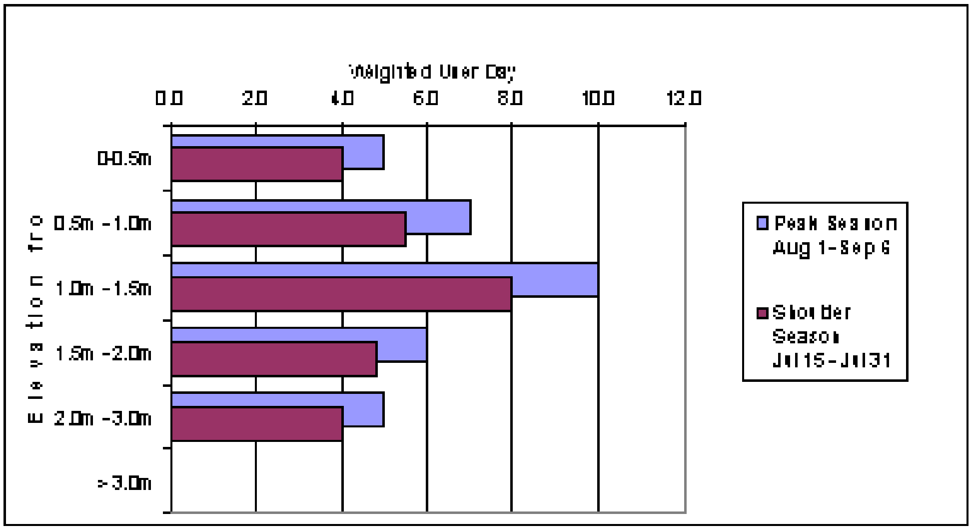


Figure F-1: Recreation Quality Weightings

Is there adequate available information to calculate this performance measure?

Yes. The information used to develop the ***Recreation Quality*** performance measure includes:

- Input from the Quality of Life/Recreation Technical Subcommittee (BC Hydro, 2003).
- A ground truthing exercise conducted in the summer of 2003 which photo-documented beach areas at various reservoir levels at Howser and Glacier creek recreation campsites (Spitler, pers. comm., 2003).
- Telephone survey of local users and recreation providers in the area (BC Hydro, 2003a).

2.0 Quality of Life Performance Measure

2.1 Mosquito Breeding Habitat

What is the Mosquito Breeding Habitat performance measure?

Mosquito Breeding Habitat is defined as ***the weighted area-days re-flooded 1 July to 31 August***. This performance measure estimates the impact of Duncan Dam operations on mosquito-breeding habitat in the lower Duncan River floodplain in late summer under different operating alternatives.[1]

[1] This performance measure was merged with the Flood Risk measure into the Flood/Mosquito Risk measure because they behaved identically.

Where is this performance measure relevant?

Mosquito breeding habitats in the lower Duncan River floodplain, including the grasslands north of Meadow Creek, from the Duncan Dam to the head of Kootenay Lake.

Why is this performance measure important?

Prior to the Duncan Dam being constructed, the lower Duncan River was known as a prime mosquito habitat area and has been a pervasive problem for many local residents. Mosquitoes can be a considerable nuisance to the residents, tourists, local industries and livestock and may lead to losses to the local economy. Mosquito production can directly affect the recreational quality (and opportunities) for local residents and tourists. An extended mosquito production season exacerbates this nuisance and may cause problems with control measures that might lead to increases in the annual cost of the mosquito abatement program.

The West Nile disease, which is carried by mosquitoes, is a concern for some local residents as the spread of the virus occurs into Western North America. The mosquito study results indicate the mosquito species that transfer the disease from birds to humans are present in the lower Duncan River.

How does this performance measure affect (or is related to) the objective?

The ***Quality of Life*** objective is to ***maximize the quality of life for residents in the Duncan Dam area***. The quality of life performance measure estimates the impact of Duncan Dam operations on mosquito-breeding habitat and is therefore related to the quality of life and recreation objectives. After the initial Lardeau River flooding cycle in May and June causes the first and typically largest mosquito hatch (note this occurs regardless of Duncan Dam operations), the measure assesses the degree to which Duncan Dam operations may cause additional mosquito breeding opportunities.

How can this performance measure be affected by operational changes?

The impact of Duncan Dam operations on mosquito breeding depends on a number of variables including the timing of Lardeau River flows, backwater effects from Kootenay Lake, magnitude, duration and timing of Duncan Dam peak flows, seepage through natural and dike channels, and climatic factors such as snowpack, rain events and temperature.

Low bench and meadowland areas in the Duncan River and Meadow Creek floodplains can become re-flooded after spring freshet from July to August inclusive, and contribute to the potential mosquito hatching of "nuisance" species of mosquitoes. Duncan Dam discharges could be modified during July to August to try and limit higher flows in the lower Duncan River, resulting in a lower Duncan Reservoir elevation to buffer or attenuate the upper Duncan River freshet or local rain events.

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

The ***Mosquito Breeding Habitat*** performance measure is based on the hypotheses that reducing the area of flooded mosquito breeding habitat will reduce the potential for mosquito production. The performance measure identifies the month of June as most likely to be affected by operations: June is also a productive period for mosquitoes, but is influenced almost solely by the Lardeau River hydrograph.

Mosquito breeding habitat was evaluated based on the assumption that the most bothersome species to humans is the Aedes variety, which breeds in low bench grassland areas. Mosquito breeding potential of re-flooded habitats was assumed to be diminished compared to those habitats initially flooded. Repeated flooding of mosquito breeding habitat results in further reductions in productive potential.

Key assumptions and uncertainties include:

- Seasonal temperatures.
- Precipitation and snowpack contribute to mosquito growth and survival.
- Water temperatures.
- Tributary influences, especially those of Meadow Creek on adjacent farmlands.
- Kootenay Lake levels.
- Long-term changes in climate.

The above factors may all affect the distribution of particular mosquito species. However, these factors cannot be directly affected by Duncan Dam operations and therefore, are not considered in this performance measure.

How is this performance measure calculated?

The BC Hydro Operations Model provides Duncan Dam discharges from specified operating alternatives.

The ***Mosquito Breeding Habitat*** performance measure reports the number of weighted area-days of meadowland and low-bench mosquito breeding habitat re-flooded from 1 July to 31 August. The selected areas are based on data collected during the mosquito study (Jackson, 2002). This performance measure reports the area of index mosquito breeding habitats flooded based on the total instream flow in the lower Duncan River below the Lardeau River confluence. Although all potential mosquito breeding habitats in the Duncan River floodplain were assessed, the data provided did not show a direct relationship between Duncan River flows and backflooding on tributary habitats, namely Meadow Creek (Klohn Crippen, 2003).

Figure F-2 illustrates the area of mosquito breeding habitat flooded based on the total instream flow in the lower Duncan River below the Lardeau River confluence.

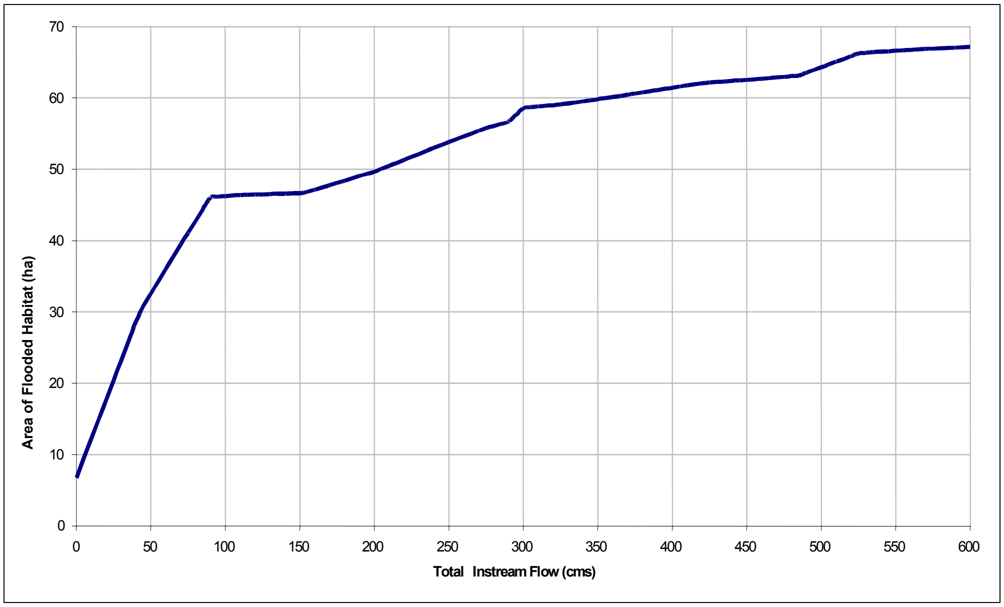


Figure F-2: Potential Aedes Mosquito Breeding Areas Flooded by Duncan River Flows

Table F-1 summarizes the mosquito breeding flooded habitat index.

Table F-1: Mosquito Breeding Flooded Habitat Index

Habitat Area	Weight
1st Flooding	1
2nd Flooding	0.5
3rd and Consecutive Floods	0.05

Equation F-1 illustrates the weighted measure of area of mosquito breeding habitat calculation.

Equation F-1:

$$A_{Mosq} = a_{1st} \bullet w_{1st} + a_{2nd} \bullet w_{2nd} + a_{3rd} \bullet w_{3rd}$$

where:

A_{Mosq}	=	weighted measure of area of mosquito breeding habitat (ha)
$a_{1st} \ldots a_{3rd}$	=	submerged areas corresponding to the three largest flow events over the period of interest
$w_{1st} \ldots w_{3rd}$	=	weights for 1st through 3rd consecutive flooding

Is there adequate available information to calculate this performance measure?

The ***Mosquito Breeding Habitat*** performance measure is based on historical information, vegetation mapping and elevation measurements made during the mosquito study (Jackson, 2002). The assumptions of area and mosquito breeding habitat potential may need to be monitored over a period of years to improve the resolution of the performance measure. The mosquito breeding habitat elevation data collected during the study requires further ground truthing to accurately calculate the degree of flooding caused by Duncan River flows. The Duncan River flows recommended are estimated from current data and existing hydrological models.

The ***Mosquito Breeding Habitat*** performance measure is based on a number of findings from the mosquito study:

- The primary human nuisance mosquito species to residents of the Meadow Creek area are Aedes Vexans and Aedes Sticticus. This genus breeds primarily in “low bench” areas and in particular in the grassland meadows around Meadow Creek and the sandbars at the head of Kootenay Lake.

- The remaining marsh, swamp and fen regions of the lower Duncan River floodplain are breeding grounds for other varieties of mosquitoes that feed primarily on birds and amphibians and for the most part are not perceived to be a great nuisance to humans.

- The first and most significant hatch of Aedes mosquitoes occurs in April and May when Duncan Dam discharges are usually negligible. The mosquito hatch appears to be worse when the Lardeau River flow is below average for the time of year. The low flow potentially leads to shallower floodwaters that warm up more quickly than the deeper pools formed in high flood years.

- Floods on grassland and other low bench areas begin to subside as the Lardeau River flow drops in July. However, if large Duncan Dam discharges occur at this time, the Duncan River flow can spill over as surface flooding into the adjacent ponds and marshes, cause backfilling in the sidechannel and lead to increased groundwater levels.

3.0 Fish Performance Measures

3.1 Duncan Reservoir

3.1.1 Fish Stranding

What is the Fish Stranding performance measure?

Fish Stranding is defined as ***the average daily dewatered area in the Duncan Reservoir***. This performance measure estimates the relative risk of fish stranding in the Duncan Reservoir under different operating alternatives.

Where is this performance measure relevant?

In the Duncan Reservoir drawdown zone, and in particular the lower extent of the drawdown zone.

Why is this performance measure important?

It is not known to what degree fish stranding occurs in the Duncan Reservoir nor which periods or elevations are most critical. It is thought to occur at the far northern end of the reservoir once the reserve is drawn down, typically beginning in the early fall when dozens of isolated pools and ponds are formed at the confluence of the upper Duncan River. It is not known to what degree fish stranding impacts fish production, but it is suspected that cyprinids and juvenile rainbow trout are most at risk. Results of the Low Reservoir Impact Study conducted during the Duncan Dam water use planning process did not address the impact of reservoir drawdown on fish stranding.

How does this performance measure affect (or is related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system***.

The ***Fish Stranding*** performance measure estimates the relative risk of fish stranding, which may impact fish production in the Duncan Reservoir and is therefore related to the fish objective.

How can this performance measure be affected by operational changes?

Fish stranding in the Duncan Reservoir drawdown zone is primarily associated with topographic features (low gradient areas, floodplain pools). Pools are located throughout the reservoir drawdown zone and controlled reduction of reservoir elevations will not eliminate fish stranding. In the lower portion of the reservoir drawdown zone, a greater area of the historic floodplain is dewatered with each meter decrease in elevation. Therefore, if water levels are not reduced to the bottom of the reservoir, there would be less fish stranding habitat exposed and accordingly less fish stranded.

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

There is considerable uncertainty associated with this performance measure as fish stranding is a complex issue which is linked to many variables, not simply wetted area. For example, the rate of filling or draining the Duncan Reservoir may significantly affect stranding risk. It is unknown how significant the fish stranding issue is and to what degree it impacts the health of the fish populations in the reservoir.

Fish stranding is likely to occur throughout the Duncan Reservoir drawdown zone, both in low gradient areas as well as the many pools associated with the historic Duncan River floodplain.

How is this performance measure calculated?

The BC Hydro Operations Model provides Duncan Reservoir elevations from specified operating alternatives and is then linked to the Duncan Reservoir Digital Elevation Model.

The ***Fish Stranding*** performance measure reports the additional area above the surface area at the minimum reservoir elevation (22 m^2). The resulting performance is the sum total of both the median cumulative yearly dewatered area between days and the average dewatered area for the 40-year operation review period.

Is there adequate available information to calculate this performance measure?

Yes. The BC Hydro Operations Model provides Duncan Dam discharges from specified operating alternatives.

The Digital Elevation Model provides the additional area at the minimum Duncan Reservoir elevation.

3.1.2 Nutrient Retention

What is the Nutrient Retention performance measure?

Nutrient Rention is defined as ***the disruption of nutrient flow to Kootenay Lake***. This performance measure estimates the quantity of total dissolved phosphorous (TDP) retained in the Duncan Reservoir, as governed by reservoir elevations, outflow rates and inflow TDP concentrations under different operating alternatives. The ***Nutrient Retention*** performance measure was used by the Fish Technical Subcommittee to determine the amount of funding required to compensate for the loss of nutrients to Kootenay Lake due to Duncan Dam operations.

Where is this performance measure relevant?

In the Duncan Reservoir.

Why is this performance measure important?

As initially outlined in a review conducted by Vonk (2001) and further assessed by Perrin and Leake (2004), nutrient retention above Duncan Dam is affected by the operations of the dam, even within the limits of the Columbia River Treaty flood operations requirements. Currently, compensation for nutrient retention effects on Kootenay Lake is provided under the Columbia Basin Fish and Wildlife Compensation Program (CBFWCP), under the assumption that nutrient retention is a footprint issue (i.e., a result of dam construction and Treaty operations).

Subsequent to the final Consultative Committee meeting in April 2004, the Fish Technical Subcommittee undertook further analysis to estimate the amount of nutrient retention caused by operations beyond that caused by the presence of the Duncan Dam and minimum Columbia River Treaty requirements.

Figure F-3 illustrates the degree of flexibility within the Columbia River Treaty flood rule curve requirements.

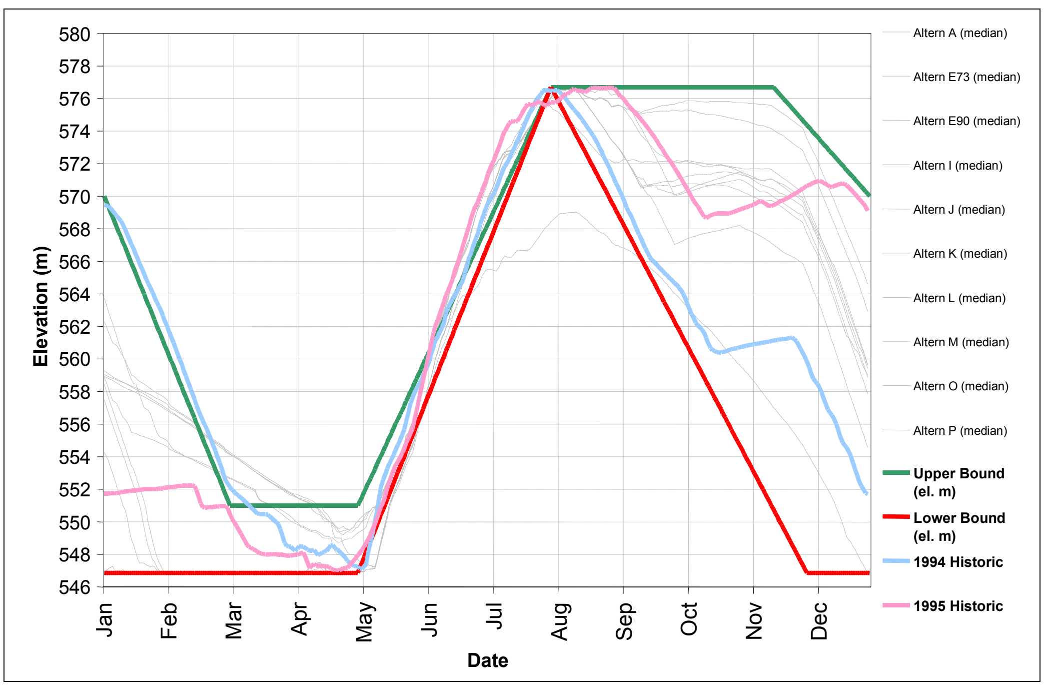


Figure F-3: Duncan Reservoir Elevations Required for the Columbia River Treaty Operations

How does this performance measure affect (or is related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system.***

The ***Nutrient Retention*** performance measure estimates the quantity of total dissolved phosphorous (TDP) retained in the Duncan Reservoir, which may impact fish production and is therefore related to the fish objective.

Reservoir nutrient retention reduces downstream food availability, particularly in Kootenay Lake. Although the issue was originally dropped by the Consultative Committee, this issue was re-introduced upon review of downstream impacts related to Duncan Dam operations.

How can this performance measure be affected by operational changes?

Perrin (1997) reported nutrient retention (expressed as TDP) for a full year between 1994 and 1995. These data are summarized in Table F-2.

Table F-2: Nutrient Retention in Duncan Reservoir by Season, 1994/1995

	1994/95 TDP Concentrations (ug/L)		
	Duncan Dam Inflow		Duncan Dam Outflow
	Duncan River	Small Streams	
Fall	3.2	1.7	1.9
Winter	2.7	2.8	2.4
Spring	4.4	2.6	3
Summer	1.7	1.4	1.7

Equation F-2 illustrates the relationship between the outflow concentration of TDP with seasonal averages of the Duncan Reservoir volume and inflow concentration.

Equation F-2:

$$[TDP]_{outQ} = {11.84 \bullet 10^{8} \bullet [TDP]_{inQ}} \big/ V_{Resvr}$$

where:

$[TDP]_{outQ}$ = concentration of TDP in DDM discharge (ug/L)

$[TDP]_{inQ}$ = concentration of TDP in Duncan River inflow (ug/L)

V_{Resvr} = volume of the Duncan Reservoir in m^3

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

Key assumptions and uncertainties include:

Theoretically, influx of nutrients, residence timing of the storage volume and the transient concentration of nutrients in the storage volume will determine the outflow concentration of nutrients. This relationship is complicated by temperature, turnover, and daily changes in nutrient loading (Arheimer and Wittgren, 2002).

The analysis undertaken for the Duncan Dam water use planning process is based on the empirical relationship expressed above derived from one year of data collected in 1994 and 1995 (Perrin, 1997). This seasonal analysis provided the basis of the relationship assumed to govern outflow concentrations as described by the equation above. While the fit of the equation to the data appears to be strong ($r^2 = 0.86$), fall data do not fit the plot well (refer to Figure F-4 below).

The model also assumes that seasonal influx concentrations of TDP for the period of interest (1968 to 1999) will be the same as those measured in the 1994 to 1995 study. While they may be untrue, given that prevailing weather conditions and forest activities (fires, drought, logging) will affect the concentration of nutrients in inflows, the trend of higher nutrient concentrations in the summer and spring and lower in fall and winter are generally true. This assumption was applied to each operating alternative, assuming the outcome will not be significantly different if known concentrations were used.

How is this performance measure calculated?

Applying the relationship described above, seasonal values of storage, and upper Duncan River TDP concentrations will be integrated to calculate the predicted TDP concentrations of flow from the Duncan Dam for each year and each alternative. These will be integrated by flow volumes from the dam for each year and alternative. The outflow of nutrients subtracted from the influx nutrient load will constitute the retention or loss of TDP in the reservoir:

Equation F-3 illustrates the total retention of TDP calculations.

Equation F-3:

$$TDP_{Rsvr} = TDP_{InQ} - TDP_{OutQ}$$

Seasonal values will be summed for each year and the median, 10th and 90th percentile annual values will be compared between alternatives.

Figure F-4 illustrates the concentration of dissolved phosphorous (TDP) exiting the Duncan Reservoir as a function of storage and TDP Concentration.

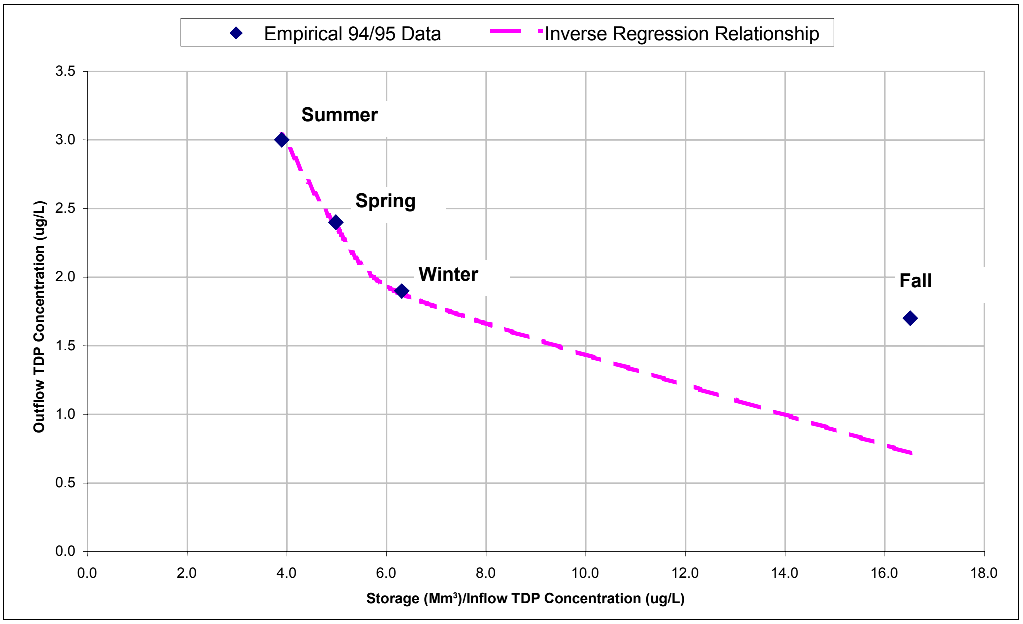


Figure F-4: Concentration of Dissolved Phosphorous (TDP) Exiting the Duncan Reservoir as a Function of Storage and Inflow TDP Concentration

At the final Consultative Committee meeting held in April 2004, members agreed to fund up to $100,000 per year to the CBFWCP nutrient loading program. Currently, the compensation program funds $600,000 per year for the application of 47 tonnes of fertilizer to Kootenay Lake. The operational portion of the nutrient retention is proposed to be calculated as the difference between the selected alternative (S73) and the power optimized alternative (A). The contribution cost is proposed to be calculated as the proportion of the current compensation amount that is calculated as operational.

Equation F-4 illustrates the cost of the contribution to the CBFWCP Nutrient retention program calculation.

Equation F-4:

$$C_{Ops} = \frac{(P_{R,S73} - P_{R,A})}{P_{Comp}} \bullet C_{Comp}$$

where:

C_{Ops}	=	Cost contribution from the Duncan Dam Water Use Plan to the CBFWCP for operational component of nutrients retained in the Duncan Reservoir, in 2003 dollars
$P_{R,\,S73}$	=	Amount of nutrient (tonnes of phosphorous) retained in the reservoir under operating alternative (Alt S (73))
$P_{R,\,A}$	=	Amount of nutrient (tonnes of phosphorous) retained in the reservoir under power optimized alternative (Alt A)
P_{Comp}	=	Compensation amount of nutrient (tonnes of phosphorous) by the CBFWCP
C_{Comp}	=	Compensation cost of nutrient application by CBFWCP, in 2003 dollars

Is there adequate available information to calculate this performance measure?

The ***Nutrient Retention*** performance measure is based on empirical data and does not account for many variables that are known to be important in predicting nutrient retention (e.g., ecological interactions, thermal stratification). However, the information available can be used to provide a relative comparison of operating alternatives and their impact on nutrient retention. Absolute measurements provided by this analysis should be considered preliminary until a more robust predictive model is developed.

3.2 Lower Duncan River

3.2.1 Mainstem Effective Habitat

What are the Mainstem Effective Habitat performance measures?

There are four measures within the ***Effective Habitat*** performance measure for the lower Duncan River mainstem:

Effective Spawning Habitat is defined as ***the area, in hectares, that has the potential to provide effective spawning mainstem habitat that is successful to the end of the incubation period***. This measure is evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.
- Kokanee: spawning 7 September to 21 October, incubating to 15 June.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is not dewatered over the spawning incubation period for whitefish and kokanee under different operating alternatives.

Effective Spawning Habitat Lost is defined as ***area, in hectares, of effective whitefish mainstem habitat lost over the spawning period*** (i.e., those habitats that are spawned in, but not effective). This measure is evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is dewatered and lost over the spawning incubation period for whitefish under different operating alternatives.

Effective Rearing Habitat Lost is defined as ***the area, in hectares, of effective rainbow and kokanee rearing mainstem habitat lost over the rearing period*** (i.e., those habitats that are available for rearing and then dewatered). This measure is evaluated for:

- Rainbow: rearing 1 April to 31 October. The rainbow-rearing period overlaps the kokanee emigration period (1 April to 30 May), and is therefore, the indicator for both species.

This performance measure estimates the quantity of effective habitat in the lower Duncan River that is dewatered and lost over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

Where are these performance measures relevant?

In the lower Duncan River mainstem from Lardeau River confluence to Kootenay Lake.

Table F-3 summarizes the reach breaks as referenced in Miles (2002) and Klohn Crippen (2003).

Table F-3: Duncan River Reach Breaks

Reach Number	Confines	Cross Section	Km Start	Km End
1	Duncan Dam – Lardeau Confluence	–	0	1.1
2	Lardeau Confluence to Sidechannel 13	21, 22, 23	1.1	2.6
3.1	Sidechannel 13 to Meadow Confluence	24, 25, 26	2.6	4.8
3.2	Meadow Confluence to Hamill Creek Confluence	27, 28	4.8	5.7
4	Hamill Creek Confluence to Cooper Creek Confluence	29, 30	5.7	6.6
5.1	Cooper Creek Confluence to Cross Section 35	31, 32, 33, 34, 35	6.6	9.0

Why are these performance measures important?

Maximizing fish productivity in the lower Duncan River mainstem requires the provision of suitable spawning and rearing habitat through Duncan Dam discharges. Habitat area is a function of depth, velocity, substrate condition and cover. The Duncan Dam water use planning process focused on wetted habitat.

The availability of spawning habitat may be limited for fish populations in the Duncan River. Increases in habitat area may lead to increases in fish populations. The provision of habitat during spawning, which is then lost to dewatering in the future, limits the effectiveness of a spawning population, drawing potentially productive spawners into unproductive areas. Provision of quality spawning habitat also benefits other species using the river at the time, through stable flows and spin-offs from increased production of target species.

The availability of rearing habitat may be limited for fry and juveniles by flow regulation, through flow change and in particular, flow reduction.

How do these performance measures affect (or is related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system***.

The ***Effective Spawning Habitat*** performance measure estimates the amount of spawning habitat, which may impact fish production in the lower Duncan River mainstem.

The ***Effective Spawning Habitat Lost*** and the ***Effective Rearing Habitat Lost*** performance measures estimate the amount of spawning and rearing habitat lost, which may impact fish production in the lower Duncan River mainstem.

How can these performance measures be affected by operational changes?

Duncan Dam discharges and Lardeau River flows dominate the hydrograph of the lower Duncan River.

Effective Spawning Performance Measures: Generally, the greater the flow, the larger the spawning habitat created, including the development of sidechannel habitats. Fish sensitivities are related to their life history timing and habitat uses; changes in the availability of spawning and incubation habitats will affect spawning success. Flow reductions proceeding the spawning period, over the incubation period may limit spawning success through egg dewatering.

Effective Rearing Performance Measures: For kokanee, emigration at the start of the rearing period will be evaluated in terms of habitat stability. Habitat instability will result in either fish stranding or lack of use in marginal areas.

What are the key assumptions and uncertainties associated with the impact that these performance measures address?

Key assumptions and uncertainties include:

- *Life History timing:* Life history timing for kokanee and whitefish spawning has been set according to field information collected in 2002 and 2003 (BC Hydro, 2004). This information must be assessed further during the review period to ensure that between-year variation is captured adequately. Rearing periodicity is set to the generally accepted growing season of 1 April to 31 October.

- *Spawning Suitability:* Due to limitations in habitat information (Klohn Crippen, 2003), velocity preferences could not be incorporated into the habitat models for kokanee and whitefish spawners. Further limitations in the resolution of the available data limited the application of typical depth preferences, requiring Fish Technical Subcommittee consent to accommodate through suitability changes (BC Hydro, 2003a).

- *Rearing Suitability:* A 21-day stability measure was used to assess rearing habitat. The untested hypothesis is that fry and juveniles will not utilize habitats unless they are stable for 10-days or greater.

- *Flow–Area Relationship:* The Klohn Crippen data (2003) is based on transects collected in 1996, although calibrations were carried out in 2002 to incorporate changes in water surface relationships that resulted from channel shifts over the 6-year period. Because it was impossible to calibrate for the entire flow series, the data are likely to be less accurate further from the calibration points (~280 m^3/s, and 505 m^3/s).

How are these performance measures calculated?

Effective Spawning Performance Measures: Habitat areas for spawners integrate the wetted area calculated in the Klohn Crippen (2003) river modelling with the suitability criteria.

Table F-4 summarizes the habitat suitability criteria for kokanee and whitefish for the lower Duncan River (BC Hydro, 2003a).

Table F-4: Habitat Suitability Criteria for Kokanee and Whitefish

	Kokanee	Whitefish
Incubation Depth (m):	0.05	0.10
Spawning Depth (m, min):	0.15	0.24
Spawning Depth (m, max):	1.20	10.00

Figure F-5 illustrates the spawning area for whitefish resulting from the integration of habitat suitability criteria and wetted area analysis by Klohn Crippen (2003).

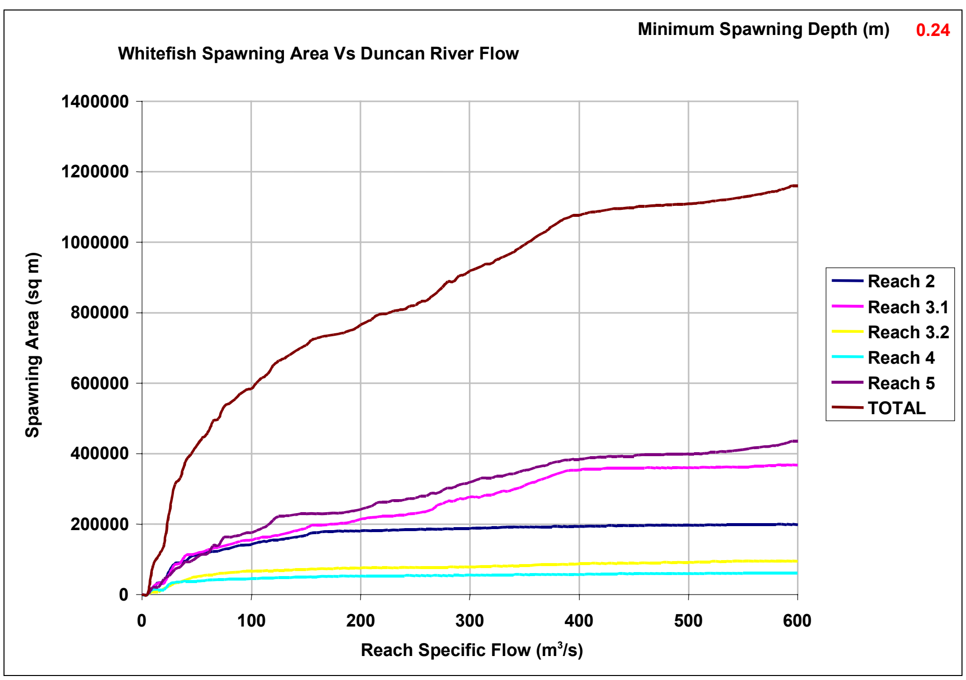


Figure F-5: Spawning Area for Whitefish

Figure F-6 illustrates the spawning area for kokanee resulting from the integration of habitat suitability criteria and wetted area analysis by Klohn Crippen (2003).

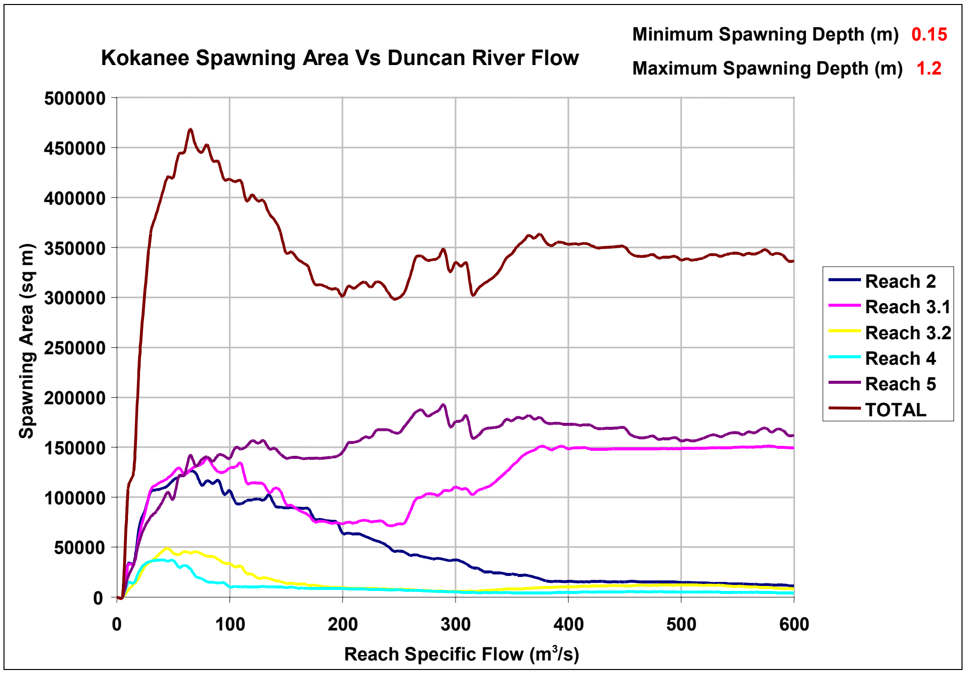


Figure F-6: Spawning Area for Kokanee

***Effective Spawning Habitat Area**:* Estimates the effective spawning habitat limited by discharges that are lower than those spawned in over the duration of egg incubation.

Equation F-5 illustrates the area of effective spawning habitat calculation.

Equation F-5:

$$A_{ES,j_i} = Min\left(\overset{j=j_i}{\underset{j_{eInc}}{A_{S,j}}}\right)$$

where:

$A_{ES,\,ji}$ = Area of effective spawning (sqm), calculated as a minimum

j = julian day; i = day of spawning

e_{inc} = end of incubation, determined by date and/or by ATU count

$A_{S,j}$ = Area of spawning on day j

Equation F-6 illustrates the median area effective spawning habitat calculation.

Equation F-6:

$$A_{ES} = \underset{y_{End}}{\overset{y=y_{St}}{Mdn}} \left(\frac{\sum_{j_{eSp}}^{j=j_{sSp}} A_{ES,j_i}}{j_{sSp} - j_{eSp} + 1} \right)$$

where:

A_{ES}	=	Species specific median effective spawning area (sq.) for the alternative
sSp and *eSp*	=	start and end dates of the spawning period
y_{St} and y_{End}	=	start and end years for the alternative

***Effective Spawning Habitat Lost Area**:* Estimates the area that was spawned in and subsequently dewatered during incubation. This denotes "wasted spawning effort."

Equation F-7 illustrates the area of cumulative dewatered spawning habitat over the spawning season calculation.

Equation F-7:

$$A_{DSH,y} = \sum_{j_{eSp}}^{j=j_{sSp}} A_{S,j} - A_{ES,y}$$

where:

$A_{DSH,y}$	=	the cumulative dewatered spawning habitat over the spawning season in year y.
$A_{s,j}$	=	the area available to spawners on julian day, j
$A_{ES,\,y}$	=	the effective spawning elevation determined for year *y* from equation 2 above

***Effective Rearing Habitat Lost Performance Measure**:* The rearing habitat lost performance measure is based on the wetted area data provided by Klohn Crippen (2003). There are no suitability criteria, except that habitat viability was dependant on 10 days of stability; it was assumed that the minimum habitat over this 10-day period would be considered stable.

Figure F-7 illustrates the rearing habitat area by flow available for rainbow juveniles in the mainstem of the lower Duncan River.

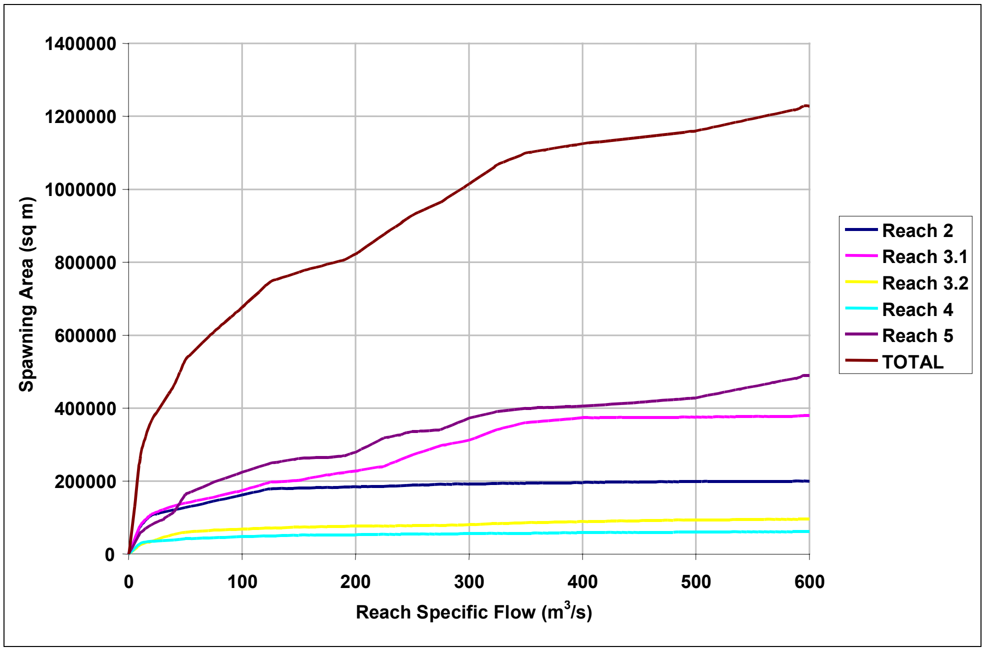


Figure F-7: Rearing Area for Rainbow

***Effective Rearing Habitat Lost Area**:* Estimates the average daily difference between habitat available and previous 10-day minimum (stable) habitats, calculated over the growing period. The performance measure is reports the median, 10th and 90th percentile of the averages calculated for the period of record.

Equation F-8 illustrates the area of rearing habitat lost calculation.

Equation F-8:

$$A_{RHL,j} = A_{R,j} - \min_{j}^{j-9}(A_{R,j})$$

where:

$A_{RHL,j}$ = the area of rearing habitat lost on day *j*

$A_{R,j}$ = the area available to rearers on julian day, j

Fish Periodicity: Fish periodicities are based on compiled regional (Vonk, 2002) and in situ (BC Hydro, 2004) observations of fish use in the lower Duncan River.

Table F-5 summarizes the fish periodicity for species/life histories of interest to the mainstem effective habitat performance measures for the lower Duncan River.

Table F-5: Fish Periodicity for Species/Life Histories for Mainstem Effective Habitat Performance Measures for the Lower Duncan River

Species	Month	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Julian	1	15	32	47	60	74	91	105	121	135	152	166	182	196	213	227	244	258	274	288	305	319	335	349
Kokanee	*Spawning (WUP)*																								
	Incubation (WUP)																								
	Outmigration																								
Mountain Whitefish	*Spawning (WUP)*																								
	Incubation (WUP)																								
Rainbow	*Rearing (WUP)*																								

Is there adequate available information to calculate these performance measures?

In 1996, the Ministry of Water, Land and Air Protection developed an HEC-2 model for the Duncan River. Using the original transect data, a HEC-RAS model of the river was calibrated using current water level information from Klohn-Crippen (2003). Wetted area calculations from this model as representative of habitat availability. Because of the biological uncertainty and the natural variation in river morphology, this information is the best available at this time.

3.2.2 Sidechannel Effective Habitat

What are the Sidechannel Effective Habitat performance measures?

There are five measures within the ***Sidechannel Effective Habitat*** performance measures for the lower Duncan River sidechannel:

Effective Rearing Habitat is defined as ***the area, in hectares, of effective rainbow rearing sidechannel habitat available (wetted area stable for 10 days).*** This measure is evaluated for:

- Rainbow: rearing 1 April to 31 October. The rainbow rearing period overlaps the kokanee emigration period (1 April to 30 May), and is therefore the indicator for both species.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is not dewatered over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

Effective Rearing Habitat Lost is defined as ***the area, in hectares, of effective rainbow and kokanee rearing sidechannel habitat lost***. This measure is evaluated for:

- Kokanee: emigration period 1 April to 31 May.
- Rainbow: rearing period 1 April to 31 October.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is dewatered and lost over a running 10-day rearing period for rainbow and kokanee under different operating alternatives.

Effective Spawning Habitat Lost is defined as ***the area, in hectares, of effective whitefish and kokanee rearing sidechannel habitat lost (i.e., those habitats that are spawned in but not effective).*** This measure is evaluated for:

- Whitefish: spawning 21 October to 21 December, incubating to 31 May.
- Kokanee: spawning 7 September to 21 October, incubating to 15 June.

This performance measure estimates the quantity of effective habitat in the lower Duncan River sidechannel that is dewatered and lost over the spawning incubation period for whitefish and kokanee under different operating alternatives.

Where are these performance measures relevant?

The Duncan River sidechannel FC1, FC11, FH2 and FH4 only. In 1996, the sidechannels were surveyed as part of the HEC-RAS modelling (Klohn Crippen, 2003), but were not modelled to assess impacts of flow changes on the sidechannels of interest.

Table F-6 summarizes the sidechannels of interest.

Table F-6: Sidechannels in the Lower Duncan River and their Wetted Areas Once Mainstem Flows Reach their Invert Elevations

Sidechannel	Wetted (m^2)	Cumulative Wetted Area (m^2)
FC9	194 940	194 940
FH2	486 000	680 940
FC4	121 500	802 440
FC3	110 940	913 380
FC13	77 760	991 140
FC1	1 594 140	2 585 280
FC11	661 500	3 246 780
FH4	194 940	3 441 720
Total	**3 441 720**	

Why are these performance measures important?

Maximizing fish productivity in the lower Duncan River sidechannels requires the provision of suitable spawning and rearing habitat through Duncan Dam discharges. Sidechannel habitats are particularly vulnerable to Duncan Dam operations, where flows adjusted beyond critical thresholds can result in entire sidechannels becoming dewatered. Therefore, it is important to document the level of dewatering (habitat lost) for periods of interest.

The availability of effective sidechannel habitat may be a limiting factor for fish populations in the Duncan River. Increases in sidechannel habitat area may lead to increases in fish populations. The provision of sidechannel habitat during spawning, which is then lost to dewatering in the future, limits the effectiveness of a spawning population, drawing potentially productive spawners into unproductive areas. Rearing salmonids will require the availability of sidechannel habitats, on a seasonal basis, to be stable.

How do these performance measures affect (or are related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system***.

The ***Effective Rearing Habitat*** performance measure estimates the amount of rearing habitat, which may impact fish production in the lower Duncan River sidechannels.

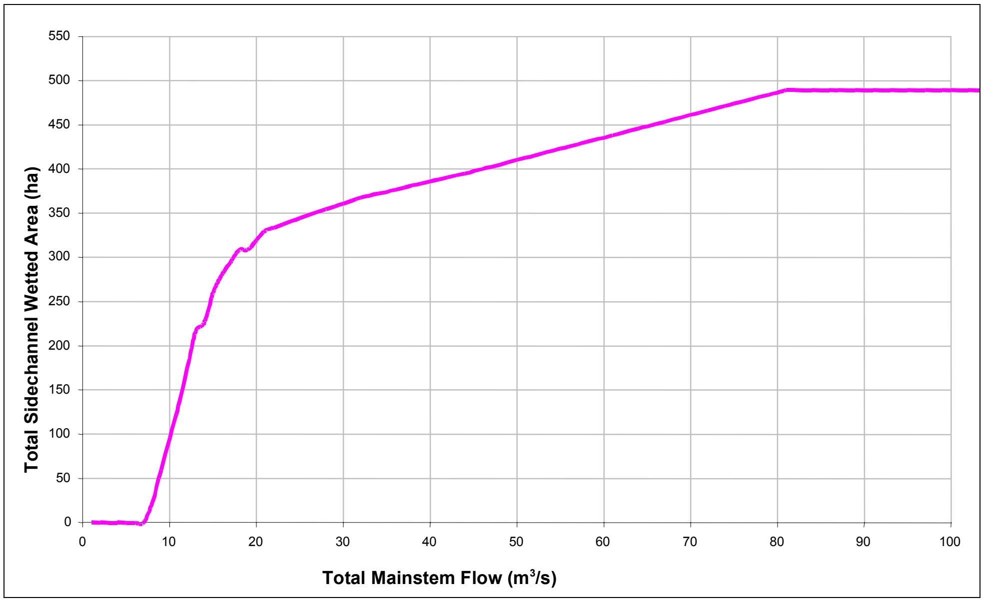
The ***Effective Rearing Habitat Lost*** performance measure estimates the amount of rearing habitat lost which may impact fish production in the lower Duncan River sidechannels.

The ***Effective Spawning Habitat Lost*** performance measure estimates the amount of spawning habitat lost which may impact fish production in the lower Duncan River sidechannels.

How can these performance measures be affected by operational changes?

Duncan Dam discharges and Lardeau River flows dominate the hydrograph of the lower Duncan River. The sidechannel flows can be directly influenced by changes in mainstem flows. A study was undertaken to investigate the relationship between mainstem flow and sidechannel activity during the Duncan Dam water use planning process (van Dishoeck and Gebhart, 2003). The sidechannels invert elevations were surveyed, and then assumptions were made about the depth of water required to activate the channels to 60 per cent. Upon ground truthing (Herbison, 2003) these assumptions were deemed inappropriate and the field results captured for the monitored sidechannels, FC1, FC11, FH2 and FH4 ("Hallum's Sidechannel") were adopted.

Figure F-8 illustrates the relationship between the Duncan River mainstem flow and sidechannel wetted area.



Note: As Measured at Kootenay Lake Confluence.

Figure F-8: Sidechannel Wetted Area (FC1, FC11, FH2 and FH4 only) vs. Mainstem Flow in the Lower Duncan River

Duncan River sidechannels may have limited access to mainstem flow dependant on their invert elevations (the channel elevation at which mainstem flows will conjoin the sidechannel). By changing water surface elevations at sidechannel inverts, operations can wet and dewater habitats by increasing or decreasing dam discharges.

What are the key assumptions and uncertainties associated with the impact that these performance measures address?

Key assumptions and uncertainties include:

Biological System: There is limited information to correlate available habitat with suitable (or usable) habitat in terms of preference by species. In other words, it assumes that wetted sidechannel habitat will be used as suitable spawning habitat for rainbow and kokanee. As well, there is uncertainty regarding the life history timing for some of the key species.

There are also uncertainties pertaining to the geomorphology of the river as the performance measure uses information from 1994 cross sections surveyed for a HEC-2 floodplain model, as well as updated survey information from Klohn Crippen (2003) for sidechannel invert elevations. Miles (2002) estimated that channel narrowing in the lower Duncan River has and will continue to occur since regulation began (1967) and the number of sidechannels will likely decrease over time. It also assumes that instantaneous wetting of sidechannels occurs once mainstem flows exceed invert-flow requirements – normally, areal wetting of sidechannels would change relative to mainstem flow magnitudes.

How are these performance measures calculated?

***Sidechannel Habitat Index**:* Estimates the average sidechannel area available over the life history period of interest.

Equation F-9 illustrates the sidechannel habitat index calculations.

Equation F-9:

$$A_{SC,y_i} = \sum_{j}^{j_{st} \to j_{ed}} A_{SC,j}$$

where:

A_{SC}	=	Area of wetted sidechannels (sq.), calculated as a minimum
j_{st} *and* j_{ed}	=	Start and end date for life history period of interest
y_i	=	year of interest

***Effective Sidechannel Spawning Habitat**:* Estimates the effective spawning habitat limited by discharges and sidechannel inverts that are lower than those spawned in over the duration of egg incubation.

Equation F-10 illustrates the area of effective sidechannel spawning habitat calculations.

Equation F-10:

$$A_{ES,j_i} = Min\left(\overset{j=j_i}{\underset{j_{eInc}}{A_{S,j}}} \right)$$

where:

A_{ES}	=	Area of wetted sidechannels (sq.), calculated as a minimum
j	=	julian day
i	=	day of spawning
e_{inc}	=	end of incubation, determined by date and/or by ATU count
$A_{S,j}$	=	Area of sidechannel spawning on day j

Equation F-11 illustrates the total area of effective sidechannel spawning habitat calculations.

Equation F-11:

$$A_{ES} = Mdn\left(\frac{\sum_{j_{eSp}}^{j=j_{sSp}} A_{ES,j_i}}{j_{sSp} - j_{eSp} + 1}\right)_{y_{End}}^{y=y_{St}}$$

where:

A_{ES}	=	Species specific median effective spawning area (sq.) for the alternative
sSp and *eSp*	=	start and end dates of the spawning period
y_{St} and y_{End}	=	start and end years for the alternative

Equation F-12 illustrates the area of dewatered spawning habitat calculations.

Equation F-12:

$$A_{DSH,y} = \sum_{j_{eSp}}^{j=j_{sSp}} A_{S,j} - A_{ES,y}$$

where:

$A_{DSH,y}$	=	the cumulative dewatered spawning habitat over the spawning season in year y
$A_{s,j}$	=	the area available to spawners on julian day, j
$A_{ES,\ y}$	=	the effective spawning elevation determined for year *y* from Equation F-10 above

The quantity of effective sidechannel spawning habitat available is correlated to specific inflows. For a range of discharges, spawning habitat availability is represented as wetted area.

Is there adequate available information to calculate these performance measures?

Yes. A survey was conducted in the lower Duncan River to provide wetted area calculations, which were used to represent habitat availability during the Duncan Dam water use planning process (van Dishoeck and Gebhart, 2003). Given the biological uncertainty and the natural variation in river morphology, this information is the best that exists. However, it is recommended that additional information be collected as a part of the monitoring program.

3.2.3 Total Gas Pressure

The ***Total Gas Pressure Days/Events*** performance measure is defined as ***the number of days when TPG levels are greater than 115 per cent through spilling and the number of events where consecutive days exceed 115%.*** This performance measure estimates the quantity of TGP under different operating alternatives.

Where is this performance measure relevant?

In the lower Duncan River from the Duncan Dam spillway to the head of Kootenay Lake 11 km downstream.

Why is this performance measure important?

The ***Total Gas Pressure Days/Events*** performance measure provides an indication of the exposure of downstream fish to the risk of gas bubble trauma disease resulting from operation of the Duncan Dam spillway. The measure is relevant throughout the year, and is expressed as the number of days when TPG levels are greater than 115 per cent based on a review of threshold levels conducted for the Columbia River water use planning process (Aspen Applied Sciences, 2002). This threshold is considered a conservative threshold at which gas bubble trauma (GBT) may be observed in fish.

Duncan Dam is known to produce TGP levels in excess of the *BC Water Quality Guidelines* (103 per cent in waters less than 1 m deep, 110 per cent in waters greater than 1 m deep) during periods of spillway discharge. Information collected from recent studies and studies conducted during the Columbia River water use planning process suggest that 115 per cent is a more appropriate level where potential impacts to fish occur (Aspen Applied Sciences, 2002).

Fish exposed to supersaturated water can develop a physically-induced syndrome called GBT, which involves the internal and external growth of gas bubbles that can directly or indirectly (e.g., through stress) lead to fish mortality or reduced productivity.

In addition to the direct observations of GBT and fish mortality below BC Hydro facilities, caged fish experiments have documented substantial mortality in surface waters. Research has demonstrated 50 per cent mortality of fry and juvenile rainbow trout exposed to TGP levels between 123 and 129 per cent saturation in waters less than 1 m deep. This mortality occurred in less than 16 to 24 hours. Adult fish were more severely affected, with 100 per cent mortalities of rainbow trout, mountain whitefish and walleye held at less than 1.5 m for less than 6 hours (RL&L, 2001).

How does this performance measure affect (or is related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system***.

The ***Total Gas Pressure Days/Events*** performance measure measures the number of days when TPG levels are greater than 115 per cent through spilling and the number of events where consecutive days exceed 115%.

How can this performance measure be affected by operational changes?

Duncan Dam discharges may increase the frequency and/or duration of spill, which has the potential to increase TGP levels and risk of GBT in fish. The Fish Technical Subcommittee concluded that TGP concentrations above 115 per cent will be counted as a "TGP Day."

Figure F-9 illustrates the relationship between spill magnitude and TGP threshold levels at the plunge pool below the Duncan Dam spillway outlet (BC Hydro, 2002).

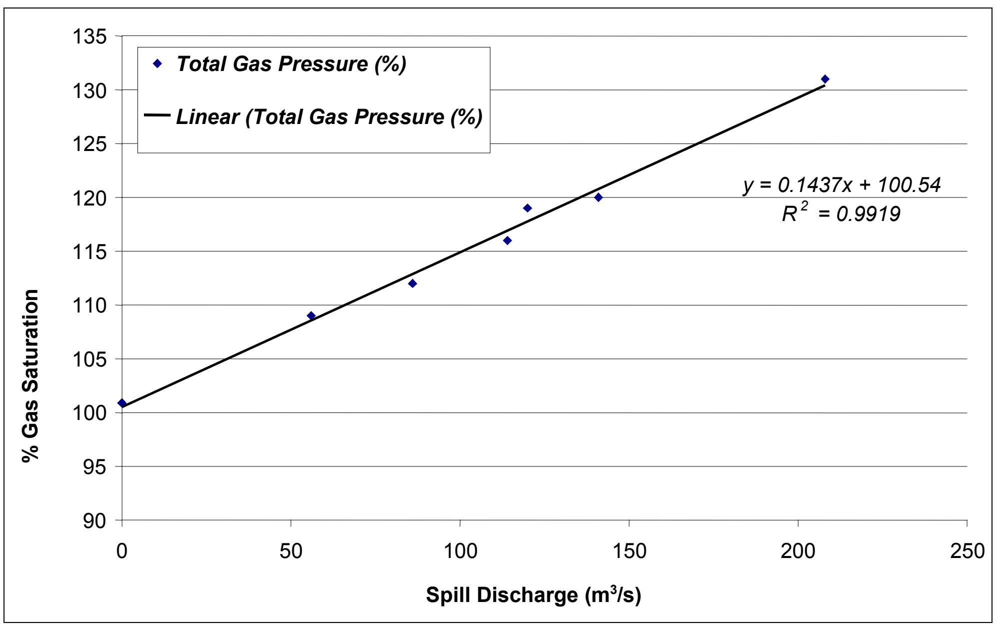


Figure F-9: Total Gas Pressure Levels for Monitored Spill Discharges (BC Hydro, 2002)

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

Key assumptions and uncertainties include:

- Fish behavioural effects caused by TGP and how this impacts fish habitat use is not clearly understood.

- The relationship between spill discharge and TGP (per cent saturation) is linear as shown in Figure F-9.
- Defined TGP threshold levels are representative of fish tolerances in the lower Duncan River.
- Fish are unable to avoid exposure through avoidance behaviours such as moving into deeper water or portions of the water column that have lower TGP levels.
- Water is first discharged through the low level outlet gates (LLOG) and excess water is spilled depending on constraints on outlet operation (maximum discharge capacity, fish weir presence).

How is this performance measure calculated?

The BC Hydro Operations Model provides discharges from the Duncan Dam of specified operating alternatives. This information is then used to determine the frequency, timing and duration of periods when TGP exceeds concentrations of 115 per cent. The performance measure reports the total number of days that TGP exceeds concentrations of 115 per cent over the period of record.

There are two periods, based on the presence of the fish weir, which limit operational flexibility around the LLOG. The threshold discharge calculations are calculated as follows:

1 May to 15 September: Discharge from the LLOG is limited to ≤ 170 m^3/s due to the bull trout weir installation. Discharge from the spillway above 115 m^3/s creates TGP levels above the threshold. Therefore, any dam discharge ≥ 283 m^3/s exceeds the TGP threshold.

Outside 1 May to 15 September as a base (or when fish weir is not installed): Maximum discharge from LLOG can be 283 m^3/s, with discharge from the spillway above 115 m^3/s creating TGP levels above the threshold. Therefore any dam discharge ≥ 398 m^3/s exceeds the threshold.

Is there adequate available information to calculate this performance measure?

Adequate information exists from a variety of sources including BC Hydro's TGP data and historic discharge records to calculate this performance measure.

Currently, the Duncan Dam facility operations modelling is conducted using a daily timestep, which is considered appropriate for assessing the influence of operations on TGP.

3.2.4 Significant Events

What is the Significant Events performance measure?

The ***Significant Events*** (>0.2 m and >0.45 m) performance measure is defined as ***the number of operational changes annually and seasonally that result in "overall river stage change" greater than 0.2 and 0.45 m respectively.*** This performance measure provides an indication of stranding risk under different operating alternatives. Overall, river stage change is a weighted average of cross sectional relationships between discharge and water surface elevation (stage) for the entire river.

Where is this performance measure relevant?

In the lower Duncan River from the Duncan Dam spillway to the head of Kootenay Lake 11 km downstream.

Why is this performance measure important?

As a flood control facility, Duncan Dam has in the past made several operational changes to meet downstream flood control requirements that resulted in significant dewatering of lower Duncan River sidechannels and mainstem habitat. During the Duncan Dam water use planning process, the Consultative Committee considered operational constraints that would limit the amount of this type of operations in the interest of protecting fisheries habitat.

How does this performance measure affect (or is related to) the objective?

The ***Fish*** objective is to ***maximize fish abundance and diversity in the Duncan River system***. This performance measure estimates the stranding risk associated with an operational change which may impact fish production in the lower Duncan River.

How can this performance measure be affected by operational changes?

Any operational regime that increases the frequency of significant events has the potential to increase fish and egg stranding in lower Duncan River mainstem and sidechannel habitats. By adding operational constraints that limit the frequency or degree of operational changes, such risk can be reduced.

Figure F-10 illustrates the relationship between Duncan Dam releases and overall stage change in the lower Duncan River.

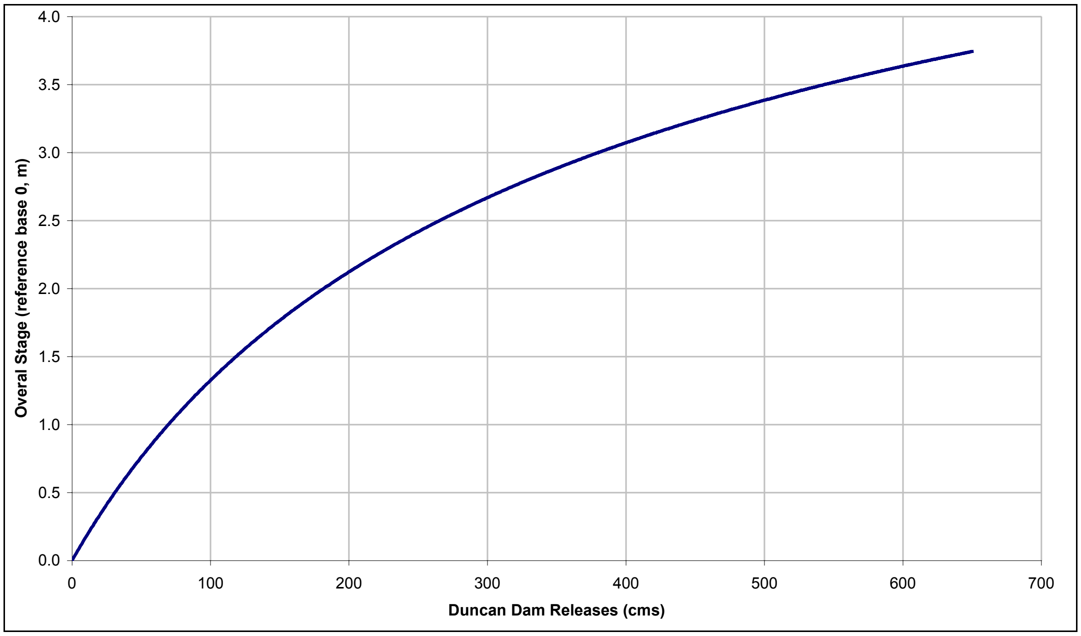


Figure F-10: Relationship between Duncan Dam Releases and Overall Stage Change in the Lower Duncan River

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

Key assumptions and uncertainties include:

- What impact a specific operational constraint would have on the frequency of significant events.

How is this performance measure calculated?

The BC Hydro AMPL model used for the Duncan Dam water use planning process provided discharge data to determine whether between-day changes in releases from Duncan Dam result in a downward stage change of 0.2 m or 0.45 m. Specifically, where instream levels drop beyond either threshold, the operation is then evaluated to determine if the change was due to operations or by natural inflow changes. The occurrence of an event is logged for each threshold.

The calculation is repeated over the years of record for all operating alternatives.

The annual results are communicated as the median, 10th percentile and 90th percentile number of significant events seen within 1 in 30 years of flows for each alternative, for each type of event.

Is there adequate available information to calculate this performance measure?

Overall stage change information was developed from HEC modelling conducted by Klohn Crippen (2003a) for the lower Duncan River, based on 1997 survey data (MELP, 1997) with two flow calibrations which may not represent actual flow levels in the river, but is believed to be appropriate for this application.

4.0 Cultural Resources Performance Measures

4.1 Cultural Site Erosion

What is the Cultural Site Erosion performance measure?

The ***Cultural Site Erosion*** performance measure is defined as ***the number of weighted days Duncan Reservoir is operated within specified elevation bands***. This performance measure estimates the impact of Duncan Dam operations on the protection and integrity of cultural sites identified in the reservoir.

Where is this performance measure relevant?

