Consultative Committee Report

Volumes 1 and 2

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Prepared on behalf of:

The Consultative Committee for the Columbia River Water Use Plan

Columbia River Water Use Plan

A Project of BC Hydro

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BC Hydro Contact:

Kootenay – Lower Columbia Community Relations

Phone: 250-365-4562

Project Team:

Trade-off Analysts and Facilitators:	Lee Failing, Basil Stumborg and Stuart Gayle
Resource Valuation Task Manager:	Basil Stumborg
Aboriginal Relations Task Manager:	John Emery
Community Relations Task Manager:	Sue Heaton
Environment Task Manager:	Wayne Duval and Pat Vonk
Power Facilities Task Manager:	Ian MacLean
Power Modeller:	Thomas Siu
Power Studies Task Manager:	Allan Woo
Recreation Task Manager:	Basil Stumborg

Project Manager:

Sue Foster

Phone: 604 528-2737

Fax: 604 528-2905

E-mail: sue.foster@bchydro.com

This report was prepared on behalf of the Columbia River Water Use Plan Consultative Committee, in accordance with the provincial government's *Water Use Plan Guidelines*.

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

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

Dedication

To Wayne Duval, BC Hydro Project Team Member

The Columbia River Water Use Plan Consultative Committee and BC Hydro Project Team would like to honour the memory of Wayne Duval who passed away in the summer of 2003. Wayne's involvement in this process reflected his commitment to the application of good science and dedication to ensuring sound decision-making. He recognized the competing interests and needs that were brought to the consultative table, and worked diligently to safeguard collaboration and respect. For some of us, our time with Wayne was all too short.

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 Columbia River Water Use Plan Consultative Committee. It is the basis for the Columbia River Draft Water Use Plan for BC Hydro's Mica, Revelstoke and Hugh Keenleyside projects. Both the Columbia River Consultative Committee Report and the Draft Water Use Plan will be submitted to the Comptroller of Water Rights.

Columbia River Treaty

The Columbia River Treaty was signed between Canada and the United States of America in 1961 and ratified in 1964. BC Hydro was appointed as the Canadian Entity under the Treaty. Under the terms of the Treaty, BC Hydro built and now operates 15.5 million acre-feet (MAF) of storage at the Mica (7.0 MAF), Hugh Keenleyside (7.1 MAF) and Duncan (1.4 MAF) projects in co-ordination with the United States to maximize power generation and flood control benefits in both countries. In return, Canada received an up-front payment for the flood control benefits as well as one-half of the annual additional power generation benefits produced at the downstream U.S. projects on an on-going basis. There is no specified termination date for the Treaty; however, the earliest the Treaty may be terminated by either party is 2024, provided notice is given 10 years prior.

Mica Project

The Mica Project is located on the Columbia River about 137 km north of Revelstoke. The project was completed in 1973, and consists of an earthfill dam, low-level outlets (now permanently closed), outlet works and a chute spillway. The generating station was completed in 1977, and contains an underground powerhouse with four operating units and space for two additional units, and a switchgear building. Kinbasket Reservoir was formed by construction of the dam, and has a total live storage capacity of 12 MAF.

Revelstoke Project

Revelstoke Dam is located on the Columbia River about 5 km upstream from the City of Revelstoke. The project was completed in 1984, and consists of an earthfill wing dam and a concrete gravity main dam. The main dam includes the power intakes with steel penstocks in the middle and spillway facilities to the right. The powerhouse is located directly downstream of the power intakes, and the switchgear building is located on the right side adjacent to the spillway chute. The powerhouse currently contains four operating units, with space to install two additional units in the future.

The reservoir formed by construction of Revelstoke Dam is known as Revelstoke Reservoir. It is fed largely by the flow discharged from the Mica Project, with additional water from local inflow. The reservoir is licensed to store 1.5 MAF.

Although the Revelstoke Project is not covered directly under the Columbia River Treaty, the project may be called upon by the Treaty to provide flood control [Article IV(2)(b)]. It is also specifically precluded from operating in a fashion that reduces the benefits contemplated by the Treaty [Article IV(5)]. Except for the obligations included in the water licences, the Columbia River Treaty and the Non-Treaty Storage Agreement (NTSA), there are no other formal agreements or obligations for the operation of the Revelstoke Project.

Hugh Keenleyside Project

Hugh Keenleyside Dam is located on the Columbia River about 8 km west of Castlegar. The project was completed in 1968, and consists of an earthfill dam, a concrete dam, four spillways, eight low-level outlets (ports) and a navigation lock. Arrow Lakes Reservoir has a live storage capacity of 7.1 MAF below its normal upper limit of 440.14 m (1444.0 ft). Prior to project development, the reservoir was two natural lakes (Upper and Lower Arrow lakes).

The Hugh Keenleyside Project is operated under the terms of the Columbia River Treaty and the Non-Treaty Storage Agreement. The original facility was not constructed to have power generating capacity. However, under a joint venture between the Columbia Power Corporation (CPC) and Columbia Basin Trust (CBT) pursuant to the provincial government's Columbia Basin Initiative[1], the Arrow Lakes Generating Station (ALH) was constructed adjacent to Hugh Keenleyside Dam. The Arrow Lakes Reservoir, Hugh Keenleyside Dam and ALH operations are co-ordinated pursuant to a Release Co-ordination Agreement, approved by the Comptroller of Water Rights.

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[1] In 1995, the provincial government created the Columbia Basin Initiative in recognition of the costs borne by the region due to construction of the Columbia River Treaty dams. Legislation was enacted establishing the Columbia Basin Trust and a financial agreement was entered into providing the Columbia Basin Trust and Columbia Power Corporation funding for power project developments in the region, including the Arrow Lakes Generating Station. The Trust's share of power project returns is used to provide benefits to the people of the region.

Consultative Committee

The Columbia River Water Use Plan Consultative Committee process was initiated in February 2001 and completed in June 2004. The consultative process followed the steps outlined in the 1998 provincial government's *Water Use Plan Guidelines*.

The Consultative Committee members included representatives of BC Hydro, provincial and federal government agencies, municipal government, industry, First Nations, and local stakeholders. The Committee held a total of seven meetings and was supported by numerous technical subcommittee meetings.

The Consultative Committee was initially comprised of 35 members. Over the course of the Columbia River water use planning process, some members opted to change their status to observer status, others were reassigned other duties, and some new members joined the Committee. Those who moved to observer status were comfortable that other Committee members represented their interests. There were 39 Committee members who actively completed the water use planning process.

Structured Decision-Making Process

The Consultative Committee explored issues and interests affected by operation of BC Hydro's Mica, Revelstoke and Hugh Keenleyside projects, and agreed to fundamental objectives for the Columbia River Water Use Plan, as outlined below in Table 1.

Table 1: Fundamental Objectives for the Columbia River Water Use Plan

Interest	Fundamental Objectives
Culture and Heritage	• Minimize erosion impacts of water on potential archaeological zones. • Minimize erosion impacts of wind on potential archaeological zones. • Minimize the impact of destructive human behaviour (traffic, pot hunting, etc.) on potential archaeological zones. • Allow access to archaeological sites by appropriate people. • Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites. • Provide access to tradition plants. • Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities.
Fish and Aquatic Resources	• Maximize the abundance, diversity and condition of wild, indigenous fish stocks in the Columbia River system.
Flood Erosion Control	• Minimize damage to property and injury to people.
Learning	• Maximize learning about the impacts of operations on non-power objectives.
Navigation	• Minimize disruptions to commercial navigation/transport.
Power Generation	• Maximize the power benefits produced by the combined operation of Mica, Revelstoke and Hugh Keenleyside facilities.
Recreation	• Maximize the community benefits from quality and diversity of recreation and tourism.
Wildlife and Vegetation	• Maximize wildlife abundance and diversity in the Columbia River system.

The Consultative Committee developed performance measures for the 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.

Scope of the Columbia River Water Use Planning Process

In addition to the general guidance provided for all of BC Hydro's water use planning programs in the provincial government's *Water Use Plan Guidelines* and related documents, the provincial government also directed the Columbia River Water Use Plan Consultative Committee to consider the following in their trade-off discussions.

In a letter dated 19 February 2001, the Chair of the Water Use Plan Steering Committee provided the following direction to the Columbia River Water Use Plan Consultative Committee: "*The Province has made a policy decision that the magnitude of change it is willing to accept on the Peace and Columbia is smaller compared to other systems undergoing water use planning. In addition government by policy has set a cap on the funding to support the implementation of water use plans, so it is important to ensure funds are available for a wide range of projects. Government recognition of the high values of these river for power generation was articulated in its 1998 response to the BC Heritage River Board, in which it endorses the Columbia and Peace remaining as working rivers compatible with natural heritage and recreational values.*"[1]

There was significant debate by the Consultative Committee over whether the Columbia River water use planning process should be limited by the provincial government's funding cap (i.e., $50 million/year in lost revenue across of all BC Hydro's facilities). A number of proposals for reasonable limits for this Water Use Plan were put forward, ranging from 1/25th (corresponding to the 25 Water Use Plans) to 45 per cent of the System Operating Fund (SOF) (corresponding to the percentage of BC Hydro's energy that is produced at the Columbia River facilities). Some members did not agree with limiting the process by the SOF because they felt that the federal government has a fiduciary responsibility to protect First Nations interests, as well as legal obligations with respect to heritage, fisheries and international agreements. Other Committee members agreed with a funding cap and the notion of the Columbia River as a "working river", recognizing the incremental nature of the process and the need to ensure that the work of the Consultative Committee is not ignored at the end of the process. In the end, the Consultative Committee agreed to the following:

- The Committee recognizes that there are legal obligations that will need to be considered and, therefore, it is impossible at this time to set a firm upper bound on cost.

[1] O'Riordon (19 February 2001). *Letter to the Peace and Columbia River Water Use Plan Consultative Committees.*

- The Committee may define alternatives that reflect participant's longer-term vision for the future of the Basin, unconstrained by budget considerations.

- The Committee recognizes that the provincial government designed the water use planning process with an upper limit on cost, and the Committee should consider the value of the SOF in developing its recommendations to maximize the probability that their work and recommendations will be implemented.

- There should be two categories of alternatives, which are treated differently in the process: alternatives that likely fall outside the scope of water use planning that will receive qualitative assessment; and alternatives that are likely within scope that will receive more rigorous analysis.

Columbia River Treaty

The *Water Use Plan Guidelines* specifically identifies the Columbia River Treaty as one of the international agreements to be taken into account when preparing Water Use Plans. The Treaty dictates required weekly flows across the United States border and thus limits the feasible scope of operational changes. However, the Treaty does allow for changes to its default operation so long as both parties (U.S. and Canadian Entities) agree to such changes and the changes would provide additional benefits for both countries.

The following guidelines were provided to assist the Consultative Committee in determining which operating alternatives could be considered within the scope of the Columbia River water use planning process.

- The Water Use Plan may consider operating alternatives that include incremental changes to existing operations that BC Hydro can unilaterally implement. A partial list includes some flex operations (swapping water between Kinbasket and Arrow Lakes reservoirs), constraints on reservoir maximum/minimum levels that can be accomodated within Treaty operations, ramping rates and incremental use of the BC Hydro portion of the Non-Treaty storage.

- The Water Use Plan may consider operating alternatives that affect Detailed Operating Plans and Supplemental Operating Agreements developed under the Treaty, or operations under the Non-Treaty Storage Agreement. However, BC Hydro's ability to secure such an operating alternative is dependent upon successful negotiations with the U.S. Entity and, possibly, other affected parties following the Water Use Plan. The likelihood of achieving such an agreement must be assessed by the Consultative Committeee when considering operating alternatives to be modelled.

- The Water Use Plan operating alternatives will recognize local and downstream flood control operations, as required by the Columbia River Treaty.

- Violating the Columbia River Treaty is outside the scope of water use planning as it may expose the Province of British Columbia to possible contractual liabilities and potentially very large financial risks associated with downstream benefits.

Non-BC Hydro Owned Facilities

BC Hydro's water use planning process was designed to specifically address BC Hydro facility operations. It was not intended to review the operations of hydroelectric facilities that are owned by entities other than BC Hydro. As such, it was established at the outset of the Columbia River water use planning process that the Water Use Plan would be restricted to review of Mica, Revelstoke and Hugh Keenleyside project operations. Although some interests in the lower Columbia River are affected by both flows out of Arrow Lakes Reservoir and the Kootenay River system, operational changes on the Kootenay River system were considered outside the scope of the process. While BC Hydro, through commercial agreements, manages water on the lower Kootenay River, these facilities are not owned by BC Hydro and therefore were excluded from the Water Use Plan.

The Operations Model developed to simulate operating alternatives for the Columbia River Water Use Plan captured operation of the Columbia River system as a whole, and was designed to determine the most economic dispatch of the generating system, subject to the operating constraints and objectives under a range of streamflow sequences. The model therefore calculated the sum of power costs at BC Hydro's Mica and Revelstoke projects, as well as ALH.

The Consultative Committee's understanding of the links between BC Hydro operations and ALH and how this was incorporated into the modelling evolved over the course of the Columbia River water use planning process. There was considerable debate by the Committee as to whether ALH should be included in the modelling of power costs associated with the proposed operating alternatives. While some Consultative Committee members felt that the focus of discussions should be on whether the benefits to interests are worth the cost as a whole (irrespective of who is bearing the costs), other Committee members felt that consideration of this lost power generation opportunity at ALH in the trade-off analysis might be beyond the scope of the water use planning policy framework and the November 1998 government policy directive to BC Hydro. Additionally, both Fisheries and Oceans Canada (DFO) and the Ministry of Water, Land and Air Protection (MWLAP) representatives maintained that the ALH Project Approval Certificate (PAC) recognized the value of flexibility in flows at Hugh Keenleyside Dam for fish and fish habitat management, and specifically included provisions to ensure that operation of ALH would not preclude beneficial opportunities for fish and wildlife. There was concern that inclusion of foregone power values at ALH might be inconsistent with the ALH PAC. The Consultative Committee agreed that this issue would be most appropriately resolved at the policy level.

Although the issue of whether the ALH PAC restrictions had any implication for the Columbia River Water Use Plan was not resolved at the Consultative Committee table, a June 2004 government policy directive to BC Hydro directing it to save CPC/CBT power projects harmless from any adverse effects resulting from implementation of the Water Use Plan meant that the financial impacts at ALH were included in the power cost calculations of the proposed operating alternatives.

Water Use Plan Recommendations

To ensure meaningful decision making for the Columbia River water use planning process, relevant information was gathered as part of Step 5 of the process to help refine estimates of flow-related impacts. In several cases, however, the process did not have resources to fully scope specific water use issues. Some of these data gaps were significant given the large geographic scope of the project and complexity of issues, and the time period and funds allocated for the Columbia River Water Use Plan. This resulting uncertainty precluded some issues from being effectively addressed through the process. Two strategies were developed to address these critical uncertainties and ensure that better information would be available for future decision making. Information Plans were proposed either when there were no quantitative data available to make informed decisions, or when existing data demonstrated a need for further study. The goal of these plans is to provide sufficient information for decision making around possible operational and non-operational physical works during the next Columbia River Water Use Plan review. Management Plans were proposed to ensure that operational changes and physical works are implemented responsibly and subsequently monitored to inform on their effectiveness before the next Columbia River Water Use Plan review. These plans were reviewed by the Consultative Committee at their final June 2004 meeting.

The following summarizes the Information and Management Plans that were recommended by the Consultative Committee for the Columbia River Water Use Plan. The Committee unanimously supported the total package of recommendations for operational changes, monitoring, physical works and the review periods. However, some members noted concern around details of implementing the Water Use Plan and issues in the watershed. Their support was conditional on one or more of the following actions being implemented:

- Resolving the conflict in the Arrow Lakes Reservoir drawdown zone between environmental interests and recreational interests.
- Protection of sensitive archaeological sites in the drawdown zone.
- Need for control over implementation of the activities and spending given the large cost of the program.
- Participation of local communities and First Nations in implementation of monitoring studies and physical works projects.

- Indemnification of CPC/CBT joint venture projects from any adverse impacts arising from implementation of this Water Use Plan[1].

Kinbasket Reservoir Fish and Wildlife Information Plan

An obstacle to making recommendations around operational changes or physical works in lieu of operational changes for Kinbasket Reservoir was the lack of quantitative data for fish and wildlife populations and supporting ecosystem processes. The Consultative Committee acknowledged the importance of better understanding reservoir ecology and the influence of current operations as an outcome of the water use planning process, and supported a plan to collect the information necessary to better inform future decision-making.

Revelstoke Flow Management Plan

The Consultative Committee supported a 5 kcfs year-round minimum flow constraint at Revelstoke Dam to meet the fish objectives for the mid Columbia River. It was recommended that the minimum flow be implemented two years after implementation of the Columbia River Water Use Plan to allow for collection of baseline data. The Committee also supported a number of studies to address uncertainties related to the benefits of a 5 kcfs minimum flow to invertebrate and fish populations, and to assess its effectiveness for future decision making.

Mid Columbia River White Sturgeon Management Plan

The Consultative Committee supported a 4-phase workplan aimed at better understanding juvenile white sturgeon habitat capabilities in the mid Columbia River, and building a self-sustaining population in Arrow Lakes Reservoir through flow treatments and conservation aquaculture. The experimental workplan is designed specifically to allow the necessary flexibility in annual fund allocations for research, experimental flow treatments for white sturgeon (in addition to the 5 kcfs year-round minimum flow) and monitoring to ensure that the program is responsive to future

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[1] Throughout the Columbia River water use planning process, Columbia Power Corporation, manager of the CPC/CBT joint ventures, worked with BC Hydro and government to clarify the policy framework underpinning BC Hydro's Columbia River (and Duncan Dam) Water Use Plan as it related to potential third party impacts on CPC/CBT and the Columbia Basin Initiative. Potential third party impacts on holders of downstream water rights were not addressed in the *Water Use Plan Guidelines* and the November 1998 government policy directive to BC Hydro. In the absence of greater clarity around this policy issue, CPC and CBT were unable to support any operating alternative before the Committee until they had an assurance from BC Hydro that CPC/CBT joint venture projects would be saved harmless from any adverse impacts resulting from implementation of the Water Use Plan. This work led to a further June 2004 government policy directive to BC Hydro directing it to save CPC/CBT power projects harmless from any adverse effects resulting from implementation of BC Hydro Water Use Plans. After BC Hydro confirmed its commitment to implementing and abiding by this government policy directive, CPC and CBT each issued letters to BC Hydro stating that they were now willing to remove their objections to recommendations of the Consultative Committee for the Columbia River Water Use Plan (refer to Section 7.7.16 and Appendix G: Correspondence Related to the Columbia Power Corporation and the Columbia Basin Trust).

learnings and related changes in priorities. This will be facilitated through comprehensive reviews at the end of each phase of the program, and an option to discontinue flow tests in the mid Columbia River (if monitoring supports this decision) and direct all or part of the conservation aquaculture effort to Kinbasket Reservoir.

The Committee supported a number of research and monitoring studies integral to supporting decision making around flow treatments and hatchery supplementation in the mid Columbia River.

Arrow Lakes Reservoir Operations Management Plan

Just prior to the final June 2004 meeting, the Consultative Committee was informed that the Non-Treaty Storage Agreement (NTSA) between BC Hydro and Bonneville Power Authority (BPA) would expire by end of June 2004, and no new agreement had been renegotiated to date. Without a new NTSA in place, it would not be possible for BC Hydro to unilaterally implement all of the monthly constraints on Arrow Lakes Reservoir under the proposed operating alternatives across all water years. The Consultative Committee recommended soft constraints on Arrow Lakes Reservoir operations to help inform the BC Hydro operators on impacts. These soft constraints would be reflected in the System Operating Orders for Arrow Lakes Reservoir. No new maximum or minimum constraints would be placed on BC Hydro’s water licenses for Arrow Lakes Reservoir, and no compliance monitoring would be required by the Water Comptroller’s office. However, it was recommended that there be annual reporting of progress on monitoring and physical works, and performance in meeting the soft constraints.

Table 2 summarizes the recommendations made by the Consultative Committee for soft constraints on Arrow Lakes Reservoir operations.

Table 2: Recommendations for Soft Constraints on Arrow Lakes Reservoir Operations

Interest	Constraint
Vegetation	• Maintain current level of vegetation in the drawdown zone through maintaining lower reservoir water levels during the growing season. No specific operating targets were identified to meet this general objective. • If vegetation is showing signs of stress as a result of inundation during the early part of the growing season (May-July), target lower reservoir levels in the fall to allow exposure of plants during the latter part of the growing season. • Preservation of current levels of vegetation at and above elevation 434 m (1424 ft) is considered a priority.
Wildlife	• Ensure that inundation of nesting bird habitat by rising reservoir water levels in early summer is no worse than that which occurred on average over recent history (1984-1999). Match operating levels to inundation statistics for elevations 434 m (1424 ft) and above over the 1984-1999 period, which were used to produce the average historic performance measure score for spring/summer nesting short-eared owl habitat. • Ensure that availability of migratory bird habitat in the fall is as good or better than that which has been provided on average over recent history (1984-1999). Draft the reservoir quickly after full pool is reached, targetting a reservoir level of 438 m (1437 ft) or lower by 7 August.

Table 2: Recommendations for Soft Constraints on Arrow Lakes Reservoir Operations (cont'd)

Interest	Constraint
Fish	• Ensure appropriate reservoir elevations for tributary access during the kokanee spawning period (late August to early November). Reservoir levels of 434 m (1424 ft) could cause tributary access to be restricted in some streams under certain conditions. Proposed monitoring study aimed at determining reservoir level thresholds under a range of tributary streamflow conditions below which spawner access becomes a problem.
Recreation	• Target reservoir water levels between 437.4 m and 438.9 m (1435.0 ft and 1440.0 ft) from 24 May to 30 September. • Flexibility to achieve lower reservoir levels of 434 m (1424 ft) during the recreation season would be acceptable with proposed construction/upgrade of boat ramps for recreation interests served by these formal access points.
Culture and Heritage	• Maintain reservoir water levels at or below 436 m (1430 ft) for as long as possible. • First Nations willing to accept water levels above this 20 per cent of the time (or for 2.5 months) provided that it is timed in accordance with the vegetation efforts. First Nations would be willing to relax this constraint if the archaeological site protection plan is underway.
Erosion	• Minimize duration of full pool events. Reservoir water levels of 439 m (1440 ft) are ideal. • Avoid sudden drawdown once full pool has been reached (particularly if high runoff has saturated the reservoir banks) to avoid slumping of the shores.
Power Generation	• Optimize power values.

During the discussion of soft constraints for Arrow Lakes Reservoir, members of the Consultative Committee identified other constraints that should be considered by BC Hydro in its operations.

- On behalf of the representative of the City of Trail, it was noted that there is a desire to keep flows below 165 kcfs at Genelle. If BC Hydro is taking actions that cause damage at Trail, then the City will seek compensation.

- A number of Committee members also highlighted the need to avoid surcharging of Kinbasket Reservoir whenever possible.

In supporting soft constraints for Arrow Lakes Reservoir, the Consultative Committee recommended a long-term data collection plan to evaluate its performance in meeting the stated objectives for the reservoir.

Kinbasket and Arrow Lakes Reservoir Revegetation Management Plan

The Consultative Committee supported reservoir-wide planting programs compatible with both the current operating regime and proposed operating alternatives to maximize vegetation growth in the drawdown zones of Kinbasket and Arrow Lakes reservoirs. The revegetation program is a multi-year program requiring intervention over five years to facilitate long-term vegetative cover.

The Consultative Committee agreed to a maximum funding cap over five years, and set out principles by which the planting programs should be implemented. It was agreed that development of a final revegetation program will require public consultation to ensure that the plan is not in conflict with other land uses (e.g., motorized and non-motorized recreation, beach areas), and will require that planting prescriptions are compatible with First Nation archaeological site protection requirements. It was also acknowledged that there are opportunities to incorporate vegetation types valued in traditional use by First Nations in to the planting program. The Committee recommended a number of studies to inventory vegetation resources, and monitor the effectiveness of planting efforts on vegetation communities and wildlife habitat use.

Kinbasket and Arrow Lakes Reservoir Recreation Management Plan

The Consultative Committee recognized that addressing recreational issues on Kinbasket and Arrow Lakes reservoirs through operational changes was not cost effective. During their final June 2004 meeting, the Committee supported non-operational means to address recreation interests around Kinbasket Reservoir and mitigate the effects of low water impacts on Arrow Lakes Reservoir. The Committee recommended the following implementation projects as part of the Recreation Management Plan.

- Kinbasket/Arrow Lakes Reservoirs and Lower Columbia Boat Access Improvement.

  The Committee supported 11 proposals for improving boat access on the Columbia River system, conditional on the Comptroller of Water Rights confirming that each project meets the criteria for Water Use Plans (i.e., there is a demonstrated operational link to the project)[1]. Acceptance of these works was also conditional on a feasibility study being undertaken to ensure that these works are undertaken in the most cost-effective manner, and that impacts on other interests (e.g., fish habitat, archaeological sites) are taken into consideration.

- Kinbasket and Arrow Lakes Reservoir Debris Management.

  The Committee supported an ongoing debris management program on Kinbasket and Arrow Lakes reservoirs to address debris issues related to reservoir operations, provided that an environmental review be undertaken to ensure that impacts on other interests (e.g., fish and wildlife habitat, revegetation efforts, archaeological site protection) are addressed, and potential uses of debris for fish habitat and wetland

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[1] Subsequent to the June 2004 Consultative Committee meeting, the Water Comptroller reviewed the recommended boat access improvement projects and concluded that a new boat ramp at Nakusp does not fit within the scope of water use planning. In view of this decision, BC Hydro committed, in a letter dated 2 November 2004, to discuss possible partnerships with local government, Columbia Basin Trust and others towards construction and maintenance of a new ramp at Nakusp. The Comptroller also concluded that there is currently insufficient information to determine whether dredging at Indian Eddy to improve access to the Columbia River fits within the scope of water use planning. Prior to making a recommendation with respect to its inclusion in the Columbia River Water Use Plan, further information would be required regarding the mechanism causing transport of sediment from the Gyro Park Beach to Indian Eddy.

habitat restoration are identified. The Committee's support was also conditional on the Comptroller of Water Rights accepting that the debris management plan is within the scope of the water use planning process.

- Lower Columbia River Debris Management.

  The Committee supported an annual expenditure of $2,000 for debris removal at Indian Eddy, subject to an environmental review being undertaken. Currently, the City of Trail removes debris that accumulates in Indian Eddy to maintain access to the river for emergency boats.

Kinbasket and Arrow Lakes Reservoir Heritage Management Plan

The Consultative Committee supported a management plan specifically aimed at reducing operational impacts to archaeological sites in Kinbasket, Arrow Lakes and Revelstoke reservoirs. The management program puts forward a strategy to address the known archaeological sites in Arrow Lakes Reservoir from Years 1 to 5, and build on the knowledge from the first interventions and data collected from Kinbasket, Revelstoke and Arrow Lakes reservoirs to address the remaining not yet discovered sites that are eroding or at risk of due to reservoir operations. Inventory and excavation work will be required to determine the number of actively eroding archaeological sites in Kinbasket and Arrow Lakes reservoirs, and their importance in terms of quantity of intact archaeological materials. A management strategy will be developed with First Nation's participation to identify First Nation preferences around intervention at these sites, mitigation and effectiveness monitoring. The depth of the archaeological information and dynamics of the erosion process will determine the best approach to protecting these archaeological sites.

Arrow Lakes Reservoir Wildlife Management Plan

The Consultative Committee supported implementation of wildlife physical works in the mid Columbia River to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife habitat and its use, particularly nesting and migrating birds. The Committee agreed to a maximum annual budget of $100,000 in Year 1 and $250,000/year for Years 2–10, which was based on a third party assuming responsibility for construction, maintenance and liability of these works. If a Memorandum of Understanding (MOU) cannot be developed with a third party, it was acknowledged that substantially less could be undertaken by BC Hydro within the agreed upon budget.

The Consultative Committee supported a number of monitoring studies to assess the effectiveness of the physical works in providing benefits to wildlife. They also supported feasibility studies to identify potential impacts on private lands, archaeological sites, vegetation, fish habitat and mosquito production, as well as any incompatibility risks with recreational use of the drawdown zone to support the development of the physical work options.

Lower Columbia Fish Management Plan

The Consultative Committee agreed that the greatest potential to provide gains to wild, indigenous fish populations in the lower Columbia River was through the following actions.

- Strategy for Managing Fish Impacts associated with Flow Reductions

  The Consultative Committee agreed that implementation of the stranding protocol and interim ramping rate criteria, in conjunction with planned ramping rate tests, monitoring and appropriate mitigation, were an acceptable approach to addressing fish stranding in the lower Columbia River until further information is gained through ongoing fish salvage, survey activities and the ramp rate study to develop a defined ramping rate matrix to the satisfaction of BC Hydro and the fisheries regulatory agencies.

- Seasonal Flow Strategy for Mountain Whitefish

  The Consultative Committee recommended that BC Hydro continue to pursue the mountain whitefish flow agreements every year through annual negotiations with the United States. The Committee supported a two-phase program implemented over a 15-year period to assess the biological effectiveness of the whitefish flow regime, with the intent of maintaining or improving current populations of whitefish below Hugh Keenleyside Dam. This involves continuation of the recent historical winter flow reductions over the first five years of the Water Use Plan, followed with optional testing of historic flows (i.e., pre-whitefish flow regime). The whitefish flow experiment and associated monitoring program is designed to test specific hypotheses and inform on critical data gaps regarding the relationship between flows and whitefish population levels.

  In a June 2004 Letter of Commitment to DFO, BC Hydro has committed to pursue the mountain whitefish flows as specified in the experimental plan as a high priority.

- Seasonal Flow Strategy for Rainbow Trout

  The Consultative Committee recommended that BC Hydro continue to pursue the rainbow trout flow agreements every year through annual negotiations with the United States. The Committee highlighted a number of high priority items for consideration in future operations, and recommended a monitoring program to address uncertainties related to the impact of the flow regime on rainbow trout populations.

  In a June 2004 Letter of Commitment to DFO, BC Hydro has committed to pursue the rainbow trout flows as a high priority.

- White Sturgeon Experimental Plan

  Given the practical and financial impediments to substantially increasing flows at the Canada/United State border for improving white sturgeon recruitment in the lower Columbia River, the Consultative Committee recommended the high flow option only on an opportunistic basis as opposed to through an operational change. The Committee recommended that an assessment be undertaken in those years when high flows occur naturally to gain a better understanding around the relationships between high flows and egg, larval and juvenile survival.

  In lieu of this operational change, the Consultative Committee recommended that physical works be undertaken to improve conditions for white sturgeon in the lower Columbia River. This plan involves turbidity augmentation through the delivery of bentonite or other turbidity agents to the river during low flow periods (i.e., when discharge at the United States boundary is below 90 kcfs) when sturgeon eggs are known to be hatching and larvae are undergoing their downstream drift phase and are most vulnerable to predation. The Committee accepted this experiment plan, recognizing that it would first require a feasibility study to address regulatory concerns around introducing a turbidity agent to the river and associated fisheries and related ecosystem issues. The Committee also supported monitoring to inform on the effectiveness of this action, as well as a provisional annual contribution to the existing Lower Columbia River sturgeon conservation aquaculture program.

  Subsequent to the June 2004 meeting, it became apparent that there was a lack of clarity around the nature of the consensus decision for the lower Columbia River white sturgeon plan. The two principle issues of concern expressed by some members of the Consultative Committee related to flexibility in the approach to physical works in lieu, and annual contributions to the conservation aquaculture program as a fallback option.

  In supporting the lower Columbia River white sturgeon plan, some Committee members believe that they accepted the annual contribution to the aquaculture program as a fallback option in the event that turbidity augmentation was found to be unfeasible. Other members believe that they supported a program that included both options and the necessary flexibility within the program to explore other physical works if the turbidity experiment does not proceed.

Non-Licence Water Use Plan Recommendations

The Consultative Committee recognized that several of their recommendations could not be considered by the Comptroller of Water Rights for inclusion within BC Hydro's Water Licences for the Columbia River hydroelectric facilities. In addition to the soft constraints for Arrow Lakes Reservoir operations and the lower Columbia River mountain whitefish and rainbow trout flows, the Committee recommended that the following go forward as non-licence Water Use Planning recommendations:

- The Committee acknowledged that, on rare occasions, BC Hydro might need to surcharge Kinbasket, Revelstoke and Arrow Lakes reservoirs for flood control under emergency conditions. On rare occasions, BC Hydro might also surcharge the reservoir to address other environmental or economic considerations. The Committee recommended that BC Hydro avoid reservoir surcharge if at all possible, and that compensation be provided to address infrastructure damage in the event of surcharge.

- BC Hydro and other parties consider funding the boat access proposals deemed outside of water use planning (Galena Bay, Anderson Point, Burton (existing ramp), Halfway Creek, Shelter Bay, Nakusp).

- BC Hydro seek clarification from the Comptroller of Water Rights as to what constitutes access to the reservoirs. Once clarification has been sought, the Committee wants the Comptroller to identify how provisions will be made and then to direct appropriate parties responsible to improve access.

- Prior to the 5-year review of Arrow Lakes Reservoir operations, BC Hydro undertake an impact assessment to determine how the Non-Treaty Storage Agreement will affect BC Hydro's ability to achieve the soft constraints and meet the objectives of the system.

Summary of Costs

Subsequent to the final June 2004 meeting, further refinements were made to the estimated costs of the flow changes, physical works and monitoring recommended by the Consultative Committee. A summary of all recommendations with the revised costs is provided in Section 8.

Table 3: Estimated Costs of Recommended Operational Changes, Physical Works and Monitoring under the Columbia River Water Use Plan

Change in Operations	**Annual Cost (Million $/Year)**
Soft Arrow Lakes Reservoir Constraints	0
Revelstoke 5 kcfs Minimum Flow	3
Mid Columbia River White Sturgeon Minimum Flows	0.5[1]
Rainbow Trout Flows for Lower Columbia River	-3[2]
Mountain Whitefish Flows	2.2[2]
Physical Works	**Total Cost (Million $)**
Arrow Lakes Reservoir Wildlife Habitat	2.35[1]
Mid Columbia River White Sturgeon Aquaculture (incl. hatchery upgrade)	3.46
Mid Columbia River White Sturgeon Program Co-ordination	1.15
Lower Columbia River White Sturgeon Aquaculture	1.88[1]
Lower Columbia River Turbidity Experiment	9.00
Arrow Lakes Reservoir Revegetation	2.10[1]
Kinbasket Reservoir Revegetation	2.00[1]
Kinbasket Reservoir Boat Ramps (4 ramps + annual maintenance)	1.00
Revelstoke Boat Ramps (1 ramp + annual maintenance)	0.43
Arrow Lakes Reservoir Boat Ramps (4 ramps + annual maintenance)	3.12
Dredging of Indian Eddy	0.20
Kinbasket, Arrow and Lower Columbia Debris Management	2.18
Archaeological Site Management and Protection	11.88
Total Physical Works	*40.75*
Monitoring*	
Kinbasket Reservoir Fish and Wildlife	5.28
Kinbasket and Arrow Lakes Reservoir Revegetation	2.96
Kinbasket, Arrow Lakes, Lower Columbia River Recreation	0.43
Kinbasket, Revelstoke, Arrow Lakes Reservoir Archaeological Site Management	1.01
Revelstoke Flow Management	5.09
Mid Columbia River White Sturgeon Management	2.79
Arrow Lakes Reservoir Operations Management	8.45
Arrow Lakes Reservoir Wildlife Management	0.40
Lower Columbia River Fish Management	9.02
Lower Columbia River White Sturgeon Management	3.75
Total Monitoring	*39.18*

* Estimated total costs of the physical works and monitoring studies are presented as current dollars over a maximum period of 15 years.

1 Costs represent a maximum financial cap agreed to by the Consultative Committee.

2 BC Hydro currently pursues the rainbow trout and mountain whitefish flow agreements through annual negotiations with the United States. As BC Hydro cannot implement these flows unilaterally, they cannot be written into BC Hydro's Water Licences and therefore do not represent a generation benefit/cost to the Columbia River Water Use Plan.

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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 to deal with 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 Columbia River water use planning consultative process was initiated in August 2000 and completed in June 2004. The purpose of this report is to document the consultative process and present the recommendations of the Columbia River Water Use Plan Consultative Committee. The interests and values expressed in this report will be used by BC Hydro to prepare a draft Water Use Plan for BC Hydro's Columbia River, Mica, Revelstoke and Hugh Keenleyside hydroelectric facilities. Both the Consultative Committee Report and BC Hydro's draft Water Use Plan will be submitted to the Comptroller of Water Rights.

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1 The Ministry of Employment and Investment responsible for electricity policy at the 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.

1.1 SCOPE OF THE COLUMBIA RIVER WATER USE PLAN

In addition to the general guidance provided for all of BC Hydro's water use planning programs in the provincial government's *Water Use Plan Guidelines*, specific guidelines were provided to assist the Consultative Committee in determining which operational changes could be considered within the scope of the Columbia River Water Use planning process.

- Violating the Columbia River Treaty is outside the scope of water use planning as it may expose the Province of BC to possible contractual liabilities and potentially very large financial risks associated with downstream benefits.