In the Duncan Reservoir. The ***Cultural Site Erosion*** performance measure assesses erosion risk associated with cultural sites identified within two ranges of reservoir elevations in the drawdown zone: (1) 552 m to 567 m, and (2) above 575 m.

Why is this performance measure important?

When Duncan Reservoir elevations are within the range of the cultural sites, there may be negative effects on the cultural sites that have been identified within the reservoir drawdown zone. These sites are important to First Nations for ceremonial, spiritual and educational uses.

These sites contain important evidence of past habitation, provide opportunities for spiritual rejuvenation and clues that shed light on past practices and lifestyles of British Columbia's indigenous people. Leaving the sites uncovered by water at key times of year may increase the risk of exposed resources being collected by unauthorized people. Loss of artefacts may result in loss of information key to clarifying the past habitation practices of aboriginal people. Further, negative impacts to the resources themselves or negative impacts to the cultural setting of the resources may reduce their value both spiritually and in their ability to provide information on past lifestyles and practices.

How does this performance measure affect (or is related to) the objective?

There are five Cultural Resources objectives:

- ***Protect cultural sites and resources from erosion in the reservoir.***
- ***Protect cultural sites and resources from exploitation in the reservoir.***
- ***Provide opportunities for archaeological investigation in the reservoir.***
- ***Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.***
- ***Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River. (Included in Fish and Wildlife performance measures.)***

The ***Cultural Site Erosion*** performance measure estimates the impact of operations on the protection and integrity of cultural sites identified in the Duncan Reservoir. Specifically, this performance measure evaluates the risk of cultural site erosion due to exposure, surface drainage and wave action. In general, this performance measure provides an indication of duration (and effects based on number of exposure days) that reservoir elevations are within certain undesirable ranges. The duration of reservoir elevations in these ranges should be minimized. This in turn will mitigate erosion effects from wave action and surface drainage.

How can this performance measure be affected by operational changes?

Duncan Reservoir elevations within the range of the cultural sites can result in wave and wind erosion of the sites, contributing to the loss and degradation of the resources. Reservoir operations can minimize impacts by operating outside of the sensitive window, or reduce the period of time reservoir levels are operated within the cultural site zones.

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

Key assumptions and uncertainties include:

- The cultural significance of the sites in the lower Duncan Reservoir elevation zone are higher than the sites observed in the upper reservoir elevation zone.[1]

[1] During the Duncan Dam water use planning process, a surface investigation of a portion of the Duncan Reservoir drawdown zone was conducted in which tools and stone flakes from stone working were found in the upper site. A spear point, stone flakes, stone tools, etc… were found in the lower elevation site(s). The content and full extent of these sites is expected to be determined under the Archaeology study of the monitoring program.

- Exposure of cultural sites during reservoir drawdown has a higher risk of erosion than during reservoir filling.

- Operations have the flexibility to maintain reservoir elevations outside a specified range. This may or may not be possible, because the rate of fill is dependent on natural inflows and the rate of draining may be restricted by other variables (physical capacity of the facilities, Flood Rule Curves). There are also likely limitations associated with the Columbia River Treaty.

- There is not a good understanding of the degree of erosion impact according to number of days of exposure of cultural sites and therefore protection.

How is this performance measure calculated?

The ***Cultural Site Erosion*** performance measure weights the number of days reservoir operations are in each elevation zone by the timing and elevation detailed in Figure F-11. The performance measure reports the 50th, 90th, and 10th percentile of the sum of the "weighted-days" over the evaluation period.

Figure F-11 illustrates the risk weightings for the two reservoir elevation zones containing culturally significant sites.

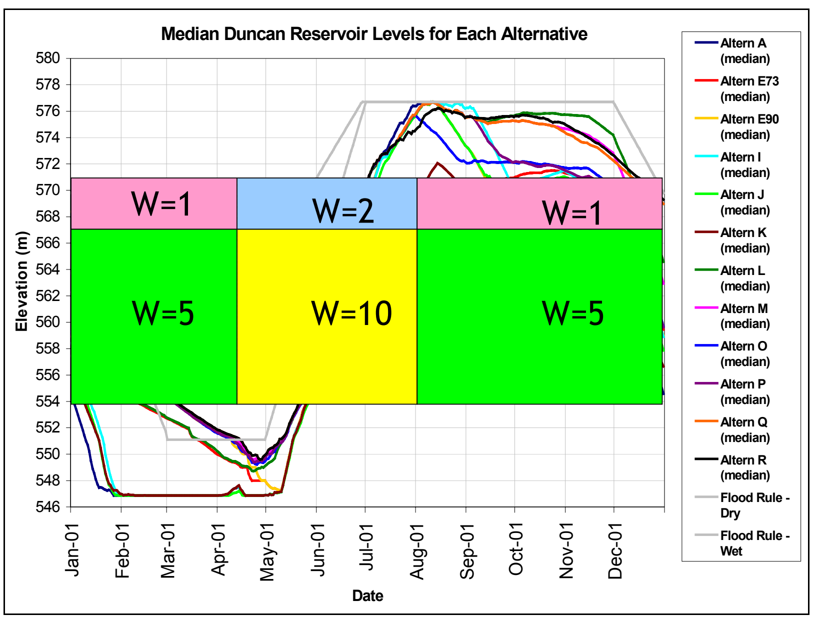


Figure F-11: Risk Weightings for the Two Reservoir Zones Containing Culturally Significant Sites

Is there adequate available information to calculate this performance measure?

The Duncan Reservoir elevations were developed by correlating the recorded daily reservoir elevations with the date of site visits by the archaeologist. The locations of the sites were determined by global positioning satellite (GPS) for the Archaeological Overview Study conducted during the Duncan Dam water use planning process (Choquette, 2002).

4.2 Exploitation Impact

What is the Exploitation Impact performance measure?

The ***Exploitation Impact*** performance measure is defined as ***the number of weighted days the Duncan Reservoir is operated above 570 m between 1 July and 31 October***. This performance measure estimates the impact of Duncan Dam operations on the protection and integrity of cultural sites identified in the reservoir.

Where is this performance measure relevant?

In the Duncan Reservoir drawdown zone. The ***Exploitation Impact*** performance measure assesses the risk of exploitation risk associated with cultural sites identified within two ranges of reservoir elevations in the drawdown zone: (1) 552 m to 567 m, and (2) above 575 m.

Why is this performance measure important?

When Duncan Reservoir elevations are within the range of the cultural sites, there may be negative effects on the cultural sites that have been identified within the reservoir drawdown zone. These sites are important to First Nations for ceremonial, spiritual and educational uses.

These sites may contain important evidence of past habitation, provide opportunities for spiritual rejuvenation and clues that shed light on past practices and lifestyles of British Columbia's indigenous people. Leaving the sites uncovered by water at key times of year may increase the risk of exposed resources being collected by unauthorized people. Loss of artifacts may result in loss of information key to clarifying the past habitation practices of aboriginal people. Further, negative impacts to the resources themselves or negative impacts to the cultural setting of the resources may reduce their value both spiritually and in their ability to provide information on past lifestyles and practices.

How does this performance measure affect (or is related to) the objective?

There are five Cultural Resources objectives:

- ***Protect cultural sites and resources from erosion in the reservoir.***
- ***Protect cultural sites and resources from exploitation in the reservoir.***

- ***Provide opportunities for archaeological investigation in the reservoir.***

- ***Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.***

- ***Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities in the reservoir and along the lower Duncan River. (Included in Fish and Wildlife performance measures.)***

The ***Exploitation Impact*** performance measure is directly linked to the objective of minimizing exploitation of cultural resources. Maintaining Duncan Reservoir elevations above the cultural sites when people are using the reservoir and when sites are not protected by naturally occurring mechanisms (snow) will discourage access to the sites or to potentially exposed artifacts. This performance will also indirectly measure the degree to which non-reservoir impacts (such as vehicular and human impacts from driving, walking or inadvertently digging or probing the site) are minimized. The duration of reservoir elevations in these ranges should be minimized.

How can this performance measure be affected by operational changes?

Options that maintain Duncan Reservoir elevations within the range of the cultural sites during key periods allow access to potentially exposed artifacts, which may then be collected. Reservoir operations can minimize impacts by operating outside of the sensitive window, or reduce the period of time reservoir elevations are operated within the cultural site zones.

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

This performance measure addresses the assumption that cultural sites have been impacted by reservoir operations in the past and that changing reservoir operations and reservoir recreation has potentially contributed to exposure and unauthorized collection of artifacts.

Key assumptions and uncertainties include:

- Cultural resources would be exploited if Duncan Reservoir elevations did not cover the resources.

- That cultural resource exploitation would not happen outside of the specified date range.

- That adequate snow levels are available to mitigate possible exploitation outside the specified date range.

- That these are the only significant cultural sites on Duncan Reservoir.

- That the reservoir elevations provided are accurate.
- That there is a difference in the potential for exploitation at different times of the year, and more so during summer.
- That the primary cultural site is more significant and vulnerable than the secondary site.
- That operations has the flexibility to maintain reservoir elevations in the recommended range.

How is this performance measure calculated?

The ***Exploitation Impact*** performance measure weights the number of days reservoir elevations are in the prescribed range during the desired time of year. The performance measure reports the 50th, 90th, and 10th percentile of the sum of the "weighted-days" over the evaluation period.

Figure F-12 illustrates the risk weightings for the two reservoir zones containing culturally significant sites.

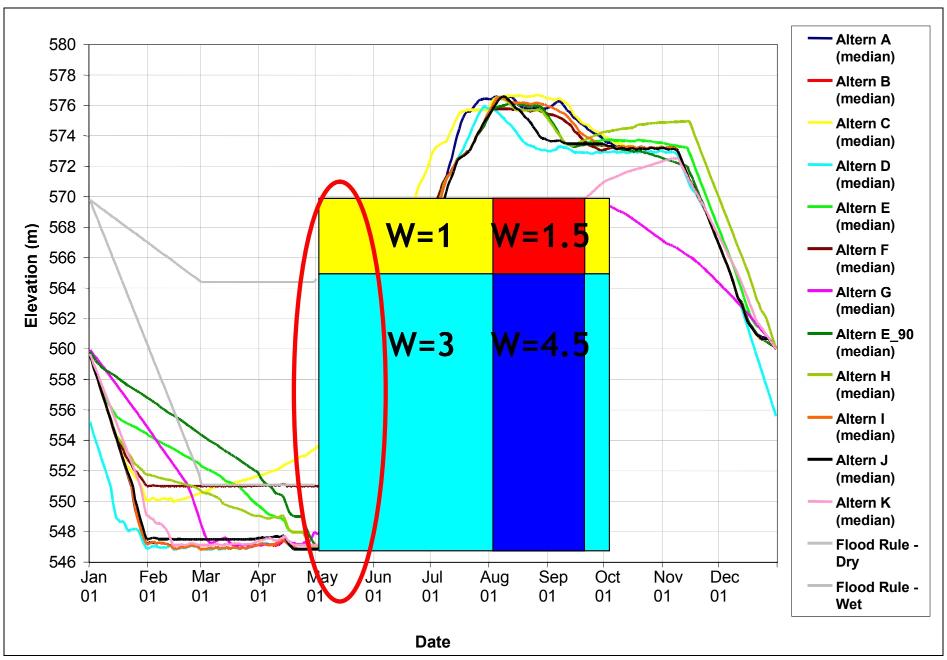


Figure F-12: Risk Weightings for the Two Reservoir Zones Containing Culturally Significant Sites

Weighting: Exploitation impacts are expected to be greatest when recreational use is heaviest. Exploitation impacts are expected to be greatest on the primary site in elevation range 556 and 565 m. Two weighting factors are therefore provided. The first weighting relates to time of year (time of year weighting). For each day that reservoir elevations are below 570 m from 1 July to 1 August, and from 16 September to 31 October, a factor of 1 would be applied, for dates between 2 August and 15 September, a factor of 1.5 would be applied. The second weighting factor relates to reservoir elevations (reservoir elevation weighting). When reservoir elevations cannot be maintained above 570 m, but are above 565 m, a factor of two would be applied to the product of the time of year weighting calculation. When reservoir elevations cannot be maintained above 565 m, a factor of 3 would be applied to the product of the time of year weighting calculation noted above. The formula is:

$$D_{ExImp} = \{[(D_{r1} \text{ x } 2) + (D_{r2} \text{ x } 3)]\ 1\} + \{[(D_{r1a} \text{ x } 2) + (D_{r2a} \text{ x } 3)]\ 1.5\} + \{[(D_{r1b} \text{ x } 2) + (D_{r2b} \text{ x } 3)]\ 1\}$$

Where:

D_{ExImp} = Exploitation Impact Days

D_{r1} = days when reservoir elevations are >565<570 m, 1 July to 1 August.

D_{r2} = days when reservoir elevations are <565 m, 1 July to 1 August.

D_{r1a} = days when reservoir elevations are >565<570 m, 2 August to 15 September.

D_{r2a} = days when reservoir elevations are <565 m, 2 August to 15 September.

D_{r1b} = days when reservoir elevations are >565<570 m, 16 September to 31 October.

D_{r2b} = days when reservoir elevations are <565 m, 16 September to 31 October.

Is there adequate available information to calculate this performance measure?

Yes. The Duncan Reservoir elevations were developed by correlating the recorded daily reservoir elevations with the date of site visits by the archaeologist. The locations of the sites were determined by global positioning satellite (GPS) for the Archaeological Overview Study conducted during the Duncan Dam water use planning process.

5.0 Wildlife Performance Measures

5.1 Riparian Productivity

What are the Reservoir Riparian Productivity performance measures?

The ***Riparian Productivity – Long-term Median*** performance measure is defined as ***the area of herbaceous vegetation in the drawdown zone above the long-term median reservoir elevation mark.***

Potential zones of vegetation have been identified in the reservoir drawdown zone to an elevation of approximately 8 m below full pool based on air photo and video interpretation. The long-term median is the median elevation over the April to October growing period averaged over the years of record, which has been shown on Arrow Lakes and Revelstoke reservoirs to describe the lower extent of herbaceous growth (Moody, 2002).

The ***Riparian Productivity – Inundation Tolerance*** performance measure is defined as ***the area of potential grassland and shrub growth in the reservoir drawdown zone.***

Potential areas of grassland colonization are those with less than five per cent gradient and meet inundation requirements of grasses in the area (Bruce, 2001). Potential areas of shrub colonization are those with less than five per cent gradient, and are of appropriate soil and drainage conditions. Inundation criteria for a shrub community may be derived from an analysis of established communities in terms of proportion of the growing season they are subjected to water level changes over a full generation (Bruce, 2001).

The ***Riparian Productivity*** performance measures estimate the impact of changes in herbaceous, shrub and grassland vegetation productivity in the Duncan Reservoir under different operating alternatives.

Where are these performance measures relevant?

These performance measures are relevant to the area of land below the Duncan Reservoir high water mark (drawdown zone) that is affected by the magnitude and timing of reservoir level fluctuations. Potential areas of herbaceous colonization have been delineated by Moody (2002), and have been analysed using GIS to determine the area of potential colonization by elevation. Most of this area exists within the submerged delta of the upper Duncan River, and adjacent stream mouths. Areas of shrub colonization are assumed to be in those areas of the reservoir drawdown zone with less than a five per cent gradient.

Figure F-13 illustrates the sites reviewed in the wildlife analysis with examples of habitat at low pool.

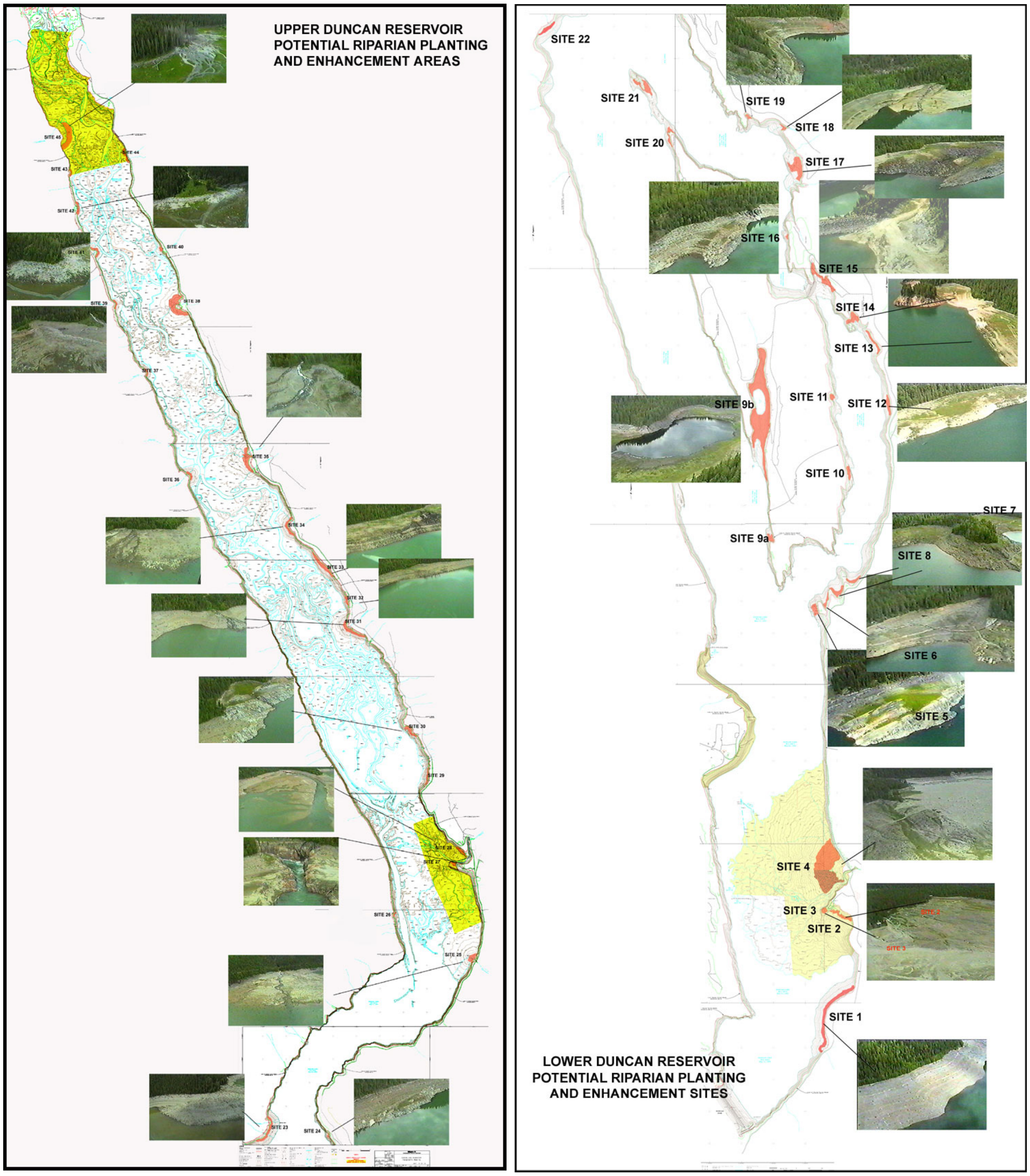


Figure F-13: Sites Reviewed in Wildlife Analysis with Examples of Habitat at Low Pool

Why are these performance measures important?

Riparian and aquatic vegetation provide habitat stability and foraging opportunities for wildlife and fish communities:

- Submerged aquatic vegetation provides habitat for invertebrate populations and is a direct food source for some fish species.

- When reservoir levels are below the riparian zone, carbon and nutrients are transported in surface runoff to adjacent pelagic habitats.

- As reservoir elevations reach their maximum level, riparian habitats become inundated and the decomposition of roots and surface vegetation provides additional carbon and nutrient inputs to adjacent pelagic waters.

- Shrub communities along the reservoir shoreline provide a source of food and cover for wildlife species.

How do these performance measures affect (or are related to) the objective?

The ***Wildlife*** objective is to ***maximize the quality and quantity of available habitat area for wildlife***. These performance measures estimate the impact of changes in herbaceous, shrub and grassland vegetation productivity under different operating alternatives. Operational changes can influence the aerial coverage of herbaceous communities and therefore, reduce the capacity of the system to encourage production. The timing and extent of inundation of shrub communities can influence the function of the riparian area for the system.

How can these performance measures be affected by operational changes?

Lowering the long-term median Duncan Reservoir elevation through slower reservoir filling rates and lower operating maximums result in increased vegetation colonization. However, operations can only influence those areas suitable for plant growth and therefore, the effects of water levels are a portion of the herbaceous production equation.

The establishment of permanent riparian zones and increased productivity of these habitats may be achieved by manipulating Duncan Reservoir levels. For example, delaying the period when the reservoir reaches full pool will extend the effective growing season. Over a series of years, this form of reservoir manipulation could substantially increase the amount and productivity of riparian habitat (shrub and/or herbaceous communities).

What are the key assumptions and uncertainties associated with the impact that these performance measures address?

Key assumptions and uncertainties include:

- The composition of the vegetation communities around the Duncan Reservoir has not been investigated in depth, highlighting the need for more baseline data collection. In addition, the growing period on the reservoir is not well established, and tolerance levels for periods of inundation for the shrub communities are not well understood. It is also recognized that water levels are only one component required for encouraging recruitment, as other factors may be at play (e.g., soil composition, groundwater influences, solar aspects, local climate factors, etc.). It has also been assumed that areas with less than five per cent gradient are adequate for shrub establishment.

- The long-term median elevation mark is a rule of thumb derived from direct analysis of the Revelstoke Reach of the Arrow Lakes Reservoir and of the Arrow Lakes Reservoir main basin riparian communities. Coarse analysis of historic air photos of Duncan Reservoir appears to confirm its application on this reservoir. Further analysis and monitoring are required to determine the reliability of this measure to predict vegetated areas. Analysis of the drawdown zone has been limited to 8 m below full pool.

- Data associated with the elevation distribution of communities in the riparian areas around the Duncan Reservoir were not collected, and therefore, inundation criteria were imported from other systems to describe the inundation tolerances for willow. Actual tolerances should be determined within the Water Use Plan review period for future water use decisions.

How are these performance measures calculated?

Area of herbaceous vegetation in the drawdown zone above the long-term median elevation*:* The extent of herbaceous growth in the reservoir drawdown zone is dependent on the long-term median elevation of the reservoir during the growing season. The lower the median elevation, the more herbaceous area is provided.

Equation F-13 illustrates the long-term median elevation calculation.

Equation F-13:

$$z_{LTM} = \underset{yr=yr_{st}}{\overset{yr_{ed}}{Median}}\left(\underset{d=d_{sg}}{\overset{d_{eg}}{Median}}\left(z_d\right)\right)$$

where:

z_{LTM}	=	long-term median elevation
yr_{st} and yr_{ed}	=	start and end years of evaluation
z_d	=	reservoir elevation on day d
d_{sg} and d_{eg}	=	start and end dates of the growing season

Equation F-14 illustrates the conversion of elevation to area of herbaceous growth, based on the aerial calculations summarized in Figure F-14:

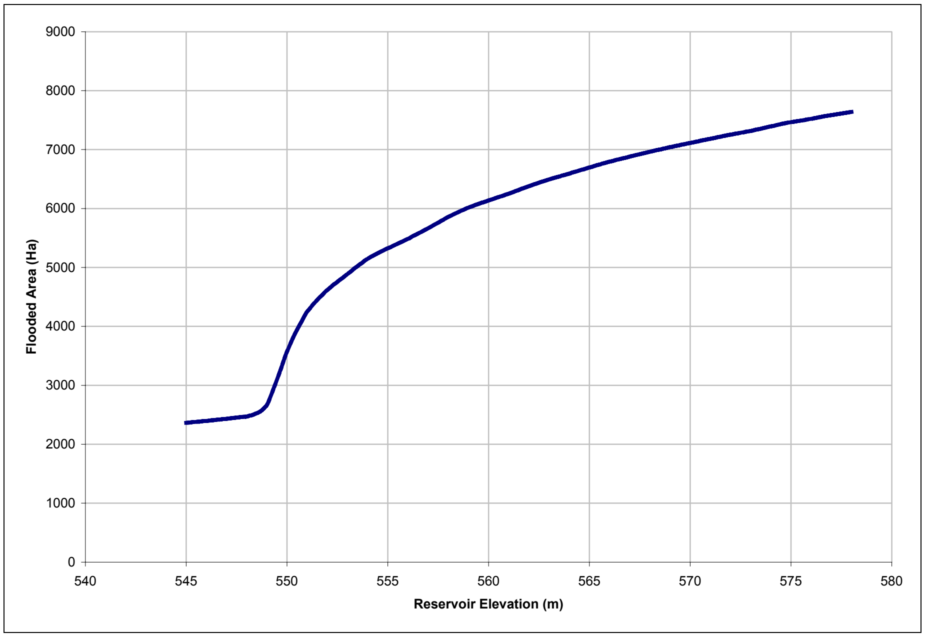


Figure F-14: Number of Hectares of Potential Riparian Area (slope <20%) Flooded

Equation F-14:

$$A_{LTM} = A_{z_{FP}} - A_{z_{LTM}}$$

where:

A_{LTM}	=	area of herbaceous growth above z_{LTM}
z_{fp}	=	reservoir elevation at full pool

Area of riparian community in the drawdown zone*:* The extent of shrub growth in the reservoir drawdown zone is dependent on the amount of exposure a particular elevation band receives over the growing season.

Table F-7 summarizes the range of exposures shrub communities in the Duncan Reservoir are known to withstand.

Table F-7: Range of Exposure Periods Known to Support Willow-Sedge Communities in the Duncan Reservoir Drawdown Zone

	Percentile %	**Proportion of Period Exposed**
Willow-Sedge Community Range	*0.05*	0.64
	0.10	0.78
	0.15	0.84
	0.25	0.85
	0.30	0.91
	0.40	0.94
	0.50	0.96
	0.60	0.99
	0.70	1.00
	0.75	1.00
	0.85	1.00
	0.90	1.00
	0.95	1.00

Notes: The 25th to 75th percentile ranges is the focal point for this performance measure.

(See Mclennan, 2001.) Moody (2002) refined the exposures to reflect conditions in the Duncan Reservoir.

Equation F-15 illustrates the Duncan Reservoir elevation range calculations where exposures match those in the tolerance table above.

Equation F-15:

$$HA_i = \sum_{P=0.25_i}^{0.75} Area(El_{P75} - El_{P25})$$

where:

El	=	Reservoir elevation (m)
Area(El)	=	Unit slope area (ha) found at elevation 'El' that is within ΔEl and has a slope ≤ 15%
P25; P75	=	25th and 75th percentiles

Exposure criterion is met when the sum of square difference between the exposures over a range of reservoir elevations and the criterion are minimized. As the difference approaches zero, the elevation band with exposures closest to the criteria is chosen, and this is repeated for each percentile within the table.

Is there adequate available information to calculate these performance measures?

The ***Riparian Productivity*** performance measures were developed based on professional judgment, a one-day field visit, a review of videos collected during the Low Reservoir Fish Assessment (Golder, 2002), air photo analysis and use of the Digital Elevation Model. While additional analysis and monitoring would refine these performance measures, the present assumptions provide a filter for assessing the operating alternatives.

5.2 Cottonwood Hydrograph Weighted Index

What is the Cottonwood Hydrograph Weighted Index performance measure?

The ***Cottonwood Hydrograph Weighted Index*** is defined as ***the difference between the operating alternative and the cottonwood hydrograph targets***. This performance measure estimates the value of a particular flow in comparison to those aspects of the natural hydrograph that contributes to the recruitment of cottonwoods in the lower Duncan River.

Where is this performance measure relevant?

In the lower Duncan River. The cottonwood performance measure incorporates the impact of the Lardeau River and information on conditions, which may have led to past cottonwood recruitment from seed including peak discharge, seed dispersal timing, and recession limb characteristics from the available literature. Because the measuring point of the historic impacts analysis was above the confluence point of Meadow Creek and Cooper Creek, this performance measure does not include their flow magnitudes in the assessment of flooding risk in the lower Duncan River.

Why is this performance measure important?

- Cottonwoods have been documented as indicators of riparian health and diversity.
- Cottonwood communities are sensitive to regulated flow regimes.
- Recruitment of cottonwood is not at historic levels for the lower Duncan River, although recruitment is occurring.

How does this performance measure affect (or is related to) the objective?

The ***Wildlife*** objective is to ***maximize the quality and quantity of available habitat area for wildlife***. This performance measure estimates the value of a particular flow in comparison to those aspects of the natural hydrograph that contribute to the recruitment of cottonwoods in the lower Duncan River.

While maintaining a diversity of riparian habitats in the lower Duncan River is a sub-objective within the Duncan Dam water use planning process, it is recognized that measuring each species that comprises the community is difficult. Therefore, cottonwoods was chosen as an indicator species for riparian health.

How can this performance measure be affected by operational changes?

Factors influencing cottonwood recruitment from seed include presence of exposed mineral soil, peak flows and recession limb suitable for seed germination and growth, and limiting water levels in the first year of growth, which may flush seedlings away.

There are three critical components to a "cottonwood friendly" operating alternative:

- Flooding period: Between June and July, provide flows well above fall to spring base flows.
- Recession period: Prior to mid August, ensure that flooding has subsided.
- Overwintering period: Over the winter and early spring months, ensure that no flooding occurs.

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

While there are no quantifiable linkages between flow release/timing and cottonwood productivity, the link between dynamic flood processes and cottonwood life history strategies has been well documented. River systems with highly regulated flows typically lack seed-generated cottonwood.

Key assumptions and uncertainties include:

- Flooding period: Cottonwood seeds germinate only on mineral soil, so high flows that create new sand/gravel deposits and deposit seeds on mineral deposits above base flow levels are considered to be important.
- Recession period: Cottonwood seed dispersal occurs during the time of normal natural flood recession in July. Germinants are drought-sensitive so they require the moist conditions created by gradual receding floodwaters.
- Overwintering period: Ice scouring or fast, high flows are known to be detrimental for small seedlings, so it is assumed that flooding during the winter months is undesirable for cottonwood.

How is the performance measure calculated?

A weighting sequence was developed to penalize those flows outside of the objective range and to more positively weight those flows that promote cottonwood recruitment. The weighting penalties are applied against the difference between the operating alternative flow and the natural hydrograph flow on a daily basis. The sum of these values is calculated for the year, and indexed such that the performance measure value is on a 0–1 scale: 0 = worst; 1 = closest to natural.

Figure F-15 illustrates the weighted index applied to specific flows in the lower Duncan River.

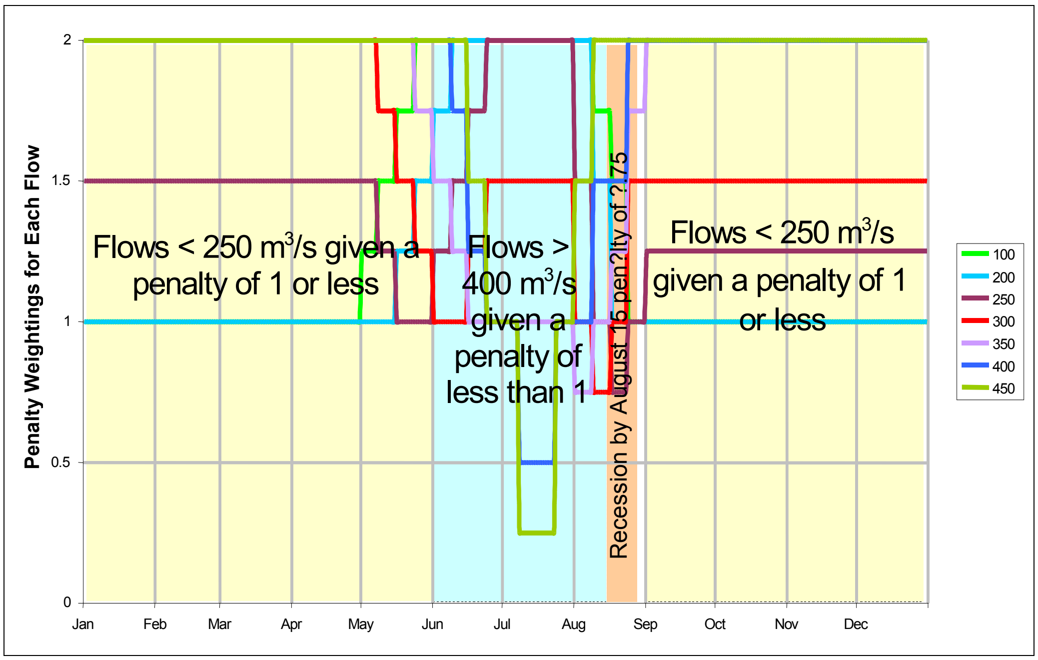


Figure F-15:   Cottonwood-Hydrograph Weighting Sequence

Figure F-16 illustrates the natural hydrograph flow in the lower Duncan River.

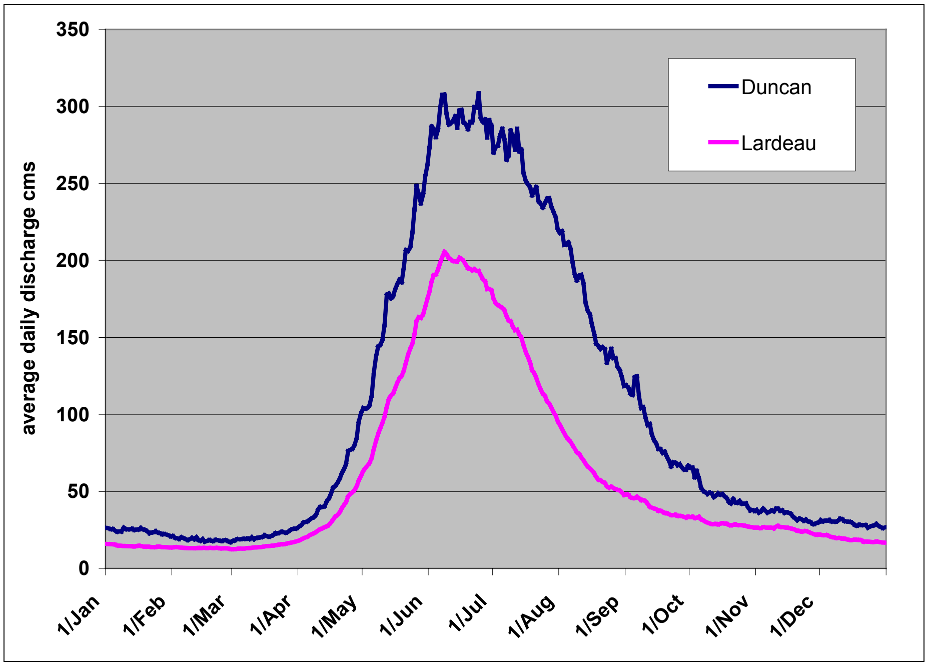


Figure F-16: Natural Hydrograph Objective Flows in the Lower Duncan River

Is there adequate available information to calculate this performance measure?

Data collected on the lower Duncan River (Klohn Crippen, 2003), and a review of existing literature (Herbison, 2002) were used to develop this performance measure. The Wildlife Technical Subcommittee supported the use of a hydrographic measure to evaluate the operating alternatives.

6.0 Flood Management Performance Measure

6.1 Flood Risk

What is the Flood Risk performance measure?

The ***Flood Risk*** performance measure is defined as ***number of days that flows in the lower Duncan River exceed threshold levels.*** This performance measure estimates the quantity of flooding under different operating alternatives.[1]

[1] This performance measure was merged with the Mosquito Breeding Habitat measure into the Flood/Mosquito Risk measure because they behaved identically.

Where is this performance measure relevant?

In the lower Duncan River from Duncan Dam to Kootenay Lake and includes Meadow Creek where backwatering from the Duncan River can influence flooding along Meadow Creek, Cooper Creek Cedar and nearby farmland.

Why is this performance measure important?

When high flow (flooding) events occur on the lower Duncan River, there are several areas within the floodplain where inundation problems have been identified. During high flows in July 2002, private property was flooded at a number of points along the river, which increased in magnitude as river discharges increased above 400 m^3/s.

Flooding impacts may include equipment damage, loss of employment, potential loss of agricultural production (primarily hay), and other water-related effects to private property.

How does this performance measure affect (or is related to) the objective?

The ***Flood*** objective is to ***minimize the flood damage to people and property on the lower Duncan River.*** The ***Flood Risk*** performance measure estimates the impact of Duncan Dam discharges, combined with Lardeau River discharges, on inundation (flooding) of private property on the floodplain of the lower Duncan River. The performance measure is relevant year round, though most likely to occur during the summer months when the Lardeau River discharge is high and the Duncan Reservoir is near (or has reached) full pool.

How can this performance measure be affected by operational changes?

Flooding on the lower Duncan River can and will occur regardless of operations of the Duncan Dam. This is primarily the result of high flows on the Lardeau River during the freshet, in combination with local rain events, groundwater influences, and other tributary influences. Operations of the Duncan Dam may, however, reduce both the likelihood and degree of flooding by reducing discharges at critical times by storing water in the Duncan Reservoir (depending on its available storage). Flooding in the lower Duncan River can occur as a result of both groundwater infiltrations as well as overbank flow.

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

Flooding in the lower Duncan River floodplain will continue to occur as it is dependent on tributary inflows, local weather patterns, groundwater effects, and Kootenay Lake levels (in the lower reaches). The performance measure will provide an indication of the relative risk of flooding associated with different Duncan Dam operating alternatives.

Key assumptions and uncertainties include:

- Maximum flows in the lower Duncan River are represented by the daily averages as generated in the BC Hydro Operations Model. In reality, instantaneous flows may be measurably higher.

- The degree of impact associated with larger flow events in the lower Duncan River is not well documented.

- Changes in the riverbed do not occur. Changes will occur in lower Duncan River channel morphology and sediment deposition; this may influence the discharge (positive or negative) at which flooding of private properties occur in the future.

- Local events or watershed issues do not increase local flooding or inundation risk. This includes logging practices, land development around the area, or even debris events like log jams clogging the river or channels in areas.

How is this performance measure calculated?

The ***Flood Risk*** performance measure estimates the number of flood risk days (as defined below) that occur annually over the number of years of record according to the Water Survey of Canada gauge, which is located below the confluence of the Lardeau River in the lower Duncan River. It is anticipated that discharges greater than one day in duration will allow water to seep/flow into low-lying areas. Soil characteristics limit the ability of water to recede and also affect access (soft ground) over the longer term.

To better represent the timing and magnitude of flooding events, each flood risk day is categorized according to the following flow thresholds:

- *> 400 m^3/s:* Flow relates to no surface water pooling on farmland, water backing up Meadow Creek, but not overtop of banks into Cooper Creek Cedar. This level relates to what some people like to refer as bankfull. There is no real flooding per se, but seepage is starting and there is risk of flooding from any increases (e.g., rain events).

- *> 450 m^3/s:* Flow relates to water overtopping the banks at Cooper Creek Cedar and into the mill yard. There is a potential for wood chips, etc. to be washed into the stream. There is also low area flooding by Rempell's and Jacob's property, and water is near bankfull at Deer Farm with limited flooding.

- *> 500 m^3/s:* Flow relates to when water is high enough to get into the electrical shed at Cooper Creek Cedar and the mill has to shut down. There is extensive flooding of low-lying areas (where the hayfields are located).

- *8 August:* Flooding (450 m^3/s to 500 m^3/s and above) which occurs before this date leads to an increased risk that hay crops will not be able to be harvested. Flooding after this date will generally have less financial impact to local farmers.

Is there adequate available information to calculate this performance measure?

The ***Flood Risk*** performance measure was derived from information supplied from local residents, BC Hydro operators and staff, aerial surveys and measurements taken in July 2003 (and from earlier flooding events), and survey data which was correlated to the real time water gauge in the lower Duncan River. This gauging station is maintained, monitored and stage-discharge curves updated by the Water Survey of Canada Staff.

7.0 Power Generation Performance Measures

7.1 Power Generation

What are the Power Generation performance measures?

There are two measures within the Power Generation performance measure:

- ***Power – Kootenay River*** is defined as ***the average annual power in megawatts (MWhrs) from the combined power generation of the Kootenay River plants.*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River plants under different operating alternatives.

- The ***Operation Flexibility*** performance measure is defined as the ***number of days per year that Duncan Dam operations are constrained***. This performance measure estimates the impact to other Columbia River projects (U.S./Canada) from a constrained Duncan Dam operation under different operating alternatives.

Where are these performance measures relevant?

Kootenay River plants and other Columbia River Treaty reservoirs.

Why are these performance measures important?

Represents the total power generated that the Province would receive from the combined generation of the Kootenay River plants under each alternative. Although Duncan Dam has no generation facilities, the regulated outflow hydrograph from Duncan Dam affects the annual power generation achieved at all downstream projects on the Kootenay River and the United States mainstem Columbia River.

How do these performance measure affect (or are related to) the objective?

The ***Power Generation*** objective is to ***minimize economic impacts to both the Kootenay River and the Columbia River generation system.*** These performance measures estimates the total power generated that the province would receive from the combined generation of the Kootenay River plants under each alternative and the potential impacts downstream projects on the Kootenay River and the United States mainstem Columbia River.

How can these performance measures be affected by operational changes?

In a typical water year, operations that are optimal for power generation will draft the Duncan Reservoir lower, and keep the reservoir higher for a longer period, than would be required purely for flood control. The costs associated with sub-optimal power generation arise from:

- Operations which increase the amount of water that is spilled at one or more downstream generating plants that could otherwise have been used for power generation.
- Operations that increase power generation during time periods when the value of generation is typically lower (i.e., March through June when supply is great and demand low, or within day shifts from higher value daytime generation to lower value night time generation).
- Operations that decrease power generation during time periods when the value of generation is typically higher (the reverse of the examples noted above).
- Operations that require spilling from Hugh Keenleyside Dam, or curtail generation from ALGS to meet downstream Columbia River Treaty requirements.

What are the key assumptions and uncertainties associated with the impact that these performance measures address?

The following downstream constraints have been incorporated into the BC Hydro Operations Model for the performance measures calculations:

- Columbia River Treaty requirements downstream of the Kootenay and Columbia rivers confluence.
- International Joint Committee (IJC) flood rule curves for Kootenay Lake.
- Brilliant Expansion Project which is expected to be in commercial operation in September 2006 and will increase the maximum turbine discharge to 1067 m^3/s from 582 m^3/s, including the minimum flow agreement.
- An implemented variable flow regime from Libby Dam (VarQ25kcfs).

- An assumed operation of Revelstoke Dam and Arrow Lakes inflows, including limitations on ALGS power generation due to low reservoir elevations.

How are these performance measures calculated?

Flow released from Duncan Dam passes through Kootenay Lake and then flows through FortisBC (formerly Aquila), City of Nelson, BC Hydro and Columbia Power Corporation's generating stations downstream on the Kootenay River. In total, seven generating plants exist downstream on the Kootenay River including BC Hydro's Kootenay Canal project.

Each Kootenay River generating plant is represented as a run-of-river facility within the BC Hydro Operations model (daily inflow = daily outflow, no net change in headpond storage). Daily power generation is calculated separately for each plant except for the City of Nelson plant that is approximated by the model as a higher flow through the Upper Bonnington plant.

The historical natural inflow to Kootenay Lake, the Lardeau River flows, the Slocan River flows and the simulated Libby Regulated Outflow remain constant for all operating alternatives. Thus, the only change to the Kootenay River outflow, and the corresponding generation at the run-of-river generating plants, is associated with changes to the regulated Duncan Dam outflow for each operating alternative. Given that this is a dynamic system where various aspects of the operation are governed by international agreements that impact the co-ordinated operation of the Kootenay and Columbia river systems, this approach provides a scoping level approximation of potential power generation impacts.

Equation F-16 illustrates the power generation calculation within the optimization.

The following equation is used for the power calculation within the optimization:

Equation F-16

$$\text{Power} = 9810\ \text{N/m}^3 * \text{Turbine Discharge} * (\text{Res Elev} - \text{Tailwater elev}) * \text{efficiency}$$

where:

Power (Watt)	=	calculated power
Turbine discharge (m^3/s)	=	optimized variable
Efficiency	=	single value, average power conversion efficiency representing the combined generator and turbine efficiencies and all friction losses over the range of normal operation.

Reservoir Elevation

= (Max Res Elev + Min Res Elev)/2[1]

for scenarios run in linear solution mode. (For projects where variations in reservoir elevation are relatively small compared to the total gross head on the plant, the use of an average reservoir elevation and linear solution mode can significantly decrease run times with little effect on the annual power calculation.)

= daily reservoir elevation for scenarios run in non-linear solution mode

Tailwater Elevation
= a single fixed value representing average tailwater conditions.

Table F-8 summarizes the power calculation parameters input for each of the Kootenay River plants.

Table F-8: Duncan Dam Water Use Plan Power Studies: Operations Model Configuration for Kootenay River Plants

Project	**Typical Reservoir Elevation (m)** (modelled as constant year-round)	**Typical Tailwater Elevation (m)** (modelled as constant year-round)	**Typical Plant Efficiency** (gross head power conversion)	**Typical Maximum Turbine Discharge (m^3/s)**	**Within Day Peaking Occurs ?**
Kootenay Canal	530.4	450.1	0.88	828	Yes
Corra Linn	530.4	513.0	0.79	340	No
Upper Bonnington + City of Nelson	513.0	491.0	0.80	410	No
Lower Bonnington	491.0	470.5	0.81	268	No
South Slocan	470.5	450.1	0.81	300	No
Brilliant Historic (pre-upgrade)	450.1	419.5	0.81	526	Yes
Brilliant Current (post upgrade)	450.1	419.5	0.85	582	Yes
Brilliant Future (post expansion)	450.1	419.5	0.88	1067	Yes

Table F-9 shows the resulting plant output for Kootenay River minimum flow conditions (142 m^3/s) and shows the plant output at typical maximum turbine discharge.

[1] "Min" is the minimum value in the data series of interest; "Max" is the maximum value in the data series; and "Med" is the median value in the data series.

Table F-9: Duncan Dam Water Use Plan Power Studies: Kootenay River Plant Outputs at 142 m^3/s and at Maximum Turbine Discharge

Project	Plant Output (MW) at 142 m^3/s (Kootenay River Minimum Flow)	Plant Output (MW) at Typical Maximum Turbine Discharge	Hugh Keenleyside Dam MWh/ m^3/s day
Kootenay Canal		574.0	16.6
Corra Linn	19.2	45.9	3.2
Upper Bonnington + City of Nelson	24.5	70.8	4.1
Lower Bonnington	23.1	43.7	3.9
South Slocan	23.0	48.6	3.9
Brilliant Historic (pre-upgrade)		127.5	5.8
Brilliant Current (post upgrade)		149.0	6.1
Brilliant Future (post expansion)		281.0	6.3

Is there adequate available information to calculate these performance measures?

Yes.

Is there adequate information to calculate these performance measures?

Yes. For each operating alternative, the BC Hydro Operations Model provides daily data on Duncan Reservoir elevation, Duncan Dam discharges, lower Duncan River flows, Kootenay Lake elevations, Kootenay River power, and lower Columbia River power generation for 20 years (1968 to 1987) of simulated flow operation. These outputs serve as inputs to the Environmental Model and the Power Values Model to calculate the performance measures for each alternative.

7.2 Financial Revenue

What are the Financial Revenue performance measures?

There are three measures within the Financial Revenue performance measure:

The ***Financial Revenue: Kootenay River and Lower Columbia River*** performance measure is defined as ***the estimated average annual value of electricity (VOE) in $/year from the combined power generation of the Kootenay River and lower Columbia River plants compared to Alternative A – Current Operations.*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River and lower Columbia River plants under different operating alternatives.

The ***Financial Revenue: Kootenay River*** performance measure is defined as ***the VOE in $/year from the combined power generation of the Kootenay River plants compared to Alternative A – Current Operations..*** This performance measure estimates the total amount of the power generated from the combined power generation of the Kootenay River plants under different operating alternatives.

The ***Financial Revenue: Lower Columbia River*** performance measure is defined as ***the VOE in $/year from the power generation at the Arrow Lakes Generating Station on the lower Columbia River compared to Alternative A – Current Operations..*** This performance measure estimates the total amount of the power generated from this lower Columbia River plant under different operating alternatives.

Where are these performance measures relevant?

The value of power generation on the Kootenay River system and at Arrow Lakes Generating Station (ALGS) were modelled and evaluated in the Duncan Dam water use planning process.

Why are these performance measures important?

These performance measures represent the direct financial impact associated with the proposed operating scenarios.

How do these performance measures affect (or is related to) the objective?

The ***Power Generation*** objective is to ***minimize economic impacts to both the Kootenay River and the Columbia River generation system.*** This performance measure estimates the total value of the power generated from the combined power generation of both the Kootenay River and the Columbia River generation system against a power optimization operating alternative.

How can these performance measures be affected by operational changes?

In a typical water year, operations that are optimal for power generation will draft the Duncan Reservoir lower and keep the reservoir higher for a longer period than would be required solely for flood control. The costs associated with sub-optimal power generation arise from:

- Operations that increase the amount of water spilled at one or more downstream generating plants that could otherwise have been used for power generation.

- Operations that increase power generation during time periods when the value of generation is typically lower (i.e., March through June when supply is great and demand low, or within day shifts from higher value daytime generation to lower value night time generation).

- Operations that decrease power generation during time periods when the value of generation is typically higher (the reverse of the examples noted above).

- Operations that require spilling from Hugh Keenleyside Dam, or curtail generation from ALGS to meet downstream Columbia River Treaty requirements.

What are the key assumptions and uncertainties associated with the impact that these performance measures address?

The following downstream constraints have been incorporated into the BC Hydro Operations Model for the performance measures calculations:

- Columbia River Treaty requirements downstream of the Kootenay and Columbia rivers confluence.

- International Joint Committee (IJC) flood rule curves for Kootenay Lake.

- Brilliant Expansion Project, which is expected to be completed in 2006 and will increase the maximum turbine discharge from 582 m^3/s to 1067 m^3/s, including the minimum flow agreement.

- An implemented variable flow regime from Libby Dam (VarQ25kcfs).

- An assumed operation of Revelstoke Dam and Arrow Lakes inflows, including limitations on ALGS power generation due to low reservoir elevations.

How are these performance measures calculated?

Flow released from Duncan Dam passes through Kootenay Lake and then flows through FortisBC (formerly Aquila), City of Nelson, BC Hydro and Columbia Power Corporation's generating stations downstream on the Kootenay River. In total, seven generating plants exist downstream on the Kootenay River including BC Hydro's Kootenay Canal project.

Each Kootenay River generating plant is represented as a run-of-river facility within the BC Hydro Operations model (daily inflow = daily outflow, no net change in headpond storage). Daily power generation is calculated separately for each plant, except for the City of Nelson plant that is approximated by the model as a higher flow through the Upper Bonnington plant.

ALGS operations are optimized where possible to maximize power generation opportunities, given limitations on a reservoir operating range and downstream Columbia River Treaty requirements. An assumed Revelstoke Dam operation and Arrow Lakes inflows provide the hydrology for the system above ALGS.

The historical natural inflow to Kootenay Lake, Lardeau River flows, Slocan River flows and the simulated Libby Regulated Outflow remain constant for all operating alternatives. Thus, the only change to the Kootenay River outflow and the corresponding generation at the run-of-river generating plants is associated with changes to the regulated Duncan Dam outflow for each operating alternative. Given that this is a dynamic system where various aspects of the operation are governed by international agreements that impact the co-ordinated operation of the Kootenay and Columbia river systems, this approach provides a scoping level approximation of potential power generation impacts.

Equation F-17 illustrates the power generation calculation within the optimization.

Equation F-17:

Power = 9810 N/m^3 * Turbine Discharge * (Res Elev – Tailwater elev) * efficiency

where:

Power (Watt)	=	calculated power
Turbine discharge (m^3/s)	=	optimized variable
Efficiency	=	single value, average power conversion efficiency representing the combined generator and turbine efficiencies and all friction losses over the range of normal operation.

Reservoir Elevation

= (Max Res Elev + Min Res Elev)/2

for scenarios run in linear solution mode. (For projects where variations in reservoir elevation are relatively small compared to the total gross head on the plant, the use of an average reservoir elevation and linear solution mode can significantly decrease run times with little effect on the annual power calculation.)

= daily reservoir elevation for scenarios run in non-linear solution mode

Tailwater Elevation
= a single fixed value representing average tailwater conditions.

Table F-10 and Table F-11 summarize the power calculation parameters input for each plant included in the model. Note that the Brilliant Future (post expansion) data was used for the Water Use Plan modelling..

Table F-10: Duncan Dam Water Use Plan Power Studies: Operations Model Configuration for Kootenay River Plants

Project	**Typical Reservoir Elevation (m)** (modelled as constant year-round)	**Typical Tailwater Elevation (m)** (modelled as constant year-round)	**Typical Plant Efficiency** (gross head power conversion)	**Typical Maximum Turbine Discharge (m^3/s)**	**Within Day Peaking Occurs?**
Kootenay Canal	530.4	450.1	0.88	828	Yes
Corra Linn	530.4	513.0	0.79	340	No
Upper Bonnington + City of Nelson	513.0	491.0	0.80	410	No
Lower Bonnington	491.0	470.5	0.81	268	No
South Slocan	470.5	450.1	0.81	300	No
Brilliant Future (post expansion)	450.1	419.5	0.88	1067	Yes

Table F-11: Duncan Water Use Plan Power Studies: Operations Model Configuration for Arrow Lakes Generating Station

Project	**Typical Reservoir Elevation (m)** (modelled as constant year-round)	**Typical Tailwater Elevation (m)** (modelled as constant year-round)	**Typical Plant Efficiency** (gross head power conversion)	**Typical Maximum Turbine Discharge (m^3/s)**	**Within Day Peaking Occurs?**
Arrow Lakes Generating Station	Minimum Turbine operating level = 424.6 m Maximum Reservoir = 440.1 m Scenario generation is based on the Daily Arrow Lakes Reservoir Elevation calculated within the model	419.9 m	0.90	1115 m^3/s above Reservoir 430.6 m Limited by approach channel capacity below Reservoir 430.6 m Maximum MW = 199 MW at full pool	No

Table F-12 summarizes the resulting plant output for Kootenay River minimum flow conditions (142 m^3/s) and the plant output at typical maximum turbine discharge.

Table F-12: Duncan Dam Water Use Plan Power Studies: Kootenay River Plant Outputs at 142 m^3/s and at Maximum Turbine Discharge

Project	**Plant Output (MW) at 142 m^3/s** (Kootenay River Minimum Flow)	**Plant Output (MW) at Typical Maximum Turbine Discharge**	**Hugh Keenleyside Dam MWh/m^3/s day**
Kootenay Canal		574.0	16.6
Corra Linn	19.2	45.9	3.2
Upper Bonnington + City of Nelson	24.5	70.8	4.1
Lower Bonnington	23.1	43.7	3.9
South Slocan	23.0	48.6	3.9
Brilliant Future (post expansion)		281.0	6.3

7.2.1 Value of Energy

BC Hydro values the power produced by a power plant using methodology developed in the Value of Electricity (VOE) Report. The VOE Report provides time-of-generation energy values with adjustments to reflect dispatch and capacity reserve capabilities.

The VOE Report uses the forecast British Columbia/United States border monthly average heavy load hour and light load hour prices, and combines them with incremental transmission cost estimates for the BC Hydro electric system to generate unit value forecasts for the nine Hydro transmission regions.

The VOE Report contains commercially sensitive information and is confidential. However, use of this methodology was reviewed and accepted by the Water Use Plan Program Interagency Management Committee.

Is there adequate available information to calculate these performance measures?

Yes. For each operating alternative, the BC Hydro Operations Model provides daily data on Duncan Reservoir elevation, Duncan Dam discharges, lower Duncan River flows, Kootenay Lake elevations, Kootenay River power, and lower Columbia River power generation for 20 years (1968 to 1987) of simulated flow operation. These outputs serve as inputs to the Environmental Model and the Power Values Model to calculate the performance measures for each alternative.

8.0 Reference Materials

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APPENDIX G: ELIGIBILITY CRITERIA FOR WATER USE PLANNING STUDIES

STUDY PROPOSALS

Studies to be undertaken in the water use planning process may include field data collection, analysis and/or model building. The costs and benefits of each study proposed will be described using the "Study Proposal Template." These will be summarized in a summary matrix (Table G-1).

Evaluation Criteria (See Figure G-1) for Flowchart Summary).

Step 1

Will the study provide information related to the calculation of a performance measure?

- If not, the study is not eligible for Step 5 studies.

Step 2

Is the data gap or uncertainty that this study addresses significant enough to affect the ranking of alternatives?

- A "no" answer should normally disqualify a study from further consideration. For some studies, the answer will be clearly "yes." For others, it may be unclear. Judgment will have to be used.

- In some cases, there may be data gaps that we could fill that would improve a performance measure, but that are unlikely to affect the ranking of alternatives. Examples of cases where an uncertainty exists but is not likely to affect ranking of alternatives include:

  - We may not know a parameter value exactly, but we can with reasonable confidence establish a range of plausible values for it. If, within that range, the performance measure value does not change significantly, then it is not essential to address the uncertainty.

  - If all alternatives are equally affected by an uncertainty (all biased up or all biased down), the absolute value of the performance measure may be wrong, but the relative ranking of the alternatives is not affected.

Step 3

Can the study provide meaningful, reliable data within the time frame available in the Water Use Plan project schedule?

- If not, the study is not eligible for Step 5 studies.
- In many cases, especially for studies involving fisheries and wildlife, year-to-year variability is significant and it is not possible to draw scientifically defensible conclusions from a single field season. If a study cannot provide data that provides useful information after a single field season, it is not a candidate for Step 5 studies. It may however be a candidate for longer term monitoring programs that are conducted as part of Water Use Plan implementation. If it turns out that participants feel that a particular uncertainty significantly affects the ability to make responsible decisions at Step 7, then a monitoring program may be designed to address the uncertainty and ensure that better information is available for the next Water Use Plan review. Participants may link their recommendations about the timing of the next Water Use Plan review to the expected timing of results from long term monitoring programs.

Step 4

Do the benefits outweigh the costs?

- If Steps 1 through 3 are yes, then it is necessary to look at the cost of a proposed study. There may be a range of study designs that will provide a range of data quality, and these should be evaluated. If the costs for studies in support of a performance measure are very high, then it may be important to consider alternative performance measures. In some cases, a simpler measure may provide better value.

STUDY PRIORITIZATION

After evaluating each study against the above criteria, it will be assigned one of five priorities:

Priority 1	The information provided by this study is essential for *Water Use Plan*. Responsible decisions cannot be made without it.
Priority 2	This study will provide information that is likely to affect the ranking of alternatives. The benefits clearly outweigh the costs.
Priority 3	This study has benefits, but is of lower priority. Some reasons for lower priority include: • Costs may outweigh benefits. • The benefits may not be significant enough to affect ranking of alternatives. • The performance measure this study addresses has less likelihood of being the “limiting factor” (relative to other performance measures).
Priority 4	This study is not necessary or desirable for *Water Use Plan*.
Priority 5	This study may be important, but cannot be completed within the *Water Use Plan* timeline.

STUDY APPROVAL

The Consultative Committee will prioritize studies as above, and will make recommendations to BC Hydro about which studies should be approved. However, BC Hydro retains the final decision-making responsibility for study approval, and will make this decision based on the recommendations of the Consultative Committee, the costs and benefits outlined as above (and in the study proposal template), and the availability of resources.

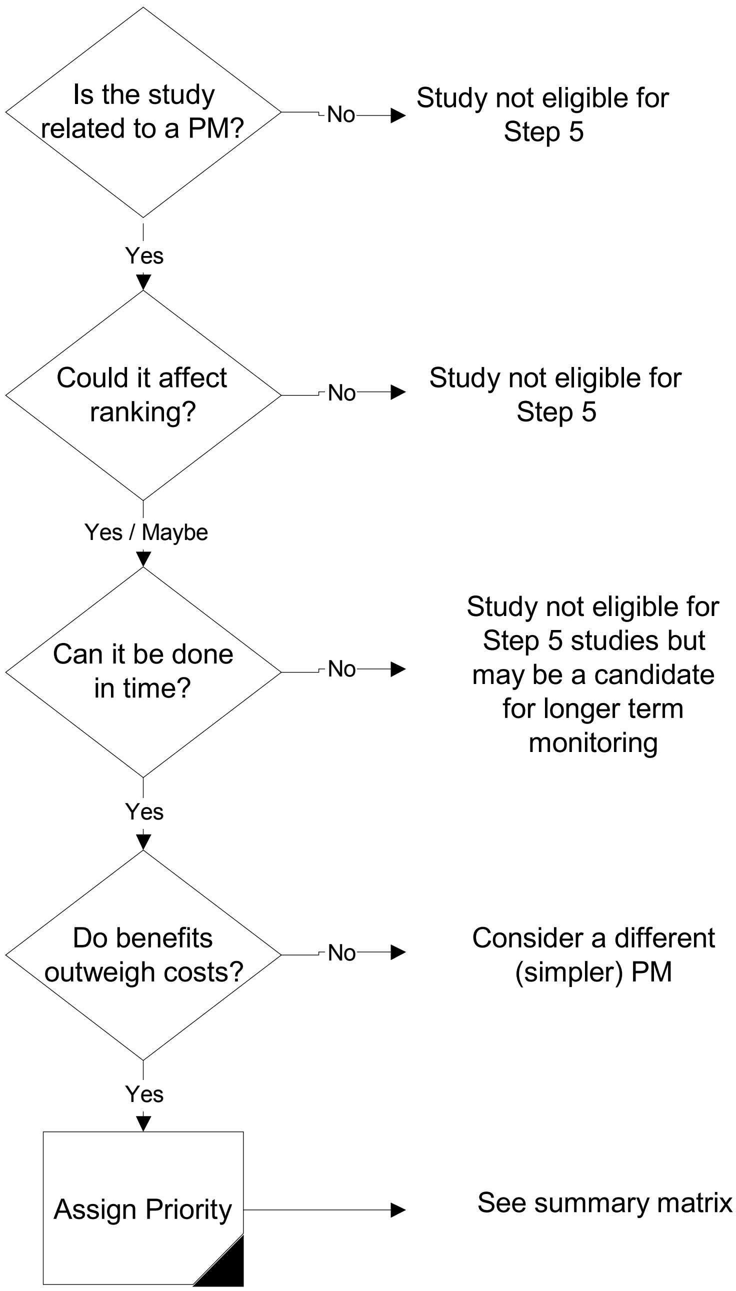


Figure G-1: Guidelines for Prioritizing Step 5 Studies

Table G-1: Summary Matrix for Priority Setting

Study	Cost	Completion Date	Uncertainty or Data Gap Affected	Affects	Benefits Ranking?	Risks	Priority Assigned

Based on the information contained in the Study Proposal Template, the summary table will be completed and used to assign a priority to each study.

APPENDIX H: NON-OPERATIONAL PHYSICAL WORKS

1.0 INTRODUCTION

During the Duncan Dam water use planning process, the Consultative Committee reviewed six proposed non-operational physical works options in lieu of operational changes as follows:

Wildlife	1)	Argenta Slough erosion protection in the Duncan River.
Cultural Resources	2)	Identified heritage and cultural sites erosion protection in the Duncan Reservoir.
Recreation	Options:	
	3(a)	Beach re-contouring at Glacier Creek.
	3(b)	Boat launch/mooring buoys at Glacier Creek.
	3(c)	Maintenance at Howser and Glayco creeks recreation sites.
	3(d)	Partial funding towards the Regional District of Central Kootenay's Mosquito Abatement Program.
Fish	4)	Partial funding for the Columbia Basin Fish and Wildlife Compensation's Kootenay Lake Nutrient Loading Program.
	5)	Exclusion fencing in affected lower Duncan River sidechannels.
Agricultural Lands	6)	Erosion protection of agricultural lands.[1]

[1] At the final Consultative Committee meeting in April 2004, the Regional District of Central Kootenay proposed erosion protection of agricultural lands; however, no further detail was provided on costs or options.

2.0 PHYSICAL WORKS OPTIONS

2.1 Argenta Slough Erosion Protection

Table H-1: Argenta Slough Erosion Protection

Element	Description
Scope	To prevent the continual erosion and loss of the Argenta Slough and Wetland in the Duncan River, four erosion protection options have been identified: 1) Bio-remediation to protect the riverbank with planting live willows and cottonwood palisades. 2) Armouring the river back with riprap. 3) Installing deflector weirs to limit water force and erosion. 4) Breaching the lower Duncan River delta to redirect the river away from the slough.
Issues	Primary: Wildlife Habitat Secondary: Ecosystem Health
Background	West of Argenta Slough, the lowest bend on the Duncan River has been eroding steadily closer to the slough bed for the past ~ 20 years. The bend is at the end of an exceptionally long meander that runs virtually perpendicular to the valley, and thus the bank receives a great deal of force. The erosion rate is rapid, 2 to 10 metres per year. Exacerbating the situation is the lack of plant roots, the fine silt-clay soil, and the height of the banks (they are ~ 3 metres high when the river is low). Local residents also believe that operations of the Duncan Dam and Kootenay Lake elevations accelerate erosion. It appears that when the river is high and the lake is low, the river velocity is increased in an “unnatural” manner. This frequently occurs during the winter months. It does not appear that erosion is particularly rapid in the summer, so capping flood peaks is not likely an effective alternative for mitigating this problem. The eroding riverbank bend is now less than 38 metres from the marsh at the closest point (March 2004). The slough itself is a 25 hectare system of marshes, swamps, and ponds. It is a unique habitat in the Duncan and Lardeau river systems, and as such represents critical habitat for many species of wildlife that are absent to rare in the surrounding landscape. Nesting birds that use the marsh include Cinnamon Teal, Sora, Virginia rail, Common snipe, Marsh Wren, Red-winged and Yellow-headed Blackbird. Birds that utilize the marsh extensively during spring and fall migration (often spending lengthy stopovers), include tundra swans, Canada geese, snow geese and well over 20 duck species. Nesting birds utilizing shrub habitats on the edge of the marsh include over six species of warblers, two species of vireo, and numerous others. Large raptors that nest nearby and hunt over the marsh include Northern Harrier, Bald Eagle, and Great Horned Owl. Amphibians including Pacific Tree frog and Western Toad congregate en masse in the marsh to breed and lay eggs in late May and June. Blue-listed Great Blue Heron utilize the marsh extensively in most seasons of the year, including winter. A small population of Blue-listed Painted Turtles are resident in the marsh. Their nest site on banks at the eastern edge of the marsh has been the subject of ongoing protection and enhancement efforts by the Columbia Basin Fish and Wildlife Compensation Program. The marsh is important for large invertebrates such as Dragonflies, Damselflies, Water Boatman, and Water Strider that require semi-permanent ponds uncommon in the rest of the floodplain. The marsh is used by several aquatic mammals for which habitat is limited to non-existent in the broader surroundings. These include Muskrat, Richardson’s water vole, Mink, and Beaver. River Otters use the marsh along with the nearby river and Kootenay Lake.

Table H-1: Argenta Slough Erosion Protection (cont'd)

Element	Description			
Operational Linkage	Primary:	The Wildlife Technical Subcommittee reviewed the impacts that are likely to occur in the sedge and willow communities with the implementation of one of the final round operating alternatives. The subcommittee assessed the potential non-operational physical works in lieu of operational changes that would offset potential negative impacts. While these impacts are expected to occur in the Duncan Reservoir, the subcommittee focused on the Argenta Slough (wetland) downstream because of the overall wildlife importance of the area in the entire region. Moreover, the risks associated with the identified physical works in the reservoir were considered high compared to Argenta Slough.		
	Secondary:	Local residents believe that flow releases from Duncan Dam into the lower Duncan River exacerbate the erosion problem by the slough, especially in the fall and winter when Duncan Dam releases are high. However, this phenomenon is not well understood nor thoroughly studied. Slough water elevations are also linked to river flows.		
Budget and Schedule	The cost estimates are preliminary. Accordingly, a 40% contingency has been included until more detailed engineering assessments are completed.			
	Option 1 – Bio-Remediation			
	- Detailed Assessment and Design	Year 1	$ 20,000	
	- Installation	Year 1	$ 210,000	
	- Annual Maintenance	Years 2 to 10	$ 5,000	
	- 10 Year Total		**$ 275,000**	
	- Average Annualized Cost		**$ 36,000 (per year)**	
	Option 2 – Riprap Armouring			
	- Detailed Assessment and Design	Year 1	$ 25,000	
	- Installation	Year 1	$ 300,000 *(see risks below)*	
	- Annual Maintenance	Years 4, 8	$ 20,000 (assumes to high inflow years)	
	- 10 Year Total		**$ 365,000**	
	- Average Annualized Cost		**$ 43,000 (per year)**	
	Option 3 – Deflector Weirs			
	- Detailed Assessment and Design	Year 1	$ 10,000	
	- Installation	Year 1	$ 70,000	
	- Annual Maintenance	Years 4, 8	$ 15,000 (2 high flow years requiring work)	
	- 10 Year Total		**$ 110,000**	
	- Average Annualized Cost		**$ 15,000 (per year)**	
	Option 4 – Redirecting the Lower Duncan River through the Delta			
	- Detailed Assessment and Design	Year 1	$ 20,000	
	- Installation	Year 1	$ 85,000	
	- Annual Maintenance	Years 4, 8	$ 25,000 (2 high flow years requiring work)	
	- 10 Year Total		**$ 155,000**	
	- Average Annualized Cost		**$ 20,000 (per year)**	

Table H-1: Argenta Slough Erosion Protection (cont'd)

Element	Description
Risks	Each of the options described above to prevent the continual erosion and loss of the Argenta Slough and Wetland are associated with different degrees of risk. In addition, erosion effects may accelerate over the coming years due to lower Kootenay Lake elevations associated as a result of VARQ which causes less backwatering and faster river flows leading to increased erosion. Option 1 – Bio-Remediation: While some professionals are confident that this option will be effective, others are skeptical given the wetness of the soil, force of the river, soil type, and limited time for the plants to take root. Option 2 – Armouring: This is a low risk option for effectively protecting the river bank and the slough. However, there is a high degree of risk associated with the cost of implementation. Accordingly, a contingency of 50% was included (rather than 40%). Both Options 1 and 2 will involve private land for road access. Option 3 – Protective Weirs: It is not clear how effective this option will be. Potentially, this option could lead to the lower Duncan River breaching the delta sooner rather than later. If this were to occur, there could be negative impacts to fish habitat. Option 4 – Redirecting the lower Duncan River: This option would likely cause significant disruption and negative impacts to fish habitat as a new channel is formed through the delta. If the river breaks through to the wetland, dyking the remaining wetland area to manage elevations is estimated to cost approximately $100,000 to $200,000.

2.2 Identified Heritage and Cultural Sites Erosion Protection

Table H-2: Identified Heritage and Cultural Sites Erosion Protection

Element	Description
Scope	To prevent the continued erosion and degradation of two significant cultural sites located in the Duncan Reservoir, two erosion protection options have been identified. 1) Riprap Blanket. 2) Non-Woven Geotextile Blanket.
Issues	Primary: Cultural Resources
Background	As a component to the archaeological overview studies completed during the Duncan Dam water use planning process, identified two significant cultural sites. These sites are extremely rare and have been defined as being globally significant given their age, location, and the condition (intactness of the materials found). It is speculated that these sites have been just recently exposed because of erosion within the drawdown zone of the reservoir. The archaeologist believed that erosion is significantly degrading these sites and will likely destroy them in the next few years if no immediate action is taken.

Table H-2: Identified Heritage and Cultural Sites Erosion Protection (cont'd)

Element	Description
Background (cont'd)	For more context, the archaeologist provided this summary. We do not yet know the exact size, archaeological contents or stratigraphic features of the two newly discovered sites in the Duncan Reservoir. However, on the basis of what has been observed on their surfaces, the artifacts suggest that both sites are very old in a North American context (likely in the 9000 to 12 000 years old range). Besides exhibiting evidence of focus on tool manufacture from locally available materials, human activities at the sites also involved using the tools, suggesting that these were localities of inhabitation in addition to resource exploitation. The sites are situated on landforms graded to two discrete higher hydrological baselines, indicating occupation when much larger lakes occupied the valley. There are also remnants of the early soils which formed around the time of this early human inhabitation. The above information represents a major contribution to our knowledge of early post-glacial human presence in the mountains of northwestern North America. However, the sites are even more significant because it appears that both are still partially intact and therefore could potentially contain more detailed information regarding human presence and activities in the millennia following deglaciation. The stratigraphy and soil development can reveal much about the timing and evolution of the landscape of the northern Purcell Trench prior to the establishment of the "historic" elevations of Duncan and Kootenay lakes and the Lardeau and Duncan rivers. Information regarding the climate and vegetation is also likely to be present in the soils and also in the activities carried out by humans as indicated by the artifacts and features in the archaeological deposits. The time and season(s) of occupation, and possibly even the social composition of the human groups may be represented within the archaeological deposits at these sites, along with evidence of the occupants' movements across the larger landscape and possibly even indications of their relationships with other early human groups elsewhere in northwestern North America. Not only is the above information important to our understanding of the evolution of the environment and human inhabitants of this locality, it also allows us to better understand those of neighbouring locations and better predict the potential locations of contemporary archaeological sites if any are still extant. Given the significant erosion and redeposition that has occurred since the early post-glacial period, such sites are very rare and often masked. It is not known whether there are any other occupation sites of this time period left in this part of the region; the present site inventory does not contain any. It is apparent that the loss of what is left of these sites would represent a major loss of potential knowledge regarding a very little-known period of human history.
Operational Linkage	Primary: When Duncan Reservoir elevations are above the cultural sites, erosion effects caused by wave action may be occurring up to 10 m below the surface. As reservoir elevations rise or fall through the cultural site areas, erosion effects are likely greater as a result of direct wave action. When reservoir elevations are below the sites, other erosion processes such as wind scour and surface run-off are likely negatively impacting the sites.
Budget and Schedule	The engineering cost estimates are preliminary. The engineering firm suggested that costs were accurate to +/- 40%. However, the archaeologists felt that the cost estimates were very conservative and that the actual areas may be considerably less. Therefore, the cost estimates do not include a contingency. The two sites are as follows: Site 1 (554 to 567 m) ~ 6 hectares Site 2 (567 to 571 m) ~ 2 hectares

Table H-2: Identified Heritage and Cultural Sites Erosion Protection (cont'd)

Element	Description		
Budget and Schedule (cont'd)	**Option 1 – Riprap Blanket**		
	- Detailed Assessment and Design	Year 1	$ 150,000
	- Installation (Site 1)	Year 2	$1,700,000
	- Installation (Site 2)	Year 2	$ 500,000
	- Annual Maintenance	Years 3 to 10	$ 0
	- 10 Year Total		**$2,350,000**
	- Average Annualized Cost		**$ 300,000 (per year)**
	Option 2 – Non-Woven Geotextile Blanket		
	- Detailed Assessment and Design	Year 1	$ 100,000
	- Installation (Site 1)	Year 2	$ 700,000
	- Installation (Site 2)	Year 2	$ 160,000
	- Annual Maintenance	Years 3 to 10	$ 10,000
	- 10 Year Total		**$1,040,000**
	- Average Annualized Cost		**$ 130,000 (per year)**
Risks	Each of the options described above to prevent the continued erosion and degradation of two significant cultural sites located in the Duncan Reservoir are associated with different degrees of risk. There is a risk of these sites being destroyed in the next few years if no action is taken. There is a high degree of risk associated with the cost of implementation. In addition, erosion effects may accelerate over the coming years as a result of lower Kootenay Lake elevations associated with VARQ which causes less backwatering and faster river flows leading to increased erosion. Option 1 – Riprap: This option is considered the only proven long-term erosion protection measure. However, placement of riprap would limit future access and investigations, if desired. Option 2 – Geotextile: Placement of the geotextile would provide a marker for the site and thus there poses a greater risk of theft or vandalism.		

2.3 Recreation Physical Works

Table H-3: Recreation Physical Works

Element	Description
Scope	As directed by the Consultative Committee, the Recreation/Quality of Life Technical Subcommittee met in August 2003 and identified four recreation physical works options in lieu of operational changes: 1) Beach Re-Contouring at Glacier Creek Recreation Site. 2) Boat Ramp Extension/mooring buoys at Glacier Creek. 3) Maintenance at Howser and Glayco recreation sites. 4) Partial funding towards mosquito abatement program.
Issues	Primary: Recreation

Table H-3: Recreation Physical Works (cont'd)

Element	Description
Background	High Duncan Reservoir elevations throughout the recreation season is one of the principal factors to attaining water-based recreation objectives. Along the periphery of the reservoir there are two main recreation sites: Glacier Creek and Howser (Glayco) sites. The Howser recreation site has a boat ramp that is accessible and can be used throughout the full range of Duncan Reservoir operations. The beach at Howser Creek is quite narrow and at full pool is almost non-existent. Accessibility and quantity of the beach is optimal when the reservoir elevation is approximately 5 to 10 feet from full pool and 4 feet is considered a minimum. The Glacier Creek recreation site is larger than at Howser and is more heavily utilized. The boat ramp is not functional when the Duncan Reservoir elevation is 2 to 3 feet from full pool. The beach area is much flatter than at Howser and as reservoir elevations drop 6 feet from full pool, many local residents believe that the recreation value is greatly diminished. The ideal reservoir elevation was determined to be approximately 3 feet from full pool. Option 1 – Glacier Creek Beach Recontouring: The Recreation/Quality of Life Technical Subcommittee identified that there was a trade-off between ideal Duncan Reservoir elevations for Howser Creek versus Glacier Creek. The subcommittee determined that it would be relatively straightforward and cost effective to excavate approximately 3 feet from the beach at Glacier Creek, which would make ideal reservoir elevations the same for both recreation sites (5 feet). This would provide a buffer to mitigate potential flooding effects, as well as benefit wildlife habitat in the reservoir. Option 2 – Glacier Creek Boat Ramp Extension/Mooring Buoys: Similar to Option 1, this option provides a means to mitigate negative impacts from lower Duncan Reservoir elevations during the recreation season. The existing boat ramp would be extended to make it accessible to ~ 7 feet from full pool throughout the summertime. This option would also include three anchored mooring buoys for boaters to use. Option 3 – Maintenance at Howser/Glayco Recreation Sites: It was identified that the Glacier and Howser creek recreation sites required some immediate maintenance (weeding, outhouse maintenance, debris removal, etc.). This options would provide an incentive for recreation opportunities at these sites. Option 4 – Partial Funding for the Regional District of Central Kootenay's Mosquito Abatement Program: While more closely related to the Quality of Life objective, mosquitoes were identified as one of the largest deterrents for local residents to be able to recreate and enjoy the outdoors. The Recreation/Quality of Life Technical Subcommittee supported partial funding of the Regional District of Central Kootenay's Mosquito Abatement Program in lieu of an operational change. The level of funding for this option as a recreation non-operating physical works was based on an assessment of historical costs (post Lardeau freshet effects).
Operational Linkage	Primary: Reservoir elevations during the peak recreation season (1 to 6 August) directly impacts the quality and accessibility of recreation opportunities. When reservoir elevations are too high, beach use is impacted; when they are low, beach and boat ramp access is impacted.

Table H-3: Recreation Physical Works (cont'd)

Element	Description
Budget and Schedule	The cost estimates are preliminary. Accordingly, a 25% contingency (except for Option 4) has been included until more detailed engineering assessments are completed.

Option 1 – Glacier Creek Beach Recontouring			
- Detailed Assessment and Design	Year 1	$ 10,000	
- Beach Recontouring	Year 2	$ 25,000	
- Annual Maintenance	Years 4,6,8,10	$ 5,000	(every other year)
- 10 Year Total		**$ 55,000**	
- Average Annualized Cost		**$ 6,000**	**(per year)**
Option 2 – Glacier Creek Boat Ramp Extension/Mooring Buoys			
- Detailed Assessment and Design	Year 1	$ 20,000	
- Boat Ramp (extend ~ 150 ft.)	Year 2	$ 100,000	
- Mooring Buoys	Year 2	$ 6,000	
- Annual Maintenance	Years 6, 10	$ 10,000	
- 10 Year Total		**$ 146,000**	
- Average Annualized Cost		**$ 18,000**	**(per year)**
Option 3 – Maintenance at Howser/Glayco Sites			
- Detailed Assessment and Design	Year 1	$ 0	
- Annual Maintenance		$ 5,000	
- 10 Year Total		**$ 50,000**	
- Average Annualized Cost		**$ 5,000**	**(per year)**
Option 4 – Partial Funding for the Mosquito Abatement Program			
- Detailed Assessment and Design	Year 1	$ 0	
- Annual Funding		$ 20,000	(~ 25% of program costs)
- 10 Year Total		**$ 200,000**	
- Average Annualized Cost		**$ 20,000**	**(per year)**

Element	Description
Risks	Each of the options described above for recreation physical works do not pose any significant risks. For the options that require dredging or excavation of beach areas, particular care will be taken to avoid any negative impacts to fish habitat.

2.4 Kootenay Lake Nutrient Loading Program

Table H-4: Partial Funding for Columbia Basin Fish and Wildlife Compensation Program's Kootenay Lake Nutrient Loading Program

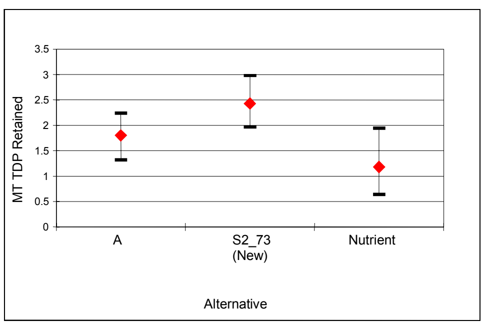
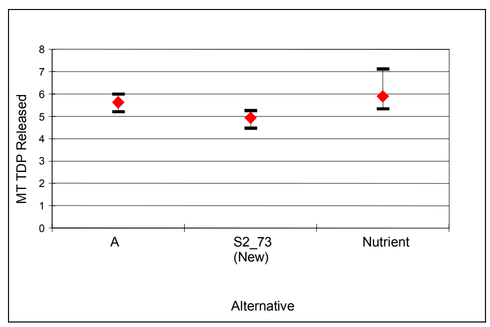
Element	Description
Scope	Partial funding of the Columbia Basin Fish and Wildlife Compensation Program's Kootenay Lake Nutrient Loading Program is in lieu of operational changes that retain nutrients (phosphorous and nitrogen) in the Duncan Reservoir. The Fish Technical Subcommittee agreed to the methodology for calculating the funding amount. There could be modifications to funding in consultation with the regulatory agencies and the Compensation Program based on new information gathered during the review period.
Issues	Ecosystem
Background	The Nutrient Retention performance measures indicate that Duncan Dam operations impact the nutrient retention within the range of operating alternatives being considered by the Consultative Committee.
Operational Linkage	The concentration of nutrients in water released from the Duncan Dam is directly linked to the Duncan Reservoir volume (i.e., Outflow [TDP]=*f*(Reservoir Vol.)). The difference between inflow nutrients and outflow nutrients is the amount retained in the reservoir. The difference between nutrient retention in Alternative S2_73(New) and other alternatives is considered the operational component of the calculated retention. Funding of the nutrient loading program is based on the operational proportion of the total cost to compensate for the nutrients retained (the compensation amount is much less than the actual retained amount). Figure H-1 and Figure H-2 illustrate the extent Duncan Dam operations has on nutrient retention in the Duncan Reservoir (A = Power optimized alternative; S2_73(New) is the preferred alternative; Nutrient = nutrient optimal alternative meeting the Columbia River Treaty):  **Figure H-1: Duncan Dam Nutrients: Total Annual Mass of TDP retained in Reservoir (MT)**  **Figure H-2: Duncan Dam Nutrients: Total Annual Mass of TDP retained in Reservoir (MT)**

Table H-4: Partial Funding for Columbia Basin Fish and Wildlife Compensation Program's Kootenay Lake Nutrient Loading Program (cont'd)

Element	Description
Budget and Schedule	At the final Consultative Committee meeting, the Committee supported partial funding for the Columbia Basin Fish and Wildlife Compensation Program's Kootenay Lake Nutrient Loading Program to a maximum cost of $100,000 in lieu of operational changes. Subsequently, the Fish and Wildlife Technical Subcommittee met to discuss four methods to calculate the funding of the operational proportion of the total cost of the program to compensate for the nutrients retained. **Option (a) – Operational nutrient retention as a fraction of total (Alt A comparison)** - Annual Operational Component Years 1 to 10 $ 172,560 (per year) **- 10 Year Total $1,725,600** **- Average Annualized Cost $ 100,000 (capped at $100,000)** **Option (b) – Operational nutrient retention as a fraction of total (Alt S_73 comparison)** - Annual Operational Component Years 1 to 10 $ 344,340 (per year) **- 10 Year Total $3,443,400** **- Average Annualized Cost $ 100,000 (capped at $100,000)** **Option (c) – Operational nutrient retention as a fraction of 47MT (Alt A comparison)** - Annual Operational Component Years 1 to 10 $ 8,910 (per year) **- 10 Year Total $ 90,000** **- Average Annualized Cost $ 9,000** **Option (d) – Operational nutrient retention as a fraction of 47MT (Alt S_73 comparison)** - Annual Operational Component Years 1 to 10 $ 17,780 (per year) **- 10 Year Total $ 180,000** **- Average Annualized Cost $ 18,000**
Risks	The nutrient background study and performance measure calculations were based on one year's empirical data that were used to determine the relationship driving nutrient concentration at the Duncan Dam, and is still considered preliminary. Until a formal review and model are prepared for this study, the Fish Technical Subcommittee will determine (a) the basis for the funding calculation, and (b) the level of funding to a maximum of $100,000.

2.5 Exclusion Fencing in Affected Lower Duncan River Sidechannels

Table H-5: Exclusion Fencing in Affected Lower Duncan River Sidechannels

Element	Description			
Scope	To prevent the use of lower Duncan River sidechannel(s) by spawning kokanee preceding kokanee spawning flows starting 1 October installation of exclusion fencing at the outlet(s) of affected sidechannel(s) has been identified.			
Issues	Primary: Fish			
Background	Kokanee have been known to spawn in the lower Duncan River sidechannels as early as 1 September. Peak spawning is assessed to start 15 September. The Consultative Committee agreed that kokanee spawning flows would be initiated on 1 October, recognizing that spawning may occur prior to the flow change. To avoid significant impacts to these early spawners, some Committee members agreed to kokanee spawning flows starting on 1 October contingent on installation of exclusion fencing at the outlet(s) of affected sidechannel(s) between 15 September and 30 September.			
Operational Linkage	Prior to the 73 m^3/s kokanee spawning flows on 1 October, Duncan Dam discharges are generally high to meet Columbia River Treaty requirements and provide flexibility to other Columbia River basin hydroelectric facilities to generate power at other times. Although the kokanee spawning period starts 15 September, the value of the increased operational flexibility for the two-week period is estimated at approximately $400,000 to $800,000.			
Budget and Schedule	The cost estimates are preliminary. Accordingly, a 40 per cent contingency has been included until more detailed engineering assessments are completed. In 2003, the effectiveness of the exclusion fencing program was not accurately assessed. Therefore, the costs of fencing will be modified during the review period to ensure that the program remains effective:			
	- Detailed Assessment and Design	Year 1	$	5,000
	- Materials	Year 1	$	30,000
	- Maintenance and Reporting	Years 1 to 10	$	5,000
	- 10 Year Total		**$**	**85,000**
	Average Annualized Cost		**$**	**9,000 (per year)**
Risks	In 2003, the exclusion fencing was not considered successful due to the lack of evidence that the (a) fish were excluded by the fencing, and/or (b) excluded fish did not spawn in other available areas that would be eventually dewatered. Therefore, it is recommended that the kokanee escapement monitoring study assess kokanee sidechannel and mainstem use to determine whether the two week delay in kokanee spawning releases impacts fish stranding.			

APPENDIX I: CORRESPONDENCE FROM COLUMBIA POWER CORPORATION AND COLUMBIA BASIN TRUST

COLUMBIA POWER CORPORATION
P.O. Box 9131, Stn Prov Govt
844 Courtney Street, 3rd Floor
Victoria, British Columbia
Canada V8W 9B5
Tel: (250) 953-5179
Fax: (250) 356-2819

April 19, 2004

Sue Foster
Duncan Dam Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C.
V3N 4X8

Subject: Duncan Dam Water Use Plan ("Duncan WUP") – Consultative Committee

In our earlier letter dated November 26, 2003, we outlined Columbia Power Corporation's ("CPC") interest and role in BC Hydro's Columbia (Mica/Revelstoke/Keenleyside) Water Use Plan ("Columbia WUP") deliberations. CPC has a similar interest in the Duncan WUP.

Specifically, CPC and the Columbia Basin Trust ("CBT") are joint venture owners of hydro-electric power projects located on the Columbia, Kootenay and Pend d'Oreille Rivers. CPC is the manager of these power projects. The CPC/CBT joint ventures and the related power projects are as follows:

- Arrow Lakes Power Corporation, for the Arrow Lakes Generating Station ("ALGS") (formerly the Keenleyside Powerplant) on the Columbia River;
- Brilliant Power Corporation, for the Brilliant Dam and Powerplant ("BRD") on the Kootenay River;
- Brilliant Expansion Power Corporation, for the Brilliant Expansion Project ("BRX") on the Kootenay River, and,
- Waneta Expansion Power Corporation, for the Waneta Hydroelectric Expansion Project on the Pend d'Oreille River.

CPC's interest in the Duncan WUP is to ensure that CPC/CBT joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from the implementation of the Duncan WUP.

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According to the information in the *Pre-Reading Package for CC Meeting #8 (April 20th, 21st, & 22nd, 2004)*, the alternatives being considered for the Duncan WUP could impose significant financial costs on the CPC/CBT joint ventures. The financial impacts at ALGS alone as measured by the estimated value of electricity foregone appear to range from -$0.8 million to -$3.1 million per year, on a mean annual basis, depending on the alternative chosen. CPC has yet to quantify the additional impacts for BRD and BRX, but our preliminary analysis suggests that those costs could also be significant.

The CPC/CBT facilities serve the interests of the Columbia-Kootenay Region in fulfillment of a public interest mandate established in the *Columbia Basin Accord*, the *Columbia Basin Trust Act* and related agreements between the Province and CBT. The public interest represented by CBT is also given prominence by section 12(2) of the *Water Act*, which requires the Comptroller of Water Rights ("CWR") to consider CBT interests in water licensing decisions in the CBT region.

To protect the important public interests represented by the CPC/CBT joint ventures, CPC must object to any WUP alternative that impairs the rights of the CPC/CBT joint ventures. Accordingly, CPC cannot support any of the current alternatives being considered for the Duncan WUP and may object to them before the CWR.

CPC are willing to consider other alternatives that protect the interests of the CPC/CBT joint ventures.

Yours truly,

Bruce Duncan

Bruce Duncan
Vice President Strategic Planning
Columbia Power Corporation

cc: Duncan WUP Consultative Committee

Gary Rodford
BC Hydro

Lorne Sivertson
Columbia Power Corporation

Ken Epp
CBT Energy Inc.

Josh Smienk
Columbia Basin Trust

BRITISH COLUMBIA

MAY 06 2004

Mr. Larry Bell
Chair
British Columbia Hydro and Power Authority
18th Floor, 333 Dunsmuir Street
Vancouver BC V6B 5R3

Dear Mr. Bell:

Re: Approval of Indemnity

Further to BC Hydro's Water Use Plans being developed in the Columbia Basin, and government's interest in the success of both Water Use Planning and the Columbia Basin Initiative, I hereby provide, pursuant to section 1.1(a) of the Guarantees and Indemnities Regulation, approval for BC Hydro to ensure that power entitlements and other benefits associated with CPC/CBT power projects are not adversely affected by the system operation changes or other measures that result from WUPs approved by the Comptroller and implemented by BC Hydro.

Specifically, to the extent that a BC Hydro WUP leads to a system operation change or another measure approved by the Comptroller that adversely affects, directly or indirectly, power benefits or costs for a CPC/CBT facility, BC Hydro may:

1. ensure that CPC/CBT power entitlements are not affected; and

2. compensate CPC/CBT for any other benefit losses or cost increases.

Sincerely,

Gary Collins
Minister

pc: Honourable Richard Neufeld
Minister of Energy and Mines

Lorne Sivertson
President
Columbia Power Corporation

Josh Smienk
Chair
Columbia Basin Trust

Phil Grewar
Director
Risk Management Branch

Ministry of Finance
Office of the Minister
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Victoria BC V8W 9E2
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Victoria

BRITISH COLUMBIA

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JUN 25 2004
COLUMBIA POWER CORPORATION

JUN 24 2004

Mr. Larry Bell
Chair
British Columbia Hydro and Power Authority
18th Floor, 333 Dunsmuir Street
Vancouver, BC V6B 5R3

Dear Mr. Bell:

By letter dated November 4, 1998, the Minister Responsible directed BC Hydro to participate in a review of its hydropower water licenses and develop water use plans (WUPs) to clarify the exercise of water rights held by BC Hydro while recognizing other social and environmental values associated with the use of the water resource. I am issuing this further Letter of Direction to:

1. amend the schedule established in the November 4, 1998 Letter of Direction; and

2. give direction on how BC Hydro is to address any adverse impacts that implementation of BC Hydro WUPs may have on power projects being developed and operated by the Columbia Power Corporation (CPC) and the Columbia Basin Trust (CBT), pursuant to the Columbia Basin Initiative (CBI), as more particularly set out in the *Columbia Basin Trust Act,* the 1995 Financial Agreement between the province and the CBT and the Columbia Basin Management Plan.

This Letter of Direction and the Letter of Direction dated November 4, 1998, as amended, are government policy directives pursuant to Heritage Special Direction No. HC2 and Order in Council No. 1123, approved November 27, 2003.

Schedule

The Columbia River Water Use Planning process is expected to take more time than originally planned. Accordingly, I am extending the completion date for BC Hydro to submit all WUPs to the Comptroller of Water Rights (Comptroller) to November 30, 2004.

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Ministry of Energy and Mines

Office of the Minister

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Website: www.gov.bc.ca/em/

- 2 -

The CBI and CPC/CBT Projects

The economic, environmental and social objectives of the BC Hydro WUP are important to the province. However, the province's commitment to the CBI is also important. The outcome of the BC Hydro WUP process must not detract from the province's commitment to the CBI and the related CPC/CBT power projects. Reconciliation of these two initiatives in a manner that best accommodates the public interest is essential.

CPC/CBT power projects include:

- Arrow Lakes Power Corporation, for the Arrow Lakes Generating Station (formerly the Keenleyside Power Plant) on the Columbia River;
- Brilliant Power Corporation, for the Brilliant Dam and Power Plant on the Kootenay River;
- Brilliant Expansion Power Corporation, for the Brilliant Expansion Project on the Kootenay River, and
- Waneta Expansion Power Corporation, for the Waneta Hydroelectric Expansion Project on the Pend d'Oreille River.

In conjunction with the enclosed approval provided by Honourable Gary Collins, Minister of Finance, pursuant to the Guarantees and Indemnities Regulation, I hereby direct BC Hydro to ensure that power entitlements and other benefits associated with CPC/CBT power projects are not adversely affected by the system operation changes or other measures that result from WUPs approved by the Comptroller and implemented by BC Hydro. Specifically, to the extent that a BC Hydro WUP leads to a system operation change or another measure approved by the Comptroller that adversely affects, directly or indirectly, power benefits or costs for a CPC/CBT facility, BC Hydro is directed to:

1. ensure that CPC/CBT power entitlements are not affected; and
2. compensate CPC/CBT for any other benefit losses or cost increases.

Sincerely,

ORIGINAL SIGNED
BY MINISTER

Richard Neufeld
Minister

Enclosure

. . ./3

pc: Honourable Gary Collins
Minister of Finance

Honourable George Abbott
Minister of Sustainable Resource Management

Honourable Bill Barisoff
Minister of Water, Air and Land Protection

Dr. Jon O'Riordan
Chair
Water Use Plan Policy Committee and
Deputy Minister
Ministry of Sustainable Resource Management

Dr. Sheila Wynn
Deputy Minister
Ministry of Energy and Mines

Ms. Dana Hayden
Deputy Minister and
Chief Executive Officer
Crown Agencies Secretariat

Mr. Robert Pellatt
Commission Secretary
British Columbia Utilities Commission

Mr. Lorne Sivertson
President
Columbia Power Corporation

Mr. Josh Smienk
Chair
Columbia Basin Trust

Mr. Jim Mattison
Comptroller of Water Rights
Land and Water British Columbia Inc.

BC hydro

Bob G. Elton
President & Chief Executive Officer

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COLUMBIA POWER CORPORATION

20 October 2004

Mr. Lorne Sivertson
President
Columbia Power Corporation
P.O. Box 9131, Stn Prov Govt
844 Courtney St., 3rd Floor
Victoria, B.C. V8W 9B5

Dear Mr. Sivertson:

Re: British Columbia Hydro and Power Authority ("BC Hydro") Water Use Planning for the Columbia Basin – Implementing the Letter of Direction dated 24 June 2004 from the Minister of Energy and Mines to BC Hydro ("Letter of Direction") and Approval of Indemnity dated 6 May 2004 from the Minister of Finance ("Approval of Indemnity")

Further to your letter dated 14 September 2004, I confirm that BC Hydro is committed to implementing and abiding by the Letter of Direction and Approval of Indemnity.

In accordance with the Letter of Direction and Indemnity Approval,
BC Hydro will ensure that the power entitlements and other benefits associated with Columbia Power Corporation ("CPC") / Columbia Basin Trust ("CBT") power projects are not adversely affected by the system operation changes or other measures that result from Water Use Plans ("WUP") approved by the Comptroller of Water Rights and implemented by BC Hydro. Specifically, to the extent that a BC Hydro WUP leads to a system operation change or another measure approved by the Comptroller of Water Rights that adversely affects, directly or indirectly, power benefits or cost for a CPC/CBT facility, BC Hydro will:

1. Ensure that CPC/CBT power entitlements are not affected; and

2. Compensate CPC/CBT for any other benefit losses or cost increases.

BC Hydro understands the CPC/CBT power projects include:

- Arrow Lakes Power Corporation, for the Arrow Lakes Generating Station (formerly the Keenleyside Powerplant) on the Columbia River;

- Brilliant Power Corporation, for the Brilliant Dam and Powerplant on the Kootenay River;

- Brilliant Expansion Power Corporation, for the Brilliant Expansion Project on the Kootenay River, and
- Waneta Expansion Power Corporation, for the Waneta Hydroelectric Expansion Project on the Pend d'Oreille River.

Yours truly,

Bob Elton
President and Chief Executive Officer

c: Honourable Richard Neufeld
Minister of Energy and Mines

Mr. Ken Epp
President, CBT Energy Inc.

Mr. Josh Smienk
Chair, CBT

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November 09, 2004

Ms. Sue Foster
Duncan Dam Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster:

Subject: Duncan Dam Water Use Plan ("Duncan WUP") – Consultative Committee ("CC")

On April 19, 2004, prior to the final April CC Meeting, we wrote setting out Columbia Power Corporation's ("CPC") interest in BC Hydro's Duncan WUP deliberations as joint venture owners, along with the Columbia Basin Trust ("CBT"), of hydro-electric power projects located on the Columbia, Kootenay and Pend d'Oreille Rivers, and CPC's role as the manager of the CPC/CBT joint ventures.

The CPC/CBT joint ventures and the related power projects are as follows:

- Arrow Lakes Power Corporation, for the Arrow Lakes Generating Station ("ALGS") (formerly the Keenleyside Powerplant) on the Columbia River;
- Brilliant Power Corporation, for the Brilliant Dam and Powerplant ("BRD") on the Kootenay River;
- Brilliant Expansion Power Corporation, for the Brilliant Expansion Project ("BRX") on the Kootenay River, and,
- Waneta Expansion Power Corporation, for the Waneta Hydroelectric Expansion Project on the Pend d'Oreille River.

As noted previously, CPC's interest in the Duncan WUP is to ensure that CPC/CBT joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from the implementation of the Duncan WUP.

To protect the important public interests represented by the CPC/CBT joint ventures, CPC registered its objection to any WUP alternative that impairs the rights of the CPC/CBT joint ventures. As recorded in the revised Duncan WUP CC Update dated June 4, 2004, CPC placed the following condition on the Preferred Alternative S73:

Ms. Sue Foster
November 09, 2004
Page 2

> *CPC, on behalf of CPC and the CPC/CBT power project companies Arrow Lakes Power Corporation, Brilliant Power Corporation and Brilliant Expansion Power Corporation (collectively "CPC/CBT"), cannot support or accept any alternative, other than Alternative A, and may object to any such alternative before the Comptroller of Water Rights, unless CPC/CBT are saved harmless or appropriately compensated for any adverse impacts resulting, directly or indirectly, from the implementation of the WUP taking into account the year to year variability of the impacts.*

Subsequently, Honourable Richard Neufeld, Minister of Energy and Mines, in a June 24, 2004 letter to Mr. Larry Bell, Chair of BC Hydro, (the "Letter of Direction") directed BC Hydro to ensure that power entitlements and other benefits associated with CPC/CBT power projects are not adversely affected by the system operation changes or other measures that result from WUPs approved by the Comptroller of Water Rights and implemented by BC Hydro. Specifically, to the extent that a BC Hydro WUP leads to a system operation change or another measure approved by the Comptroller that adversely affects, directly or indirectly, power benefits or costs for a CPC/CBT facility, BC Hydro is directed to:

1. ensure that CPC/CBT power entitlements are not affected; and
2. compensate CPC/CBT for any other benefit losses or cost increases.

The Letter of Direction is a government policy directive pursuant to Heritage Special Direction No. HC2 and Order in Council No. 1123, approved November 27, 2003. The resulting BC Hydro indemnity to CPC/CBT was approved on May 6, 2004 by Honourable Gary Collins, Minister of Finance, (the "Approval of Indemnity") pursuant to section 1.1(a) of the Guarantees and Indemnities Regulation of the *Financial Administration Act.*

Mr. Bob Elton, President and Chief Executive Officer of BC Hydro, in an October 20, 2004 letter to Mr. Lorne Sivertson, President of CPC, (the "Letter of Commitment") confirmed that BC Hydro is committed to implementing and abiding by the Letter of Direction and the Approval of Indemnity.

Relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment (both of which are attached), CPC, on behalf of the CPC/CBT joint ventures Arrow Lakes Power Corporation, Brilliant Power Corporation and Brilliant Expansion Corporation, can now accept Preferred Alternative S73.

Yours truly,

Bruce Duncan

Bruce Duncan
Vice President, Strategic Planning
Columbia Power Corporation

Attachments

Ms. Sue Foster
November 09, 2004
Page 3

cc: Duncan WUP Consultative Committee

Mr. Bob Elton
President and CEO
BC Hydro

Mr. Lorne Sivertson
President
Columbia Power Corporation

Mr. Ken Epp
President
CBT Energy Inc.

Mr. Josh Smienk
Chair
Columbia Basin Trust

Mr. Chris Trumpy
Deputy Minister
Ministry of Sustainable Resource Development

Dr. Sheila Wynn
Deputy Minister
Ministry of Energy and Mines

Ms. Dana Hayden
Deputy Minister and CEO
Crown Agencies Secretariat

Mr. Glen Davidson
Deputy Comptroller of Water Rights
Land and Water British Columbia Inc.

Mr. Pieter Bekker
Director, Water Use Planning and Utilities
Land and Water British Columbia Inc.

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January 31st, 2005

Ms. Sue Foster
Duncan Dam Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster,

Subject: BC Hydro Duncan and Columbia Water Use Planning Processes

At the April 20th, 2004 Consultative Committee meeting for the Duncan Dam Water Use Planning Process (Duncan WUP), and the June 21st meeting for the Columbia River Water Use Planning Process (Columbia WUP), the Columbia Power Corporation (CPC) member formally registered an objection to any WUP alternative that impaired the rights of the Columbia Basin Trust Energy (CBTE) and CPC joint venture power projects on the Columbia/Kootenay System (Arrow Lakes Power Corporations, Brilliant Power Corporation, Brilliant Expansion Power Corporation, Waneta Expansion Power Corporation).

The CBT consultative committee member supported this position, and indicated that the WUP process needs to account for any potential negative impacts on all interests and values that result from an alternative operating regime, and that appropriate compensation or mitigation measures should be implemented. As such, the CBT could not support any WUP alternative that may have negative financial impacts on the CBTE/CPC joint venture projects. It was also noted that financial impacts to these joint venture projects could impact the benefits CBT delivers to Basin residents, the very residents who were most directly impacted by the creation of the Columbia River Treaty Dams. Should the CBTE/CPC joint venture power assets not be kept whole through the WUP process, the Province of BC and BC Hydro could be unduly burdening the people of the basin with the financial costs associated with improved operations at the BC Hydro facilities. The Columbia Basin Trust would then need to consult with its constituents prior to indicating support for any such alternatives. CBT's views on this issue would be similar should impacts be identified for any other interest or value.

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Subsequently, Honourable Richard Neufeld, Minister of Energy and Mines, in a June 24, 2004 letter to Mr. Larry Bell, Chair of BC Hydro, directed BC Hydro to ensure that power entitlements and other benefits associated with CBT/CPC power projects are not adversely affected by the operation changes or other measures that result from WUPs approved by the Comptroller of Water Rights and implemented by BC Hydro.

Honourable Gary Collins, Minister of Finance, approved the resulting BC Hydro indemnity to CBT/CPC on May 6, 2004.

Mr. Bob Elton, President and Chief Executive Officer of BC Hydro, in an October 20, 2004 letter to Mr. Lorne Sivertson, President of CPC, confirmed that BC Hydro is committed to implementing and abiding by these decisions.

Given the above noted direction provided by the Minister of Energy and Mines, the indemnity granted by the Minister of Finance and the commitment by the President and Chief Executive Officer of BC Hydro, the CBT is now willing to remove its objections as stated above on both the Duncan and Columbia WUPs, and continue to positively engage and contribute at both consultative committee tables.

Yours truly,

Kindy Gosal
Manager Water Initiatives
Columbia Basin Trust

CC:
Josh Smienk
Chair
Columbia Basin Trust

Ken Epp
President
CBT Energy

Lorne Sivertson
President
Columbia Power Corporation

James Mattison
Comptroller of Water Rights
Land and Water British Columbia Inc.

Duncan WUP Consultative Committee

Columbia WUP Consultative Committee

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January 31st, 2005

Ms. Sue Foster
Duncan Dam Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster,

Subject: BC Hydro Duncan Water Use Planning Processes

Thank you for the opportunity to provide comments on the Draft Consultative Committee Report for the Duncan Water Use Plan (WUP).

The Columbia Basin Trust (CBT) participation on the Duncan Water Use Plan Consultative Committee (Duncan WUP CC) was undertaken with the objectives of ensuring that a broad range of interests and values had the opportunity to participate at the CC table and were given adequate consideration in the CC discussions. We are confident in saying that these objectives were met on the Duncan Water Use Plan.

We would like to commend BC Hydro and the Process team for their efficiency and professionalism throughout this three-year process. We also commend BC Hydro for the openness and participatory nature of the consultative committee make up. It is my observation that the Process team made every effort to ensure that any individual or group who wished to be represented at the consultative committee table had the opportunity to do so.

We note, however, that due to the technical nature of the discussions at the consultative committee table, the extensive commitment of time that this process required, and the financial implications of volunteers donating their time, that most community-based organizations have difficulty in effectively participating in such processes. We further note that, while the Provincial, Federal and First Nations organizations had paid resource people to participate and ensure that their interests were well represented, other community interests were largely reliant on volunteer contributions. We emphasize that this reflected an inequity of resources representing various interests. In future, such processes should ensure that if effective engagement is sought from all interest groups, resources and support mechanisms need to be in place to provide the capacity for community-based organizations to effectively participate.

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We would also like to commend the BC Hydro Process team on their process design. The process design is to be singled out for praise for creating a framework to make "consensus-based" decisions on some very complex and technical issues. From the perspective of a consultative committee member, it was a very rewarding and educational experience.

However, it should be noted that the overall water use planning process, and the recommendations coming out of the process, were developed under a specific set of constraints imposed by those involved in the creating the process:

- It should be emphasized in the consultative committee report that this process was designed to look at potential improvements in current operations, but specifically did not address historical footprint issues of the facilities involved. This operational linkage was a very important factor through the decision-making process and the trade-offs that were made.
- There was an indication of a "nominal" cap on anticipated province-wide costs resulting from the WUPs of approximately 50 million dollars per year. It was our early understanding that the Provincial Government had put this "cap" on the Water Use planning process. Thus, operational changes that may have provided significant benefit for a number of values, but had major financial impacts, were eliminated from consideration early in the process.
- To our knowledge there was no consideration given to the percentage of generation attributed to each facility or region and an equitable distribution of this "nominal provincial cap". Thus, from a proportional perspective, the Columbia Region which provides approximately 50% of the power generated in the province should expect to see a large share of this benefit.
- It was stated in the beginning of the process that operations under Columbia River Treaty would be considered as a "hard" constraint. Later after much discussion it was decided that some operational changes could be realized if the US entities agreed to the operation. As a consultative committee member, CBT would like to see a list of the operations that are possible to realize with and without the CRT in place so we can effectively analyze at the next WUP review if any of these operations are worth pursuing negotiation with the US Entity.

The recommendations contained in the CC report represent an "adaptive management" approach. The CC has made some recommendations to change operations, in the hope of seeing a wide range of benefits. The monitoring package is a recognition that we need to learn whether or not these changes have the desired outcomes. The same can be said for the proposed monitoring of interests/values for which CBT wants to understand how they are affected on an on-going basis by the proposed operation. While the price for this monitoring package may appear high, the investment into understanding how the regulated system works, and its effect on various values, is long overdue. This information will help to focus and refine river-system operations for generations to come.

From our perspective the Draft CC report accurately captures the discussions, trade-offs and decisions that were made at the Duncan Water Use Plan table over the course of three years. Again, we would like to compliment the Process team for their diligence and accuracy of information.

The CBT supports the Consultative Committee in its decision to recommend the implementation of preferred operating alternative S(73). We also support the Consultative Committees recommendations with respect to the non-operational physical works, the monitoring studies and the non-water use plan recommendations, subject to the comments listed below.

The following is a list of specific comments on the Draft Consultative Committee Report for the Duncan Water Use Plan:

Section 4 Issues, Objectives and Performance Measures

- It should be made clear both in the executive summary of the report and in this section that the Scoping report for the Duncan WUP did not include all potential issues on fishing or property interests on Kootenay Lake or the Kootenay River System (as noted on page 12 of the CC meeting #8)

Section 7.7 Round 3 Final Trade Off Analysis

- The Columbia Basin Trust would like the following statement inserted on page 7-32, clarifying our position and concerns with respect to the Columbia Basin Trust Energy/Columbia Power Corporation Joint Venture Power Projects: *The CBT consultative committee member indicated that the WUP process needs to account for any potential negative impacts on all interests and values that result from an alternative operating regime, and that appropriate compensation or mitigation measures should be implemented. As such, the CBT cannot support any WUP alternative that may have negative financial impacts on the CBTE/CPC joint venture projects. It was also noted that financial impacts to these joint venture projects could impact the benefits CBT delivers to Basin residents, the very residents who were most directly impacted by the creation of the Columbia River Treaty Dams. Should the CBTE/CPC joint venture power assets not be kept whole through the WUP process, the Province of BC and BC Hydro could be unduly burdening the people of the basin with the financial costs associated with improved operations at the BC Hydro facilities. The Columbia Basin Trust would then need to consult with its constituents prior to indicating support for any such alternatives. CBT's views on this issue would be similar should impacts be identified for any other interest or value.*

7.7.11 Non-operational Physical Works

7.7.11.6 Partial Finding Towards the Regional District's Mosquito Abatement Program

- As noted in the CC report and documented over the 3 year WUP process the Duncan WUP CC has looked extensively at the mosquito issues in the Lower Duncan Valley. The CC deliberations have spent a lot of time and effort looking at operational cause and effect with respect to mosquito impacts. The new proposed operational alternative S(73) has built-in operational constraints to limit and reduce late summer re wetting events that are suspected to contribute to increased mosquito hatching events.
- The CBT supports continued monitoring of Duncan Dam operations to evaluate operational linkages to increased mosquito habitat and hatching in the lower Duncan River.

7.7.11.7 Partial funding of the Columbia Basin Fish and Wildlife Compensation Program's Nutrient Loading Program

- The outcome at the last CC meeting was *"No clear direction from the CC regarding providing funding contributions to the CBFWCP for the Kootenay Lake Fertilization Program. Further analysis of Nutrient Loading impacts from Duncan operations is required. BCH will determine whether operational impacts warrant funding".*
- The Fish and Wildlife Technical Committee might have made a determination on this issue, however the CC as a whole has not agreed to make this particular item part of the

recommendations coming forward in the CC report. We also did not make a group CC decision as to whether this particular item should be within the scope of the WUP. There are some incrementality issues associated with this project that need to be clearly identified. This is an existing program that has been implemented as a "footprint" issue. As such, it raises some questions as to whether this item should be considered under the jurisdiction of the WUP. Since the CC as a whole has not had the opportunity to consider this issue further, including it in the WUP report at this time is not acceptable.

- BC Hydro is welcome to make its own decisions as to whether it chooses to fund this project outside of the WUP CC decisions.

7.7.11.8 Erosion Protection Measures of Agricultural Lands in the Lower Duncan River

- The CBT supports the need to recognize and address local agricultural community concerns over erosion issues linked to dam operations.
- To this end, we support the CC in their efforts to implement a monitoring program to assess the impacts of operations on erosion on agricultural lands in the lower Duncan River area.

Section 8 Monitoring Program:

8.2 Proposed Monitoring Studies

- With respect to the Mosquito Monitoring study, in order to ensure local residents are informed that the Duncan CC placed a high priority on quality of life issues, public education and participation should be sought in this program. Such public engagement will also provide people with information on the anticipated benefits of alternative S73 with respect to the mosquito issue.
- Given the uncertainties expressed by CC members with respect to the assumptions used to evaluate recreational use/benefit on the Duncan reservoir, it would be beneficial to monitor recreation use on the reservoir by season of use, preference of reservoir elevation, type of use and location, so that we can better address operational impacts on recreation in this area

8.5 Recommended Monitoring Studies

- Are there not 13 proposed monitoring studies?
- Which of the proposed monitoring studies are designed to look at the erosion issues on the Lower Duncan River area?
- As stated at the CC meetings, the CBT requests preference be given to hiring or contracting out to local Columbia Basin residents for any work awarded under the Monitoring program or Physical Works program coming out of the BC Hydro WUP process

Yours truly,

Kindy Gosal
Manager Water Initiatives
Columbia Basin Trust

APPENDIX J: CORRESPONDENCE WITH THE REGIONAL DISTRICT OF CENTRAL KOOTENAY

The following table is a summary of recent correspondence between the Regional District of Central Kootenay and BC Hydro regarding the Duncan Dam water use planning process. Correspondence subsequent to the final Consultative Committee meeting in April 2004 is attached.

Table J-1: Summary of Recent Correspondence between the Regional District of Central Kootenay and BC Hydro

Date	Item	Subject
27 November 2001	Letter from BC Hydro to the Regional District of Central Kootenay re: announcement of the Duncan Dam water use planning process.	Requests the Regional District to select a representative for the Duncan Dam Water Use Plan Consultative Committee.
10 December 2001	Letter from BC Hydro to Larry Greenlaw, Area D Director.	Outlines the process taken to establish the Duncan Dam Water Use Plan Consultative Committee.
5 March 2002	Letter from the Regional District of Central Kootenay to BC Hydro outlining Resolution No. 186/02.	Resolution informing BC Hydro of the apparent lack of representation from the Business, Industry and Tourism sectors in the Duncan Dam water use planning process.
7 March 2002	Letter from BC Hydro to Carol McGowan, Secretary/Assistant Administrator, Regional District of Central Kootenay re 5 March 2002 letter.	Outlines the process taken to establish the Duncan Dam Water Use Plan Consultative Committee.
19 March 2002	Letter from BC Hydro to Mr. Hans Cunningham, Chair Regional District of Central Kootenay re Regional District's 5 March 2002 letter.	Provides background information on the Duncan Dam water use planning process.
8 May 2002	Letter from the Regional District of Central Kootenay to BC Hydro outlining Resolution No. 489/02.	Resolution clarifying that the lack of representation from specific sectors on the Duncan Dam Water Use Plan Consultative Committee is factual and not just perceived.
5 June 2002	Letter from BC Hydro to Carol McGowan, Secretary/Assistant Administrator, Regional District of Central Kootenay re 8 May 2002 letter.	Outlines the process taken to establish the Duncan Dam Water Use Plan Consultative Committee.
3 February 2003	Letter from the Regional District of Central Kootenay to BC Hydro outlining Resolution No. 37/03.	Resolution expressing the Regional District's continued concerns with the composite of the Duncan Dam Water Use Plan Consultative Committee.

Table J-1: Summary of Recent Correspondence between the Regional District of Central Kootenay and BC Hydro (cont'd)

Date	Item	Subject
10 February 2003	Letter from Larry Greenlaw, Director, Electoral D, Regional District of Central Kootenay to Gary Rodford, VP, BC Hydro.	Expresses concerns with the make-up and mandate of the Duncan Dam Water Use Plan Consultative Committee and includes recommendations for changes to Duncan Dam operations.
25 February 2003	Letter from BC Hydro to Carol McGowan, Secretary/Assistant Administrator, Regional District of Central Kootenay re Resolution No. 37/03.	Outlines the process taken to establish the Duncan Dam Water Use Plan Consultative Committee.
25 March 2003	Letter from BC Hydro to Larry Greenlaw, Director, Electoral D, Regional District of Central Kootenay from Gary Rodford, Director of Operations, Generation.	Outlines the make-up and mandate of the Duncan Dam Water Use Plan Consultative Committee and responds to Mr. Greenlaw's recommendations for changes to the Duncan Dam operations.
17 April 2003	Letter from Regional District of Central Kootenay to BC Hydro re Resolution No. 323/03.	Acknowledges receipt of 25 February 2003 letter from Sue Heaton, Public Affairs Officer, BC Hydro responding to Resolution No. 37/03 regarding the Regional District Board's continued concerns with the composition of the Duncan Dam Water Use Plan Consultative Committee.
22 April 2003	Letter from BC Hydro to Carol McGowan, Secretary/Assistant Administrator, Regional District of Central Kootenay requesting the Regional District host a Public Information Session for the local community.	Request by Duncan Dam Water Use Plan Consultation Committee to alleviate concerns raised by Larry Greenlaw, Regional District Area D Director regarding the structure of the Consultative Committee and address misinformation circulating in the community.
26 May 2003	Letter from Regional District of Central Kootenay to BC Hydro re Resolution No. 652/03.	Referring BC Hydro's request for a community information meeting for reconsideration by the Regional District Board at their 21 June 2003 board meeting.
30 June 2003	Letter from Regional District of Central Kootenay to BC Hydro re Resolution No. 693/03.	Resolution suggesting that BC Hydro undertake hosting the information session and that Regional District representatives would be in attendance.
3 October 2003	Letter from Regional District of Central Kootenay to BC Hydro re Resolution No. 1056/03.	Resolution – Whereas, in the opinion of the Regional Directors appointed by the Regional District Board to BC Hydro's Columbia and Duncan Dam water use planning groups, there is a lack of meaningful public consultation and a lack adequate attention being given to the human and social impacts with an over-attention given to biological issues

Table J-1: Summary of Recent Correspondence between the Regional District of Central Kootenay and BC Hydro (cont'd)

Date	Item	Subject
21 October 2003	Letter from BC Hydro to Mr. Don Harasym, Planning Manager, Regional District of Central Kootenay re Resolution No. 1056/03.	Outlines BC Hydro's activities to date to recruit individuals and organizations to participate both in the Columbia and Duncan Dam water use planning processes and confirms that BC Hydro will attend the 5 November meeting to discuss the Regional District of Central Kootenay's concerns.
17 December 2003	Letter from Carol McGowan Regional District of Central Kootenay, Secretary/Assistant Administrator.	Advises BC Hydro that the board appointed Directors to represent them on BC Hydro's Columbia River and Duncan Dam Water Use Plans.
6 February 2004	Letter from Carol McGowan Regional District of Central Kootenay, Deputy Chief Administrative Officer re: resolution 76/04.	Outlines that the Regional District will continue to participate in the water use planning process for both the Columbia River and Duncan Dam.
11 March 2004	Letter from Larry Greenlaw to Sue Heaton, BC Hydro Public Affairs Officer.	Outlines Mr. Greenlaw's concerns with regard to the Duncan Dam water use planning process.
30 April 2004	Letter from Sue Foster, Project Manager, Duncan Dam Water Use Plan to Larry Greenlaw.	Responds to Larry Greenlaw's concerns raised in his 11 March 2004 letter.
19 May 2004	Letter from Carol McGowan, Regional District of Central Kootenay, Deputy Chief Administrative Officer re: resolution 605/04.	Resolution advising BC Hydro that the District Board will not endorse the outcome of the Duncan Dam Water Use Plan if it does not include significant ongoing financial contribution to the mosquito abatement program.
13 June 2004	Letter from Larry Greenlaw to Blair Suffredine, MLA Nelson-Creston. Sue Heaton was copied on the letter.	Outlines Mr. Greenlaw's concern with regard to the Duncan Dam water use planning process and asks Mr. Suffredine to bring forth his concerns to the public.
24 June 2004	Letter from Sue Foster, Project Manager, Duncan Dam Water Use Plan to Carol McGowan.	Outlines the outcome of the Duncan Dam water use planning process and requests clarification of the Regional District's 19 May 2004 letter.
5 December 2004	Letter from Larry Greenlaw to Sue Foster, Project Manager, Duncan Dam Water Use Plan.	Outlines Mr. Greenlaw's concerns with the Duncan Dam water use planning process.
23 December 2004	Letter from Gordon Boyd, BC Hydro Duncan Dam Water Use Plan Corporate Representative.	Outlines the Consultative Committee recommendation for a Glacier Creek Boat Ramp Extension contingent upon the RDCK accepting responsibility for maintenance. Seeking confirmation that the RDCK would accept responsibility.

Regional District of Central Kootenay

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May 19, 2004

BC Hydro & Power Authority
601 – 18th Street
Castlegar, BC V1N4G7

Attention: **Sue Heaton, Public Affairs Officer**
Community Relations, Kootenay/Lower Columbia

Dear Ms. Heaton:

Please be advised that the Board, at its meeting held April 24, 2004, adopted the following resolution:

605/04 *A letter be forwarded to B.C. Hydro advising that further to the Board's previous concerns regarding the Duncan Water Use Planning process, the Board will not endorse the outcome of the Duncan Water Use Plan if it does not include significant ongoing financial contribution to the Regional District of Central Kootenay – Electoral Area D Mosquito Control service for the Duncan and Meadow Creek areas as a cost of operations of the Duncan Dam.*

Yours truly,

C. McGowan.

Carol McGowan
Deputy Chief Administrative Officer

CM:mem
Cc: Director Greenlaw

Document1

MUNICIPALITIES: **Cities:** Castlegar, Nelson **Town:** Creston **Villages:** Kaslo, Nakusp, New Denver, Salmo, Silverton, Slocan
ELECTORAL AREAS: •**A** -Wynndel/East Shore Kootenay Lake •**B**•**C**•**D**•**E**•**F**·**G**•**H** -The Slocan Valley •**I**•**J** -Lower Arrow/Columbia •**K** -The Arrow Lakes

Larry Greenlaw
DIRECTOR, ELECTORAL AREA D
HIGHWAY 31, MEADOW CREEK, BC V0G 1N0 Telephone: 250 366-4216 (home)
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June 13, 2004

Blair Sufferdine,
M.L.A. Nelson Creston
540 Baker Street
Nelson, B.C. V1L4H9

Dear Blair,

As the R.D.C.K. member on the Duncan Water Use Planning Committee I have been frustrated and aggravated by the process. The committee forum is 8 technocrats, 2 very questionable community representatives and 1 local government representative. The technical people control the procedures and use the other 3 members to legitimize the process. We provide amusement for them with our uneducated input.

The following are examples of my aggravations and concerns.

(1) The committee recommendation for water levels for recreation are to lower the full pool by one meter (3 feet) vertical to provide a beach for swimming at Howser Beach.

Consequences? This will negatively impact use at Howser Creek, South Bay, Duncan Island Estates, Orchard Beach and Glacier Creek Park.

Other considerations? Cost of spilling the water? Boating and other recreational activities enhanced by full pool. Naural beauty of full pool versus ugliness of lower elevations.

Practical solutions? Excavate Howser Beach area and leave the water up.

(2) The community has a mosquito control program. It is very expensive and a burden on the tax payers. We have requested B.C. Hydro pay it's fair share of the cost as they pay no taxes on the dam.

Results? The committee believes their flood control recommendations represent Hydro's fair share.

(3) My request for farmland protection from erosion caused by water releases of the dam was refused. Reasons? They say the river will finds it's own coarse and its useless to fight it.

Reality? The Duncan Dam completely controls the upper river. Is the committee too ignorant to realize the lower river can be controlled for the foreseeable future?

(4) The committee recommended 2.4 million dollars be allocated for a questionable archaeological coverup on the resevoir at the same time they turned down 20 thousand per year fro a mosquito control program.

Larry Greenlaw
DIRECTOR, ELECTORAL AREA D
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2

This recomendation clarifies the priorities of the technocrats and their disregard for the tax payers and the community in general.

The Duncan W.U.P. committee is a perfect example of A in school - E in common sense. The process is flawed and they are in the box.

As our M.L.A. I request you to bring forward the concerns of the local community about the W.U.P. We need your help.

Yours truly,

L E Greenlaw

C/2 R.D.C.K.
C/2 Water Comptroler
C/2 Sue Heaton/B.C.Hydro

BC hydro

THE POWER IS YOURS

Sue Foster
Project Manager
Duncan Dam Water Use Plan
Phone: (604) 528-2737
FAX: (604) 528-2905

24 June 2004

Carol McGowan
Deputy Chief Administrative Officer
Regional District of Central Kootenay
Highway 31
Meadow Creek, BC V0G 1N0

Dear Ms. McGowan:

This letter is in response to your 19 May 2004 letter (attached) to Sue Heaton, BC Hydro Public Affairs officer regarding Resolution 605/04 advising BC Hydro that the Regional District of Central Kootenay Board (RDCK) will not endorse the outcome of the Duncan Dam Water Use Plan if it does not include significant ongoing financial contribution to the Regional District Mosquito Control service for the Duncan and Meadow Creek areas as a cost of operations of the Duncan Dam.

At the final April 2004 Consultative Committee meeting, Committee members made a conditional consensus-based recommendation on a preferred operation for Duncan Dam, physical works in lieu of operational changes, a Water Use Plan review period, a monitoring advisory committee, and prioritized post-Water Use Plan monitoring studies.