- The Columbia River Water Use Plan may consider operating alternatives that include incremental changes to existing operations that BC Hydro can unilaterally implement. A partial list includes some flex operations (swapping water between Kinbasket and Arrow Lakes reservoirs), constraints on reservoir maximum/minimum levels that can be accommodated within Treaty operations, ramping rates and incremental use of the BC Hydro portion of the Non-Treaty storage.

- The Water Use Plan may also consider operating alternatives that affect Detailed Operating Plans and Supplemental Operating Agreements developed under the Treaty, or that affect operations under the Non-Treaty Storage Agreement. However, BC Hydro's ability to secure such an operating alternative is dependent upon successful negotiations with the U.S. Entity and, possibly, other affected parties following the Water Use Plan. The likelihood of achieving such an agreement must be assessed by the Consultative Committee when considering operating alternatives to be modelled.

- Operating alternatives will recognize local and downstream flood control operations, as required by the Columbia River Treaty.

BC Hydro's water use planning process was designed to specifically address BC Hydro facility operations. It was not intended to review the operations of hydroelectric facilities that are owned by entities other than BC Hydro. As such, it was established at the outset of the Columbia River water use planning process that the Water Use Plan would be restricted to review of Mica, Revelstoke and Hugh Keenleyside project operations. Although some interests in the lower Columbia River are affected by both flows out of Arrow Lakes Reservoir and the Kootenay River system, operational changes on the Kootenay River system were considered outside the scope of the process. While BC Hydro, through commercial agreements, manages water on the lower Kootenay River, these facilities are not owned by BC Hydro and therefore were excluded from the Columbia River Water Use Plan.

1.2 REPORT ORGANIZATION

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*:

2	Description of the Columbia River Project	Describes BC Hydro's Columbia River hydroelectric system.
3	Consultative Process	Describes the Columbia River water use planning consultative process, including initiation, Committee participants and Committee structure *(Steps 1, 3)*.
4	Issues, Objectives and Performance Measures	Documents the issues raised during the initial stages of issue identification and objective elicitation (*Steps 2 and 4*) and describes the objectives and performance measures *(Step 4)*.
5	Information Collection	Describes the information gaps and information collected in the water use planning process *(Step 5)*.
6	Operating Alternatives	Describes operating alternatives considered by the Consultative Committee *(Step 6)*.
7	Trade-Off Analysis and Consensus Agreements	Describes the trade-off process and the package of recommendations developed by the Consultative Committee *(Step 7)*.
8	Summary of Consultative Committee Recommendations	Describes operating and non-operating alternatives supported by the Consultative Committee to meet different interests on the Columbia River.
9	Review Period	Describes the timing and process for review of the Columbia River Water Use Plan.
10	Implementation of Recommendations	Describes the implementation plan of the Columbia River Water Use Plan.

2 DESCRIPTION OF THE COLUMBIA RIVER PROJECT

2.1 INTRODUCTION

This section summarizes the planning and operations of BC Hydro's hydroelectric and storage facilities on the mainstem Columbia River (Mica, Revelstoke and Hugh Keenleyside projects; refer to Figure 2-1), and the agreements and obligations under which they are operated.

The Mica and Hugh Keenleyside projects were constructed under the Columbia River Treaty, and are operated to maximize mutual benefits with respect to flood control and power generation for Canada and the United States. Mica is the largest of the Treaty projects and the only one in Canada initially designed to generate power. Revelstoke Dam and Generating Station were not built under the Treaty but benefit from the regulation improvements provided by the storage in Kinbasket Reservoir. Hugh Keenleyside Dam was built to provide storage for downstream flood control and increased power generation in the United States. The original facility was not constructed to generate power. However, under a joint venture between the Columbia Power Corporation (CPC) and Columbia Basin Trust (CBT), the Arrow Lakes Generating Station (ALH) was constructed adjacent to Hugh Keenleyside Dam in 2002.

2.2 COLUMBIA RIVER TREATY

The Columbia River Treaty was signed between Canada and the United States of America in 1961 and ratified in 1964. BC Hydro was appointed as the Canadian Entity under the Treaty. Under the terms of the Treaty, BC Hydro built and now operates 15.5 million acre-feet (MAF) of storage at the Mica (7.0 MAF), Hugh Keenleyside (7.1 MAF), and Duncan (1.4 MAF) projects in co-ordination with the United States to maximize power generation and flood control benefits in both countries. In return, Canada received an up-front payment for the flood control benefits as well as one-half of the annual additional power generation benefits produced at the downstream U.S. projects on an on-going basis. There is no specified termination date for the Treaty; however, the earliest the Treaty may be terminated by either party is 2024, provided notice is given 10 years prior.

2.2.1 Flood Control Operating Plan

The Columbia River Treaty requires that a Flood Control Operating Plan (FCOP) be prepared and agreed to by the Canadian and U.S. Entities. The first FCOP was prepared in 1968 and major revisions were completed in 1972 and 1999. The FCOP specifies Flood Control Curves for each of the three Treaty projects in Canada, and the Libby Reservoir in the United States portion of the Columbia River basin. It also defines the flood protection objectives and outlines the system flood control operation of the Columbia River basin.

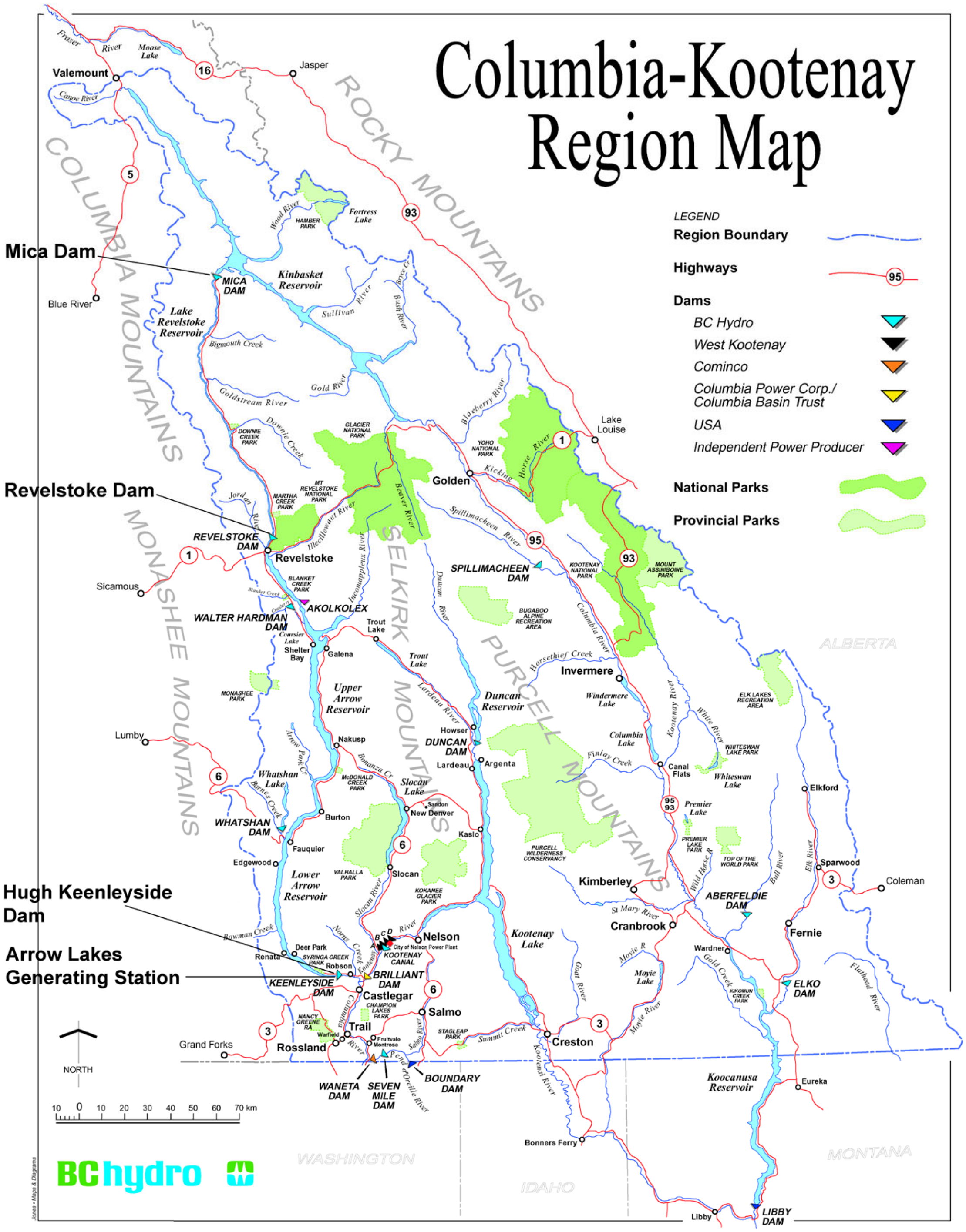

Figure 2-1: Columbia Kootenay Region Map

For Kinbasket and Arrow Lakes reservoirs, the Flood Control Rule Curves specify an amount of storage that must be evacuated at various dates between 1 October and 30 April. For Kinbasket and Arrow Lakes reservoirs, the specified storages are a function of the runoff volume forecast for The Dalles, Oregon. Except for extremely high runoff years, the maximum amount of storage that must be evacuated at Kinbasket and Arrow Lakes reservoirs for flood control are 4.08 and 3.6 MAF, respectively. The required flood control evacuation at Kinbasket Reservoir can be decreased by up to 2.0 MAF by increasing the flood control evacuation at Arrow Lakes Reservoir by 1.5 MAF in accordance with the FCOP. The Columbia River Treaty also contains a provision for the full evacuation of Arrow Lakes Reservoir (7.1 MAF) and Kinbasket Reservoir (12.0 MAF) storages in extremely high runoff years, with additional compensation to Canada for power losses. In this case, the U.S. Army Corps of Engineers may start the consultation process as early as November with all affected parties to ensure that the evacuation space is available by 1 April of the following year. This on-call flood control provision has not been exercised up to 2005.

2.2.2 Assured Operating Plan

The Columbia River Treaty requires that an Assured Operating Plan (AOP) be prepared and agreed to each year by the Entities for the operation of Treaty storage during the sixth succeeding year. The AOP provides information to the Entities for planning the power systems in the two countries which are dependent on or co-ordinated with the operation of Treaty storage.

Key results from the AOP studies include a set of four “critical rule curves” (CRC) for each reservoir that guide the operation to meet firm load in the United States and parameters for deriving operating rule curves (ORC) used to direct the operation to meet the secondary market. Each of the CRCs corresponds to one of the four years of the critical runoff sequence for the combined system (generally from mid August 1928 through February 1932). The curves represent the month-end reservoir level trajectories that would have resulted over this time period had the reservoir been full at the start, empty at the end, and operated optimally to meet firm energy of the U.S. Pacific Northwest area during the critical runoff sequence. The maximum amount of firm load that the system can meet with certainty during the critical period is the Firm Energy Load Carrying Capability (FELCC).

Under the Columbia River Treaty, all storage reservoirs in the combined United States and Canadian system are to be drafted “proportionately” between rule curves whenever needed to meet the FELCC. For example, if one reservoir is drafted to a point halfway between its second and third CRCs, then every reservoir in the system should also be drafted to that point. Individual project constraints, such as minimum flows, sometimes override this principle.

The AOP also outlines special "Mica Project Operating Criteria," designed to keep the Columbia River Treaty storage contents at Kinbasket and Arrow Lakes reservoirs in appropriate balance. For each month (or half-month during April and August), a target Mica Dam discharge or end-of-period Mica Treaty storage content is specified. The Mica targets depend on the end-of-period Arrow Treaty storage content for the previous period.

The Determination of the Downstream Power Benefits document is attached to each AOP and defines the Canadian Entitlement for that operating year.

2.2.3 Detailed Operating Plan

Under the provision of the Columbia River Treaty, a Detailed Operating Plan (DOP) is also prepared each year for the operation of Treaty storage in the following year. Operating rules developed in the AOP for the following year may be updated and/or altered by mutual agreement between the two Entities. If no agreement is reached, then the rules developed in the AOP are repeated in the DOP. The DOP contains detailed information on project-specific constraints and special operating rules, and, once completed, is the guiding document for Treaty storage operation for the year.

2.2.4 Treaty Storage Regulation Study

Under the provisions of the Columbia River Treaty, the Entities undertake a Treaty Storage Regulation (TSR) study at least twice per month according to the rules governing Canadian Treaty storage operation, as outlined in the DOP. The study determines monthly storage rights and obligations for the Canadian Treaty projects and is used by the Entities to determine the weekly Treaty storage operation request. The TSR study simulates storage operations for all projects in the Columbia River basin (Canada and United States). System reservoirs are filled or drafted, based on the principle of proportional draft, as needed to meet the specified FELCC first and then if possible, the secondary load, subject to system refill criteria.

If the FELCC cannot be met even after drafting all system reservoirs to empty, the TSR study determines the deficit in FELCC. If the FELCC can be met while maintaining system reservoirs on or above the ORCs, then the TSR study may show generation surplus to the FELCC. In the study, reservoirs are not allowed to fill above their ORCs until a specified non-firm energy market is served. Once this market is served, the reservoirs are filled proportionately between ORCs and Flood Control Curves.

2.2.5 Storage Transfers between Treaty Projects

The Columbia River Treaty specifies that Canada may alter releases at Mica Dam, Hugh Keenleyside Dam, and/or Duncan Dam, as long as the sum of Arrow and Duncan releases are unchanged from the official Treaty request and the flood control requirement is individually met at each Treaty project. This provision allows Mica Dam to release more or less than that specified by the DOP (over run or under run, respectively), as long as Hugh Keenleyside Dam discharges are unchanged. In addition, this provision allows storage (and release) transfers from the Duncan Reservoir to the Arrow Lakes Reservoir or Kinbasket Reservoir, and vice versa, to suit BC Hydro's needs. These transfers are often referred to as "flex" operations, since they are derived from the internal flexibility BC Hydro has to move water among the basin reservoirs.

2.2.6 Departures from Treaty Storage Regulation – Specified Storage Levels

At various times, it may be advantageous to both the Canadian and U.S. Entities to draft the total Columbia River Treaty storage below TSR levels or to store above TSR levels. This may be done only with prior agreement from both Entities. Special agreements have been signed and implemented each year since 1993 to allow such an operation, benefiting non-power generation interests on both sides of the border.

2.2.7 Non-Treaty Storage Agreement

The Columbia River Non-Treaty Storage Agreement (NTSA) with the Bonneville Power Administration (BPA) was signed in 1984 and expanded in 1990. Under this agreement, BC Hydro and BPA co-ordinate the operation of storage additional to Treaty storage in Kinbasket and Arrow Lakes reservoirs and share the use of mainstem Columbia River power generation facilities in Canada and the United States, with benefits to both parties. Under the NTSA, both BC Hydro and BPA may request daily changes in the scheduled discharges from Mica Dam. These flow changes are then passed through the Revelstoke and Hugh Keenleyside projects and made available for use by the U.S. Under many circumstances, these requests do not result in an actual change in Mica or Revelstoke operations due to BC Hydro operation flexibility. Discharges at Hugh Keenleyside Dam, however, are adjusted in response to these daily requests, since these releases are intended to change flows at the international border.

At Kinbasket Reservoir, 4.5 MAF is designated as "Active" NTSA storage, and is always available for use (release or storage) by either party. A further 0.5 MAF at Kinbasket Reservoir and 0.26 MAF at Arrow Lakes Reservoir is designated as "Recallable" NTSA storage. Recallable storage is normally at a zero balance and is not open for activity for either party until BC Hydro declares the recallable storage "open" for a specified length of time. At the end of the open period, the storage accounts must be returned to a zero balance.

The release provisions of the current NTSA expired on 30 June 2004. Under the agreement, BC Hydro and BPA will have seven years (by 30 June 2011) to refill their respective accounts to full. However, the parties expect to negotiate a replacement agreement prior to the full termination of the NTSA.

2.2.8 Discharge Requirements

2.2.8.1 Columbia River Treaty Operations

Through a Thursday conference call, BC Hydro's Generation Operations (acting on behalf of the Canadian Entity under the Columbia River Treaty) and the U.S. Entity (BPA and the Corps of Engineers) agree on a preliminary Treaty release schedule for the following week (beginning on Saturday and ending on the following Friday). The weekly Treaty release schedule is normally finalized prior to Friday at 1200 hours.

2.2.8.2 Non-Treaty Storage Agreement Operations

Activity (release or storage) under the NTSA can modify the Hugh Keenleyside Project release schedule on a daily basis. NTSA activity is agreed to by BC Hydro and BPA by 0930 hours each working day for the following working day(s).

2.3 MICA PROJECT

The Mica Project is located on the Columbia River about 135 km north of Revelstoke. The project was completed in 1973 and consists of an earthfill dam, low-level outlets, outlet works, and a chute spillway (Photo 2-1). The generating station was completed in 1977 and contains an underground powerhouse with four operating units and the space for two additional units as well as a switchgear building. The reservoir formed by the dam is known as Kinbasket Reservoir. Seven MAF of its total 12 MAF of storage is operated under the terms of the Columbia River Treaty.

Photo 2-1: Mica Dam

The location of Mica Dam and Kinbasket Reservoir is shown in Figure 2-2.

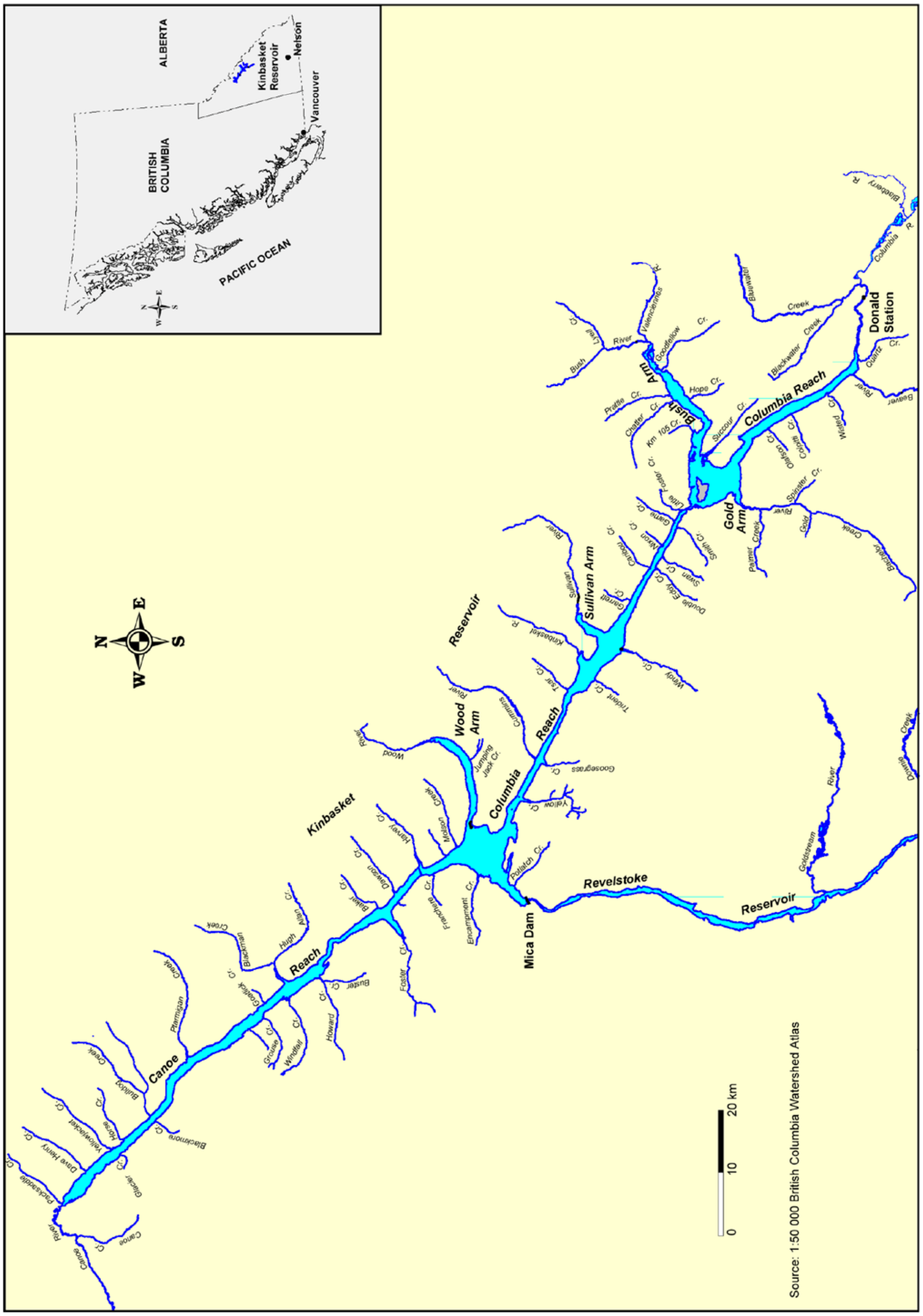

Figure 2-2: Mica Dam and Kinbasket Reservoir

2.3.1 Water Licence Rights and Obligations

2.3.1.1 Kinbasket Reservoir Storage Licences

BC Hydro is authorized by Conditional Water Licences No. 27068 and 39432 to store a maximum of 7 MAF and 5 MAF, respectively. The normal operating range of the reservoir is elevation 754.38 m (2475.0 ft) and 706.96 m (2319.42 ft). However, applications may be made to the Comptroller of Water Rights for additional storage for environmental or other purposes if there exists a high probability of spill.

2.3.1.2 Mica Project Diversion Licence

BC Hydro is authorized by Conditional Water Licence No. 39431 to divert a maximum of 1840 m^3/s (65 kcfs) for power purposes. This represents six units, but to date only four units have been installed.

2.3.2 Mica Powerhouse Operation

There are no known restrictions on water releases in the operation of Mica generating units with respect to dam safety and environmental concerns (i.e., a “zero” project discharge is acceptable). Total gas pressure (TGP), or gas supersaturation, levels are normally elevated in the tailwater of any project that is spilling or with units in synchronous condense mode of operation. Reasonable efforts are made in operating the Mica powerhouse to avoid prolonged sync-condense operations to prevent high TGP levels.

There are no known limits on the rate of increase or decrease on turbine releases for dam safety or any other purposes.

2.3.3 Kinbasket Reservoir Operation

2.3.3.1 Low Reservoir Elevation Conditions

BC Hydro does not draft Kinbasket Reservoir below the normal minimum reservoir elevation of 706.96 m (2319.42 ft) without prior approval from the Comptroller of Water Rights. To date, Kinbasket Reservoir has not been drawn down below elevation 712.40 m (2337.27 ft) since the reservoir was initially filled in 1976.

2.3.3.2 Normal Reservoir Elevation Conditions

Subject to the constraints imposed by the Columbia River Treaty and the NTSA, BC Hydro plans and operates the Mica Project to optimize the net benefit to the province. All factors are taken into consideration, including system security, safety, head gain, spill probability, plant operating efficiency, transmission losses, and local and environmental issues.

2.3.3.3 High Reservoir Elevation Conditions

Kinbasket Reservoir levels above the normal full pool level of elevation 754.38 m (2475.0 ft) may result in some erosion concerns due to wave action in the reservoir area, and should be avoided when possible. Where inflow conditions require reservoir surcharging, care should be taken to minimize the levels and duration.

2.3.3.4 Reservoir Rate of Filling and Drafting

There are no known restrictions on the rate of filling or drafting of Kinbasket Reservoir for dam safety or other concerns.

2.3.3.5 Flood Flow Release Notification

There are no known requirements for flood flow release notification.

2.3.4 Fisheries Interests at Mica Project

There are no known formal agreements, restrictions or obligations for specific fisheries operations at the Mica Project. At present, BC Hydro makes reasonable efforts to avoid prolonged sync-condense operation to prevent elevated levels of total gas pressure (TGP), which may be hazardous to fish. The current criteria calls for either a 30 minute flush of each generating unit by operating at a low output of approximately 100 MW, or a 15 minute flush operating at a higher output of approximately 300 MW, for every 12 cumulative hours of sync-condense operation.

2.4 REVELSTOKE PROJECT

Revelstoke Dam is located on the Columbia River about 5 km upstream from the City of Revelstoke. The project was completed in 1984 and consists of an earthfill wing dam and a concrete gravity main dam. The main dam includes the power intakes with steel penstocks in the middle and spillway facilities to the right (refer to Photo 2-2). The powerhouse is located directly downstream of the power intakes and the switchgear building is on the right side, adjacent to the spillway chute. The powerhouse has four operating units installed and the space to install two additional units in the future.

The reservoir formed by the dam is known as Revelstoke Reservoir. It is fed by the Mica Project discharges and additional water from local inflow.

Although the Revelstoke Project is not covered directly under the Columbia River Treaty, the project may be called upon by the Treaty to provide flood control [Article IV(2)(b)]. It is also specifically precluded from operating in a fashion that reduces the benefits contemplated by the Treaty [Article IV(5)].

Photo 2-2: Revelstoke Dam and Generating Station

Except for the obligations included in the water licences, the Columbia River Treaty and the NTSA, there are no other formal agreements or obligations for the operation of the Revelstoke Project.

Figure 2-3 shows the location of Revelstoke Dam and Revelstoke Reservoir.

2.4.1 Water Licence Rights and Obligations

BC Hydro is authorized by Conditional Water Licence No. 47215 to divert 2550 m^3/s (90 kcfs) for power purposes at the Revelstoke Project. This flow represents six units, but to date only four units have been installed.

The water licence specifies the normal full pool level to be elevation 573.02 m (1880.0 ft). The maximum storage for power purposes is 1 500 000 acre-feet, and the licensed minimum level is elevation 554.74 m (1820.0 ft).

Under normal conditions, the reservoir draft limit is elevation 571.50 m (1875.0 ft). Under emergency conditions, the reservoir can be drafted to elevation 568.80 m (1866.14 ft) and under extreme emergencies (e.g., if required to meet firm loads), the reservoir can be drafted to elevation 557.80 m (1830.0 ft).

Applications to the Comptroller of Water Rights for additional storage above elevation 573.02 m (1880.0 ft) for environmental and other purposes may be made during an emergency to avoid spill losses or if there is high probability of spill.

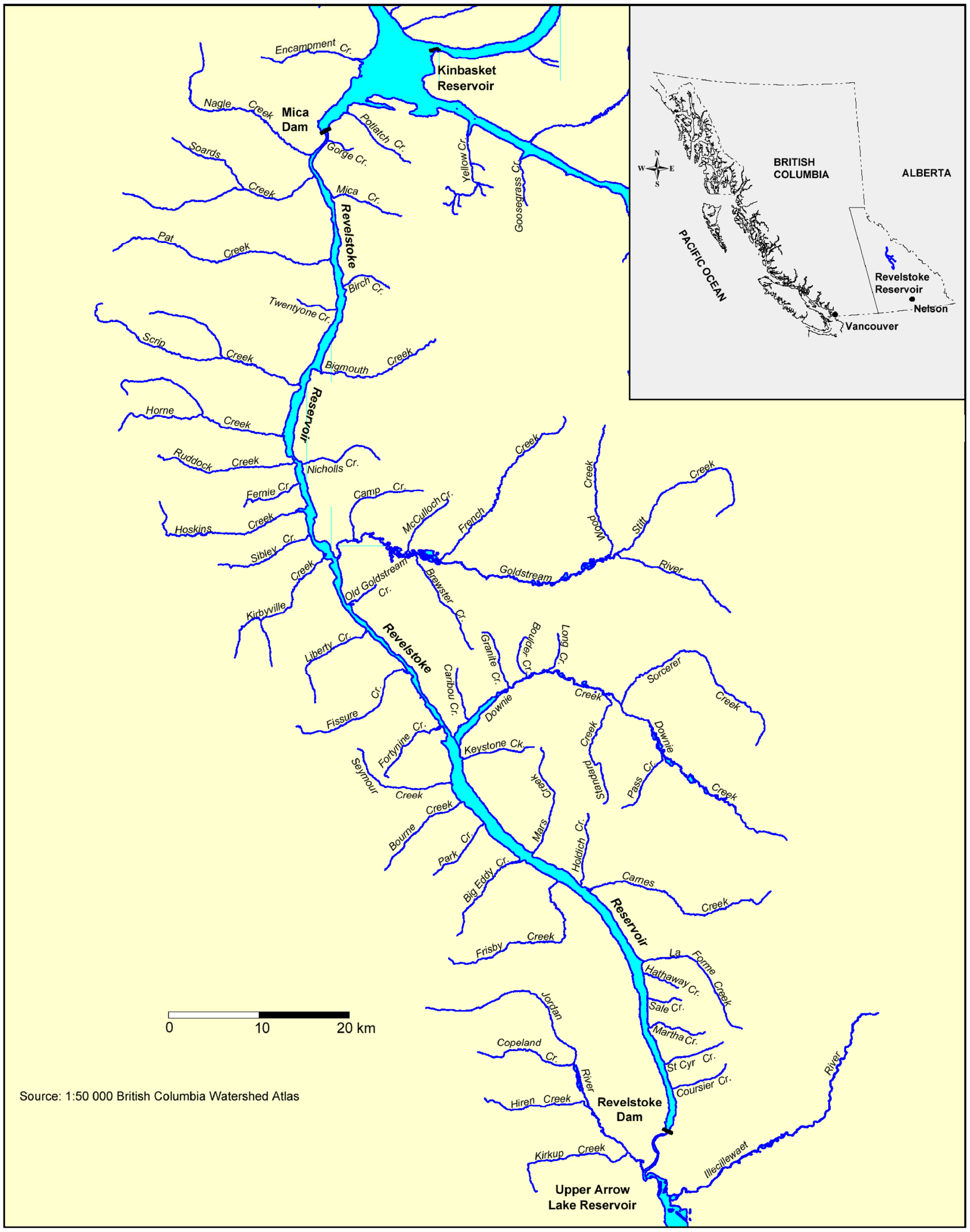

Figure 2-3: Revelstoke Dam and Reservoir

2.4.2 Revelstoke Powerhouse Operation

There are currently no restrictions on water releases at the Revelstoke Generating Station with respect to dam safety. Zero project discharge is acceptable, although BC Hydro has agreed to take reasonable efforts to avoid a zero discharge during daylight hours whenever the Arrow Lakes Reservoir level is below an elevation of 437.80 m (1436.35 ft). Total gas pressure (TGP), or gas supersaturation, levels are normally elevated in the tailwater of any project that is spilling or with units in synchronous condense mode of operation.

2.4.3 Revelstoke Reservoir Operation

2.4.3.1 Normal Operation

Revelstoke Reservoir is normally kept between elevation 572.0 and 573.02 m (1876.64 and 1880.0 ft) for maximum turbine hydraulic head, except during spring runoff period or unusual system conditions. During these times, it may be necessary to draft the reservoir by up to 1.5 m to avoid spill or to meet short term system load requirements. The reservoir is rarely drafted below elevation 571.50 m (1875.0 ft).

Subject to the constraints imposed by the Columbia River Treaty and the NTSA, BC Hydro plans and operates the Revelstoke Project to optimize the net benefit to the province. All factors are taken into consideration, including system security, safety, head gain, spill probability, plant operating efficiency, transmission losses, and local and environmental issues.

2.4.3.2 Reservoir Rate of Filling and Drafting

Normal maximum draft or fill rate	0.8 m per day (2.5 ft per day)
Emergency draft rate	1.5 m per day (5.0 ft per day)

2.4.4 Revelstoke Dam Outlet Works and Spillway Operation

A washout of the right bank of the spillway plunge pool occurred in August 1991, when spills of up to 1750 m^3/s (62 kcfs) were discharged. Therefore, until rehabilitation of the right bank is complete, spillway discharges should be limited to no more than 700 m^3/s (25 kcfs), unless higher discharges are necessary to preserve the safety of Revelstoke Dam.

2.4.5 Fisheries Interests at Revelstoke Project

There are no known formal agreements, restrictions or obligations for specific fisheries operations at the Revelstoke Project.

2.4.6 Revelstoke Project Operation and Other Users

There are no known formal agreements, restrictions or obligations to be observed in the operation of the Revelstoke Project for recreational, commercial interests, residential and/or industrial interests.

There are no known restrictions to be observed in the operation of the Revelstoke Project regarding land use impact or shoreline erosion control.

2.5 HUGH KEENLEYSIDE PROJECT

Hugh Keenleyside Dam is located on the Columbia River about 8 km upstream of Castlegar. The project was completed in 1968 and consists of an earthfill dam, a concrete dam, four spillways, eight low-level outlets (ports), and a navigation lock (refer to Photo 2-3). Arrow Lakes Reservoir, formed from the former Upper and Lower Arrow Lakes, has a live storage capacity of 7.1 MAF below its normal upper limit of 440.14 m (1444.0 ft). The mean annual discharge is approximately 1040 m^3/s.

2.5.1 Water Licence Rights and Obligations

BC Hydro is authorized by Water Licence No. 27066 to store 7.1 MAF of water for power purposes. This corresponds to the live storage at Arrow Lakes Reservoir between elevations 419.99 and 440.14 m (1377.92 and 1444.03 ft).

In many years prior to 1997, BC Hydro has obtained permission from the Comptroller of Water Rights to store an additional 0.262 MAF of water at Arrow Lakes Reservoir between elevations 440.14 and 440.75 m (1444.03 and 1446.03 ft) when required for flood control. Even when these temporary permits are granted, the actual elevation of the reservoir may not necessarily need to encroach into the surcharge zone for additional power generation benefits to be gained due to the added flexibility.

Photo 2-3: Hugh Keenleyside Dam

The project is operated under the terms of the Columbia River Treaty ratified by Canada and the United States in 1964.

Figure 2-4 shows the location of Hugh Keenleyside Dam.

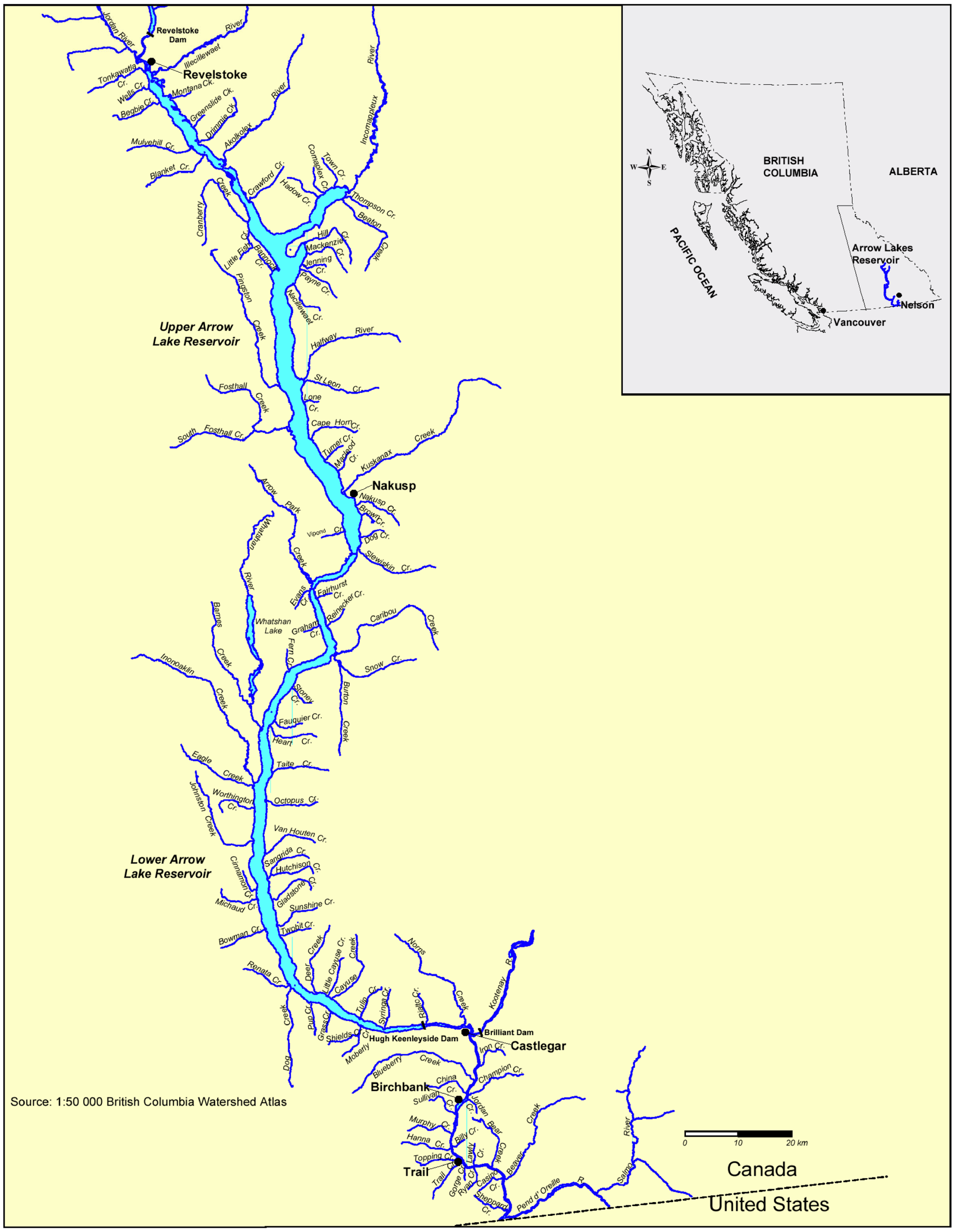

Figure 2-4: Arrow Lakes Reservoir and Hugh Keenleyside Dam

2.5.1.1 Normal Operation

The normal minimum Arrow Lakes Reservoir discharge is 142 m^3/s (5 kcfs). However, to facilitate log-handling operations immediately downstream, the project discharge is not normally reduced below 283 m^3/s (10 kcfs). Short-term discharges of less than 142 m^3/s (5 kcfs) may be required periodically for testing and/or repair work at the dam, but this operation requires the approval of the Ministry of Water, Land, and Air Protection (MWLAP). A flow of 425 m^3/s (15 kcfs) or greater at Trail (Birchbank) is desirable for Teck Cominco's water supply operation. This is downstream of the confluence with the Kootenay River, however, such that the restriction is seldom if ever constraining.