The following is a summary of the recommendations of the Consultative Committee:

1. Conditional recommendation of a operating alternative which includes Duncan Reservoir elevations and flows in lower Duncan River to improve fish and wildlife habitat, recreation opportunities and reduce flooding events.
2. Physical works in lieu of operations including:
   - archaeological work pending the study results and discussions with First Nations, BC Hydro, and the government regulatory agencies to maximum funding of $2.4 million to address archeological sites.
   - risk assessment and implementation of physical works to protect Argenta Slough to maximum funding of $150,000 to improve wildlife habitat.
   - Glacier Creek boat ramp extension to maximum funding of $126,000 with the caveat that the RDCK would be responsible for ongoing maintenance of the boat ramp to improve recreation access and use.
3. Prioritized post-Water Use Plan monitoring studies, including a $66,000 mosquito study to address key uncertainties and answer specific questions that may change future decisions.
4. A 10-year review period for the Duncan Dam Water Use Plan unless triggered earlier.
5. Monitoring Advisory Committee.

Our records indicate that Larry Greenlaw, representative of the RDCK supported the Duncan Reservoir and Duncan River operations, the Argenta Slough physical works, and the Glacier Creek boat ramp extension with the caveat that RDCK would be responsible for maintenance. Mr. Greenlaw left the meeting prior to the discussions of the proposed monitoring studies, the Monitoring Advisory Committee and the Water Use Plan review period.

British Columbia Hydro & Power Authority 6911 Southpoint Drive Burnaby, BC V3N 4X8 (E04)
www.bchydro.com

The degree to which discharges from Duncan Dam directly affects mosquitoes and their breeding grounds in the lower Duncan River was not fully understood at the initiation of the Duncan Dam water use planning process. During the Duncan Dam water use planning process, the Consultative Committee undertook a study of the impact of Duncan Dam operations on mosquito breeding. One of the findings of the study was that Duncan Dam operations do not impact the first hatch of mosquitoes typically after 1 June, when dam discharges are approximately 3 m^3/s. Mosquito issues prior to mid-July are primarily related to freshet flows from the Lardeau River and Meadow Creek, which typically peak, by the beginning of July.

For the Duncan Dam water use planning process, the focus was on mitigating the negative impacts of higher flows in the lower Duncan River to avoid subsequent mosquito hatching events after the reservoir is nearing full pool in mid-July. The recommended operating alternative specifies decreased lower Duncan River flows in August, which is expected to better address the mosquito problem over current operations. Implementation of this operational change is also expected to negatively impact power generation. Therefore, the Consultative Committee did not support additional costs to fund the mosquito abatement program. However, the Committee did recommend a $66,000 mosquito study to determine if the mosquito performance measure and index site are appropriate for other sites in the lower Duncan River.

As mentioned above, one of the key recommendations of the Consultative Committee was a Glacier Creek boat ramp extension to maximum funding of $126,000 with the caveat that the RDCK would be responsible for ongoing maintenance of the boat ramp once it is built. Therefore, could you please clarify as to whether the RDCK Board is not endorsing the entire Duncan Dam Water Use Plan or just components of the plan? If the RDCK does not accept responsibility for maintenance of the boat ramp, it will not be included in BC Hydro's draft Water Use Plan.

I will contact you during the first week of July 2004 to discuss further. I would also be pleased to meet with the RDCK Board to review the recommended operating regime and the water use planning process for the Duncan Dam facilities.

attachment

Sincerely,

Sue Foster

cc Jim Mattison, Water Comptroller
Glen Davidson, Deputy Comptroller of Water Rights
Anita Mathur, Water Comptroller Office
Duncan Dam Consultative Committee
Regional District of Central Kootenay Board of Directors
Graeme Matthews, WUP Program Manager

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Telephone: 250-352-6665 or 1-800-268-RDCK(7325)
Fax: 250-352-9300

DEC. 5, 2004

Sue Foster
Project Manager
Water Use Plans

Dear Sue,

AS you know the R.D.C.K. passed a resolution not to sign-off on the plan until our people concerns are addressed.

I again offer the following for consideration in the plan.

(1) B.C. Hydro pay its fair share of the mosquito control program.
(2) Protection of farmland from erosion be addressed.
(3) For many practical reasons summer water levels for recreation be held at full pool.
(4) Inform the general public, the taxpayers, the people, of what and why the special interest majority on the WUP team is recommending spending three million dollars a year.

In conclusion, I find it incredible that a committee of federal and provincial employees can recommend spending the publics money so freely, without justification to the taxpayers.

Yours truly,

L.E. Greenlaw

C/2 Blair Sufferdine, M.L.A.
C/2 Richard Neufeld, Min.of Energy and Mining
C/2 R.D.C.K.

BC hydro THE POWER IS YOURS

Gordon Boyd
B.C. Hydro
Generation
Phone: 250-365-4573
Fax: 250-365-4571
E-mail: gordon.boyd@bchydro.com

23 December 2004

Carol McGowan
Deputy Chief Administrative Officer
Regional District of Central Kootenay
Box 590
202 Lakeside Dr.
Nelson, BC
V1L 5R4

Dear Ms. McGowan:

Subject: Duncan Water Use Plan – Glacier Creek Boat Launch

Please refer to letter Sue Foster to yourself dated 24 June, 2004, specifically the Duncan Dam Water Use Plan (WUP) recommendation for a Glacier Creek Boat Ramp Extension to a funding cap of $126,000 with the caveat that the Regional District of Central Kootenay would be responsible for maintenance of the boat ramp upon completion of construction.

It is my understanding that RDCK has a long term lease with the Province for the Glacier Creek camp area and that RDCK is responsible for ongoing maintenance of that camp area.

In anticipation of approval of the Duncan Dam WUP recommendations I would like to determine if RDCK will accept the responsibility for the ongoing maintenance of a boat launch extension at Glacier Creek. While the boat launch extension has not been designed as yet, it is anticipated that it would be about 4 m wide, would have sufficient length to allow boat trailers to access the reservoir within the top 2.1 m (7 ft) of the maximum Duncan Reservoir water level, would be constructed of concrete strips or slabs on the ground and would be sloped towards the water at an appropriate grade. Final details of the boat launch extension would be determined through discussions with RDCK and others.

We believe that the ongoing maintenance requirements for the boat launch extension will not be significant, but could include removal of beached woody debris, silt/sand accumulations, any garbage and vandalism repair. Although the structure itself will be low maintenance, repairs to the structure will be necessary over time. Removal of accumulations within the reservoir that would hinder water access to the ramp may also be necessary.

Are RDCK willing to accept the responsibility for maintenance (both undertaking the work and the cost of the work) of a boat launch ramp at the Glacier Creek campground?

Should RDCK not wish to accept responsibility for maintenance of the boat launch then construction of the boat launch will be removed from the scope of the works to be completed under the Duncan Dam WUP.

British Columbia Hydro & Power Authority, 601 18th Street, Castlegar, B.C. V1N 2N1
www.bchydro.com

- 2 -

I look forward to hearing from you.

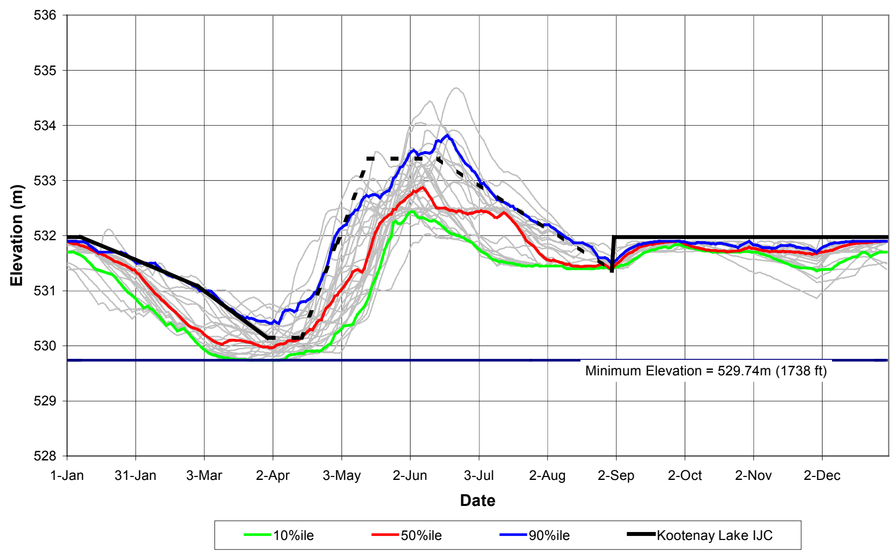
Yours truly:

Gordon Boyd
BC Hydro Duncan WUP Representative

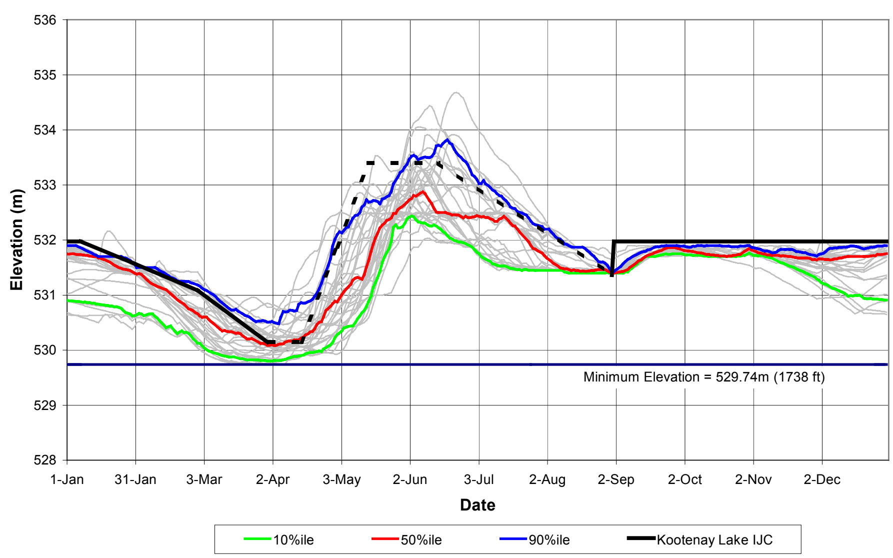
.cc W. Friml
S. Foster
Mary Lou Nesbitt (Min of Forests, Kootenay Lake Forestry Centre)

APPENDIX K: HYDROGRAPHS AND RESERVOIR ELEVATIONS FOR CURRENT OPERATIONS AND THE RECOMMENDED OPERATING ALTERNATIVE

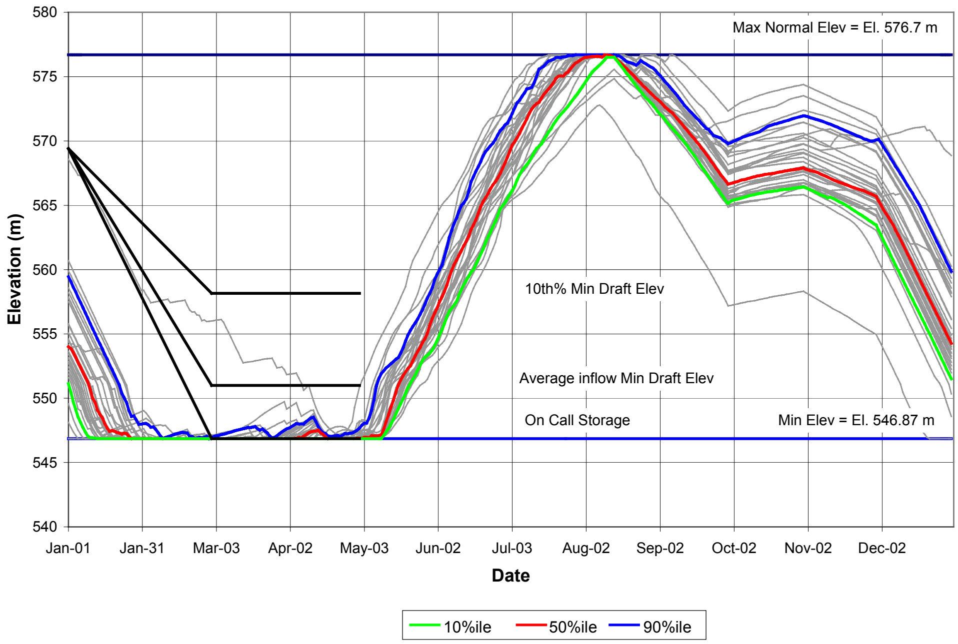
Alternative A – Current Operation
Kootenay Lake Elevation



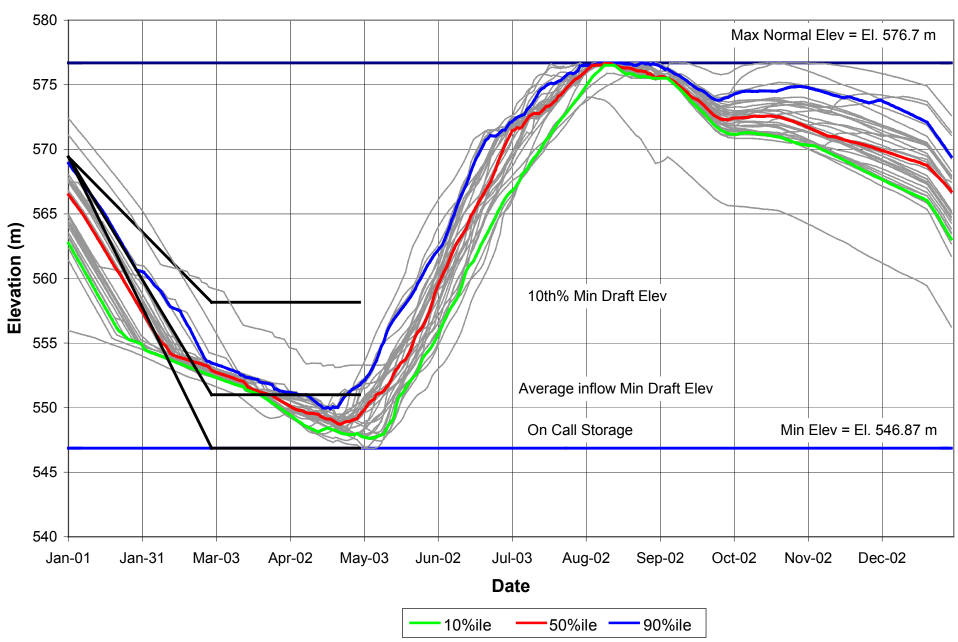
Alternative S (73)
Kootenay Lake Elevation



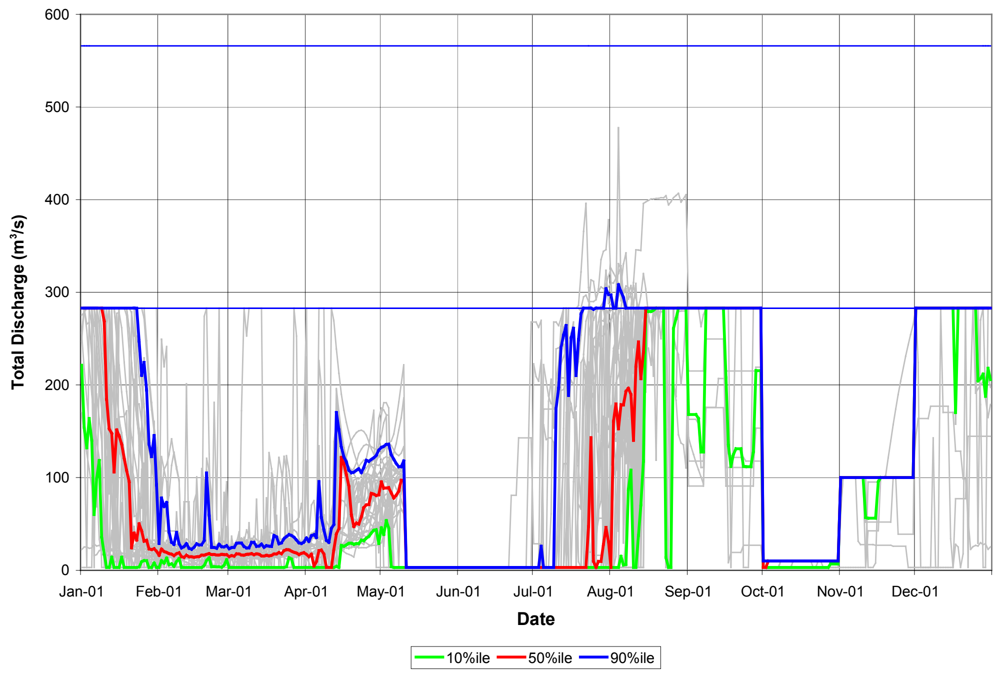
Alternative A – Current Operation
Duncan Reservoir Elevation



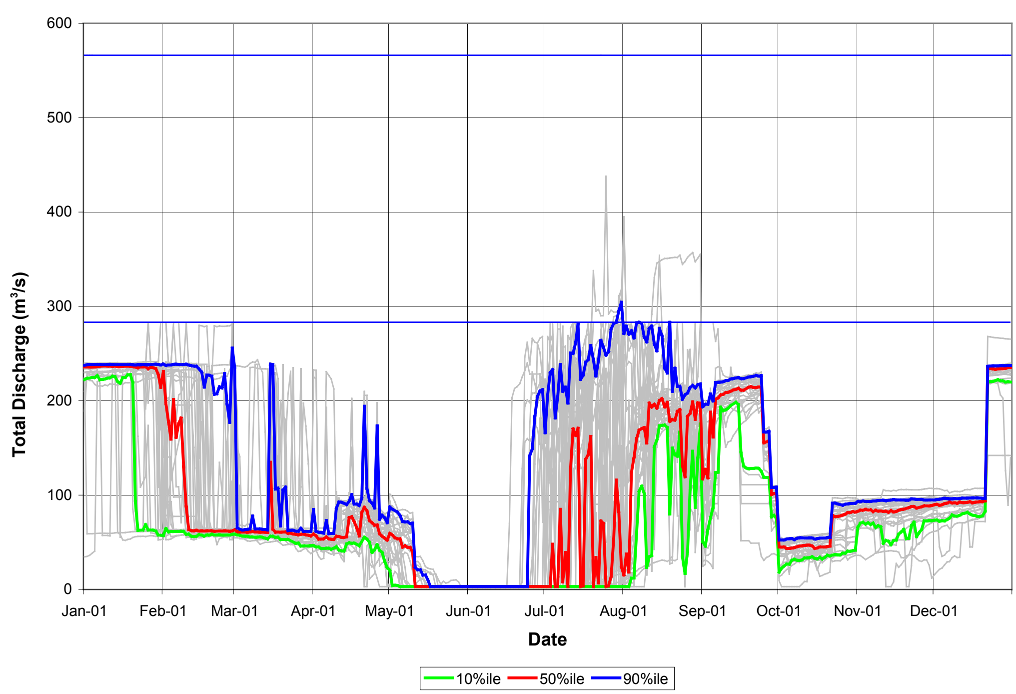
Alternative S (73)
Duncan Reservoir Elevation



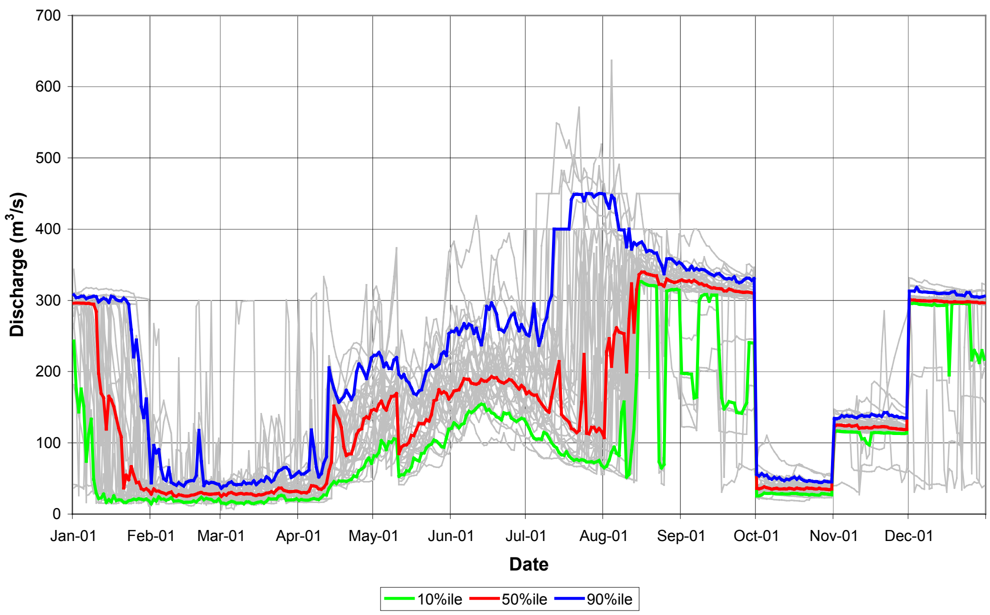
Alternative A – Current Operation
Duncan Dam Daily Outflow



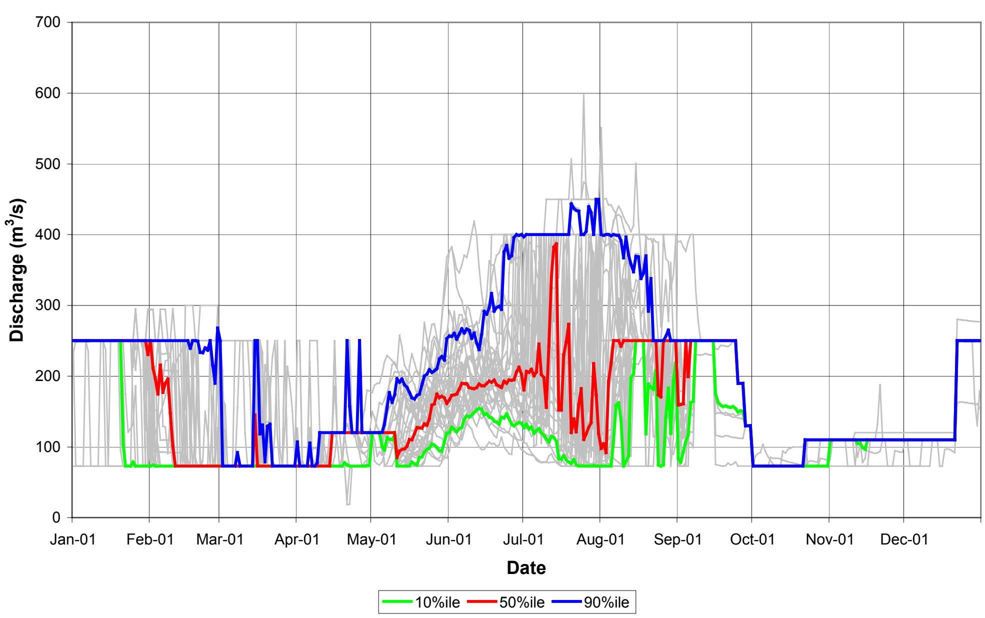
Alternative S (73)
Duncan Dam Daily Outflow



Alternative A – Current Operation
Lower Duncan River (Downstream of Lardeau Confluence)



Alternative S (73)
Lower Duncan River (Downstream of Lardeau Confluence)



APPENDIX L: ENVIRONMENTAL MONITORING PROGRAM

1.0 DUNCAN RESERVOIR RIPARIAN STUDY

Introduction

On behalf of the Consultative Committee, the Duncan Dam Water Use Plan Wildlife Technical Subcommittee developed performance measures for wildlife interests in the Duncan Reservoir. The Consultative Committee used the performance measures to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility.

In the Duncan Reservoir, riparian productivity was identified as an important element contributing to wildlife productivity. During the Duncan Dam water use planning process, Anne Moody (2002) conducted a review of riparian requirements. The performance measure developed from this study and other studies completed for the Wahleach Water Use Plan (McLennan, 2001), focused on the ability of reservoir elevations to meet the wetting requirements of riparian species.

The Duncan Reservoir operating regime of the recommended operating alternative may benefit riparian productivity. The monitoring study is an opportunity to assess the benefits of the reservoir operating regime through observation of riparian success and test the hypotheses underlying the approach taken in the Duncan Dam water use planning process.

Hypotheses

In the Duncan Dam Water Use Plan, the uncertainty related to wildlife interests in the Duncan Reservoir is:

> *Will the implementation of the Duncan Dam Water Use Plan result in neutral, positive or negative changes in wildlife resources for the Duncan Reservoir?*

The first hypothesis relates to the relationship between the reservoir operating regime and riparian productivity. The performance measure inputs were based on riparian criteria developed for Wahleach Reservoir and may not be appropriate for the Duncan Reservoir. Addressing the following hypothesis will contribute to the development of site specific data for further performance measure refinement.

> H_A: *The new operating regime will result in increases to the area and alterations in the species of both wetland and riparian vegetation communities.*

> H_{A1}: Reservoir elevations affect riparian productivity through the duration and frequency of root-zone flooding.

The final hypothesis relates to the relationship between riparian productivity and wildlife productivity and tests whether riparian community is an indicator of wildlife productivity.

> H_B: *Riparian ecosystems are an indicator of wildlife diversity and productivity.*

Objectives

The monitoring study will focus on each of the areas outlined above, according to the following objective:

- Determine the pre-alteration distribution of wetland and riparian vegetation and monitor changes in the aerial coverage and plant species composition of vegetated communities within the drawdown zone of Duncan Reservoir.

The monitoring study will consider any traditional use plant species, which occur within the reservoir drawdown zone or are introduced into the area with the riparian planting program.

Aerial photography of the reservoir at 1:5000 scale will be required to adequately map and quantify baseline conditions and changes. Colour photography is essential to maximize vegetation discrimination. The proposed frequency is pre-implementation (baseline); then 2, 5 and 10 years post alteration. Pre-implementation photography will be required because the most recent available photography is a decade old. Cost savings could be achieved by planning the photography to coincide with other ongoing projects.

Methods

Vegetation Monitoring

- *Mapping of Vegetation (in association with existing Digital Elevation Model):* Mapping based on large scale, colour aerial photography will allow for the maximum discrimination of environmental characteristics (e.g., plant community composition and density) and will allow for quantification of any changes in the area of plant communities. Repeated photography and mapping will provide the ability to document and measure change over time. Although some baseline mapping of vegetation distribution was done during the Duncan Dam water use planning process, the timing and scale of photography was not adequate. It is recommended that this be repeated with new photography to achieve true baseline conditions prior to implementation. The aerial photography would also provide essential information for other components such as wildlife, heritage and aquatic resources.

- *Habitat Analysis (Ground Truthing):*
    - Field verification and quantification of mapping.
    - Transects within existing plant communities to document species composition (including traditional use species), ranking of biomass and vigour. Global Positioning System documentation of community boundaries to confirm photo mapping.
    - Monitoring of habitat enhancement (planting and fertilization of riparian/herbaceous vegetation) where needed.
    - Establishment of ground level photo monitoring points (fixed positions) to allow for repeat close-up photography to document change over time. Number of fixed-points to be determined. This is a semi-quantitative procedure that will allow rigorous documentation of change over time at minimal expense.

Wildlife Monitoring

The following data will be collected over the review period to assess the bird use associated with the riparian areas being monitored:

- *Establish index sites*: At each transect identified in the vegetation monitoring component, a 50 m radius plot will be monitored five times per year (concentrated in spring and summer months).
- *Monitor bird use*: For each site visit, professional observers will document the bird activity, both visual and audible, for a five minute period, within the early morning period (no later than four hours after sunrise). Species, type of activity and a sound recording will be documented for each visit.
- *Monitor other use*: Observers will document other wildlife use (e.g., extent of browse, presence of scat, species observed, evidence of nesting) during each site visit.

Reporting

- *Baseline Status Report*: Upon completion of baseline inventory.
- *Data Reports:* For each monitoring period including photo records.
- *Summary Report*: At end of the monitoring phase.

Schedule and Costs

Duncan Reservoir is a steep-sided reservoir with limited road access to the presently vegetated sites at the upper end of the reservoir. This monitoring study includes costs for helicopter access to the vegetated sites for monitoring purposes with consideration for:

- Field time – travel time by road and boat to the sites is extensive and savings in personnel and boat rental charges would offset most of the helicopter costs.
- Safety – road and boat access to the upper end of the reservoir is hazardous.
- Ancillary benefits – helicopter use will facilitate:
  - An aerial overview of change within the vegetation communities.
  - Access to sites of specific concern which may not be visible on the ground.
  - Digital videography for future reference.
  - Easy relocation of permanent photo-monitoring sites.

The monitoring study will be initiated prior to implementation of the Duncan Dam Water Use Plan in order to develop a baseline. The study will be repeated in years 2, 5 and 10 of the 10-year Water Use Plan review period. Reporting in “YR0” and “YR10” will be extensive to outline the methods and conclusions respectively.

Table L-1 summarizes the Duncan Reservoir Riparian Study schedule and costs.

Table L-1: Summary of Duncan Reservoir Riparian Study Schedule and Costs

Step	Component	YR0	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Data Collection	*Aerial Photography*	$ 10	$ -	$ 10	$ -	$ -	$ 10	$ -	$ -	$ -	$ -	$ 10
	Vegetation Surveys	$ 15	$ -	$ 15	$ -	$ -	$ 15	$ -	$ -	$ -	$ -	$ 15
	Expenses	$ 5	$ -	$ 5	$ -	$ -	$ 5	$ -	$ -	$ -	$ -	$ 5
	Wildlife Monitoring	$ 30	$ -	$ 30	$ -	$ -	$ 30	$ -	$ -	$ -	$ -	$ 30
Analysis	*GIS Analysis*	$ 5	$ -	$ 5	$ -	$ -	$ 5	$ -	$ -	$ -	$ -	$ 5
	Performance Measure Development	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5
Project Management		$ 7	$ -	$ 7	$ -	$ -	$ 7	$ -	$ -	$ -	$ -	$ 7
Reporting		$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5
Total		$ 82	$ -	$ 72	$ -	$ -	$ 72	$ -	$ -	$ -	$ -	$ 82

References

This study proposal is based on the monitoring section of a memo prepared by Anne Moody:

AIM Ecological Consultants. (2003). *Duncan Reservoir - Potential Riparian Enhancement Sites, Treatment Options, Preliminary Planting Costs and Monitoring Requirements (Draft).* Prepared for BC Hydro Duncan Dam Water Use Plan Project, Burnaby, B.C.

Boulanger, John, John G. Woods, Janice Jarvis. (2002). *Songbird use of four floodplain vegetation types in the Revelstoke Reach, Upper Arrow Reservoir, British Columbia, Canada.* Prepared for BC Hydro Generation Environment, Burnaby, B.C.

AIM Ecological Consultants. (2002). *Duncan Water Use Plan: Potential Areas for Vegetation Establishment in Duncan Reservoir.* Prepared for BC Hydro Duncan Dam Water Use Plan Project, Burnaby, B.C.

2.0 LOWER DUNCAN RIVER COTTONWOOD STUDIES

Introduction

On behalf of the Consultative Committee, the Duncan Dam Water Use Plan Wildlife Technical Subcommittee developed performance measures for wildlife interests in the Duncan River. The Consultative Committee used the performance measures to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility.

In the lower Duncan River, cottonwood productivity was identified as an important element of riparian habitat linked to diversity of habitat and fauna, and natural ecosystem function. During the Duncan Dam water use planning process, a review of cottonwood requirements was conducted, as well as in-situ data collected that attempted to relate cottonwood recruitment to specific annual regulated flow regimes (Herbison, 2002). The performance measure focused on the ability of flows to meet elements of a “cottonwood hydrograph,” as follows:

- Peak flow disturbance: Geomorphic flows that create areas for cottonwood recruitment through bank erosion, channel scour and sidechannel abandonment.

- Seedling dispersal: The timing of peak flows must precede cottonwood seed release, which has been shown to be greatly affected by photoperiod (Braatne, 1996). Disjointed timing can result in seeds being flushed through the system.

- Germination/seedling development: Cottonwood seedling development during the post flood recession can be hindered through variations in recession rates. The acceptable range is 2 to 4 cm per day water table stage recession.

- Late season maintenance: Maintaining seedling development through the late growing season requires the provision of a base flow.

The Duncan River flow regime of the recommended operating alternative may benefit cottonwood recruitment in any or all of the categories listed above. The monitoring study is an opportunity to assess the benefits of the river flow regime through observation of recruitment success and test the hypotheses underlying the approach taken in the Duncan Dam water use planning process.

Hypotheses

In the Duncan Dam Water Use Plan, the uncertainty related to wildlife interests in the lower Duncan River is:

> *Will the implementation of the Duncan Dam Water Use Plan result in neutral, positive or negative changes in wildlife resources for the lower Duncan River?*

The first hypothesis relates to the relationship between the Duncan River flow regime and cottonwood recruitment success. Cottonwood productivity was a key indicator of overall ecosystem function, and was the main focus of studies and performance measures for wildlife interests in the lower Duncan River. The hypotheses that support this relationship relate groundwater to instream flow, and components of the hydrograph to cottonwood recruitment success:

> H_A: *Cottonwood recruitment in the lower Duncan River floodplain will benefit from the implemented hydrologic regime*.
>
> H_{A1}: Providing for hydrologic regime provides cottonwood recruitment benefits in isolation of each other.
>
> H_{A2}: Current operations on the lower Duncan River do not provide for a sustainable cottonwood population.

Another component of the cottonwood recruitment study tests the underlying hypothesis of the cottonwood recruitment box model from the performance measure. This performance measure was based on a literature review of hydrologic linkages to cottonwood productivity, and field studies identifying periodicity of model parameters. These studies did not address possible limitations to the application of the model on the lower Duncan River.

H_B: *Cottonwood recruitment in the lower Duncan River watershed is dependent on instream flows*.

H_{B1}: The water table for the lower Duncan River floodplain is dependent on the hydrologic regime.

The third component of the study tests the hypothesis linking cottonwood recruitment with wildlife diversity and riparian ecosystem health.

H_C: *Cottonwood forests are an indicator of riparian diversity.*

Riparian diversity is defined as both riparian forest diversity and wildlife diversity. To simplify the study design and ensure effective outputs, bird use is proposed as the indicator of wildlife diversity, as their habitat requirements can be observed directly in the field. As a response indicator, birds utilize habitats much faster than other species and therefore their use can be directly correlated to habitat changes that may be caused by operations.

Objectives

The monitoring study will focus on each of the areas outlined above, according to three objectives:

- Evaluate the benefits to cottonwood forests associated with operational changes.
- Determine the linkages between lower Duncan River cottonwood growth and instream flows.
- Quantify the wildlife values associated with cottonwood forests.

Methods

Establish Index Sites, Transects and Plots

The study area includes the lower Duncan River, and the lowest reach of the Lardeau River. Index stations, permanent sample transects, and repeatable survey routes for physical and biological monitoring in the lower Duncan and Lardeau rivers floodplain will be established and integrated with the Digital Elevation Model.

There will be between two to four zones chosen per reach, per system, and four to five 100 m^2 sites per zone, intensity commensurate with reach size and cottonwood suitability. Assuming one reach is chosen from the Lardeau River, the number of sites will range between 80 to 100. A 2 m wide “belt” transect will be associated with each site, defined by data from the Digital Elevation Model. Along each belt transect, five 2 m^2 plots will be identified. Therefore, the number of plots will range between 400 to 500. Riparian ecologists will select index sites and zones based on the following requirements:

- Associated with active channel.
- Substrate conditions optimal for cottonwood growth.
- Encompasses a range of cottonwood age classes.
- Reasonable access for groundwater monitoring and surveys.
- Large enough area to capture spatial changes in age distribution and maintain a large sample size for dendrology and phenology.

Index Site Monitoring

The following data collected at the index sites will be used to evaluate assumptions in the cottonwood recruitment box model developed for the Duncan River performance measures:

- *Physical record:* The following steps will be taken to record the physical parameters of each site:
    - On initial survey, Global Positioning System (GPS) each plot for future reference.
    - Annually photodocument each belt transect from the water's edge out to develop a record of phenological and physical changes to each transect.
- *Vegetation surveys:* Five plots within each belt transect established in each index site will be surveyed annually to characterize vegetation composition by location on the floodplain, linked to the Digital Elevation Model. The indices will be:
    - Number of stems, life stage and percent cover.
    - Growth form of each species (grass, forb, shrub, small/large tree).
    - Percent cover by species and physical conditions (particle size – per cent cover by category, slope angle, and sun penetration).
- *Cottonwood surveys:* The analysis of cottonwood success will be comprised of three measures:
    - Dendrochronological analysis will be done in years 1, 5 and 10, by linking tree age to inflow year, and revisiting work done (Herbison, 2002) for over 100 cottonwoods trees of various ages and locations.

- Health and vigor of cottonwood from young sapling to mature stages in representative sites every three years starting in year 1.

- Reaction of cottonwood germinants and seedlings to stage changes and flow rates at representative index sites will be recorded each year for the first five years. Monitoring will be reviewed after five years to determine whether further data are required.

- *Groundwater monitoring*: Peizometers installed at selected transects will be monitored using water level data-loggers. Monitoring will be reviewed after five years to determine whether further data are required.

- *Wildlife monitoring*: The following data will be collected over the review period to assess the bird use associated with the riparian areas being monitored:

  - Establish index sites: At each transect identified in the vegetation monitoring component, a 50 m radius plot will be monitored five times per year (concentrated in spring and summer months).

  - Monitor bird use: For each site visit, professional observers will document the bird activity, both visual and audible, for a five minute period, within the early morning period (no later than four hours after sunrise). Species, type of activity and a sound recording will be documented for each visit.

  - Monitor other use: Observers will document other wildlife use (extent of browse, presence of scat, species observed, evidence of nesting, for example) during each site visit.

Analysis

The results from the data collected will be analyzed using the following approaches:

Map Work

For the entire study area, the following mapping analysis will be done:

- Annually map and tally areas of potential new cottonwood nursery site in late summer (i.e., new sand and gravel deposits).

- Annually map and tally areas of new germinants in the fall.

- Aerial photography – 1:10000 over-flights will be done in early spring or late fall of years 1, 5 and 10 and ortho-rectified to update channel and index site morphology changes.

Performance Measures

To document the performance of each variable of interest over the monitoring study, the following performance measures are proposed:

- Cottonwood recruitment index: There are several inputs into the measure describing the response of cottonwoods to the flow regime changes, each as a comparison with the control samples:
    - Area of new germinants: Results of aerial assessments of germination after each freshet.
    - Health and vigour of existing cottonwood stands: Results of assessments of cottonwood success.
    - Recruitment success: Results of monitoring of new germinants.
- Vegetation diversity index: The results of the vegetation surveys of each plot will be analyzed to describe the diverse nature of the riparian vegetation community as a comparison with the control plots.
- Wildlife use index: Bird and general wildlife use will define the wildlife use index:
    - Species diversity: An index of diversity of wildlife use and in particular bird use has been developed in Boulanger, et al. (2002).
    - Species abundance: The results of the bird surveys will be compiled to compare the degree of use between test and control areas.

Predictive Tools

The cottonwood recruitment box model assumptions that feed into the performance measure developed for the Duncan Dam Water Use Plan is also being tested in this study. The following results will be integrated to develop a new box model for predicting cottonwood success associated with instream hydrology:

- Groundwater modelling: Determine the relationship with groundwater levels in the cottonwood recruitment zones, and instream flows.
- Evaluate recruitment response: Define the relationship between groundwater elevation and the success of cottonwood germinants over time.

The existing model will be re-developed based on site-specific inputs on hydrologic requirements, professional opinion and available literature.

Schedule and Costs

The monitoring study will be initiated prior to implementation of the Duncan Dam Water Use Plan in order to develop a baseline. The study will be repeated annually where necessary, but the majority of the study will be repeated in years 2, 5 and 10 of the 10-year Water Use Plan review period.

Table L-2 summarizes the lower Duncan River Cottonwood Recruitment Study schedule and costs.

Table L-2: Summary of Lower Duncan River Cottonwood Recruitment Study Schedule and Costs

Step	Component	YR0	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Data Collection	*Establish Index Sites*	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Physical Record	$ 5	$ -	$ 5	$ -	$ -	$ 5	$ -	$ -	$ -	$ -	$ 5
	Vegetation Surveys	$ 20	$ -	$ 20	$ -	$ -	$ 20	$ -	$ -	$ -	$ -	$ 20
	Cottonwood Surveys	$ 20	$10	$ 20	$10	$10	$ 20	$10	$10	$10	$10	$ 20
	Groundwater Monitoring	$ 30	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8
	Wildlife Monitoring	$ 40	$ -	$ 40	$ -	$ -	$ 40	$ -	$ -	$ -	$ -	$ 40
Analysis	*Mapping*	$ 10	$ -	$ 10	$ -	$ -	$ 10	$ -	$ -	$ -	$ -	$ 10
	Aerial Photography	$ 15	$ -	$ 15	$ -	$ -	$ 15	$ -	$ -	$ -	$ -	$ 15
	PM Development	$ -	$10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Model Development	$ -	$10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Project Management		$ 15	$ 4	$ 12	$ 2	$ 2	$ 12	$ 2	$ 2	$ 2	$ 2	$ 12
Reporting		$ 10	$ 3	$ 5	$ 3	$ 3	$ 5	$ 3	$ 3	$ 3	$ 3	$ 10
Total		$170	$44	$134	$22	$22	$134	$22	$22	$22	$22	$139

References

This study proposal is based on a proposal originally completed for funding prior to the Duncan Dam water use planning data collection phase:

Higgins, Paul. (2002). *Water use planning project proposal: Evaluation of the influence of past streamflow on stands of Black Cottonwood (Populus balsamifera [triplocarta]) and riparian vegetation communities of the Duncan and Lardeau Rivers.* Prepared for BC Hydro Duncan Dam Water Use Plan project, Burnaby, B.C.

Boulanger, John, John G. Woods, Janice Jarvis. (2002). *Songbird use of four floodplain vegetation types in the Revelstoke Reach, Upper Arrow Reservoir, British Columbia, Canada.* Prepared for BC Hydro Generation Environment, Burnaby, B.C.

Braatne, J.H. , S.B. Rood and P.E. Heilman. (1996). *Life history ecology, and conservation of riparian cottonwoods in North America.* Pp. 57-85 *in* Biology of Populus and its implications for management and conservation, Stettler, R.F., H.D. Bradshaw, Jr., P.E. Heilman, and T.M. Hinckley, eds. National Research Council of Canada, Ottawa.

Herbison, Brenda. (2002). *Black cottonwood along the lower Duncan River: interpretation of current conditions relevant to future flow management for riparian diversity.* Prepared for BC Hydro Duncan Dam Water Use Plan project. Burnaby, B.C.

3.0 LOWER DUNCAN RIVER FISH MONITORING STUDIES

Introduction

On behalf of the Consultative Committee, the Duncan Dam Water Use Plan Fish Technical Subcommittee developed performance measures for fish interests in the lower Duncan River. The Consultative Committee used the performance measures to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility.

In the Duncan River, fish habitat was identified as an important element contributing to fish productivity, but limited information was available on habitat use, timing and operational impacts of river fish populations. Therefore, the Consultative Committee recommended collection of baseline information and monitoring data to assess the changes in productivity associated with the recommended operating alternative, and to inform future planning processes.

Data collection, analysis and reports completed prior to and during the Duncan Dam water use planning process (BC Hydro, 2003; Klohn Crippen, 2003 and 2003a; Miles, 2002 and 2002a; Perrin and Korman, 1997; van Dishoek and Gebhart, 2003; and Vonk, 2001) were used to develop preliminary performance measures.

- *Effective spawning (kokanee, whitefish) and rearing habitats (rainbow and kokanee):* By integrating Duncan River sidechannel surveys and river HEC-RAS modelling (Klohn Crippen, 2003 and 2003a), and fish habitat suitability information for indicator species, flow-habitat relationships were developed for spawning and rearing fish species to evaluate different flow scenarios and recommend operational constraints. The performance measures evaluate both the daily fish habitat values and the long-term viability of those habitats in consideration of incubation needs (for spawners) and rearing stability (for rearers).
    - *Kokanee (sidechannel) effective spawning area and habitat lost* performance measures.
    - *Kokanee (sidechannel) effective rearing habitat lost* performance measure.
    - *Rainbow (sidechannel) effective rearing area and habitat lost* performance measures.

    - *Kokanee (mainstem) effective spawning area* performance measure.
    - *Kokanee (mainstem) effective rearing habitat lost* performance measure.
    - *Whitefish (mainstem) effective spawning area* performance measure.
    - *Rainbow (mainstem) effective rearing habitat lost* performance measure.

- *Burbot Spawning Access:* Determines the average width of access available at the Water Survey of Canada transect in the lower Duncan River through burbot migration and spawning for each operating alternative, based on burbot passage velocity requirements (BC Hydro, 2003a).
- *Total Gas Pressure (TGP) risk analysis:* The number of "TGP-days," defined as a day where spilling causes TGP levels above 115 per cent, is evaluated for each operating alternative.

Hypotheses

In the Duncan Dam Water Use Plan, the uncertainty related to fish interests in the lower Duncan River is:

> *Will the implementation of the Duncan Dam Water Use Plan result in neutral, positive or negative changes in fisheries resources for the lower Duncan River?*

To address this key uncertainty, the review period will focus on assessing the fish habitat composition and fisheries use of the lower Duncan River floodplain. Baseline information is required to address uncertainties related to fish habitat use, periodicity and habitat preferences of fish in the Duncan River and its sidechannels. The following hypotheses will be addressed by collecting baseline data:

> H_{A1}: *Duncan River sidechannels provide important rearing habitats for resident and outmigrating juveniles and adult fish species.*

> H_{A2}: *Duncan River spawning is limited to the mainstem for whitefish and is prevalent in the mainstem and sidechannels for kokanee.*

The recommended operating alternative includes a minimum flow to preserve the integrity of kokanee spawning areas in the lower Duncan River, assuming that the river population is distinct from the Lardeau River and Meadow Creek runs. The following hypothesis will test this assumption:

> H_{B1}: *The kokanee population spawning in the Duncan River mainstem and sidechannels is distinct from spawning populations in Meadow Creek and Lardeau River.*

The only effectiveness monitoring study is to address kokanee spawning and stranding risk. Kokanee spawning is the main performance indicator of minimum flows for fish. The following hypothesis is proposed:

> H_{B2}: *Minimum flow provisions will increase adult spawning returns to the Duncan River through increased spawning success.*

The Consultative Committee was receptive to make water use decisions based on limited available data, but were reluctant to incur significant costs without better understanding the value of such decisions. Baseline information on fish habitat versus flow relationships and water quality versus flow relationships, are required prior to additional operating changes on the Duncan River. The following hypothesis is proposed:

> H_{C1}: *Habitat-flow relationships in the lower Duncan River floodplain are not adequately captured under the 2003 models.*

> H_{C2}: *Total gas pressure-flow relationships in the lower Duncan River are not adequately captured in the 2001 data set.*

Trial studies will be implemented to evaluate the stranding risk under different conditions (magnitude, rate, season and diel timing of flow changes). The following hypothesis is proposed:

> H_D: *Stranding risk below Duncan Dam is related to ramping rates (and their timing and magnitude), channel morphology and tributary hydrology.*

> H_{D1}: Sidechannel stranding is a major contributor to stranding risk in the lower Duncan River.

> H_{D2}: The diel timing of Duncan Dam operations changes can reduce stranding risk in the lower Duncan River.

> H_{D3}: Seasonal fish habitat use changes affect the vulnerability of fish species and life histories to stranding risk.

The Duncan River fish monitoring program proposes to assess the benefits of providing bull trout migration and understand bull trout habitat use in the watershed. Migration is facilitated by the weir and flip bucket operation at the Duncan Dam low level outlet tailrace. The following hypotheses relates to the effectiveness of both passage on bull trout productivity and the weir on facilitating fish passage:

> H_{E1}: *Facilitated bull trout passage through the Duncan Dam improves recruitment of juveniles into Kootenay Lake.*

> H_{E2}: *The weir increases genetic diversity in the bull trout population by enhancing access for a greater size range of adults.*

Objectives

The monitoring study will focus on each of the areas outlined above, according to three objectives:

- Assess the fish habitat availability and use of the lower Duncan River floodplain.
- Document the benefits of an altered flow regime on kokanee spawning populations.
- Finalize a stranding protocol in the lower Duncan River that minimizes stranding risk through operations.
- Assess the benefits of facilitating bull trout passage through Duncan Dam.

Methods

Mapping, Digital Elevation Model and Hydraulic Modelling

The development of a hydraulic response model for the lower Duncan River floodplain is essential for both future performance measure and stranding protocol development. Each phase of data collection must coincide with conducive seasonal and operations conditions. There are three components to this study:

- *Mapping:* Collection of air photos and ortho-rectification will be required to develop mapping for the lower Duncan River floodplain. Prior to photography, survey control will be set throughout the area for photogrammetric analysis. Additional survey may be obtained using LiDAR or equivalent.
- *Bathymetric Data Collection:* An instream detailed survey of the Duncan River sidechannel bottom will be required to properly model the hydraulic response to operational changes.
- *DEM Analysis:* Photogrammetric analysis and integration of data collected through each phase will be encapsulated in a single Digital Elevation Model of the lower Duncan River floodplain. The precision and density of data will support a 0.1 m contour interval.
- *Hydraulic Modelling:* Hydraulic modelling will be a two phase approach, over two years:
    - Hydraulic response model: With the completion of the Digital Elevation Model and baseline water elevations, the response model will be developed in year 1 and flow-breaklines established, incorporating backwater situations and natural inflow sources.

- Calibration and Habitat Simulations: The model will be calibrated in year 2 with field measurements from associated monitoring programs. Fish habitat simulations for each of the likely operational scenarios and fish species life history types will be developed.

Adaptive Stranding Protocol

In partnership with BC Hydro's Columbia Generation Area, a comprehensive ramping and stranding protocol will be developed for Duncan Dam operations comprised of an in-depth assessment of fish habitat use (stranding risk) and ramping rate impacts. As summarized in the schedule below, an initial protocol is being developed by Hydro's Columbia Generation based on the best available information, and will be modified if necessary based on updated information within two years. The following describes a four stage planning process. Note that the Duncan River fish monitoring program proposes to fund only stages 3 and 4:

Stage 1: Interim Protocol Development (pre-WUP Fiscal 03/04)

The Fish Technical Subcommittee recommended that BC Hydro's Columbia Generation Area develop, in consultation with fisheries regulatory agencies, a stranding protocol over the 2003/04 fiscal period. The stranding protocol will cover the four facets described above. Specifically:

- Ramping rates: Suggested that the finest ramping rates possible be implemented as soon as possible.

- Re-contouring: Designs for Hallum sidechannel improvements will be reviewed.

- Evaluate impacts: Index sites and assessment methods will be developed.

- Protocol development: An experimental design will be developed to develop a stranding risk index around various ramping rates, season, flow changes, time of day and fish species. The design will be based on the ramping rate investigation proposal from Golder and Associates (April 2003) for the Columbia and lower Kootenay rivers. In addition, data being collected on seasonal fish habitat use and life history information will continue to inform ramping rate development.

Stage 2: Interim Protocol Implementation (pre-WUP Fiscal 04/05)

After fisheries regulatory staff review, the protocol and experiments will be implemented. In total, three studies will be initiated:

- Ramping rate experiments: Three separate ramping rate experiments will be conducted within the fiscal year. Each experiment will evaluate the impacts of approximately five ramping rate conditions.

- Seasonal Fish Habitat Use studies: Continuation and expansion of the original 2002/2003 studies conducted on the Duncan River to assess the suitability of mainstem and sidechannel fish habitats for target fish species.

- Life history timing: Continuation and expansion of 2002/2003 telemetry and electrofishing studies, to address spawning, rearing, and outmigration timing.

Stage 3: Extended Protocol Implementation (WUP Years 1–2)

The stage 2 studies are continued for an additional two years, with three years combined data collection for ramping rate, fish habitat use and life history studies. In addition, the following programs will be funded for two years to develop a hydraulic model for the system:

- Develop a Digital Elevation Model: Survey and compile a bathymetric profile for the lower Duncan River floodplain (described above).

- Develop and calibrate hydraulic model: Compile water level information and develop calibrated hydraulic response model (described above).

Stage 4: Finalize Protocol and Monitor (WUP Years 3–10)

At this stage, all information will be compiled to develop a comprehensive stranding mitigation strategy for the Duncan River. Following the implementation, monitoring for each year will provide insight into further refinements or, where more appropriate, opportunities for physical works. The final protocol will require review by fisheries regulatory staff.

Fish Habitat Utilization Study

In partnership with BC Hydro's Columbia Generation Area, develop the stranding protocol and collect baseline information prior to implementation of the Duncan Dam Water Use Plan.

Stage 1: Data Collection (pre-WUP Fiscal 04/05)

- Seasonal and Diel Habitat Use Assessments: Expand on previous fish habitat use assessments, specifically into the sidechannels and unstable fish habitats, generating a comprehensive database of habitat preferences varied by fish species, location, season and time of day.

- Life History Timing (whitefish, bull trout, rainbow and kokanee): In addition to the spawner surveys conducted under this monitoring study, adult spawning timing will be assessed by telemetry and visual surveys for bull trout, rainbow and whitefish species in the lower Duncan River. Costs of this study have been estimated assuming that rainbow and bull trout will be tagged, but it is uncertain whether rainbow will also be tracked to determine spawning habits and timing.

Stage 2: Data Collection (WUP 05-07)

Once BC Hydro is directed to implement the Duncan Dam Water Use Plan, data collection will continue under the monitoring program for an additional two years.

Kokanee Spawning Surveys

Two studies are proposed for kokanee spawning in the lower Duncan River, including Meadow Creek and Lardeau River assessments.

- *Stock Abundance Monitoring:* Annual kokanee escapement surveys will take place for the lower Duncan River, Lardeau River and Meadow Creek to monitor population level response to flow changes and document relative abundance between stream populations. The current monitoring study conducted by Ministry of Water, Lands and Air Protection in the Kootenays cover the Lardeau River and Meadow Creek runs. The Water Use Plan study proposes to expand the current study to include the Duncan River assuming that the current study will continue to be funded by the Ministry over the review period. Where possible, the Ministry will assist in the data collection.

- *Genetic Assessment:* This study assesses the genetic differences between kokanee populations that spawn in the Lardeau, Meadow Creek and Duncan rivers. A similar study currently being undertaken on Kootenay Lake tributaries may influence the importance of this proposal, in terms of the viability of reaching a conclusive outcome.

Bull Trout Passage Study

It is proposed that the benefits of operations of the flip-bucket passage facilities for adult bull trout be evaluated with respect to recruitment to Kootenay Lake. The passage study will determine whether or not adults migrating into the reservoir spawn and juveniles emigrate into Kootenay Lake.

- *Adult telemetry study:* A range of bull trout males and females will be radio-tagged at the flip bucket facility in the summer to determine their migration behaviours and spawning destinations (upper Duncan River tributaries Houston Creek, and the Westfall River, and the upper Duncan River mainstem, as described in O'Brien (1999)). This is a one year study to help focus outmigration enumeration efforts, and provide more information on migration behaviour.

    - *Juvenile outmigration assessment:* Once spawning destinations have been confirmed, a two stage trapping program is planned for the following three years that would determine the extent of juvenile outmigration from Duncan Reservoir:

    - Stage 1 – Upper Duncan River outmigration: One to two rotary screw traps will be incorporated into a full mark recapture experiment for the entire outmigration period (May to July). The locations of the traps will be downstream of known spawning and rearing areas, while attempting to enhance trap efficiency. This may require focusing on Houston Creek and Westfall River tributaries.

    - Stage 2 – Duncan Dam outmigration: One to two traps will be located below Duncan Dam, likely in the canal below the low level outlet facilities, above the confluence with spillway and Lardeau River discharges. Traps will be operated through the outmigration period, and mark-recaptures will be set up to estimate trap efficiency over the range of low level outlet facilities release magnitudes and run-timing.

- *Evaluation of weir efficacy:* In lieu of any design alterations and new weir installation, the Fish Technical Subcommittee proposes a long term assessment of bull trout migration in relation to weir installation be undertaken over the review period. The project costs will cover annual maintenance of the weir, the enumeration and marking of adults passing through the flip bucket, and an annual report.

Spillway Total Gas Pressure Monitoring

Limited Total Gas Pressure (TGP) monitoring was conducted prior to the trade-off analysis stage of the Duncan Dam water use planning process. Further monitoring is required to understand the relationship between spill magnitude and TGP concentration at locations downstream of the spillway plunge pool. It is proposed that the Duncan River fish monitoring program fund the installation and data reporting of TGP metering at two stations (above the Lardeau River confluence and at the Water Survey of Canada station 08NH118). Metering will be continuous over the spill risk period for two years, or until adequate data is collected to complete the TGP-discharge relationship required at both sites. Reporting will be annual and a final report will be prepared at the end of the study.

Analysis

Analysis will focus on the development of performance measures related to the outcomes of the studies defined above. Refining life history timing and fish habitat use, defining available habitats, and monitoring population level impacts of operations will more clearly outline impacts of operations on lower Duncan River fish populations and inform future planning processes.

Mapping and Hydraulic Modelling

Where possible, map and photo analysis will be conducted using GIS ArcView software and repeatable measures developed for each of the associated projects. Hydraulic modelling will be done using Telemac 3-D hydraulic modelling software or an equivalent program.

Adaptive Stranding Protocol and Fish Habitat Utilization Study

After the first year of implementation, study results will be integrated with the hydraulic model to assess ramping rate alternatives to the initial recommendations, and changes will be made to the monitoring program where appropriate. This will be repeated for the next two years while new data is collected. Over the duration of the review period following the protocol completion, any additional information will be integrated into the protocol at the end of the review period.

Performance Measures

- *Operations Performance:* The only fish performance measure being proposed in this monitoring program is kokanee spawner escapement. Spawner escapement for the Duncan, Lardeau and Meadow Creek runs will serve as a general measure operational impact.

- *Development of Performance Measures:* The existing performance measures will be calculated annually and updated when appropriate information is available.

Reporting

- *Annual Reporting:* Annual monitoring program reports will be submitted to the Water Comptroller and be available to the public.

Schedule and Costs

The Duncan River fish monitoring program is extensive and covers many aspects of data collection: fish habitat data collection, baseline species information, baseline productivity monitoring and long term productivity monitoring. The program will start in year “0” to account for baseline data collection. Due to inter-agency commitments agreed to outside of the Duncan Dam water use planning process, year “0” projects will be initiated and funded from BC Hydro’s Columbia Generation Area.

Table L-3 summarizes the Duncan River Fish monitoring program.

Table L-3: Summary of the Duncan River Fish Monitoring Program

Project	Phase	Component	YR0**	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Mapping, DEM and Hydraulic Model	***Data Collection***	*Mapping*	$ -	$ 75	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Bathymetric data collection	$ -	$ 50	$ 50	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Calibration and Habitat Simulation	$ -	$ -	$ 75	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Analysis and Reporting	*DEM Analysis*	$ -	$ 25	$ 25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Hydraulic Response Model	$ -	$ 25	$ 25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		PM Re-Development	$ -	$ -	$ 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Reporting	$ -	$ 5	$ 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Adaptive Stranding Protocol Development	***Planning and Data***	*Ramping Rate Experiments*	$ 105	$ 85	$ 85	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Annual Operations Monitoring	$ -	$ -	$ -	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40	$ 40
	Reporting	*Develop/Adapt Protocol*	$ 9	$ 15	$ 15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 15
		PM Report	$ -	$ 10	$ 10	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
		Stranding Report	$ 9	$ 15	$ 15	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
Fish Habitat Utilization Studies	***Data Collection***	*Seasonal/Diel Habitat Use Studies*	$ 77	$ 115	$ 100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Life History Timing	$ 23	$ 75	$ 75	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Analysis and Reporting		$ 9	$ 10	$ 25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Kokanee Spawning Surveys	***Data Collection***	*Helicopter Surveys*	$ -	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15	$ 15
		Genetic Assessment	$ -	$ 25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Analysis and Reporting	*PM Report*	$ -	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
		Genetic Report	$ -	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bull Trout Passage Study	***Data Collection***	*Adult telemetry study*	$ -	$ 60	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Juvenile enumeration - Upper River	$ -	$ 40	$ 40	$ 40	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Juvenile enumeration - Lower River	$ -	$ 50	$ 50	$ 50	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Evaluate Weir efficacy (in lieu)*	$ 23	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10	$ 10
	Analysis and Reporting	*Telemetry Report*		$ 5									
		Juvenile Migration Reports	$ -	$ 10	$ 10	$ 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Spillway TGP Monitoring	***Data Collection (two stations)***		$ -	$ 10	$ 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Analysis and Reporting	*PM Re-Development*	$ -	$ -	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Reporting	$ -	$ 5	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Project Management			$ 25	$ 73	$ 65	$ 18	$ 8	$ 8	$ 8	$ 8	$ 8	$ 8	$ 10
Total			$ 280	$ 818	$ 735	$ 198	$ 88	$ 88	$ 88	$ 88	$ 88	$ 88	$ 105

* weir efficacy to be monitored in lieu of weir design options
** YR"0" costs are covered by BC Hydro's Columbia Generation Area

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4.0 DUNCAN RESERVOIR FISH MONITORING STUDIES

Introduction

On behalf of the Consultative Committee, the Duncan Dam Water Use Plan Fish Technical Subcommittee developed performance measures for fish interests in the Duncan Reservoir. The Consultative Committee used the performance measures to compare the benefits and trade-offs between different operating alternatives for the Duncan Dam facility.

In the Duncan Reservoir, fish habitat was identified as an important element contributing to fish productivity, but limited information was available on the habitat use, timing and operational impacts on reservoir fish populations. Therefore, the Consultative Committee recommended collection of monitoring data to assess Duncan Reservoir fish habitat requirements associated with the recommended operating alternative, and to inform future planning processes.

Data collection, analysis and reports completed prior to and during the Duncan Dam water use planning process (BC Hydro, 2002; Golder Associates, 2002; Perrin, 2002; Perrin and Korman, 1997; and Vonk, 2001) were used to develop preliminary performance measures:

- *Dewatered area:* Indicates the extent of dewatering occurring under each alternative, by calculating the average, median, 25th and 75th percentile events each year.

- *Burbot spawning:* Indicates the stability of the Duncan Reservoir during the spawning and incubation period for burbot, as a percent of that period the reservoir is stable within 0.25 m.

Hypotheses

In the Duncan Dam Water Use Plan, the uncertainty related to fish interests in the Duncan Reservoir is:

> *Will the implementation of the Duncan Dam Water Use Plan result in neutral, positive or negative changes in fisheries resources for the Duncan Reservoir?*

The hypotheses to be tested addresses the uncertainty expressed above regarding the life history habitat requirements of fish species in the Duncan Reservoir. Integrating this information with reservoir operations will help develop performance measures for future planning processes, while documenting important trend information on fish species of interest.

> H_A: *Duncan Reservoir operations affect life history success for reservoir fish populations.*
>
> H_{A1}: Duncan Reservoir fluctuations during burbot, kokanee and rainbow spawning and incubation periods reduce spawning success of each species.
>
> H_{A2}: Duncan Reservoir operations affect the availability of fish food resources.

The monitoring program will also collect trend information on fish population status for fish species of interest to document changes associated with the recommended operating alternative over the review period. The following hypothesis will test this assumption:

> H_B: *Operations do not have a negative impact on populations of kokanee in the Duncan Reservoir.*

Objectives

The monitoring study will focus on each of the areas outlined above, according to three objectives:

- Determine the life history habitat requirements of species of interest in the Duncan Reservoir.
- Document the influence of Duncan Reservoir operations on life history success for fish species of interest in the reservoir.
- Document the population level response of kokanee to operations over the review period of the Duncan Dam Water Use Plan.

Methods

Site Selection

For each surveys, sites will be selected that are representative, accessible for study, and appropriate (i.e., accessible to fish, affected by operations and available for long-term monitoring):

- *Stream surveys:* Surveys will focus on four to five index streams with full access through the drawdown zone, and consistent annual streamflow. The survey length will extend from the Duncan Reservoir confluence to 100 m (stream length) above the full pool mark.

- *Littoral surveys:* Surveys will focus on the confluence zones of the candidate streams described above. The survey area will extend 50 m either side of the confluence point, and into the Duncan Reservoir to a point that can be defined as littoral or 50 m, whichever is less.

- *Offshore surveys (pelagic and profundal):* Three to four index sites will be selected in the pelagic zone to conduct stock surveys, distributed along the length of the Duncan Reservoir to reflect available fish habitats.

Collect Habitat Information

Collection of fish habitat information is a one-time data requirement to adequately contextualize Duncan Reservoir information from the fish surveys.

- *Bathymetric data collection:* A detailed DEM will be developed for the Duncan Reservoir consistent with reservoir bathymetry in other BC Hydro basins. Bathymetric surveys will occur at full pool to maximize the amount of information.

- *Stream spawning habitat evaluation:* Within the Duncan Reservoir drawdown zone of fish bearing streams, substrate maps will be produced to develop area of substrate by size category relationships with elevation. Surveys will take place at low pool to maximize the amount of information.

Collect Life History Information

- *Seasonal Habitat Use Study:* Evaluate on a seasonal basis (late summer – CPSF, late spring, fall and winter) the habitat use of Duncan Reservoir fish species affected by reservoir operations. Surveys will occur once per season, unless stated otherwise, over a two-year period.

    - Littoral Habitat Use: To document juvenile fish use, Gee-traps will be set over a 24 hour period in a minimum of 10 sites within each index area, set at various fish habitat types and proximities to stream mouths. To document adult fish use in the littoral area at each index site, a six panel variable mesh size floating gill net will be set at two different times of day: early morning and late afternoon, four hours each set. In both survey types, fish will be enumerated (species, age, length, weight, adult scale sample), indicating their habitat preference (adjacent substrate size, depth, proximity to shoreline, and local cover/vegetation).

- Stream Habitat Use: In a minimum of 10 locations per stream, juvenile fish habitat use will be documented by overnight gee-trapping in a variety of habitat types and cover situations. Trapped fish will be enumerated and habitat preference noted, including elevation of habitat relative to full pool. Stream fish adult use will be evaluated in spawner surveys defined below.

- Offshore Habitat Use: Gill netting will be conducted on one day each season to determine the pelagic (off shore, light penetrating) distribution of adult fish species of interest, adjacent to the Duncan Reservoir survey locations determined above. Net panels will be configured to drift in the pelagic areas and sink in profundal zone. Both sets will be conducted twice per day, in early morning and late afternoon, at four hours each set.

- *Spawner Surveys:* Each of the three spawning seasons (timing will be reflective of current information: kokanee and bull trout (late summer/early fall), rainbow (mid spring), burbot (mid winter)), field technicians will visit index streams and stream fans to document adult fish escapement, spawning location and/or fish habitat preference. If spawning numbers are low within the established survey, the survey will be extended above to adequately capture fish habitat preference and use of spawners for that particular season, and into the future. Year “0” surveys will focus primarily on the timing extents and locations of spawning, and refining methodologies for future assessments.

  - Start-up data collection: Based on local information, and periodicity defined in the Duncan Dam Water Use Plan, plan for additional field visits in Year “0” survey to ensure the full spawning period is known. Utilize this information for future surveys to minimize wasted effort.

  - Annual data collection: Seasonal spawner surveys will be conducted by experienced field technicians at a frequency of no less than one in ten days. The frequency should reflect spawner intensity, and in particular the fish species spawning life.

Kokanee Stock Assessment

Annual hydroacoustic surveys of kokanee stocks will be conducted to assess abundance in the Duncan Reservoir. Trawling will also be conducted in concert with the surveys to define size at age distributions for the stock estimates gained in the hydroacoustic work. It is recommended that this study utilize the same survey crews doing similar work on Kootenay Lake (Ministry of Water Land and Air Protection – Dale Sebastian).

- *Hydroacoustic surveys:* Approximately 20 transects will be surveyed using a dual beam sounder, east-west across the width of the Duncan Reservoir.

- *Trawl sampling:* To be conducted in concert at four 5 m depth ranges > 20 m deep. The stations selected for repeated surveys will be representative of the Duncan Reservoir, and trawling equipment will be consistent for the entire review period.

Burbot Spawning Assessment

Of particular interest in the Duncan Reservoir is the life history requirements of burbot spawning and incubation. Currently, the population of burbot in the reservoir is believed to be strong (Spence, 2002), but changes in operations may impact the population through spawning success. The following study components are planned in co-ordination with the other activities listed above.

- *Adult telemetry study:* Adult burbot will be caught and radio-tagged in late fall to determine their pre-spawn and spawning behaviours and habitat preferences in each case. This study will be conducted for the first three years of the review period to determine burbot habitat use and spawning behaviours. The study will expand on those completed by Spence (2000a, 2000b).

- *Spawning observations:* This study will focus on spawning burbot and their patterns of use over the period, documenting the impacts of Duncan Reservoir operations during the spawning period, using telemetry and ground-level observations (weir installation in known tributaries is likely). Observations will be conducted in years 2 and 3, integrating information from the telemetry data in year one.

- *Population age-structure study:* In years "0", 2, 5 and 10, burbot will be captured and enumerated (length, weight, sex) and a proportion will be preserved for otolith aging. The timing (late fall), catch sites, depth and number of traps and catch unit effort will be constant for each year of study. The resulting age distribution for each year of study will describe spawning success over the review period.

Analysis

Analysis will focus on the development of performance measures based on the results of the studies defined above. Refining life history timing and fish habitat use, defining available habitats, and monitoring population level impacts of operations will more clearly outline impacts of operations on Duncan Reservoir fish populations and inform future planning processes.

Fish Habitat – Elevation Profiles

Based on bathymetric and stream habitat surveys, all fish habitats within the Duncan Reservoir drawdown zone will be compiled and habitat-elevation relationships will be developed from enhanced Digital Elevation Models. This will be completed directly after the data is collected.

Compile Life History Information

Based on information collected in the seasonal habitat use studies and spawner surveys, life history timing and fish habitat preferences will be defined after the three year data collection program is completed. Data gaps will be identified and fish species periodicity charts revised.

Performance Measures

- *Operations Performance:* Two performance measures are proposed to evaluate the effectiveness of Duncan Reservoir operations on fish populations:

    - *Kokanee stock abundance:* Based on hydroacoustic surveys, the kokanee population will serve as a key indicator of operational performance in the reservoir

    - *Spawner escapement:* For the four key fish species of interest (kokanee, bull trout, rainbow trout, burbot), spawner escapement for index tributaries will serve as a general measure of reservoir productivity and fish abundance.

- *Performance Measures:* With additional information on reservoir operations, it is proposed that new performance measures be developed or the existing measures be revised. The following performance measures will be developed mid-way through the review period, and revised as information is collected:

    - *Effective littoral zone:* Based on recommendations from Perrin (2002), the habitat use of fish may justify the development of a littoral model of operational impacts. This will integrate bathymetry, habitat use, productivity information from Perrin and Korman (1997), and life history timing.

    - *Effective habitat:* This performance measure uses the available fish habitat information in streams and littoral areas within the drawdown zone to track regulation of habitat over the course of discrete life history events (spawning, rearing, migration). This will be calculated for all species, with a particular interest in burbot.

Reporting

- *Annual Reporting:* Annual monitoring program reports will be submitted to the Water Comptroller and be available to the public.

Schedule and Costs

The Duncan Reservoir fish monitoring program is extensive and covers many aspects of data collection: fish habitat data collection, baseline species information, baseline productivity monitoring and long term productivity monitoring. The program will start in year “0” to account for baseline data collection. Due to inter-agency commitments agreed to outside of the Duncan Dam water use planning process, year “0” projects will be initiated and funded from BC Hydro’s Columbia Generation Area.

Table L-4 summarizes the Duncan Reservoir Fish monitoring program.

Table L-4: Summary of the Duncan Reservoir Fish Monitoring Program

Project	Phase	Component	YR0	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
Collect Habitat Information	***Data Collection***	*Establish index sites*	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Bathymetric data collection	$ -	$25	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Stream spawning habitat	$ -	$15	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Analysis and Reporting	*Habitat Elevation Profiles*	$ -	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Reporting	$ 3	$ 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Collect Life History Information	***Data Collection and Analysis***	*Seasonal Habitat Use: Littoral*	$ -	$ 22	$ 22	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Seasonal Habitat Use: Stream	$ -	$ 6	$ 6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Seasonal Habitat Use: Offshore	$ -	$ 20	$ 20	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Spawner surveys (all species)	$ 35	$ 25	$ 25	$25	$25	$ 25	$25	$25	$25	$25	$ 25
	Reporting	*Habitat Preference Summary*	$ -	$ -	$ 8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5
		Milestone Reporting	$ 5	$ 3	$ 10	$ 3	$ 3	$ 3	$ 3	$ 3	$ 3	$ 3	$ 10
Kokanee Stock Assessment	***Data Collection***	*Hydroacoustic surveys*	$ 15	$ 15	$ 15	$15	$15	$ 15	$15	$15	$15	$15	$ 15
		Trawl sampling	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
	Analysis and Reporting		$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5	$ 5
Burbot Spawning Assessment	***Data Collection***	*Adult telemetry study*	$ 20	$ 20	$ 20	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Spawning observations	$ -	$ 30	$ 30	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Population age-structure study	$ 15		$ 10			$ 10					$ 10
	Analysis and Reporting		$ 3	$ 5	$ 5	$ -	$ -	$ 5	$ -	$ -	$ -	$ -	$ 5
Project Management			$ 11	$ 21	$ 18	$ 5	$ 5	$ 7	$ 5	$ 5	$ 5	$ 5	$ 8
Total			$122	$227	$199	$58	$58	$ 75	$58	$58	$58	$58	$ 88

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APPENDIX M: ELIGIBILITY CRITERIA FOR WATER USE PLAN MONITORING STUDIES

British Columbia

Monitoring Programs at BC Hydro's facilities

The Water Use Planning processes for BC Hydro's water storage and power generation facilities are intended to develop recommendations for operational changes in response to issues identified with respect to existing operations.

For some facilities, the proposed Water Use Plan (WUP) may recommend a new operating regime to remain in place for the duration of the Plan.

For other facilities, the WUP may recommend two or more parameters for operations to each be "tested" for particular periods during the period of the first WUP.

In some instances there may not be sufficient information available to make immediate recommendations for operational changes. Thus, it is possible that a first WUP may propose maintaining existing operations while monitoring is carried out to gather more information.

Monitoring programs after the first WUPs are implemented will be important to evaluating the effectiveness of changes to operations and/or to collecting additional data that may guide decisions on future changes.

Defining the Effectiveness Monitoring Program

The individual WUP Consultative Committees will be asked to define and prioritize the recommended post-WUP monitoring studies.

The primary objectives of a post-WUP Monitoring Program will be to assess whether the operations, as specified in the WUP, provide the expected results in terms of the fundamental objectives or specific performance measures.

Each monitoring study must be designed to meet the following requirements:

- The result from the study will have the potential to either confirm the effectiveness of the operating regime or to demonstrate that adjustment is needed (which may include a return to pre-WUP operations).
- Any competing hypotheses will be tested. (eg. the weight of evidence should distinguish between western science, independent professional judgement and/or traditional ecological knowledge).
- The results will be available in a timely manner (eg. by the next scheduled WUP period).
- Be the most cost effective way to add information that is of particular significance to the WUP, may be of benefit to other WUPs, and is not unnecessarily duplicative.

To assist WUP Consultative Committees in meeting these requirements, the accompanying Decision Tree should be followed and the Information Matrix should be completed. Proposals for monitoring studies should be described in sufficient detail to allow the evaluation of objectives, methodologies, deliverables and estimated costs.

The WUP Consultative Committee recommendations for monitoring studies will be included in the CC Report and the proposed WUP presented to the Comptroller of Water Rights.

Compliance Monitoring

In addition to programs for monitoring the effectiveness of BC Hydro operations in providing the expected results of the fundamental objectives or specific performance measures set out in a WUP, the provincial and federal regulatory authorities (eg. Comptroller of Water Rights and DFO) will specify other measurement and reporting requirements that monitor BC Hydro's performance (eg. water levels, flows) in compliance with the WUP.

The combined elements of effectiveness monitoring and compliance monitoring will be important to achieving a broader range of values from the operation of BC Hydro's facilities.

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Monitoring Programs at BC Hydro's facilities

Decision Tree for Evaluating WUP Monitoring Requests

The following decision tree embodies the principles of monitoring laid out by the ad hoc WUP interagency committee developing monitoring protocol. This tree is to be used in conjunction with input from the WUP MC, RVAT and FAT and will be used by the facilitator to assist subgroups and the CC in assessing monitoring requests. Note that this process does not address monitoring activities that are geared towards assessing compliance to the WUP. Step 1 starts at the subgroup level and this process is carried out for each proposed study.

1. State the issue of concern and list the hypotheses of the proposed monitoring study. Would the realization of any of these hypotheses change the decision of the CC?
   - no → Proposed study is not eligible. Identify alternate funding sources if appropriate.
   - yes ↓
2. Given the hypotheses listed in 1., does the monitoring plan have the ability to distinguish amongst these? [This may be answered in a range of ways from computing statistical power to judging the weight of evidence. The appropriate WUP advisory committee will assist with this step.]
   - no → Proposed study is not eligible.
   - yes ↓
3. State the time frame in which this information is needed (i.e. during this WUP, in time for the scheduled review of the next WUP, or for WUPs beyond the next WUP). Will the proposed study program deliver results in time to assist in decision making?
   - no → Proposed study is not eligible.
   - yes ↓
4. Is there a way to obtain roughly the same reduction in uncertainty at a lower cost for this WUP? [The appropriate WUP advisory committee will assist with this step. Alternatives may include expert judgment]
   - yes → Proposed study is not eligible.
   - yes ↓
5. Is there a way to obtain roughly the same reduction in uncertainty at a lower cost by carrying out monitoring through other WUPs? [The appropriate WUP advisory committee will assist with this step.]
   - yes → Proposed study is not eligible.
   - yes ↓
6. Within each subgroup (e.g. fish, wildlife, recreation, etc.) fill out the first seven columns of the "Information Matrix for WUP Monitoring Requests" by explicitly considering cost, specific lessons that may be learned, importance of these lessons.
   ↓
7. With the whole CC, fill out the last two columns of the "Information Matrix for WUP Monitoring Requests" by carrying out sensitivity analyses and noting the changes in choices made by the CC under the competing hypotheses.

Monitoring Programs at BC Hydro's facilities

Information Matrix for WUP Monitoring Requests

(subgroups fill out the first seven columns, the last two are filled out at the CC level)

I. Study (WUP, Title of Study, Interest Area)	II. Description	III. Data Gap Addressed (list the issue, the competing hypotheses, and the estimates of the probability of these competing hypotheses being true.)	IV. Amount of learning expected through monitoring (high, medium or low)	V. Estimated Duration of Study Program.	VI. State the time frame in which this information will be used: before the next WUP, during the next WUP, after the next WUP.	VII. Estimated Cost (including lost power values)	VIII. Willingness of CC to change water allocation (high, medium, or low)	IX. Rating of Study

"Willingness to change water allocation" Scale Explained.

These scales will be developed once the final choice of the CC has been made. At that time, key uncertainties about the PMs and/or their link to fundamental objectives can be tested through sensitivity analyses, and the change in the support from the CC for the various alternatives considered can be observed.

High Importance: It is *clear* that the CC will change its final choice if one of the alternative hypotheses prevails. This change includes a shift in support *away* from the original choice made and the convergence of the CC's support on another, *existing* alternative.

Medium Importance: A large shift in support away from the final choice of the CC takes place under one of the competing hypotheses. This shift in support may include some people preferring to block the original choice of the CC. However, *it is not clear* that another, *existing* alternative would be chosen by the CC under this competing hypothesis.

Low Importance: A shift in support away from the final choice of the CC may occur. However, *it is clear* that the final choice of the CC will not be changed to another, existing alternative. This decision may be a non-consensus WUP.

Learning Scales Explained.

High: monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.

Medium: monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses.

Low: likely to allow only qualitative comparisons among a few competing hypotheses.

Rating of Study Explained

High Importance: There is a clear consensus, or close to consensus that this monitoring study should be included as a request within the consultative report.

Medium Importance: There is no clear consensus within the group as to whether this monitoring study should be included as a request within the consultative report.

Low Importance: There is a consensus, or close to a consensus, agreement that this monitoring proposal should *not* be included as a request within the consultative report.

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APPENDIX N: DUNCAN WATER USE PLAN CONSULTATIVE COMMITTEE MEETING # 8
Final Meeting Minutes

Version: September 24, 2004

MEETING DATE: **Day 1 –** 9am to 6pm, Tuesday April 20, 2004
Day 2 – 8:30am to 6pm, Wednesday April 21, 2004
Day 3 – 8:30am to 5:30pm, Thursday April 22, 2004

LOCATION: Senior Recreation Center, Kaslo, B.C.

MEETING ATTENDEES

April 20	21	22	*Attendee*	*Organization / Company*
			CC Members:	
√	√	√	Steve Macfarlane	DFO
√	√	√	Gene Anderson (alternate for Sue Dyer)	Aquila
√	√	√	Terry Anderson	MLAP
√	√	√	Gail Spitler	Local Resident
√	√	√	Mark Tiley	CCRIFC
√ left at 2:30	√ joined at 9:30	√	Kindy Gosal	CBT
√	√	√	Gordon Boyd	BC Hydro
√ not in attendance 12:30 –5:45	√	√ jointed at 10:00	Vic Clement	Ktunaxa Kinbasket
√	√	√	Llewellyn Matthews	CPC
√ left at 4:00	√ left at 3:00	√ left at 1:00	Larry Greenlaw	Regional District of Central Kootenay
√	√	√	Fred Thiessen	Ministry of Forests
√ joined at 4:15	√	√	Stephan O'Shea	Local Resident
			Alternates / Observers:	
√	√	√	Steve McAdam	Ministry of Water, Land and Air Protection
√	√	√	Jayson Kurtz	DFO
√	√	√	Anita Mathur	Ministry of Sustainable Resource Development
			BC Hydro Staff:	
		√	John Emery	Aboriginal Affairs
√	√	√	Kelvin Ketchum	Resource Management
√	√	√	Alf Leake	Environment
√	√	√	Michael Harstone	Resource Valuation/Facilitator
√	√	√	Sue Heaton	Community Relations
√	√ left at 12:30		Sue Foster	Project Management
√	√	√	Patricia Vonk	Environment/Rapporteur
√ joined at 11:45	√	√ left at 1:00	Kim Meidal	Operations Planner
√	√	√	Kathy Groves	Power Supply Engineering

Distributed Materials

- The following materials were handed out and/or were made available at the meeting:
  - Pre-Reading Package for CC Meeting #8
  - Appendix A Hydrographs - Pre-Reading Package for CC Meeting #8
  - Letter from the Regional District of Central Kootenay
  - Revised Consequence Table
  - Revised Monitoring Study Table
  - Non-Operating Alternative Summary Table
  - *Provincial Guidelines for Water Use Planning*
  - *WUP Fact Sheets (Principles of WUP, Financing WUP)*
  - *Participant Funding Sheet*
  - *Water Use Planning at BC Hydro Facilities Brochure*
  - *Water Use Planning Brochure*

Day 1 - Tuesday April 20 (9am-6pm)

1. WELCOME AND INTRODUCTIONS

- The facilitator welcomed everyone and requested a clarification of each attendees' status as there have been some changes in participation during the course of the DDM WUP process:
  - Gene Anderson confirmed that he was the alternate for Sue Dyer of Aquila
  - Llewellyn Matthews confirmed CPC's participation as a CC member
  - Larry Greenlaw confirmed RDCK's participation as a CC member

2. REVIEW GUIDING PRINCIPLES

- The facilitator reviewed the WUP guiding principles that the CC had agreed to earlier on in the process.
  - Inclusion and respect
  - Be hard on the problem, easy on the people
  - Speak in terms of interests, not positions
  - Think creatively
  - Seek common ground
  - Provide rationale for your opinions
  - Stay focused
  - Open-minded and participatory

3. WUP GUIDELINES

- The facilitator reviewed the WUP guidelines and the steps that the CC has worked through. The final step after this meeting will be to write up all the deliberations and proceedings into a Consultative Committee Report (Step 8).

4. REVIEW OF MEETING OBJECTIVES AND AGENDA

- The following meeting objectives were agreed to:

Meeting Objectives

- Review changes to performance measures;
- Update progress and ongoing work;
- Select the preferred operating alternative
- Select the monitoring studies
- Select a review period
- Express support other recommendations

- The agenda was agreed to as follows:

Agenda

Day 1	
9:00 – 10:00am	Introductions and Overview
10:00 – 11:00am	Update - Action Items, Subcommittee Work
11:00 – 11:15am	Break
11:15 – 12:00pm	DDM WUP Scope
12:00 - 12:30pm	AMPL Model Changes
12:30 – 1:30pm	Lunch
1:30 – 2:15pm	DDM Scope - Cont'd, if required
2:15 - 3:00pm	Alternatives / Hydrographs
3:00 - 3:30pm	Changes to PMs
3:30 – 3:45pm	Break
3:45 – 4:30pm	PM Results
4:30 - 5:30pm	Comparing & Ranking Alternatives
Day 2	
8:30 – 9:00am	Overview of day
9:00 – 9:30am	Review of Non-Operating Alternatives
9:30 - 10:45am	Trade-Off Analysis for Alternatives
10:45 - 11:00am	Break
11:00 – 12:30pm	Ranking Alternatives
12:30 – 1:30pm	Lunch
1:30 – 3:30pm	Selecting an Alternative (Non-Operations?)
3:30 - 3:30pm	Break
3:30 – 5:00pm	Review and decide on Cottonwood flows (Alternative K?)
Day 3	
8:30 – 9:00a	Overview of day
9:00 – 11:00am	Review Monitoring Studies
11:00 - 11:15am	Break
11:15 – 12:00pm	Endorsing Monitoring Studies
12:00 - 12:30pm	Selecting a Review Period
12:30 – 1:30pm	Lunch
1:30 – 2:30pm	Review Recommendations
2:30 - 3:30pm	Endorsing Recommendations
3:30 - 3:45pm	Break
3:45 – 5:00pm	Next Steps and Future Communication

- Kindy: Asked what will happen once the CC report has been reviewed by the CC.
- Michael: BCH will be finalizing the CC report based on comments received from the CC and then will prepare the Water Use Plan (WUP). Both the CC report and WUP will be submitted to the Water Comptroller. The WUP will be referred to the federal and provincial agencies and First Nations by the Comptroller. Once the WUP is approved, it will get written into BC Hydro's water license.
- Anita: Implementation of the WUP will be an order on top of the water license.
- Steve Macfarlane: The WUP will get referred to DFO concurrently with approval process. Joint meetings will be held with the First Nations. The order will come after the referral process.
- Kindy: This represents an amendment to the WUP guidelines, which indicated that the referral process would occur after approval by the CWR.

5. Overview of the Duncan WUP

- The facilitator reviewed the Duncan WUP process and how the committee had progressed from their first meeting. Some of the points that were highlighted included:
  - Culmination of almost 3 years of effort
  - Incorporates lots of values, information, changes, research, learnings, challenges and compromises
  - The process was designed to help the committee find the best balance of water uses across the competing interests
- CC members personal goals stated at the onset of the process were reviewed:
  - Increase the knowledge base
  - Be involved in a process that helps the ecosystem
  - Undertake more archaeological research in the area
- It was noted that historically resource management decisions were based on:
  - Usually lack of widespread support (especially at the local level)
  - Usually the outcome included a winner and loser
  - Conflicting science and jurisdictions
  - A non-integrated approach that was sectorally based
- Water Use planning has:
  - Put aside competing jurisdictions to look at the best use of water allocation
  - Been participatory with involvement with anyone who has expressed a stake in the water management at the DDM facilities
  - Been values and science based
  - Been committed to collaborative research
  - Paid attention to uncertainty
  - Committed to ongoing monitoring and adaptive management

6. UPDATE AND ACTION ITEMS

Distributed Materials to the CC since their last meeting:

- CC Meeting Minutes #7
- Pre-Reading Package for CC Meeting #8
- Appendix A – Hydrographs – Pre-Reading Package #8
- Interactive Consequence Table
- Past E-mail Correspondence

Update on Activities

- Community Meeting - October 8th, 2003
  - 8 local residents participated in the meeting
  - ran through alternatives and articulated where we came from
  - follow up from concerns expressed by the Regional District
  - received lots of positive comments from residents
  - Kindy: He also requested BCH to hold this meeting. Expressed thanks for following up, but disappointed that so few residents showed up at meeting. BCH has attempted to bring the community in, but it has been very difficult to engage in such a complex process.
  - Larry: The RD was not represented at the meeting because of RD meeting held that night.
  - Michael: Mentioned that the BC Hydro process team was not made aware of any conflicts until a few days beforehand (after it was too late to reschedule)
- Technical Committee meetings - 2 FTC; 1 REC/QOL, 2 WTC + Site visit

ACTION: CC TO PROVIDE ANY COMMENTS ON THE CC MEETING #7 MINUTES TO MICHAEL HARSTONE WITHIN THE NEXT WEEK

Comments on Distributed Materials

- Pre-Reading Package #8
  - Terry: Financial Revenue PM Graph – missing an alternative (column)
  - Mark: In Section 7.0 (p. 36), it is noted that seed dispersal is timed to coincide with the end of freshet. This should be peak freshet. Seeds are dispersed as early as June. Alf noted his agreement.

Past Action Items

1. Follow-up with RDCK for community meeting - ***done***
2. Send copies of WNV report to CC members - ***done***
3. Max/min flow from the dam within +/- 0.25m tolerance range in the reservoir during spawning - ~***15 cms***
4. Change TGP threshold to 285cms (170 +115) - ***done***
5. Feedback from Anne Moody about PMs and alternatives - ***done***
6. Anne Moody to be asked to attend next WTC meeting - ***done***
7. TGP constraint incorporated into new alternatives - ***done***
8. Rename PM to erosion impacts (not protection) - ***done***
9. REC/QOL Committee to review and refine recreation quality PM - ***done*** (phone and face-to face surveys completed with recreational user – came up with new weightings and timings)
10. REC/QOL Committee to tap a broader range of recreation stakeholders to provide input on PM - ***done***
11. Are Alt Es within the treaty flood rule curves, and can they be operationalized – see below

    Discussion:

    - Kelvin: BC Hydro will need to ask for a variance from the Army Corp of Engineers in order to provide a min flow of 73 or 90 cms in the March/April time period. BCH can't get permanent variance until the system–wide flood control review for the

Columbia system is complete (currently underway and expected to be completed in 5 years time). BCH will need to ask for an annual variance of the flood control curves to provide enough storage capacity to meet the min flows (until the freshet begins). This would occur in the fall based on expected snowpack. In average and below average years, it is likely that BC Hydro will get the variance. However, in above years, it is unlikely. In a high water year, if we did not get the variance, we would have the reservoir as high as possible at the end of Feb. BC Hydro will ask for the min flow to be incorporated in the system-wide study. There will be the intent to implement, but BC Hydro may be limited by the flood control curves in some years. It may be difficult to get the min flows later in March/April if BCH doesn't get the variance.

- Kathy: This is not as pronounced in the 73 cms scenarios as in 90 cms scenarios. Even if the 73 cms cannot be obtained, it is likely that a lower minimum flow could be provided (e.g. 50 cms).
- Mark: With high snowpack, what flexibility would there be to release some min flow?
- Kelvin: There may be a problem getting the variance in as many as 1 in 3 years (i.e. above water years). How should this be operationalized (drop lower immediately, or release 73 cms and risk getting something less later on)? A revised flood rule curve for DDM—*as a part of the Columbia Flood Review*—will likely end up at the same point at the end of May.

ACTION: REVIEW THE LIKELY IMPACT ON FISHERY BENEFITS OF NOT GETTING VARIANCE APPROVAL (E.G. DROPPING TO A 50 CMS MINIMUM FLOW FROM 73 CMS) AND DETERMINE WHAT THE PROBABILITY/FREQUENCY IS OF THIS SCENARIO? – FTC MEMBERS AND MODELLERS (SEE DAY 2 FOR RESULTS)

- Kelvin: The Corp of Engineers would be able to let BC Hydro know by January. During above water years, the Corp of Engineers would have to think very carefully about giving BC Hydro a variance. May be less than 1 in 3 years, but this would probably be worst case. If BC Hydro has strong biological evidence this would be presented to the Corp of Engineers.
- Kindy: If we only meet the min flow 66 % of the time, will we get the same benefits for these alternatives?
- Alf: BC Hydro may not get the 73 or 90 cms min flow but there would be some benefits of a lesser min flow.
- Michael: Is there an opportunity to optimize?
- Kelvin: This has been modeled to give the highest chance of getting the min flow.
- Kathy: The recession is independent of snowpack in the coming year.
- Mark: Is there any flexibility in the system where additional flood control could be provided?
- Kelvin: Flood control is specific to the location (Libby, Duncan and Kootenay). If there is flexibility in the Kootenay, the Corp will see this. It is unlikely that the NTSA (Non-Treaty Storage Agreement) would help. If there is a downstream problem, BC Hydro could swap MCA and DDM. If it is a local issue, then only Libby, Kootenay and Duncan matter. The Kootenay is restricted by the IJC. The flood control curves were developed in the 60s and are considered conservative.
- Michael: May need trigger if best intentions are not doing anything.

- Kelvin: A CC recommendation would provide BCH with more ammunition with the Corp. The NTSA is being renegotiated with Bonneville (Mica Arrow) with MCA WUP in mind. This has little to no impact on DDM.
- Kathy: BCH can provide a 50 cms min flow in years when the variance is not obtained.
- Alf will summarize impacts of 73 or 90 cms to 50 cms.
- Kelvin: The first snowpack measurements are Jan 1. Would need a decision by mid Feb. The Feb 1 measurements are a better forecast.
- This issue is more around the start of freshet. With an early freshet, BCH could maintain a 73 or 90 cms min flow. However, if it is a late freshet, it would be more difficult to get so would be best to go with lower min flow.

Past Action Items Continued:

12. Kindy's recommendation about wider hydro system flexibility review – ***(discussed during Day 3)***
    - Kindy: Review period for WUP and what are the triggers? (New flood control rule curve, Kootenay WUP). Trigger wording will need to be very clear – see Day 3
    - How do we ensure that recommendations don't have negative implications on other interests
    - Kelvin: BC Hydro will be reviewing cross-system impacts once all of the WUPs are completed.
    - Vic: The monitoring component will be important to address cross-system impacts.

13. Check with M. Jackson about significance of the September spike for mosquitoes

    - Alf: During average to low temperature years, there will be no impact on mosquito production. However, flooding will provide opportunities for hatching in high temperature years (bad month = high temperatures and flooding). In the Lardeau area, the temperature is typically low enough that it is not a problem. June, July, and August are the primary production months.

14. Ask Brenda Herbison about impacts of E and E90 on cottonwoods and shrub re-inundation after October 31st – ***done***
15. Erosion effects with September high flows (spike) on cottonwoods– ***done***

    - Mark: The Sept spike will not impact the cottonwoods unless there is a lot of silt with inflow. Depositing silt at the wrong time would choke the seedlings. After October, high flows don't seem to have as much of an impact on them.

Post meeting clarification from Mark
"Further regarding my comment, I was referencing a statement made to me by Brenda Herbison over the telephone. She was the one that observed the effects of the high September or October spike in the fall of 2003. I believe she felt that if sedimentation occurred during the growing season, seedlings may be impacted more so compared to the fall dormancy period."

16. Develop physical works options (wildlife, cultural resources and recreation) – ***done***

17. Refine monitoring studies *– **done***
18. Remodel at E (L, M) *– **done***
19. Check with Stewart Rood about fall flows for cottonwoods, how often is a flow regime required, what kind of recruitment is required *– **done***
20. Re-model Alternative K *– **done***
21. Check a high water inflow year against Alt K to compare cottonwood recruitment benefits *– **done***
22. What river flow is considered bank full *– **400cms***

   - Confirmed as 400 cms. At this flow, saturation of the banks begins. Bank full flow is when the water flows over the banks. A staff gauge has been installed near Mary Hallam's property. Will try to tie stage discharge in with river flows, which will act as early warning system.

23. Is IJC min elevation 529.74 m in Kootenay Lake?

   - Kelvin: This is not in any water license, but it is an effective min (1738') to use given Grohman Narrow discharge capabilities.

24. Nutrient transfer impacts on Kootenay system – ***Ongoing (see discussion Day 3)***
25. TGP at HLK *– **to be determined (see Day 2)***
26. Send mosquito monitoring to Gail, Brenda and Mark

ACTION: ALF TO SEND MOSQUITO MONITORING TO GAIL, BRENDA AND MARK

7. NEW BUSINESS ITEMS?

CPC Letter Addressed to Sue Foster (BC Hydro) dated April 19th, 2004

- Llewellyn circulated a letter from CPC (as manager of the CPC/CBT power project joint ventures) to all meeting participants, indicating CPC's interest and role in the DDM Water Use Planning process.
- Llewellyn noted that CPC's interest in the DDM WUP is to ensure that the CPC/CBT joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts resulting from implementation of the WUP. Based on estimated adverse financial impacts from foregone power values at ALGS (and, as yet, unspecified impacts at BRD and BRX) from operating alternatives being considered for the WUP, CPC cannot support any of the alternatives and may object to them before the Comptroller of Water Rights. There are substantial financial impacts at ALGS associated with the new operating alternatives, with the range depending on each of the alternatives. Most of the foregone power values occur at CPC/CBT facilities. At this point, there is no commitment to save CPC/CBT harmless from any potential adverse impacts on CPC/CBT joint ventures. Therefore, the interests of the CPC/CBT joint ventures are not being met by the WUP and CPC cannot support or accept any of the alternatives other than Alt A.
- Llewellyn: CPC abstained at a previous MCA WUP CC meeting held in November 2003. CPC thought it would be helpful to clarify its interests.

- Kindy: CBT has right of first refusal to develop power facilities at the Duncan Dam. Net income from CPC/CBT power projects is shared between CBT and CPC; CBT's one-half share goes to benefit the people in the basin. If there is an adverse financial impact then CBT will be talking to the Regional District and FN regarding direct consequences to the programs. If CPC and CBT were kept whole that would change things completely.
- Any financial impacts to BCH's generation are covered under SOF. The province would reimburse BC Hydro through water license remissions only after establishing the impact relative to current operations.
- Steve Macfarlane: CPC would have to go through the same process as BC Hydro through evaluation of their existing licenses base case. CPC can anticipate the costs, but would need to re-affirm their license. CPC has not done the analysis and has been using costs generated as part of WUP modeling.
- Alternative A is the power optimal scenario (not the existing license rights). It does not necessarily represent Base Case to BC Hydro.
- Llewellyn: CPC is concerned about future as well as present revenue streams. Any adverse financial impacts to CPC/CBT joint ventures are not acceptable. Model runs indicate there could be significant potential adverse impacts at CPC/CBT Kootenay River plants (i.e. BRD and BRX) as well as at ALGS.
- Kindy: This uncertainty is poignant to communities as well. The financial burden falls upon the people. The premise of WUPs has changed.
- Llewellyn: CPC is currently seeking government policy clarification. This issue has not yet been resolved.
- Steve McAdam: The Ministry of Energy & Mines and Ministry of Sustainable Resources Management have been invited again to participate in the water use planning process. With regards to ALGS, the provincial government (through) Land Water BC has recently been requested to clarify the license rights and, in particular, determine what the base case for the license is. This issue needs to be resolved and affects how power impacts have been represented for the Duncan WUP.
- Kindy: This is affecting our ability to endorse a recommendation if there is going to be a financial impact.
- Gordon: We are trying to make the best use of water across whole range of accounts. There is give and take so that we can make best use of the resource. I would still like to go through process despite CPC not being able to accept anything other than Alt A. Is there any leeway that would allow CPC to participate in this meeting?
- Llewellyn: This doesn't mean that CPC is not participating, only that CPC cannot support or accept any alternative that could have adverse impacts on CPC/CBT joint ventures. CPC could support or accept an alternative other than Alt A if CPC/CBT joint ventures were saved harmless.
- Anita: Compensation needs to be dealt with through regulation. If the CWR makes an order that causes an financial impact, can elect to give remissions. Regulation needs to directly affect the licensee (not a general fund).
- Steve Macfarlane: Is CBT echoing the statements in the CPC letter?
- Kindy: If CBT-funded programs are going to be impacted then we need to know how this will impact the communities. Not ready to come to a final endorsement on any alternative until the final financial impact is clear. CBT is willing to work with the CC to identify alternatives that tries to optimize use of water. We do not have sufficient information to fully endorse any alternative until the responsibility for any financial impacts are clearer.
- Jayson: Revenue to the joint ventures from ALGS will not be affected until 2014. Does the review period give CPC some flexibility?

- Llewellyn: No. The terms of the agreement between BCH and CPC/CBT are commercial confidential, and therefore cannot speak to this. There are also other considerations such as potential adverse impacts at BRD and BRX. Further, potential future adverse impacts at ALGS would limit CPC's ability to raise long-term commercial debt in the bond market. This long-term debt is required to finance the construction of CPC/CBT's BRX and Waneta Expansion projects.
- Michael: Proposed that Kindy and Llewellyn participate assuming that the joint ventures are kept whole (process and negotiations ongoing). It will be written in the minutes and CC report that the parties block all alternatives except for Alt A (i.e. non-consensus WUP) if this is not resolved. Is this acceptable?
- Mark: If there is a financial hit to CPC and CBT, could the province negotiate an increase rate to taxpayers?
- Llewellyn: CPC/CBT joint ventures do not have ratepayers, and there is no currently no mechanism to recoup those costs.
- Vic: This is an interesting discussion about costs, but who has talked to the Ktunaxa about cost? It is our resource.
- Steve McAdam: This conflicts with the release co-ordination agreement between CPC and BCH.
- Llewellyn: CPC does not agree with Steve's interpretation of the release coordination agreement.
- Larry: Expressed concern about any impact on the joint venture projects.
- Kindy: CBT would take this stand about impacts on FN or other issues, just happens to be about finance. From CBT's perspective, it is not only about the money. We consider all values.
- Steve McAdam: There are two questions: Can a third party be compensated through the SOF? What would the amount of compensation be?
- Steve Macfarlane: CBT/CPC has already drawn a line in the sand. The CC could have received the letter three years ago. CBT/CPC may agree to this approach but it will be very difficult.
- Michael: Proposed that the assumption be made that outcome of the negotiations is favorable to CPC and CBT (regarding their joint ventures) ***and*** that the CC move forward with CBT/CPC participating in selection of alternatives. This will ensure that their values can at least be elicited and documented, regardless of the outcome of the ALGS cost base case and whether they are kept whole.

<u>CPC and CBT Condition:</u>

CPC and CBT agreed to continue to participate in the selection of a preferred alternative for the Duncan WUP, on a non-prejudicial basis, on the condition that there would be no adverse impacts borne by any CPC/CBT Joint Ventures. In other words, CPC/CBT Joint Ventures would be saved harmless or appropriately compensated for adverse impacts arising from the implementation of the Duncan WUP. <u>If this did not occur, CPC would block all alternatives except A. CBT may block all alternatives except A, but would make a determination after they had all the information.</u>

<u>OUTCOME: THE CC AGREED TO MOVE FORWARD BASED ON THIS CONDITION</u>

Regional District of Central Kootenay Letter to Sue Heaton (BC Hydro), Re: Larry Greenlaw's Concerns (dated March 11, 2004) *(included in Appendix A)*

- Larry: The letter summarizes his concerns related to the DDM WUP. It does not necessarily represent concerns of the Regional District.
- Terry: Does not agree with everything that is presented in RDCK letter
- Michael: We do not need to reach consensus on every point in the letter. This is Larry's opinion.

8. SCOPING ANY ADDITIONAL CROSS-SYSTEM IMPACTS

- The facilitator reviewed the changes in context and potential issues associated with broader cross system issues since the last meeting. This was precipitated by two factors: (1) the realization that Duncan alternatives affect power interests on the lower Columbia system, resulting in an upgrade to the Duncan AMPL model, and (2) the direction from the WUP Management Committee that the Duncan WUP CC needs to clarify and define the scope and boundaries to be included for the Duncan WUP.
- In preparation for the CC's deliberations on this, both the FTC and WTC scoped potential impacts associated with Duncan Alternatives on both the Kootenay and lower Columbia systems.
- It was noted that it was always assumed that BC Hydro would do an evaluation of cross system impacts once the front-running alternatives were identified by the CC. In the interim, the Operational Flexibility PM was serving as a proxy for this.
- From a power generation perspective, it was determined that there were cross system effects, at times, when flow changes at DDM would result in flow increases at Arrow to meet Treaty flow requirements. At certain times this would result in spilling at Arrow because flows passing through ALGS were already at (or near) capacity. This would in turn result in lost power generation opportunities. A decision was therefore made to include these interactions (through a new PM) into the decision making. Accordingly, the Operational Flexibility PM was dropped, as it became redundant as a proxy.
- As mentioned, the technical committees were asked to review the available information for their opinion on additional significant downstream issues that are influenced by changes in operations at Duncan. The committees considered which interests should be considered within the WUP through scoping out potential issues and preliminary PMs for impacts at Keenleyside, Kootenay Lake and Kootenay plants.
- Relevant background information used by the committees included the following:
    - Natural inflows to Kootenay Lake account for about 50 % of inflow, with Libby representing about 40 % and Duncan about 10 % (a small player in the overall system).
    - Kootenay lake levels are more controlled by outlet flows down Kootenay River rather than inflows into lake.
    - The magnitude of operational changes at Duncan to the Kootenay system must be weighed against changes with flows at Libby (VARQ) and as a result of changes to the minimum flows at Brilliant (BRL).

- Therefore, since the last CC meeting, changes were made to the AMPL model to include:
- Doubling or tripling of min flows at BRL (from 5 kcfs + Slocan to between 16-18 kcfs)
- Integration of Columbia power generation impacts
- Changed VARQ25 kcfs flow records
  - Additional 12 years of inflow data with new VARQ file
  - Kootenay Lake inflow file was upgraded

  - ➢ Llewellyn: There is a minimum flow stipulated in the PAC for Brilliant Expansion, which will come into effect when the plant becomes operational in 2006. This will have an impact on load shaping (based on historical average flows), but not sure it would have an effect on the Duncan alternatives.
  - ➢ Kelvin: The minimum flow has always been exceeded.

- Issues reviewed by technical committees included:
  - Changes to Kootenay Lakes levels (kokanee spawning, littoral use, sturgeon spawning)
  - Nutrient transfer from Duncan to North Arm of Kootenay Lake
  - Changes to Kootenay River flows (spilling, TGP)
  - Downstream of BRL (TGP, stranding)
  - Below Keenleyside (TGP, entrainment)
- Conclusion by the technical committees:
  - No appreciable difference in the flows or lake levels were identified (as evidenced in the hydrograph reviews). Accordingly, it was felt that across the range of Duncan alternatives there was not likely to be any significant cross system impacts, except potentially nutrient loading or Keenleyside TGP (see Day 2 for a follow-up on this)
  - TGP model based on Robson station (Columbia upstream of confluence)
  - It was also noted that Duncan alternatives were not affecting the ability to meet Brilliant Expansion minimum flows (changes are within upper and lower end)
  - Maintain PMs for Duncan, and financial impact PMs for Kootenay plants and ALGS

ACTION: NUTRIENT LOADING AND TGP PMS TO BE DISCUSSED AT FTC MEETING TONIGHT (see Day 2 for results)

  - ➢ Kindy: What about recreational interests on Kootenay Lake or down Kootenay Canal?
  - ➢ Michael: These questions were not posed; however, there is only a 4-7 “ maximum deviation in Kootenay Lake levels at different times of year (from median lines). And, given this, no other interests were known that may be impacted by these small changes across the Duncan alternatives.
  - ➢ Kelvin: Libby operations are the same across all of the alternatives
  - ➢ Kindy: Question regarding need for a trigger if cross-system impacts are observed.
  - ➢ Michael: A trigger would need to be well thought out; ideally with specific quantifiable cross system measures or impacts.

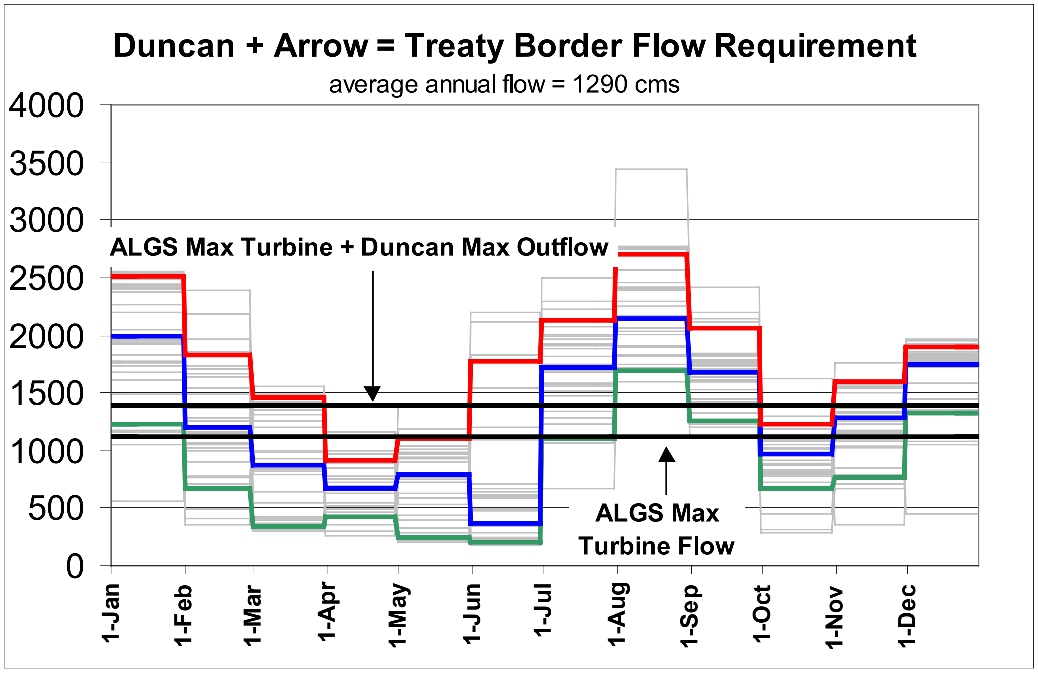
- Jayson: Uncomfortable with removing Kootenay Lake from the scope, as there may be some impacts that have not been identified.
- Michael: We have not taken all Kootenay Lake interests into account, as there has not been consultation with other stakeholders. We have tried, however, to focus on those areas where DDM operations has a chance of impacting.
- Steve Macfarlane: Ranking will identify level of importance that CC place on PMs
- Alf: No monitoring items were included to address downstream issues in Kootenay Lake or Kootenay River system.
- Michael: If the CC decides to select monitoring studies for Kootenay or the Columbia system, they may want to remember that the Duncan system is a relatively small contributor (~10% of inflows) as compared with the natural variability of the region and as compared to resource decisions at Libby and down the Kootenay River.
- Kindy: There is a need to be clear in the CC report that scoping did not include all potential issues on fishery or property interests in Kootenay Lake or the Kootenay River system.

9. *CHANGES TO AMPL MODEL (Kathy)*

As mentioned, the AMPL model was upgraded to include better information since we last met, as follows:

- Period of record extended
  - 1968-1999 (WAS 1968-1987)
  - average values across board 1.5% higher
- Kootenay Lake natural inflows – QA'd
  - Minor changes to original file
- Libby VarQ 25kcfs flows
  - Re-simulated and extended to 1999
- BRILLIANT EXPANSION minimum flows
- Lower Columbia generation inputs included into the model
  - ARR inflow, ARR lake storage, ALGS, Treaty Border flow requirement
    - ARR inflow = Columbia WUP base Case 1194 cms (REV regulated outflow + ARR natural inflow)
    - ARR outflow = HLK non-power release (spill) + ALGS power release (generation)
    - Sensitivity test against MCA WUP Base Case to determine incremental costs caused by DDM alternatives
    - ARR + DDM Treaty Flow: ARR Out (Total) + DDM Out = prescribed treaty release (as per Columbia Base Case AOP06)
  - End of month flow targets are achieved through weekly targets. The theoretical number is based on Arrow and Duncan alone (referred to as US border flow). Pend d'Oreille is not included in this.
  - ALGS does not generate year round
  - ALGS Max turbine flow - 1100 cms
  - Can not eliminate spill at ARR
  - 283 cms difference between ALGS Max turbine + DDM max outflow and ALGS max turbine flow

- *See the graph below illustrating the interactions between ARR, DDM, and treaty flows*

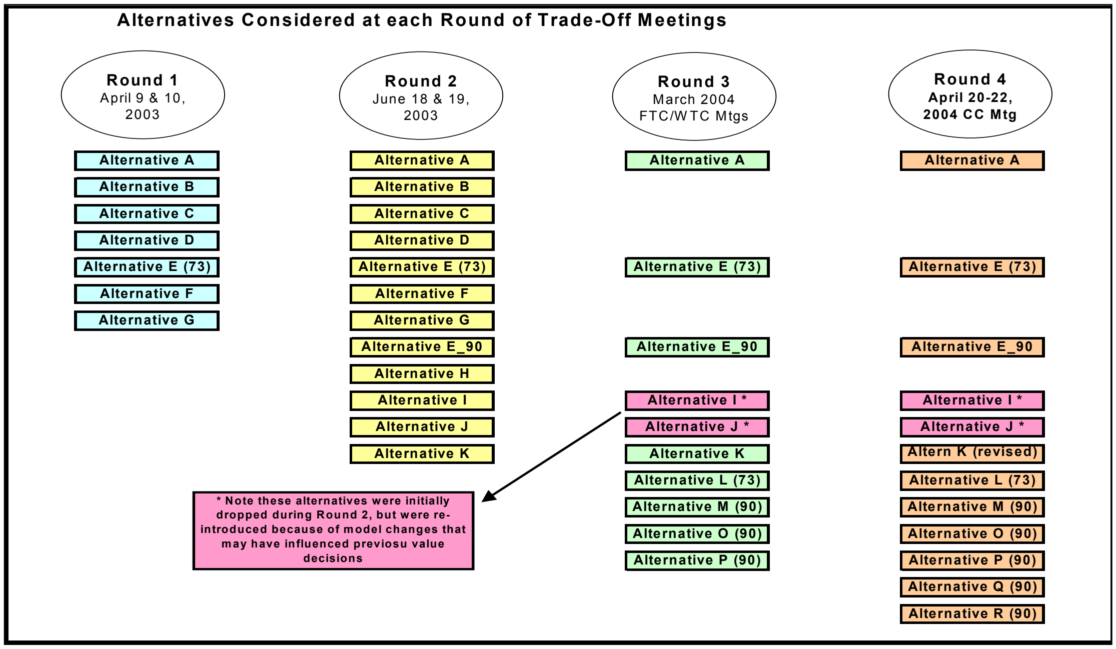


- Duncan Average Annual Inflow / Outflow = 102 cms
- Duncan Max Outflow = 283 cms
- Therefore total Duncan Inflow is equivalent to ~ 4 months maximum outflow at Duncan Dam
- Want to utilize Duncan discharge in months where this will help to reduce spill at Lower Columbia
  - In June/July of some years, but BC Hydro is trying to fill Duncan.
  - In all years, it is beneficial to operate Duncan at its maximum in September
  - In October, ALGS almost never benefits from Duncan outflow. Water released from DDM will cause generation at ALGS to be curtailed.
  - In December/January, Duncan discharge helps to meet treaty requirements.
  - Limited ability at Duncan to minimize spills at ALGS during freshet.
- What is the impact on the Kootenay plants during October?
- There will be some storage release from Kootenay Lake if Duncan releases are held back, but levels will return quickly.
- There would be a $400-800k cost to the lower Columbia system by curtailing Duncan to Oct 1 as opposed to Sep 15.

10. ALTERNATIVES AND HYDROGRAPHS

Alternatives

- The facilitator reviewed the evolution and main components of the Round 4 alternatives that the CC has to decide upon. The figure below illustrates all the alternatives considered by the CC during each round.



- Deliberations for this meeting will focus on Alt A, E73, E90, I, J, K, L (73), M (90) O(90) and P(90)
- Note that Alt K (cottonwood recruitment) is a separate decision because it is not required every year (~1 every 5th year)
- Alt A approximates a power optimum base case
- Treated all Megawatt hours the same across ALGS and Kootenay
- The main elements that were built into the new alternatives in Round 3 included:
  - Meet recreation targets
  - Smooth large decrease in September
  - Reduce August trough (due to increased DDM storage to meet recreation targets)
  - Minimize re-wetting of mosquito habitats (cap of 300 cms Aug1-Sep 15)) after Lardeau freshet
  - Mitigate freshet pulse flow (ensure enough reserve storage for min flow) 10 day prior to freshet. Usually spike in mid April undesirable to fish. Cap to reduce stage change.
  - Reduce TGP (limit flows to below 285 cms)

- For the two new alternatives in Round 4, there were some additional constraints added as follows:
  - New whitefish spawning timing (originally Oct 15- Dec 15; now Oct 21 to Dec 31). Now variable target flow.
  - Minimize washing of cottonwood seedlings (after freshet passes, cap flow until following spring; this also helps with mosquito flooding)
  - Reduce August trough
  - Alt A is essentially a new alternative but doesn't incorporate these new revisions above.

(See Pre-Reading Package for detailed descriptions of the Round 4 Alternatives)

Hydrographs – *Refer to Appendix A in the Pre-Reading Package*

General Comments Made about the Alternatives

Alt A - Power Optimal

DDM Reservoir

- This is the base case scenario. All of the other alternatives add constraints to this.
- Duncan Reservoir is essentially empty in April/May, and fills in May through August.
- In August, water is opportunistically released to help with the DDM/ARR treaty flow, but BC Hydro needs to consider Kootenay Lake levels (trying to keep lake levels down under the IJC commitment by end of August).
- Duncan Reservoir water levels start to come down in August when possible.
- A flow of 283 cms is typically released from Duncan throughout September in this scenario.
- Duncan discharge is normally curtailed to the minimum flow during the month of October because treaty flows can be met through generation flows out of ALGS.
- December is a high value month, therefore send water through the Kootenay projects. Outflow from Duncan is maximized during December and continues until the reservoir is close to empty (Jan-Feb depending on year). After which, dam releases match inflows into the reservoir.
- Two effects are related to power impacts at ALGS: lost power because of ARR spilling; and lower Arrow Reservoir levels as a result of prior spilling.

Note. All alternatives built upon Alt A (will default to this operation during unconstrained periods)

Alt E

- Pre-spills to mitigate flooding effects in lower Duncan in June/July
- No constraints in Aug/Sept 14– reservoir starts to come down
- Constraint on reservoir drawdown to meet flow target (73 or 90 cms) in lower Duncan from Sep 15-Nov 15
- Max outflow in December

Alt I

- Target full pool (576.2 m) by Aug 1 and then decrease to 573.3 m in Aug-Sept. Uses rest of Sept to get reservoir down. Curtails flow in Oct-Nov for treaty flow requirements (as Alt A). The resulting lower Duncan profile is not unlike power optimal except that it is curtailed in Aug to keep reservoir levels up.

Alt J

- Reservoir target is to opportunistically decrease level to el. 573.7 m but stay above 570 m
- Few constraints in the lower Duncan. The only difference from the power optimal is that it hits el. 570 m and evens itself out
- Target full pool by Aug 1, then decrease to 573.7 m after reaching full pool.
- Hold reservoir stable (± 0.25 m) for the burbot spawning period (Feb 15-Apr 15). Largely satisfies burbot constraint most of the time.
- The reservoir level is brought down before Feb 15 for power.
- Looks identical to Alt A but there is a significant cost associated with the back end of September constraint.

  - Mark: If the median from Lardeau discharge is 300 cms from June 3-July 15. Wouldn't adding the 150 cms would violate the 400 cms flood control?
  - Kathy: This is a combined flow (which includes the Lardeau River).
  - Mark: Is this doable in high water years?
  - Kathy: We can't meet the objectives of Alt K in high inflow years because we cant get the river to come down.

Alt K

- Objective is to increase cottonwood recruitment
- This alternative is to be implemented on an opportunistic basis (in a high water year) to reduce costs and better meet treaty requirements.

Alt L (73)

- Reservoir reaches full pool by Aug 1, then decreases to el. 575.5 m for recreation and held at this until Sep 5. There is about 10 days when it reverts back to Alt A to release water from Duncan.
- Pulls the reservoir down to Sep 15, at which time downstream fishery constraint (73 cms target flow) is implemented.
- Min/max flow scenario until mid Nov.
- Reservoir levels have a more gradual drawdown to better ensure the minimum flow is achieved.
- Early part of freshet (Apr to May), cap to 120 cms until Lardeau flows increase above it.

Alt M (90)

- Identical to Alt L except a slightly steeper drawdown in the winter because of the higher target/minimum flow of 90 cms.

Alt O

- Many features of Alt M but tries to better mimic a more desirable cottonwood recession (but later in the freshet).
- Tries to keep reservoir at el. 575.5 m after Aug 1 until Sep 5

Alt P

- Identical to Alt M except fish flow starts Oct 1 as opposed to Sep 15
- Forego flow during the first two weeks of kokanee spawning

Alt Q

- Essentially Alt M except for one feature: target fish flows (Sep 15 – Oct 21) as close to 90 cms as possible, then allow flows to go between 90-130 cms from Oct 22 to Dec 31 for whitefish spawning.

Alt R (90)

- Basically Alt Q with a 250cms flow cap starting after Aug 1 till the freshet for the lower Duncan River
- Incurs additional financial impact over Alt M as a result of Jan constraint (250 cap) to prevent inundation of cottonwood seedlings.

  - Could still maintain incubation between 90 and 130 cms. Some deep water spawning.
  - Kathy: Once we get to 250 cms can we drop down rapidly or is it better to gradually decrease?
  - Mark: Not an issue because of groundwater. From cottonwood perspective, key is to keep below 250 cms.

11. CHANGES TO PERFORMANCE MEASURES

- The facilitator summarized the changes to the performance measures that occurred since the last CC meeting (see the Pre-Reading Package for more details of the changes).

Dropped PMs

- Dropped PMs were a result of both decisions by the CC and through recommendations from technical committees. Some PMs were dropped because they were either insensitive across the alternatives, were redundant to other PMs or they were associated with too much uncertainty. To date, the following PMs have been dropped from decision making:
  - Burbot Spawning
  - Kokanee Lost Rearing PM
  - TGP PM
  - Exploitation Protection PM
  - Flood/Mosquito Risk >450 cms
  - Flood/Mosquito Risk >500 cms
  - Power Generation PM
  - Operation Flexibility Pm
  - HLK TGP *(To be determined by FTC – see Day 2 for recommendation)*
  - Nutrient Transfer *(To be determined by FTC – see Day 2 for recommendation)*
  - All of these PMs were calculated with the new alternatives to confirm that they should still be dropped or whether they provided any new information.
- Technical committees agreed that these PMs should be dropped, as they were insensitive across the alternatives and not helpful for decision making.

- The FTC also recommended that Rainbow Lost Rearing PM be dropped because it was insensitive across the front-running alternatives.
- The Operation Flexibility PM was dropped because it was considered to be redundant to the new Financial Revenue PM in the lower Columbia, which more effectively takes into account cross-system impacts and flexibility.

New PMs

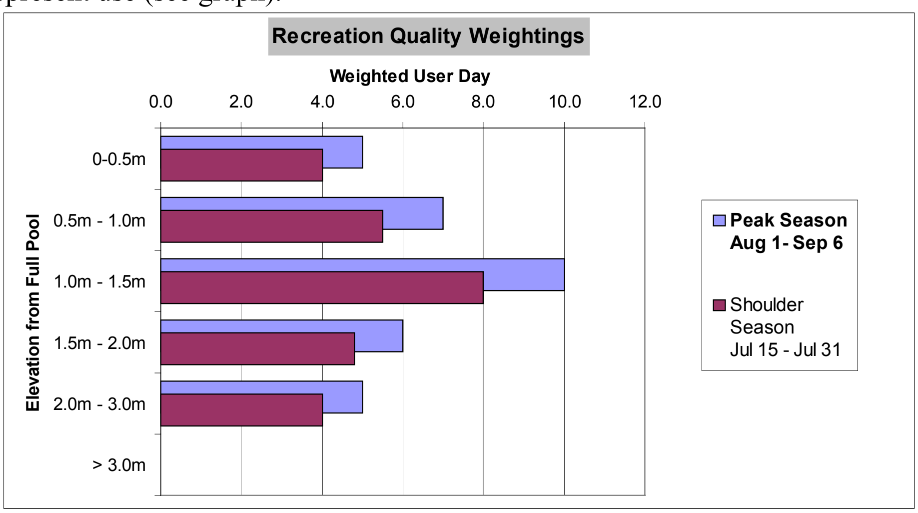
- A couple of new PMs were introduced since the last meeting, as follows:
  - Kokanee Lost Spawning (side channel) PM. This is a new PM, which should be used in conjunction with the Kokanee Spawning PM: together they provide a more complete picture of spawning (and lost relating to fish and egg stranding) opportunities.
  - Financial Revenue (VOE) PM – Lower Columbia

Changed PMs

- A number of PMs have been revised since the last meeting, as follows:

Recreation Quality PM *(Changed)*

- Changes made to the timing and weightings for ideal reservoir levels based on results of field surveys conducted at Glacier Creek, Glayco and Howser recreation sites.
- Recreation season split into a peak season and two shoulder seasons to more accurately represent use (see graph).



- The low spring shoulder season was not used in the weightings for the PM since it was considered redundant as most of the alternatives behaved similarly during this period and because it was of lesser consequence.
- The weightings for the high shoulder season were estimated at 80% of peak season.

➢ Larry: Reservoir water levels below full pool would impact recreation at Glacier Creek. The quality of recreation would be affected at the estates from North to South Bay. The ideal water level for recreation at Glacier Creek is 0-2 feet below full pool.

- Michael: Based on telephone surveys and opportunistic surveys, the ideal is thought to be 0-3 ft below full pool at Glacier Creek. At Howser Creek, the ideal level would be about 5 ft below full pool. The results of these surveys were discussed at the Recreation/QOL Sub-committee meeting, and formed the basis of the revisions made to the Recreation Quality PM.
- Larry: The reservoir is a beautiful lake at full pool. Once the water levels are dropped below this, the reservoir is not as attractive.
- Michael: By Aug 1, the reservoir would be at full pool and then levels drop a bit to benefit recreation, as well as riparian productivity.
- There are proposed physical works to dredge beach areas at Glacier Creek to match ideal elevations at Howser Creek.
- Larry: Are there any cost estimates done? This would require extensive excavation, as well as hauling in sand cover for the beach.
- Larry: Stated that he was not notified of the last Recreation/QOL meeting.
- Alf: Invitations were sent to all DDM WUP participants via email, and the Regional District's alternative (Bob Douglas) did attend this meeting.
- Fred: More beach area would be created if the reservoir were slightly below full pool.