Under normal (non-flood control) operation, the Arrow Lakes Reservoir discharge should not exceed 2830 m^3/s (100 kcfs) and should not cause the collective (Kootenay plus Keenleyside) river flows at Birchbank to exceed 4531 m^3/s (160 kcfs). Increasing flooding impacts can be expected along the river at discharges exceeding these values. At river flows above 4760 m^3/s (168 kcfs), the septic system at the Whispering Pines Trailer Court is impacted.

Under normal operation, the maximum daily Arrow Lakes Reservoir discharge change (increase or decrease) is 425 m^3/s (15 kcfs) to avoid impacts on river retaining structures and to minimize river bank sloughing. Higher rates-of-change are allowable in limited cases, such as:

a) When necessary to control the Arrow Lakes Reservoir level below full pool.

b) When necessary to accommodate maintenance and/or inspections.

c) Flood control.

2.5.1.2 Flood Control Operation Requirements

Operation of Hugh Keenleyside Dam for flood control purposes in Canada and the United States is governed by the Columbia River Treaty as outlined in the 1999 Treaty Flood Control Operating Plan. The Plan specifies end-of-month maximum reservoir levels during the period September to April, and then a daily refill curve during the period May through August.

The Columbia River system flood control operation is defined to begin 20 days before the unregulated discharge at The Dalles, Oregon is forecast to reach 12 750 m^3/s (450 kcfs). During flood control operation, the U.S. Army Corps of Engineers (Corps) co-ordinates operations at all U.S. projects in the Columbia River basin and at the three Treaty projects in Canada (Mica, Hugh Keenleyside, and Duncan). During this period, the Corps directs BC Hydro, through BC Hydro's Generation Operations, on the daily release schedules.

Under the Columbia River Treaty Flood Control Operating Plan, minor flooding damage is deemed to commence at Castlegar when the river level at the abandoned Robson Ferry site reaches elevation 426.7 m (1400.0 ft), and at Trail when the discharge reaches 6370 m^3/s (225 kcfs). Major flooding damage is deemed to commence at Castlegar for a river level of elevation 428.2 m (1405.0 ft) and at Trail for a discharge of 7930 m^3/s (280 kcfs). Flood control objectives at Castlegar are normally met if the flood control objectives at Trail are met.

2.5.2 Arrow Lakes Reservoir Operation

2.5.2.1 Normal Operation

BC Hydro does not operate Arrow Lakes Reservoir outside of its normal operating range of elevation 419.9 m (1377.9 ft) to elevation 440.1 m (1444.0 ft) without prior approval from the provincial Comptroller of Water Rights.

Subject to the constraints imposed by the Columbia River Treaty and the NTSA, BC Hydro plans and operates the Hugh Keenleyside Project to optimize the net benefit to the province. All factors are taken into consideration, including system security, safety, head gain, spill probability, plant operating efficiency, transmission losses, and local and environmental issues.

2.5.2.2 Reservoir Rate of Filling and Drafting

The maximum monthly drawdown for Arrow Lakes Reservoir, as specified in the Columbia River Treaty Detailed Operating Plan, is equivalent to 0.3 m (1.0 ft) per day. However, this limit applies only to the total monthly drawdown, and no daily drawdown rate maximum is specified.

2.5.3 Fisheries Interests

In December 2003, BC Hydro and Fisheries and Oceans Canada (DFO) entered into an Alternative Measures Agreement related to a July 2001 incident on the lower Columbia River that resulted in the stranding and loss of juvenile fish. Under this agreement, BC Hydro has committed to initiate studies and develop established procedures, in conjunction with DFO, to reduce the potential for future fish stranding incidents. This includes an overview assessment of fish stranding risks at its Columbia River Basin facilities, development of a Fish Stranding Protocol for Hugh Keenleyside Dam (as well as Duncan Dam and Cranberry Creek), flow ramping studies to assess fish stranding impacts downstream of Hugh Keenleyside and Duncan dams, and continuation of whitefish and rainbow trout index population monitoring studies in the lower Columbia River. BC Hydro has also committed to develop a strategy to address fish entrainment at its facilities in the Columbia River Basin.

In consultation with regulatory agencies, BC Hydro has developed and implemented a draft Stranding Protocol for managing fish stranding impacts associated with flow reductions at Hugh Keenleyside Dam. The strategy defines communication requirements between BC Hydro and the agencies, as well as recommendations for flow ramp rates, monitoring and mitigation activities. It is expected that this strategy will be updated as additional information from ongoing surveys and studies become available.

In consultation with DFO and MWLAP, BC Hydro has also set out principles and operational procedures to be used to guide future actions for the preservation and enhancement of rainbow trout, mountain whitefish, and other fish species downstream of Hugh Keenleyside Dam. These are described in the following subsections.

2.5.3.1 Rainbow Trout Spawning

Between March and June each year, rainbow trout spawn in gravel areas along the shores of the Columbia and Kootenay rivers. A prime spawning area between Hugh Keenleyside Dam and the United States border is the Norns (Pass) Creek fan, just east of Robson on the north side of the Columbia River. River levels at the fan are determined primarily by Hugh Keenleyside Dam discharge, and, to a lesser extent, by the backwater effect of the Kootenay River discharge.

BC Hydro makes efforts to provide "flows for fish" each year during the spawning period. An important objective is that the river level at the Norns Creek fan does not drop between 1 April and 30 June.

Hugh Keenleyside Dam discharges may decrease during this time if compensated for by higher Kootenay River discharges which creates higher Hugh Keenleyside Dam tailwater levels through a backwater effect. If this operation can be successfully accomplished, then all redds made after 1 April would remain watered until after fry emergence, considered to be complete by 30 June.

Each year, BC Hydro makes efforts to maintain the viability of rainbow trout redds that are constructed prior to 1 April above the set water level by salvaging eggs from dewatered redds. As the spawning season progresses, BC Hydro also undertakes egg stranding surveys and redd salvage as required when a significant decrease in discharge from Hugh Keenleyside Dam is planned.

There are ongoing discussions with the fisheries regulatory agencies to define "flows for fish" during the Norns Creek fan spawning period. An initial discharge of 425 m^3/s (15 kcfs) has been used in most years since 1992. However, initial flows depend on many factors and may be higher or lower than 425 m^3/s (15 kcfs). Efforts are made to set initial flows that could be maintained with a high probability. In each of the years since 1993, special agreements have been signed with the U.S. Entity to improve the probability of completing this operation successfully.

2.5.3.2 Mountain Whitefish Spawning

In December and January each year, mountain whitefish spawn in the Columbia River between Hugh Keenleyside Dam and the United States border. Mountain whitefish are broadcast spawners and, as such, their eggs are not deposited in well defined redds like rainbow trout. Typically, the eggs hatch March through May. Actual timing is dependent on temperatures and flows.

BC Hydro makes reasonable efforts to minimize the number of dewatered mountain whitefish eggs between the time of peak spawning and the time of fry emergence. This is accomplished by attempting to keep Hugh Keenleyside Dam discharges during spawning as low as possible and minimizing any subsequent drop in flows during the incubation/emergence period. There are annual in-season discussions with the fisheries regulatory agencies and the U.S. Entity to determine the feasibility of achieving a reasonable level of protection with respect to mountain whitefish.

2.5.3.3 Total Gas Pressure Reduction

Total gas pressure (TGP), or gas supersaturation, levels are normally elevated in the tailwater of any project that is spilling or with units in synchronous condense mode of operation. Readings of over 140 per cent have been measured at Hugh Keenleyside Dam. High TGP readings generally correspond to times when the spillways, rather than the ports, are in use. In addition, use of the north bank of ports instead of the south bank, has been shown to produce lower TGP levels.

BC Hydro has received advice from the fisheries regulatory agencies to the effect that elevated TGP levels cause gas-bubble trauma in fish. Provincial guidelines identify 110 per cent as a goal, whereas, federal draft guidelines list 103 per cent, if fish reside in less than one metre of depth.

To address this concern, BC Hydro has agreed, whenever possible within project constraints, to preferentially discharge water through the north bank of ports (nos. 1 to 4), then the south bank (nos. 5 to 8), and then the spillways. This operation minimizes the level of TGP produced during normal operations at Hugh Keenleyside Dam.

Arrow Lakes Generating Station can divert up to 1115 m^3/s (~40 000 cfs) of the flows away from the ports at Hugh Keenleyside Dam where TGP is produced, and pass it through its generators where no TGP is produced. This has been shown to significantly reduce downstream TGP levels. However, high TPG levels remain a concern downstream of Hugh Keenleyside Dam to the point in the river where flow from ALH has fully mixed. Operational methods to reduce the production of high TGP levels at Hugh Keenleyside Dam are considered important to reducing impacts in this area of the river.

2.5.4 Project Operation and Other Users

There are no known formal agreements, restrictions, or obligations to be observed in the operation of the Hugh Keenleyside Project for industrial, commercial, residential, and/or recreational interests. Neither are there any known formal restrictions regarding land use impact or shoreline erosion control. However, whenever the Arrow Lakes Reservoir level is below elevation 437.4 m (1435.0 ft), there exists the potential for dust storms around the reservoir during the spring and summer. Fine silty material on the reservoir bottom, exposed to the air at low reservoir levels, can be picked up and transported during wind storms. BC Hydro has at times undertaken a program of seeding selected exposed areas with grass as soon as the snow has melted in the spring to reduce dust storms. The corporation has also attempted to steadily fill the reservoir once the refill begins to avoid re-exposing recently flooded areas.

2.6 ARROW LAKES GENERATING STATION

2.6.1 Description of the Arrow Lakes Generating Station

The Arrow Lakes Generating Station (ALH) is owned by the Arrow Lakes Power Corporation (ALPC), a joint venture of the Columbia Power Corporation and the Columbia Basin Trust. It is a 185 MW power plant constructed on the north bank of Hugh Keenleyside Dam located on the Columbia River approximately 8 km upstream of Castlegar, British Columbia. The powerhouse contains two 92.5 MW Kaplan turbine units. The powerhouse is located approximately 400 m downstream of the existing dam, with flows diverted past the dam to the powerhouse by means of a 1500 m long approach channel. The plant came into service in 2002.

Energy from ALH is fed into the BC Hydro Integrated System at 230 kV via a 50 km transmission line, designed 2L289, which originally terminated at the Selkirk Substation (SEL). In March 2004, this line was interconnected to the Brilliant Terminal Station (BTS) splitting the transmission line into 15 km 2L290 from ALH to BTS and 35 km 2L289 from BTS to SEL. In this arrangement, ALH delivers its power into the FortisBC system en route to its final delivery to BC Hydro.

2.6.2 Parties and General Responsibilities

Hugh Keenleyside Dam is one of three dams built in British Columbia under the terms of the Columbia River Treaty between Canada and the United States. BC Hydro, the designated Canadian Entity under the Treaty, is responsible to establish the Facility Discharge Requirement consistent with the Treaty and other operating agreements. BC Hydro’s Generation Operations is responsible for planning, scheduling, and directing the generation at ALH and the discharge at Hugh Keenleyside Dam to achieve the Facility Discharge Requirement.

ALPC has overall operating responsibility for all ALH equipment. ALPC is responsible for the determination of the maximum powerhouse generation and Powerplant Flow Capacity of ALH, the local operation of ALH equipment and facilities, and the maintenance of ALH equipment and facilities. ALPC has contracted B.C. Transmission Corp (BCTC) for the remote dispatch and operation services under the Dispatch Operations Agreement.

BC Hydro and ALPC have entered into a Release Co-ordinating Agreement to co-ordinate the operation of their respective facilities. The Agreement requires the establishment of an Operating Committee consisting of four representatives; two representatives are each from ALPC and BC Hydro. The Arrow Lakes Hydro Operating Committee is responsible for carrying out duties as set out in the Release Co-ordination Agreement, including preparation and implementation of detailed operating procedures and plans.

2.6.3 Water Licences Rights and Obligations

Conditional Water Licence 109831 issued to ALPC allows the diversion of water up to 1200 m^3/s (42.4 kcfs) for power production and conformance with the Columbia River Treaty, Project Approval Certificate E98-04, and the Release Co-ordination Agreement.

2.6.4 Arrow Lakes Generating Station Operation

2.6.4.1 Generator and Turbine Operation

ALH is normally operated from BCTC's South Interior Control Center located in Vernon. The ALH units are also capable of being operated from BC Hydro's Burnaby System Control Center, locally through the Plant Control System, or via the Manual Control System located between Units 1 and 2 on the generator level at 420.7 m (1380.3 ft).

The ALH generators are rated 102.8 MVA and 0.9 power factor at 13.8 kV. The minimum reservoir level for one unit operation is 425.08 m (1394.62 ft), as measured at the navigation lock at Hugh Keenleyside Dam, at a flow of 142 m^3/s (5 kcfs). The minimum reservoir level for two-unit operation is 426.83 m (1400.36 ft) at a total flow of 292 m^3/s (10 kcfs). The output of ALH is highly dependent on hydraulic head. The minimum net operating head is 4.6 m (15.1 ft), and the maximum operating head is 20.0 m (65.6 ft).

The Project Approval Certificate for ALH does not permit the plant to be used for daily load flow shaping unless permission from the Comptroller of Water Rights is obtained. Under normal operating conditions, the rate of change in facility discharge is limited to a maximum of 425 m^3/s (15 kcfs) change per day.

The ALH units are not enabled for Automatic Generation Control and are not capable of synchronous condense or black start operation.

2.6.4.2 *Responsibility for Spill Gate*

Apart from discharges at the generating units, there are no discharge facilities at ALH. ALH has priority use of discharges from Arrow Lakes Reservoir with any balance of the Facility Discharge Requirement being discharged by Hugh Keenleyside Dam. Hugh Keenleyside Dam is staffed during normal working hours 364 days per year and discharges from the dam are set manually at the site on a day-to-day basis to meet the Facility Discharge Requirement.

The Release Co-ordination Agreement requires the development of an automatic alert and primary response mechanism to respond to unscheduled changes in the powerplant discharge with the intent of restoring the facility discharge to meet the Facility Discharge Requirement. This requirement was to minimize impacts to the aquatic environment downstream of Hugh Keenleyside Dam. In August 2002, a Remote Gate Operating (RGO) system was installed at ALPC's cost, that allows BCTC dispatchers to remotely open some of the Hugh Keenleyside Dam discharge facilities should there be an unscheduled change of discharge at ALH and should there not be any staff on duty at Hugh Keenleyside Dam. This remote operation will allow continued discharge into the Columbia River downstream of ALH and the dam while ALH and Hugh Keenleyside Dam staff are responding to the unscheduled flow change at ALH.

2.6.4.3 *Approach Channel Operating Parameters*

The approach channel operating parameters include maximum flow rates for a given reservoir level. These parameters are included in the operating range of ALH and are controlled in the plant control system. There are no headgates on the approach channel, so isolation of the channel is not possible without extensive effort.

2.6.5 Water Release Co-ordination

2.6.5.1 *Release Co-ordination Agreement*

A condition of the ALH Project Approval Certificate required ALPC to enter into an agreement with BC Hydro relating to the details of the operation of the power plant in co-ordination with the storage release from the Arrow Lakes Reservoir. The Release Co-ordination Agreement between ALPC and BC Hydro, dated 16 December 1998, sets out the operational responsibilities of the two parties and describes the co-ordination of Hugh Keenleyside Dam and ALH with respect to flow discharge.

2.6.5.2 *Priority of Powerplant Discharge*

The Release Co-ordination Agreement requires the operation of ALH be co-ordinated with the operation of Hugh Keenleyside Dam so as to maximize the discharge from the powerplant subject to the Facility Discharge Requirement, the ALH Powerplant Flow Capacity, physical characteristics of the Hugh Keenleyside

Project, and legal obligations. This requirement is normally satisfied by operating ALH at maximum output whenever the Facility Discharge Requirement exceeds the Powerplant Flow Capacity. When the Facility Discharge Requirement is less than the Powerplant Flow Capacity, ALH is operated at the output required to discharge the Facility Discharge Requirement.

BC Hydro's Generation Operations is responsible to determine the Facility Discharge Requirement in accordance with the Columbia River Treaty[1] and other operating agreements.

2.7 LINKAGE OF COLUMBIA RIVER BASIN TO THE KOOTENAY AND COLUMBIA RIVERS

The Kootenay River originates in the Rocky Mountains southeast of Golden 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 half of Kootenay Lake storage as well as the owner of Corra Linn Dam, which regulates the lake levels.

In the central 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. Water from the north and south arms of Kootenay Lake then flows through the west arm of the lake (where the city of Nelson is located) and past Grohman Narrows and the Corra Linn Dam as well as other dams en route to the Columbia and Kootenay rivers confluence at Castlegar.

From Castlegar, the Columbia River continues its journey south where, 100 m north of the Canada/United States border, the Pend d'Oreille River joins the Columbia River. From this confluence, the Columbia River flows across the border 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 (refer to Figure 2-5).

[1] This includes all formal agreements with the U.S. Entity developed under the Columbia River Treaty, including changes to the Detailed Operating Plans and Supplemental Operating Agreements such as the Non-Power Use Agreement for lower Columbia River rainbow trout flows, and the lower Columbia River mountain whitefish flow agreement.

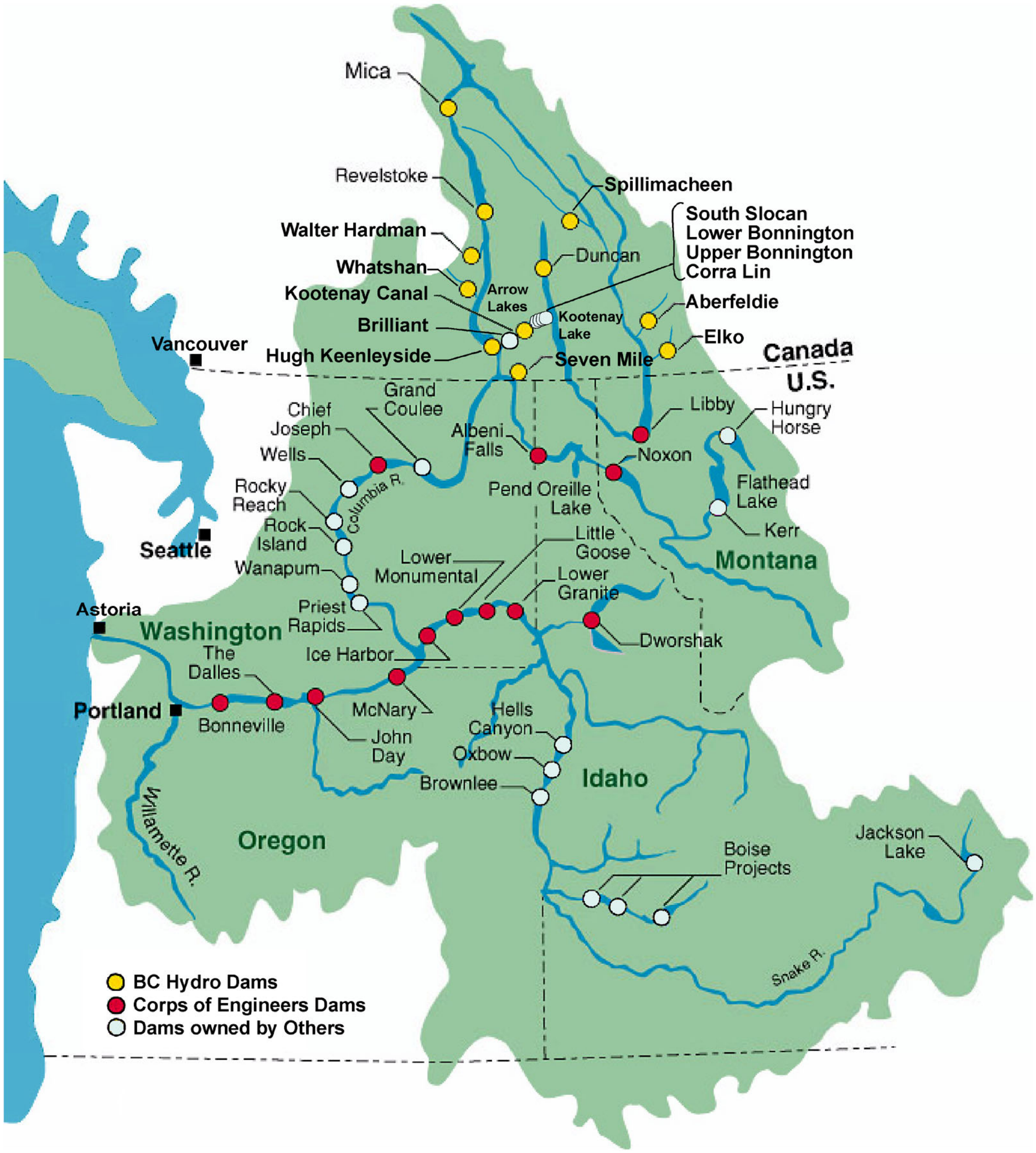

Figure 2-5: Columbia River Basin

3 CONSULTATIVE PROCESS

3.1 INTRODUCTION

This section describes the Columbia River water use planning consultative process including initiation, Consultative Committee participants and Committee structure.

The Columbia River water use planning consultative process followed the steps outlined in the provincial government's *Water Use Plan Guidelines* (Province of British Columbia, 1998). Table 3-1 summarizes the steps, which provide the framework for a structured approach to decision making. Steps 3 to 8 encompass the consultation aspect of the Columbia River water use planning process and are the focus of this report.

Table 3-1: Steps in 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 the 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

The Columbia River water use planning process for the Hugh Keenleyside, Mica and Revelstoke facilities was initiated in the summer of 2000. Throughout the summer, BC Hydro contacted approximately 160 key stakeholders including agencies, organizations, industries, First Nations, local governments, elected officials (Mayors, Regional District Directors, Members of the Legislative Assembly, Members of Parliament) and other interested groups by phone to determine whether they would be interested in participating in the water use planning process. Those contacted also suggested others in the community who might be interested in the process that BC Hydro could contact. BC Hydro also responded to individuals who inquired about the news release or advertisements.

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 Columbia River. Letters were mailed to water licence holders along the Columbia River system to inform them about the Columbia River water use planning process and to extend an invitation to participate.

In May 2000, prior to initiation of the Columbia River water use planning process, the BC Hydro project team met with both fisheries and non-fisheries agencies to scope potential issues. Applicable reference material was gathered for undertaking a review of fish, recreation and wildlife information. Provincial and federal regulatory agencies and First Nations were asked to identify representatives to participate in the water use planning consultative process.

On 23 August 2000, BC Hydro sent a letter initiating the Columbia River water use planning process to the Comptroller of Water Rights. On 30 August 2000, BC Hydro issued a news release to publicly announce the water use planning process to the media in Nakusp, Castlegar, Trail, Valemount, Golden and Revelstoke. On 6, 13 and 20 September, BC Hydro placed an advertisement in the *Arrow Lakes News, Valley Voice, Castlegar Citizen, Castlegar Sun, West Kootenay Weekender, Trail Times, Revelstoke Times, Unique Magazine, Golden Star,* and *Valley Sentinel* inviting the public to one of six public information sessions and open houses. Public open houses and information sessions were held in Valemount on 19 September, 20 September in Golden, 21 September in Revelstoke, 26 September in Nakusp, 27 September in Castlegar and 28 September in Trail.

In addition to direct contact, information on the Columbia River water use planning process was posted on BC Hydro's Water Use Plan website, www.bchydro.com/wup.

In February 2001, the BC Hydro project team identified interests and issues and submitted a summary report (*Issues Identification Report*, BC Hydro, February 2001) to the Comptroller of Water Rights. This report completed Step 2 of the provincial government's *Water Use Plan Guidelines*.

3.3 CONSULTATIVE COMMITTEE STRUCTURE AND PROCESS

The Columbia River Water Use Plan Consultative Committee consisted of Committee members and observers (refer to Appendix A: Columbia River Water Use Plan Consultative Committee, Alternates, Observers and Subcommittees). Observers attended on a drop-in basis and provided input, but did not participate in decision making. The Committee began with 35 members. Over the course of the Columbia River water use planning process, new members joined, some members opted to change their status to observer status, and others were reassigned other duties or moved out of the area. Those who moved to observer status were comfortable that their interests were represented by other Committee members. There were 39 Committee members who actively completed the water use planning process.

The Consultative Committee met on seven occasions between February 2001 and June 2004 to complete the Columbia River water use planning process (refer to Appendix B: Schedule of Consultative Committee Meetings and Activities). Detailed meeting notes recorded the discussions and decisions made at meetings and during conference calls (refer to Appendix C: List of Documents Generated during the Columbia River Water Use Planning Process). For each meeting, Consultative Committee members and observers were provided with pre-reading and meeting handout materials, as well as the meeting minutes.

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 D: Review Comments and Signoff on the Draft Consultative Committee Report).

3.3.1 Canadian Wildlife Service Participation

Throughout the Columbia River water use planning process, the BC Hydro project team worked diligently to encourage the participation of the Canadian Wildlife Service (CWS) in the process (refer to Appendix E: Correspondence from BC Hydro regarding the Canadian Wildlife Service and Appendix F: Correspondence from the Canadian Wildlife Service). Although resource and budget constraints prevented the agency from fully engaging in the process and providing representation on the Consultative Committee, the project team sought input/comment from CWS staff on work being undertaken by the Fish and Wildlife Technical Subcommittee and Consultative Committee. This included the development of operating and non-operating alternatives and performance measures, and identification of monitoring needs. In addition, an agency representative attended one joint Fish and Wildlife Technical Subcommittee meeting, and two Wildlife Technical Subcommittee meetings. All pre-reading materials, meeting minutes and other documentation prepared for the Fish and Wildlife Technical Subcommittee meetings and Consultative Committee meetings were provided to the CWS representative to ensure that they were kept apprised of the progress of the Committee.

3.3.2 Columbia Power Corporation Participation

Throughout the Columbia River water use planning process, Columbia Power Corporation (CPC), as manager of the CPC/CBT joint ventures, worked with BC Hydro and government to clarify the policy framework underpinning BC Hydro's Columbia River (and Duncan Dam) Water Use Plan as it related to potential third party impacts on CPC/CBT and the Columbia Basin Initiative[1]. Potential third party impacts on holders of downstream water rights were not addressed in the *Water Use Plan Guidelines* and the November 1998 government policy directive to BC Hydro.

In a letter dated 26 November 2003, CPC indicated that their interest in the Columbia River water use planning process was to ensure that these joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from implementation of the Columbia River Water Use Plan (refer to Appendix G: Correspondence related to the Columbia Power Corporation and the Columbia Basin Trust). CPC's participation in the process was primarily to assist BC Hydro in understanding and measuring the potential impacts on the CPC/CBT facilities that might result from operating alternatives being considered by the Consultative Committee.

3.3.3 District of Central Kootenay Participation

At a September 2003 meeting, the Board of the Regional District of Central Kootenay (RDCK) adopted a resolution to withdraw from the Columbia River and Duncan Dam water use planning processes (refer to Appendix H: Correspondence from the Regional District of Central Kootenay). This motion was submitted to the Board due to concerns regarding a lack of public consultation and adequate consideration of human/social impacts in the process. Representatives from BC Hydro met with the Board to discuss the RDCK's concerns and continued involvement in the water use planning process on 5 November 2003. In a letter dated 6 February 2004, the Board advised BC Hydro that it had reconsidered its involvement in the water use planning process, and adopted a resolution at its 24 January 2004 meeting that the RDCK would continue to participate in both the Columbia River and Duncan Dam water use planning processes.

3.3.4 Technical Subcommittees

In addition to the Columbia River Water Use Plan Consultative Committee, participants formed five Technical Subcommittees consisting of Committee members, experts and technical support as required (refer to Appendix B: Schedule of Consultative Committee Meetings and Activities) to focus on specific issues, and provide technical advice to the Committee. Committee

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[1] Construction of the Columbia River Treaty dams brought current and future benefits to the Province, but also significant economic, environmental and social costs to the region. In 1995, the provincial government created the Columbia Basin Initiative in recognition of the costs borne by the region. The provincial government enacted the *Columbia Basin Trust Act*, creating the Columbia Basin Trust, and entered into a 1995 Financial Agreement with the Columbia Basin Trust, providing funding to the Columbia Basin Trust and Columbia Power Corporation for power project developments in the region, including the Arrow Lakes Generating Station. The Trust's share of power project returns is used to provide benefits to the people of the region.

members were free to join any subcommittee, provided they were prepared to make the necessary time commitment required for full participation.

Subcommittees were tasked by the Consultative Committee to assist with the more detailed work relating to development of objectives and performance measures, and provide input into operating alternatives. Subcommittee meetings were conducted both at breakout sessions during Committee meetings and at separate meetings as necessary.

These subcommittees included:

- Fish Technical Subcommittee, which addressed fish and fish habitat issues in the Columbia River from Valemount down to the Canada/United States border.
- Culture and Heritage Subcommittee, which addressed traditional use and archaeological issues along the historic Columbia River and in the reservoir drawdown zones from Valemount down to the Canada/United States border.
- Wildlife Technical Subcommittee, which addressed wildlife issues along and in the Columbia River from Valemount down to the Canada/United States border.
- Recreation Technical Subcommittee, which addressed recreation concerns along and in the Columbia River from Valemount down to the Canada/United States border.

Working with subcommittees offered the Consultative Committee several advantages:

- Issues involving detailed analysis (such as biological, hydroelectric or cultural issue specifics) could be explored in depth without alienating non-specialized participants.
- Summary information of complex technical data had more credibility with the Consultative Committee if vetted through a subcommittee with specific interest or knowledge first.
- Subcommittees offered a more effective and efficient use of participant's time.
- The smaller group size facilitated more open interest-based dialogue, exploration of issues and options and an amenable atmosphere for some participants.

The Technical Subcommittees met between February 2001 and June 2004 to support the Columbia River water use planning process. This included eight Fish Technical Subcommittee meetings, three Wildlife Technical Subcommittee meeting, seven joint Wildlife and Fish Technical Subcommittee meetings[1], seven Recreation Technical Subcommittee meetings, six Culture and Heritage Subcommittee meetings, and a vegetation workshop (refer to Appendix C: List of Documents Generated during the Columbia River Water Use Planning Process). The Technical Subcommittees also held many conference calls, and communicated by email and/or royal mail as required.

3.3.5 Terms of Reference

In February 2001, the Consultative Committee developed and adopted a *Terms of Reference and Code of Conduct* (refer to Appendix I: Consultative Committee Terms of Reference and Code of Conduct). The terms of reference were included in the *Proposed Consultative Process Report: Columbia River Water Use Plan* (BC Hydro, September 2001), and submitted to the Comptroller of Water Rights to fulfil Step 3 of the provincial government's *Water Use Plan Guidelines*.

The *Terms of Reference and Code of Conduct* helped Committee members gain a clear understanding of their roles and responsibilities and the procedures followed during the Columbia River water use planning process. Key sections in the final approved document included:

- Code of conduct.
- A description of the water use planning process and deliverables.
- Roles and responsibilities of Consultative Committee members, the BC Hydro project team members and facilitators.
- Public communication.
- Procedures in the event of disagreement.

3.3.6 Facilitation and Decision Analysis

A BC Hydro project team was responsible for overseeing the Columbia River Water Use Plan consultation process, and working with a team of independent facilitators and consultants to assist the Committee (refer to Appendix J: BC Hydro Project Team, and Facilitation and Decision Analysis Team). The facilitator was responsible for ensuring that the information and methods used for consultation and analysis maintained the integrity of the decision process as outlined in the provincial government's *Water Use Plan Guidelines*. The mandate of the facilitator was to ensure that the consultation process delivered information that is useful for informing regulatory decisions about the approval of the Water Use Plan. Given the diversity and complexity of the issues associated with the Columbia River system operations, specialized consultants were also contracted

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[1] Several joint meetings of the Fish and Wildlife Technical subcommittees were held to provide efficiencies in the process where possible. These meetings generally involved discussion of cross-disciplinary issues that required input by both the fish and wildlife technical specialists.

to assist the project team and Committee throughout the process, at the request and approval of the Committee.

Due to conflicts arising from extension of the Columbia River water use planning process into 2004, the Consultative Committee was notified of the need to replace the existing facilitator (L. Failing) (refer to Appendix K: Correspondence from Compass Resource Management Ltd.). At their June 2003 meeting, the Committee was offered three options for providing resource valuation and facilitation services for the remainder of the Columbia River water use planning process:

- Services to be provided solely by independent consultants,
- Services to be provided solely by BC Hydro's resource valuation staff, or
- Services to be provided by a combination of BC Hydro staff and consultants.

These options had been used for various BC Hydro Water Use Plans, and there were several examples where the division of roles between consultants and BC Hydro staff had changed over the course of the process.

The Consultative Committee decided to request an independent consultant to facilitate Committee meetings, and a BC Hydro staff member to lead the decision analysis team. Technical Subcommittee meetings were facilitated by the project team members.

3.3.7 Consultation Work Plan

Throughout the Columbia River water use planning process, some members of the Consultative Committee expressed concern regarding the limited number of meetings and the general lack of time available for effective communication of information to the Committee and Technical Subcommittees, specifically as it related to information gained through ecological studies, power studies and modelling efforts. These concerns were formally expressed in letters from the MWLAP and DFO to the BC Hydro project team in November 2002 (refer to Appendix L: Correspondence from Ministry of Water, Land and Air Protection and Fisheries and Oceans Canada). Given the complexities of the Columbia River system, it was felt that the informational and procedural limitations imposed on the Columbia River water use planning process might pose a risk to the Committee's acceptance of the methods and modelling results, and their ability to make good informed decisions.

To address these concerns, the BC Hydro project team developed a revised work plan for the Columbia River water use planning consultation process. This involved extending the schedule to provide additional time required for power modelling and in-depth discussions of the Technical Subcommittees related to operating alternatives and trade-off analysis, and additional meetings of the Consultative Committee and Technical Subcommittees. BC Hydro met with representatives from the MWLAP, DFO , and the Canadian Columbia River

Intertribal Fisheries Commission (CCRIFC) in April 2003 to review the proposed work plan, and address any outstanding issues or concerns of the agencies (refer to Appendix M: Minutes of the April 2003 BC Hydro/Agency Meeting). A more formal review of the proposed work plan was undertaken with the Consultative Committee during their June 2003 meeting.

3.3.8 Learning Opportunities

The Columbia River water use planning consultative process was designed to provide Consultative Committee members with opportunities to gain knowledge and insight into interests and issues being addressed in the Water Use Plan. To assist this learning, field trips were organized in conjunction with Committee meetings and presentations on technical issues related to operation of the Columbia River system were included on the agenda for Committee and Technical Subcommittee meetings. A summary of these activities is presented in Table 3-2.

Table 3-2: Columbia River Water Use Plan Educational and Technical Presentations

Topic	Presenter (Organization)	Date
Environmental Data Summary and Gap Analysis	Patricia Vonk (DVH Consulting) Gary Ash (RL&L Environmental Services)	8 to 9 November 2000
Introduction to the Columbia River Treaty	Tim Newton (BC Hydro)	16 February 2001
Overview of Hugh Keenleyside Dam and Operation	Will Friml (BC Hydro)	16 February 2001
Overview of Mica and Revelstoke Facilities and Operation	Ian Maclean (BC Hydro)	16 February 2001
First Nations Cross-cultural Awareness Training	Representatives of Ktunaxa–Kinbasket Tribal Council, Shuswap Nation Tribal Council, Okanagan Nation Alliance	17 February 2001
Overview of Columbia River Hydroelectric Generation (refer to Appendix N: Columbia Overview Document)	Al Geissler/Tim Newton (BC Hydro)	31 May 2001 27 June 2001
Power Modelling Overview	Alan Woo (BC Hydro)	8 May 2002
Kinbasket Reservoir Community Group Presentation	Randy Priest (KRCG)	11 June 2003
Overview of the Columbia River Treaty	Kelvin Ketchum (BC Hydro)	28 April 2003
Overview of the Non-Treaty Storage Agreement	Kelvin Ketchum (BC Hydro)	22 June 2004

3.4 COMMUNITY AWARENESS AND COMMUNICATION

In September 2000, BC Hydro held six Open Houses and Information Sessions at the following locations:

- Valemount Civic Centre (Valemount) 19 September 2000
- Golden Seniors Branch (Golden) 20 September 2000
- Revelstoke Community Centre (Revelstoke) 21 September 2000
- Nakusp Seniors Centre (Nakusp) 26 September 2000
- Sandman Inn (Castlegar) 27 September 2000
- Best Western Terra Nova (Trail) 28 September 2000

The Open Houses and Information Sessions attracted approximately 140 individuals. The sessions allowed BC Hydro to promote awareness and provide information on the Columbia River water use planning process, obtain preliminary input on issues and the consultation process, and invite potential participants on the Consultative Committee.

During the Columbia River water use planning process, BC Hydro issued four news releases and three newsletters to inform the public in the Columbia River basin area about developments in the Columbia River Water Use Plan. 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 Columbia River Water Use Plan, as well as those interested in other Water Use Plans for other BC Hydro facilities in the province.

3.5 FIRST NATION INVOLVEMENT

The Columbia River project is in the claimed traditional territories of the Ktunaxa-Kinbasket Tribal Council (KKTC), the Shuswap Nation Tribal Council (SNTC), the Little Shuswap Indian Band (LSIB), the Okanagan Nation Alliance (ONA), and the Spallumcheen Indian Band (SIB). All of these First Nations were contacted to determine their desired level of participation in the Columbia River water use planning process.

At the initiation of the Columbia River water use planning process, most of the First Nations contacted agreed to participate, except for the ONA who opted not to participate. The ONA were kept informed of the water use planning process proceedings. The SIB and LSIB participated until the spring of 2002 and 2003 respectively, at which time they chose to move to observer status. The SNTC community members' interests were represented on the Consultative Committee through the Secwepemc Fisheries Commission (SFC) which was initially named the Shuswap Nation Fisheries Commission (SNFC). When the SIB moved to observer status, their interests were represented on the Committee table through the SFC.

The KKTC represent the St. Mary's, Lower Kootenay, Tobacco Plains, Shuswap and Columbia Lake (Akisq'nuk First Nation) Indian Bands' interests on traditional territory, while the individual Bands represent their interests on-reserve. The SNTC, whose interests were represented on the Consultation Committee through the SFC, represent the Neskonlith, North Thompson, Adams Lake, Kamloops Spallumcheen and Skeetchestn Indian Bands' interests on traditional territory while the individual Bands represent their interests on-reserve.

The Little Shuswap Indian Band operates independent of the SNTC, the ONA or the KKTC.

The KKTC and the SFC and their aquatic resource advisors, the CCRIFC, participated as Consultative Committee members. A CCRIFC representative participated on the Fish and Wildlife Technical Subcommittee. First Nations also participated to varying degrees on the Culture and Heritage, Recreation, Wildlife and Fish Technical Subcommittees. The CCRIFC consistently attended the Fish and Wildlife Technical Subcommittee meetings. First Nation participation in the Culture and Heritage Subcommittee was maintained throughout the Columbia River water use planning process. In May 2003, First Nations participated in a vegetation workshop to develop options for revegetation of the drawdown zone to address fisheries, culture and heritage and wildlife interests.

First Nations participating in the Columbia River water use planning process were provided aquatic technical assistance through CCRIFC and the SNFC (later changed to the SFC). These two groups were responsible for communicating information from the Columbia River water use planning process to their community members and bringing their community members' interests to the table for discussion. Wayne Choquette, Consultant Archaeologist, provided cultural resource advice to the First Nations.

Throughout the Columbia River water use planning process, the CCRIFC and the SFC arranged workshops to keep the communities they represent up to date on the process and to receive feedback from community members on objectives, performance measures, operating alternatives, and trade-offs.

A BC Hydro Aboriginal Relations Task manager was assigned to the BC Hydro project team. The Task manager worked closely with the Community Relations 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 and to secure those resources needed.
- Co-ordinate any tasks involving First Nations.

The BC Hydro Aboriginal Relations Task Manager met with the Culture and Heritage Subcommittee and the First Nations and their archaeologist to develop cultural and heritage objectives, study terms of reference, performance measures, and monitoring study and physical works proposals. Communications also included conference calls, emails, phone calls and one-on-one discussions.

At the February 2001 Consultative Committee meeting, representatives from KKTC, ONA and Shuswap Nation presented a cross-cultural awareness session to the BC Hydro project team and the Committee. Presentations included First Nations' history, values, their connection to the land in the Columbia River basin, and their political organization and aspirations.

3.6 TRADITIONAL ECOLOGICAL KNOWLEDGE

Throughout the Columbia River water use planning process, the subjects of traditional ecological knowledge and traditional use knowledge were raised on numerous occasions. Both First Nations and the Consultative Committee had an interest in collecting information to develop water use planning objectives, performance measures and revegetation programs, provide context to the results of archaeological studies, and help prioritize proposals for physical works in lieu of operational changes.

The culture and heritage studies consisted of two components: an archaeological component and a Traditional Use component (refer to Section 5.2). The information gained from these studies was provided to the First Nations' representatives on the Consultative Committee for review and feedback on how the information could be used in the planning process.

Information on traditionally used plants was specific enough to use in the Columbia River water use planning process. Through discussions with First Nations and the Wildlife Technical Subcommittee, it was agreed that where traditionally used plants were suited to site conditions in the drawdown zone, they would be proposed for planting. Another area was the identification of landforms that do, or may, contain cultural sites or be culturally significant to First Nations. As revegetation and cultural resource mitigation programs proceed, it is expected that this information will also be helpful in assigning priority to revegetation of areas in the drawdown zone.

4 ISSUES, OBJECTIVES AND PERFORMANCE MEASURES

4.1 INTRODUCTION

As per Step 4 of the provincial government's *Water Use Plan Guidelines*, the Consultative Committee expressed their interests and issues in terms of specific objectives for desired outcomes of the Columbia River water use planning process. In defining the objectives, the participants articulated what they sought to achieve through incremental changes in BC Hydro operations (e.g., maximize fish production). The Committee defined one or more performance measures to quantify how the objective will be measured (e.g., square metres of fish habitat), and to assess the benefits of the proposed operating alternatives on the objective.

This section of the report provides an overview of the issues identified through the Columbia River water use planning process, and the objectives and performance measures developed by the Consultative Committee.

4.2 ISSUES

A preliminary list of issues for the Columbia River Water Use Plan was developed through consultation with regulatory agencies, First Nations, federal, provincial and municipal governments, and key stakeholders in the Columbia River watershed. These issues were documented in *Preliminary Issues Reports* prepared for the Mica and Revelstoke Water Use Plan (BC Hydro, 2001a) and Hugh Keenleyside Water Use Plan (BC Hydro, 2001b) based on a series of public meetings, interviews, open houses, questionnaires, and an environmental information review and data gap analysis (RL&L, 2001). A summary of the issues identified in these reports is provided in Appendix O: List of Initial Issues Identified for the Columbia River Water Use Plan.

Issues were identified for a number of key values including:

- Flood control, erosion, and water management.
- Navigation and industry.
- Aesthetics, recreation and tourism.
- Power generation and ancillary services.
- First Nations, heritage and traditional use.
- Wildlife and wildlife habitat.
- Fish and fish habitat.
- Water supply and quality.

- Forestry.
- Public safety.

Preliminary identification of issues provided an initial step towards creating a clearer understanding about the relationship between various water use interests as they relate to BC Hydro's current operations on the Columbia River, and assisting the Consultative Committee in confirming the full range of interests and corresponding objectives to be considered in the Columbia River Water Use Plan.

As the Consultative Committee worked through the steps of the provincial government's *Water Use Plan Guidelines*, consideration was given to whether issues were eligible to be addressed through the Columbia River water use planning process. Issues were considered to be within the scope of water use planning if:

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

In many cases, provisions were made outside the Columbia River water use planning process to address issues identified by the Consultative Committee that were not within the scope of the process. Wherever possible, these were directed to other programs or initiatives in the Columbia River watershed (e.g., Columbia Basin Fish and Wildlife Compensation Program).

4.3 OBJECTIVES AND PERFORMANCE MEASURES

Objectives for the Columbia River Water Use Plan were developed based on initial input from the Consultative Committee in February and June of 2001, and subsequent meetings and discussions with the Technical Subcommittees focused on recreation/navigation, fish and wildlife, and cultural/heritage objectives. Refinements were made to the initial set of objectives and performance measures as new information became available about the relative importance of different issues, uncertainties were addressed through Step 5 studies, and opportunities to address the issues through the Columbia River water use planning process were identified.

In developing performance measures, consideration was given to the following criteria:

- Accuracy: They provide information about progress toward the objective.
- Predictive capability: They can be estimated with available data and modelling tools.

- Sensitivity: They are sensitive to the alternatives. If they do not vary across the range of alternatives, they are not useful in evaluating them.
- Meaningful measure: They must be reported in units that make sense to decision-makers. It is often helpful if they refer to some known threshold.
- Manageable number: If there are too many performance measures, it becomes difficult to keep track of the impacts and often means insufficient effort was put into issues scoping and prioritizing.

The exact specifications and calculations for performance measures evolved throughout the Columbia River water use planning process. Modifications were made to the performance measures in cases where:

- Preliminary modelling and analysis demonstrated that the performance measure was insensitive (did not change significantly) across the range of operating alternatives.
- Studies and model development provided the means to improve accuracy.
- Further deliberations clarified participants' values and resulted in changes to ensure the performance measure was relevant to Consultative Committee members' concerns.
- Expert technical judgment was used to combine multiple performance measures into a summary measure reporting net effects on an endpoint (e.g., vegetation) so that non-technical Consultative Committee members could make value judgments without detailed technical expertise.

To assist in evaluating relative performance among the proposed operating alternatives, a Minimum Significant Incremental Change (MSIC) was estimated for most of the performance measures. The MSIC is the amount by which any two alternatives must differ on a performance measure score before one alternative can be considered to perform significantly better than the other. Two alternatives are considered to perform equally on an objective when the difference in the performance measure scores is equal to or less than the MSIC. Significant differences were largely subjective estimates, which accounted for modelling uncertainty in:

- The calculation of reservoir discharge/elevations.
- The calculation of the performance measures.
- The link between the performance measure and the fundamental objective.
- Measurement error.

The Consultative Committee and Technical Subcommittees developed final objectives and performance measures for eight categories that represented their key interests related to operation of BC Hydro's Columbia River hydroelectric facilities (Mica, Revelstoke and Hugh Keenelyside). These are discussed below and summarized in the accompanying tables in no implied order of priority.

4.4 FLOOD EROSION CON TROL

4.4.1 Issues

4.4.1.1 Reservoir Surcharge

When Kinbasket or Arrow Lakes Reservoir surcharges, property adjacent to the reservoir may be affected by bank erosion from wave action. In Kinbasket, surcharging may also mobilize large amounts of accumulated debris along the shorelines. This may affect the easement around Arrow Lakes Reservoir, and logging roads around Kinbasket Reservoir.

On Arrow Lakes Reservoir, the surcharge[1] limit is set at 440.74 m (1446 ft) (i.e., 2 ft above full pool). Use of the surcharge zone could lead to increased erosion but any erosion is still within the flowage easement[2] that extends to 443.48 m (1455 ft). There are no other structures in the reservoir because it has been cleared up to the limit of the surcharge. BC Hydro has applied to use the surcharge on Arrow Lakes Reservoir to provide greater flexibility for meeting flood control requirements, although the surcharge area has only been rarely used. The ability to use the surcharge is, however, important to BC Hydro due to restrictions on downstream flows associated with the Columbia River Treaty.

On Kinbasket Reservoir, full pool is 754.38 m (2475 ft) and there are no structures within the surcharge area. The surcharge level in this reservoir is not set at a specific elevation. Instead, the Comptroller of Water Rights authorizes a spill curve based on expected inflows. At 3 ft above full pool (755.29 m; 2478 ft), the spillway must be fully open, at which point Mica Dam is on free spill and water levels in the reservoir are totally dependent on inflow. BC Hydro has surcharged the reservoir twice since construction of the project – once in 1988 (at which time the Comptroller of Water Rights authorized a spill curve with a maximum of a one foot surcharge), and once in the late 1990s (at which time the Comptroller authorized a spill curve with a maximum surcharge of six inches).

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1 Surcharging means to fill the reservoir beyond full pool. BC Hydro is entitled to do this under special circumstances on both Kinbasket and Arrow Lakes reservoirs, but must apply to the Water Comptroller each time.

2 The flowage easement was purchased by BC Hydro for almost the entire perimeter of Arrow Lakes Reservoir (some properties are not included) up to the level of 443.48 m (1455 ft) (i.e., 11 ft above full pool). The additional easement allows for any sloughing or erosion due to wave action.

4.4.1.2 Lower Columbia River Flooding

Flood flows in the lower Columbia River have the potential to affect property at Genelle and Trail. Trail has experienced occasional floods in the past, with one flood in 1948 causing water depths up to 3 ft. However, since construction of the Columbia River hydroelectric facilities, flood risk has been substantially reduced from historic levels. There have been three inflow years comparable to 1948 without any impact on Trail. In addition, a retaining wall has been constructed at Trail to provide further protection. The City of Trail representative emphasized that damage to the city's infrastructure starts when river flows reach 165 kcfs.

In 1992, a daily average flow rate of almost 180 kcfs (approximately equivalent to a "100-year" flood[1]) at the Birchbank gauge[2] disabled the septic system at a mobile home park and damaged other minor encroachments (e.g., boats, firewood, storage sheds, etc.) at Genelle. However, all these areas were on the floodplain and there was no notable property damage. Flooding at the trailer park in Genelle was estimated to start at flows of 165 kcfs. BC Hydro has managed to maintain flows at or below 165 kcfs in recent years, although flows could exceed that threshold in the future and BC Hydro has marked the "100-year flood" and "200-year flood" levels on maps and various benchmarks in the area.

4.4.1.3 Other Flooding-related Issues Considered but not Pursued

Some flooding and erosion concerns were identified by the Consultative Committee, but not pursued further through the water use planning process. These issues and rationale for not addressing them further are outlined below in Table 4-1.

Table 4-1: Flooding-related Issues Discussed but not Pursued by the Consultative Committee

Interest	Location	Issue/Concern	Decision/Rationale
Daily Flow Fluctuations	Lower Columbia River	The one area where daily fluctuations are a large concern is in the lower Columbia River (from Hugh Keenleyside Dam to the Canada/United States border), where flows can change dramatically from day to day or week to week.	Due to the influence of the Kootenay River system (which was outside of the scope of the Columbia River water use planning process) and lack of control over flow changes (due to the constraints of the Columbia River Treaty), a modelling approach and performance measures to capture these interests were not developed. A high level assessment by the BC Hydro project team concluded that none of the operating alternatives being considered by the Consultative Committee would make ramping impacts worse in the lower Columbia River.

[1] This term is used to describe a flood that would be expected to occur once every 100 years. A 200-year flood (larger than a 100-year flood) would be expected to occur once every 200 years.

[2] A waterflow gauge on the Columbia River between Castlegar and Trail.

4.4.2 Objectives and Performance Measures

The following objective and sub-objectives were developed by the Consultative Committee to address concerns related to flooding in the lower Columbia River and surcharging of Arrow Lakes Reservoir.

Minimize damage to property and injury of people:

- *Minimize the frequency and duration of flood flows at Trail.*
- *Minimize the frequency and duration of reservoir surcharging.*

Table 4-2 summarizes the flood and erosion control performance measures used by the Consultative Committee to evaluate operating alternatives for the Columbia River facilities.

Table 4-2: Flood Erosion Control Performance Measures

Location	Performance Measure	Unit of Measure	Description	MSIC
Kinbasket Reservoir	Frequency of Surcharge	# of days per year when Kinbasket Reservoir elevations exceed full pool at 754.38 m (2475.0 ft)	Surcharge of the reservoir may cause bank erosion, and mobilize shoreline debris. This performance measure tracks the expected frequency with which elevations will rise above full pool in any given year.	7 days per year
Arrow Lakes Reservoir	Frequency of Surcharge	# of days per year when Arrow Lakes Reservoir elevations exceed full pool at 440.1 m (1443.9 ft)	Surcharge of the reservoir may cause erosion damage to the easement area around Arrow Lakes Reservoir. This performance measure tracks the expected frequency with which elevations will rise above full pool in any given year.	7 days per year
Arrow Lakes Reservoir	Frequency of High Water Events	# days per year when Arrow Lakes Reservoir is at or above 439 m (1440 ft)	High water levels in the reservoir, approaching the full pool mark, have been associated with erosion and slumping of the shores.	7 days per year
Lower Columbia River	Frequency of Flood Flows on Lower Columbia River	# of potential flood days per year at Genelle (>165 kcfs)	On the lower Columbia River, the flow rate that will cause property damage at Genelle has been identified. This performance measure tracks the expected frequency with which flows exceed this threshold.	N/A

Note: All reservoir elevations and river flows were calculated on a monthly time step (refer to Section 6 for more details), with daily or weekly values found through interpolation between months. As a result of this averaging, the daily variation experienced on the system was not captured.

4.4.2.1 Kinbasket Reservoir Flood/Erosion Control

Results of the Round 1 trade-off analyses suggested that the frequency of surcharge on Kinbasket Reservoir is low and unlikely to be affected by operating alternatives being considered by the Consultative Committee (refer to Section 7.3.2). For this reason, this performance measure was not carried forward for Kinbasket Reservoir.

4.4.2.2 Arrow Lakes Reservoir Flood/Erosion Control

During the June 2003 meeting, the Consultative Committee noted that the Alternative 11s for Arrow Lakes Reservoir provided erosion control benefits. Specifically, the reservoir would only rise within 0.5 m of full pool at the end of July twice over the 60 years of records under Alternative 11C and once under Alternative 11D. As this was not being captured in the surcharge performance measure, a new metric was developed to report on the frequency that the reservoir is at or above 439 m (1440 ft). This measure replaced the surcharge performance measure, which showed little difference across the alternatives.

4.4.2.3 Lower Columbia River Flood Control

To address concern related to flood damage to private/public property downstream at Genelle, a performance measure was developed to track the expected frequency (number days/year) at which a maximum flow threshold (192 kcfs) was exceeded. This flow rate was selected since flooding impacts occur at Genelle at 192 kcfs. This performance measure was subsequently modified to track exceedances of a 165 kcfs threshold (as measured at the Birchbank gauge) to capture potential impacts at both Genelle and Trail. It was recognized that a limitation to the use of flows at the Birchbank gauge as a flooding threshold is that flows at this point on the lower Columbia River also include those from the Kootenay River, which vary independently from those released through Hugh Keenleyside Dam.

4.5 NAVIGATION

4.5.1 Issues

Commercial operations (primarily local forest companies surrounding Kinbasket Reservoir) can be affected by reservoir elevations and river flows. Either low or high reservoir elevations and high river flows or large fluctuations in river flows can result in a disruption to operations. When reservoir levels do not fall within critical elevations, forest companies respond by changing sites or routes, altering facilities or equipment, and/or by delaying logging or transport operations, all of which increase costs.

The primary region of concern related to navigation is Kinbasket Reservoir because of its use by local forest companies and its extensive drawdown zone. Nevertheless, commercial navigation remains an area of some concern for other areas within the Columbia River. Changes in river flows in the lower Columbia River are not expected to be of a magnitude that would cause a significant impact on commercial navigation.

4.5.2 Objectives and Performance Measures

The following navigation objective and sub-objective were developed by the Consultative Committee for the Columbia River water use planning process.

Minimize disruptions to commercial navigation/transport:

- *Maximize the frequency that commercially important routes are navigable and sites are accessible.*

Table 4-3 summarizes the navigation performance measure used by the Consultative Committee to evaluate operating alternatives for Kinbasket Reservoir.

Table 4-3: Navigation Performance Measure

Location	Performance Measure	Unit of Measure	Description	MSIC
Kinbasket Reservoir	Navigability	# site-days per year	The frequency that a site is navigable to commercial operators, summed over sites.	7 site-days per year

To determine appropriate performance measures, a preliminary list of sites in Kinbasket Reservoir affected by BC Hydro operations was identified by the Navigation/Transportation Technical Subcommittee, and the critical elevations at which disruption to navigation occurs were then defined. These are presented below in Table 4-4.

Table 4-4: Preliminary List of Sites in Kinbasket Reservoir affected by BC Hydro Operations

Site	Critical Elevation	Commercial Operators Affected
Harvey Creek	2415 ft and above	Bell Pole
Bear Island Shortcut	2450 ft and above	Mica Marine and others
Bush Harbour	2400 ft and above	Mica Marine
Downie Timber	2360 ft and above	Wood River Forest Products
LP Golden	2400 ft and above	LP Golden

The navigation performance measure estimates the frequency (in number days per year) that a key site is navigable, summed over sites in the area.

$$N = \sum_{1}^{s} d_i$$

where:

N = total number of navigable site-days during a given year within a region (waterbody);

s = number of key sites/areas in the region, and

d = number of days per year when the i^{th} site is within a range of reservoir elevations or river stages that permit satisfactory commercial navigation/access.

The assumptions used in calculation of this performance measure were considered appropriate as they are based on the experience of commercial operators in the region.

4.6 RECREATION

4.6.1 Issues

Recreational access and associated benefits are important throughout the region from Kinbasket Reservoir to the lower Columbia River. Local communities benefit from improvements to the quality and diversity of recreation and tourism experiences through a greater quality of life, as well as through local economic development benefits that result from increased usage. Key factors affecting recreational quality and use include:

- The diversity and abundance of fish and wildlife, since many recreational activities are focused around enjoyment of these natural resources.
- The ability to safely access the water or shorelines for water-based and shore-based activities.
- The visual quality of viewscapes (appearance of the reservoir/river, related to the avoidance of exposed mudflats/dust and exposed standing debris.)

For each part of the Columbia River system, the Consultative Committee specified preferred elevations for shore-based activities, water-based activities and visual quality. Recreational use rates, present and future, can be forecast as a function of these preferred water levels, and the local economic impacts resulting from both recreation and tourism can be estimated.

4.6.2 Objectives and Performance Measures

The following recreation objective and sub-objective were developed by the Consultative Committee for the Columbia River water use planning process.

Maximize the community benefits from quality and diversity of recreation and tourism:

- *Maximize water and shoreline access, visual quality and boating/swimming safety on Kinbasket and Arrow Lakes reservoirs and in the mid and lower Columbia River.*

Table 4-5 summarizes the recreation performance measure used by the Consultative Committee to evaluate operating alternatives for the Columbia River facilities.

Table 4-5: Recreation Performance Measure

Location	Performance Measure	Unit of Measure	Description	MSIC
Kinbasket Reservoir, Arrow Lakes Reservoir, mid and lower Columbia River	Total Economic Activity	Thousands $ per year (10th percentile)	Net local economic activity resulting from formal recreational and tourism use. Provides an indicator of the relative desirability of each operating alternative from a recreation perspective.	$300k per year

During initial trade-off discussions, the Consultative Committee used a recreation performance measure that reported on the sum of number of days that elevation and flow rate is within the preferred ranges (as defined by the Recreational Technical Subcommittee) for each recreational activity/attribute (shoreline access, visual quality, boating, swimming safety) on Kinbasket and Arrow Lakes reservoirs, and the mid and lower Columbia River. As the sheer number of recreation performance measures was confusing to most Committee members, the measures were consolidated into a summary measure that reported the sum across all activities for each region.

In many cases, the recreation performance measures largely offset each other with the result that there were few significant net gains or losses from the proposed alternatives. The Recreation Technical Subcommittee agreed that recreation benefits could be summarized by the economic value of recreation and tourism activities to local economies, and a related study was commissioned as part of Step 5 of the process (refer to Section 5.3).

A new recreation performance measure was subsequently developed to estimate the net local economic activity resulting from recreation and tourism use in Kinbasket Reservoir, the mid Columbia River, Arrow Lakes Reservoir and the lower Columbia River. It provided an indication of the relative desirability of each operating alternative based on changes to shoreline access for shoreline-based activities and from improved boat access. The Recreation Technical Committee recognized the importance of visual aesthetics and the indirect impacts associated with improvements to vegetation, fish and wildlife, but felt that developing performance measures to address these impacts would be too difficult.

The recreation performance measure was developed using a recreation demand model, which was developed as part of the information collection phase (Axys and Gustavson, 2002). To aggregate the number of access days across regions and activities, a value per access day measure was derived for each location and activity. This measure of "average dollars per access day" when combined with "the number of access days" allowed the recreational impacts of the different alternatives to be aggregated across areas and across activities. It was emphasized by the Recreation Technical Subcommittee that this was not a measure of benefits. Rather, it was a rough estimate of the additional direct economic activity generated by having the reservoir at a preferred elevation.

For each sub-region and each activity, the following formula was used to determine the total number of user days under the various operating alternatives:

$RUD_x = ((AUD \times PSU)/DPS) \times PM_x$

where:

RUD_x = regional user-days for Alternative X

AUD = estimated annual user days for the sub-region

PSU = percentage of use occurring in the defined recreational season

DPS = number of days in the defined season

PM_x = recreation performance measure (# of access days) for Alternative X

A relative "Community Importance Modifier" was applied as a way of allocating regional user days among communities, thereby apportioning the estimated economic benefits of recreation. The community importance modifier represents the number of user days for each alternative that are likely to originate from a particular community relative to other communities, and was calculated as follows:

$CUD_x = RUD_x \times CIM$

where:

CUD_x = community user days for Alternative X

RUD_x = regional user days for Alternative X

CIM = community importance modifier

Table 4-6 provides a breakdown of the parameters used in calculating the recreation performance measure. Critical elevations for the mid Columbia River and Arrow Lakes Reservoir were revised several times by the Recreation Technical Subcommittee. The following table provides the final definitions used in the calculations.

Table 4-6: Recreation Access Performance Measure Calculation Parameters

Area	Measure	Dates	Critical Elevation Zones	Users/ Day	% Local	% Tourist	$/ Local	$/ Tourist	Average $/Access Days
Kinbasket Reservoir	Boat Access Days	24 May to 8 September	# days Kinbasket Reservoir between 2395 and 2475 ft	67	80%	20%	$ 57	$ 154	$ 5,119
	Shoreline Access Days	1 May to 30 September	# days Kinbasket Reservoir between 2444.2 and 2473.4 ft	63	80%	20%	$ 40	$ 137	$ 3,742
Mid Columbia River	Boat Access Days	1 May to 30 September	# days Arrow Lakes Reservoir is above 1435 ft	183	70%	30%	$ 57	$ 154	$15,756
	Shoreline Access Days	1 May to 30 September	# days Arrow Lakes Reservoir is below 1435 ft	784	70%	30%	$ 40	$ 137	$54,174
Arrow Lakes Reservoir	Boat Access Days	1 May to 30 September	# days Arrow Lakes Reservoir is between 1435.4 and 1443.9 ft	1046	80%	20%	$ 57	$ 154	$79,914
	Shoreline Access Days	1 May to 30 September	# days Arrow Lakes Reservoir is between 1425 and 1435 ft	1150	80%	20%	$ 40	$ 137	$68,310
Lower Columbia River	Boat Access Days	1 May to 30 October	# days Hugh Keenleyside + Brilliant dams flows between 70 902 and 102 823 cfs	24	80%	20%	$ 57	$ 154	$ 1,834
	Shoreline Access Days	1 May to 30 October	# days Hugh Keenleyside + Brilliant dams flows between 60 309 and 99 327 cfs	348	90%	10%	$ 40	$ 137	$17,296

The Recreation Technical Subcommittee expressed concern that current recreation patterns may shift with a change in the current reservoir operating regime. Axys and Gustavson (2002) concluded that there was no strong evidence that the alternatives being considered by the Consultative Committee would impose changes large enough to radically change recreational patterns. As a result, the subcommittee agreed to adopt the more simple method of calculating recreational impacts, as outlined above.

4.7 POWER GENERATION

4.7.1 Issues

4.7.1.1 Financial Value of Power

The combined power generation facilities at Mica and Revelstoke facilities produce approximately 38 per cent of BC Hydro's annual energy. Constraints on reservoir elevations and river flows may affect the revenue that can be generated by these projects. Given that BC Hydro is owned by the Province of British Columbia, lost energy production represents losses in revenue for the provincial government. In addition to BC Hydro's generating facilities, generation at ALPC's Arrow Lakes Generating Station (ALH) may also be affected.

4.7.1.2 Ancillary Services

Mica facilities currently support 12 ancillary services that could be affected by operational changes resulting from implementation of the Columbia River Water Use Plan. Ancillary services are services that help maintain the reliability of the interconnected power systems. If a significant loss of a service occurs at one part of the system, the service must be replaced or obtained elsewhere. The most important services include voltage control, supplemental reserves and dynamic scheduling. The complete list of services includes:

- Backup supply.
- Blackstart.
- Dynamic scheduling.
- Energy balance.
- Load following.
- Network stability.
- Operating reserve (spinning).
- Operating reserve (supplemental).
- Regulation.
- System control.
- Transmission losses.
- Voltage control.

4.7.2 Objectives and Performance Measures

The following power generation objective and sub-objectives were developed by the Consultative Committee for the Columbia River water use planning process.

Maximize the power benefits produced by the combined operation of Mica, Revelstoke and Hugh Keenleyside facilities:

- *Maximize financial value of power.*
- *Maximize ancillary service capability.*

Table 4-7 summarizes the power generation performance measures used by the Consultative Committee to evaluate operating alternatives for the Columbia

River facilities. No performance measure was developed for ancillary services, as modelling results suggested that they would not be affected by alternatives under consideration by the Committee.

Table 4-7: Power Generation Performance Measures

Location	Performance Measure	Unit of Measure	Description	MSIC
Columbia River generating facilities	Total Power Cost	Power Value Loss M$ per year	Average annual cost relative to Base Case for meeting load requirements at all Columbia River facilities over 60 years of modelled data.	10%
	Total Power Cost (Revelstoke)	Power Value Loss M$ per year	Average annual cost relative to Base Case for meeting load requirements at Revelstoke Dam over 10 years of modelled data.	10%
	Total Power Cost (ALH subtracted)	Power Value Loss M$ per year	Average annual cost relative to Base Case for meeting load requirements less revenues at ALH over 60 years of modelled data.	10%
	Cost of Mountain Whitefish Flows	Power Value Loss M$ per year	Average annual cost of providing mountain whitefish flows, involving capping of January flows and providing fall flow augmentation.	10%
	Cost of Rainbow Trout Flows	Power Value Loss M$ per year	Average annual cost of providing protection flows for rainbow trout, involving 1 MAF of storage in Arrow Lakes Reservoir and summer flow augmentation.	10%
	High Cost Years (90^{th} percentile)	Power Value Loss M$ per year	Estimate of high cost (90^{th} percentile) year for annual costs over 60 years of modelled data.	10%

4.7.2.1 Total Power Cost

The total power cost performance measure estimates the combined loss of annual power values (in levelized dollars per year)[1] from energy production at Mica, Revelstoke and ALH. This was calculated using the BC Hydro HYSIM operations model, which simulated operation of the Columbia/Peace system on a monthly time step to minimize the cost of meeting system load (refer to Section 6.3). The power values for each operating alternative were reported as the relative difference from this cost-minimizing alternative (referred to as Base Case[2]).

1 Levelized dollars per year is defined as the present value of the total cost over the 60 years of inflow data based on equal annual payments and a constant interest rate.

2 Base Case is unconstrained reservoir and river operations to minimize the cost of power production, subject to Columbia River Treaty obligations.

The cost of operational constraints at Revelstoke Dam was estimated by the General Optimization Model (GOM)[1]. This model ran on a bi-hourly time step over a 10-year period. Average annual costs were reported as the relative difference from an unconstrained, cost-minimizing alternative. This reference case contained no minimum flows at Revelstoke Dam, whereas BC Hydro's practice at the time had been to provide daytime minimum flows of 5 kcfs when practical. As well, this power optimal flow included an informal restriction on the drawdown in Revelstoke Reservoir, although no such formal constraints exist within BC Hydro's water licence.

At the November 2003 Consultative Committee meeting, the Committee requested that the loss of power values from operations in the lower Columbia River (ALH) be separated out from loss of power values at the Mica and Revelstoke projects. This request was made due to concern that consideration of ALH in the trade-off analysis was beyond the scope of the water use planning policy framework and might be inconsistent with the ALH Project Approval Certificate (refer to Section 7.6.1).

As power values were calculated for the system as a whole and were not tracked on a facility by facility basis, calculation of this performance measure required post-processing to estimate power generation impacts to ALH. The financial impacts arising from changes in ALH operations arise from three sources: the change from Base Case due to the change in the entire system, and changes arising from flow agreements for rainbow trout and mountain whitefish in the lower Columbia River (see below). These elements were summed and presented as average annual power costs across the 60 years of modelled data.

4.7.2.2 Power Cost of Fish Friendly Flows

In the early stages of the Columbia River water use planning process, it was estimated that the net financial costs of providing the mountain whitefish flows, rainbow trout flows, and Arrow/Libby swap would be approximately zero. As a result, both flow agreements were modelled together with an assumed net financial impact of zero. However, as the Consultative Committee tried to understand the impact of these agreements on Arrow Lakes Reservoir, it became necessary to separate these elements and estimate their financial value separately.

The power costs associated with the mountain whitefish flows are due, in part, to head losses caused by drafting of Arrow Lakes Reservoir in September to meet the commitment for fall flow augmentation in the United States. They are also the result of losses to BC Hydro's market opportunity as the price differential between the September and the October/November periods is reduced by this action. These two costs associated with the mountain whitefish flows have been estimated to be approximately equal in magnitude.

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1 A detailed description of the General Optimization Model and the HYSIM operations model is provided in the Columbia River Water Use Plan Power Studies Report (BC Hydro in prep).

Provision of protection flows for rainbow trout in the spring results in a power gain to BC Hydro. This is a result of increased head on Arrow Lakes Reservoir associated with the storage of an additional 1 MAF for the July/August release to benefit United States salmon.

4.7.2.3 High Cost Years

Concerns were raised by the BC Hydro corporate representatives and the representative for BC Energy and Mines that performance of the proposed operating alternatives for power generation was reported as long-term averages and, therefore, was not capturing the variability of costs in any given year and from year-to-year. BC Hydro produces income forecasts each year, both for its internal planning and to assist the provincial government in planning its budgets. As large deviations from these forecasts can cause disruptions to the government's fiscal planning, BC Hydro and the province expressed interest in maintaining its ability to meet revenue forecasts and minimizing its risk of delivering less than its forecast revenues.

Concern was also expressed that, in some years, power costs can be very high and not commensurate with the environmental benefits expected from implementing the constraints of the operating alternative. The Consultative Committee expressed an interest in developing a performance measure to report on these extreme cost years. At the final Committee meeting in June 2004, the BC Hydro project team presented a new performance measure that reported on the estimated annual cost of the operating alternatives in high (90th percentile) cost years. This would allow Committee members to gauge whether the power losses in a high cost year were worth the environmental benefits gained through constraining the system in that year.

4.8 CULTURE AND HERITAGE

4.8.1 Issues

BC Hydro's projects on the Columbia River are located within the traditional territory of several First Nations. There are known historical trails and archaeological sites within the drawdown zone of the reservoirs, and it is expected that other sites of significance to both First Nations and non-First Nations exist within areas affected by reservoir operations. Such sites may provide opportunities to learn about the history and culture of the region.

Archaeological studies conducted to date suggest that BC Hydro's operations are most likely to affect sites within and around Arrow Lakes Reservoir. Potentially thousands of hectares in the reservoir drawdown zone are partially intact terraces, and these areas may contain culturally important sites. A high-level landform study conducted as part of Step 5 of the Columbia River water use planning process (Choquette, 2002; refer to Section 5.2) identified four sites within the drawdown zone of Arrow Lakes Reservoir with intact archaeological information, as well as a major escarpment likely to contain a large number of intact and actively eroding sites. The base of this escarpment was estimated to be at elevation 436 m (1430 ft).

While there could be a few areas around Kinbasket Reservoir of archaeological importance, the majority of sites are expected to be located primarily on the old valley bottom and, therefore, at elevations below the reservoir drawdown zone and outside the zone of influence of any reservoir operations resulting from implementation of the Columbia River Water Use Plan. Various sites may also exist around Revelstoke Reservoir, but this area is considered relatively stable and unlikely to be affected by operation of the reservoir. Since the creation of the dams on the Columbia River has dramatically decreased peak flows, any significant sites in the lower Columbia River are expected to be located well above the influence of current water levels. Inundation patterns suggest that the potential for finding sensitive archaeological sites that are subject to active erosion in the lower Columbia River was low to zero. It was recognized that the only risk to culturally important sites would be in the unlikely event that flushing flows (for fish habitat enhancement) greater than historic flood flows (e.g., 1948) were implemented in the lower Columbia River.

4.8.2 Objectives and Performance Measures

The following culture and heritage objectives were developed by the Consultative Committee for the Columbia River water use planning process.

- *Minimize erosion impacts of water on potential archaeological zones.*
- *Minimize erosion impacts of wind on potential archaeological zones.*
- *Minimize the impact of destructive human behaviour (traffic, pot hunting, etc.) on potential archaeological zones.*
- *Allow access to archaeological sites by appropriate people.*
- *Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.*
- *Provide access to traditional plants.*
- *Maximize abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities. (See Fish and Wildlife Performance Measures.)*

Table 4-8 summarizes the culture and heritage performance measures used by the Consultative Committee to evaluate operating alternatives for the Columbia River facilities.