<u>Kokanee Spawning PMs *(Changed)*</u>

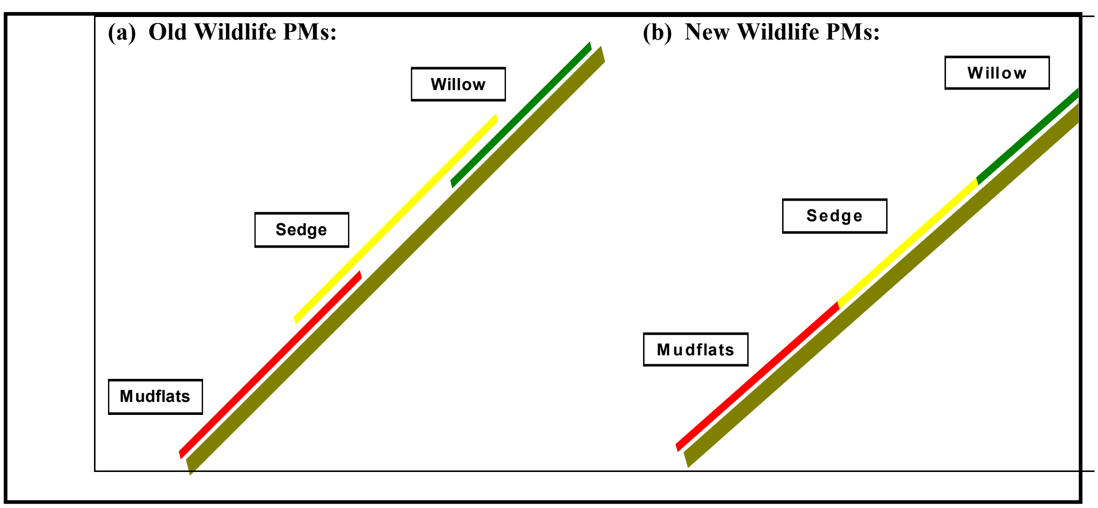
- Kokanee spawning timing changed to: Sep 7-Oct 21

<u>Whitefish Spawning PM *(Changed)*</u>

- Whitefish spawning timing changed to: Oct 21-Dec 31

<u>Riparian Productivity PM *(Changed)*</u>

- While this PM was initially dropped, revisions showed some sensitivity across the alternatives and therefore the WTC recommended that it be used.
- The way in which areas—*mudflat, sedge and willow*—were calculated was refined (as the figure below illustrates). These changes helped to avoid double counting areas.



<u>Cottonwood Habitat Area PM for lower Duncan (Changed)</u>

- Based on advice from Brenda Herbison and Stewart Rood, the PM was revised in terms of flows and timing to better reflect desirable conditions for encouraging and maintaining cottonwood recruitment.

12. Performance Measure Results

- The facilitator reviewed the performance measure using the graphical results *(refer to the Pre-Reading Package to see the 10^{th}%, Median, and 90^{th}%ile PM Result graphs that were used).*

Recreation Quality PM
- All latest generation alternatives (Alts L – R) perform well, except Alt O because it draws the reservoir lower at the end of the recreation season.

Kokanee Effective Spawning PM (Main Stem)
- Alternatives A, I, and J perform significantly worse than the other alternatives.
- Alt P performs slightly worse because it delays the spawning target flow until Oct 1 (from Sep 15).

Whitefish Effective Spawning PM (Main Stem)
- Alternatives I and J perform worst.
- Recently generated alternatives perform best.

Rainbow Lost Rearing PM (Main Stem)
- There was not a lot of difference across the alternatives. Alt I performed slightly worse.
- Across the front-running alternatives, there was not a significant difference.

Kokanee Spawning PM (Side Channel)
- Alterns Es and L through R perform significantly better
- Alt A, I and J perform worst because side channels become dewatered
- Note. If side channels are made to be productive for kokanee, other fish species will benefit

Kokanee Lost Spawning PM (Side Channel)
- Loss of habitat under Alt E, and L-R but not as much as under Alt A, I and J.
- Proxy for stranding PM

  - Steve Macfarlane: 500,000 m^2 is not an insignificant amount of habitat
  - Alf: Modeling only takes into account area, not substrate suitability or other factors
  - Kokanee use of Duncan is low relative to the Lardeau
  - Larry: There was an abundance of kokanee in Kootenay Lake in the 1970s and 80s. When **?** were introduced, there was an increase in fish size, which was followed by a subsequent decline.

Erosion Impacts PM
- The lower the PM score, the better
- Alt I performs best

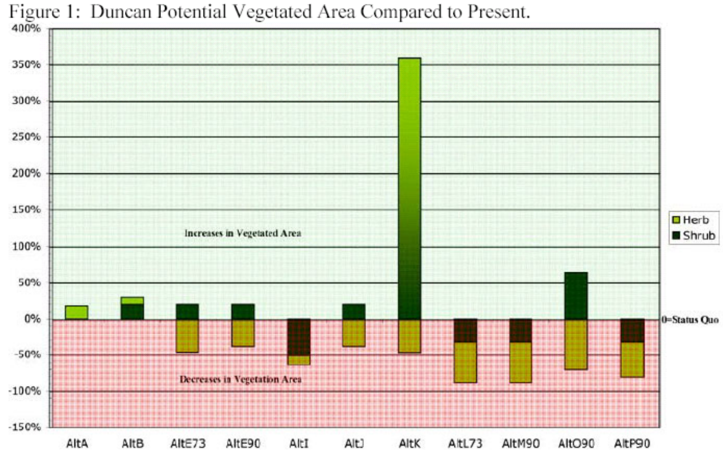
Riparian Productivity – Shrubs and Grasses PMs

- Negative impact across all alternatives except under Alt J for shrubs and O for grasses both relative to Alt A (Alt A not exactly status quo but a comparison with historical condition shows a close approximation).

<u>Riparian Productivity – Based on Anne Moody's Assessment (compared to present state)</u>

- With exception to Alt A, B, J and O (90), there would be a loss of vegetated area under the alternatives.

Figure 1: Duncan Potential Vegetated Area Compared to Present.



<u>Cottonwood Habitat Area PM</u>

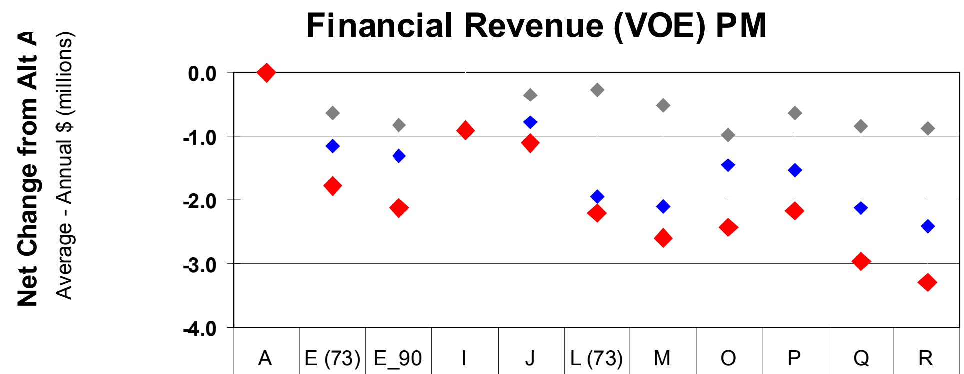
- This PM was also potentially linked to the question of a separate flow regime (Alternative K) for recruiting cottonwood areas.
- In the absence of implementing Alternative K, the newest alternatives showed the best performance: with Alternative R and O having the highest values (followed closely by Alternatives P and Q, which were within the uncertainty or MSIC)
- The CC also reviewed comments from both Brenda Herbison and Stewart Rood.

<u>Flood/Mosquito Risk >450cms (average values)</u>

- On average, 6 day in a year flows are just over 400 cms under Alt A. In a bad year, may be as high as 20 days in a year.
- At 450 cms, 2-3 days on average under Alt A. All other alternatives are insensitive (no days at or above 450 cms)

<u>Financial Revenue (VOE)</u>

- Revised graph from the pre-reading package



	A	E (73)	E_90	I	J	L (73)	M	O	P	Q	R
◆ Kootenay (K)	0.0	-0.6	-0.8	0.0	-0.3	-0.3	-0.5	-1.0	-0.6	-0.8	-0.9
◆ Columbia (C)	0.0	-1.2	-1.3	-0.9	-0.8	-1.9	-2.1	-1.5	-1.5	-2.1	-2.4
◆ Total Net VOE (K +C)	0.0	-1.8	-2.1	-0.9	-1.1	-2.2	-2.6	-2.4	-2.2	-3.0	-3.3

Alternatives

- Llewellyn: Why is variability in cost not presented?
- Kathy: This PM was modeled based on Jan 1-Dec 31. In a high water year, water is released in Dec through Feb, which confounds the scenario. The MCA WUP modeling was run on an Oct-Oct year, which removes this confounding effect.
- Steve McAdam: There could be just a few outlier years that are causing high variability under some alternatives, which could be mitigated.
- Steve Macfarlane: This can not be addressed for this meeting.
- Kelvin: Cost variability could be addressed through attaching conditions on the constraints to reduce the downside risk.
- Kathy: Brilliant is being modeled with the Expansion plant.
- The VOE is the overall provincial loss of power generation.
- Alt Q represents a 72 GWh per year loss or 1% of the Kootenay power generation.

(Note: Larry Greenlaw left the CC meeting at 4:00; outside the meeting he mentioned to Sue Heaton that he liked Alternative I.)

13. COMPARING ALTERNATIVES

In order to more easily compare alternatives, the facilitator reviewed the performance measures to see if some were insensitive and not informing the decisions to be made. The process to compare alternatives was and highlight key trade-offs was as follows:

Steps:

- Identify insensitive PMs
- Pairwise comparisons
- Drop dominated alternatives
- Tradeoff objectives between alternatives

Simplify the numbers of PMs

- The facilitator used the colour-coded interactive consequence table to help with narrowing the number of performance measures.
- The following figure illustrates the entire consequence table that was used at the beginning of this discussion (with Alternative A being highlighted as the reference)

DUNCAN WUP CONSEQUENCE TABLE

14 16	A	E 73	E 90	I	J	L	M	O	P	Q	R
Rec Quality (+)	244	234	235	260	225	313	314	174	315	316	318
Ko Spawning (Main) (+)	24	42	41	25	32	42	42	42	38	42	42
MWF Spawning (Main) (+)	26	56	60	29	38	56	60	60	60	62	62
Rb Lost Rearing (Main) (-)	16	16	16	19	17	17	16	13	17	16	15
Ko Spawning (Side) (+)	45	306	323	45	124	306	323	323	323	323	323
Ko Lost Spawning (Side) (-)	231	32	30	229	143	23	14	16	50	12	10
Erosion Protection (-)	674	687	820	563	609	613	730	765	790	674	671
Shrub (reservoir) (+)	406	338	360	299	421	132	146	233	299	146	129
Grasses (reservoir) (+)	408	224	243	275	146	289	288	419	204	288	284
Cottonwood (river) (+)	0.47	0.50	0.54	0.43	0.48	0.50	0.55	0.60	0.56	0.58	0.62
Flood/Mosq Risk (400) (-)	6	5	5	5	4	6	6	5	6	6	7
VOE (Kootenay) (+)	0.0	-0.6	-0.8	0.0	-0.3	-0.3	-0.5	-1.0	-0.6	-0.8	-0.9
VOE (Columbia) (+)	0.0	-1.2	-1.3	-0.9	-0.8	-1.9	-2.1	-1.5	-1.5	-2.1	-2.4

- The Flood/mosquito risk PM does not help to discern across alternatives, and therefore does not help in decision making.
- ➢ Gail: This is true for averages, but looking at the 10 and 90th percentile there are significant differences across the alternatives. It was pointed out that this was only for 400cms, which was really before any significant inundation/flooding occurs.

OUTCOME: CC AGREED TO REMOVE THE FLOOD MOSQUITO RISK PM

- A comparison of kokanee and WF spawning mainstem PMs shows that the PMs are tracking the same across all of the alternatives except Alt P for kokanee. It was therefore proposed that the kokanee PM be used as it is more sensitive than the WF PM.

OUTCOME: CC AGREED TO USE THE KOKANEE PM AS A PROXY FOR WHITEFISH SPAWNING IN THE MAINSTEM

- All the alternatives significantly out perform Alt A, I and J for spawning kokanee effective area (side channels). Kokanee spawning habitat lost PM tracks the same except for Alt P and was therefore considered more informative for making decisions.

OUTCOME: CC AGREED TO USE KOKANEE SPAWNING HABITAT LOST PM (SIDE CHANNEL) AS A PROXY FOR KOKANEE EFFECTIVE AREA

- Some CC members valued the financial revenue between Columbia and Kootenay impacts differently; so they were kept separate.

- ➢ Steve Macfarlane: Would like to keep the PMs separate.

- Steve McAdam: There may be background information on why people value these differently. Doesn't have any argument with the Kootenay numbers. The challenge with the VOE PM for the Columbia is if BCH could provide any assurance that restrictions on ALGS license are captured in Alt A. My preference would be to present only Kootenay and total VOE PMs.
- Kelvin: When BCH signed the Treaty, the idea was that it would give Canada the right to operate the three facilities as a whole. There is a requirement for discharges at the border but BC Hydro has negotiated the right to transfer water in basin provided targets are kept whole. BC Hydro has tried to recognize the total value of the system. System efforts are to make the most beneficial use of the water. System tradeoff has historically occurred and will continue to do that. There will be tweaks as new things are added (e.g. Brilliant Expansion, ALGS). There are provisions in the ALGS PAC to ensure that CPC can not interfere with BC Hydro's ability to meet treaty obligations. The PAC does not prevent BC Hydro from making small tweaks.
- Llewellyn: This is a value judgment; each CC members prerogative. Alt A is not viewed as an option; it is used as a reference point for comparison.
- If the benchmark is biased then our comparisons are biased.
- Jayson: We are confident with the Kootenay numbers. Does the CC feel the same way about the Columbia numbers?
- Kathy: Even Kootenay numbers are relative to one another. Costs for ALGS are relative differences to the Base Case.
- Kelvin: If the value of power moves, the relative difference of alternatives to Base Case would likely remain the same.
- Jayson: Important to look at the differences from Alt A as opposed to the absolute value.

OUTCOME: CC AGREED TO KEEP COLUMBIA AND KOOTENAY PMS SEPARATE

- Stephan: Recreation should be dropped because fish, animals and the overall ecosystem need more care than the people. Recreation is heavy handed. He expressed concern over the effect that a lack of flooding would have on the productivity of the soils.

Alternative Comparisons

<u>Alt A vs. Alt I</u>

- Alt A dominates Alt I for all PMs being considered. There is no reason to keep Alt I.

DUNCAN WUP CONSEQUENCE TABLE

14 16	A	I
Rec Quality (+)	244	260
Ko Spawning (Main) (+)	24	25
Rb Lost Rearing (Main) (-)	16	19
Ko Lost Spawning (Side) (-)	231	229
Erosion Protection (-)	674	563
Shrub (reservoir) (+)	406	299
Grasses (reservoir) (+)	408	275
Cottonwood (river) (+)	0.47	0.43
VOE (Kootenay) (+)	0.0	0.0
VOE (Columbia) (+)	0.0	-0.9

- Kathy: Alt A has a very different hydrograph than Alt I. Used old recreation targets that were initially assumed.
- Fred: We do not know the reasons for Larry's preference for Alt I or his opinion on the other alternatives, since he is not here to articulate why he liked Alternative I.
- Stephan: Alt A is better for grasses.
- Gail: The timing of full pool is different between Alt A and I. Alt I holds the reservoir high through the month of Aug, whereas the reservoir fills earlier (Jul 15) and starts emptying earlier under Alt A.
- Alt I reduces flood risk.
- Gail: Alt I seems better for recreation, and has more buffer for flooding. Don't understand why Alt A is better.
- Kathy: There are alternatives that perform better for recreation than Alt I or Alt A. These are not the "recreation" alternatives.
- Michael: Offered the suggestion to remove Alt I from further consideration
- Steve Macfarlane: There are several alts that perform better for flooding/ mosquito risk than Alt I.
- Gail: Stressed the importance of the need for rationale behind decisions and values expressed by CC members in ranking. The following wording around the CC's decision to dropping Alt I is acceptable.

OUTCOME: CC AGREED TO REMOVE ALT I FROM FURTHER CONSIDERATION AS IT IS EFFECTIVELY DOMINATED BY ALT A. ALT A PERFORMS BETTER OR EQUAL THAT OF ALT I FOR ALL THE PERFORMANCE MEASURES.

<u>Alts E73 vs. E90 vs. P</u>

- Alt E 73 performs better than Alt P for everything except recreation quality and cottonwood recruitment

DUNCAN WUP CONSEQUENCE TABLE

14 16	E 73	E 90	P
Rec Quality (+)	234	235	315
Ko Spawning (Main) (+)	42	41	38
Rb Lost Rearing (Main) (-)	16	16	17
Ko Lost Spawning (Side) (-)	32	30	50
Erosion Protection (-)	687	820	790
Shrub (reservoir) (+)	338	360	299
Grasses (reservoir) (+)	224	243	204
Cottonwood (river) (+)	0.50	0.54	0.56
VOE (Kootenay) (+)	-0.6	-0.8	-0.6
VOE (Columbia) (+)	-1.2	-1.3	-1.5

- CC not ready to drop Alt P given there has not been a discussion (or decision) of Alt K
- Alt E73 performs the same as E90 except Kootenay and Columbia VOE PMs

- Alf: We developed 60 % as threshold when side channels become active. At 73 cms, there is 57-58 % (close to 60 %). Amount of area lost is not very significant. Used as a trigger point.
- Gail: Not comfortable with dropping Alt P at this point.

OUTCOME: CC AGREED TO REMOVE ALT E90 FROM FURTHER CONSIDERATION AS IT IS EFFECTIVELY DOMINATED BY ALT E73. ALT E73 PERFORMS BETTER OR EQUAL TO ALT 90 FOR ALL PERFORMANCE MEASURES.

Alt L vs. M vs. Q

- With the exception of kokanee lost spawning (side channel), Alt L is better than Alt M for all performance measures.

DUNCAN WUP CONSEQUENCE TABLE

	L	M	Q
Rec Quality (+)	313	314	316
Ko Spawning (Main) (+)	42	42	42
Rb Lost Rearing (Main) (-)	17	16	16
Ko Lost Spawning (Side) (-)	23	14	12
Erosion Protection (-)	613	730	674
Shrub (reservoir) (+)	132	146	146
Grasses (reservoir) (+)	289	288	288
Cottonwood (river) (+)	0.50	0.55	0.58
VOE (Kootenay) (+)	-0.3	-0.5	-0.8
VOE (Columbia) (+)	-1.9	-2.1	-2.1

- Mark: Stewart Rood noted that Alt M is best for cottonwood. Not sure what he thinks about Alt Q.
- Alf: We do not have Stewart's comments on the last 2 most recently generated alternatives.
- Steve: Why not compare Alt E to Alt L since this is a variation of E?
- Michael: The comparison of alternatives did not show one alternative as being clearly dominant. Alt Q is a slight variation on Alt M. If anymore narrowing through pairwise comparisons are to occur, it will be with this comparison.
- Steve McAdam: This comparison will help later on in the tradeoff but doesn't dominate enough to drop any of these at this point.
- Difference in kokanee lost spawning PM is significant, but effective spawning PM is not significantly different across these three alternatives.
- Gordon: Noted that he would be okay with dropping Alt M
- Llewellyn: Why not drop Alt Q?
- Michael: Alt Q performs better for cottonwood based on the PM scores (not yet confirmed by Stewart Rood).

OUTCOME: CC UNWILLING TO REMOVE ALT M OR Q FROM FURTHER CONSIDERATION

- Gordon: Noted that he does not consider Alt A as an alternative. It is just a reference case only.
- Terry: Why not consider dropping Alt J?

- Llewellyn: Alt J is the only reservoir-based alternative left. Alt J performs better than other alternatives for shrub and erosion protection.
- Stephan: Why have we dropped Alt A. It has no cost and performs as good or better for all PMs other than fish PMs (kokanee spawning). Grass is very important to fish and wildlife. He would error in favour of the ecosystem but not at a high cost.

OUTCOME: CC AGREED TO REMOVE ALT A FROM FURTHER CONSIDERATION AS IT DOES NOT PROVIDE ANY OPPORTUNITY FOR CONSENSUS. KEEP IT AS A REFERENCE CASE.

14. RANKING EXERCISES

Purpose is to:

- Gain insight and simplify the value tradeoffs within and between alternatives to make decisions
- Highlight where the key tradeoffs are
- These exercises are a learning tool for CC members to help clarify their preferences
- There is no right answer, as everyone's rankings and preferences are unique
- Results will be documented in the minutes and may be summarized in the CC report.

Two Ranking Exercises were undertaken by the CC – ***Direct Ranking and Swing Weighting*** (the results of which were discussed during Day 2)

DAY 2: Wednesday, April 2004 (8:30am to 5:30pm)

1. UPDATE

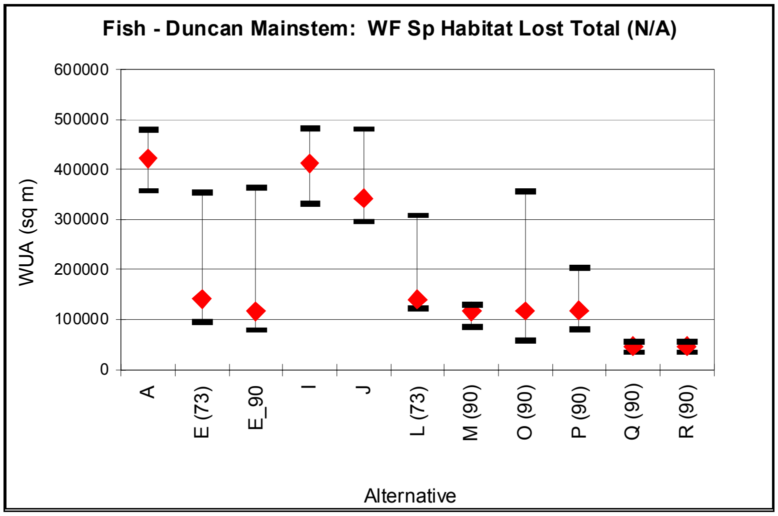
Results of the FTC Meeting held last night (evening of April 20)

- New PM for lost whitefish spawning habitat (mainstem) was recommended *(and accepted by the CC).*
- Nutrient Loading PM – no performance measure was recommended by the FTC as this issue was associated with a non-operating alternative.
- Flood Rule Curve Protocol – to be developed to mitigate the risk of not getting a variance for the rule curve and still try to optimize the minimum flow requirements.
  - In years when BC Hydro can not get the variance, implement the protocol to minimize running out of water in the event of a late freshet. The intent is to better keep side channels wetted for as long as possible (given the high degree of uncertainty with the timing of the freshet and therefore the needed storage).
  - Depending on the frequency of not getting a variance, between 10-30 % of the habitat benefits for the side channels might not occur. An estimate of the minimum flow that could be met each year within the curve requirements was approximated as 50 cms or slightly higher.
- More likelihood to get variance on 73 cms as opposed to 90 cms.
- BC Hydro would need to get an answer from the Army Corp of Engineers by early February based on January snowpack.

  ACTION: KELVIN TO GET SOME ASSURANCE FROM THE CORP AS TO THE LIKELIHOOD OF GETTING A VARIANCE (NOT SURE IF THIS IS AN ACTION ITEM OR PART OF THE PROTOCOL DEVELOPMENT?)

- TGP @ HLK was recommended to be dropped as a potential cross-system issue *(accepted by the CC).*

- **New WF lost spawning in mainstem PM –** The FTC felt that the whitefish flow benefits were not being adequately captured with the current suite of performance measures. They therefore recommended that a new PM for Whitefish Lost Spawning (main stem) be introduced and used by the CC for decision making *(accepted by the CC).*
  - Significant difference in PM between Alt Q and R and the remainder of the alternatives
  - Under Alt M, there could potentially be significant stranding of WF eggs in Jan and Feb due to higher flows in Nov and Dec
  - Under Alt Q, downstream flows in Nov/Dec are not as high, so would expect less stranding potential under this alternative.
  - Note that whitefish spawning flow requirements were not considered at odds with providing Columbia fish flows.
  - Also note that whitefish spawning flows are allowed to fluctuate between 90 and 130 cms in Oct-Dec (providing more flexibility) and this may result is some stranding.
  - The new performance measure values were calculated and presented to the CC in the following graph.



2. *New Business*

Desirable Reservoir Levels for Recreation

- Larry expressed that recreation is a real concern because it affects the economics of the area. In addition, the discharge of water for some of the proposed operating scenarios is costly to the public. He disagrees with the findings of earlier surveys conducted and reviewed by the *Recreation Technical Committee* (RTC) last summer around reservoir levels that are considered desirable for recreation. The RDCK alternate (Bob Douglas) attended the *Recreation Technical Committee* meeting, but was not an official representative for the District (according to Larry).
- Last night, Larry undertook his own telephone survey of local residents of Meadow Creek, Howser, Argenta, Lardeau, Cooper Creek and Kaslo that use Duncan Reservoir most consistently for recreation. The key messages from his survey were that:
  - an overwhelming number of individuals surveyed (72%) felt that full pool was most desirable,
  - some wanted the reservoir to be 6”-1 ft below full pool for beach area, and
  - one individual felt that as much as 1 m below full pool would be most desirable.
- Surveys conducted last summer indicated that desirable levels were 1-2 ft below full pool at Glacier Creek and 5 ft below full pool at Howser. The RTC weighted these two sites equally. These results are not significantly different from Larry’s survey. It was also noted that all the frontrunning alternatives behave more or less the same in the first two weeks in August (with reservoir levels near full pool).

Erosion of Agricultural Lands

- Larry: Expressed support for protecting the Argenta Slough and the need to consider erosion problems on agricultural lands. There is a major erosion problem north of Hamill Creek. Both of these areas should be targeted for physical works.
- The question was posed as to whether there is an operational link to allow for physical works for erosion of agricultural land.
- Larry: There is greater erosion caused by higher volumes of flow later in the year. This is an ongoing issue that has existed since operation of the dam.
- Llewellyn: This issue was raised earlier in the process.

- Michael: A geomorphologic study was done of the lower Duncan to determine how operations have affected the erosion potential of the river. The dam has reduced peak flows by 30%. Erosion happens naturally.
- Alf: Mike Miles looked at erosion contribution from the operating alternatives being considered. It was determined that there would not be any fundamental difference in erosion. The major change would be the lack of flooding due to imposing a maximum cap of 400 cms.
- Larry: Agrees that erosion protection is required at Argenta Slough but this is also needed for farmland as well.
- Gail: Agricultural lands provide important wildlife habitat. There is justification for undertaking some form of physical works. One of the problems is the lack of plant growth along the riverbanks. There has been a loss of riparian habitat that would have helped to stabilize the soils.
- Steve: The farmers have created the erosion problem by planting right up to the bank.
- Gail: Suggested that cottonwoods could be planted to enhance riparian habitat along the river. Farmers may have contributed to the erosion problem by removing vegetation close to the banks.
- Jayson: Planting willow will not help solve the erosion problem, as it would take 80 years before these plants would be effective. Rip rapping the riverbank would address the erosion problem, but from a regulator perspective, this would not be an acceptable option. Installing big woody debris structures would be costly, and there is no guarantee that this would be effective either.
- Alf: This is a floodplain with highly erodible soils. Mike Mile's professional opinion is that the dam has decreased erosion. From a footprint issue, we are seeing a narrowing of the river, and less erosion. Active erosion is different from causing erosion. There will always be active erosion.
- Fred: All of the alternatives reduce the risk of erosion relative to the natural state.
- Larry: Suggested installing weirs to change the direction of the river current. Dig trenches and plant. Physical works should be considered from a public perspective.
- Michael: There are two possible ways of including this within the WUP:
  - There is remaining concern about high winter/fall flows increasing erosion along the river (against expert opinion). Implement a monitoring program to address this uncertainty.
  - If there is a need to provide a non-operating alternative in lieu of a change to reservoir operations and protecting agricultural areas downstream are considered the best and most effective way to provide wildlife benefits, then they could be included.
- Stephan: Expressed concern over the removal of riparian vegetation and historic high flows.
- Jayson: There are other potential funding avenues that the farmers could explore. Not convinced this is a WUP issue.
- Steve Macfarlane: There may be soft treatments that could be implemented.
- Gail: The deer farm is very important to the economy of the valley. It is a viable working farm, which provides important wildlife habitat. Cottonwood provide habitat for birds. It also provides ideal bobolink breeding habitat.
- Terry: How can this be called valuable wildlife habitat when it is fenced off for fallow deer.
- Michael: Asked the CC how they wanted to deal with this issue: as a recommendation for non-WUP funding, include for consideration for wildlife physical works, or (if operational link is erosion) recommend monitoring?
- Larry: As Duncan is a navigable river, debris management should continue. This could tie into land erosion.

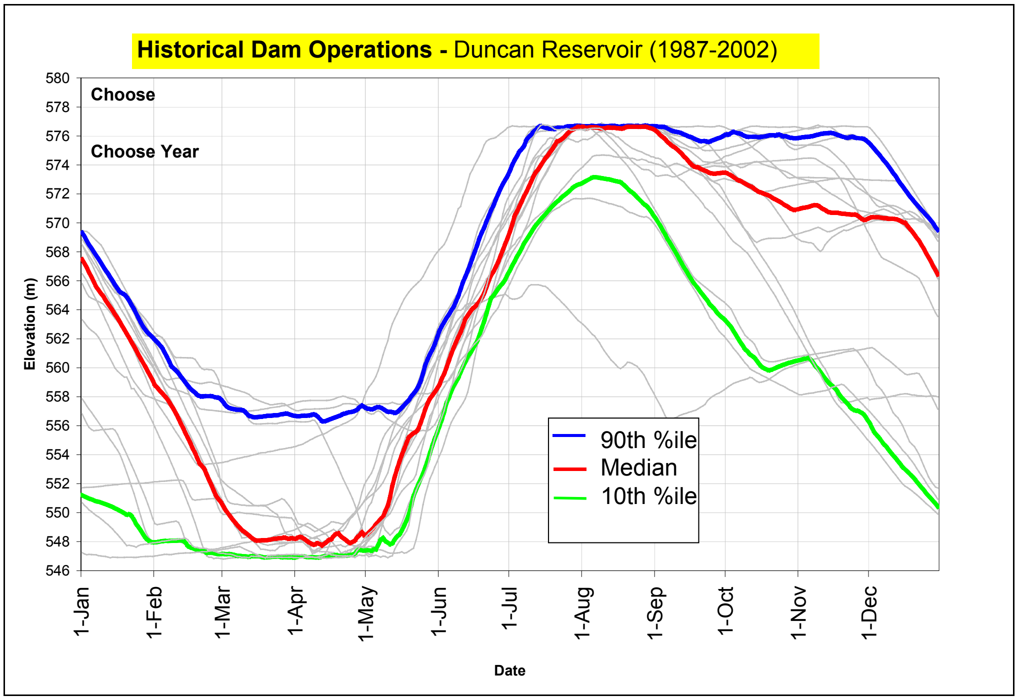
- Steve Macfarlane: Unlikely that any of the alternatives are affecting woody debris in the river.
- Jayson: The alternatives would act to decrease the amount of wood over time. From a fish perspective, I would want to see more wood than less.
- Gail: Should monitor the erosion.
- Jayson: Erosion is not doing anything positive for fish habitat. There would be benefits for fish habitat. Use this as the operational link for making a recommendation (possible funding through Rural Land Stewardship).
- Kindy: Has the Wildlife Technical Committee considered how much wildlife benefits there would be from implementing physical works?
- Michael: No. This issue has just been raised.
- Alf: There is a monitoring program as part of the adaptive stranding protocol ($80k program). This could be adapted to look into erosion at those agricultural areas considered a priority.
- Kindy: We need to have some confidence that there would be some wildlife benefits to spending the $$ on physical works for agricultural lands.
- Stephan: Planting of willows would be inexpensive and would be effective in stabilizing the banks. Still trying to change something that isn't' going to change. It is still a flood plain.
- Larry: Would like to see some investigation of possible soft techniques in specific areas.
- Jayson: Preference is not to do a test site but to monitor the rate of erosion and expand on the work of Mile Miles. There is plenty of knowledge and experience in the province in treating erosion. If you want to monitor rate of erosion that is one question (i.e. expanding on work by Mike Miles). Alternatively, either pick a treatment or put it to an erosion protection expert for the best approach.
- Steve Macfarlane: Does not believe there is a logical linkage to protection of agricultural land within the WUP, but does think there are ways to incorporate it if framed as a study.
- Michael: There may be a need to do physical works if it is found through monitoring that operations are affecting erosion.
- Jayson: Would not propose a test site. This would be a very expensive test ($400k) due to need to test an entire section.
- Michael: Suggested reviewing what is to be done when a decision is made with the proposed Argenta Slough erosion protection physical works.
- Larry: Emphasized that there is a public perception issue that should be addressed if there are to be any physical works benefiting wildlife done. There should also be physical works for the working people in the area.

3. *REVIEW OF HISTORIC OPERATIONS*

The facilitator provided more context about the alternatives currently being reviewed by the CC by illustrating how operations have been historically operated in the last 16 years.

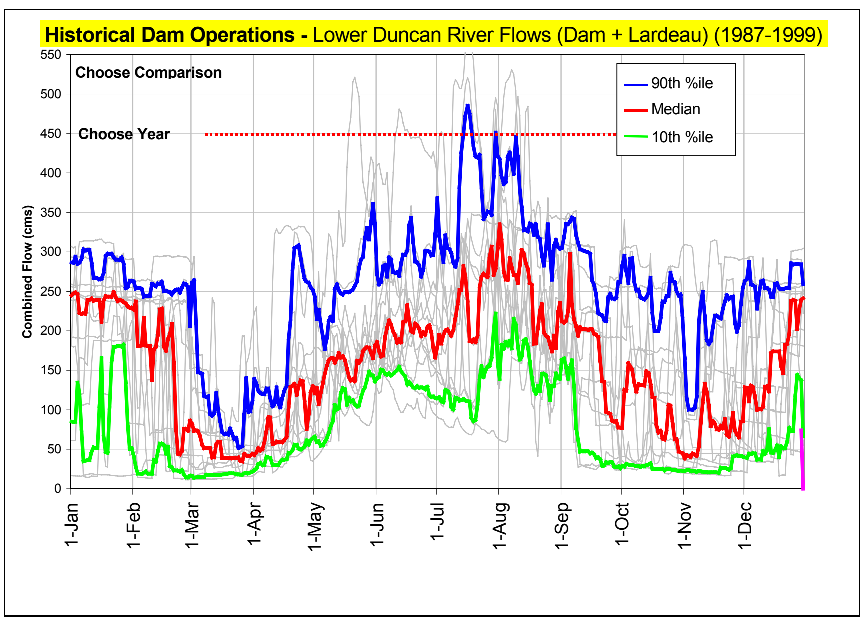
DDM Reservoir

- See graph below
- 50% of the time reservoir is below full pool in August
- Each year there is a 30 m draft in the reservoir
- On average, discharge a lot of water in Jan and Feb
- Min elevation is historic river level



Lower DDM River

- See graph below
- Argenta wetland and marsh area is of greatest concern.
- Reach 2 is the most constrained.
- Reaches 4 and 5 are being targeted for cottonwoods.



- Fred: Erosion site at Argenta Slough is private land.
- Jayson: Erosion rates at this site should be slower than the site further upstream.

- Steve Macfarlane: Propose installing a hydraulic control downstream to control river direction, which would reduce flow and perhaps reduce the rate of erosion on the bend by the Argenta wetlands.

4. *REVIEW OF NON-OPERATING ALTERNATIVES*

The facilitator reviewed when non-operating alternatives can be introduced and considered within the WUP process.

Within WUPs there is an opportunity to consider non-operational alternatives if:

1. the benefit can be obtained through operations
2. the alternative can be done within BC Hydro's jurisdiction and w/i legal and safety agreements
3. the alternative can provide the commensurate benefits (or more)
4. the alternative is more effective (compared to other impacts: e.g. costs, other PM effects, etc.)

To date, committee members have identified the following non-operating alternatives for possible use and consideration by the CC when making their final trade-offs:

1. Argenta Slough Erosion Protection
2. Erosion Protection for Heritage and Cultural sites
3. Recreation Benefits Options
   - Glacier Creek Beach Re-contouring
   - Glacier Creek Boat Ramp Extension
   - Maintenance at Howser/Glayco Recreation Sites
   - Partial Mosquito Abatement Funding
4. Nutrient Loading Funding

The costs, benefits and risks for each identified non-operating alternative was reviewed (see Section 8.0 of the Pre-Reading Package for more details)

4.1 Argenta Slough

- There has been a considerable amount of erosion in the lower Duncan River over the past 5 years and this situation now threatens the viability and health of the Argenta slough and wetland area.

<u>Scope – 4 options were identified, with varying levels of erosion protection</u>

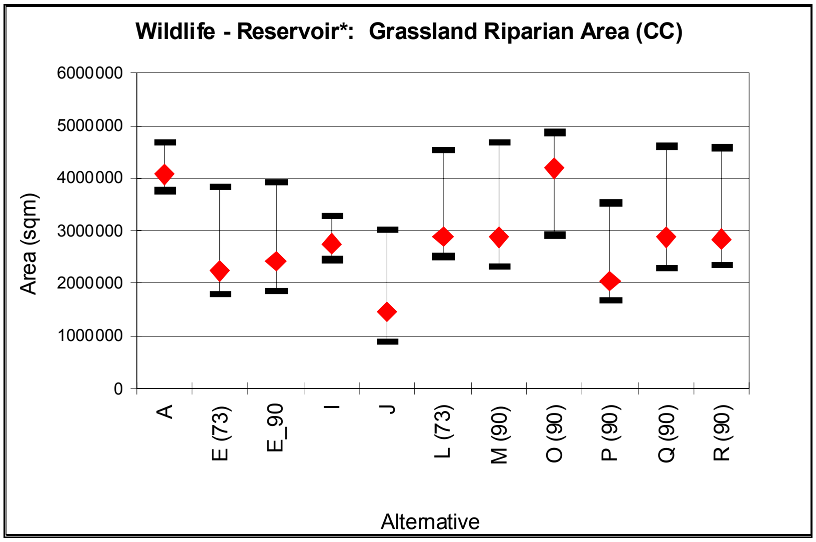
1. Bio-Remediation (soft works, planting)
2. Riprap Armoring
3. Deflector Weirs (reducing currents and flow and thereby erosion)
4. Breaching the lower Duncan River

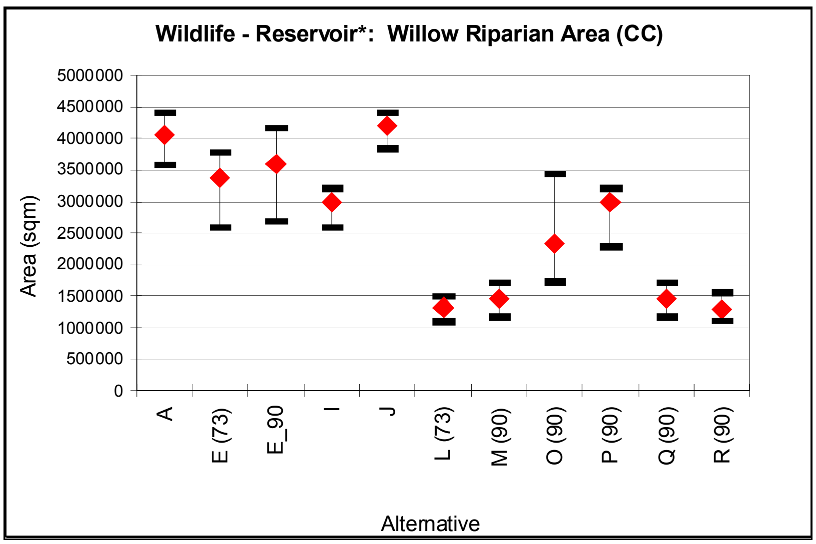
- Mark: Suggested that an another possible option would be installation of a beaver-type dam/weir upstream of the erosion site in the lower river.
- Alf: The last two options are the cheapest alternatives.

<u>Operational Link</u>

1. Reservoir levels are adversely affecting the total area of available shrub and grass habitat area (a loss of between 20-50% as compared with current operations and Alternative A).
2. Lower Duncan River high fall/winter flows increasing erosion. Based on local resident opinion.

Comparison with Relevant PMs





- Some CC members felt that the predicted impacts of the alternatives to be overly pessimistic (compared with experience gained on other parts of the Columbia system). It was also recognized that Anne's PMs are based on long-term averages.
- Predominant impact on grasses is in the last month and a half of the growing season.
- Some alternatives hold the reservoir higher for recreation and thereby cause an impact to vegetation in the fall. Whereas Alt A reservoir levels consistent drop through the late growing season (from Aug 15 onwards) benefiting vegetation growth.
- The WTC was tasked with coming up with physical works. The group looked at a fertilization program, planting and crib structures in the reservoir. The most favorable was a planting program for shrubs. But there is a great deal of uncertainty around soil suitability and whether the benefits would accrue. From a wildlife perspective, it is still relatively healthy. The WTC concluded that it would be much better to spend $200k to protect Argenta Slough, which would provide equal or greater benefits than a reservoir planting program.

- Gordon: Are we looking at an impact from the alternatives being considered?
- Alf: The only difference is during the summer. The management flexibility among the alternatives is very small. The upper meter is important to riparian opportunities.
- Mark: Trading off some grass for fish and recreation. Alt A is best for grasses.
- Alf: Alt A performs best for riparian growth. Compensation programs are in lieu of Alt A.
- Stephan: Suggested putting in pilings to create a hydraulic weir. No way of stopping erosion at the elbow due to highly erodible soils.

- Alts A and J perform best for willow riparian area, while Alts A and O perform best for grassland riparian area.
- Under Alt O, Anne suggests there would be a negative impact on grasses and a positive impact on shrub.

<u>Benefits</u>

- Better protects 25 ha wetland

<u>Costs</u>

	Total Cost	*Avg Annual*	*Risks (of getting benefits)*
1) Bio-Remediation	$275k	$36k/yr	Med/low
2) Riprap Armour	$365k*	$43k	Low
3) Deflector Weirs	$110k	$15k	Med
4) Breaching the delta	$155k	$20k	High

(* Largest uncertainty around cost estimate)

- Steve Macfarlane: Costs seem low for the breaching option.
- Alf: This would include setting up the weir structure and letting flow breach the delta.
- Larry: Expressed full support for protecting Argenta, but re-iterated the need to address public perception around the need to also protect agricultural land.
- Gordon: Does this mean that there will be no work or monitoring in the reservoir.
- Michael: This would not eliminate the need for monitoring. This is a menu of works in lieu of operational changes in the reservoir, if required.
- If we do not go for protection of Argenta Slough, what are the options for the reservoir?
- Michael: Alt A or J
- Are there works in lieu in the reservoir?
- There were works explored by the WTC for the reservoir but they all paled in comparison to the physical works for Argenta in terms of overall wildlife benefits.
- Stephan: The reservoir is used by numerous species of wildlife (bear, deer, elk). Argenta slough is located in the middle of a populated area and does not support the same number of wildlife. He does not consider this to be an acceptable tradeoff.
- Steve Macfarlane: Is it part of the monitoring plan to deal with uncertainties around a future planting scheme?
- Alf: There is a riparian monitoring program for the reservoir to deal with this specific uncertainty.
- Kindy: Find this curious as the finding of the Columbia WTC is that planting in Kinbasket Reservoir would be very viable option.
- Alf: This is based on potential sites in the drawdown zone. Only a portion could be planted. Other than Alt A, none of these sites posed viable future riparian enhancement sites.

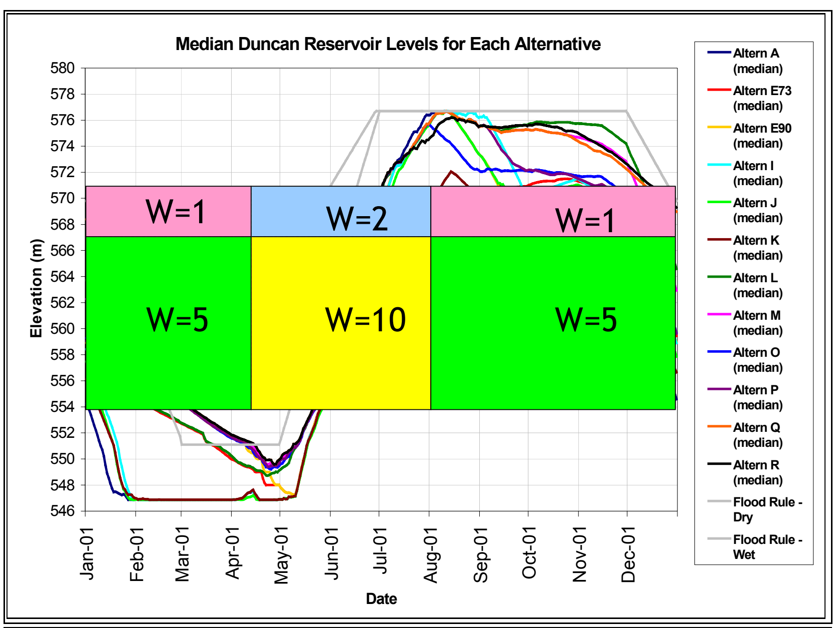
- Michael: Keeping the reservoir high for recreation is the key tradeoff to riparian vegetation in the reservoir.
- Kathy: We are not jeopardizing what is currently there.
- Most historical trends kept the reservoir higher into October. So what is the difference under the alts being considered?
- Historically, on average, the reservoir was at full pool from July to Sept. Under Alt M, the reservoir would cause inundation into Oct (time of concern is April to end of Oct). Alt P is close to historical.
- Physical works in lieu are needed only if the CC selects an alt that inundates longer.
- Steve McAdam: Alt A is better than historical for riparian vegetation. Otherwise the other alternatives are improvements.
- Michael: These are a suite of non-operating alternatives if there are still concerns over shrubs and grasses that the operating alternatives are not addressing.
- Larry: What are we mitigating in the upper Duncan. Historically, there was very little wildlife. Existing conditions are much better for wildlife than historically.
- Michael: We are not comparing the alternatives to historic (pre-dam). Impacts of footprint have been addressed through compensation programs.

4.2 Erosion Protection of Cultural Sites in the Reservoir

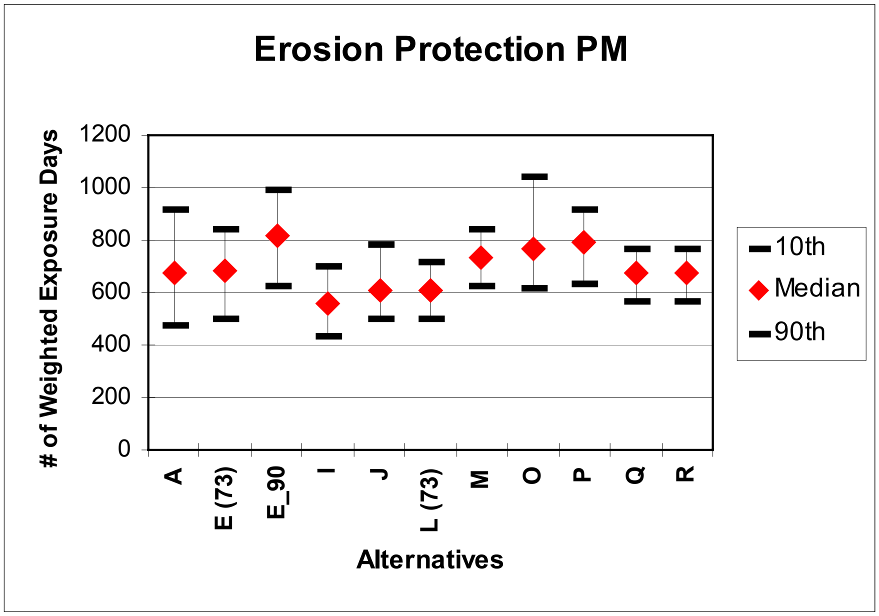
Scope – 2 options were identified, with similar levels of erosion protection

1. Riprap blanket
2. Non-woven geotextile blanket

Operational Link
Reservoir levels move through cultural sites increasing erosion (see the weighted scale of impact according to alternative)



Comparison with Relevant PMs



- Cumulative total days within undesirable elevation range based on median reservoir levels
- High degree of uncertainty with PM (MSIC of 20%)
- Concern mostly around drawing down of reservoir as opposed to filling of the reservoir
- Alt E90 performs worst for this PM

Benefits
Better protects the 2 identified significant sites
Site 1 – 6 ha
Site 2 – 2 ha

Costs

	Total Cost (10yr)	*Average Annual (10-yr)*	*Risk (of getting benefits)*
1. Riprap blanket	$2,350k	$300k/yr	Low

- Area to protect may be considerably less than 6 ha
- There is a monitoring program to study archaeological sites.
- Varying degrees of protection required between the two sites. Artifacts are quite intact. Having not found sites of this age (8-11,000 years) and in this location adds to the significance of these sites.

- Terry: If artifacts can be destroyed by erosion, won't the placement of rocks do more damage?
- Fred: The down side of installing blankets is that it clearly identifies the location of these sites.
- Steve Macfarlane: Why have these costs been annualized over 10 years?
- Michael: To match the duration of the monitoring programs.

- Steve Macfarlane: The decision of the WUP Management Committee was to be consistent with the application of annualized costs for non-power (monitoring, physical works). This does make a difference when the CC are considering physical works. Committees can make a decision but 20 years should be consistently used. Arguing for consistency.
- Michael: Chose a 10-year annualization period so that future CCs do not inherit the cost of decisions of previous committees.
- Steve: Should understand that costs can be presented to the CWR in a very different way.
- Gail: How are annualized costs different from dividing total by the 10 years.
- Gordon: The cost is discounted every year by 8%.
- Michael: CC to decide the annualization period.
- Gordon: Has no preference for 10 or 20 years. It is about the payment schedule but this has nothing to do with this table.

		Total Cost	*Average Annual (10-yr)*	*Risk*
2.	Geotextile Blanket	$1,040K	$130k/yr	Low-Med

- Fred: More subject to wave action, and a higher probability of pot holing.
- Gordon: Possible that this work will fall under the *Heritage Act*.
- Fred: Responsibility for work falls on the developer.
- Gordon: May still go ahead under the Heritage Act if not under WUP.
- Steve Macfarlane: Was consideration given to salvaging as an alternative?
- Vic: This was considered, but is undesirable.
- Sites were identified through the WUP process as a result of an overview archaeological assessment. There is an operational link and therefore could be looking at an operational change to address as opposed to a physical works.
- Vic: Does the WUP supersede the Columbia Treaty?
- Michael: The intent is that changes under WUP will not affect Treaty requirements.
- Kelvin: There are tweaks that came be made that would not have an impact on downstream benefits.

4.3 Recreation Options

<u>Scope – 4 options were scoped out by the RTC for recreation physical works in lieu of operations, if required by the CC</u>

1. Glacier Creek beach re-contouring
   - Excavate 2 ft off beach to keep water levels commensurate with Howser Creek

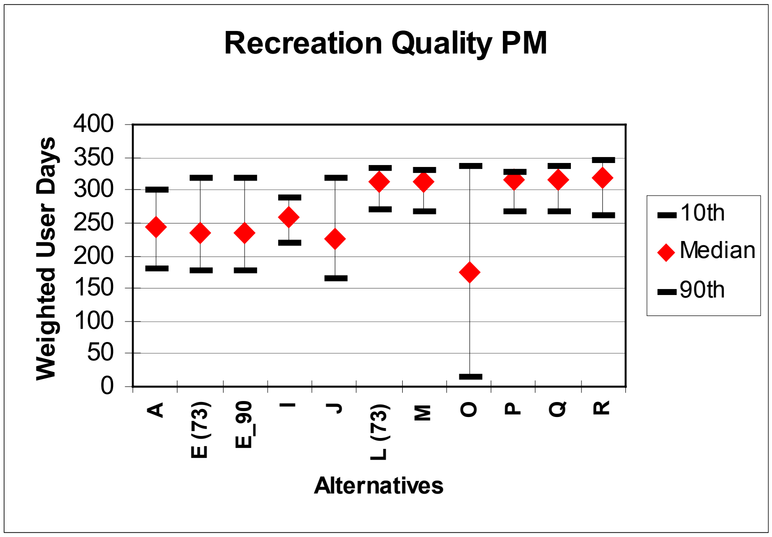
2. Glacier Creek Boat ramp extension + buoys
   - Useable to 2-4 ft from full pool

3. Maintenance at Howser and Glayco
   - Benefit recreation provide maintenance fee (debris removal etc)
   - MoF property. MoF has three years of funding for maintenance of the site. Will see better maintenance than past 3-4 years.

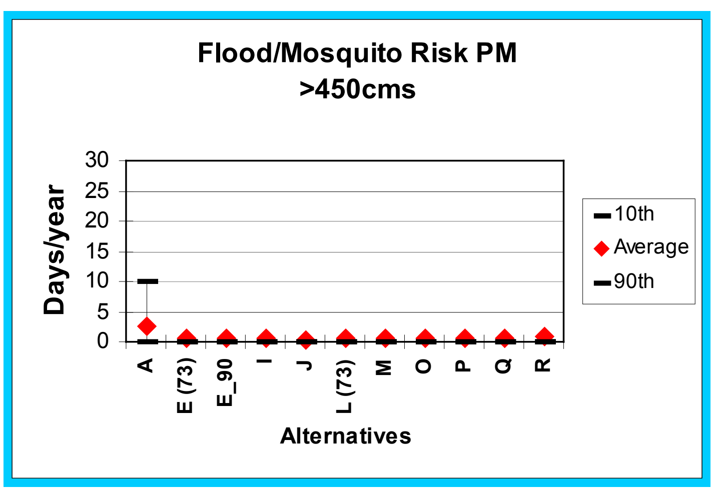
4. Partial mosquito abatement funding

Operational Link
Reservoir levels for some of the alternatives under consideration may adversely impact recreation opportunities.

Comparison with Relevant Performance Measure



- Alt O performs worst. The later generation alternatives (L, M, P,Q and R) perform best
- Tradeoff exists between recreation and impacts on vegetation, since vegetation wants a lower level compared to desirable recreation levels.
- While not directly related to recreation in the reservoir, the Flood/Mosquito Risk PM was included to show that across the alternatives there wasn't much sensitivity to affect mosquito production in the lower river. This was because all the alternatives (except A) tried to avoid the re-wetting of potential mosquito habitat areas after the initial freshet from Lardeau River peaked and the risk of high discharges from the dam were reduced (generally from August 1 onwards combined flows in the lower river were targeted to be below 400cms, 350, or 250cms depending on the alternative).



- Not a lot of sensitivity across the alternatives
- Alt A does not incorporate pre-spill so doesn't perform as well as the other alternatives

Benefits
Provides improved quality (and/or quantity) for recreation opportunities

Costs

	Total Cost(10yr)	*Avg. Annual (10yr)*	*Risks*
1. GC Beach recontouring	$55k	$6k/yr	low

- Larry: Costs are unrealistic. It would be very costly to recontour due to large boulders. This is not a feasible option, and doesn't want it unless recontoured and re-sanded.
- Alf: Do you have a cost figure?
- Larry: The RD looked into it and the costs were considered too high so it was not pursued.
- Kindy: If recontouring can be done, does this make sense? Is this worthwhile pursuing?
- Larry: Open to exploring.
- Gail: Comments from Glacier Creek was concern over safety of small children and distance to the water from the campsite. Could it be recontoured for safety?
- Gordon: Is Glacier Creek a Regional District or MOF site?
- Fred: Glacier Creek is crown land with a forest service notation on top and long-term agreement with the Regional District to maintain. MoF funding will not affect this site.

	Total Cost	*Average Annual*	*Risks*
2. GC Boat ramps	$146k*	$18k/yr	low
3. Howser Maintenance	moot point *(MOF has secured funding)*		
4. Mosquito abatement	$200k**	$20k	low

* Includes maintenance
(** This represents 1/3-1/4 of the overall mosquito abatement program costs)
This is connected more to the recreation objective recognizing the link between recreation experience and mosquitoes

4.4 *New* Partial Funding for Nutrient Loading

Scope
1) Partial funding to the Fertilization Program

Operational Linkage
Timing of Duncan Dam releases may adversely impact nutrient loading going in to the North Arm of Kootenay Lake

Benefits
Provide benefits to nutrient loading and offset costs for the fertilization program funded through CBFWCP

Costs

	Total Cost (10yr)	*Avg Annual (per/yr)*	*Risks*
1. Partial Funding	$1,000k	$100k/yr	Low

- Steve McAdam: This issue came up when considering downstream effects of the operating alternatives. Some feel that it is a footprint issue. But when the reservoir is drawn down to low pool (historic river elevation) there is a nutrient impact. Most of the operations that are causing nutrient retention effects are Treaty operations. About 3.5 to 7.9 tonnes of phosphorus retention can be attributed to operations. There is not an alternative to address this issue. Alt A performs best for nutrient transfer in Kootenay Lake.

- Mark: An operation to address nutrient loading would be to drawdown the reservoir as quickly as possible (closest would be Alt A)
- Max/min treaty obligations to meet 2 critical dates (reservoir drain and refill). There are two variations in operations (associated with nutrient retention of 3.5 and 7.9).
- This represents about 10% of total nutrient input to the reservoir; therefore the FTC suggests a 10% contribution to fertilization program; not to exceed $100k/yr. More work is required to refine these numbers.
- Llewellyn: The fertilization program is thought to be over fertilizing given the current state of knowledge. BC Hydro is already providing funding to this program.
- This is not to be in addition to what is being spent but the contribution would free up some of the compensation $ for other work.
- There is a component that is an operational issue, which should be captured under WUPs.
- Steve McAdam: Most nutrient trapping occurs in the spring but there is a fall/winter component as well.
- Gordon: BC Hydro currently provides $600k/yr to the fertilization program in the North Arm under the compensation program; 10% would be about $60k, with cap of $100k.
- Stephan: Objected to fund the fertilization program unless it uses organic fertilizer. Over the long term, you will weaken the fish genetics.
- Steve McAdam: Confirmed that the fertilizer is not an organic product.
- Alf: A comparison of Alt A and another alternative shows that the range is only differing during the fall period. During this period, phosphorus would not be biologically available in Kootenay Lake. Would need to develop the rationale for this strategy. There needs to be some analysis/research behind the funding strategy. Refine the estimate once an alternative is developed.
- Kindy: The question to the CC is whether the committee wants this in the suite of non-operating alternatives. Bringing on a new issue is quite unfair at this point. It seems the issue is within BC Hydro and the Ministry around what is or is not a footprint issue.
- Steve McAdam: The scope question came up very late in the process. But this is the only issue that came out of the scoping. The WUP should address any of the operational issues.
- Steve Macfarlane: The contribution would not be in addition to $600k and this would free up other funds for fish and wildlife programs in region.

OUTCOME: CC TO INCLUDE NUTRIENT LOADING AS A POTENTIAL NON-OPERATING ALTERNATIVE FOR THE CC TO USE LATER BASED ON A CAP OF $100K FOR FERTILIZATION BASED ON FUTURE STUDY

4.5 Other Potential Non-Operating Alternatives?

Does the CC want to include a physical works for agricultural lands?

- Terry: Only if we tie it to providing wildlife benefits.
- Llewellyn: We should be looking at impacts to humans as well as wildlife. It is a question of whether there is an operational link.
- Alf: The rationale for not including this issue was that the linkage to operations hasn’t been made.
- Michael: The issue here is to first determine whether there is an operational linkage (since this is the first time it has been raised in the process and given the geomorphologist’s assessment that operations have likely slowed the rate of erosion).

Therefore, strictly speaking a linkage needs to be made before a physical works option can be brought into consideration in lieu of an operational change.

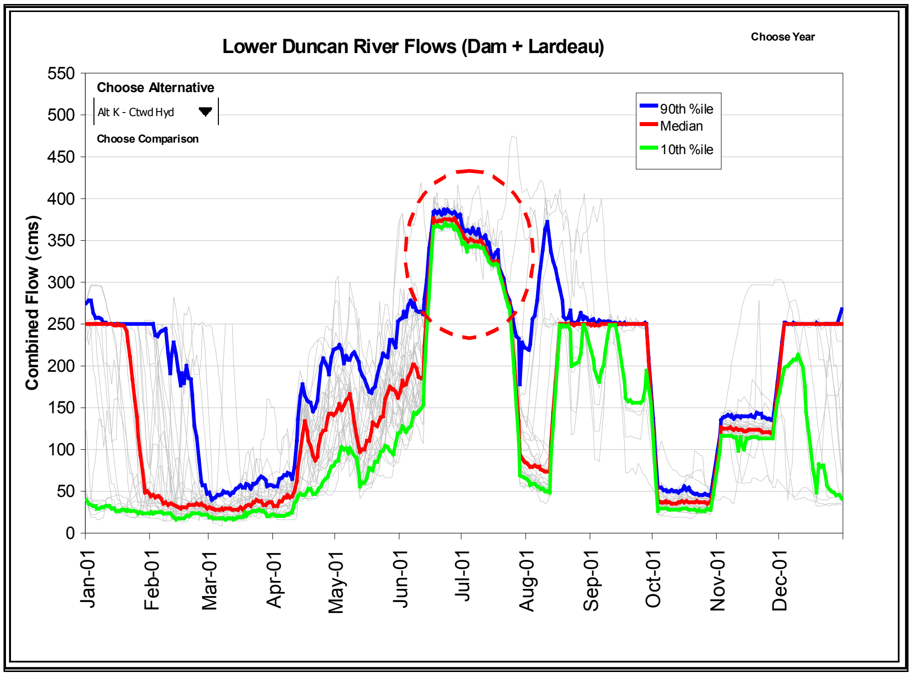
- Gail: Perhaps we need professional opinion.
- Mark: There are funding sources available to the farmers for erosion protection. The CC can make a non-WUP recommendation.

5. *OVERVIEW OF ALTERNATIVE K – FLOW REGIME FOR COTTONWOODS*

The facilitator discussed the scope, operational linkage, benefits, costs and risks associated with an infrequent flow regime to provide cottonwood benefits in the lower Duncan River.

<u>Scope</u>

- Alt K is based on better meeting a flow regime that mimics more natural conditions during seed dispersal that would be beneficial to cottonwood recruitment. Initially in early alternatives this included elements related to peak timing of freshet, delivering recession flow in a manner that allows roots to stay within the water table, and providing a late fall overwintering condition that does not incur flows higher than threshold. These factors were incorporated in the cottonwood PM. As the process evolved more input was solicited from experts on the ideal conditions and desired target areas for recruitment. This information fed into both the PMs and the refinement of Alternative K. The key timing period was late spring/early summer for 1 in approximately every 5th year. The target areas for recruitment were above a stage level in the river represented by a flow of 250cms.
- There was an impact on recreation interests as higher dam releases meant pushing out a lot more water lowering the summer reservoir levels.
- Objective is to peak as close to the natural freshet but also not to reflood areas colonized by cottonwoods. All of the alternatives (particularly the early generated alts) had a degree of flooding that would not be as natural, and therefore were ranked lower than Alt K. The new alternatives incorporated the cottonwood cap, but these were not reviewed by Brenda Herbison or Steward Rood.
- Alt M and P have a more naturalized recession but the recession comes later and is not as desirable.
- One of the action items was to compare Alternative K with a higher inflow year from one of the other alternatives (M was used). The results showed that in 7 out of 32 years, 80 % of benefits for cottonwood were achieved. However these were not evenly distributed over the 32 years (in one stretch the span was 14 years).
- Difference with Alt K relative to other alternatives is that it provides recruitment conditions earlier to better ensure the success for seed dispersal (in June and July).
- This alternative is expensive because it causes higher amounts of water to be released from June through August, at a time when Kootenay is normally spilling (June-July). Therefore water is forced down the Kootenay River when the plants are already at capacity.
- If Alt K is implemented in every year, it would cost on average $3 million in the Kootenay and $3 million in the lower Columbia.
- If implemented 1/5 years, the total cost of Alt K would be approximately $6 million per event or an average annual cost of $1.5 million/yr (annualized over 10 years).
- The natural recession associated with Alt K would have other ecological benefits, as cottonwood served as a proxy for the riparian community and wildlife interests.
- The key elements for Alternative K—in terms of timing and key flow levels (above 250cms)—are identified in the dotted circle in the lower river hydrograph.