Table 4-8: Culture and Heritage Performance Measures

Location	Performance Measure	Unit of Measure	Description	MSIC
Arrow Lakes Reservoir	Heritage – Water Erosion	# days per year at or above 436 m	Frequency (in days per year) at which water levels on Arrow Lakes Reservoir are between 436 and 440.4 m. This is the elevation of a major escarpment on which First Nations heritage sites are believed to exist.	7 days per year
	Heritage – Wind Erosion	3 point scoring scheme (-1 to +1)	Based on vegetation presence at elevations 434 to 440 m.	0.5

The Culture and Heritage Subcommittee examined several ways in which reservoir operations could affect existing archaeological sites. These impacts can be direct through active erosion of a site by wave action at the edge of the water or under the water, or they can be indirect through retarding vegetation growth and exposing sites to wind erosion. Since erosion can occur at sites located at, slightly above or slightly below the reservoir level, the only operation that could fully address direct impacts is through keeping water levels below the critical elevation. However, since the presence of vegetation acts to stabilize the land, an indirect method to preserve archaeological sites would be to promote vegetation growth through reservoir operations.

The water erosion performance measure estimates the frequency (in days per year) at which water levels on Arrow Lakes Reservoir are between 436 and 440.4 m (1430 and 1444.9 ft). This is the elevation of a major escarpment on which intact archaeological sites are believed to exist.

Impacts of wind erosion on archaeological sites within the drawdown zone were tracked using the reservoir riparian vegetation performance measure (refer to Section 4.9.2.1). This measure initially reported on the area (hectares per week summed over weeks) of unvegetated area within the drawdown zone. However, as a better understanding around vegetation characteristics at different elevation zones emerged, this performance measure was refined to track vegetation presence across elevations 434 to 436 m (1424 to 1430 ft) and 436 to 440 m (1430 to 1444 ft). Potential gains/losses were reported relative to the current vegetation conditions (i.e., that which became established over the 1990–1999 period as a result of low inflow years and BC Hydro's dust control program). The relative ranking of vegetation presence across each of the operating alternatives was based on inundation statistics for 60 years of modelled data. It was concluded by the Culture and Heritage Subcommittee that establishing the existence of vegetation in these sensitive areas would likely be the most effective way of protecting eroding archaeological sites.

Both the water and wind erosion performance measures were also used to address concerns related to erosion impacts caused by human/vehicle activity within the reservoir drawdown zone, and maintenance of cultural, aesthetic and ecological context of cultural resources and spiritual sites. It was agreed that the most appropriate means of addressing the objective of providing access to areas containing archaeological sites would be through development and implementation of appropriate communication protocols related to low water levels, while provision of access to traditional plants would be addressed through vegetation initiatives.

4.9 WILDLIFE AND VEGETATION

Wildlife interests explicitly recognized the need to move away from single species management, and toward an ecosystem management approach for the Columbia River water use planning process. Nevertheless, it was acknowledged that ecosystem-based performance measures would likely be impractical, given the existing knowledge base. As evident in the structure of the objectives (below), the Consultative Committee viewed the ecological health of the Columbia River system as the fundamental objective, but viewed the explicit management for wildlife as the practical means of achieving that objective.

4.9.1 Issues

4.9.1.1 Kinbasket and Arrow Lakes Reservoirs

Riparian Vegetation

Riparian vegetation (i.e., vegetation around the reservoir in the zone that is periodically wetted) is an indicator of the effects of BC Hydro operations on wildlife (e.g., abundance, condition, diversity) and recreation/aesthetics (e.g., visual quality, dust control). Because valley bottom habitat is limited in the Columbia River system, riparian habitat is viewed as critically important to a wide variety of wildlife including birds, ungulates, bears, furbearers, reptiles and amphibians. It is estimated that a half million birds and many other species, including some red- and blue-listed species (e.g., painted turtle) use the existing vegetated areas around Kinbasket and Arrow Lakes reservoirs. Wildlife provide a source of organic fertilizer that benefits both fish and wildlife, and vegetated areas that are subsequently flooded benefit fish through localized benefits to littoral productivity. Vegetation also improves aesthetic quality, helps to control dust, and may serve to protect cultural sites from erosion and human access.

Shoreline vegetation can occur around the perimeter of reservoirs when the upper reservoir drawdown zone is exposed for more than 50 per cent of the growing season, and has substrate and slope suitable for emergent vegetation. The availability of this important habitat type depends on the duration and timing of exposure of emergent vegetation during the growing season, as well as the maximum full pool level of the reservoirs. Conditions that favour the growth of riparian vegetation may or may not be met depending on the operating regime of the reservoir.

Riparian vegetation in Kinbasket Reservoir is limited to the highest elevations around full pool. However, given the timing of reservoir refill under the current operating regime (i.e., one month later than Arrow Lakes Reservoir), the potential for greater vegetation establishment is considered high with intervention (Carr, 2001). The key areas of riparian potential are the flat deltaic areas in Canoe Reach, Columbia Reach and Bush Arm. Carr (2001) estimated that permanent vegetation could be developed down to 7 m below full pool provided it is kick-started through a planting program. An operating regime that involves a faster or earlier fill would reduce the potential for expansion by intervention.

Riparian vegetation in Arrow Lakes Reservoir, and in particular Revelstoke Reach, presently extends over an elevation range of about 10 m (430 to 440 m; 1411 to 1444 ft). Prior to 2001, the distribution of vegetation was predominantly at 434 m (1424 ft) and above. Expansion of vegetation into the lower elevations has been largely the result of:

- The fall rye seeding program that began in the early 1990s, and has facilitated the spread of natural vegetation (sedge and grass) by incorporating the naturally produced seed into the substrate and by functioning as a nurse crop.

- A series of low water years during the 1990–1999 period, which made possible the establishment of natural vegetation by allowing the seedlings sufficient growing time to develop into mature plants capable of tolerating subsequent extended inundation.

These factors have worked in concert over the past decade to allow the establishment and persistence of extensive areas of natural vegetation currently dominating the drawdown zone of Revelstoke Reach and smaller areas in the main body of Arrow Lakes Reservoir (AIM Ecological, 2003).

4.9.1.2 Revelstoke Wetlands

Breeding and Migratory Bird Habitat

The Revelstoke Wetlands is unique in that it comprises the largest known area of waterbird habitat within the impounded waters of the Columbia River. It provides critical wetland habitat for 213 birds species (84 species of waterbirds, 21 birds of prey, and 108 species of land birds), as well as habitat for migratory, breeding and wintering birds, critical breeding habitat for the painted turtle and short tailed weasels, and important wintering habitat for ungulates.

Large numbers of shorebirds have not been observed in the Revelstoke Wetlands, but they are considered a high management priority. This is because of the limited existing data on fall migration of shorebirds in the wetlands and concern that high water levels during the fall migratory period (peaks in mid July and mid September) could limit the availability of suitable habitat for these species. A study completed during the Columbia River water use planning process suggested that optimal water levels for retaining maximum available habitat for shorebirds is 435 m (1427 ft) (Axys and Manning Cooper, 2002).

The Revelstoke Wetlands undergo annual and seasonal fluctuations in water levels due to variations in precipitation and snow pack melt, and water use requirements downstream at Hugh Keenleyside Dam and upstream at Mica Dam and Revelstoke Reservoir. The reach at Drimmie Creek starts flooding when water levels reach 430 m (1411 ft) elevation, and becomes fully flooded at 440 m (1444 ft). Rising water levels can affect bird nesting success by causing impacts such as direct losses of nests due to flooding, or by creating areas that are unsuitable for nesting because of early reservoir flooding. Optimal water levels for retaining maximum available habitat vary among species, ranging from 434 m (1424 ft) for the Mallard and Short-eared Owl to 439 m (1440 ft) for the Willow Flycatcher (Axys and Manning Cooper, 2002).

4.9.1.3 Lower Columbia River

Riparian Habitat

The lower Columbia River below Hugh Keenleyside Dam to the Canada/United States border provides only limited riparian habitat due to the largely steep-sided banks. One area of particular interest to the Consultative Committee was a cluster of gravel bars at Genelle, and the potential effects of flow changes on riparian vegetation and wildlife use of these bars. In their present early successional state, these bars are used by a variety of wildlife species. As the complexity (biodiversity) and structure of the vegetation communities mature, it is expected that wildlife use and diversity will increase (Robertson Environmental, 2001).

Great Blue Heron Winter Refuge Habitat

The Consultative Committee expressed concern around foraging/refuge habitat of Great Blue Heron at Waldie Island and Breakwater Island, and the potential effects of flows on habitat availability and use. Studies undertaken by Machmer (2003) support the assumption that Waldie Island and Breakwater Island represent an important winter refuge for herons, particularly during the period from 15 November to 21 December when increased flows are released from Hugh Keenleyside Dam prior to reducing flows to enhance whitefish spawning and incubation. Herons appear to aggregate at Waldie Island in highest numbers during this period due to limited shallow-water foraging habitat and access to fish prey elsewhere because of high water elevations, freezing conditions, and human and other disturbance. Low flows and water elevations during the post-whitefish flow period correspond with fewer heron on Waldie Island, which may be due to the availability of off-island shallow-water foraging sites that allow heron to disperse more widely to forage. Heron return to the island in summer. The extent of use for breeding in the spring is uncertain; there has been only one breeding attempt recorded on Waldie Island (spring 2001).

Machmer (2003) identified two key areas of concern related to heron use of Waldie Island:

- The period of high flows in early winter, which could be reducing the availability of suitable shallow-water foraging habitat and access to fish prey, and increasing heron dependency on Waldie Island and localized competition for food.

- Low flow and water elevations during the spring/summer period, allowing for easy access to and persistent public use of Waldie Island and resulting in significant disturbance to heron.

Machmer (2003) recommended that, in years of high flows, consideration be given to modifying the current flow regime to maintain water levels at or below 421 m (1381 ft) to ensure some parts of Breakwater Island and Waldie Island foreshore remain exposed and usable by heron during peak winter flows.

At water elevation 421 m (1381 ft), there is about 1 m of freeboard at Breakwater Island (submerged at El. 422 m; 1385 ft), and only the treed portion of Waldie Island is above water. At this water elevation, the herons were able to feed and loaf without appearing to be crowded. Machmer (2003) recommended that, in low water years, elevations during the 1 April to 31 August period are maintained at or above 418.7 m (1373.7 ft) to keep channels separating Waldie Island and Breakwater Island from the mainland wetted to limit public use of the island. Heron disturbance associated with public use of Waldie Island area is considered potentially significant given the lack of nearby undisturbed alternate habitat.

4.9.2 Objectives and Performance Measures

The fundamental wildlife objective of the Columbia River Water Use Plan was to maximize wildlife abundance and diversity in the Columbia River system. The Consultative Committee recognized that the most significant opportunity for affecting wildlife abundance and diversity through water use changes lay in riparian vegetation, wetland vegetation and the riparian/wetland interface. Not only are these key habitats used by a diversity of wildlife, but they are also the only habitat types that can be substantially affected by changes in BC Hydro operations. For simplicity, these habitat types are collectively referred to as "riparian vegetation." Species that are expected to benefit from improvements to riparian habitat vary, but include water-associated birds, large and small mammals, reptiles and a variety of invertebrates.

The Consultative Committee developed the following sub-objectives for wildlife and vegetation interests on the Columbia River:

- *Maximize riparian habitat area on Kinbasket and Arrow Lakes reservoirs.*

- *Maximize the capacity of the Revelstoke Wetlands to provide habitat for shorebirds.*

- *Maximize the capacity of the Revelstoke Wetlands to provide habitat for spring nesting and fall migratory birds.*
- *Maximize winter refuge habitat for Great Blue Heron at Waldie Island.*

Table 4-9 summarizes the wildlife performance measures used by the Consultative Committee to evaluate operating alternatives for the Columbia River facilities.

Table 4-9: Wildlife and Vegetation Performance Measures

Location	Performance Measure	Unit of Measure	Description	MSIC
Revelstoke Wetlands/ Arrow Lakes Reservoir	*Riparian Vegetation*			
	Vegetation Biomass (434 to 438 m)	Index	Reports loss or gain (qualitatively) in biomass. Does not indicate areal extent of vegetation coverage, but biomass presence on vegetated areas. Affects littoral productivity and shorebird habitat.	0.5
	Vegetation Diversity (436 to 438 m)	Index	Reports loss or gain (qualitatively) in shrub growth, which provides for plant diversity. Gains for shrubs accompanied by losses for grass biomass over same areas. Gains on this performance measure indicate increases in plant diversity and habitat complexity, with benefits to breeding birds and other wildlife.	0.5
	Vegetation Presence (434 to 440 m)	Index	Reports loss or gain (qualitatively) in vegetation presence within elevation zones 434 to 436 m, and 436 to 440 m.	0.5
	Birds			
	Early Summer Nesting Birds (average)	% nesting habitat availability	A measure of the per cent of habitat that is not inundated during nesting season. Short-eared owl used as a proxy for multiple species.	3%
	Fall Migrating Birds (10^{th} percentile)	% migratory habitat availability	A measure of the per cent of habitat that is available for fall migratory birds. Shorebird fall migration used as a proxy for multiple species.	4%
Lower Columbia River (Waldie Island)	*Great Blue Heron*			
	Foraging/Winter Refuge Habitat	#days/year water elevations ≤ 421 m	Number of days during the winter peak flow period (15 November to 21 December) when water levels at Waldie Island are at or below 421 m (as measured at Norns Creek Fan gauge).	N/A
	Disturbance during Spring Breeding Period	#days/year water elevations > 418.5 m	Number of days during the spring (15 February to 31 March) when water levels at Waldie Island are above 418.5 m (as measured at Norns Creek Fan gauge).	N/A

4.9.2.1 Reservoir Riparian Vegetation

A riparian habitat performance measure was developed for Kinbasket and Arrow Lakes reservoirs to estimate the area that would become vegetated with grasses and deciduous shrubs under each of the proposed operating alternatives. For Kinbasket Reservoir, there was no estimate of the area under the Base Case and, as a result, the performance measure reported only the incremental area resulting from a planting program. This performance measure was considered zero in the absence of planting, and was expected to vary little across any alternatives considered for Kinbasket Reservoir.

A simple vegetation model was developed to calculate the area that would become vegetated under each of the operating alternatives being considered for Arrow Lakes Reservoir. The model predicted the presence of three vegetation types in each 1-metre elevation band within Revelstoke Reach based on duration of inundation. A band would be classified as mudflat if the inundation frequency over the growing season exceeded 18 weeks; sedge-grass-herb if the inundation frequency was between 18 and 12 weeks; and willow if the inundation frequency was less than 12 weeks. Inundation frequencies for each elevation band were computed by interpolating monthly elevations from the BC Hydro HYSIM model (refer to Section 6.3) to weekly values and determining the depth of flooding for each 1-metre band. The number of weeks where the depth of flooding exceeded 0 m over the growing season was then computed and compared to the inundation tolerances to classify the vegetation type for each band. The area of each band that contained a vegetation class was summed to determine the total amount of area for each class. Model parameters were derived based on an analysis of flood tolerances of vegetation monitored in the Revelstoke Reach (Korman, 2002).

Concern was expressed by the Fish and Wildlife Technical Subcommittee that the vegetation model did not account for a number of factors influencing establishment of riparian vegetation within the drawdown zone. This included the effects of:

- Different growth rates among species that determine their end-of-growing-season biomass.
- The depth of inundation on survival of mature plants and their growth rates.
- Desiccation on the survival and growth of flood-tolerant plants.
- The increased sensitivity of seedling establishment to dry and wet conditions.
- The biomass of last year's plant community on the starting conditions of biomass in the subsequent year.

Korman (2002) developed a model that incorporated these dynamics as part of the reservoir revegetation project on Arrow Lakes Reservoir. As the model was available in the Integrated Response Modelling (IRM) framework, it replaced the simpler version described above for the operating alternative analyses (refer to Appendix P: Integrated Response Model). The model operated on a weekly timestep and used multi-year input of reservoir operations as the main forcing variable. The switch from the simple model to the more complex one occurred when the operating alternative analyses switched from using statistical water years to the 60-year period of record provided by the HYSIM model.

Despite refinements made to the more complex vegetation model, there was discomfort among some members of the Wildlife Technical Subcommittee concerning a few assumptions in the model. In particular, there was concern that the model did not account for the accumulation of wet stress across years or substantially reduced growth rates in the late summer and fall following exposure of previously inundated areas. It was recognized that there was a great deal of uncertainty around these issues that prevented this from being incorporated into the model. This line of inquiry led to the creation of a new set of vegetation performance measures based on observational data and professional judgment of Anne Moody, a vegetation ecologist who has worked on Arrow Lakes Reservoir for over a decade.

A ranking system was developed based on the number of flooded weeks for each elevation band, the week of first flooding, and the accumulated number of weeks a band was inundated across two and three successive years. These statistics were computed based on the interpolated weekly reservoir elevation levels based on monthly predictions from the HYSIM model, as was done for the IRM version of the vegetation model.

Given differences in the characteristics of vegetation communities that have become established within the Arrow Lakes Reservoir drawdown zone (refer to Table 4-10), potential impacts of reservoir operations were tracked separately for three elevation zones that are of importance to various interests of the Consultative Committee.

Table 4-10: Revelstoke Reach Vegetation by Elevation Band

Elevation Band	Area in DEM*	Description
434 to 436 m (1424 to 1431 ft)	760 ha	Vegetation present, low biomass, low diversity. Dominated by perennial sedge and reed canary grass.
436 to 438 m (1431 to 1437 ft)	591 ha	Vegetation present, high biomass, moderate diversity. Dominated by perennial sedge and reed canary grass but supports a number of other species.
438 to 440 m (full pool) (1437 to 1444 ft)	375 ha	Vegetation present, moderate biomass, high diversity. More terrestrial in nature. Significant component of shrubs and lower biomass of herbaceous species than 436 to 438 m (1431 to 1437 ft).

* Area calculations based on the Digital Elevation Model, which covered only ¾ of Revelstoke Reach.

Although some vegetation has become established between elevation 430 and 434 m (1411 and 1424 ft), the Consultative Committee recognized that this has occurred largely by chance hydrology in 2001, and that it was not reasonable to target operations to maintain vegetation at these levels. However, protecting vegetation that existed prior to 2001 was considered a high priority. Based on this, analysis of the operating alternatives focused on performance within elevation bands 434 to 440 m (1424 to 1444 ft) using the three sets of inundation statistics for the 60 years of modelled data.

The primary assumption behind the performance measure was that current vegetation distribution within Revelstoke Reach has evolved in response to recent historic water levels (1990–1999). Therefore, a change in average conditions should dictate trends in vegetation change. If an operating alternative does not impose more severe conditions than that experienced historically at a particular elevation band, current characteristics of the vegetation should be maintained. If an elevation zone experiences inundation similar to another zone, it would be expected that the vegetation characteristics would change to that which exists in this other zone.

A relative rating scheme was used to identify potential negative and positive impacts resulting from the predicted average water conditions. This scheme was based on a five-point scale (+2 to -2) that was applied to each vegetation characteristic (presence, biomass, diversity) across the three reservoir elevation zones, where:

-2 = Significantly worse than historical (pre-2001) vegetation levels; maximum plant tolerance for inundation exceeded more than five times. Strong negative signal from at least one other performance measure (inundation duration or timing) at more than two elevation bands.

-1 = Worse than historic (pre-2001) vegetation levels; maximum plant tolerance for inundation exceeded by five times or less. Strong negative signal from at least one other performance measure (inundation duration or timing) at up to two elevation bands.

0 = About the same as historic (pre-2001) vegetation levels; no exceedance of maximum plant tolerance for inundation. No strong signal from inundation statistics around potential negative or positive impacts on vegetation (includes some mixed results).

1 = Better than historic (pre-2001) vegetation levels; no exceedance of maximum plant tolerance for inundation. Strong positive signal from at least one other performance measure (inundation duration or timing) at up to two elevation bands.

2 = Significantly better than historic (pre-2001) vegetation levels; no exceedance of maximum plant tolerance for inundation. Strong positive signal from at least one other performance measure (inundation duration or timing) at more than two elevation bands.

This exercise generated hundreds of performance measure scores that produced complex and often conflicting messages. As a result, a more simplified approach was developed to assist the Consultative Committee in making recommendations at their June 2004 final meeting. This involved a three-point scoring scheme (+1 to –1) for each of the three vegetation characteristics defined over their relevant elevation zones to indicate whether vegetation will decline, remain unchanged or improve relative to the current levels of vegetation.

- Vegetation presence – important for various interests across all elevations (434 to 436 m, and 436 to 440 m).
- Vegetation biomass – important mostly in the middle range of elevation (436 to 438 m).
- Vegetation diversity – important mostly in the upper range of elevations (438 to 440 m).

A key assumption used in deriving the performance measure scores was that one week earlier flooding could only be compensated by at least two weeks less of flooding. At present, the relative contribution and importance of duration and timing of inundation to vegetation trends and plant survival is untested. The Consultative Committee recognized the importance of further study in validating this assumption (refer to Section 8.2.7.2).

4.9.2.2 River Riparian Vegetation in the Lower Columbia River

The Wildlife Technical Subcommittee considered using a River Riparian Habitat performance measure to assess the impact of BC Hydro operations on riparian vegetation in the lower Columbia River. It was determined that the only riparian habitat that could be significantly affected by incremental changes to flows is located on the gravel bars at Genelle. The bars appear to be large enough to support some wildlife use if the sapling black cottonwoods on the gravel bar are allowed by local conditions to mature. Over time, this would benefit a diversity of wildlife species including cavity-nesting wildlife and raptors, and provide cover for local deer populations.

The key assumption of this performance measure was that the pattern of river discharges and associated sediment transport have helped create the gravel bar at Genelle, and that if this pattern does not change appreciably a cottonwood habitat might develop. It was noted that linking this assumption to Hugh Keenleyside Dam is only partially valid, as the river at this reach (downstream of the confluence with the Kootenay River) is almost equally affected by operations at Brilliant Dam.

A preliminary review of available information on the Genelle gravel bars and the suitability of the proposed performance measure was undertaken on behalf of the Wildlife Technical Subcommittee (Robertson Environmental, 2001). This review led to the conclusion that flows of 160 kcfs do not result in significant erosion or deposition to these bars. Provided that flows at Genelle are below this, water levels will not have a measurable impact on these bars or the vegetation that has become established on them. It was recommended that the River Riparian Habitat performance measure be dropped as there were no operating alternatives being considered by the Consultative Committee that involve flows of this magnitude in the lower Columbia River. There was discussion around a seasonal high flow treatment (30-day flow of 200 kcfs at the border) to improve white sturgeon recruitment; however, this option was eventually dropped due to concerns around potential impacts on other interests (e.g., downstream flooding) and the high level of uncertainty around the feasibility/dependability of delivering on this flow (refer to Section 7.7.12).

It was recognized that the lower Columbia River flooding performance measure could be used as a proxy for those interested in tracking the potential impact of proposed operating alternatives on riparian habitat. This performance measure reports the frequency (number of days per year) at which flows at Genelle exceed 165 kcfs. Using data from 1985–2000 (representative of current operations), results of modelling indicated that none of operating policies (with or without rainbow trout/whitefish flows) would cause flows to exceed this threshold.

4.9.2.3 Migratory and Breeding Bird Habitat in Revelstoke Wetlands

During Round 1 of the trade-off analysis, concern related to operational impacts on migratory bird habitat was addressed through a simple performance measure that tracked the frequency (number of days) at which an operating alternative met preferred conditions for Revelstoke Wetlands to function as a migratory bird stopover. More detailed bird habitat performance measures were subsequently developed to estimate the area per week (in hectare-weeks) of available habitat for a range of migratory shorebirds and breeding birds in Revelstoke Reach. The performance measures were based on a habitat suitability model with specific time windows for habitat use by migratory shorebirds (last two weeks of July, and the first two weeks of September), and nesting chronology of each breeding bird species. For each 1-metre elevation band and week during the fall migration and breeding periods, the performance measure was computed using the equation:

$$PM_{ibird} = \sum_{wk}\sum_{elev} HSI_{ibird,mud} * SI_{mud} * Area_{elev} + HSI_{ibird,grass} * PC_{grass} * Area_{elev}$$

where $HSI_{ibird,mud}$ and $HSI_{ibird,grass}$ are the bird group-specific suitability multipliers (defined in a breeding bird and shorebird study completed by Axys and Manning Cooper (2002)), SI_{mud} is the hypothesized value of the mudflat based on the amount of cover that is on it, PC_{grass} is the proportion of total grass cover, and $Area_{elev}$ is the area of the 1-metre elevation band.

The suitability multipliers were used to reflect differences in the importance of habitat with different extent of coverage by grasses. For shorebirds, the model assumed that any mudflat area with total grass cover less than 50 per cent is potentially usable. There is a peak amount of cover (25 per cent) that reflects increased invertebrate productivity associated with grasslands, but not too much cover so that there is no mudflat over which migratory birds can forage. Linear interpolation between breakpoints was used to derive suitability values based on model-predicted grass cover estimates.

During a Wildlife Technical Subcommittee meeting, concern was expressed that the shorebird habitat performance measure did not adequately consider the impacts of reservoir levels on fall migratory birds. Specifically, it was felt that the performance measure would underestimate habitat availability for birds in the fall due to selection of the most sensitive species as an indicator species and failure to account for availability of micro-habitat. In addition, the performance measure would fail to report habitat quality improvements associated with an alternative that provides brief inundation at full pool and then steadily declines versus one that never reaches full pool. It was also noted that the need to provide a lower or declining water elevation for migratory birds would extend through mid August to mid September, as opposed to the two-week periods used in computing the performance measure.

The Wildlife Technical Subcommittee also expressed concern that the Breeding Bird Habitat performance measure would likely overestimate nesting habitat availability due to selection of a less sensitive species as an indicator. Further, it does not account for the effects of late water rise on the success of late breeders (i.e., loss of nests and fledgling mortality).

It was highlighted that a new set of performance measures was needed to address these issues. Based on input from several subcommittee members, a new set of parameters was used for modelling the impacts of nest inundation, and for calculating habitat availability in the early fall (Table 4-11).

Table 4-11: Parameters for Nest Inundation and Fall Migration Habitat

	Grassland Nesting Waterfowl	Late Nesting Waterfowl	Ground Nesting Landbirds	Grass Nesting Landbirds (lower veg)	Shrub Nesting Landbirds	Short-Eared Owls	Fall Migration	Shorebird Fall Migration
Start Nest Date	2 Apr	14 May	14 May	14 May	14 May	30 Apr	30 Jul	23 Jul
End Nest Date	18 Jun	16 Jul	16 Jul	16 Jul	16 Jul	16 Jul	22 Oct	24 Sep
Peak Nest Date	14 May		4 Jun	4 Jun	4 Jun	28 May	10 Sep	27 Aug
Fledge Time (weeks)	9	9	6	6	6	11	1	1
Lower Elevation Range (metre)	433	434	434	436	436	436	432	432
Upper Elevation Range (metre)	440	439	439	440	440	439	439	438

Based on the above parameters, performance measures were developed to track the per cent availability of nesting and migratory bird habitat. The performance measures assume that, for each particular species or group, there is a peak date at which the birds arrive, with fewer arriving towards the start and end date of the migratory period. They then distribute themselves across their range of elevations, and remain there until their fledge time has elapsed. If the reservoir elevation increases up to the nest level, then it is assumed that that nest is destroyed and will not be rebuilt. It was also assumed that nests that are lost, or habitat that is not available at the start of nesting, will not be rebuilt elsewhere. This is based on the assumption that habitat outside of the reservoir drawdown zone is fully occupied by other birds. Similarly, it was assumed that a reservoir that stays over potential foraging area denies birds habitat to feed en route south. Since such habitat is in short supply, the Wildlife Technical Subcommittee concluded that this poses a direct risk of mortality to these birds.

For spring/summer nesters, the metric reported on the average performance measure scores across species, across the alternatives. It was derived as though 100 birds nested, and the number reported represents the number of nests not being inundated or birds not being denied nesting habitat due to reservoir elevations. For fall migrants, the metric reported on the per cent habitat availability using the 10^{th} percentile statistics. This measure was adopted based on discussions of the Wildlife Technical Subcommittee, which suggested that good years and bad years do not offset each other (i.e., average out), but rather years with low habitat availability will have a long-term impact on population levels, even if they are followed by years with good habitat availability. The subcommittee agreed that this very risk averse measure was appropriate.

Given that the operating alternatives performed similarly for all the summer nester groupings, the Wildlife Technical Subcommittee agreed to use the short-eared owl (a provincially listed species of concern) as a proxy for impacts on all the nesting species. Similarly, since the performance measure scores for fall migration habitat were well correlated, the shorebird fall migration was selected as a proxy measure for impacts on all fall migrating birds in the area.

The Wildlife Technical Subcommittee recognized that "what is good for birds" is both a function of habitat availability during critical periods as well as the quality of vegetation growing in the area. As a result, the proxy summer nesting and fall migration performance measures were integrated with the vegetation measures across the range of operating alternatives. The results of this analysis were presented to the Consultative Committee at their final June 2004 meeting as a final ranking of alternatives according to how well each performs in terms of providing suitable vegetated habitat for summer nesters and fall migrating birds.

4.9.2.4 Great Blue Heron of Waldie Island

To address potential flow-related impacts on heron habitat and its use in the lower Columbia River, preliminary performance measures were developed to track the number of days that water elevations at Waldie Island would be at or below 421 m (1381 ft) during the winter peak flow period, and above 418.5 m (1373.0 ft) during the spring under each of the proposed operating alternatives (with and without rainbow trout and whitefish flows). Based on flow data for the period 1985−2000, two main conclusions were reached based on the performance measure scores:

- Both the winter and spring heron measures are the same across all non-fish friendly alternatives, and there are only slight differences across alternatives with fish friendly flows.

- Alternatives perform better in terms of achieving the winter elevation constraint than the spring elevation constraint. (Differences between these alternatives in terms of spring flows are due to water being shifted between Kinbasket and Arrow Lakes reservoirs.)

Given these results, the Wildlife Technical Subcommittee agreed that the performance measures were insensitive (did not change significantly) across the range of operating alternatives and should be dropped from further consideration. New performance measures were not developed to address these issues as the subcommittee recognized that:

- Keeping the channel between the island and mainland wetted would only help to minimize access to the island, but would do little to minimize disturbances from water-based activity.

- A management plan for the area should be implemented by the Nature Trust before operational changes or physical works are considered further through the water use planning process.

- Given fish flow and Treaty requirements in the lower Columbia River, it would be difficult to maintain flows from Hugh Keenleyside Dam to ensure that water elevations at Waldie Island do not exceed 421 m (1381 ft) during pre-whitefish flow period (15 November to 21 December). Based on the Norns Creek discharge rating curve, flows would have to remain below 65 kcfs. Taking into consideration Kootenay discharges, Hugh Keenleyside flows would have to be below 60 kcfs. While this could be physically achievable in some years, it would be difficult to achieve in a large number of years, and would not be in compliance with the Treaty.

However, given the importance of Waldie Island as winter refuge and foraging habitat for heron, the Wildlife Technical Subcommittee viewed this as a critical issue that should be studied further through the Columbia River Water Use Plan monitoring program.

4.10 FISH AND AQUATIC RESOURCES

4.10.1 Issues

The Fish Technical Subcommittee recommended that, where possible, water management under the Columbia River water use planning process should favour approaches that support ecological health, without focusing on specific species. However, the group found it necessary to identify species of management priority to focus discussion around which ecological functions were most critical, and to allow trade-offs between species to be made if necessary. Selection of management priorities was based on the following criteria:

- Extent to which the species is endangered.
- Extent to which it can be restored.
- Extent to which it addresses the needs of other species.
- Importance in maintaining ecological functions.
- Extent to which it can be affected by operational changes.

The Fish Technical Subcommittee also explicitly stated a long-term goal of salmon restoration. However, the adoption of water management strategies targeted specifically at salmon was not considered practical until downstream migration barriers are removed. It was recognized that, in the interim, management strategies for species with similar needs (e.g., large trout, kokanee) could be viewed as a surrogate for maintaining suitable salmon habitat for the future.

The following summarizes the fish-related issues brought forward by the Consultative Committee to be addressed through the Columbia River Water Use Plan.

4.10.1.1 Kinbasket and Arrow Lakes Reservoirs

Pelagic Productivity

The pelagic zone is the large open water area of the reservoir that produces phytoplankton and zooplankton, which are important food sources for pelagic-feeding species (e.g., kokanee). Kokanee are a key driver of the ecosystem, as they provide an important food source for other sport fish species (e.g., bull trout) and listed species (e.g., white sturgeon), as well as a source of nutrients to the ecosystem on completion of their life cycle.

Nutrient and light availability affect phytoplankton production in reservoirs, which in turn affects the abundance and biomass of zooplankton. Physical dynamics of the reservoirs (turbidity, thermal stratification, water circulation patterns and water retention time) also affect the abundance and distribution of zooplankton. During periods of winter drawdown, erosion of littoral/shoreline habitats may increase water turbidity thereby reducing light penetration, depth of the euphotic zone and primary production, particularly during the beginning of the growing season.

At the start of the Columbia River water use planning process, the potential impacts of reservoir operations (particularly drawdown) on the amount of food available for fish and the amount of food lost through entrainment were identified as one of the most important reservoir fish issues to be addressed through the water use planning process. Several possible opportunities to enhance pelagic productivity in Kinbasket and Arrow Lakes reservoirs through operational changes were identified by the Fish Technical Working Group (Failing, 2002), and further explored by the Fish Technical Subcommittee.

- Raise the reservoir earlier, fill it higher and hold it stable.
- Raise the minimum reservoir elevation during the summer months.
- Raise the minimum reservoir elevation during the winter months.

A fertilization program has been ongoing in Arrow Lakes Reservoir for several years, and has been successful in boosting pelagic production by 4500 tonnes carbon per year (4000 tonnes in Upper Arrow, 500 tonnes in Lower Arrow). The Fish Technical Subcommittee recognized that continuation of the existing program and possibly direct fertilization of Lower Arrow Lakes Reservoir might provide greater benefits than any operational changes alone.

Littoral Productivity

Large storage reservoirs in British Columbia are typically ultra-oligotrophic. In such waterbodies, pelagic productivity tends to be low and the contribution of the littoral zone to ecosystem productivity may be important. The Revelstoke Reach would be one example of this. The littoral zone is the area near the shoreline that receives adequate light for photosynthetic activity and supports the development of aquatic plants and benthic invertebrates. It also provides refugia primarily for non-sport fish species, which are important for the maintenance of biodiversity and ecological functions. Although there are some littoral-feeding sport fish such as burbot and rainbow trout that utilize these shallow nearshore habitats, fish typically found within the littoral zones of Kinbasket and Arrow Lakes reservoirs are species such as suckers and other bottom feeders.

The Fish and Wildlife Technical Subcommittee recognized that any operating alternative that increases area of shoreline that is vegetated and periodically inundated will increase local littoral productivity in the area immediately adjacent to the vegetated area. The most promising opportunity for improving littoral productivity was thought to be through increasing the minimum water surface elevation in winter (Perrin, 2001). A preliminary estimate suggested that productivity in Arrow Lakes Reservoir could increase by up to 20 per cent from this operating change (C. Perrin, Limnotek Research, pers. comm.). However, there is only limited littoral development in Kinbasket Reservoir compared to Arrow Lakes Reservoir, with shallow water being limited to only four areas due to large fluctuations in water levels (RL&L, 2001). For this reason, and the fact that the alternatives considered for Kinbasket Reservoir would not significantly affect water levels, the Fish and Wildlife Technical Subcommittee concluded that it was unnecessary to track littoral productivity for Kinbasket Reservoir.

Other Issues Considered but not Pursued

Several other fish issues related to operation of Kinbasket and Arrow Lakes reservoirs were identified through the initial scoping exercise. During a Fish Technical Working Group meeting held in November 2001 (Failing, 2002), agreement was reached that either long-term monitoring would be needed before operating alternatives could be identified to address these issues, or that many of the issues were a lower priority that did not need to be addressed through the Columbia River Water Use Plan. These issues and the rationale for not pursuing them further are outlined in Table 4-12.

Table 4-12: Fish-related Issues in Kinbasket and Arrow Lakes Reservoirs Discussed but not Pursued by the Consultative Committee

Interest	Location	Issue/Concern	Decision/Rationale
Fish Stranding	Kinbasket Reservoir	While this issue was considered relevant to all the Columbia River Basin reservoirs, it was agreed that the greatest potential risk of fish stranding existed in Kinbasket and Arrow Lakes reservoirs due to their extensive drawdown zones. The potential for stranding within Revelstoke Reservoir was considered very limited given the steep shoreline of most of the reservoir and the small drawdown during most years (i.e., except under emergency drawdown).	No studies have been undertaken in Kinbasket Reservoir to determine the extent of fish stranding under various discharge and drawdown conditions or its impact on population levels. While it is believed that stranding impacts are likely relatively minor (RL&L, 2001), the Consultative Committee recognized that there is considerable uncertainty about this hypothesis, which would need to be addressed through further study. This led to completion of a high-level review undertaken as part of Step 5 (Section 5.11), as well as recommendations for Columbia River Water Use Plan monitoring (Section 8.2.1).
	Arrow Lakes Reservoir		Areas of Arrow Lakes Reservoir most affected by water level fluctuations would be shallow habitat located at the upstream end of the reservoir between Beaton Arm and Revelstoke in the Halfway River, Fostall Creek, Nakusp, Burton, Edgewood and Renata areas. Fish stranding has been observed in sidechannels along the upper section of the reservoir during drawdown; however, it is not thought to affect a large percentage of fish populations within Arrow Lakes Reservoir (RL&L, 2001). The Fish Technical Subcommittee agreed with a relatively high degree of confidence that fish stranding is unlikely to cause population level impacts and, therefore, this issue was not considered further in the Columbia River water use planning process.
Tributary Access	Kinbasket and Arrow Lakes Reservoirs	Concern was expressed that access to tributary spawning areas could be eliminated due to low water levels in Kinbasket and Arrow Lakes reservoirs. In Kinbasket Reservoir, exposure of barriers to upstream fish passage has been noted in the Wood River, Beaver River and Foster Creek at elevations around 735 m (2411 ft) (GG Oliver, 2001; RL&L, 2001). While the significance of restricted or blocked access is not well understood, it is thought that these tributaries contribute little to the overall reservoir production of spring and fall spawners (rainbow trout, bull trout, mountain whitefish). In Arrow Lakes Reservoir, low water levels prevent access to spawning areas in a few tributaries, including Mosquito, Cayoosh, Bannock, Deer and Salmon creeks (RL&L, 2001). The critical elevation at which access to some tributaries is eliminated is thought to be 429.8 m (1410.1 ft). While this was not considered a significant issue during spring as freshet flows would allow fish access, low water levels during the fall spawning period for kokanee or bull trout could be a greater problem.	Based on the available literature, the Fish Technical Working Group agreed that the effects of drawdown on fish access into tributaries was not likely to be a major concern for Arrow Lakes or Kinbasket reservoirs (Failing, 2002). It was noted that if access to one tributary was eliminated, spawners would likely select another accessible stream. Further, total tributary spawning habitat is not expected to be a limiting factor to fish production. This issue was considered to be a low priority for the Columbia River Water Use Plan, and performance measures were not created to track these impacts. It was highlighted that there are opportunities for the removal of some physical barriers to tributaries in Kinbasket (GG Oliver, 2001) and that this could be considered through the Columbia Basin Fish and Wildlife Compensation Program. **Towards the end of the Columbia River water use planning process, requirements to lower Arrow Lakes Reservoir in the fall to benefit vegetation raised concerns around tributary access issues. Subsequent to the final Consultative Committee meeting, the Fish Technical Subcommittee discussed the need for further assessment and monitoring of tributary access in Arrow Lakes Reservoir.**
Tributary Backwatering	Kinbasket and Arrow Lakes Reservoirs	Concern was expressed that rising reservoir levels during freshet may cause inundation of spawning habitats in the lower section of tributaries within the drawdown zone, reducing water velocities through the gravel and thereby decreasing the survival of incubating eggs and alevins (i.e., through lack of oxygen supply and removal of waste products). Incubating eggs can also be smothered by sediment deposition as the water velocity over redds decrease due to rising water levels. In Kinbasket Reservoir, water levels typically increase by over 1 m per week during reservoir refilling, which could cause substantial changes in water depth and velocity over the egg incubation and alevin residence period. Spring spawning species with longer egg incubation/gravel residence times (e.g., rainbow trout) are more likely to be affected by tributary backwatering than species with short egg incubation/gravel residence times (e.g., suckers).	While it was recognized that there was limited information available to assess the impacts of current operations or alternative policies on tributary backwatering, the Fish Technical Subcommittee agreed that little could be done operationally that would mitigate this effect given limited flexibility in the timing and magnitude of reservoir refill. Consequently, this issue was not considered further for either Arrow Lakes or Kinbasket reservoirs in the Columbia River water use planning process.
Total Gas Pressure	Mica Dam	Mica Generating Station has four generating units – Units 1, 2 and 3 discharging into tailrace 1 and Unit 4 into tailrace 2. Units 1 and 2 are capable of synchronous condense operation, which is used to supply voltage support and quick unit return to service, and can result in higher localized total dissolved gas levels below Mica Dam. Localized supersaturation in the draft tube occurs when surface water is exposed to pressurized air as well as air entrained into water leaking from wicket gates or unit cooling water. While the units are operated in sync-condense mode to some extent every month, this operation occurs primarily during spring (March to May) and fall (October to November). Fish kills in the Mica Dam tailrace were formally investigated by BC Hydro in 1996 and 1997. Potential causes of these mortalities included entrainment from Kinbasket Reservoir, fish moving into draft tube and potential injury during unit start-up, fish completing their life cycle (kokanee), and gas supersaturation. Fish are able to move up into the draft tubes when the units are operating in sync-condense mode. There was particular concern in September and October when kokanee congregate at the base of the dam. From 1996 to 1998, total gas pressure (TGP) data were collected at Mica Dam during a range of unit operation combinations. These data showed that TGP levels can reach levels of 200 per cent saturation in the draft tube when both Units 1 and 2 were operated in sync-condense mode; however, there was no conclusive relationship between time spent operating in sync-condense and TGP levels. Since 1998, periodic TGP data collection and observations for further fish kills has been ongoing.	In 1996, BC Hydro implemented a TGP Best Management Practice, which was developed in consultation with the fish regulatory agencies. The current operating criteria stipulates a 15-minute flushing operation (200 MW or 5000 cfs) for each generating unit for a cumulative 12 hours of sync-condense. Given the effectiveness of the current best management practice at minimizing TGP production below Mica Dam (very localized and dissipates quickly), the Fish Technical Subcommittee agreed that this was not a priority issue to be addressed through the Columbia River water use planning process. However, it was highlighted that further study should be undertaken to assess whether this operation could be optimized (i.e., duration, season) to reduce costs (refer to Section 8.2.1). It is estimated to cost about $10,000 per day to follow Best Management Practices for TGP during the spring months.
Entrainment	Mica Dam	Fish entrainment is the drawing in of fish into dam release structures (spillways, ports, outlets) and generating station intakes, which results in the loss of resident fish of reservoir populations. This negative effect on reservoir populations can countered to varying degrees by a positive effect downstream, where entrained fish can contribute to downstream population levels and/or become an important food source for downstream fish and wildlife.	Based on results of kokanee population monitoring in Kinbasket Reservoir, the Fish Technical Subcommittee concluded that entrainment of kokanee is not likely negatively affecting this population. However, subcommittee members identified entrainment of bull trout as a potential concern due to limited recruitment of the populations, and suggested that there could be opportunities to monitor bull trout populations in Kinbasket Reservoir (refer to Section 8.2.1).
	Revelstoke Dam	Although fish entrainment was viewed as an area of concern, the Fish Technical Subcommittee did not recommend any performance measures or operating changes be developed to address the issue at the Mica, Revelstoke and Hugh Keenleyside facilities. There were no quantitative data or applicable studies with which to base any decision- making, and no satisfactory study design that could have been implemented during Step 5 that would have provided conclusive results given the short time frame available for study completion. It was agreed that better information on the negative upstream impacts on affected populations would be needed to improve future decision-making. The issue of entrainment was, therefore, deferred to the Fisheries Advisory Committee to initiate a process whereby an effective monitoring program would be implemented during the review period of this Water Use Plan. As part of the Alternative Measure Agreement between BC Hydro and DFO, BC Hydro committed to co-operatively develop an entrainment strategy for all of its facilities.	The Fish Technical Subcommittee concluded that entrainment at Revelstoke Dam should not be considered within the Columbia River Water Use Plan, as the reservoir is operated at the upper end of the operating range, which is currently considered to be good from a fish habitat perspective. This operation also limits entrainment if it is assumed that entrainment is a function of reservoir volume. It was recognized there is no ability to influence entrainment through reservoir volume management, as it is already maximized.
	Hugh Keenleyside Dam		Entrainment of fish and plankton from Arrow Lakes Reservoir provides a food source for white sturgeon, bull trout and burbot, as well as fish-eating wildlife in the lower Columbia River. Entrained fish that do not die may contribute to downstream populations and, in turn, may contribute to the sport fishery. While the Fish Technical Subcommittee suspected that the net effect of entrainment from Arrow Lakes Reservoir on fish populations was likely to be positive, concern was expressed for bull trout and particularly white sturgeon.
Large River Habitat	Upper Columbia River/ Kinbasket Reservoir		The Consultative Committee considered large river habitat in the upper Columbia River at the southern end of the Kinbasket Reservoir. However, it was agreed that this habitat type is unlikely to be limiting in Kinbasket Reservoir and that opportunities to enhance it through operations would be limited. The Committee viewed the riverine habitat between Revelstoke Dam and Arrow Lakes Reservoir as being the area most affected by hydro operations, and the area of greatest potential for improving through operational change.

4.10.1.2 Mid Columbia River

Large River Habitat

Hydro peaking operation at Revelstoke Dam results in highly variable discharge throughout most of the year, and periods of low and zero discharge (refer to Figure 4-1). During periods of low power demand (night), flow through the plant is typically reduced and frequently ceases completely (except for seepage, which maintains some flow in the riverine section of the downstream channel). Periods of zero flow occur mainly during the spring (March to May) and fall (September to November). These short-term and diel variations in flow limit the availability and suitability of large river habitat for fish in the tailwater and the mid Columbia River, and can be potentially harmful to fish utilizing this section of river.

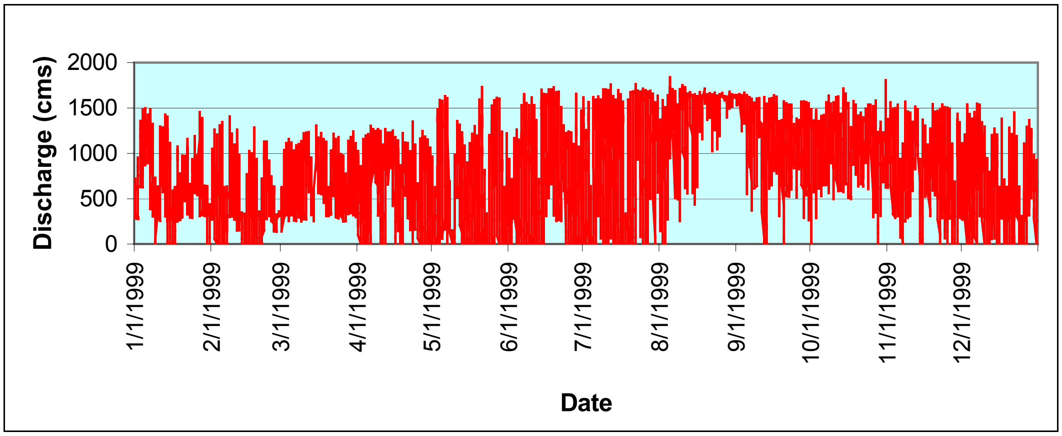

Figure 4-1: Revelstoke Dam Discharge, 1999

At minimum Arrow Lakes Reservoir levels (417.6 m; 1370.1 ft), the section of flowing river in the mid Columbia River can extend downstream for about 50 km (i.e., to Arrowhead). At full pool (440.1 m; 1444 ft), the reservoir zone extends upstream to near the town of Revelstoke and only a short section of flowing riverine habitat remains below Revelstoke Dam.

From an ecosystem perspective, operating alternatives that support large river habitat may provide important benefits for a diversity of fish species. The key species of interest identified by the Fish Technical Subcommittee were bull trout, rainbow trout, sculpins and dace, and, possibly, white sturgeon. It was recognized that the quantity and quality of this habitat type could be increased either by:

- Changing the level or timing of maximum levels in Arrow Lakes Reservoir (which would change the extent of backwatering of the riverine channel),
- Changing ramping rates in the mid Columbia River, or
- Increasing the minimum width of the mid Columbia River by introducing a continuous minimum flow release from Revelstoke Dam.

White Sturgeon Juvenile Recruitment

The first confirmed report of white sturgeon between Revelstoke and Hugh Keenleyside dams since impoundment of the system in 1968 was in June 1992. Since this initial capture, research has indicated that the current population is between about 46 to 50 individuals, and all appear to be older than the 1968 year-class (Tiley, 2004; RL&L, 2000). Based on the small size of this remnant population and the advanced age of these individuals, there appears to be a total lack of recruitment into the population. Failure to diagnose the cause and to support this population with hatchery operations and other management interventions is expected to lead to extirpation of the population.

White sturgeon are known to spawn, in at least some years, below Revelstoke Dam. However, to date, there has not been any evidence that this has resulted in recruitment of individuals to the population. Two spawning events have been documented near Revelstoke Golf Course (1999 and 2003) (Tiley, 2004). Developmental staging of the eggs indicated that two separate spawning events had occurred in both years, in late July and August. This represents the latest recorded spawning event for this species, which is likely related to cold-water temperatures below Revelstoke Dam (Tiley, 2004). Both spawning events occurred during a period of fairly stable flow following a period of peaking operation. The implications of the late timing of spawning and variable flows from Revelstoke Dam on white sturgeon spawning behaviour and spawning success remain unclear.

There are several hypotheses about what may be limiting successful recruitment to the Arrow Lakes Reservoir white sturgeon population (refer to Figure 4-2). While the delay of spawning may be affecting egg viability, the lack of recruitment may be related to reduced survival of sturgeon larvae and juveniles. Potential factors contributing to recruitment failure include:

- Low flow releases and water velocities that may allow for greater predation of these life stages, and prevent deposition in suitable rearing areas.
- Increased water clarity resulting from upstream regulation that increases the susceptibility of post-hatch sturgeon during their drift and early benthic stages to increased predation.
- Low productivity due to low nutrient levels and peaking operations.
- High embeddedness due to lack of scouring flows that further reduce productivity and refuge from predation and high velocity.
- Stranding of embryos, larvae and juveniles.
- Cold water temperatures that may interact synergistically with the above.

Given the small size of the white sturgeon population in Arrow Lakes Reservoir, it is not expected that management intervention alone will be successful in preserving a genetically distinct population in the long term. However, it is possible that, by providing suitable flow and habitat conditions to support spawning and recruitment, the chances of achieving a self-sustaining population of white sturgeon from hatchery stock could be increased in the future.

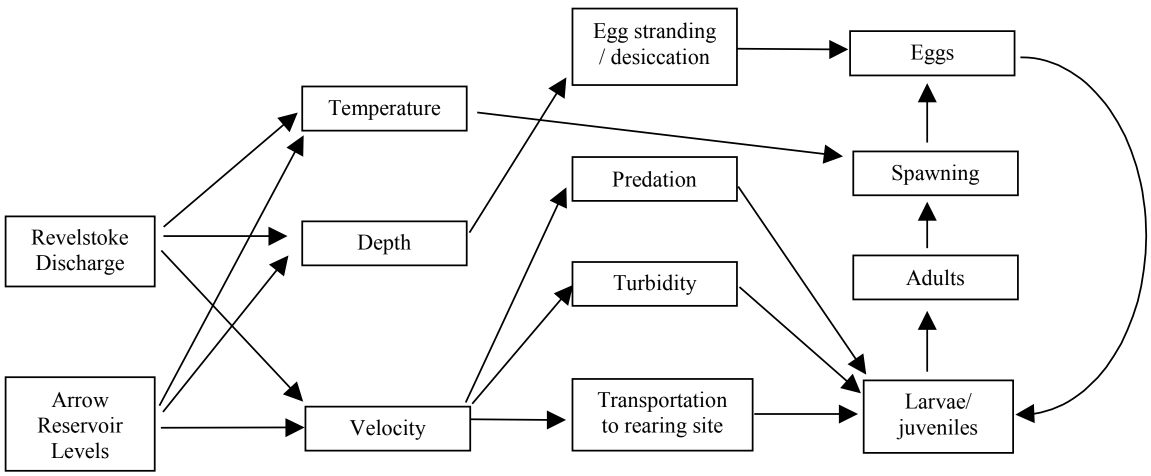

Figure 4-2: Impact Pathways for White Sturgeon in the Mid Columbia River (below Revelstoke Dam)

Other Issues Considered but not Pursued

Several other fish issues related to operation of Revelstoke Dam were identified through the initial scope exercise and considered by the Fish Technical Subcommittee early on in the Columbia River water use planning process. However, it was agreed that no performance measures or operating alternatives needed to be specifically developed to address these issues either because they were considered a lower priority, or operating alternatives designed to benefit other interests would help to mitigate these impacts (Failing, 2002). These issues and the rationale for not pursuing them further are outlined in Table 4-13.

Table 4-13: Fish-related Issues on the Mid Columbia River Discussed but not Pursued by the Consultative Committee

Interest	Location	Issue/Concern	Discussion/Rationale
Total Gas Pressure	Mid Columbia River	Under normal operation of the turbines, little gas pressure is induced during passage of water through the units at Revelstoke Dam. However, synchronous condense operation has been shown to result in increased localized total gas pressure (TGP) levels below the dam. TGP readings typically increase with a greater number of units operating in sync-condense mode. Sync-condense operations usually last for about 7.5 hours, and occur most often in March through May, on weekends and at night. Other sources of increased TGP include: air injection into the draft tube in the rough load zone to minimize cavitation; running units in the rough load zone; and use of the blower in Unit 1. In March 2003, coincident with the tailrace channel excavation project, BC Hydro began undertaking TGP monitoring at Revelstoke Dam to determine changes in TGP following the excavation project and to determine changes in TGP during sync-condense operations (Ramsay & Associates, 2003). With four units in sync-condense, TGP levels of 150 per cent were recorded downstream of the tailrace. However, TGP was found to decrease with distance downstream, with readings in the plunge pool usually below about 120 per cent and further dropping to about 110 per cent by the Revelstoke Golf Course.	The Fish Technical Subcommittee recommended that specific objectives and performance measures were not required to evaluate effects of operating changes at Revelstoke Dam on TGP production for the following reasons: • Current operations of the dam result in very localized effects on TGP levels (i.e., immediate vicinity of the dam). • The only operating alternative considered for Revelstoke Dam involved provision of a minimum flow release, which would be beneficial as it would act to dilute/dissipate TGP levels downstream. • BC Hydro is currently exploring ways to operationalize sync-condense to reduce TGP production below the dam.
Fish Stranding	Mid Columbia River	Concern was expressed that water level fluctuations in the mid Columbia River may cause stranding of fish and aquatic invertebrates (interstitial stranding, isolation in pools, beaching and dewatering of eggs). The risk of stranding is affected by daily discharge changes from Revelstoke Dam, the levels of upper Arrow Lakes Reservoir, and zero generation discharge. The Fish Technical Subcommittee agreed that the best opportunity for minimizing the risk of stranding might be through establishing ramping rates for critical water elevations. At present, there are no restrictions on the rate of ramping of flows released from Revelstoke Dam. The frequency of ramping is greatest during spring from March to April, when extensive hydro peaking operation coincides with low water levels in the upper Arrow Lakes Reservoir. During the remainder of the year, changes in depth and wetted width caused by peaking operation are moderated somewhat by backwatering of the reservoir and/or operation of the plant at or near full load.	Given the large daily fluctuations in flow from Revelstoke Dam (0 to 60 kcfs), the Fish Technical Subcommittee concluded that there would be little fish habitat benefits from ramp rate restrictions in the absence of a maximum flow ceiling. It was noted that it is not the ramp rate itself that that would provide the benefit, but the reduction in magnitude of daily fluctuations that would occur as a result of the reduced ramp rate.

4.10.1.3 Lower Columbia River

Fish Stranding

The Fish Technical Subcommittee highlighted the short-term frequency and magnitude of flow fluctuations below Hugh Keenleyside Dam as an important issue to be addressed through the Columbia River water use planning process. Stranding of fish as a result of daily/weekly flow changes is believed to be a potentially significant factor affecting fish abundance in the lower Columbia River, particularly sculpins and dace and early life stages (juvenile rainbow trout, whitefish) due to their use of shallow-water habitats.

Fish Population Response

Early in the Columbia River water use planning process, the Fish Technical Subcommittee agreed that the focus of fish management in the lower Columbia River should be on white sturgeon, burbot, mottled and shorthead sculpin, Umatilla dace, bull trout, indigenous rainbow trout and mountain whitefish. The subcommittee identified factors that are potentially limiting populations, with the aim of identifying operating opportunities that could induce population level responses. While several options were discussed by the subcommittee, it was agreed that the greatest potential to provide gains to these fish populations was through exploring seasonal changes in the shape of the hydrograph in the lower Columbia River.

White Sturgeon Juvenile Recruitment

The white sturgeon population in the Columbia River between Hugh Keenleyside Dam and the Canada/United States border has been estimated in the range of 980 to 1300, consisting primarily of older fish with few younger individuals. Sturgeon spawning has been documented annually near the United States border. However, 1997 was the last year where a recruitment signal for white sturgeon spawning success was suspected to have occurred in the Columbia River system. This occurred in another sub-population on the United States side of the border and coincided with a peak flow of 272 900 cfs, which was substantially greater than in any year since 1990.

Potentially suitable spawning habitat for white sturgeon is available at several locations in the Columbia River downstream of Hugh Keenleyside Dam. However, spawning has only been documented below Waneta Dam at the confluence of the Pend d'Oreille and Columbia rivers. It is thought that this may be due to the fact that the Pend d'Oreille River warms more rapidly and exhibits a more natural flow pattern in spring than the Columbia and Kootenay rivers. Based on available data, it appears that spawning intensity is greatest when discharges in the Pend d'Oreille River are high and steady (as was the case in 1996 and 1997), which would have increased the likelihood of egg to hatch survival due to the maintenance of high velocities and turbidity levels that would help to reduce predation.

Although the white sturgeon eggs collected from the Waneta Eddy area appear to be viable, the extremely low numbers of juvenile white sturgeon both in the Canadian portion of the river and in the Columbia River system in the United States suggests a near complete mortality of young sturgeon. The causes of recruitment failure are not known. However, it is believed that it may be due to high predation rates on post-hatch stages or during the juvenile stage in rearing habitats located downstream in the United States, which may be due, in part, to reduced turbidity in the river due to upstream impoundments. Other contributing factors may include changes in predator species abundance and composition (e.g., introduction of walleye), and stranding of eggs, larvae and juveniles (refer to Figure 4-3).

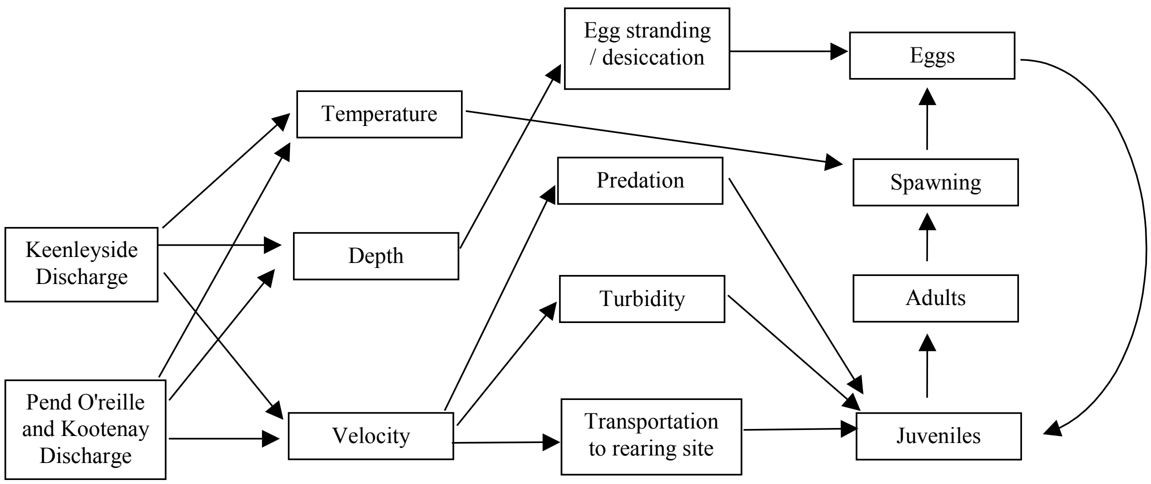

Figure 4-3: Impact Pathways for White Sturgeon in the Lower Columbia River (below Hugh Keenleyside Dam)

Due to the ongoing recruitment failure of white sturgeon in the Columbia River below Hugh Keenleyside Dam, the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) Team has pursued conservation fish culture of white sturgeon. The goal of this program is to maintain the population in this manner while allowing time for investigating mitigation options such as flow restoration, and provide fish for a variety of experimental programs that are aimed at investigating causes of recruitment failure. Hatchery supplementation is occurring in the lower Columbia River, and juvenile releases have been shown to survive. Further, individual fish have shown impressive growth, indicating that food and habitat is available for this life stage. However, hatchery releases are one year old at the time of release and food requirements and susceptibility to stranding may be radically different from post hatch larvae and early juvenile stages. Further, the number of families produced each year is still not sufficient to meet genetic requirements.

With the assistance of the UCWSRI Team, the Fish Technical Subcommittee considered possible ways to improve conditions for white sturgeon with the aim of increasing the probability of successful natural recruitment. A number of operating alternatives were proposed to test the most plausible hypotheses about what is limiting or preventing sturgeon recruitment:

- Shift the timing of the hydrograph peak to mid June.
- Increase the magnitude of the peak.
- Provide multiple declining limbs to the hydrograph.

In addition to flow augmentation strategies, consideration was also given to physical works options to address possible non-flow related factors that may also be limiting sturgeon recruitment.

Total Gas Pressure

Monitoring of total dissolved gas levels below Hugh Keenleyside Dam throughout the 1990s indicated that use of the spillways often produced total gas pressure (TGP) levels in excess of 140 per cent saturation. TGP levels were substantially below this when the low-level ports were used. Experimental testing involving selective use of specific low-level port and spillway gate settings was subsequently undertaken to develop a protocol for minimizing TGP production in the lower Columbia River. This resulted in development of a model that recommends real-time dam operations to reduce TGP, and revisions to the facility's local operating orders that significantly reduce TGP production. The current operating protocol followed by BC Hydro has been shown to minimize the TGP production for any head/flow combination at Hugh Keenleyside Dam.

Arrow Lakes Generating Station (ALH) can divert up to 1115 m^3/s (~40 000 cfs) of the flows away from the ports at Hugh Keenleyside Dam where TGP is produced, and pass it through its generators where no TGP is produced. This has been shown to significantly reduce downstream TGP levels. However, high TGP levels remain a concern downstream of Hugh Keenleyside Dam to the point in the river where flow from ALH has fully mixed. Operational protocols to reduce the production of high TGP levels at Hugh Keenleyside Dam are considered important to reducing impacts in this area of the river.

Given the mitigating effect of ALH operations and current operating protocols at Hugh Keenleyside Dam on TGP production, development of different operating alternatives to reduce TGP levels in the lower Columbia River was not considered necessary. However, the Consultative Committee expressed concern that operating regimes developed to support other objectives on Arrow Lakes Reservoir and below Hugh Keenleyside Dam may increase TGP levels in the lower Columbia River and increase the risk to fish below the dam.

Other Issues Considered but not Pursued

Some fish-related issues in the lower Columbia River were not pursued by the Consultative Committee either because they would not be influenced by operational changes or would cause significant impacts to other interests. These issues and the rationale for not assessing them further are outlined in Table 4-14.

Table 4-14: Fish-related Issues in the Lower Columbia River Discussed but not Pursued by the Consultative Committee

Interest	Location	Issue/Concern	Decision/Rationale
Water Temperature	Lower Columbia River	Water temperature in the lower Columbia River below Hugh Keenleyside Dam was identified as a limiting factor for burbot and bull trout, and possibly sturgeon spawning and incubation near the Pend d'Oreille River confluence.	It was recognized that any operational changes considered could not significantly influence temperatures below the dam. Further, it was acknowledged that the Columbia River Integrated Environmental Monitoring Program (CRIEMP) is interested in long-term monitoring of temperature in the lower Columbia River with respect to global warming and effects on other aspects of ecosystem health. Consequently, the Consultative Committee did not consider this issue further in the water use planning process.
Flushing Flows	Lower Columbia River	River impoundments due to dam construction leads to changes to the flow regime, which in turn affect sediment transport downstream. The Fish Technical Subcommittee discussed the possibility of providing flushing flows below Hugh Keenleyside Dam to provide flows of sufficient magnitude to move and flush substrate sediment to maintain suitable habitat for fish and insect production.	BC Hydro has collected depth/velocity transect information and developed an HEC model of the Columbia River below Hugh Keenleyside Dam, but no estimation of flushing flow requirements have been completed to date. Significant development has occurred on the historic floodplain of the Columbia River, which limits the volume of water that can be discharged without causing damage to private property and infrastructure (e.g., roads, water intakes). The current operating constraint related to flushing flows is a maximum flood control limit of 165 kcfs (as measured at Birchbank), which limits flooding of the lower septic system at Whispering Pines Trailer Court. A flow of 225 kcfs is the Columbia River Treaty trigger for on-call flood operation (Westcott, 2001).

4.10.2 Objectives and Performance Measures

The fundamental fish objective for the Columbia River Water Use Plan was to maximize the abundance, diversity and condition of wild, indigenous fish stocks in the Columbia River system. To this end, the Consultative Committee developed the following sub-objectives.

- *Maximize the probability of successful juvenile recruitment of white sturgeon in the mid Columbia and lower Columbia rivers.*
- *Improve the response of indigenous rainbow trout, burbot, whitefish and other populations to the hydrograph in the lower Columbia River.*

- *Minimize risks to fish associated with elevated total gas pressures in the lower Columbia River.*
- *Maximize pelagic and littoral productivity in Kinbasket and Arrow Lakes reservoirs.*
- *Maximize large river habitat in the mid Columbia River between Revelstoke Dam and Arrow Lakes Reservoir, for the purpose of:*
  - *Maximizing ecological productivity.*
  - *Increasing juvenile fish use.*
  - *Maximizing adult fish abundance, condition, growth and fecundity.*
  - *Triggering rainbow trout spawning.*

Preliminary performance measures were considered by the Fish Technical Subcommittee to address issues such as temperature, tributary access and backwatering and entrainment, but were eliminated either because the issue was of minor significance, unlikely to be affected by operations, or too uncertain to inform decisions (and thus candidates for post-implementation monitoring).

Table 4-15 summarizes the fish performance measures used by the Consultative Committee to evaluate the operating alternatives developed for the various rounds of the trade-off analysis. The evolution of these measures and rationale for the modifications is described in the following sections.

Table 4-15: Fish Performance Measures

Location	Performance Measure	Unit of Measure	Description	MSIC
Kinbasket and Arrow Lakes Reservoirs	Pelagic Productivity	tonnes Carbon per year	The Pelagic Productivity performance measure reported primary production (tonnes of carbon per year).	N/A
	Littoral Productivity	Index based on vegetation presence (see riparian vegetation performance measure)	Index of food availability and refugia primarily for non-sport fish species. Initially reported as carbon production from periphyton and benthic invertebrates (tonnes of carbon per year). This performance measure was dropped and the riparian vegetation performance measure was used as proxy.	N/A
Mid Columbia River	Total Wetted Area	Hectare-days	Represents habitat availability. Calculated as the annual average of the minimum wetted area each month, where minimum wetted area is calculated for each cross section across all days in the month. The sum is only conducted for cross sections that are riverine in nature (average velocity ≥0.2 m/sec). This performance measure was dropped since it strongly and consistently co-varied with the productive area statistic.	

Table 4-15: Fish Performance Measures (cont'd)

Location	Performance Measure	Unit of Measure	Description	MSIC
Mid Columbia River (cont'd)	Total Productive Area	Hectare-days	Represents lower trophic productivity. Calculated as the annual average of the minimum area that is continuously wetted each month for a period of 21 days or more, where productive area is calculated for each 0.25 m cross section slice that is considered productive over each month. The statistic reports the sum of monthly productive area across all cross sections that are riverine in nature.	10%
	Maximum Velocity Difference	m/sec	Represents energy requirements and displacement effects of flow changes on fish. Calculated as the annual average of the maximum daily change in velocity, where daily maximum is calculated for each day of the month for each riverine cross section and then averaged over the month. A weighted average over the riverine length is reported (weighted by the river length associated with that cross section).	10%
	Large River Length	Average km/year	This performance measure reports the average of the minimum annual river length below Revelstoke Dam. It represents food availability (area over which bugs are produced), but is also serves as a proxy for habitat availability and energy requirements for key fish species.	1 km/ year
	White Sturgeon Habitat Suitability	WUA (m^2)	This performance measure reports on the minimum weighted usable area based on depth and velocity during the suspected white sturgeon spawning period (15 July to 15 August).	
Lower Columbia River	Winter Smoothing	kcfs	Calculated as the absolute value of sum of changes in mean monthly flow across the months December to January, January to February, and February to March.	10%
	Summer Magnitude	kcfs	Reports the mean monthly flow at Birchbank during June and July.	10%
	Rainbow Trout Flows	Index	This is a yes/no criterion that indicates whether flow adjustments have been made to Arrow Lakes Reservoir and Hugh Keenleyside Dam releases to achieve stable/rising flows at Birchbank during spawning and incubation period of mid-timed rainbow trout. Yes = good (stable or rising). No = bad (declining).	N/A

Table 4-15: Fish Performance Measures (cont'd)

Location	Performance Measure	Unit of Measure	Description	MSIC
Lower Columbia River (cont'd)	Mountain Whitefish Flows	Index	This is a yes/no criterion that indicates whether flow adjustments have been made to Arrow Lakes Reservoir and Hugh Keenleyside Dam releases to achieve non-decreasing flows at Birchbank during the spawning and incubation period of mountain whitefish Yes = good (stable or rising). No = bad (declining).	N/A
	Total Gas Pressure	# days above threshold 115% 120%	Provides an indication of the exposure of downstream fish to the risk of gas bubble trauma disease. Reports on the total number of days over 15 years of simulation during which the average daily TGP exceeds the thresholds of 115 or 120 per cent.	

4.10.2.1 Reservoir Pelagic Productivity

A reservoir pelagic performance measure was developed by the Fish Technical Subcommittee to assess the impact of changes in pelagic productivity from different operating alternatives on food availability for key fish stocks in Kinbasket and Arrow Lakes reservoirs. This measure was initially considered relevant to both reservoirs because of their extensive drawdown zones and large fluctuations in water levels. However, it was eventually dropped for Kinbasket Reservoir when it became apparent that the cost of implementing any operational changes for this reservoir would outweigh the environmental benefits.

The initial model developed to simulate the effect of alternative operating policies on pelagic productivity in Arrow Lakes Reservoir was developed using an Excel spreadsheet. Carbon fixation rates developed from in-situ C14 measurements taken in the upper and lower section of the reservoir were used to derive an area-weighted average. A relationship predicting reservoir surface area as a function of water surface elevation was used to estimate the surface area on a weekly basis. Monthly reservoir elevations predicted by the HYSIM model were interpolated to weekly values to determine average weekly surface areas. The product of the area-weighted carbon fixation rate and the reservoir area for each week was used to derive the total amount of carbon fixed for the entire reservoir. This product was summed over the growing season that ran from April to mid October. The model predicted the total tonnes of carbon fixed for the entire reservoir over the growing season for each operating alternative.

The initial pelagic model considered only the linkage between operations and carbon fixation via the effects of reservoir elevation on reservoir surface area. The Fish Technical Subcommittee questioned whether the model was sufficiently complex to correctly capture the relative response of pelagic productivity to operations. In particular, they were concerned that the loss of carbon from epilimnetic water withdrawn through Hugh Keenleyside Dam could vary among alternatives, and that this could alter the relative ranking of operating alternatives. Stockner and Korman (2002) revised the pelagic model for Arrow Lakes Reservoir to account for this dynamic. They found that the carbon budget in the reservoir was dominated by the amount of carbon fixed. The large surface area and high daily photosynthetic rate resulted in the production of large amounts of carbon (ca. 3000 tonnes Carbon/month (tC/month)) during the summer months. The loss of carbon through Hugh Keenleyside Dam was relatively low (usually < 100 tC/month) because the predicted carbon concentration at the dam was low. Loss rates through the dam increased with discharge, but were relatively small (~2 per cent) compared to the amount of carbon produced. As a result, the amount of carbon retained in the Arrow Lakes Reservoir was very consistent across scenarios. Carbon retention rates were typically greater than 98 per cent. Thus, incorporation of the effects of carbon losses through Hugh Keenleyside Dam did not alter the ranking of operating alternatives. The simpler original model was, therefore, used for subsequent analyses.

Model analyses were initially performed using a statistical water year approach. Rather than simulating monthly operations for the entire 60-year period of record, simulations for dry, average and wet years were conducted based on a simple operations model developed by Compass Resource Management. The pelagic productivity performance measure predicted the annual amount of carbon fixed for any scenario for each of the three water year types. Eventually, predictions of discharge and reservoir elevations were replaced by the HYSIM model, which used natural inflows for the last 60 years. Predictions of monthly reservoir elevations were interpolated to weekly values and run through the pelagic model described above to predict annual carbon fixation rates for each of the 60 years. As this simulation approach was computationally more burdensome, the spreadsheet version of the pelagic model was reprogrammed as a sub-routine in the Integrated Response Model (Korman, 2002).