<u>Operational Linkage</u>
Lower Duncan River flows affect cottonwood recruitment.

<u>Operationalizing Alt K (discussion by Kathy Groves)</u>

- One of the challenges with Alternative K identified at the previous CC meetings, is how to opportunistically implement it while trying to mitigate impacts to other objectives
- Alternative K tie to higher forecasted year or pick every 5th year?
- In years of inflows greater than 110 %, would not want to implement Alt K because the desired recession flow could not be achieved (it would remain high throughout the see dispersal timing) and thus the expected benefits would not occur.
- If Alt K is limited to years with inflows of 102-110%, this would represent only 6 years over the 32 period of record.
- This is based on reservoir elevation traces that Kathy thought would be acceptable to the CC (i.e. not adversely impacting high reservoir levels too greatly in the summer months).
- Average annual cost of Alt K if implemented every year would be estimated at $6 million; but would likely be less than this.
- $4-6million per event to implement – Does the CC want years to be selected opportunistically?
- If we select years to implement Alt K, what would they look like with another alternative?
- The other scenarios do not meet the target of moving the recession earlier.
- Would not need to decide to implement Alt K until refill. BC Hydro would have a better idea by May 1 as opposed to Feb 1. As the alternative would not be implemented until June, the decision could wait until there is better information on how the runoff is coming in.
- There may be flexibility at Arrow if we need Duncan to be below full pool.

- In high inflow years, we would need to use all the storage under the Treaty. In low inflow years, the reservoir would not reach full pool. By releasing peak flow for cottonwood, downstream flows for fish interests or recreation interests in reservoir would not be met.
- Alt K does not help out downstream fish interests.
- Alt K ends in August, at a time when there is still flexibility in the reservoir to implement other constraints.
- Inflow years of 100-110% represent 12 years over the 32 period of record.
- Reducing the duration of peak flow would increase the chances of getting Alt K but would reduce the benefits to cottonwood recruitment. If the duration of peak flow were reduced then we would need to have a good handle on when the seeds are starting to be released.
- May not be that dissimilar to the benefits gained by Alt M (80% of cottonwood recruitment in high inflow years; 7 out of 32 years)
- Stepping down lower Duncan flows over a 2-week period in Aug incurs a cost. In addition, holding flows below a cap (e.g. 250cms) in Nov-Jan forces release in Feb, which is a slightly lower value month.

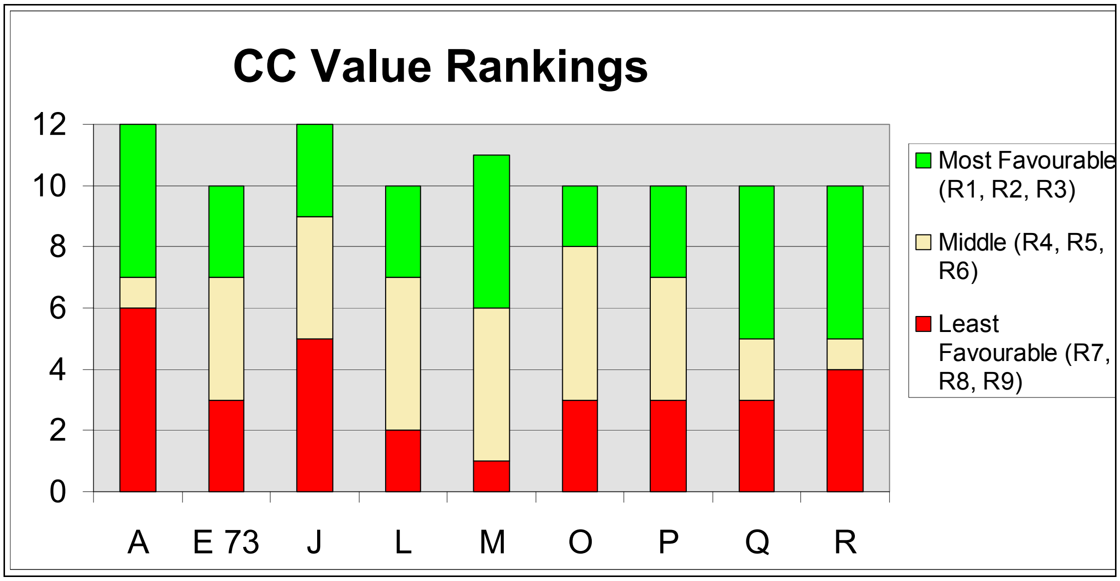
➢ Llewellyn: Could we mitigate the cost of Alt K by relaxing some other constraints?
➢ Kathy: We could tweak Arrow costs but not the Kootenay cost impact. In average inflow years, we would have to shorten or reduce peak flows in June/July. In low inflow years, this would create problems meeting the Treaty, as the reservoir would not reach full pool.
➢ Mark: Alts R and Q are also fairly good for cottonwood benefits (if Alt K is difficult to implement).
➢ Llewellyn: Suggested taking an experimental approach for cottonwood recruitment.
➢ Cottonwood is also a surrogate for wildlife. It helps to structure riparian habitat.
➢ Steve McAdam: Alt R does not have the right peak and recession flows, but satisfies other naturalness criteria.
➢ Alt R gives recruitment but a month later than Alt K.
➢ Jayson: Suggested augmenting with a nursery program.
➢ Stephan: Using mini excavators (not heavy impact machine) and a water pump in the river, the cottonwoods would seed themselves.
➢ Mark: In Arrow, fall rye is planted through drill seeding. This could be done in the lower Duncan by punching seeds into the substrate. This would get around reflooding and genetic diversity.
➢ Fred: Why not gather natural seed.
➢ Gail: The system will be healthier if we provide a more natural hydrograph. So it is not clear why we are discussing planting.
➢ Gordon: Is anyone keen with Alt K? Is it still on the table?
➢ Michael: Has not heard any reason to take Alt K off the table at this point. A decision on Alternative K can be made after the CC makes a selection on a preferred flow regime in every year.

6. *TRADE-OFF ANALYSIS – SELECTING AN OPERATING ALTERNATIVE*

The facilitator reviewed the ranking exercises completed by the CC at the end of yesterday (Day 1). Most CC members provided their preferences according to direct ranking, swing weighting, and whether they endorsed, accepted, or blocked each alternative. The results from these 3 exercises were reviewed by the committee.

6.1 Direct Ranking (ordinal ranking of alternatives)

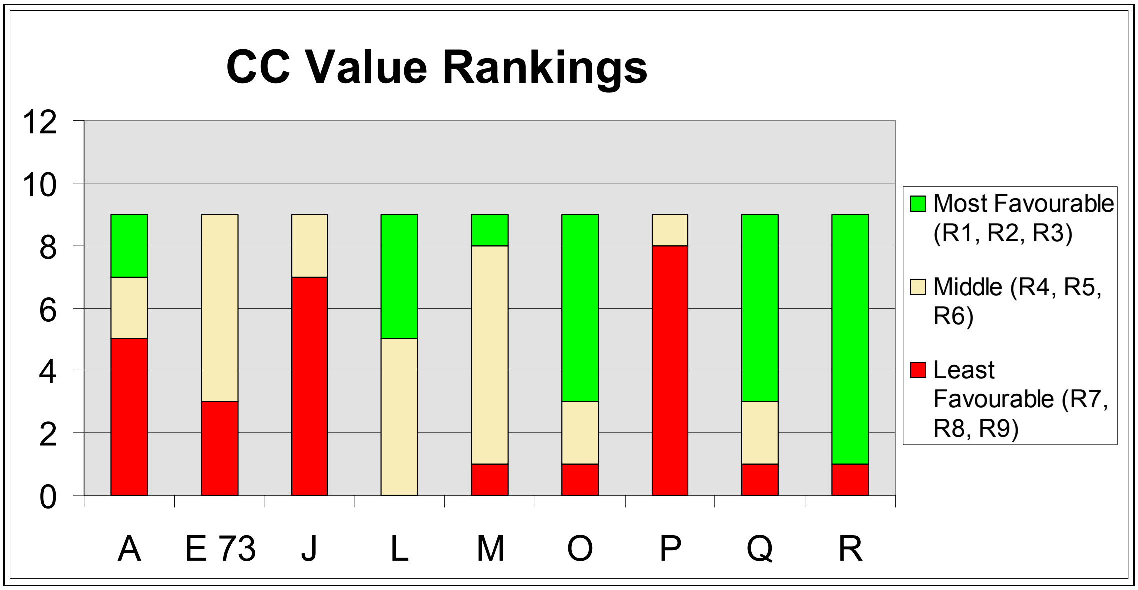
- Reviewed CC value rankings (green rank (best)= 1,2,3; tan=4,5,6; red (least favourable 7,8,9)
- See summary graph below of the results.



- Alt M or a hybrid of this alternative received the most green and tan ranks and the fewest red rankings. However, it was not clearly universal in its support from the entire CC.

6.2 Swing Weightings Rankings

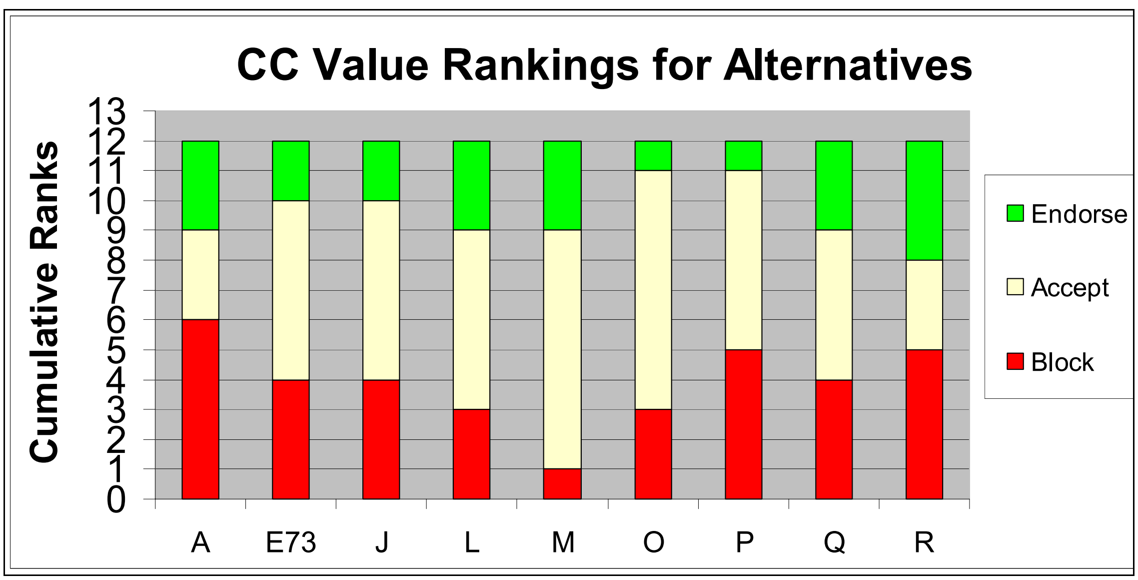
- Rankings were received from most CC members (with conditional rankings from Llewellyn). No rankings were received from Kindy, Gene or Larry.
- Each CC member's results were reviewed by the committee including a summary of their preferences by key performance measure and a consistency check with their direct ranking selections.
- The results of their swing weighting rankings by alternatives is shown in the following graph.



- The results showed that Alternative L had no “least favourable” rankings and, except for one CC member, Alternative R would best serve CC members’ interests based on a top 3 alternative performance (indicated by green colour bar).

6.3 Acceptance Ranking - Endorse, Accept or Block

- This exercise entailed each CC member to state their preference of acceptance for each alternative according to endorse, accept, block (cannot live with).
- It was noted that CC members’ rankings might have been different based on the discussions from this morning (specifically related to cottonwood and the new whitefish lost spawning habitat PM in the main stem).
- The results are summarized in the following graph.

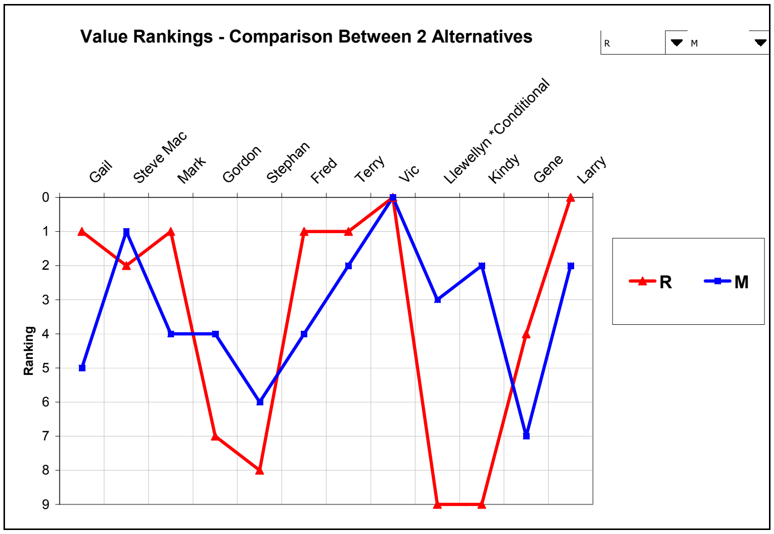


- Alt M received only one block from Vic; he also blocked all the other alternatives except for A and J

- The facilitator highlighted that if the CC still wanted to focus on achieving consensus, then the alternatives that may have the best chance of this would probably be Alternatives L or M. It was also evident that if Alternative R could be amended, then it may best serve the CC's interests.

Discussions/Comparisons Between the Alternatives
The facilitator did pair-wise comparisons of CC member (direct) rankings for select alternatives

<u>Alt M and R</u>



- No consistent trend
- Zeros from Vic and Larry indicate no ranking

<u>Alt L and M</u>
- Except Steve and Gordon, rankings within one

<u>Alt M and A</u>
- No trend

<u>Alt P and M</u>
- Alt M is better than P but slight differences between rankings for some CC members
- Would have consensus around Alt M, except one CC member blocked this alternative (and conditional acceptance by CBT and CPC)

Note. Larry left the meeting at the 3pm break and did not return for the remainder of the day's discussions.

- Michael: Noted that Vic blocked all but A and J.
- Vic: Has a problem with the overall process. Instructed to represent the Ktunaxa people. He has an issue with the fact that footprint issues are not being brought to table. The Ktunaxa are in the middle of the treaty process.
- Steve Macfarlane: This process is not meant to interfere with the treaty process
- Mark: There is a process outside of WUPs to address footprint issues (grievance procedure to address footprint issues).

- Vic: Did not block other WUPs because they were different systems. For the Duncan WUP did not block A, J and K.
- Are there any conditions so that there isn't a block?
- Vic: If you are looking for acceptance of an operating alternative, there are four conditions that need to be met:
  - Footprint issues—BC Hydro to engage in a grievance process to address outstanding issues associated with the construction of the Duncan facilities.
  - Cultural resource issues to be addressed.
  - Treaty-related issues. Treaty issues will have some impact on WUPs.
  - First Nations involvement in the WUP monitoring.
- Steve Macfarlane: We all expect that the WUP will have to be adapted to the outcome of the treaty process.
- Michael: Is there a condition that can be written in today?
- Steve Macfarlane: This is beyond what the CC can address at this table.
- Gene: Does Alt M meet the Columbia treaty?
- Mark: With exception to Alt K, all of the operating alternatives meet treaty.
- There is a preference for Alt M over Alt L, but there is a better probability that Alt L can be operationalized and it is cheaper. However, Alt L does not perform as well as Alt M for kokanee lost spawning.
- During the Acceptance Ranking exercise, Stephan and Larry both blocked Alt L.
- Larry was not in attendance at the meeting to hear other's values and to potentially change his decisions/preferences for the alternatives.
- Vic: If conditions are met, he would accept an alternative
  - BC Hydro to engage in the grievance process for footprint issues
  - need to revisit WUP after Treaty process is completed (trigger for when WUP should be re-opened)
  - hire FN to assist in monitoring programs
- Steve Macfarlane: The WUP process is a provincial process. There is a requirement for fairness for contracting (related to monitoring work).
- Steve McAdam: There are negotiations ongoing between BC Hydro and First Nations to address this. This issue has not been satisfied yet, so can not preferentially accept contracts using FNs in a team.
- Llewellyn: The issues raised by Vic are beyond the scope of the CC. We have the basis for consensus on Alt M or L.
- Steve Macfarlane: It has been common for FNs to have made a statement on all the WUPs that their approval is conditional on their involvement in monitoring.
- Mark: Changing the minimum flow to 73 cms as opposed to 90 cms would cost less money and would have to rely on variability less often (less stranding issues over the long term). Some blocks may have been due to the high costs. Would anyone remove blocks if we reduce the min flow to 73 cms?
- Steve Macfarlane: Expressed concern over the declining nature of the hydrograph, and extending the drop farther into the spawning season. There may be an issue over stranding of kokanee.
- Gordon: Changing the min flow from 73 to 90 cms would represent cost savings of $300-400,000/year under alts E, L and M. Sept is a high energy value part of the year. Delaying the target flow by 2 weeks from Sep15 to Oct 1 would save $800,000/yr under Alt E73, $500,000/yr under Alt L, and $450,000/yr under Alt O.

Alt L

- No appreciable difference in PMs (except kokanee lost spawning) between Alt L and M
- The difference in kokanee lost spawning PM scores (14 and 16) represents about 90,000 m^2 (or 9 ha out of approximately 300 ha)

- Gail: Expressed far less comfort with Alt L than M.
- Michael: Alt M is associated with a greater degree of risk because of the flood control curve. Therefore, more variances from the US would be required and therefore it is likely to assume that there would be more occurrences of having to use the Flood Control Curve Protocol (when permission is not granted).
- Gail: There is a significant difference in cottonwood recruitment between the two alternatives.
- Michael: It is within the MSIC (0.50 vs. 0.55). Although within MSIC, there are differences in:
  - cottonwood
  - erosion protection
  - VOE

  It still appears that Alts L and M are the most likely to reach consensus by the CC. Michael suggested a go around on acceptance of these alternatives (potentially with add ons) assuming conditions of the Ktunaxa and CPC/CBT are met.

Level of Support for Alternative L

CC Member	Acceptance/Block	Comments/Conditions
Kindy Gosal	Accept	At this point in the process I would accept with the conditions already mentioned
Stephan O'Shea	Accept	Confused, swing weightings are out of balance, recreational interests are out of balance. Will accept Alt L. Need to keep the reservoir lower in spring for grasses; neither M nor L has this.
Gail Spitler	Accept	Acceptable conditional on downstream monitoring programs; absolute bottom line is that we need more data.
Llewellyn Matthews	Accept	With conditions tabled, Alt L is acceptable
Gene Anderson	Accept	Acceptable if there are ways to minimize impacts on downstream power without adversely affecting the other PMs (soft condition)
Mark Tiley	Accept	Agrees with Gail. Will accept but need to monitor to ensure that we are not affecting the lower river. There is substantial kokanee side channel spawning. Need to monitor this as well. Would want to see a detailed assessment around the need to protect Argenta Slough. Need good data on this to compensate for loss of cottonwood under Alt L.
Fred Thiessen	Accept	
Gordon Boyd	Accept	Acceptance pending overall package. Would be interested in determining if there is some way to get costs down by delaying dam discharges later in the fall to get more water through system. Moving to Oct 1 would make it more acceptable. But still acceptable (soft conditions).

Level of Support for Alternative L (cont'd)

CC Member	Acceptance/Block	Comments/Conditions
Vic Clement	Accept	Accept with conditions already tabled including attention to cultural sites
Steve Macfarlane	Accept	Acceptance with the new PMs is marginal but will continue to accept. Losses of whitefish are high. This is not best option but could live with it. Obviously monitoring is critical. I would like to see the cultural work done in the reservoir and would be interested in anything to enhance cottonwood in addition to flows.
Terry Anderson	Accept	Would like to see if we can tweak to address the whitefish issue (soft condition), and possibly look for a more natural hydrograph during the growing season. Median line will never really occur. There are two patterns that could occur under Alt L (really high and then drop down or high and drop down).

- Jayson: Noted that many of these soft conditions we have tried to address through other alternatives.

Level of Support for Alt M

CC Member	Acceptance/Block	Comments/Conditions
Kindy Gosal	Accept	Accept with same provisions as Alt L.
Stephan O'Shea	Accept	Alt M is hard on erosion relative to Alt L and costs more money. Will accept, but still likes Alt A
Gail Spitler	Accept	Acceptable with same conditions and that we study Argenta Slough.
Llewellyn Matthews	Accept	With conditions already tabled. Alt M is acceptable. Alt L is preferable to M
Gene Anderson	Accept	Acceptable but conditions are less soft
Mark Tiley	Accept	Agree with Gail. Will accept but with the same conditions. Reduces stranding. Prefers Alt M for cottonwood recruitment.
Fred Thiessen	Accept	
Gordon Boyd	Accept	Prefers Alt L to M. Need to see overall package. Accept but not as happily.
Vic Clement	Accept	Accept with conditions already tabled including attention to cultural sites
Steve Macfarlane	Endorse	Subject to meeting the same conditions
Terry Anderson	Accept	Acceptance with the same condition. Would like to see cultural work done. Prefers Alt M over L.

- The question was asked as to whether there are ways to improve these alternatives?
- Mark: If we develop hybrid alternatives, there will be a request for the PMs.
- Kindy: Yes, the CC would need all the analyses done to make a decision.
- Michael: The CC could make a condition that if changes are within the MSIC, acceptance of an alternative would still be valid.
- Steve Macfarlane: Asked whether interpolation of the existing data would be acceptable?

- Mark: Would people be willing to remove a block on Alt R with a minimum flow of 73 cms as opposed to 90 cms?
- Michael: Can you estimate how this will change the PMs?
- Kathy: We can guess but more of a wild card.
- Kindy: The block was purely around cost. Alt R outperforms both alts L and M.
- Michael: Could save about $400k/year based on differences between L and M.
- Kathy: That would be in the ballpark for decision making.
- Michael: $3.3 million - $400,000 = $2.9 million. Difference from Alt L would be $700,000.
- Steve Macfarlane: This would be a good alternative if we could make it work. It would be more preferable than Alt L or M.

Based on these changes, would those CC members who had previously blocked Alt R (Gordon, Stephan, Vic, Llewellyn and Larry) be willing to remove the blocks?

- Kathy: The consequence of tweaking Alt R would be the risk of not being able to get water out of the reservoir in winter, which would drive the reservoir level higher and increase the risk of flooding downstream.
- Michael: Could reduce flood risk by pulsing more water out before the spawning flow or moving spawning flows later. The shift from Alt M to P saves about $450,000.
- Suggestion to relax kokanee spawning flows from Sep 15 to Oct 1
- Stephan: He would be concerned about the impact of higher reservoir levels in the fall on plants.
- Gordon: This is difficult to answer without the PM results. It is still going to be a very expensive option. He would have to see the final costs of the overall package. Cost savings associated with moving the timing of the kokanee spawning flow ($450k) could make Alt R costs around $2.4 million, which would be more acceptable.
- Stephan: Expressed concern over hollow ice formations on the reservoir in November due to dropping of reservoir levels after freezing and the potential impacts this could have on ungulates.
- Michael: The reservoir would be a few meters below full pool in November on average. It would normally reach full pool after the first week of August.
- Stephan: This would not be leaving much room for flood. This alternative would be acceptable if the flooding risk was addressed.
- Gordon: Bringing the reservoir down would be better for grasses.
- Mark: A loss of 50% of grasses would be overly pessimistic.
- Vic: He would remove the block of Alt R.
- Llewellyn: He would want to see the PM results of the tweaked alternative first, as Alt R would have a higher flood risk associated with a minimum flow of 73 cms.
- Michael: If Alt R incorporates a later target flow to buffer the flood risk and there is the additional benefit of less financial impact, would you remove the block?
- Llewellyn: Yes, Would be willing to remove the block.

OUTCOME: VIC, LEWELLYN, GORDON AND STEPHAN WOULD ACCEPT REMOVING THE BLOCK OF ALT R WITH THE PROPOSED CHANGES AROUND TIMING AND MAGNITUDE OF KOKANEE SPAWNING FLOWS AND ASSOCIATED REDUCED FINANCIAL IMPACT.

The facilitator asked CC members for their level of support for a new hybrid alternative of Alternative R (73) as described above, in general terms (since it had not been modeled nor the PMs estimated).

Level of Support for Alt R (73)(delayed target flow to October 1)

CC Member	Acceptance/Block	Comments
Steve Macfarlane	Accept	Kokanee lost spawning PM 10 would jump to 50, which is substantial. Prepared to accept provided that detailed monitoring is undertaken to assess real extent of kokanee stranding and the need for an exclusion fence across channel to prevent use of side channel (2 week period Sep 15 to Oct 1).
Terry Anderson	Accept	Also concerned about kokanee
Vic Clement	Accept	Erosion PM looks better due to higher reservoir. Cost is not a concern.
Gordon Boyd	Accept	
Fred Thiessen	Accept	Assuming that the recreation PM stays the same
Mark Tiley	Endorse	With the same conditions as Steve Macfarlane. Probably wouldn't need Alt K to get cottonwood recruitment. There will be a need to monitor grasses in the reservoir.
Gene Anderson	Accept	
Llewellyn Matthews	Accept	With the same conditions
Stephan O'Shea	Accept	
Gail Spitler	Endorse	With the condition that monitoring studies are undertaken.
Kindy Gosal	Accept	Want to see the PM results to give some level of comfort. Assuming results were within the MSIC and if the financial and grass PMs improve, would accept.

OUTCOME: ALT R (73)(DELAYED KOKANEE SPAWNING FLOW) WAS ACCEPTED/ENDORSED BY ALL CC MEMBERS WITH CONDITIONS

ACTION: KATHY AND ALF TO ESTIMATE PMs (ESTIMATES BASED ON CUT AND PASTE) FOR THE REVISED ALT R FOR TOMORROW

- End of Day 2 -

Thursday, April 22, 2004 (Day 3 – 8:30am to 5:30pm)

- Michael: Asked Larry whether he would be willing to remove his blocks on the alternatives, since he was not present yesterday for the decisions made by the CC.
- Larry: Did not intend to block any alternative. Would accept Alt L and M without conditions. He has concerns around the willingness to spend $ on cultural sites and less into people problems.

1. *REVIEW OF NEW ALTERNATIVE S73 (Revised from Alt R90)*

Comparing Alternatives L, M, R, S

- Alt R has been revised to be more acceptable to CC by changing the kokanee spawning flow to 73 cms and delaying the timing of the target flow until Oct 1, which would provide a greater buffer in the reservoir and reduce financial impacts (new Alt S73).

- Kathy: Developed new Alt S(73) by cutting and pasting from other alternatives. Flow was capped at 110 cms as opposed to 130 cms in Nov-Dec, and 250 cms in Jan-Feb. Flow was pro-rated through the recession limb. There is reasonably good confidence in the accuracy of this cut and pasted alternative. This alternative is completely constrained except for Sep 5-15 and Oct 22-Nov 1. There is not a lot of time during the year where there would be uncertainty around whether BC Hydro would operate as modeled. Was not expecting the reservoir profile in January (above the flood control curve). May have to go beyond the 250 cms cap for the lower river during this time to avoid exceedance of the flood curve.
- Kelvin: There is concern around being above the flood control curve throughout the drawdown period starting in Jan 1st. It is doubtful that USACE would accept this.
- Kathy: We could release more water in Nov-Dec by increasing the maximum flow from 110 to 130 cms.
- Steve McAdam: There is concern regarding potential stranding of eggs by capping flow at 130 cms and then dropping to 73 cms.
- Kathy: The maximum cap of 250 cms from mid Aug to mid Sep is for cottonwood.
- Steve McAdam: There are three distinct spikes in April. The concern is over these spikes.
- Kelvin: Unlikely that it would occur like that. There is a danger in over constraining. There needs to be some flexibility.

Can constraints be relaxed in 80th percentile years? Suggestion to use 250 cms as a target but relax in some years.

- Llewellyn: Concerned that flows would be constrained 90% of the time. What does this loss of flexibility mean to BC Hydro and their ability for Duncan/Arrow swaps to get whitefish and rainbow trout flows in the lower Columbia.
- Kelvin: The power losses are captured. Limited flexibility will likely have an impact on some of the other PMs. The Sep-Feb period is highly constrained. High discharges in January will help with fish flows in the lower Columbia in general.
- Alf: It aligns more with our whitefish periodicity (Dec 21 as opposed to Dec 31)
- Could also go to 130 as opposed to 110 in some years, and 300 as opposed to 250 cms cap in wet years.

2. *REVIEW OF PMS UNDER ALT S (73)*

Note Alf, Kathy and Michael estimated the PM values and these were summarized and explained in the Interactive Consequence Table.

DUNCAN WUP CONSEQUENCE TABLE

	L	M	R	S 73
Rec Quality (+)	313	314	318	315
Ko Spawning (Main) (+)	42	42	42	37
MWF Lost Sp (Main) (-)	14	12	5	6
Rb Lost Rearing (Main) (-)	17	16	15	17
Ko Lost Spawning (Side) (-)	23	14	10	42
Erosion Impacts (-)	613	730	671	700
Shrub (reservoir) (+)	132	146	129	250
Grasses (reservoir) (+)	289	288	284	154
Cottonwood (river) (+)	0.50	0.55	0.62	0.71
VOE (Kootenay) (+)	-0.3	-0.5	-0.9	-0.7
VOE (Columbia) (+)	-1.9	-2.1	-2.4	-1.9

<u>Recreation Quality PM</u>
- Reservoir levels in August will be similar to that under Alt P
- The reservoir will reach full pool by Aug 1, and will be 1 m below full pool by mid Aug until Labour Day weekend on average.

<u>Ko Spawning (mainstem) PM</u>
- This PM will be less due to Oct 1 timing and 73 cms min flow

<u>MWF Lost Spawning (mainstem) PM</u>
- Difference of 2 ha in whitefish lost spawning and 9 ha kokanee lost spawning. Alt M performs better than Alt L for these PMs.

<u>RBT lost rearing PM</u>
- Alt S(73) will perform the same as Alts L and P but not as good as R

<u>Ko lost spawning (side channels) PM</u>
- Will perform better than Alt P but worse than Alts L, M and R
- Exclusion fencing is a possible option to help mitigate this impact but wont guarantee that the kokanee will not spawn somewhere else.

<u>Erosion Impacts</u>
- Similar across alternatives (within MSIC)

<u>Shrub and Grasses</u>
- Alt S(73) performs considerable better than Alts L, M and R for shrubs because the reservoir is lower after the first week of September
- Not better for grasses because the reservoir is not coming as low

➢ Stephan: This will also help to address concerns about potential ice entrapment of ungulates.

- Gail: May not be as bad as it looks because we have separated out shrubs and grass areas.
- Stephan: Spring grass should be the same, but fall grass will change. The primary concern is over spring grass.
- Mark: According to Anne Moody's observations the sedges can grow all winter long to a limited extent as long as they are above the snow level and can photosynthesize.

Cottonwood

- 50% of the years the PM could be 0.71 for cottonwood, but may get less in some years due to need to relax the 250 cms cap constraint

Flooding

- Alt S(73) is on average 1 day better than Alt R

VOE

- Kootenay: $200k more than Alt M, and $400k more than Alt L
- Columbia: same as Alt L but cheaper than Alt M
- Total cost 2.6 million (same as Alt M)

- Steve: What effect would relaxing the constraints (allowing a cap of 300cms from 250) have on the VOE?
- Gordon: The financial impact would be less as a result of relaxing constraints. This would cause a doubling of volume over 10 days (about 2 metres of water) This would translate to about $200k less.
- Changing the cap from 250 to 300 cms would cost less (difference between Alt Q and R if done every year)
- A cap of 250 cms would have a small impact on HLK WF in some years. However, BC Hydro does not always have to use Duncan flexibility for whitefish flows in the lower Columbia.
- The risk of hitting the flood control curve and meeting the LCR whitefish flows occurs at same time.
- BCH will need to document the rationale for violating the constraints in some years for future WUPs.

ACTION: NEED TO REMODEL ALT S(73)

OUTCOME: IF REMODELING SIGNIFICANTLY CHANGES THE TRADEOFFS FOR ALTS73, THEN THE MERITS OF THE CHANGES WOULD NEED TO BE REVIEWED BY THE CC.

3. CC PREFERENCE OF ALT S(73)

On the basis of conditions placed on acceptance of the alternatives and pending results of remodeling of Alt S(73), the CC was asked whether they prefer the new alternative over Alts L and M.

Preference/Acceptance of Alt S (73) over Alts L and M

CC Member	Preference of Alt S	Comments
Kindy Gosal	Prefer	CBT's stance is that costs should not be borne by residents of the basin. Based on conditions stated previously, I would accept/prefer this alternative. However, I am still concerned over system-wide flexibility issues that need to be discussed. I also echo Stephan's concern around the need for local involvement in monitoring. This is a recommendation as opposed to condition to acceptance.
Gail Spitler	Prefer	I prefer this alternative, assuming that all conditions placed on Alts L and M also apply to Alt S.
Stephan O'Shea	Prefer	Recreation is still coming out with lots of days. 288-154 from Alt M to S represents a loss of grasses for ungulate habitat. I would accept/prefer Alt S with monitoring. It is not better for my interests, but recognize that this alternative is better for other people's interests. There is a need more hunters rather than scientists involved in monitoring (more local involvement).
Gene Anderson	Prefer	Prefer this alternative over Alts Land M
Mark Tiley	Prefer	Prefer, provided the rationale for violation of the constraints is given by BC Hydro
Fred Thiessen	Prefer	
Gordon Boyd	Prefer	We will be helping the system and are tweaking at top end. A $2.6 million cost is getting up there. I like this alternative but what else is coming with the package. I will accept based on the total cost of package.
Llewellyn Matthews	Accept	Not sure I prefer Alt S to L (additional costs for benefits). My preference is with Alt L, but would accept Alt S subject to conditions of CPC stated earlier. There should be exclusion fencing to keep kokanee out of sidechannel during the 2-week (Sep 15-Oct 1) period under Alt S.
Steve Macfarlane	Prefer	This alternative is not the best alternative for fish alone but we should be trying to implement an alternative for all other interests. I would reinforce that my preference for Alt S is conditional on exclusion fencing.
Terry Anderson	Prefer	I accept Alt S as my preferred alternative. It provides for a more natural hydrograph through the fall. I would like to see cultural sites identified. There is still a nutrient issue – we could be losing more nutrients than originally thought. This needs more work.
Larry Greenlaw	Accept	I am more comfortable with the grass PM under Alts L and M, so my preference is for these alternatives (better water levels in August and Sept), but could accept Alt S.
Vic Clement	Prefer	With the same conditions as noted earlier for Alts L and M

- Alf: The shrub and grass PMs share overlap but are being expressed only as shrub.
- Kindy: There is a need for a monitoring program. As we continue with the process, local involvement and local participation is key (FN and local community input into monitoring and providing information to scientists). We need to build capacity in the

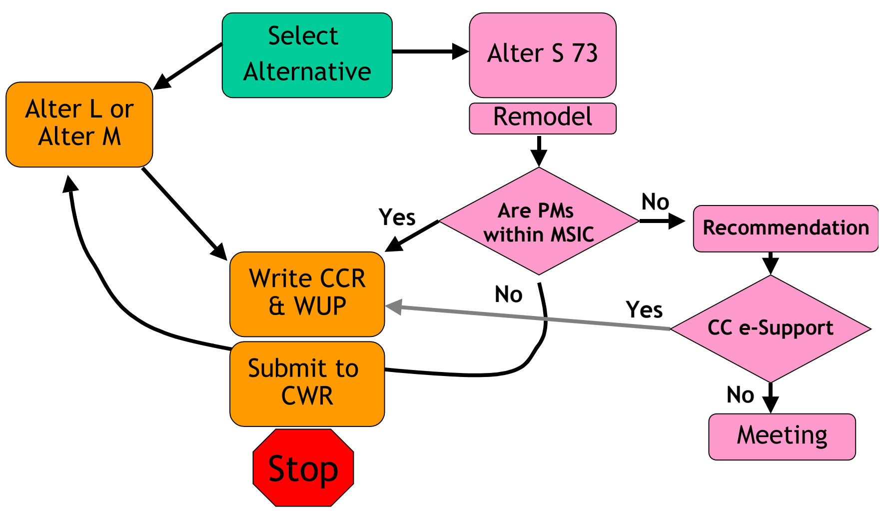
people that are going to be affected by this process, and improve community engagement. This has been somewhat lacking. Community involvement is a recommendation, and is not predicated on acceptance of Alt S.

OUTCOME: ***THE CC AGREED TO RECOMMEND ALTERNATIVE S73 AS THEIR PREFERRED ALTERNATIVE (WITH THE CONDITIONS NOTED BY CPC, CBT AND KKTC).***

Note 2 CC members preferred Alternatives L and M over S, but were willing to accept S.

Post Meeting Note
After the meeting the regional district removed their support for this alternative and for the water use planning process. See the *June* and *August CC Updates* for more details on this and for additional comments from other CC members about the modeled results for Alternative S73.

Next Steps
The following schematic was discussed and agreed to for what the next steps would be followed.



- Kindy: There is a step missing from the diagram. There is a need to send out the modeling results of Alt S (73) to the Consultative Committee before preparing the CC report and WUP.
- Michael: If conditions of acceptance of the alternative can not be met, then there will be a non-consensus WUP. This will be communicated to the CC. Some of the conditions are not tied to a specific alternative (i.e. they are more broad conditions).

4. CC DECISION TO IMPLEMENT ALT K

- Gordon: I would have a lot of difficulty accepting Alt K with the improvements made to Alt S. There would be a loss to recreation under Alt K as well.

OUTCOME: ***CONSENSUS WAS REACHED BY THE CC THAT ALT K BE DROPPED FROM FURTHER CONSIDERATION***

5. *SUPPORT FOR NON-OPERATING ALTERNATIVES*

The facilitator asked the CC for their level of support for the proposed physical works that had been identified.

5.1 Argenta Slough Erosion Protection

Note. None of the CC members made erosion protection of Argenta Slough a condition of selecting an operating alternative, although there was support for monitoring around this issue.

- Mark: There is a great deal of uncertainty around the impacts and risks. There are hydraulic controls (e.g. beaver dams) upstream of where the delta would be breached. The expense of this would need to be justified.
- Steve Macfarlane: Does the Alt S leave the CC with the feeling that we need to still proceed with these works? Vegetation has been enhanced under Alt S.
- Gordon: Reducing flows from 300 to 250 cms during the winter will help with the erosion problem.
- Michael: The question is whether reservoir vegetation has been addressed to the satisfaction of the CC.
- Fred: Would the landowner consent to these works?
- There may be motivation for BC Hydro to do the works regardless of the CC decision because of public perception.
- Mark: These works were proposed in lieu of planting and fertilization, and still supports this. The direction from CCRIFC was to protect the slough.
- Steve Macfarlane: Make sure that hydraulic controls are maintained.
- Gail: There is very little time. Something needs to be done in four years or less. Personally, I would like better evidence of what we think will happen. If we lose the slough this will be significant, as it is the core of the wetland.
- Alf: Suggested tying the decision on options for protection to a risk assessment to determine the least costly alternative. The CC would need to agree to a maximum funding cap that they are comfortable with. There may be other opportunities that are not as obvious as Argenta.
- Mark: Proposed that the riprap option be removed from the suite of options.
- Steve Macfarlane: Agree
- Jayson: DFO’s policy is that riprap is not acceptable. We are looking for softer approaches.
- Mark: Suggested stabilization of habitat to delay erosion by contouring and establishing a willow bank. There is currently no vegetation on the bank and this is causing some of the problem.
- Steve Macfarlane: This is an option but there is still a need for deflector weirs to protect the slough.
- Gordon: I would prefer to work with nature as opposed to working against nature. The river will move.
- Steve Macfarlane: Planting would be associated with considerably higher costs.
- Jayson: BC Hydro has already come up with detailed prescriptions for bio-remediation for strictly soft engineering. The estimated total cost was $120k
- Jayson: It is also important to look at the upstream end of slough as the river moves laterally as well. We will need to make sure that the upstream end does not break through. The risk assessment would involve 1-day on ground. The funding cap should be sufficient to include the cost of the risk assessment.
- Fred: There would be a need for involvement of a geomorphologist in the risk assessment.

OUTCOME: THE CC AGREED TO A RISK ASSESSMENT AND IMPLEMENTATION OF WORKS TO PROTECT ARGENTA SLOUGH TO A MAXIMUM CAP OF $150K

5.2 Erosion Protection for Cultural Sites in Reservoir

2 options were identified:

1. Riprap blanket: $2,350k
2. Non-woven geotextile blanket (more prone to being identifiable); $1,040K

- Vic: While he agrees that works should be done, he is unsure which approach is best.
- Mark: Wayne Choquette pointed out that the extent of cultural sites is unknown. This is difficult to recommend because we haven't consulted with the bands. Preference would be to hold off until a complete reservoir inventory is completed.
- John: It is likely that conservation works to characterize sites will show that the sites are smaller. The majority of these might be excavated. Suggested a similar approach as with Argenta Slough: undertake monitoring work and then works based on a maximum funding cap.
- Llewellyn: What is the operational link to these works?
- Michael: Erosion of the sites is caused by both fulfilling treaty requirements (i.e. footprint) and as a result of annual operations. It should also be mentioned that a number of CC members made addressing this issue a condition in their selection of a preferred operating alternative (S73).
- Gordon: How long will this likely take? The 2 sites have been exposed as a result of the reservoir moving through these sites.
- Kindy: The CC could have a shorter review period to address issues such as Argenta Slough and cultural sites.
- Michael: The archaeologist mentioned that these sites are deteriorating quickly and in a few years time there may be nothing left to protect. Sites will not last for much longer. It is likely that this would be too late.
- Gordon: If the CC believes that something needs to be done, then the extent of the problem will need to be determined.
- Michael: A detailed arch assessment, conservation excavation, and FN investigations have been included within the monitoring program
- Terry: Could this be done outside WUP?
- John: Sites are recently exposed and are likely to be affected significantly in the near future. BC Hydro is currently working on a Heritage Conservation Strategy. There is a need to undertake more mapping. Yes something will be done, but it can be done more expeditiously through this WUP.
- Steve Macfarlane: Implementation of the Duncan WUP will not likely occur before Jan 2006. Is this expeditious?
- The Heritage Strategy will not be the vehicle to get something done quickly.
- Steve McAdam: The CC should make a strong recommendation that these studies be undertaken as soon as possible.
- Michael: Does BC Hydro agree to fund these studies (totaling $220k) before the WUP is ordered.
- Gordon: No, does not have the authority to agree to this.
- Kindy: The CC can agree that this is a priority and recommend strongly to BC Hydro that this be addressed prior to implementation of the WUP. The CC would like it to be addressed through WUP but timing does not allow this.

- Stephan: If this is really an important issue, adequate funding needs to be made available to do the work. Doesn't feel that the estimated costs are sufficient.
- John: Need to first determine the effects of reservoir operations on these sites as baseline ($36k over 10 years). It is not necessary to spend all $ prior to WUP implementation.

The CC was asked to express their level of support for the archaeological study and erosion study (erosion monitoring, conservation excavations, traditional use and cultural assessment).

OUTCOME: THERE WAS CONSENSUS BY THE CC THAT THE ARCHAEOLOGICAL MONITORING STUDIES SHOULD BE UNDERTAKEN AND THAT THE FOLLOWING RECOMMENDATIONS BE MADE IN THE WUP.

<u>RECOMMENDATION #1:</u> ***CC AGREES THAT IT IS IMPORTANT THAT THE PROPOSED CULTURAL MONITORING STUDIES BE UNDERTAKEN IN DUNCAN RESERVOIR BUT RECOGNIZES THAT THE TIMEFRAME TO UNDERTAKE THESE STUDIES AND IMPLEMENT POSSIBLE WORKS IS SHORT AND THE WUP MAY NOT MEET THESE TIME FRAMES. THEREFORE, THE CC STRONGLY RECOMMENDS THAT THE MINISTRIES AND BC HYDRO CONSIDER FUNDING THESE STUDIES PRIOR TO IMPLEMENTATION OF THE WUP. THE GOVERNMENT AGENCIES SHOULD WORK WITH THE KTUNAXA KINBASKET TRIBAL COUNCIL ON THIS ISSUE.***

<u>RECOMMENDATION #2:</u> ***DUE TO THE URGENCY OF THE SITUATION, THE CC ALSO RECOMMENDS THAT ANY FUNDS THAT BC HYDRO SPENDS UPFRONT FOR UNDERTAKING THE CULTURAL STUDIES BE REIMBURSED THROUGH THE WUP PROCESS.***

- Mark: Realistically this is a very sensitive issue with the Ktunaxa. Should not cut any corners. Recommends a funding cap of the more expensive option of $2.4 million.

The CC was asked to express their level of support for a funding envelope <u>*of up to* $2.4 million</u> to do cultural protection works, if KKTC want protection to be undertaken.

- Gordon: If other cultural sites are located, do works for these additional sites fall within this funding cap?
- Michael: Part of the monitoring studies include a more detailed archaeological overview to try and identify additional sites. However, the sites that were found a particularly unique and it was the archaeologist's opinion that there would not be other sites in the area of this significance. For the time being therefore, the CC should express their level of support for funding on what is known. And the cap of up to $2.4 million should be considered for the protection of the two sites and for any other sites identified (as a part of the monitoring) needing some form of protection. The idea is that regardless of the number of sites ultimately found in the reservoir, the CC can make a decision now on the financial parameters. If additional significant sites are found and these require protection works costing more than the $2.4 million, then this will be left up to the regulators, BC Hydro and First Nations to reconsider.

The CC was asked again for their level of support for a funding envelope of up to $2.4 million for protection works for the cultural sites.

OUTCOME: WITH THE EXCEPTION OF LARRY GREENLAW, ALL OF THE CC AGREED WITH A MAXIMUM FUNDING CAP OF $2.4 MILLION FOR THE ARCHAEOLOGICAL WORK (PENDING THE STUDY RESULTS AND DISCUSSIONS WITH KKTC, BCH, AND THE GOVERNMENT REGULATORY AGENCIES).

- Gordon: Is Larry uncomfortable with the dollar amount, or the fact that we are doing something in the reservoir and not downstream?
- Larry: Can not rationalize spending large amounts of money for cultural sites, and pinching in other areas that deal with present people.

5.3 Recreation Non-Operating Alternatives

3 options were identified as follows:

1. Glacier Creek beach recontouring
2. Glacier Creek boat ramp extension
3. Partial mosquito abatement funding

- Larry: Did not support the beach recontouring option from the RD's perspective and it was therefore dropped from further consideration by the CC.
- Gail: Still need a boat ramp extension because we have lowered the reservoir level and reduced recreation opportunities at Glacier Creek.
- Fred: Under Alt S, the reservoir would be about 1 m below full pool from mid Aug until Labour Day weekend. Does this require an extension for August to Labour Day (highest recreation season)?
- The boat ramp was designed for use down to 7 ft below full pool between the 3rd week of July to Sep 10-15, which is the recreation season.
- Michael: Full pool is delayed with Alt S73 (and most of the other alternatives) by about 1 week each year to help mitigate potential flooding events.
- Larry: The reservoir did not reach full pool last year, as it was a dry year. The Regional District considered extending the boat ramp about 50 ft in elevation.
- Terry: Can we tie this to an operation if the alternative is keeping the reservoir at full pool through the recreation season?
- Larry: If we keep the reservoir at the high end, then we don't need to extend the boat ramp.
- Gail: The reservoir is generally about 5 ft below full pool before the long weekend and only a small area of the boat ramp is wetted. Can't believe that the ramp is useable to 7 ft below full pool.
- Steve: It does not appear that physical works are necessary.
- Kindy: Undertaking the physical works will allow us to work within the flexibility needed with the operating plan.
- Fred: A boat launch extension that is useable to –2 m will provide more flexibility.

The CC was asked whether there is a need to consider a recreation physical works?

OUTCOME: THE CC REACHED CONSENSUS ON A RECREATION PHYSICAL WORKS. THE CC SUPPORTED THE GLACIER CREEK BOAT RAMP

EXTENSION UP TO A FUNDING CAP OF $126K WITH THE CAVEAT THAT THE REGIONAL DISTRICT WOULD BE RESPONSIBLE FOR MAINTENANCE OF THE BOAT RAMP AFTER IT IS BUILT. THIS DOES NOT PRECLUDE WORKS AT ANOTHER SITE IF IT IS FOUND TO BE MORE BENEFICIAL AND LESS EXPENSIVE.

Partial funding for mosquito abatement program
The facilitator noted that having 3 recreation options for physical works was in response to the CC's request at Meeting #7 in the event of recreation alternatives among the frontrunning alternatives of for more effectively delivering benefits. Since the boat ramp extension was recommended to provide more flexibility with Alternative S73, there wasn't a justification to consider the remaining recreation non-operating options.

The CC was asked if they could only pick one physical works for recreation, would this have changed their decision with the boat ramp extension?

- Larry: $20/yr for mosquito abatement in the lower river would do more for recreation than the boat ramp extension.
- Gail: The CC has been very conscientious about developing operating alternatives to reduce the mosquito problem. It is difficult to find a rationale for supporting abatement funding, as Alt S73 avoids the high flows in August that was causing the problems from the dam for mosquitos.
- Larry: The RD went to the Minister to have BC Hydro pay for some of the mosquito abatement program. The RD was told that they would get funding if they participated in the Duncan WUP.
- Michael: Operations have been changed in Alt S73 to better address the mosquito issue (over current conditions). So there is not a justification from the mosquito perspective. However, the RTC did include it as an option under possible recreation non-operating alternatives as they recognized a link between mosquitos and recreation in the lower river.

Level of Support for Partial funding of the Mosquito Abatement Program

CC Member	Acceptance/Block	Comments
Terry Anderson	Do not support	The mosquito issue has been addressed through the operating alternative.
Kindy Gosal	Abstain	
Gail Spitler	Can not support	
Stephan O'Shea		
Vic Clement	Abstain	
Llewellyn Matthews	Abstain	
Gene Anderson	Do not support	This has been addressed operationally.
Mark Tiley	Abstain	
Gordon Boyd	Do not support	Will be much better operationally. Can not justify.
Steve Macfarlane	Do not support	Has been addressed operationally.
Fred Thiessen	Do not support	Have tried to reduce the risk operationally.

Level of Support for Partial funding of the Mosquito Abatement Program (cont'd)

CC Member	Acceptance/Block	Comments
Larry Greenlaw		The government has told the RD to participate in the process to enable getting funding for the abatement program. So I have spent 4 years in the process and now have to go back to the public with nothing. *Steve Macfarlane noted that this is not true, as operations will be much better for mosquito production. The $20k funding is double dipping.*

Note at the break Larry left (1pm) and did not return for the remainder of the meeting.

5.4 Nutrient Loading Funding

As discussed in Day 2, a new non-operating alternative was proposed.

- If Alt S is found to impact nutrient loading to the North Arm of Kootenay Lake, $100k/year would be provided to the CBFWCP for the ongoing Kootenay Lake Fertilization Program, which would free up funding for other fish and wildlife programs.

- Steve McAdam: The numbers provided by Chris Perrin may be low based on information from Eva. There is a component that is connected with operations that should be dealt with through the WUP. There is a need to modify Chris's numbers.
- Is $100k adequate? Need to determine how much is dealt with through Alt S.
- Steve Macfarlane: Would like to see a contribution to the ongoing program as part of this WUP. The cost of the program is $670k/yr, of which $400k is fertilizer.
- Stephan: There are other ways to fertilize the lake. Studies need to be done.
- Steve McAdam: A phosphorus study for Duncan Reservoir has already been done. We just need further analysis ($10k).
- Steve Macfarlane: The analysis needs to be done now as part of this process. This money should not be spent on admin.
- Stephan: Studies need to be done. Does not support the ongoing fertilizer program.
- Steve McAdam: Based on study by Chris Perrin, the total phosphorus retention is 7.9 t, of which 3.5 t was due to operations at Duncan. About 8-18 t are delivered to the North Arm from the fertilizer program. Prior to the dam, nutrient loading to the North Arm from the Duncan was about 60T.
- Gordon: Need to clarify that this is a maximum cap of $100k to compensate for that part of the nutrient contribution not covered by Alt S (Alt S vs. the max. under the Treaty).
- Kathy: Two scenarios were developed. Scenario #1 involved holding the reservoir as high as possible within flood control curves. Scenario #2 involved draining the reservoir as quickly as possible. The difference between these operations is the operational component .

The CC was asked to express their level of support for partial funding of the fertilization program (up to a maximum of $100k per year) if the analysis shows that there is a nutrient loading impact under Alt S. This would be considered a physical works in lieu.

Level of Support for Nutrient Loading Funding

CC Member	Acceptance/Block	Comments
Gordon Boyd	Accept only from baseline conditions	Don't believe the calculations are correct. It should be calculated from baseline condition.
Fred Thiessen	Accept	
Mark Tiley	Accept	Will there be an assessment of how the 2 fertilization programs holistically affect Kootenay Lake? *It was noted that there is a major study being undertaken on the lake.* If the US is going to add significant nutrition to lake and we don't know how nutrients are going to circulate within the lake, there is a risk of over fertilizing. Could we look at this as part of the study? The contribution shouldn't be made until this uncertainty is addressed.
Gene Anderson	Accept	
Llewellyn Matthews	Do not support	Agree with undertaking the study on Duncan, but do not support providing funding for the fertilization program. It is being done already with contributions from BC Hydro.
Gail Spitler	Accept	But calculations seem bizarre
Vic Clement	Abstain	
Stephan	Do not support	Can't support a fertilizer program that involves the use of chemicals. Will not support this unless the current program is re-evaluated.
Kindy Gosal	Abstain	It is an existing program, and out of the purview of this committee. Should be focusing on operational changes or works in lieu. Seems bizarre. This is an accounting issue.
Steve Macfarlane	Accept from baseline	Accepts but needs to be measured from a base case as opposed to a hypothetical scenario that would never happen (i.e., Alt A).
Terry Anderson	Accept	This is an operational issue.

OUTCOME: ***NO CLEAR DIRECTION FROM THE CC REGARDING PROVIDING FUNDING CONTRIBUTIONS TO THE CBFWCP FOR THE KOOTENAY LAKE FERTILIZATION PROGRAM. FURTHER ANALYSIS OF NUTRIENT LOADING IMPACTS FROM DUNCAN OPERATIONS IS REQUIRED. BCH WILL DETERMINE WHETHER OPERATIONAL IMPACTS WARRANT FUNDING.***

5.5 Erosion control/monitoring of Agricultural Lands

This was a new non-operating alternative proposed by Larry on Day 2. The justification was related to public perception if there was erosion protection works on the river that focused on wildlife interests and not people working in the region. This item was therefore deferred until a decision had been made related to the Argenta Slough protection works (see Day 2-Item 2, under new business for more context). A comment was made that some of the agricultural lands requiring protection may have important wildlife habitat.

- Gail: There are three properties discussed. One is not viable farmland but provides great avian habitat. The deer farm is viable, but the 3rd piece is a vacant lot that is flat and provides winter habitat for elk and deer.
- Alt S already provides considerable benefits to wildlife. Costs of undertaking erosion control for agricultural areas could be very high and uncertain.
- Can't demonstrate that operations of Duncan have an impact on agricultural land. If anything, operations have alleviated erosion problems to agricultural lands.

OUTCOME: THE CC AGREED THAT THIS ISSUE SHOULD NOT BE CONSIDERED FURTHER

- Terry: We have not addressed Howser/Glayco maintenance or recontouring of GC.
- Kindy: MoF is committed to maintain the Howser and Glayco sites. The RD does not want recontouring of Glacier Creek.

6. MONITORING

At the Technical Committee level, there was a need to decide which monitoring studies should be considered by the CC. The following criteria were considered:

- Would the study outcome result in a change to operations?
- Can the study provide meaningful results?
- Is the study the most cost-effective?
- Do the benefits of the information exceed the costs of the study?

Learning Expected Scales (Filled in by Technical Committees)
High – monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.
Medium – monitoring study will likely lead to the ability to discriminate qualitatively and/or quantitatively among some of the competing hypotheses.
Low – likely to allow only qualitative comparisons among a few competing hypotheses.

Overall CC rating of study
There are two components to be considered with an overall study rating:

- Likelihood that a study result will lead to a change in a future water management decision
- Relative important of the study given the uncertainty, study cost, value of information

High – this study must be undertaken in order to make responsible future water management decisions
Medium – this study is recommended as it will likely affect future water management decisions
Low – this study is not likely going to serve as a basis to make future water management decisions

6.1 Review/Ranking of Monitoring Studies

Alf provided an overview of the monitoring studies as summarized in handout tables (see also Pre-Reading materials for additional details).

Adaptive Stranding Protocol

- Stage I already being carried out – developing studies and protocol and implementing stranding studies for this fiscal
- Stage 3 and 4 – to meet WUP needs and conditions of the Alternative Measures Agreement.
- Minimize stranding and evaluated stranding on an ongoing basis.
- Protocol – study index sites selected based on detailed hydraulic modeling. Will document impacts at index sites. May include some salvage works.

➢ Steve Macfarlane: The objectives are to develop ramping rates, identify key stranding sites and identify mitigation
➢ Kindy: Understand the importance of the monitoring studies but concerned about public perception ($5million over next 10 years). In previous WUPs, what has happened with monitoring.
➢ Steve Macfarlane: This is consistent with other WUPs. Monitoring is typically expensive because they are detailed thorough assessments. The CWR will want to know that the amount of money being spent on operations and non-operational works is a wise decision. Monitoring programs will provide this. This is the level of effort that is necessary to answer these questions.
➢ Kindy: It is the responsibility of the provincial and federal agencies to manage the resources. This may be perceived as a money grab.
➢ Steve Macfarlane: The money is not going into existing management programs. It is all being directed to operations and learnings.
➢ Stephan: Would like to see another study that addresses effects of the fertilizer program on fish

- Stages 1 and 2 involve developing and implementing the interim protocol funding (CGA Funding). This will be completed by time WUP is implemented
- Stage 3: Data collection and Interim Protocol Continued (WUP funding). Potential changes in PMs and remodeling will be passed on to the CWR
- Stage 4: finalize Protocol and monitor (WUP funding)
    - 8 years of annual studies
    - evaluation of residual impacts (out in field before planned event, set traps, monitor fish in site prior to and after flow event)
    - have agreed to an upper cost for evaluating residual impacts at index sites and developing mitigation
    - monitoring of mainstem and side channel changes will assist in re-calibration of hydraulic model (recommended by Mike Miles)

Kokanee spawning study

- Genetic assessment removed as it was ranked as low by the FTC
- Objective is to evaluate run timing and escapements of Meadow Creek, Duncan and Lardeau kokanee runs
- This is the only productivity indicator for the lower Duncan River
- Annual assessments will be done in conjunction with MLAP as part of their Meadow Creek work
- Alt S may increase use of Duncan side channel by kokanee that would have otherwise been using Meadow Creek or the Lardeau River. Monitoring in these other systems will provide useful information to asses whether changes in use reflect changes in numbers or change in distribution of use
- Rated as high by the FTC

Bull Trout Passage Study

- Juvenile enumeration study
  - to address issue of whether current passage operations are causing reversed entrainment or whether outmigrants are making their way downstream through the dam
- Weir study
  - Any weir changes will affect min flow
  - Are there benefits of the weir, and if so can it be retrofitted

Temperature and TGP Monitoring

- To determine cues to life history timing of species of interests
- 6-10 temperature probes in river
- Might preferentially use LLO or SPOG
- Two years of spill data and install TGP monitor (plunge pool and WSC gauge)
- Would change relationship between TGP and spill
- TGP costs high because anticipating TGP probe problems

Cottonwood Study

- Cottonwood response and model study would determine recession effects and response of cottonwood
- Wildlife study would document use of cottonwood (i.e., what is the wildlife affinity to cottonwood?)
- Studies separated for CC as results of wildlife study would not change operations

Quality of Life Study

- Mosquito study to survey in low bench areas; reconfirm life history characteristics; confirm effects of second and third flooding on production (1-year program)
- Management plan to help the RD in their abatement program
- Quality of life committee asked for development of the monitoring program for mosquitoes. The management plan was a logical outcome of the monitoring.

➢ Is there likely to be an operation that would go below the 400 cms cap?
➢ Concern that the management plan would be provided to the RD but not willing to contribute $ to abatement program.
➢ Prove with PMs that operations are doing what can be done for mosquitoes. Ensure assumptions are correct.
➢ The development of a management plan was dropped.

Stock Assessment and fish habitat utilization study

- Seasonal habitat use assessment would document use within drawdown zone and stream use within zone for juveniles, littoral use in stream fans and pelagic use by netting
- $90/yr over 2 years
- Kokanee hydroacoustic work for stock assessment
- Annual surveys
- Will inform on index abundance
- No baseline data to determine effect of operational change. Do we collect information now for next WUP?

- ➢ Steve McAdam: This was not a focus of this WUP – can we cut down the study?
- ➢ Mark: Are we likely to change operations to benefit a pelagic species?
- ➢ Could be done adequately within 3 years
- ➢ 3 years at end of review period at $28k/yr (total $84k) $140k

<u>Tributary spawning assessment</u>

- Would focus on kokanee. Would be difficult to add in rainbow trout spawner use.

- ➢ Can it be done every second year?
- ➢ Need spawner correlation to determine what is happening to the population
- ➢ Would be useful to inform for next WUP
- ➢ $175K for 5 years

<u>Burbot study</u>

- The original thought was to study how operations affect size distribution, but would have to sacrifice a lot of adults for aging.
- FN concern around whether any changes in operation that result in drawdown during winter would have a population impact? Study length frequency distributions over time (sacrifice about 20 fish) in conjunction with telemetry for 2-3 years
- 10-year study
  - $160/y for 2 years for telemetry ($320k)
  - $60k/y for 8 years to monitor burbot response to operations ($480k)

- ➢ Can sampling be done every other year to save on $$s
- ➢ Suggestion to use adult fish abundance as base case initially
- ➢ Will provide quantitative results
- ➢ Max cost of $800k
- ➢ Stephan: CBFW has been doing burbot work in last few years
- ➢ Steve Macfarlane: Makes sense to spend $320k for telemetry but 8 years for monitoring seems too much.
- ➢ Amount of learning of both studies is high
- ➢ Steve McAdam: There is difficulty in linking this to operational changes and justifying changes in future.

<u>Cultural Resources Studies</u>

- Ranking already done by CC
- Considered high

<u>Wildlife studies</u>

- Riparian mapping and document riparian response to reservoir management
- Will document grass production in the drawdown zone
- Wildlife habitat use study to document wildlife use of riparian habitat

- ➢ Stephan: Suggests fencing to see what is being eaten by wildlife. Need for a detailed study.
- ➢ Steve McAdam: The cost of the cottonwood recruitment study seems high. Can this be done every other year? Important to monitor.
- ➢ Mark: If constraints are going to be violated in some years, don't really want to break up effort.