Modelling results indicated that there were no substantial gains in carbon production across the range of operating alternatives being considered for Arrow Lakes Reservoir. Compared to the benefits achieved through the fertilization program, it appeared that pursuits to enhance pelagic productivity through operational changes were not likely worthwhile. Stockner (2001) estimated that full stabilization of Arrow Lakes Reservoir (at mean high elevation 438.5 m; 1438.7 ft) during the growing season would increase carbon production by about 10 per cent (from about 10 400 tC/year to 11 400 tC/year). In contrast, addition of fertilizer to the upper Arrow Lakes Reservoir has increased production by about 4000 tC/year.

The Fish Technical Subcommittee recommended that the pelagic productivity performance measure should not be considered further in the Columbia River water use planning process. It was decided that efforts should focus on operating alternatives that enhance riparian and large river habitat, where more significant gains could be achieved through operational changes.

4.10.2.2 Reservoir Littoral Productivity

The Fish Technical Subcommittee initially proposed to use the effective littoral zone (ELZ) as a performance measure for reservoir littoral productivity until a more practical and sensitive measure could be determined. This measure was to report on the total area of Arrow Lakes Reservoir, in hectares, that has potential to function productively (i.e., receive adequate light for photosynthetic activity and remain wetted for specific time periods) during the growing season. Early in the Columbia River water use planning process, the subcommittee concluded that a more appropriate measure would be carbon production (tC/year) from periphyton and benthic invertebrate communities. An ELZ model was never developed.

The Reservoir Littoral Productivity performance measure predicted the biomass of periphyton for each 1-metre elevation band in Arrow Lakes Reservoir between 421 and 440 m (1381 to 1444 ft) based on the depth of inundation and duration that each band has been inundated. Carbon fixation rate parameter estimates were provided by J. Stockner based on data collected in the Stave Reservoir. Carbon fixation rates were 45 mgC/m^2/day for areas that were flooded to a depth of 8 m or less. A lower rate of 18 mgC/m^2/day was used for elevations flooded to a depth of 8 to 15 m. No carbon fixation was assumed for elevations flooded to a depth of greater than 15 m. The effect of the duration of inundation on the carbon fixation rate was simulated using a type-III functional response, where the rate was assumed to be one-half of the maximum value if the elevation band had been flooded for three weeks. This parameter was set so that the maximum fixation rate would occur about six weeks after inundation, which was the assumed period for complete colonization.

Carbon fixation rates were increased by a factor of 1.44 in cases where riparian vegetation was present in an elevation band when it was flooded. The adjustment factor was based on the observed periphyton carbon fixation rates in the presence of flooded vegetation in Stave Reservoir of 65 mgC/M^2/day (i.e., 1.44 fold higher than the value of 45 mgC/m^2/day). Determination of vegetation presence was based on predictions from the riparian vegetation model (refer to Section 4.9.2.1).

An Excel spreadsheet macro was used to derive the amount of carbon fixed per m^2 for each elevation band for a given scenario. This biomass was multiplied by the area that each band represented to derive the total number of tonnes of carbon fixed over the growing season. The model was applied using the statistical water year approach described above.

The littoral productivity model was never imported into the Integrated Response model because it was dropped from further evaluation of operating alternatives for Arrow Lakes Reservoir. Given refinement of the riparian vegetation performance measure to account for timing and duration of inundation, cumulative annual impacts and elevation of vegetation (refer to Section 4.9.2.1), the Fish Technical Subcommittee felt confident that potential impacts on littoral productivity would be best tracked by changes in riparian vegetation. It was assumed that greater vegetation establishment within the drawdown zone would directly benefit littoral productivity.

4.10.2.3 Mid Columbia Large River Habitat

The Consultative Committee agreed to review a series of alternative flow regimes for Revelstoke Dam that would limit the extent of flow variation, and maximize large river habitat in the mid Columbia River. For preliminary analysis of these minimum flow alternatives, two simple performance measures were developed to track the physical response of the mid Columbia River. One metric reported on the area of flowing riverine habitat, broken out by sub-habitat type (mid channel, sidechannel) and season (reported as kilometre-days). A second measure was developed to report on the quality of large river habitat, which was defined as the minimum continuous flow (in kcfs) over the summer period (1 May to 31 August) and winter period.

Based on a conceptual model of how habitat factors could influence the growth and survival of key fish populations in the mid Columbia River (refer to Figure 4-4), a series of new performance measures were developed by the Fish Technical Subcommittee. A physical habitat model was developed to estimate changes in the key habitat features that are hypothesized to affect these fish populations (Korman et al., 2002; Appendix Q: Fish Habitat Performance Measures to Evaluate Minimum Discharge Requirements for Revelstoke Canyon Dam).

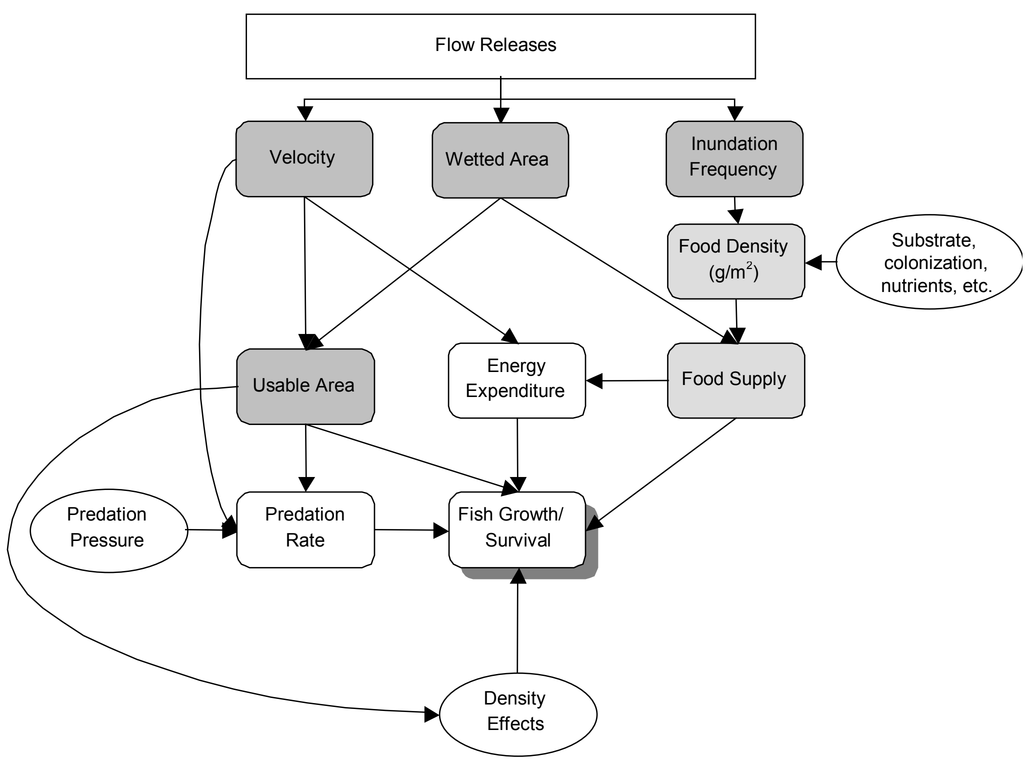

Figure 4-4: Conceptual Model of Fish Response to Flow in the Mid Columbia River

While it was recognized that estimating the effects of flow regimes on the endpoints (fish populations) directly would be ideal, a lack of data on current fish status and gross uncertainties about fish response to flow precluded quantitative modelling. Three habitat-based performance measures were, therefore, developed to account for the dynamics of these hypotheses.

- Maximum Velocity Difference – The average maximum daily velocity difference over the month (in m/sec), as a measure of potential energy expenditure and predation risk.
- Productive Area – The amount of productive habitat defined as the area of substrate that is continuously submerged for more than 21 days (in hectare-days), as an index of the response of lower trophic levels (algae and benthic invertebrates) to reduced flow fluctuations.
- Wetted Area – The total amount of wetted area (in hectare-days), as an index of habitat availability, recognizing that increasing wetted width may have some benefits to fish even if the increased width occurs over areas that are not colonized by a benthic community.

Computation of these performance measures was based on results of the HEC-RAS one-dimensional backwater hydraulic model (refer to Appendix Q: Fish Habitat Performance Measures to Evaluate Minimum Discharge Requirements for Revelstoke Canyon Dam for a detailed description of the modelling methodology). The model was run under a range of dam discharges and Arrow Lakes Reservoir elevations to generate the water elevation, wetted width and average cross-sectional velocity statistics. These statistics were calculated for 245 cross sections covering a 37-km distance (Revelstoke Dam to below the confluence of the Akolkolex River).

Analysis of the modelling results indicated that the total wetted area performance measure was strongly and consistently correlated with the productive area statistic across all of the flow alternatives considered for the mid Columbia River. Consequently, this performance measure was dropped and productive area was used as a proxy for habitat availability. The subcommittee used this statistic to evaluate the expected performance of the Revelstoke minimum flow alternatives in meeting the fish and learning objectives.

The Fish Technical Subcommittee agreed that a separate performance measure would be needed to track the potential impacts of operating alternatives proposed for Arrow Lakes Reservoir on fish values in the mid Columbia River. As the productive area measure was not sensitive across the range of operating alternatives, the subcommittee agreed that a more sensitive statistic would be the minimum area in the upper reach of the river that is not inundated as a result of reservoir backwatering. This was based on a reach-integrated analysis of the modelling results of the mid Columbia River flow alternatives, which showed that the greatest benefits to physical conditions in the mid Columbia River would be realized in the uppermost reach (above Highway 1 Bridge). This is due to the lack of major tributary inflow and limited influence of reservoir backwatering relative to the downstream reaches. The final performance measure used to track the effects of Arrow Lakes Reservoir operating alternatives on large river habitat was the average minimum length of river above Highway 1 Bridge.

4.10.2.4 Mid Columbia River White Sturgeon Juvenile Recruitment

During the Round 1 trade-off analysis, a very simple scale was used to track whether flow conditions suitable for white sturgeon recruitment were met by the constraints of the alternatives. A new performance measure was subsequently developed to assess the potential benefits of minimum flow scenarios and changes in Arrow Lakes Reservoir elevations on spawning habitat suitability for white sturgeon below Revelstoke Dam. Computation of the performance measure was based on results of the HEC-RAS model (Korman and Lin, 2003; provided in Appendix R: Documentation of Preliminary White Sturgeon Spawning Habitat Suitability Model for the Middle Columbia River and summarized briefly below).

A small subset of the 245 cross-sections was used to model the hydraulic geometry in the area suspected of being used for spawning by white sturgeon. This smaller model area extends 300 m upstream and downstream of the confluence with the Jordan River. Predictions of depth and velocity for a given discharge were used to compute spawning habitat suitability based on published sturgeon spawning habitat suitability relationships.

Water surface profiles computed by HEC-RAS were used to predict depth and velocity at individual vertical cells (20 per cross section averaging 10 to 12 m in width) for each modelled cross-section. Predictions of depth and velocity for each cell were translated into suitability values ranging from 0 to 1. Weighted-usable-area (WUA) for a specific discharge was computed as the sum of the product of the cross-sectional area for each cell (A_I) and its suitability value for velocity only (S_v), or velocity and depth (S_vS_d):

Velocity Only Model: $$WUA_v = \sum_{i=1}^{ncells} A_i S_v$$

Depth and Velocity Model: $$WUA_t = \sum_{i=1}^{ncells} A_i S_v S_d$$

Time-integrated WUA values were computed to derive a single statistic for each model that was used to evaluate alternative minimum flows. This was performed by integrating the predicted WUA values from a cross-sectionally averaged function based on the depth-velocity suitability model. The model used to produce a time-integrated WUA estimate was:

WUA=-4.99 – 1.13e-01 * Q + 8.37e-04 * Q^2 – 4.23e-07 * Q^3 + 6.70e-11 * Q^4,

where Q is discharge in m^3/sec.

WUA was calculated for each two-hour timestep in June based on bi-hourly discharge data for Revelstoke Dam, averaged over all timesteps. These WUA values were summed over the month of June, and divided by the total number of timesteps in the month. The procedure was repeated using discharge input that included both Revelstoke Dam discharge and an estimate of the discharge from the Jordan River (based on the total local Arrow Lakes Reservoir inflow for the month and the proportion of the Jordan River drainage to the total local drainage). The performance measure reported the average of the Revelstoke Dam only and Revelstoke Dam plus Jordan River WUA estimates under the assumption that the potential spawning areas upstream and downstream of the Jordan River confluence are equally important.

The Fish Technical Subcommittee recognized the uncertainty around whether white sturgeon spawning success is driven by average conditions (as assumed by the performance measure), or maximum, minimum or diel variation in WUA values over the month. Changes were subsequently made to the performance measure to report on the minimum WUA at various minimum flow alternatives and Arrow Lakes Reservoir elevations. The temporal component of the performance measure was also changed to the 15 July to 15 August period to approximately coincide with the timing of the two reported spawning events that occurred in the mid Columbia River in 1999 (31 July and 20 August; RL&L, 2000) and 2003 (2–3 July and 13–14 August; Tiley, 2004).

Based on the results of the modelling, it became apparent that, at high reservoir elevations, a minimum discharge of 30 kcfs would be needed to achieve suitable velocity for white sturgeon spawning/recruitment in the mid Columbia River. Further, it was noted that a white sturgeon flow could be implemented independently of any of the Revelstoke Dam minimum flow alternatives or Arrow Lakes Reservoir operating alternatives being considered by the Consultative Committee. Consequently, the Fish Technical Subcommittee agreed that further consideration should be given to an experimental white sturgeon flow treatment and agreed to seek the guidance of the UCWSRI in developing the experimental design and protocol. The white sturgeon performance measure was no longer required for decision-making by the Consultative Committee.

4.10.2.5 Lower Columbia River Hydrograph Response

The Consultative Committee established specific fish objectives for the lower Columbia River. These were to:

- *Maintain or enhance rainbow trout populations.*
- *Maintain or enhance mountain whitefish populations.*
- *Maintain or enhance sculpin/dace populations.*
- *Maintain or enhance ecological productivity.*

- *Increase the probability of successful white sturgeon recruitment.*
- *Increase learning about how fish respond to flow.*

The Consultative Committee initially explored how much gains could be achieved by using existing flexibility within the Columbia River Treaty to change flows in the lower Columbia River to benefit fish, but this was not considered significant from a biological perspective. It was realized that more significant changes could be made by changing Treaty flows through annual negotiations with the United States. The focus of flow management, therefore, was directed at flow changes that could be made through annual negotiations as opposed to changes that BC Hydro could implement unilaterally.

The Fish Technical Subcommittee identified a set of flow options that could be pursued in annual negotiations to meet the key fish objectives. These consisted of two primary flow management actions: hydrograph enhancement through delivery of seasonal flow options, and opportunistic controlled flow release to improve white sturgeon recruitment.

Figure 4-5 illustrates the relationship between the flow management actions and the fish objectives for the lower Columbia River.

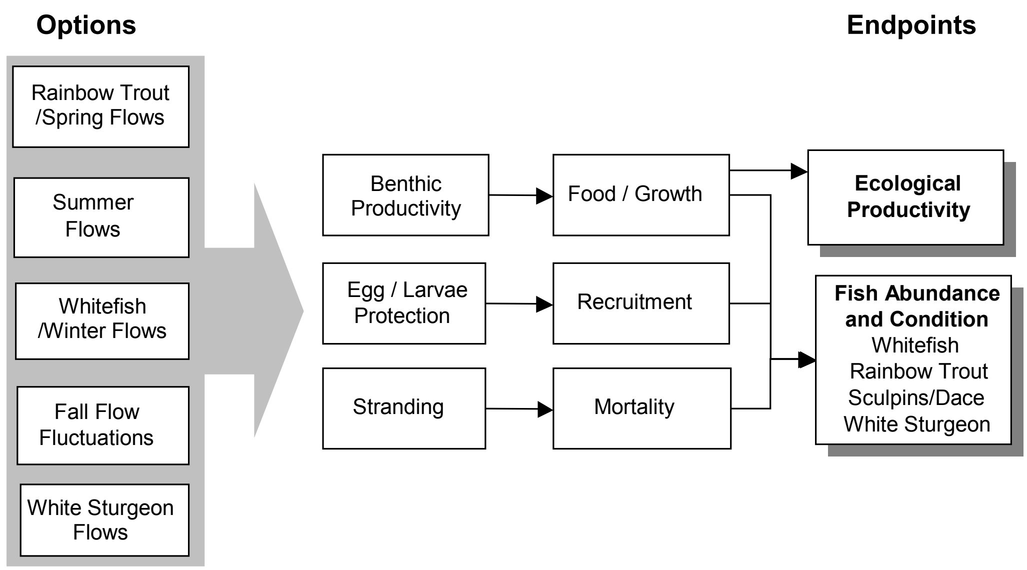

Figure 4-5: Relationship between Flow Options and Aquatic Endpoints in the Lower Columbia River

Preliminary flow options considered by the Fish Technical Subcommittee included:

- Winter Flow Magnitude – Limit maximum flows during the peak period of whitefish spawning (1 to 21 January) to minimize subsequent egg dewatering and mortality.

- Winter Smoothing – Reduce the magnitude and variability of winter flows (avoid month-end spike in January, smooth February/March flows) to benefit primary and secondary productivity, minimize energetic requirements of white sturgeon and facilitate burbot migration.
- Spring Flow Management – Provide stable or increasing flows from 1 April through 30 June to minimize dewatering and potential egg losses of mid-timed spawning rainbow trout. Potentially beneficial to other spring spawning species, including mottled sculpin and Umatilla dace.
- Summer Flow Augmentation – Increase the average river discharge by 20 per cent during July and August to improve habitat conditions (reduce embeddedness), provide spawning/rearing habitat and limit stranding of sucker, sculpin, pikeminnow and shiners, and improve survival of sturgeon larvae.
- White Sturgeon Flows – Provide a periodic high flow in June/July to improve white sturgeon juvenile recruitment.
- Fall Flow Management – Allow fall flow fluctuations as a trade-off for whitefish flows. This would affect productivity of cyprinids and sculpins due to use of shallow-water habitats, and habitat suitability for rainbow trout.
- Sampling Flows – Provide stable flows for four weeks in September and October to increase precision of fish and productivity sampling. *(This was viewed as a secondary priority to the other flow options.)*

Winter flow objectives around reducing January flows, and smoothing discharge over the January to March period were subsequently combined into one flow option. This option set limits on minimum flows in January and February/March to avoid stage changes greater than 0.5 m.

To provide insight into the likely biological significance of the flow alternatives, the Fish Technical Subcommittee developed the following physical performance measures.

- Winter Smoothing – Reported as the absolute value of sum of changes in mean monthly flow across the months December to January, January to February, and February to March (i.e., the period when water temperature is 5°C or less). (Note: This was originally reported as the total volume of flow at Birchbank from 1 December through 28 February to reflect the hypothesis that multiple species would benefit from lower winter flows.)
- Summer Magnitude – Reported as the mean flow over the period June through September during the peak growing season and timing of summer spawning.
- Sturgeon Summer Flows – Reported as the total volume of flow at Birchbank from 1 July to 31 August, reflecting the hypothesis that higher flows during this period may improve the probability of early sturgeon survival.

- Rainbow Trout Protection Flows Maintained – A yes/no criterion to indicate whether stable or increasing discharge is provided during the spawning and incubation period of mid-timed spawning rainbow trout.

The connection between the first two performance measures and their endpoints of interest was loose at best, and a large number of data gaps prevented the Fish Technical Subcommittee from understanding the link between specific flow measures and "what is good for fish." Moreover, the ability to make any changes to flow patterns in the lower Columbia River was constrained by the Columbia River Treaty. After much discussion, the subcommittee prioritized the maintenance of the rainbow trout flows and mountain whitefish flows and provision of sturgeon flows as operational changes to be pursued in this area. Monitoring studies were subsequently designed to examine the effectiveness of these flow options, and to address existing data gaps between flows and the other endpoints of interest. Consequently, the other fish performance measures for the lower Columbia River were dropped from further consideration.

The rainbow trout flow performance measure initially tracked whether flow adjustments were made in modelling for Arrow Lakes Reservoir and the lower Columbia River to resemble both rainbow trout and mountain whitefish flow agreements. This was subsequently changed to separately account for rainbow trout and whitefish operations. These measures remained a qualitative "yes/no" index.

4.10.2.6 Fish Stranding

River flows in the lower Columbia River were modelled as monthly averages, and therefore did not capture daily or weekly flow changes that might affect fish stranding. Each of the operating alternatives developed for Arrow Lakes Reservoir were assessed qualitatively in terms of their likely influence on downstream flow fluctuations and their potential to strand fish in the lower Columbia River. The alternatives were assessed based on two conditions:

- Would changes from the Base Case influence BC Hydro's ability to smooth short-term flow changes from Hugh Keenleyside Dam?

- Would changes from the Base Case influence the magnitude of flow fluctuations coming out of the Kootenay River system (via Brilliant Dam)?

The assessment was based on professional judgment. It was concluded that none of the alternatives examined would have a significant impact on these two causes of short-term flow fluctuations. Consequently, no detailed performance measures were developed beyond a preliminary measure that reported qualitatively on the magnitude and frequency of daily flow fluctuations expected on the lower Columbia River, as an indication of stranding potential.

The Fish Technical Subcommittee agreed that the best opportunity to manage fish stranding impacts was through development of a flow reduction protocol and standard methods for assessment, data collection, and mitigation responses (Vonk, 2003). The subcommittee also identified the need to develop further understanding of flow ramping impacts.

4.10.2.7 Total Gas Pressure

Early efforts at tracking the potential impact of operating alternatives for Arrow Lakes Reservoir on total gas pressure (TGP) production below Hugh Keenleyside Dam focused on tracking the height differential between Arrow Lakes Reservoir elevations and tailwater elevations below the dam. Previous experience had shown that TGP production increased dramatically as this height differential crossed 17 m as this requires use of the spillways. However, the Fish and Wildlife Technical Subcommittee expressed discomfort with this approach as it used monthly elevations as its inputs, whereas TGP production tends to be brief in duration (spiky). As well, it was noted that TGP production was a function of both head differential and flows.

A second attempt to track TGP production involved superimposing a series of daily flows and elevations based on historical fluctuations on the monthly output from the HYSIM model of alternatives. This analysis considered TGP production as both a function of head and flows, based on a model developed by Aspen Applied Sciences. However, it was recognized that this measure did not consider:

- The influence of the Arrow Lakes Generating Station (ALH).
- The most recent decade of modelled flow data used for the Arrow Lakes Reservoir operating alternatives.
- The link between TGP production and fish mortality.

Further study (Aspen Applied Sciences, 2002, 2003) and discussion by members of the Fish Technical Subcommittee led to refinements to the TGP performance measure calculations (refer to Appendix S: Total Gas Pressure Performance Measure Results Summary Note). The revised performance measure calculations imposed daily deviations, simulated from historical data, onto the monthly outputs of the alternative modelled to data for the years 1984/85 to 1999/00. In addition, the measure captured the fact that the ALH can divert up to 1115 m^3/s (~40 000 cfs) of the flows away from the ports at Hugh Keenleyside Dam where TGP is produced, and pass it through its generators where no TGP is produced. The TGP performance measure assumes that the ALH takes as much water as possible.

The relative differences among the operating alternatives were reported as the number of days that TGP production exceeds two threshold values (115 per cent and 120 per cent) over the 15-year period. Each day above the threshold is treated equally, regardless of its absolute magnitude and disregards all TGP occurrences below that cutoff.

Given the order of magnitude difference between the analysis results for Hugh Keenleyside Dam operations with and without ALH, the Fish Technical Subcommittee agreed that the risk of gas bubble trauma (GBT) to fish in the lower Columbia River with the ALH operations is extremely small. Furthermore, with ALH, the differences between cumulative risk factors for the different operating alternatives are exceptionally small relative to the differences in the with/without ALH comparison. Based on this assessment, the subcommittee concluded that further performance measure calculations or information around TGP production in the lower Columbia River would not assist the Consultative Committee in making operating recommendations, and the TGP performance measure was dropped from further consideration.

4.11 LEARNING

4.11.1 Issue

The ability to make informed water management decisions in the Columbia River water use planning process was hindered by a lack of knowledge, particularly with respect to ecological health objectives. Learning over time, so that future decisions may be better informed and deliver better societal value, is an explicit objective of the Columbia River water use planning process.

It is possible that different water management decisions will lead to different levels of learning, or quality of information. For example, a water management plan with high learning potential might involve a sequence of planned flow releases, each with a detailed monitoring program, designed to discriminate among competing hypotheses and deliver information about the impacts of the flow release. Such a water management plan may have costs, both in terms of financial losses and ecological risks (or foregone opportunities).

4.11.2 Objectives and Performance Measures

The following learning objective and sub-objective were developed by the Consultative Committee for the Columbia River water use planning process.

Maximize learning about the impacts of operations on non-power objectives.

- *Improve the quality of baseline information and the quality of information from monitoring.*

Based on a review of objectives, performance measures and operating alternatives, it became clear that there were a number of candidates for active (experimental) adaptive management in the Columbia River Water Use Plan (e.g., white sturgeon flow trials in the mid Columbia River). Thus, evaluating the benefits of better information over time was recognized as an important task of the Columbia River Water Use Plan. Where appropriate, performance measures were designed to be sensitive to different degrees of information quality.

4.12 OTHER ISSUES

4.12.1 Revelstoke Reservoir

4.12.1.1 Issues

Revelstoke Reservoir is run-of-the-river and generally not subject to dramatic fluctuations in water levels. Variability in the water level of the reservoir is small throughout most of the year because discharges generally approximate inflows. Records maintained by BC Hydro indicate that the reservoir is usually maintained within 1.0 m of its maximum elevation (573 m; 1880 ft). Once or twice a year, however, the reservoir is drawn down by more than a metre, either to maintain acceptable discharge rates during periods of high inflow or to serve high electrical loads during periods of cold weather. During these times, drawdown of the reservoir is generally within the normal draft range (i.e. El. 573.02 to 571.50 m; 1879.99 to 1875.0 ft) as determined by the System Operating Order 4P-30.

- In May and June, Revelstoke Reservoir is typically drawn down by between 0.9 and 2.4 m to compensate for the high local inflows associated with the spring freshet.

- Depending on weather conditions and the demand placed on other BC Hydro facilities, the reservoir may be drawn down to meet abnormal load requirements. For example, during a 3-week cold spell in 1993, it was necessary to draft the reservoir by 1.5 m.

There are two combinations of circumstances (scenarios) where drawdowns in excess of these normal levels might be required. It is emphasized, however, that BC Hydro would always pursue the availability of alternate energy sources (including those from the United States) before considering emergency drawdown of the Revelstoke Reservoir because of the high economic value of the head behind Revelstoke Dam and high opportunity cost of such drawdowns.

While extreme drawdowns have yet to be required at the Revelstoke Reservoir, a powerhouse outage at Mica Dam or prolonged periods of basin drought may necessitate drawdown beyond the extent of riprap protection (El. 568.45 m; 1864.99 ft) to the extreme emergency draft limit (El. 557.20 m; 1828.08 ft). Extreme drawdowns would generally only occur under two circumstances:

Scenario #1 – Loss of Mica Generating System During Winter

This scenario could take place if there was a loss of power to BC Hydro's system from the Mica Generating System during the period from December to mid February. Potential causes of this loss of power include a prolonged loss of power generating capacity from the Mica powerhouse or serious damage to the transmission lines linking Mica to the main BC Hydro transmission grid. Unusual or unpredictable events such as catastrophic storms, sabotage, or war causing major power plant or transmission line failure could trigger such a scenario, although it is estimated that the probability of such a scenario actually occurring is once every 100 years. The worst case would be to have this scenario coincide with a prolonged period of cold weather when energy requirement from the BC Hydro grid would be highest.

Up to a 20 per cent loss in BC Hydro's total generating capacity could result from this scenario and, if this power could not be replaced from other sources in Canada or the United States, it would be necessary to operate the Revelstoke Generating Station at a time when local inflows are low, thereby drawing down the reservoir. This scenario could result in the following reservoir and downstream (Columbia River) impacts:

- Drawdown of Revelstoke Reservoir by as much as 15.2 m over a period of less than two weeks. Daily drawdown rates during this period would be expected to be about 1.2 m per day.
- Refilling of the reservoir to normal levels over about a one-month period after power generation at Mica was restored or alternate power sources secured by BC Hydro. It is estimated that refill rates during this period could range from 0.3 m per day to 0.6 m per day.
- An increase in the frequency of high river levels on the Columbia River between Revelstoke Dam and the Upper Arrow Lakes Reservoir, compared to the normal regime of high day and low night flows during this mid December to mid February period. These higher discharge rates would not exceed current peak discharges.

Scenario #2 – Prolonged Drought

Scenario #2 has an even lower probability of occurring (1 in 150 years) than Scenario #1. It would occur in the month of April if, after three or more successive dry years, both Kinbasket and Williston reservoirs were nearly empty. Under such a scenario, it may be necessary for BC Hydro to draw down Revelstoke Reservoir to meet its domestic and firm energy load requirements. The anticipated reservoir and downstream impacts of this scenario are as follows:

- Drawdown of Revelstoke Reservoir by as much as 15.9 m over about a two-week period if full drawdown is required.

- Refilling of the reservoir quickly during the May spring freshet.

- A greater frequency of high water levels in the Columbia River during the period of drawdown (normally river levels are low in April, with frequent periods of zero flow). Levels would not exceed current peak discharges. Mean downstream flow velocities would also increase, but again would not exceed peak velocities normally recorded in this portion of the Columbia River system.

The Fish Technical Subcommittee agreed that while there are potentially negative impacts on fish, wildlife, recreation and property associated with normal current operation of Revelstoke Reservoir (1.0 to 1.5 m drawdown), these were not considered significant to warrant exploring operating alternatives for the reservoir. However, the subcommittee was concerned that operational changes being considered for other objectives (e.g., ramping rates, minimum flows at Revelstoke Dam) could affect the timing, extent and duration of normal drawdown, and the frequency of emergency drawdown events.

4.12.1.2 Objectives and Performance Measures

The Consultative Committee agreed that specific objectives related to Revelstoke Reservoir did not need to be developed, as there were no operating alternatives being considered for the reservoir. However, to confirm that operational changes proposed for Kinbasket and Arrow Lakes reservoirs and the mid Columbia River would not affect the reservoir, three indicators of operational characteristics were tracked. These included:

- Probability of emergency drawdown – This measure reported on the frequency (percentage of years) that an emergency drawdown is to be expected. This was based on the judgment of BC Hydro operational engineers.

- Normal drawdown – This measure reported on the lowest elevation reached by Revelstoke Reservoir in a year.

- Frequency of surcharge – This measure reported on the frequency with which reservoir elevations exceed full pool.

Based on results of the Round 1 trade-off analysis, it became apparent that none of the operating constraints being considered for other parts of the system would affect the timing, depth or duration of normal drawdown or the frequency of emergency drawdown on Revelstoke Reservoir. However, the Consultative Committee expressed concern that changes in operation of Revelstoke Dam might have a negative impact on the productivity of the reservoir.

A preliminary analysis was undertaken to assess possible changes in the physical structure and dynamics of Revelstoke Reservoir resulting from implementation of a minimum flow (2500 or 5000 cfs), and to assess possible productivity impacts of these changes (Leake, 2002; refer to Section 5.8). The study concluded that neither retention time nor thermal characteristics would likely be affected by a year-round minimum discharge of up to 5000 cfs.

The Consultative Committee agreed not to consider ramping rate alternatives or minimum flow regimes that would affect water levels in Revelstoke Reservoir. Consequently, the performance measures were dropped and no further modelling was conducted.

4.12.2 Greenhouse Gas Emissions

4.12.2.1 Issues

Other environmental issues of concern identified by the Consultative Committee included the emission of greenhouse gases, which may cause climate change impacts. It is generally understood that as power generation is curtailed in hydroelectric facilities, it will be replaced at least partially by production at other facilities, which will likely result in greenhouse gas emissions.

4.12.2.2 Objectives and Performance Measures

The Consultative Committee agreed that a specific objective and performance measure to address the issues of greenhouse gas emissions was not required. However, it was acknowledged that those interested in greenhouse gas impacts could use the power performance measure as a proxy for greenhouse gas emissions (i.e., as power revenues decline, greenhouse gas emissions are likely to increase).

4.13 FINAL PERFORMANCE MEASURES

Figure 4-6 illustrates the relationships among final objectives and performance measures for issues addressed by the Consultative Committee during the Columbia River water use planning process.

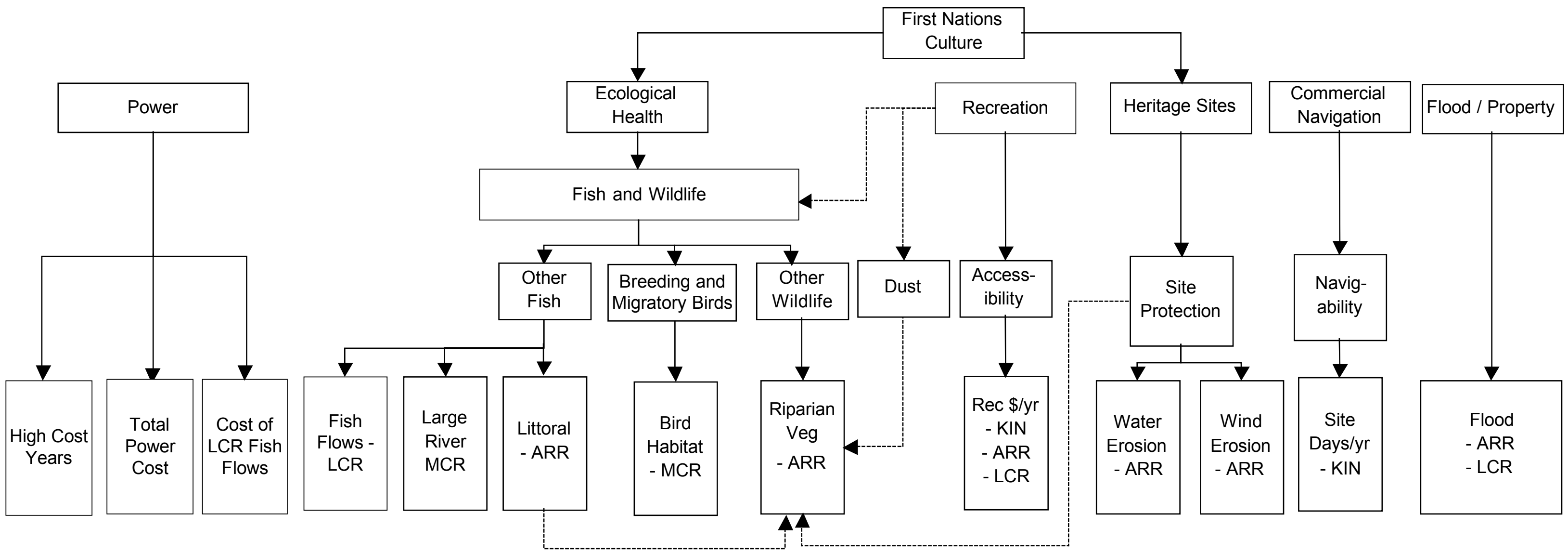

Figure 4-6: Relationships among Objectives and Performance Measures

Table 4-16 summarizes the final performance measures used by the Consultative Committee to evaluate operating alternatives for the Columbia River facilities.

Table 4-16: Final Performance Measures used at the June 2004 Consultative Committee Meeting

Objective/Location	Performance Measure	Units	Description
FLOOD/EROSION CONTROL			
Arrow Lakes Reservoir	Frequency of High Water Events	# days per year	# days per year Arrow Lakes Reservoir approaches full pool (439 m (1440 ft) or above).
Lower Columbia River	Frequency of Flood Flows	# of potential flood days per year at Genelle (>165 kcfs)	Frequency with which flows exceed 165 000 cfs (flood threshold at Genelle).
NAVIGATION			
Kinbasket Reservoir	Navigability	# site-days per year	The frequency (in # site-days per year) that a site is navigable to commercial operators, summed over sites.
RECREATION			
Arrow Lakes Reservoir	Total Economic Activity (10th percentile)	$M per year	Net local economic activity resulting from formal recreational and tourism use. Provides an indicator of the relative desirability of each operating alternative.
POWER GENERATION			
Revenue	Cost of Mountain Whitefish Flows	$M per year	Annual average cost of providing mountain whitefish flows involving capping of January flows and providing fall flow augmentation.
	Cost of Rainbow Trout Flows	$M per year	Annual cost (benefit) of providing rainbow trout flow package of 1 MAF of storage and summer flow augmentation.
	Total Power Cost (ALH subtracted)	$M per year	Average annual cost relative to Base Case for meeting load requirements less power costs at ALH.
	Total Power Cost (gains)	$M per year	Average annual cost relative to Base Case for meeting load requirements.
	High Cost Years	$M per year	Estimate of high cost (90th percentile) year for annual costs over the 60 years of modelled data.
	Potential Impacts to BC Hydro's NTSA negotiations*	Index	Impacts to BC Hydro's negotiating strength with the United States, from –1 (undercuts Hydro's negotiating position on the Non-Treaty Storage Agreement (NTSA)) to –2 (severely undercuts Hydro's negotiating position on NTSA).