Gordon asked the committee if they were comfortable with the overall costs for the monitoring studies amounting to annual costs of $600k/yr.

- All CC expressed comfort with these costs.
- Steve Macfarlane: Some studies are deal breakers so uncomfortable with BCH writing up the monitoring.
- Gordon: The CC will have a chance to review CC report
- Gail: Medium rankings vs. high rankings does not mean nonconcensus.
- Gordon: BC Hydro will discuss with CC members if some studies are nonconcensus.
- The monitoring plan will not be included in the CC report, but it will show the level of support for each study.
- Llewellyn: Uncomfortable with the total cost of monitoring. Assuming BC Hydro will prioritize these studies to a budget constraint.

The facilitator asked the CC to rate each of the proposed monitoring studies to indicate their level of support for funding. Each CC member filled in the table separately. The results of this are provided in the table below.

Additional Comments made by CC members on their study ranking sheets:

- Kindy: Abstained from the study rankings and ceded to the knowledge of the various technical committees.
- Steve Macfarlane: Felt that kokanee hydroacoustic and tributary spawning assessment in the reservoir should be less frequent and recommended that these amounts be cut in half. For the burbot study, he mentioned that he would prefer the abundance frequency reduced.
- Terry Anderson: Burbot study ranking was high for telemetry, but considered expensive.
- Gene: Study estimates appear excessive without justification/support. His ratings were based on importance not approval of funds. Specifically, the mosquito study will have RDCK collect the data; kokanee acoustic work will inform next WUP; and CBF & W are possibly conducting similar work for the proposed burbot studies.
- Gail: Based her assessment ranking of high for the stock assessment studies in the reservoir on half the cost (5 years) at FTC recommendation. For Burbot study follow the recommendation from the FTC.
- Mark: Base stock assessment (hydroacoustic) work in the reservoir on 5 years.

				Overall CC Rating of Study (High, Med, Low, Abstain)										
Area	**Objective Area**	**Study**	**Components**	**Vic**	**Kindy**	**Steve Macf**	**Terry**	**Gene**	**Llewellyn**	**Gail**	**Mark**	**Fred**	**Gordon**	**Stephan**
Lower Duncan River	Fish	**Adaptive Stranding Protocol Development Stage 1 and 2: Develop and Implement Interim Protocol (CGA Funding)**	Ramping experiments, habitat use, life history, etc.	H	A	H					H	H		H
		Adaptive Stranding Protocol Development Stage 3: Data Collection and Interim Protocol Continued (WUP Funding)	Ramping experiments, habitat use, life history, mapping, hydraulic modelling, adapt protocol	H	A	H	H	H	H	H	H	H	H	H
			PM Redevelopment and Reporting	H	A	H	H	H	L	H	H	H	H	H
		Adaptive Stranding Protocol Development Stage 4: Finalize Protocol and Monitor (WUP Funding)	Document fish stranding at key index sites	H	A	H	H	H	H	H	H	H	H	H
			Evaluate residual impacts of stranding through index studies	H	A	H	H	H	M	H	H	H	H	H
			Develop recommendations for mitigation including physical works or site salvage	H	A	H	H	H	M	H	H	H	H	H
			Finalize ramping protocol	H	A	H	H	H	H	H	H	H	H	H
			Monitor Mainstem Channel Changes	H	A	H	H	H	H	H	H	H	H	H
			Monitor Sidechannel Changes	H	A	H	H	H	H	H	H	H	H	H
		Kokanee Spawning Study	Stock Abundance Monitoring A & B	H	A	H	H	H	H	H	H	H	H	H
		Bull Trout Passage Study	Juvenile enumeration of Upper Duncan River outmigrants into Lower Duncan River	H	A	H	H	M	H	H	H	M	M	H
			Evaluation of Weir efficacy	H	A	M	H	L	M	H	H	M	M	H
		Temperature and TGP Monitoring	Temperature Monitoring	H	A	L	H	M	L	M	H	M	M	H
			TGP Monitoring and PM Changes	H	A	M	M	M	L	M	H	H	M	H
	Wildlife	**Cottonwood Study**	Cottonwood Recruitment Study	H	A	H	H	H	H	H	H	H	H	H
			Wildlife habitat use study	H	A	M	M	H	H	H	H	L	L	H
	Quality of Life	**Mosquito Management Study**	Resurvey of Mosquito areas and PM calibration	H	A	H	H	L	L	H	H	H	M	H
Reservoir	Fish	**Stock Assessment and Fish Habitat Utilization Study**	Seasonal Habitat Use Assessment	H	A	H	H	M	L	H	H	M	M	H
			Kokanee Hydroaccoustic Work	H	A	M	M	M	L	H	H	M	M	H
			Tributary spawning assessment	H	A	M	M	M	M	H	H	M	M	H
		Burbot Study	Telemetry study	H	A	H	H	L	M	A	H	M	M	H
			Burbot response monitoring	H	A	H	M-L	L	M	A	H	M	L	H
	Cultural Resources	**Archaeology Study**	Archaeology Study	H	A	H	H	H	H	H	H	H	H	H
		Erosion Study	Erosion Monitoring Study	H	A	H	H	H	H	H	H	H	H	H
			Conservation Excavations	H	A	H	H	H	H	H	H	H	H	H
			Traditional Use and Cultural Assessment	H	A	H	H	H	H	H	H	H	H	H
	Wildlife	**Reservoir Riparian Study**	Vegetation Monitoring	H	A	H	H	H	M	H	H	H	H	H
			Wildlife habitat use study	H	A	H	M	H	H	H	H	M	M	H

6. REVIEW PERIOD AND TRIGGERS

6.1 Review Period

- Every CC needs to decide on an appropriate review period for when the next water use plan will be started
- At a minimum, want to ensure that the next CC has better information to make decisions with
- At a maximum could agree to a long review period with safeguards built into the WUP.
- For example a monitoring study could have a trigger, which would bump up winter flows by a certain amount?

➢ Many CC members indicated that a 5-year review period was too short, while others felt that 15 years was too long.

OUTCOME: THE CC AGREED TO A 10-YEAR REVIEW PERIOD FOR THE DUNCAN WUP. THIS DOES NOT PRECLUDE THE FOLLOWING TRIGGERS, WHICH WILL BE WRITTEN INTO THE WUP.

6.2 Triggers

- Kootenay River WUP being undertaken
- IJC Order being re-opened
- Biologically significant trigger
- Max normal dam discharges above 283 cms (due to TGP issues) with recognition that dam safety would take precedence
- If external factors affect the ability to deliver the preferred flow alternative. For example:
  - KKTC Treaty Negotiations
  - Changes to Libby, Flood Curves, MCA WUP, etc.
  - *System-wide flexibility review*

➢ Kindy: If the Duncan WUP proposed operating alternative reduces system-wide flexibility and BCH feels the alternative can not be implemented, the CC will need to reconvene. If there are system-wide impacts, the CC of both the Columbia and Duncan WUPs would need to reconvene.
➢ Steve Macfarlane: The plan at the outset was to do an umbrella look at the Columbia and Duncan, but this went on the rails. This is supposed to be done by the Policy Committee when all the WUPs are completed.
➢ This issue is covered off by 5th trigger (factors affecting the ability to deliver the preferred flow alternative).
➢ 283 cms is the maximum normal dam discharge stated in the LOO but this is not in the water license. There is no reason to go beyond the 283 cms.
➢ There are no plans or indication of any different use of water or units going in. This would trigger re-opening of the WUP.
➢ Redesign for safety reasons would not be included as a trigger.

7. OPERATIONS-RELATED RECOMMENDATIONS

The facilitator handed out sheets to the CC to be filled out indicating their level of support (support, disapprove, or indifferent) for each of the previously identified WUP operating related recommendations. These included:

1. Adaptive stranding/ramping protocol (Stages 1-4)
2. TGP
   - When dam releases are nearing 285cms, ensure that flows through one low level outlet are near maximum flow of 170cms to restrict spill volumes to 115 cms (in the spillway) and therefore limit TGP levels downstream
3. Normal maximum dam discharge not to increase above 283 cms
   - Current normal maximum dam discharges are restricted to 283 cms in the water license. Do not want to see this volume increased in the future because of concerns around increasing TGP levels
   - Note. This was deleted since it was addressed with the trigger above.
4. Nutrient Loading – this was already discussed and ranked as a non-operating alternative (earlier today in Section 5.5). Therefore it was removed as a recommendation.
5. Flood Rule Curve Protocol – this was considered necessary as a risk measure in the event that a variance to clip the bottom of the flood rule curve would not be allowed by USACE (It is yet to be developed).

A summary of the CC's level of support is presented below.

Duncan WUP Operating Related Recommendations

#	Operating Recommendation	Overall CC Rating of Study (S)upport, (D)isapprove, (I)ndifferent, (A)bstain										
		Vic	Kindy	Steve Macf	Terry	Gene	Llewellyn	Gail	Mark	Fred	Gordon	Stephan
1	Adaptive Stranding / Ramping Protocol	S	A	S	S	S	S	S	S	S	S	S
2	TGP - Dam release 285cms (170 from LLO)	S	A - I	S	S	S	S	S	S	S	S	S
5	Flood Rule Curve Protocol	S	A	S	S	S	S	S	S	S	S	S

- Kindy: Abstained to technical committees, as he felt he did not have enough information

8. NON-WUP RECOMMENDATIONS

The facilitator handed out sheets to the CC to be filled out indicating their level of support for non-WUP recommendations.

- Non-WUP recommendations are those that are beyond the scope and mandate of water use planning (and normally not within the direct jurisdiction of BC Hydro)
- CC support for any non-WUP recommendation does not translate into any action or implementation unless volunteered by a CC stakeholder
- Each recommendation and its level of support will be documented in the final CC Report
- The following recommendations were brought forward for consideration by the CC:

1. Forest Services site maintenance – this was dropped as MOF now has funding
2. BCH to continue the reservoir debris program
3. BCH to participate in a regional hydro-electric system review

   Kindy prepared and read the regional hydro-electric system review recommendation. It follows:

   System Wide Operations Review

   Background:
   Once the Duncan and Columbia Water Use Plans have been completed and operational alternatives implemented there may be cross system impacts and/or operational flexibility issues that occur.
   These impacts include unexpected negative (or positive) impacts to values on other parts of the hydro system as a result of implementing the Water Use Plan Operating alternative or trying to achieve the performance measure objectives set therein.
   These impacts will need to be identified and verified through a number of mechanisms including the monitoring program implemented under the two WUPS.

   Recommendation:
   In Conjunction with the Duncan and Columbia Water Use Plan Review process, it is recommended that the consultative committees struck for these processes should participate in a review of system wide operations.
   The objective of this review is to:
   - Provide recommendations to BC Hydro on addressing any operational flexibility issues.
   - Provide BC Hydro with recommendations in dealing with cross system and/or system wide impacts that may occur.
   - Provide a variety of interest group with an opportunity to better understanding how system wide operations are interlinked and function and provide input to BC Hydro.

   The make up of this committee should reflect the diversity of interest currently participating in the Water Use Planning Process.

   (Note this recommendation is partially tied in with the triggers supported above)

4. That the CC supports the undertaking of a watershed management plan to be developed for the Upper Duncan River System

- Terry: Would like to see big debris (root wads) removed and used for habitat projects as opposed to burning.
- Gordon: Effort depends on the budget for debris removal.
- Stephan: There are lots of bugs on the debris, which is good for fish.
- Llewellyn: The issue of cost variability was not discussed within decisions around an operating alternative. This has not been quantified, and it is a significant concern to CPC. Requests that once a final financial PM is calculated, that BC Hydro provide an assessment of the variability that is likely to be associated with this cost.
- Gordon: High costs could be due to two outlier years due to high inflow.

ACTION: BCH TO DISCUSS COST VARIABILITY ISSUE WITH CPC

- Kelvin: While BCH will try to meet the spirit of the WUP, it may not be able to meet in real time for all interests in all years.

- Steve Macfarlane: The CC has agreed to a set of operating constraints but acknowledges that there is a band of flexibility.
- Kelvin: Sometimes there may be a short-term rainfall event that would necessitate a decision to be made (e.g., if there is a tradeoff between constraints for fish or cottonwood). There are outliers in the 32 years of record.
- Gail: If this happens frequently then there is something wrong with decisions made by the CC.
- There is a trigger around ability to deliver.

A summary of the CC's level of support for the Non-WUP Recommendations is presented below.

#	NON WUP Recommendation	Overall CC Rating of Study (S)upport, (D)isapprove, (I)ndifferent, (A)bstain										
		Vic	Kindy	Steve Macf	Terry	Gene	Llewellyn	Gail	Mark	Fred	Gordon	Stephan
2	BCH to continue reservoir debris management program	S	S	S	S	S	S	S	S	S	S	S
3	Undertake regional hydro-electric system review	S	S	I	S	S	S	S	S	S	A	S
4	Develop a watershed management plan for the Duncan Reservoir	S	S	S	S	S	S	S	S	D	A	S

Additional Comments made by CC members on their ranking sheets (yellow cells above were conditional terms for support)

- Kindy: Commented that debris should be salvaged for the valuable timber. And that for the regional overview a specific emphasis be put on including local communities and residents of the Columbia Basin.
- Steve Macfarlane: Mentioned that his support for the debris program was conditional on the material collected to be used for ecological purposes (e.g. large debris made available for downstream habitat complexing.
- Terry: Supported the debris program conditional on salvaging the root wads and other large woody debris appropriate for watershed restoration projects. He didn't want any burning to take place with the collected debris.
- Llewellyn: Supported the debris program and suggested that the debris be given to MWLAP for watershed restoration.
- Gail: Wanted to save and use the good debris collected.
- Mark: For the debris program wanted to see the root wads and other desirable pieces for stream/lake fish habitat enhancement works. For the regional review, wanted to ensure that alternatives do not have impact on system. As for a watershed plan, he was concerned with ATV use in the drawdown zone and related impacts to cultural heritage resources.
- Fred: Cannot support the watershed management plan for the area since they are a Land Use Plan requirement coordinated by Ministry of Sustainable Development and this has already been done for KBLUP.
- Stephan: Supports the debris program regardless of burning. He also suggested that a 100m creek reserve and 500m reservoir reserve or buffer be built into the watershed management plan.

9. FINAL STEPS AND COMMUNCIATIONS

Final Steps

- Last step in the CC's involvement of the WUP will be to review and comment on a Consultative Committee Report (CCR).
- The CCR documents the process and captures all the decisions and information collected along the way.
- After CC comments have been integrated into a final draft of the report, they will be asked to sign off on it as an accurate record of the proceedings.
- BC Hydro will take the report and write a WUP - *which is a technical document for how Duncan facilities will be operated.*

Communication

The CC was asked how they want to be informed or updated as to the monitoring study results?

- Annual update
- Or an annual meeting
- Or simply receive a copy of the study results
- is there a need or desire for BCH to consult with a monitoring committee?

➢ A 5-year review or monitoring committee would be technical members but annual reviews should be open to anyone interested.
➢ Kindy: Suggested using the web site for posting monitoring results.
➢ Alf: A data distribution system will be setup for the web site for all monitoring. All reports will be made public.

OUTCOME: CC EXPRESSED A DESIRE FOR ANNUAL MEETINGS TO BE HELD IN LARDEAU OR KASLO TO REVIEW COMPLIANCE AND MONITORING RESULTS.

MEETING ADJOURNED.

APPENDIX O: FISH TECHNICAL SUBCOMMITTEE MEETING MINUTES, 16 AUGUST 2004 AND 26 NOVEMBER 2004

FINAL DUNCAN DAM WATER USE PLAN
FISH TECHNICAL SUBCOMMITTEE MEETING MINUTES

August 16th 2004 by Conference Call and
November 26th 2004 by Conference Call

In Attendance

Mark Tiley, CCRIFC (16 August only)
Jayson Kurtz, DFO
Steve Macfarlane, DFO (16 August only)
Steve McAdam, MWLAP
Alf Leake, BCH
Michael Harstone, BCH (16 August only)
Bob Westcott, BCH
Gordon Boyd, BCH
Kelvin Ketchum (26 November only)
Gary Birch (26 November only)
James Baxter (26 November only)

Meeting Objectives

- Review and finalize operating protocols from final April 2004 Duncan Dam Water Use Plan (DDM WUP) Consultative Committee (CC) meeting
- Discuss and finalize approach for sidechannel exclusion fencing
- Review changes and finalize DDM WUP monitoring table
- Review and recommend funding level for nutrient retention
- Review WUP operations wording

Distributed materials

- FTC Information Sheet on Nutrient Retention (pdf)
- FTC Information Sheet on Duncan Dam flood rule curve operating protocols (pdf)
- DDM WUP Non-Operating Alternatives summary (pdf)
- Nutrient calculations spreadsheet (xls)
- CC Monitoring Table corrections (xls)

Operating Protocols Discussion

Fall/Winter Operations to Correct Reservoir Levels

The FTC discussed the three options outlined in the DDM FTC Info Sheet that could be implemented if an inflow event requires releases to exceed those in the WUP:

- not enough information currently to define a long-term approach for least-risk corrective option
- under the Adaptive Stranding Protocol (ASP), will evaluate options towards long-term solution

☐ ***Interim Agreement:*** *Until results from ASP are available, the FTC agreed that between the inflow event and Dec 21st, BC Hydro will release inflows and additional storage to bring reservoir levels below storage curve (Option 2 outlined in the discussion paper): after Dec 21st, exceed 250m^3s^{-1} cap for short period if required. BC Hydro will consult with DFO, MWLAP and CCRIFC prior to initiating any action deviating from the WUP. If necessary, Option 3, shortening the MWF spawning flow release cap for approximately 11 days, may be implemented. It is understood that the WUP constraints, including the 250m^3s^{-1} cap, will be the default and preferred operation in normal years.*

☐ ***Nov 26th Update****: At the Nov 26th meeting, the FTC members present agreed to extend the rationale for deviating from WUP conditions to include the consideration of Arrow Lakes flow releases in early January. Any deviation would require prior DFO and MWLAP consultations.*

Early Spring Operations

FTC reviewed three options for ensuring sustained flows can be released prior to freshet flow "relief":

- assuming the risk is identified and action implemented March 1st, a release of 60m^3s^{-1} can be sustained in all but 1 of the years BC Hydro is not granted a variance; alternatively, adaptive corrective action was considered.
- under the Adaptive Stranding Protocol, expect to gain insights into risk of sidechannel dewatering/redd stranding associated with any corrective action plan

☐ ***Interim Agreement:*** *Until results from the ASP are available, the FTC agreed that BC Hydro will reduce it's target to 60m^3s^{-1} from March 1st until freshet flows relieve the situation. BC Hydro will consult with DFO and MWLAP prior to initiating any action deviating from the WUP.*

August Operations

The FTC recommended maintaining the Alt S73 operations, at the expense in some years of not meeting the Aug. 1st fill date.

Nutrient Retention Issue

The FTC reviewed the PM Info Sheet and Discussion Sheet:

- FTC deliberated over Chris Perrin's comments that the PM was too coarse and did not consider ecological interactions with nutrient retention and the possible effects of settling velocities. In the end, this is the most up-to-date analysis available
- FTC agreed to accept $100K CBFWCP funding recommendation in analysis, with Gordon Boyd to review prior to agreement

☐ ***Interim Agreement:*** *Subject to a review of the calculations between Chris Perrin and Gillian Larkin, $100K funding will be transferred annually to the CBFWCP from the DDM WUP to compensate for operational effects on nutrient retention. If further analyses warrant a review of this recommendation, BC Hydro will require agreement from MWLAP reps to revise funding below the $100K cap.*

☐ ***Action:*** *Gordon Boyd to review calculations with ?? (Alf Leake?, Gary Birch?) prior to agreement.*

☐ ***Nov. 26th Update:*** *The conclusions to date based on another review by Chris Perrin are to proceed with the August 16th decision to fund the CBFWCP. Possible concerns related to discrepencies between Larkin/Binsted (1998 and in draft) and Perrin/Korman (1997) reports are not going to be resolved by actions of the FTC and therefore will not be reviewed until a* *third party advances the discussion. At that point, if the funding amount is deemed too high, MWLAP will be consulted to revise the funding allocation.* ***This ends this issue as far as DDM WUP is concerned.***

Exclusion Fencing

The FTC reviewed the Non-Operating Alternatives Info Sheet:

- Highlighted C11, H2, and H4 as possible targets for exclusion fencing
- Concerns were raised that exclusion fencing could be costly and ineffective. Fence installed in H4 in 2003 was not monitored and quite possibly was ineffective.

☐ ***Agreement****: FTC concluded that the cap of $135K over 10 years be applied to exclusion fencing and monitoring effectiveness.*

☐ ***Nov 26th Update:*** *meeting in Castlegar (MWLAP, DFO & BCH) was spent discussing options to proceed. The local technical representatives present at the meeting agreed to delay indefinitely any program that would explicitly implement sidechannel exclusion until after a proper review of options and trials had been conducted.*

☐ ***Action:*** *A sidechannel kokanee spawning stranding mitigation plan will be developed in advance of WUP operations implementation by Bob Westcott to address the concerns discussed at the meeting, through a suite of alternative approaches that would be implemented at the costs agreed at the August 16th FTC conference call.*

Monitoring Program

FTC reviewed changes to the monitoring program suggested by James Baxter:

- delay formal data collection for burbot as currently outlined in the monitoring program until a pilot feasibility study is completed that indicates that radio-tracking burbot to tributary spawning sites can be safely and effectively performed. This recommendation was made under the impression that there are technical and safety issues associated with tagging and tracking burbot during the January/February spawning season. It is acknowledged that these issues may be easily overcome during the pilot feasibility study, leading to the initiation of the long term monitoring project as proposed.
- extending the field data collection for RB and BT monitoring in mainstem
- collect seasonal habitat use over 4 years
- shifting some studies into later dates to consider prior information being collected

☐ ***Agreement:*** *FTC agreed to final changes made to monitoring program.*

WUP Operations Wording

The FTC reviewed a draft section of the DDM WUP dealing with proposed gate operations. The FTC agreed with the wording, adding that there should be an opportunity to review the effects of the operations and correct any impacts caused by the interpretation. Another comment to ensure that dam operations are only made to be within WUP constraints was made.

☐ ***Action****: Alf Leake to add comments to WUP document for final review by FTC.*

End of Meetings

APPENDIX P: CONSULTATIVE COMMITTEE COMMENTS ON DRAFT CONSULTATIVE COMMITTEE REPORT

To:

Sue Foster
Project Manager
Duncan Dam Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

TERRY ANDERSON
WATER LAND & AIR PROTECTION
401 333 VICTORIA ST
NELSON BC V1L 4K3

Duncan Dam Water Use Plan Consultative Committee Report

This draft Duncan Dam Water Use Plan Consultative Committee Report records the deliberations of the Duncan Dam Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Duncan Dam hydroelectric facilities.

The undersigned confirm that this draft Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Duncan Dam water use planning process. VERY WELL DONE !

Name & Organization: WATER LAND & AIR PROTECTION

Signature:

From: Anderson, Terry WLAP:EX [Terry.Anderson@gems3.gov.bc.ca]
Sent: Thursday, January 20, 2005 2:49 PM
To: 'sue.foster@bchydro.bc.ca'; 'MHarstone@compassrm.com'
Cc: McAdam, Steve WLAP:EX; 'Heaton, Susan'

Subject: Duncan WUP comments and signoff

Hi Sue and Michael. Steve and I have had a chance to review the Duncan CC report. The report was thorough, comprehensive and well written. The critics say.... "It is truly a novel of epic proportions." "It had me on the edge of my seat for days." "....better than Gone with the wind".

That being said, the report is well done and is an accurate reflection of the discussions and deliberations. We offer the following comments for your consideration.

1) P5 the consequence table indicates that there will be no change to Kootenay Lake with implementation of physical works. While technically true, we also have modelling that shows that the operational impact may be greater than the WUP contribution to the solution. Not sure what to do about that, since the wording elsewhere in the document is reasonable. Possibly no change required.

2) P8 bullet 4 Refers to "...to address tech impacts to nutrient retention in the North Arm of Kootenay Lake." More accurately it is the nutrient delivery to the lake, or retention in Duncan Reservoir.

3) P2-1 The distance between the dam and Kootenay Lake is listed as 8 km here, and 11 km (10+1) elsewhere. Numbers should be consistent.

4) P4-9 Scientific names should be in italics. Also throughout sturgeon should be white sturgeon in most cases. There is no such species as sturgeon.

5) Page 7-41 Figure 7-11 Alt O is also similar to AltQ & R

6) Figure 7-12 Alt M appears to be as favourable as Alt A, Q & R

7) Page 7-45 Table 7-17 shouldn't the comment be that Larry accepted Alt M90 rather than Alternative 73?

8) Page 7-60 second line should be maximum flow constraints, not minimum.

9) Page 7-65 7-59 & N-43 Table 7-24 I'm not sure why 10K was added to each of years 5 and 10 (for a total of $120k) for the Glacier Creek boat ramp when the Regional District was going to be tagged with the maintenance. This is a moot point anyway since the RDCK has declined to accept responsibility for the maintenance and thus will not be included in the WUP document as a non-operational alternative. (see page 7-59). Also, page N43 has the cost of the Glacier Creek boat ramp at 146k?.

10) Page B-3 Table B-4 Steve McAdam works for WLAP not Ministry of Fisheries

11) Page F-30 & Table F-10 The elevations in the "Where is this performance measure relevant?" don't appear to jive with the elevations in Figure F-10.

12) Page H-10 The last option should be d not b.

Sue, thanks for giving us the opportunity to provide verbatim comments to be included in an appendix. No other WUP has offered that opportunity. I am working on some comments for you but I'm having a little difficulty with being hard on the issue and easy on the people. I hope to have something for you soon.

The sign-off sheet will go out in tomorrow's mail

Terry Anderson

To:

Sue Foster
Project Manager
Duncan Dam Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

FISHERIES & OCEANS CANADA
112 McDonald Drive
Nelson B.C.
V1L 6B9

Duncan Dam Water Use Plan Consultative Committee Report

This draft Duncan Dam Water Use Plan Consultative Committee Report records the deliberations of the Duncan Dam Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Duncan Dam hydroelectric facilities.

The undersigned confirm that this draft Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Duncan Dam water use planning process.

Name & Organization: JAYSON KURTZ, Fisheries & Oceans Canada

Signature: Jayson Kurtz

From: KurtzJ@pac.dfo-mpo.gc.ca
Sent: Monday, January 31, 2005 10:41 AM
To: Sue.Foster@bchydro.bc.ca
Cc: Sue.Heaton@bchydro.bc.ca
Subject: RE: Duncan Dam Draft CC Report- comments????

Sue, as I mentioned on the phone, I reviewed the report and although I didn't do an extensive review of grammar, sentence structure etc as I usually do, I focused on the overall accuracy and content. I congratulate you (and your team) on doing and excellent job of summarizing 3 years worth of convoluted meetings/discussions/decisions into a well written, concise, clear document that accurately reflects the Duncan WUP CC process. Steve and Terry already raised the few technical issues I noticed. The only outstanding issue is exclusion fencing, and I think it is appropriate simply to comment that an alternative to exclusion fencing is/will be developed by BCH in consultation with DFO, WLAP and FN (I believe Alf has some wording to that effect that we suggested at the FTC meeting). To be clear, I fully support the alternative to exclusion fencing approach. My sign-off sheet will be sent you in the mail tomorrow. Thanks again for helping this process along so well.

Cheers,

Jayson

- 3 -

To:

Sue Foster
Project Manager
Duncan Dam Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

GAIL SPITLER

RR-1, S-4, C-16

KASLO BC V0G 1M0

Duncan Dam Water Use Plan Consultative Committee Report

This draft Duncan Dam Water Use Plan Consultative Committee Report records the deliberations of the Duncan Dam Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Duncan Dam hydroelectric facilities.

The undersigned confirm that this draft Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Duncan Dam water use planning process.

Name & Organization: GAIL SPITLER

Signature: Gail Spitler

- 3 -

To:

Sue Foster
Project Manager
Duncan Dam Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Ministry of Forests
515 Columbia St.
Kamloops, BC
V2C 2T7

Duncan Dam Water Use Plan Consultative Committee Report

This draft Duncan Dam Water Use Plan Consultative Committee Report records the deliberations of the Duncan Dam Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Duncan Dam hydroelectric facilities.

The undersigned confirm that this draft Consultative Report captures the water use interests, objectives and associated values expressed by the Consultative Committee members during the Duncan Dam water use planning process.

Name & Organization: Fred Thiessen
Recreation Forester
~~Ministry of Forests~~
Southern Interior Forest Region

Signature: F. Thiessen

Duncan Draft CC Report

CCRIFC Comments

by Mark Tiley,

CCRIFC Hydro Impacts Biologist

CCRIFC is neither a consultative nor a representative body. Governments are legally obliged to consult with First Nations' governments regarding potential effects of projects and activities on aboriginal interests. The information contained in this letter does not satisfy the obligations of Government and the proponent to consult with concerned First Nations Governments. These consultation obligations can only be satisfied through mechanisms approved by First Nations governments. The ***approval*** *of the Consultative Committee report is undertaken without prejudice to the aboriginal title and rights of CCRIFC member nations and communities.*

I have reviewed the November, 2004 'Draft Consultative Committee Report – Duncan Water Use Plan.' **Subject to the final report addressing the changes requested in the attached 'Comments on Draft Consultative Committee Report – Duncan Water Use Plan'**, I agree that the consultation report accurately summarizes the deliberations of the Duncan Water Use Plan (WUP) Consultative Committee, including the context for, and the committee's recommendations for the future operations of the Duncan hydroelectric facilities. I note that all of the committee's recommendations were made by non-consensus, with the non-consensus WUP the result of the single rejection by the Regional District of Central Kootenay representative, Larry Greenlaw, who critiqued the WUP process for most of it's duration.

I hereby confirm that this report, pending the changes requested below are incorporated, adequately describes the water use interests, objectives and associated values expressed by the Consultative Committee members during the process. The report also accurately reports the committee's recommendations regarding Duncan Generating Station operations and monitoring plans.

Comments

In cases where I have added a word, phrase or statement, or made modes changes to existing text, I identified my changes using italic font.

Page 1 under Duncan Dam Project.

Identify specific objectives and target species for fish flow regulation for the Lower Duncan River. I am only aware of two pre-WUP operations: the bull trout passage operations through the LLOG, flows intended to reduce dewatering of kokanee redds and possibly operations to reduce TGP?

In the Channel Stability Assessment Report produced by Mike Miles (2002), the length of River downstream of Duncan Dam is documented at 11km, not 8 km as stated twice in the same paragraph. 11km is also the length of river I recall reading in other reports and hearing at meeting discussions. 10km is used in Herbison et. al. 2002 in the Wildlife information Review. 10km is used on page 4-14 of the CC report, excluding the 1km man-made discharge channel immediately downstream of Duncan Dam. Please determine the accurate length of river and make changes accordingly.

Page 2 under section 2.2.4

Please explain more clearly how daily average flows are compressed into a shorter period each day as the example used is unclear to me. The basic math makes sense but how would the flow regime over the entire 24hour period appear if 24 m^3/s (cms) were released for three hours? Would there be a period of zero flow despite the fact that there is a 3cms min flow requirement? If so, what current agreements does BCH have that permits them to release 0 flows?

Page 3, Recommendations Section. Clarify how the Duncan WUP reached a "conditional consensus" given the fact that the RDCK did not support the Duncan WUP. The August 04, 2004 CC update indicated a conditional non-consensus WUP. In recalling that the RDCK left the final CC meeting immediately after the CC declined the request by Larry Greenlaw to provide funding for the mosquito abatement program, and given the number of RDCK absences from CC meetings in general, raising question as to the legitimacy of RDCK participation, is the Duncan WUP considered a consensus or is it a non-consensus? Furthermore the statement " Upon review of calculated performance measures, Committee members confirmed the same level of support for the recommended alternatives……" adds to this confusion. If Larry did not participate in alternative S73 review following accurate PM calculations, is the Duncan WUP therefore a consensus based on the default of RDCK to properly participate in the process? Please provide further clarity within this recommendations section as it appears from page 3 that the Duncan WUP was a consensus.

A later conversation with Sue Foster indicated that the WUP is a non-consensus. I assume this statement is now final.

Furthermore, it is not absolutely clear whether the Columbia Basin Trust supported the Duncan WUP although that appears to be the case as per the CPC Correspondence letter dated November 09, 2004. Could Kindy Gosal provide confirmation for CBT support?

Page 4, Table 1.

For the fifth bullet, 73cms from *Oct* 1 to Oct 21. Include the abbreviation "Oct" as it refers to Oct 1.

Under the 7th bullet, CCRIFC indicated at the final CC meeting that CCRIFC must be notified whenever the 250cms maximum flow constraint would be violated. Please include CCRIFC as an agency that must be contacted in years whenever there is the potential for the 250cms maximum flow constraint to be violated (foot note #3). CCRIFC indicated that acceptance of the final alternative would require the adherence to the 250cms maximum in the majority of years over the course of the 10 year review period. The current wording suggests that the 250cms maximum does not need to be met in any particular year and that the 300cms could be implemented in any year if necessary; which is not what CCRIFC intended (and probably the WTC and CC also). Based on Duncan Dam discharge data from previous years and presented as figure 2-4, the likelihood of maintaining a 250cms max flow in the fall, winter and early spring in most years appears reasonable; however, there is still some uncertainty as to how the MCA WUP and VarQ will affect Duncan operations. I would prefer that the wording be changed to indicate that the 250cms cap will be maintained in some or the majority of years and that CCRIFC will be involved in timely discussions prior to implementation of flow modifications to meet flood control rule curves, whitefish flows, etc. The monitoring program may indicate that brief periods of flows > 250cms during the winter cottonwood dormancy period will not significantly affect recruitment, but until such observations are made, the 250cms cap should be maintained in most years.

Page 5, Table 2.

<u>Fish in Lower Duncan River</u>: "Increase in overall aquatic productivity……….,physical works, *and a more natural-like hydrograph*.

<u>Wildlife in Duncan Reservoir</u>: "Decrease in riparian productivity with implementation of reservoir elevation targets *due to loss of sedge/grass meadow area*.

Page 6, first sentence.

The final CC meeting occurred on April 20-22, 2004, not April 14, 2004.

Page 1-2. Just wondering why the CC process summary is numbered from 2 to 11 and not 1 to 10?

Page 2-1, third paragraph.

Specify what fish flow regulation is. Is it bull trout passage? Is the Lower Duncan 8km in length or is it 10 or 11km?

Page 2-9, section 2.2.6

"bull trout migrate downstream through Duncan Dam to overwinter in Kootenay Lake". I don't think all bull trout migrate through Duncan Dam shortly after spawning in the upper Duncan River system as this statement implies. I suggest changing the sentence to indicate that *some* adult bull trout (or X percentage of bull trout based on the tagging studies) pass through the dam to overwinter in Kootenay Lake.

Page 4-8, Section 4.6.1.

2001 was a record drought year, not a high water year. It would be very interesting to hear from locals that 2001 was a bad mosquito year. Are you sure 2001 was a year indicated as a bad year for mosquitoes?

Page 4-12, second paragraph.

It is important to note that there is no strong scientific data to indicate the relative health of this burbot population.

"If this hypothesis proven correct, stable water levels during burbot spawning would be required……" Burbot embryos and larvae developing in a tributary from a spawning event that occurred at a tributary/reservoir interface may not necessarily experience de-watering or sedimentation with falling reservoir elevations as it cannot be assumed that such tributaries would move (necessary for dewatering) or that the banks would slough (necessary for sedimentation). I would therefore replace the phrase "would be required" with "may be required".

4.7.2.1.

The phrase "recovery of riparian zone" is misleading. Colonization of the floodplain by upland species will increase, as is the case for plant succession in the absence of flows regularly exceeding bankfull. I disagree that encroachment by upland vegetation on the floodplain should be classified as "recovery of riparian vegetation". Such encroachment due to regulation of flows will result in riparian habitat loss. Some colonization by riparian vegetation of exposed bank, mineral soil and sediment deposits etc may occur, particularly under alternative S73, in comparison to previous operations, but there may be a net loss of riparian habitat due to upland vegetation encroachment. Please remove the phase "recovery of riparian zone".

Page 4-14. There was a burbot PM, which was the number of days the reservoir remained stable +/-0.25m during a "guestimated" burbot spawning and incubation period of February 15 to April 15. I recall the PM being dropped due to lack of support for operations to protect burbot other than First Nations community representatives and due to the uncertainty in regards to when and where burbot spawn and the duration of the incubation period. As a condition for supporting the WUP, CCRIFC agreed to remove the burbot PM and the burbot alternative provided that a suitable burbot monitoring program would be implemented to address the identified uncertainties. See page 6-10 which mentions the burbot PM.

Page 4-15, <u>Mainstem Passage</u>.

I reviewed van Dishoeck and Gebhart (2003) and disagree that there is sufficient data to make the conclusion that a velocity barrier to burbot upstream movement does not exist, particularly at the higher discharges. There were three adult burbot observed in total observed by Dishoeck and Gebhart (2003), which were located in logjam and deep/fast habitat. I don't think the velocities at the point where the fish were holding were measured, nor is it known whether the burbot were migrating or moving upstream. I believe velocity measurements were determined at 5 points along a "lane" swum parallel to shore. I would be more comfortable in stating the following: "Based on a model output incorporating depth and channel width for the cross section of the Lower Duncan River located at the Water Survey of Canada gauging station, the presence of a velocity barrier was not apparent". Efforts to capture burbot in the Duncan River some time prior to the implementation of the Duncan WUP resulted in the capture very few (I think less that 10 individuals) individuals. Thus, it would currently be very difficult to definitively determine whether or not a velocity or other barriers exist to upstream burbot movement. I therefore did not consider it feasible to conduct an effective monitoring program to effectively test the velocity barrier hypothesis.

My response to FTC Aug 16, 2004 and November 26, 2004 FTC telecon minute notes.
Note, I was not able to participate in the November 26, 2004 telecon.
Alf, I agreed to relaxing the 250cms constraint in some years if absolutely necessary, in consideration of frequency of MWF (mountain white fish) and flood control requirements, given that natural cottonwood recruitment often occurs in non-regulated rivers at a frequency of approximately 1 in 7 years. Your statement above does not confirm that the 250cms cap would be enforced throughout any year in particular, so I disagree with your statement above as it is currently worded. I clearly stated that CCRIFC should be involved in any decisions involving the relaxation of the 250cms winter cap at any time and that the 250cms cap must be enforced at least once within a seven year period. I would revise the above statement to indicate that in some years the 250cms cap would be enforced.

Furthermore, at the final CC meeting, I remember members of the FTC agreeing to relax the MWF in the late fall to meet the January through to March flood control rule curve if the 250cms max flow had been violated in previous or other years. It is rather strange that the FTC decided this without involving the WTC or CC in discussions or some other form of correspondence prior to making this decision.

Page 4-28, Table 4-18

It should be made clear, perhaps using a footnoted definition, that "recruitment of cottonwood" in the context of the Duncan WUP is defined specifically as the recruitment of cottonwood from naturally produced and naturally dispersed seed. Recruitment from seed is required in order to maintain genetic diversity and diversity of age-classes.

Page 4-30, Section 4.9.4.2, Last paragraph

"The measure incorporates……………on conditions that may have led to past cottonwood recruitment from *seed*, including……"

Page 4-36, third paragraph

"If a variance were not granted, BC Hydro would need to consult with………and affected First Nations…"

Page 4-39

See comment above regarding burbot on page 4-14.

Page 4-41, table 4-28

Under Fish: The PM kokanee effective spawning habitat lost is repeated. I believe the first Kokanee spawning PM is simply *kokanee effective spawning habitat*?

Page 6-9

"The purpose of target flows in lower Ducan River…………….optimize the potential availability……for successful spawning *and rearing* in side channels.

Page 6-15

We might indicate that Alt N 90 was created, also with the purpose of increasing cottonwood recruitment while at the same time incorporating fish flows. However, Alt M 90 was believed to be better for cottonwood and therefore Alt N was dropped. However, Brenda Herbison did feel that Alt N 90 performed the best for cottonwood in low flow years.

Page 6-20, table 6-5.

Lower Duncan River Flows, Alt Q: Does the 90cms target flow span between 15 Sept and 21 or 31 of Oct? Table not consistent with Alternative definition on previous page.

Page 7-52

Clarify whether the Duncan WUP was a conditional non-consensus or consensus so that we have a consistent story. There should be a clarifying statement in the Executive Summary to indicate the consequence of the RDCK position: that the WUP was a non-consensus WUP as a result.

Page 7-60, first sentence.

"…….has addressed the mosquito issue by including *maximum* (not minimum) flow (400cms) constraints……."

Page 7-69

I also recall a commitment by BCH to conduct a feasibility study for protecting the Argenta Slough and Cultural Heritage sites this summer or fall, prior to the implementation of the WUP. Were these studies implemented this year? If not, why weren't they and when are they expected to be implemented? It was stated that BCH could do the assessment studies this year prior to the implementation/approval of the WUP. BCH would then be reimbursed from the Province.

Page 7-71,

-regarding complexing with woody debris for habitat restoration restoration.

I recall requests to utilize woody debris for enhancing fish habitat within the reservoir. I doubt any more woody debris will be needed in the Lower Duncan within the 10 year review period.

Page B-3

Mary Williams served as the CCRIFC Hydro Impacts Technician and attended some of the Duncan WUP CC and technical committee meetings. He should probably be identified as an observer.

F-9, How is this performance measure calculated.

"Fish stranding performance measure…………………………….surface area at the minimum reservoir elevation (22 sq km)".

Why not use scientific units: km^2 ?

F-8. Fish stranding is also an important issue because unauthorized stranding is a violation of the Fisheries Act. Include this statement under the "why is the fish stranding performance measure important" section. The reference to the Fisheries Act should also be stated in the body of the CC report, not just in the appendix.

Pages F15, F19, F25 and F26: the acronyms min and mdn used in the model formulas are not always defined. I think for clarity sake, especially for folks reviewing this document after the 10-year review period, it would help in understanding these models. I'm sure most modellers will figure them out, but the final WUP CC report, I'd expect, will be reviewed by a cross-section of society.

I think the burbot PM should be presented in appendix 3.0 for completeness and may prove useful in the future.

F-30. Section 4.1.

The ***Cultural Site Erosion*** performance measure is important because destruction of archaeologically significant artefacts is a violation of the Heritage Conservation Act. Reference to the Heritage Conservation Act should be made in the appropriate section of the main body of the CC report.

F-31, first bullet "The cultural significance of sites…….are higher *than the sites observed* in the upper reservoir elevation zone".

I would provide a footnote as a reference to this assumption to clarify that only a surface investigation of a portion of the Duncan drawdown zone was conducted in which tools and stone flakes from stone working was found in the upper site whereas a spear point, stone flakes, stone tools etc were found in the lower elevation site(s). The contents and full extent of these sites is expected to be determined under the Archaeology study of the monitoring program.

F-37-Riparian Productivity Performance Measure.

One of the benefits of increasing vegetation in the Duncan Drawdown Zone was the protection of cultural heritage sites from erosion and illegal looting. I would add this benefit to the "Why are these performance measures important" section.

F-39. Second bullet under key assumptions and uncertainties.

"The long-term median elevation mark……..of Revelstoke *Reach of the Arrow Reservoir* (?) and *of the* Arrow Lakes Reservoir *main basin* riparian communities."

I'm not aware of any riparian studies or investigations completed by Anne Moody in the Revelstoke Reservoir, so I am assuming Revelstoke Reach is being referred to in this section.

F-41

Possible error in formula: Area (EI) = "Unit slope……..and has a slope ≤ *5%* not 15% as stated on page F-41.

F-43

"Factors influencing cottonwood recruitment *from seed* include……"

F-47

Under section "How is this performance measure calculated".

State why local tributaries such as Meadow Creek and Cooper Creek are not included in performance measure estimates. I think it would be very useful to provide a detailed map of the Lower Duncan River to identify tributary locations in ***Section 2, Description of Duncan Dam Project***.

F-52

VOE is defined both as Value of Energy and average annual revenue, which may be a bit confusing. Explain why VOE has two definitions.

End of comments by Mark Tiley.

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January 31st, 2005

Ms. Sue Foster
Duncan Dam Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster,

Subject: BC Hydro Duncan Water Use Planning Processes

Thank you for the opportunity to provide comments on the Draft Consultative Committee Report for the Duncan Water Use Plan (WUP).

The Columbia Basin Trust (CBT) participation on the Duncan Water Use Plan Consultative Committee (Duncan WUP CC) was undertaken with the objectives of ensuring that a broad range of interests and values had the opportunity to participate at the CC table and were given adequate consideration in the CC discussions. We are confident in saying that these objectives were met on the Duncan Water Use Plan.

We would like to commend BC Hydro and the Process team for their efficiency and professionalism throughout this three-year process. We also commend BC Hydro for the openness and participatory nature of the consultative committee make up. It is my observation that the Process team made every effort to ensure that any individual or group who wished to be represented at the consultative committee table had the opportunity to do so.

We note, however, that due to the technical nature of the discussions at the consultative committee table, the extensive commitment of time that this process required, and the financial implications of volunteers donating their time, that most community-based organizations have difficulty in effectively participating in such processes. We further note that, while the Provincial, Federal and First Nations organizations had paid resource people to participate and ensure that their interests were well represented, other community interests were largely reliant on volunteer contributions. We emphasize that this reflected an inequity of resources representing various interests. In future, such processes should ensure that if effective engagement is sought from all interest groups, resources and support mechanisms need to be in place to provide the capacity for community-based organizations to effectively participate.

a legacy for the people

We would also like to commend the BC Hydro Process team on their process design. The process design is to be singled out for praise for creating a framework to make "consensus-based" decisions on some very complex and technical issues. From the perspective of a consultative committee member, it was a very rewarding and educational experience.

However, it should be noted that the overall water use planning process, and the recommendations coming out of the process, were developed under a specific set of constraints imposed by those involved in the creating the process:

- It should be emphasized in the consultative committee report that this process was designed to look at potential improvements in current operations, but specifically did not address historical footprint issues of the facilities involved. This operational linkage was a very important factor through the decision-making process and the trade-offs that were made.
- There was an indication of a "nominal" cap on anticipated province-wide costs resulting from the WUPs of approximately 50 million dollars per year. It was our early understanding that the Provincial Government had put this "cap" on the Water Use planning process. Thus, operational changes that may have provided significant benefit for a number of values, but had major financial impacts, were eliminated from consideration early in the process.
- To our knowledge there was no consideration given to the percentage of generation attributed to each facility or region and an equitable distribution of this "nominal provincial cap". Thus, from a proportional perspective, the Columbia Region which provides approximately 50% of the power generated in the province should expect to see a large share of this benefit.
- It was stated in the beginning of the process that operations under Columbia River Treaty would be considered as a "hard" constraint. Later after much discussion it was decided that some operational changes could be realized if the US entities agreed to the operation. As a consultative committee member, CBT would like to see a list of the operations that are possible to realize with and without the CRT in place so we can effectively analyze at the next WUP review if any of these operations are worth pursuing negotiation with the US Entity.

The recommendations contained in the CC report represent an "adaptive management" approach. The CC has made some recommendations to change operations, in the hope of seeing a wide range of benefits. The monitoring package is a recognition that we need to learn whether or not these changes have the desired outcomes. The same can be said for the proposed monitoring of interests/values for which CBT wants to understand how they are affected on an on-going basis by the proposed operation. While the price for this monitoring package may appear high, the investment into understanding how the regulated system works, and its effect on various values, is long overdue. This information will help to focus and refine river-system operations for generations to come.

From our perspective the Draft CC report accurately captures the discussions, trade-offs and decisions that were made at the Duncan Water Use Plan table over the course of three years. Again, we would like to compliment the Process team for their diligence and accuracy of information.

The CBT supports the Consultative Committee in its decision to recommend the implementation of preferred operating alternative S(73). We also support the Consultative Committees recommendations with respect to the non-operational physical works, the monitoring studies and the non-water use plan recommendations, subject to the comments listed below.

The following is a list of specific comments on the Draft Consultative Committee Report for the Duncan Water Use Plan:

<u>Section 4 Issues, Objectives and Performance Measures</u>

- It should be made clear both in the executive summary of the report and in this section that the Scoping report for the Duncan WUP did not include all potential issues on fishing or property interests on Kootenay Lake or the Kootenay River System (as noted on page 12 of the CC meeting #8)

<u>Section 7.7 Round 3 Final Trade Off Analysis</u>

- The Columbia Basin Trust would like the following statement inserted on page 7-32, clarifying our position and concerns with respect to the Columbia Basin Trust Energy/Columbia Power Corporation Joint Venture Power Projects: *The CBT consultative committee member indicated that the WUP process needs to account for any potential negative impacts on all interests and values that result from an alternative operating regime, and that appropriate compensation or mitigation measures should be implemented. As such, the CBT cannot support any WUP alternative that may have negative financial impacts on the CBTE/CPC joint venture projects. It was also noted that financial impacts to these joint venture projects could impact the benefits CBT delivers to Basin residents, the very residents who were most directly impacted by the creation of the Columbia River Treaty Dams. Should the CBTE/CPC joint venture power assets not be kept whole through the WUP process, the Province of BC and BC Hydro could be unduly burdening the people of the basin with the financial costs associated with improved operations at the BC Hydro facilities. The Columbia Basin Trust would then need to consult with its constituents prior to indicating support for any such alternatives. CBT's views on this issue would be similar should impacts be identified for any other interest or value.*

7.7.11 Non-operational Physical Works

7.7.11.6 Partial Finding Towards the Regional District's Mosquito Abatement Program

- As noted in the CC report and documented over the 3 year WUP process the Duncan WUP CC has looked extensively at the mosquito issues in the Lower Duncan Valley. The CC deliberations have spent a lot of time and effort looking at operational cause and effect with respect to mosquito impacts. The new proposed operational alternative S(73) has built-in operational constraints to limit and reduce late summer re wetting events that are suspected to contribute to increased mosquito hatching events.
- The CBT supports continued monitoring of Duncan Dam operations to evaluate operational linkages to increased mosquito habitat and hatching in the lower Duncan River.

7.7.11.7 Partial funding of the Columbia Basin Fish and Wildlife Compensation Program's Nutrient Loading Program

- The outcome at the last CC meeting was *"No clear direction from the CC regarding providing funding contributions to the CBFWCP for the Kootenay Lake Fertilization Program. Further analysis of Nutrient Loading impacts from Duncan operations is required. BCH will determine whether operational impacts warrant funding".*
- The Fish and Wildlife Technical Committee might have made a determination on this issue, however the CC as a whole has not agreed to make this particular item part of the

recommendations coming forward in the CC report. We also did not make a group CC decision as to whether this particular item should be within the scope of the WUP. There are some incrementality issues associated with this project that need to be clearly identified. This is an existing program that has been implemented as a "footprint" issue. As such, it raises some questions as to whether this item should be considered under the jurisdiction of the WUP. Since the CC as a whole has not had the opportunity to consider this issue further, including it in the WUP report at this time is not acceptable.

- BC Hydro is welcome to make its own decisions as to whether it chooses to fund this project outside of the WUP CC decisions.

7.7.11.8 Erosion Protection Measures of Agricultural Lands in the Lower Duncan River

- The CBT supports the need to recognize and address local agricultural community concerns over erosion issues linked to dam operations.
- To this end, we support the CC in their efforts to implement a monitoring program to assess the impacts of operations on erosion on agricultural lands in the lower Duncan River area.

Section 8 Monitoring Program:

8.2 Proposed Monitoring Studies

- With respect to the Mosquito Monitoring study, in order to ensure local residents are informed that the Duncan CC placed a high priority on quality of life issues, public education and participation should be sought in this program. Such public engagement will also provide people with information on the anticipated benefits of alternative S73 with respect to the mosquito issue.
- Given the uncertainties expressed by CC members with respect to the assumptions used to evaluate recreational use/benefit on the Duncan reservoir, it would be beneficial to monitor recreation use on the reservoir by season of use, preference of reservoir elevation, type of use and location, so that we can better address operational impacts on recreation in this area

8.5 Recommended Monitoring Studies

- Are there not 13 proposed monitoring studies?
- Which of the proposed monitoring studies are designed to look at the erosion issues on the Lower Duncan River area?
- As stated at the CC meetings, the CBT requests preference be given to hiring or contracting out to local Columbia Basin residents for any work awarded under the Monitoring program or Physical Works program coming out of the BC Hydro WUP process

Yours truly,

Kindy Gosal
Manager Water Initiatives
Columbia Basin Trust

Columbia Power Corporation
Comments on the Duncan Dam Water Use Plan
Draft Consultative Committee Report
November 2004

Columbia Power Corporation ("CPC") has reviewed the Duncan Dam Water Use Plan ("WUP") Draft Consultative Committee ("CC") Report, November 2004, ("the Draft Report") and has the following comments.

Executive Summary

1. Page 2, Power Generation bullet:
   - Add "and Columbia River" after "Kootenay River" in line 1, and delete "and downstream Columbia River Treaty plants" in line 2. It is not clear if the reference to downstream CRT plants refers to U.S. plants; the only impact considered during the WUP process was lower Columbia impacts at Keenleyside and Arrow Lakes Generation Station ("ALGS"), which is not downstream, but rather upstream on the Columbia River. Further, ALGS is not a Columbia River Treaty plant.

2. Page 3, paragraph 3, under Recommendations, last sentence:
   - Replace "stating that they could now accept the preferred Alternative S (73)." with "stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, Columbia Power Corporation, on behalf of the Columbia Power Corporation/Columbia Basin Trust joint ventures, can now accept the preferred Alternative S (73). (see Appendix I)".

3. Page 8, 4th bullet under Physical Works:
   - The introductory paragraph to this section leads one to believe that the CC recommended partial funding of the Nutrient Loading Program. However, the CC did not recommend the partial funding for the Columbia Basin Fish and Wildlife Nutrient Loading Program, rather, this was a subsequent recommendation of the Fish Technical Subcommittee, as noted on page 7-62. This should be clarified via a footnote or a parenthetical comment.

Body of the Draft Report

4. Section 2, page 2-10, paragraph 1:
   - Line 8 – replace "for Kootenay Lake storage" with "for one-half of Kootenay Lake storage".
   - Line 9 – insert after "which regulates the lake levels." the following sentence: "Brilliant Power Corporation, a CPC/CBT joint venture that owns the Brilliant Powerplant, is the water-licence holder for the other one-half of Kootenay Lake storage."

5. Section 2, page 2-10:
   - Insert a short paragraph after paragraph 2 to note that CPC/CBT's Brilliant Powerplant ("BRD") and Brilliant Expansion Project ("BRX"), which is currently being constructed, are located near Castlegar and use regulated Columbia River Treaty flows. Further, it should be noted that, because of the need to achieve certain Columbia River Treaty flow levels at the Canada-U.S. border, there are cross-system impacts at lower Columbia River facilities (including CPC/CBT's Arrow Lakes Generating Station) as a result of the various options studied for Duncan Dam (and thus Kootenay River flows). See, for example, section 7.6, paragraph 2 and footnote 1, page 7-30.
6. Section 2, page 2-11:
   - Add BRX and ALGS to Figure 2-5.
7. Section 4, page 4-16:
   - Insert "owned by Arrow Lakes Power Corporation (a joint venture of Columbia Power Corporation/Columbia Basin Trust)".
8. Section 4, page 4-37, table 4-26:
   - The unit for the Power–Kootenay River performance measure ("PM") should be "megawatt hours (MWh)".
9. Section 4, page 4-38, paragraphs 2, 3, 4 & 5:
   - Paragraphs 2, 3, 4 & 5 – delete "that the Province would receive". This is misleading in that it suggests the provincial government may own all of these facilities.
   - Paragraphs 3, 4 & 5 – line 2 of each paragraph – replace "the average annual revenue (VOE)" with "the estimated average annual value of electricity (VOE)". The term "revenue" in these PMs suggests that they estimate the returns earned by plant owners or BC Hydro as the system operator. "Value" is the more accurate term, and leads into the discussion in section 4.11.4.1 on page 4-39.
   - Paragraphs 2, 3, 4 & 5 – It should also be clarified in each paragraph that the PM values, respectively for MWh of generation and VOE, are differentials from Alternative A, the power optimal operations alternative.
10. Section 4, page 4-38, second to last bullet:
    - Replace "completed in 2006" with "in commercial operation in September 2006".
11. Section 4, page 4-40, table 4-27, Power Generation, "All plants in Canada affected by Duncan operations" row:
    - In the rationale for the eliminated Performance Measure "Operational Flexibility", insert "Difficult to estimate a meaningful metric;" before "Replaced by". Also see point 19 below.

12. Section 4, page 4-41, table 4-28, Power Generation row, Units of Measure column:
    - Replace “compared to current operations” with “compared to Alternative A” or “compared to power optimal operations”.
    - As noted on page 7-27, Alternative A does not represent current or historic operations (although it is the closest to it), but rather an alternative that maximizes generation.

13. Section 6, page 6-2, paragraph 1:
    - Line 3 – replace “Columbia Power Corporation’s” with “Columbia Power Corporation/Columbia Basin Trust”.
    - Line 6 – after “Project” add the following: “and an eighth generating station, the 125 MW Brilliant Expansion Project, is currently under construction and is scheduled to be in commercial operation in September 2006”.

14. Section 6, page 6-8, table 6-1, Alternative A, row 1, column 1:
    - Replace “Current Operations” with “Power Optimal Operations”.
    - See comments in point 12 above.

15. Section 7, page 7-27, first paragraph, line 3 to 4 and last paragraph, Alternative A, line 1:
    - Replace “Current Operations” with “Power Optimal Operations”.
    - See comments in point 12 above. You may want to do a “find all” search of the document to catch and replace other occurrences of “Current Operations”.

16. Section 7, page 7-32, second paragraph:
    - Insert the following paragraph prior to: “At the beginning of”:

      In a letter of April 19, 2004 to BC Hydro, Columbia Power Corporation, as manager of the CPC/CBT joint ventures stated that: CPC’s interest in the Duncan WUP is to ensure that CPC/CBT joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from the implementation of the Duncan WUP; to protect the important public interests represented by the CPC/CBT joint ventures, CPC must object to any WUP alternative that impairs the rights of the CPC/CBT joint ventures; accordingly, CPC cannot support any of the current alternatives being considered for the Duncan WUP and may object to them before the Comptroller of Water Rights; however, CPC are willing to consider other alternatives that protect the interests of the CPC/CBT joint ventures.

    - Line 3 to 6 – Replace “their interests were not being met ... operational changes at the Duncan Dam facility. Since” with “since”.

17. Section 7, page 7-32, third paragraph, Columbia Power Corporation and Columbia Basin Trust Condition:
    - Line 6 - replace "arising" with "arising, directly or indirectly,".
    - Line 8 - replace "except Alternative A - Current Operations." with "except Alternative A - Power Optimal Operations, and may object to them before the Comptroller of Water Rights."

18. Section 7, page 7-32, fourth paragraph, line 2:
    - Replace "stating that they could now accept" with "stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, CPC, on behalf of the CPC/CBT joint ventures, can now accept".

19. Section 7, page 7-36, Table 7-12, Operational Flexibility, Rationale for Removal:
    - Replace "Considered redundant with the addition of the new Financial Revenue performance measure for the lower Columbia River System" with "Difficult to estimate a meaningful metric."
    - Cross-system impacts at lower Columbia facilities and impacts on overall system operational flexibility are two different issues. Cross-system (Columbia versus Kootenay) impacts at Keenleyside/ALGS were originally overlooked, as a result of WUP simplifying assumption, and arise because of Columbia River Treaty flow requirements at the Canada/U.S. border, as described in section 2 and on page 7-30, footnote 1. Once again, this is different from the issue of developing a performance measure to evaluate changes in operational flexibility.

20. Section 7, page 7-51, Table 7-21, "Support for Alternative S (73)" column:
    - For CC Member Bruce Duncan, replace "Supports as per CPC condition (section 7.7)" with "Accepts as per CPC condition (refer to Section 7.7 and Appendix I)".

21. Section 11, page 11-1, 2nd paragraph, last line:
    - Replace "stating that they could now accept the preferred Alternative S (73)." with "stating that, relying on the Minister's Letter of Direction and BC Hydro's Letter of Commitment, Columbia Power Corporation, on behalf of the Columbia Power Corporation/Columbia Basin Trust joint ventures, can now accept the preferred Alternative S (73). (see Appendix I)".

22. Section 11, page 11-2, Table 11-1, "Physical works in lieu" row:
    - As noted in point 3 above, the CC did not recommend the "Partial funding for the Columbia Basin Fish and Wildlife Nutrient Loading Program", rather, this was a subsequent recommendation of the Fish Technical Subcommittee, as noted on page 7-62. This should be clarified via a footnote or a parenthetical comment.

February 9, 2005

Columbia Power Corporation
Comments on
31 August 2005 - DRAFT - Consultative Committee Report
Duncan Dam Water Use Plan

Columbia Power Corporation ("CPC") has reviewed subject document and has the following further editorial comments.

1. Executive Summary, page 3, paragraph 2 of the "Recommendations" section:
   - Line 6 – Insert "joint" before "ventures,"
   - Line 7 – Replace "Alternatives" with "Alternative"

2. Sections 2 through 7:
   - A search of the document shows that "Arrow Lakes Generating Station" is used 12 times and "ALGS" is used 17 times. The acronym "ALGS" is not defined the first time "Arrow Lakes Generating Station" occurs on page 2-10, and then is subsequently defined – i.e. "Arrow Lakes Generating Station (ALGS)" is used – on pages 4-16, 4-17, 4-35 (where it is defined twice on the same page), 4-38 and 7-30 (where it is defined once in the text and once in a footnote). I suggest you standardize the treatment and consider deleting all occurrences of "ALGS" and simply using "Arrow Lakes Generating Station" in all places.

3. Section 6.2, page 6-2, paragraph 1:
   - Lines 3 to 4 – Replace "the Columbia Power Corporation's (CPC)/Columbia Basin Trust (CBT)" with "Brilliant Power Corporation". Brilliant Power Corporation has already been introduced as a CPC/CBT joint venture and the owner of the Brilliant Powerplant on page 2-10.
   - Lines 7 to 8 – Replace "the 125 MW Brilliant Expansion Project," with "the Brilliant Expansion Project, owned by Brilliant Expansion Power Corporation (a joint venture of Columbia Power Corporation/Columbia Basin Trust), which". This parallels the treatment of Brilliant Power Corporation in the first paragraph of page 2-10 and Arrow Lakes Power Corporation at the bottom of page 4-16.

4. Section 7.7, page 7-32, paragraph 2:
   - Line 3 – insert a "," after "joint ventures" and replace "interests" with interest".

5. Section 7.7, page 7-33, paragraph 1, comment box:
   - Line 7 – insert a "," after "indirectly".

6. Section 7.7, page 7-33, paragraph 2:
   - Line 5 – insert "joint" before "ventures" and replace "Alternatives" with "Alternative".
   - Line 6 – insert a paragraph break and start a new paragraph beginning with: "The following...".

7. Section 7.7.9, page 7-52, table 7-21:
   - Column “Support for Alternative S (73)” and row for “Bruce Duncan” – Line 4 – Replace “Appendix J” with “Appendix I”.

8. Section 7.7.9, page 7-53, comment box:
   - Third bullet point, line 2 – insert “and Appendix I” after “Section 7.7”.

September 9, 2005