Table 4-16: Final Performance Measures used at the June 2004 Consultative Committee Meeting (cont'd)

Objective/Location	Performance Measure	Units	Description
CULTURE AND HERITAGE			
Arrow Lakes Reservoir	Heritage Archaeological Impacts from Water	# days per year	Average # days per year Arrow Lakes Reservoir is above 436 m (1430 ft).
	Heritage Archaeological Impacts from Wind	Index (see vegetation presence)	Assumes that more vegetation cover will reduce wind and water erosion.
WILDLIFE AND VEGETATION			
Arrow Lakes Reservoir/Mid Columbia River	Vegetation Biomass	Index	A three point scale (better (+1), same (0), or worse (-1) than current) summing up impact on the amount of growing vegetation per unit area. Affects littoral productivity and shorebird habitat.
	Vegetation Diversity	Index	A three point scale (better (+1), same (0), or worse (-1) than current) summing the impact on the number of different plant species per unit area. Gains for shrubs accompanied by losses for grass biomass over same areas. Gains on this and habitat complexity, with benefits to breeding birds and other wildlife.
	Vegetation Presence	Index	A three point scale (better (+1), same (0), or worse (-1) than current) summing up the impact of reservoir elevation on vegetation area cover, by elevation band.
Arrow Lakes Reservoir/Mid Columbia River	Early Summer Nesting Birds	Ranking	Ranking of the impacts on available nesting habitat, which is a function of vegetation impacts and inundation of nesting habitat. Short-eared owl used as a proxy for multiple species.
	Fall Migrating Birds	Ranking	A ranking of the impacts on available habitat for fall migratory birds, which is a function of water levels and impacts to vegetation.
FISH AND AQUATIC RESOURCES			
Mid Columbia River	Average Annual Minimum River Length	# km	Measures the smallest amount of large river habitat made available in the mid Columbia River.
	Littoral Habitat		Based on vegetation performance measure, assuming that greater vegetation presence will increase littoral productivity.
Lower Columbia River	Whitefish and Rainbow Trout	Index	Measures whether flow adjustments have been made to the Arrow Lakes Reservoir and lower Columbia River to resemble rainbow trout flow and mountain whitefish flow agreements.

* This performance measure was presented in the briefing material for the June 2004 meeting, but was not discussed or used by the Consultative Committee in evaluating the proposed operating alternatives.

5 INFORMATION COLLECTION

During the process of identifying issues, structuring objectives and developing performance measures, the Consultative Committee identified a number of information gaps related to many of the resource values affected by BC Hydro's Columbia River system operations. The Committee prioritized those information gaps that significantly hindered their ability to make informed decisions about preferred operating alternatives, and that could be addressed through short-term studies. These formed the basis for scoping studies undertaken in Step 5 of the provincial government's *Water Use Plan Guidelines*. These studies were evaluated by the Committee using the eligibility criteria developed by the Water Use Plan Program (refer to Appendix T: Eligibility Criteria for Studies Conducted during the Columbia River Water Use Planning Process).

Several studies were undertaken by BC Hydro as part of the Columbia River water use planning process to support work of the Technical Subcommittees and help inform decision-making by the Consultative Committee (refer to Table 5-1). The objectives of these studies, key uncertainties they were designed to address, and key findings with respect to performance measures and alternatives are discussed below.

Table 5-1: Summary of Studies Undertaken during the Columbia River Water Use Planning Process

Interest	Information Collected	Documentation	Description/Rationale
Fish, Wildlife & Recreation – Upper and Lower Columbia River	Literature review and data analysis	Environmental Information Review and Data Gap Analysis. Volume 1: Upper Columbia. Volume 2: Lower Columbia. RL&L Environmental Services, 2001	A review of existing information on fish, wildlife and recreational use of the Columbia River system, and hydro-related impacts on these key interests to facilitate initial scoping of water use issues.
Heritage and Culture – Upper and Lower Columbia River	Archaeological Site Investigation	Archaeological Component of Arrow, Mica And Revelstoke Reservoirs. Water Use Planning Process. Choquette (2002)	High level field study to identify sites with high potential for containing archaeological material.
	Traditional Use Study	Spallumcheen (Splatsin) Traditional Use Study – Columbia River. Clough and Gillespie (2003); Columbia WUP Culture & Heritage Report (Upper Columbia Region), Ernst (2002); Ktunaxa-Kinbasket Treaty Council Columbia River Water Use Planning Traditional Use Study. Keefer (2002)	Collection and synthesis of traditional ecological knowledge.

Table 5-1: Summary of Studies Undertaken during the Columbia River Water Use Planning Process (cont'd)

Interest	Information Collected	Documentation	Description/Rationale
Recreation – Upper and Lower Columbia River	Recreation Demand Study	Mica-Revelstoke-Keenleyside (MCA) Water Use Plan – Recreation Study. Axys Environmental Consulting and Gustavson Ecological Resource Consulting (2002)	An evaluation of the proposed operating alternatives with respect to recreational use (total user days), future recreation demand (total user days projected to the year 2012), and local and regional economies.
Vegetation - Kinbasket and Arrow Lakes Reservoirs	Kinbasket Reservoir Revegetation Program	Mica-Revelstoke-Keenleyside Water Use Plan – Potential Areas for Vegetation Establishment in Kinbasket Reservoir. AIM Ecological Consultants and CARR Environmental Consultants (2003)	Identification of areas within the drawdown zone that have the highest potential for vegetation establishment, and development of a planting strategy to facilitate development of this potential.
	Arrow Lakes Reservoir Revegetation Program	Mica-Revelstoke-Keenleyside Water Use Plan – Potential Areas for Vegetation Establishment in Arrow Lakes Reservoir. AIM Ecological Consultants and CARR Environmental Consultants (2003); AIM Ecological Consultants (2005)	Determination of existing vegetation and potential planting areas within the drawdown zone, and identification of enhancement opportunities.
Fish – Kinbasket, Revelstoke and Arrow Lakes Reservoirs	Littoral/Pelagic Productivity Assessment	Implications of Reservoir Operational Changes to Littoral Productivity in Arrow Lakes Reservoir. Perrin (2001)	Expert opinion on possible operating alternatives that merit further exploration based on hypotheses about potential benefits to littoral productivity.
		Some Implications of Reservoir Operation on Littoral and Pelagic Production in Upper Columbia Reservoirs. Stockner (2001)	Expert review of key variables driving pelagic/littoral production, estimates of pelagic/littoral C production and estimates of rearing capacity for juvenile kokanee.
		Pelagic Carbon Production in Kinbasket, Revelstoke and Arrow Lakes Reservoirs. Stockner and Korman (2002)	Revision of the pelagic model and recalculation of the performance measure to account for loss of carbon through Hugh Keenleyside Dam.
		Preliminary Analysis of Minimum Flow Impacts on Revelstoke Reservoir. Leake (2002)	Preliminary modelling to assess impacts to pelagic productivity in Revelstoke Reservoir as a result of changes in residence time and thermal stratification caused by minimum dam releases.

Table 5-1: Summary of Studies Undertaken during the Columbia River Water Use Planning Process (cont'd)

Interest	Information Collected	Documentation	Description/Rationale
Fish – Kinbasket, Revelstoke and Arrow Lakes Reservoirs (cont'd)	Fish Stranding Assessment	Review by Fish Technical Subcommittee reported in Failing (2002)	A high-level review by the Fish Technical Subcommittee to identify elevation thresholds and potential high-risk areas within the drawdown zone of Kinbasket Reservoir.
	Assessment of Tributary Access	2001 Fish Access Assessment of Selected Tributaries to Kinbasket Reservoir (G.G. Oliver, 2001)	Field assessment of Kinbasket Reservoir tributaries to assess potential access restrictions within the drawdown zone on fall spawning fish species.
Wildlife – Revelstoke Wetlands	Nesting and Migratory Bird Habitat Assessment	Mica-Revelstoke-Keenleyside (MCA) Water Use Plan – Breeding Bird and Migratory Shorebird Use of the Revelstoke Wetlands. Axys Environmental Consulting and Manning Cooper & Associates (2002)	Assessment of potential impacts of reservoir water elevations under proposed operating alternatives on breeding bird and migratory shorebird habitat in Revelstoke Reach.
		Draft Conceptual Proposal for MCA WUP FWTC - Creation of Elevated Habitat Enhancement Islands in Revelstoke Reach. Carr (2003)	Conceptual design and feasibility assessment of nesting islands in the Revelstoke Wetlands as possible mitigation for loss of nesting habitat caused by high reservoir levels.
Fish – Mid and Lower Columbia River	Minimum Flow Assessment	Fish Habitat Performance Measures to Evaluate Minimum Discharge Requirements for Revelstoke Canyon Dam. Korman et al. (2002)	Development of performance measures to predict changes in velocity, wetted area and productive area in the mid Columbia River across a range of minimum flow alternatives, using the HEC-RAS model.
		Literature Review of Load-Following Impacts on Stream Biota. Cooper and Korman (2003)	Summary of literature documenting response of fish and benthic invertebrates to flow stabilization and minimum flow restrictions observed in other river systems to assist in building a 'prior probability distribution' of potential benefits of flow restrictions in the mid Columbia River.
		Description of Results for Middle Columbia River Minimum Flow Analysis. Korman and Lin (2003)	Summary of fish habitat performance measure results under four minimum flow scenarios and two Arrow Lakes Reservoir operating strategies.

Table 5-1: Summary of Studies Undertaken during the Columbia River Water Use Planning Process (cont'd)

Interest	Information Collected	Documentation	Description/Rationale
Fish – Mid and Lower Columbia River (cont'd)		Documentation of Preliminary White Sturgeon Spawning Habitat Suitability Model for the Middle Columbia River. Korman and Lin (2003)	Development of a model to assess potential benefits of minimum flow alternatives and changes in Arrow Lakes Reservoir elevations on white sturgeon spawning habitat suitability.
	White Sturgeon Spawning and Recruitment Assessment	Upper Columbia White Sturgeon Recovery Initiative Hypotheses to Water Flows, Reservoir Levels and Water Quality. Green (2002)	Summary of hypotheses developed by the UCWSRI related to possible factors limiting successful spawning and recruitment of sturgeon in the middle and lower Columbia River.
		A Feasibility Assessment of Proposed WUP Flow and Turbidity Experiments to Increase Natural Recruitment of White Sturgeon. Hildebrand et al. (2003)	An assessment of proposed flow and turbidity experiments with respect to logistics, delivery capability, regulatory and legal issues, risks, likelihood of success, and estimated costs.
	Lower Columbia River Total Gas Pressure Assessment	TGP Performance Measures for the Columbia River Water Use Planning Process – A Review and Evaluation of Relevant Information and Data. Aspen Applied Sciences (2002)	Recommendations for interim TGP thresholds to be used in developing performance measures, based on a review of current B.C. guidelines, and field and lab studies of TGP and gas bubble trauma (GBT) in fish.
		TGP Performance Measures for the Mica Water Use Plan – A Derivation Summary. Aspen Applied Sciences (2003)	Development of a model and modification of the TGP performance measure to reflect the relative biological risk of GBT.
	Lower Columbia River Fish Stranding	Strategy for Managing Fish Impacts Associated with Flow Reductions at Keenleyside Dam – Working Draft. Vonk (2003)	Development of a protocol to provide a communication strategy, interim flow reduction strategies and environmental response actions relating to planned flow changes at Hugh Keenleyside Dam.
	Assessment of flow regimes on productivity of the lower Columbia River	Study 24 Briefing Note. LCR Fish PMs. Failing (2003)	Development of preliminary fish performance measures and flow options for the lower Columbia River.
Wildlife – Lower Columbia River	Assessment of Riparian Habitat Performance Measure	Habitat associated with the Genelle Gravel Bars, Columbia River. Robertson Environmental (2001)	Field observations and assessment of gravel bars at Genelle as a suitable performance measure.

5.1 ENVIRONMENTAL INFORMATION REVIEW AND DATA GAP ANALYSIS

In preparation for the initial issue scoping phase of the Columbia River water use planning process, a review was undertaken to summarize available technical information related to water flows and their potential impacts on fish and aquatic ecosystems, and other water uses in the Columbia River system (RL&L, 2001). This involved a comprehensive review of all documented literature on fish, wildlife and recreation that may be affected by operations of the Mica, Revelstoke and Hugh Keenleyside facilities, and a summary of current understanding around potential operation-related impacts on these key interests. Information gaps that hindered evaluating the nature/significance of these impacts were identified, and recommendations for future studies to address these deficiencies were included for consideration by the Consultative Committee.

Information gained through this work was compiled with other data collected through various consultative efforts and documented in Preliminary Issues reports prepared for the Mica and Revelstoke projects (BC Hydro, 2001a) and the Keenleyside project (BC Hydro, 2001b).

5.2 CULTURE AND HERITAGE STUDIES

Two separate culture and heritage studies were undertaken as part of Step 5 of the Columbia River water use planning process.

- Archaeological investigations of Kinbasket, Revelstoke and Arrow Lakes reservoirs and the lower Columbia River.
- Traditional Use and Traditional Ecological Knowledge Studies.

Archaeological investigations were conducted to identify areas where cultural/heritage sites are most likely to exist, determine how these sites are potentially affected by operations, and provide the basis for development of performance measures to track the effects of operating alternatives on these sites (Choquette, 2002). Based on landforms and selective sampling, high potential sites for containing archaeological materials were identified in Kinbasket, Revelstoke and Arrow Lakes reservoirs and the lower Columbia River. These investigations identified Arrow Lakes Reservoir as the area with the greatest potential for the existence of cultural sites. There are potentially thousands of hectares of partially intact terraces in the drawdown zone that have potential for previous human habitation, and are susceptible to erosion by wind and wave action. In particular, there is a major escarpment at elevation 436 m (1430 ft) that likely contains numerous sites and artifacts.

As a result of the archaeological investigation, the Culture and Heritage Subcommittee established the heritage objectives and performance measures as outlined in Section 4.8 (protection from erosion from water, wind and human activity; access to archaeological sites; and access to traditional plants).

Traditional Use (TUS) and Traditional Ecological Knowledge (TEK) studies were undertaken to support water use planning decision-making around ecological objectives. These included:

- Spallumcheen (Splatsin) Traditional Use Study – Columbia River, Secwepemc Fisheries Commission (Clough and Gillespie, 2003).
- Columbia WUP Culture & Heritage Report (Upper Columbia Region), (Ernst, 2002).
- Ktunaxa–Kinbasket Treaty Council Columbia River Water Use Planning Traditional Use Study, Ktunaxa–Kinbasket Treaty Council (Keefer, 2002).

These involved reviewing existing publications and Tribal Council and Band databases and conducting interviews with elders to gain information on cultural use and ceremonial sites, as well as information related to fish, wildlife, vegetation and habitat conditions. Information collection proved difficult due to the loss or ill health of elders, and general loss of knowledge given that habitation patterns have changed drastically in the last 100 years and that many areas traditionally used have been inundated for the past 40 years.

The findings of these studies suggested that traditional use and traditional ecological knowledge as well as site visits to existing wetlands at Invermere and Golden could be used to assist in identifying plant species for revegetation efforts to mitigate erosion impacts on cultural/heritage sites. However, it became apparent that knowledge about vulnerable areas was not developed sufficiently to help guide where planting efforts should be made. It was decided that criteria for site selection should include zones with high potential for archaeological sites and a high potential for erosion. It was recognized that more information on the most effective planting/remediation strategies for erosion control would be required.

5.3 RECREATION DEMAND STUDY

Current recreational activities along the Columbia River system are in part a function of existing operations. Weighting the relative importance of the Recreation Performance Measure in each region by using existing user-day data proved problematic because existing use patterns would be “hard wired” into the calculations, potentially discriminating against areas with high growth potential under more favourable recreational conditions. A recreation demand study was undertaken to establish reasonable bounds of possibility around this uncertainty by estimating the “upside” and “downside” potential for recreation use and related economic development (Axys and Gustavson, 2002).

The recreation study assessed present demand for recreation in the Columbia River system, and determined projected changes in demand for future recreation use under a range of operating alternatives being considered by the Consultative Committee. Using the Recreation Performance Measure developed by the

Recreation Technical Subcommittee (number of user-days), a recreation demand model was used to estimate:

- Total user days resulting from the different alternatives based on preferred conditions identified by the Recreation Technical Subcommittee for shore- and water-based recreation.
- Future demand for recreation and tourism projected to 2012.
- Local economic benefits ($ per year) resulting from increased access to shore- and water-based recreation.

Results of the modelling suggested that, of the earlier generation alternatives modelled, Alternative 2 would provide the most benefits to communities around Kinbasket Reservoir. However, recreational improvements would offer the fewest local economic benefits to the region, given current and projected usage rates. Alternative 11 would offer the most recreation/tourism benefits overall, and these would be shared by communities between and including Revelstoke and Trail. Alternatives 7 and 10 would also offer net benefits to Arrow Lakes Reservoir.

The report identified a number of non-operational alternatives for improving recreational access in the area (e.g., revegetation, debris clearing, boat launches, trails/signage, recreation sites), and opportunities for improving communications protocols, which most survey participants indicated could significantly improve opportunities for recreational use regardless of the operating alternative implemented. The report does not identify any specific non-operational improvement projects, or provide estimates of the costs or relative benefits of such projects. Survey respondents also indicated that fishery enhancements would be an important means of enhancing recreational quality/use.

Based on recommendations of the Recreation Technical Subcommittee, the Recreation Performance Measure was revised to report on the net economic impacts (in $ per year), as it was viewed as a good integrator of the various recreational user days that were originally reported as the Recreation Performance Measure (refer to Section 4.6.2).

5.4 KINBASKET RESERVOIR VEGETATION STUDY

Preliminary analysis revealed that the limiting factor to vegetation establishment in Kinbasket Reservoir was not the operating regime, but the need for initial vegetation establishment, which could only be achieved through planting. One of the scoping decisions of the Consultative Committee was to reject further analysis of Kinbasket Reservoir operating alternatives for the purpose of enhancing vegetation potential, and focus instead on planting potential.

Existing maps, air photos and inundation regimes of Kinbasket Reservoir were analyzed to identify areas within the drawdown zone with the highest potential for successful vegetation establishment through planting, and to propose a revegetation strategy that would facilitate development of this potential (AIM Ecological Consultants and CARR Environmental Consultants, 2003). Limited field study of reservoir margin wetlands, riparian vegetation, drawdown soil material and operational access was undertaken to verify the suitability of identified areas.

A total of 120 sites were identified within the drawdown zone of Kinbasket Reservoir as having potential for planting, with 68 of these areas already vegetated and 52 having the potential for vegetation development. The vegetated sites, ranging in size from 1 to 559 ha, represented a total area of 2395 ha around the periphery of the reservoir. The sites identified as having a potential for vegetation development covered a total area of 2259 ha, and ranged in size from 1 to 496 ha. The area supporting the greatest amount of vegetation at present is Bush Arm (1169 ha), followed by Canoe Reach (698 ha). The Sullivan Arm area supports the least existing or potential for vegetation because of its steep shorelines.

Three opportunities for enhancement of riparian and wetland habitats were identified through the study. These included: (1) water level modifications, (2) vegetation establishment by seeding and planting, and (3) enhancement of existing vegetation growth by fertilization. The fertilization strategy was concluded to have the highest potential at the lowest cost per hectare. Treatment strategies (including plant species) were provided for all sites having a moderate or high potential for vegetation development. The report provides site-by-site planting prescriptions, probability of success, factors to consider and estimated area costs.

5.5 ARROW LAKES RESERVOIR VEGETATION STUDY

A study was undertaken to assess the potential for wildlife habitat enhancement in Arrow Lakes Reservoir through promoting reservoir vegetation via changes in operating regimes and direct intervention (i.e., planting) (AIM Ecological and CARR Environmental, 2003; AIM Ecological, 2005). This study identified areas within the drawdown zone of the reservoir that have the potential for vegetation establishment, based on site characteristics interpreted from satellite imagery, vegetation maps for dust control areas of Revelstoke Reach (Moody, 2002) and elevation information from historic maps and the Digital Elevation Model (DEM) for Revelstoke Reach. A multi-year revegetation program was recommended for sites of high and high-moderate enhancement potential, including treatment options, probability of success, factors to consider and estimated area costs.

A total of 59 sites with potential for vegetation development were identified from the satellite imagery. These sites cover a total area of 1637 ha, with the majority occurring in Revelstoke Reach (885 ha) and the remainder between upper (400 ha) and lower (360 ha) Arrow Lakes Reservoir. In upper Arrow Lakes Reservoir, the main areas with wetland development potential are located in the north-east arm near Beaton and the narrow between upper and lower Arrow Lakes Reservoir. Other sites are relatively small in comparison. In lower Arrow Lakes Reservoir, potential enhancement areas are limited due to the steep shorelines and coarse substrates. The main areas with development potential include large fans such as those at Burton and Renata. Smaller pockets occur in the general vicinity of Fauquier.

Areas of existing vegetation and potential planting areas will require field verification to further assess the site suitability (i.e., slope, substrate, elevation) and their enhancement potential.

5.6 IMPLICATIONS OF OPERATING CHANGES TO RESERVOIR LITTORAL/PELAGIC PRODUCTIVITY

As part of preliminary scoping, expert opinion was solicited to provide some insight into the potential benefits to littoral productivity from operational changes that might be explored for Arrow Lakes Reservoir (Perrin, 2001). The emphasis of this exercise was on establishing whether there is a reasonable expectation, based on current knowledge, that littoral productivity would be significantly different under different operating strategies, and if so, by how much. This review defined the spatial bounds of the littoral zone, provided approximated benthic invertebrate density and biomass data for each littoral area of the reservoir, and predicted potential effects on area of littoral habitat and benthos biomass over a range of hypothetical operating regimes.

Further expert opinion was solicited by the Fish Technical Subcommittee to address key questions related pelagic and littoral production in Kinbasket, Revelstoke and Arrow Lakes reservoirs (Stockner, 2001). The report provides comment on the structure, function and age of the upper Columbia reservoirs, the key drivers of pelagic/littoral production, and estimates of C production. Using the Photosynthetic Rate (PR) model, predictions of kokanee juvenile production and pelagic ecosystem rearing capacity are also provided.

5.7 MODELLING OF ARROW LAKES/KINBASKET RESERVOIRS PELAGIC PRODUCTIVITY

Preliminary model analysis indicated that, across the range of operating alternatives being considered for Kinbasket and Arrow Lakes reservoirs, the impact to pelagic productivity would be small (i.e., less than 5 per cent). The initial model runs were based on annual mean C production data over two years of analyses (1999, 2000) for Arrow Lakes Reservoir, and values of pelagic productivity for the Kinbasket Reservoir simulation were surrogate production values. To address uncertainties around these findings, a study was undertaken to re-examine the model predictions and associated assumptions to confirm these preliminary projections, and provide some direction to the Consultative Committee regarding decisions to retain the pelagic productivity performance measure (Stockner and Korman, 2002).

A ^{14}C primary production run was completed in Kinbasket Reservoir to provide better estimates around ambient conditions in the pelagic euphotic zone during the peak plankton growth period. More recent C production data (2001) for Arrow Lakes Reservoir was also available to improve the reliability of monthly mean production estimates for the upper and lower lakes.

The pelagic model was revised for Arrow Lakes Reservoir to address concerns of the Fish Technical Subcommittee around whether the model was correctly capturing the effect of Keenleyside releases on carbon losses from the epilimnion across the range of operating alternatives. It was found that the carbon budget in the reservoir was dominated by the amount of carbon fixed. The large surface area and high daily photosynthetic rate resulted in the production of large amounts of carbon (ca. 3000 tonnes per month) during the summer months. The loss of carbon through Hugh Keenleyside Dam was relatively low (usually <100 tonnes per month) because the predicted carbon concentration at the dam was low. Loss rates through the dam increased with discharge, but were relatively small (~2 per cent) compared to the amount of carbon produced. As a result, the amount of carbon retained in Arrow Lakes Reservoir was very consistent across scenarios. Carbon retention rates were typically greater than 98 per cent. Thus, incorporation of the effects of carbon losses through Hugh Keenleyside Dam did not alter the ranking of alternatives.

5.8 REVELSTOKE RESERVOIR PHYSICAL MODELLING

Concern was expressed by the Fish Technical Subcommittee that the proposed minimum flow alternatives being considered for Revelstoke Dam could have negative implications to the productivity of Revelstoke Reservoir. Specifically, there was uncertainty around whether any of the flow alternatives could significantly affect the water retention time or thermocline depth sufficiently to cause impacts on the biological productivity of the reservoir.

A preliminary analysis was undertaken to assess possible changes in the physical structure and dynamics of Revelstoke Reservoir resulting from implementation of a minimum flow (2500 or 5000 cfs), and to assess possible productivity impacts of these changes and recommend an appropriate performance measure (Leake, 2002).

The study concluded that neither retention time nor thermal characteristics would likely be affected by a year-round minimum discharge of up to 5000 cfs. Any reservoir changes would be insignificant for the following reasons.

- Changes in the daily distribution of mid Columbia River flows (i.e., by provision of a minimum flow) do not change the total weekly outflow. The 7-day operations will balance outflow volumes between historic and minimum flow alternatives.

- The frequency and extent of drawdown or surcharge would not increase between regimes and will more than likely decrease.
- The volume of the hypolimnion, from which water is withdrawn, is large (approximately 2/3 of the reservoir volume) and therefore, will not be affected by shifting water withdrawals from high load hours to low load hours.

It was concluded that no further investigations of thermal processes would be required to address this concern.

5.9 KINBASKET RESERVOIR FISH STRANDING ASSESSMENT

While RL&L (2001) reported that fish stranding impacts in the drawdown zone of Kinbasket Reservoir are likely relatively minor, the Consultative Committee recognized that there was considerable uncertainty about this hypothesis that needed to be addressed before they would be comfortable with removing this issue from further consideration. This led to completion of a high-level review by the Fish Technical Subcommittee to identify elevation thresholds and potential high-risk areas within the drawdown zone of Kinbasket Reservoir (Failing, 2002).

Based on a review of pre-impoundment topographic maps, it was noted that the majority of the top elevations of Kinbasket Reservoir are steep sided, which would limit the amount of fish stranding. However, there are areas in the main arms of the reservoir (Bush, Canoe and Columbia) that may have some potential for stranding due to their lower gradient slopes. Some high-level estimates were made of reservoir surface area changes at various water elevations. It was estimated that drafting the reservoir from 754.4 to 740 m (2475.1 to 2428 ft) would cause the loss of about 10 per cent of the reservoir surface area, while a drop in elevation from 740 to 725 m (2428 to 2379 ft) could cause the loss of about 20 per cent surface area.

The Fish Technical Subcommittee acknowledged that further work would be required to assess the potential impacts of reservoir drawdown on fish stranding and proposed a monitoring study be undertaken to inform future water use planning decisions.

5.10 KINBASKET RESERVOIR TRIBUTARY ACCESS STUDY

Up to 30 tributaries to Kinbasket Reservoir were surveyed to assess potential fall spawner access issues within the drawdown zone, as a consequence of minimum storage levels resulting from below average run-off. Physical aspects of stream channels within the drawdown zone were characterized in terms of their capability to support spring and fall spawning fish species. As well, physical barriers restricting further upstream passage were also documented. The survey focused on tributaries with important fisheries values but included a wide cross section of streams representative of different size and gradient class. Site-specific evaluations relative to these issues were provided for individual tributaries and opportunities for water level management or access restoration were discussed. Recommendations were also provided for those tributaries where further investigation and investment are warranted.

Drawdown areas for the majority of immediate tributaries to Kinbasket Reservoir provide variable quality spawning habitat for spring and fall spawning species. Most streams are accessible and offer higher quality fish habitat in upstream reaches. In a few cases, upstream reaches are inaccessible due to barriers that prevent fish passage at reservoir elevations less than full pool. Opportunities for water level management to minimize fish access issues will not likely be achievable during low run-off years, but pro-active measures to restore physical access are available to off-set temporary fish passage impacts.

The report was provided to the Columbia Basin Fish and Wildlife Compensation Program for review and potential remediation of physical barriers within the drawdown zone as a footprint impact.

5.11 MID COLUMBIA BIRD STUDY

To provide increased benefits to vegetation and bird habitat, the Consultative Committee considered operating alternatives that would lower the elevation of Upper Arrow Lakes Reservoir during the spring/early summer period. A study was conducted in the Revelstoke Reach area to assess the potential effects of reservoir drawdown on habitat for breeding and fall migratory birds, and help determine optimal water levels for maintenance of vegetation communities and bird habitat (Axys and Manning Cooper, 2002).

Habitat availability and suitability indices for nesting and migratory birds were defined and a model was developed to estimate bird habitat over a range of water levels (434 to 440 m; 1424 to 1444 ft). Habitat performance measures were generated for each breeding bird species and for shorebirds as a group to determine operating alternatives for Arrow Lakes Reservoir that would have the least negative impact on bird use in the Revelstoke Wetlands. The performance measure reports bird habitat in hectare-days, which is the amount of habitat available on any given day (a function of water level, and weighted by habitat suitability) summed over the days of the nesting/migratory season.

The study concluded that low stable water levels (below 434 m; 1424 ft) from 1 May to 15 September would perform best in protecting breeding and migratory bird habitat. The model was applied to the Arrow Lakes Reservoir operating alternatives and predicted relative impacts on habitat availability, at an accuracy sufficient for ranking alternatives. Some members of the Fish and Wildlife Technical Subcommittee identified limitations or uncertainties in the study methodology (e.g., selection of indicator species, failure to account for microhabitat, and overweighting of mudflats as suitable habitat). While the mudflat weighting for migratory shorebirds was subsequently modified (Korman and Buszowski, 2003), some controversy about other limitations remained.

5.12 WILDLIFE PHYSICAL WORKS IN LIEU FOR REVELSTOKE REACH

The Fish and Wildlife Technical Subcommittee discussed the potential to create more higher elevation area in Revelstoke Reach to facilitate the expansion of willow and willow/cottonwood habitats to compensate for the loss of lower elevation nesting bird habitat due to reservoir flooding. Based on experience in other systems (e.g., Hayward Reservoir), a conceptual design was developed for a series of nesting islands within the reach, including target elevations, construction and vegetation planting requirements, size range of islands, approximate cost per hectare, probabilities of success, and potential risks (e.g., predation, recreation conflicts) (Carr, 2003).

While Carr (2003) predicted that the probability of creating successful nesting islands was high, considerable uncertainties remained around the risks of creating sink habitat for breeding birds, providing habitat for less desirable species (i.e., geese or other aggressive predatory species), and ongoing maintenance requirements. In addition, preliminary cost estimates for construction of the islands were very high, ranging between $426,000 and $633,000 per hectare (based on a surface elevation of 441 m; 1447 ft). Concerns around high costs and uncertain benefits to target species led the Fish and Wildlife Technical Subcommittee to explore less intrusive, smaller scale enhancement works to mitigate operation-related impacts on nesting birds.

5.13 MID COLUMBIA RIVER FLOWS

Recognizing that it would be impossible to reliably predict fish and ecosystem response to a minimum flow in the mid Columbia River, the Consultative Committee agreed, in principle, to an experimental adaptive management approach. A study was undertaken to examine various alternative flow regimes in the mid Columbia River, and provide probabilistic estimates of their fish benefits and costs to allow the Committee to make informed decisions about the merits of an experimental adaptive approach (Korman et al., 2002). A literature review was undertaken to summarize documented fish response to flow changes in other systems (Cooper and Korman, 2003) to assist in building a “prior probability distribution” of potential benefits of flow restrictions in the mid Columbia River.

A simple conceptual model was developed of how minimum flow restrictions would influence physical condition of the mid Columbia River, and how these factors could in turn affect the somatic growth and survival rates of fish populations. Three performance metrics were developed to account for the dynamics of these hypotheses: velocity (an indicator of fish energy requirements), wetted area (amount of habitat available for fish to use), and productive area (amount of habitat that is likely producing food). Computation of the habitat performance measures was based on results from an one-dimensional backwater hydraulic model (HEC-RAS), which was developed for the mid Columbia River using a series of 245 cross sections covering the area from Revelstoke Dam to the confluence with the Akokolex River. The HEC model was run under a large range of discharges and downstream boundary conditions (Arrow Lakes Reservoir elevations), generating a series of lookup tables for water elevation, wetted width and average cross-sectional velocity.

Predicted changes to the three performance metrics (Korman and Lin, 2003) enabled the Fish and Wildlife Technical Subcommittee to assess, using professional judgment, the probability and magnitude of a population response under each flow policy, and to assess the potential for learning about the relationships between flow changes and ecological benefits to aid in future decision making. Ranking of each alternative, along with cost estimates of implementing the flow restrictions, helped to identify flow regimes that may be worth testing as part of the adaptive management program

5.14 MID COLUMBIA WHITE STURGEON PERFORMANCE MEASURES

An algorithm was developed to provide an index of spawning habitat suitability for white sturgeon in the mid Columbia River below Revelstoke Dam (Korman and Lin, 2003). This performance measure was used to assess the potential benefits of minimum flow requirements and changes in Arrow Lakes Reservoir elevations to sturgeon spawning habitat.

A small subset (5) of the 245 cross sections used to develop the HEC-RAS model for the mid Columbia River was used to model the hydraulic geometry in the area used for spawning by white sturgeon. This smaller modelled area extends 300 m upstream and downstream of the confluence with the Jordan River. Predictions of depth and velocity for a given discharge were used to compute spawning habitat suitability based on published sturgeon spawning habitat suitability relationships. Weighted-usable-area (WUA) for a specific discharge was computed as the sum of the product of the cross-sectional area for each cell and its suitability value for velocity only, and velocity and depth. Time-integrated WUA values were computed to derive a single statistic for each model (velocity only, velocity and depth) that was used to evaluate alternative minimum flow regimes.

The velocity-only model predicted a very small amount of suitable habitat (9 m^2) at 5000 cfs, while the velocity-depth model predicted that a minimum flow of over 8500 cfs would be required to generate a similar WUA value. Both models suggested that relatively large flows (40 000 cfs) would be required to reach reasonably high (>500 m^2) WUA levels.

Based on the modelling results, subsequent discussions of the Fish Technical Subcommittee focused on designing an experimental approach to implementing a seasonal flow treatment (30 000 cfs) to improve spawning conditions and increase natural recruitment of white sturgeon in the mid Columbia River.

5.15 SUMMARY OF WHITE STURGEON HYPOTHESES

Hypotheses about possible factors limiting white sturgeon recovery in the middle and lower Columbia River were summarized from work of the Water and Habitat Management Subcommittee of the UCWSRI (Green, 2002). This summary helped to characterize the uncertainty about the extent to which actions undertaken through water use planning may affect white sturgeon recovery, and assisted the Fish and Wildlife Technical Subcommittee in developing proposals for operational and non-operational changes for consideration by the Consultative Committee.

5.16 FEASIBILITY STUDY OF PROPOSED FLOW AND TURBIDITY EXPERIMENTS FOR WHITE STURGEON

A study was undertaken to assess the feasibility of flow and turbidity augmentation experiments proposed by the Fish Technical Subcommittee to increase natural recruitment of white sturgeon in the mid and lower Columbia River (Hildebrand et al., 2003). Based on preliminary experimental design, this study examined the feasibility of these options in terms of:

- The ability of the generation system to provide the experimental flows within existing physical, operational, water availability, and flood control constraints.
- Logistical consideration of turbidity supply and delivery.
- Regulatory and legal considerations and potential risks.
- The likelihood that experimental flows and turbidity supplementation will result in an increase in sturgeon recruitment in either the middle or lower Columbia River.
- The probability that any recruitment response that results from the experiments will be detectable.
- The estimated costs to conduct and monitor the experimental programs over the 10 year temporal scope of the program.

The results of this assessment were reviewed by members of the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI), and provided the basis for further refinements to the experimental plans.

5.17 TOTAL GAS PRESSURE GENERATION FROM HUGH KEENLEYSIDE DAM

Preliminary scoping analysis revealed that, while there are opportunities to improve the lower Columbia hydrograph for fish through changes in Arrow Lakes Reservoir operations (Alternative 7), this would likely result in an increased risk of elevated dissolved gas levels below Hugh Keenleyside Dam. Given concerns about the effects of Total Gas Pressure (TGP) on fish in general, and on white sturgeon larvae in particular, a study was undertaken to review available data related to current British Columbia guidelines for dissolved gas supersaturation, and effects of TGP and gas bubble trauma (GBT) on fish, and provide recommendations on development of a performance measure and data collection requirements (Aspen Applied Sciences, 2002, 2003). A workshop was held in June 2002 with members of the Fish Technical Subcommittee and various external experts to provide expert review of the available information.

This study resulted in delivery of a model that predicts TGP levels for each operating alternative, and a performance measure that reflects the relative biological risk of GBT associated with each alternative. This metric reflects the non-linear relationship between TGP and “time to 20 per cent mortality” from GBT, and temperature effects (risk rises with temperature). It reports relative risk among the operating alternatives as opposed to absolute risk (whether or not a given risk level will actually result in mortality), as data do not exist for the lower Columbia River.

The key conclusions of this study were that:

- Operation of Arrow Lakes Generating Station will result in reductions in TGP levels, such that TGP risks from all operating alternatives will be lower than they have been historically.

- Very low levels of disease from TGP exposure have been observed in the lower Columbia River despite extended exposures to elevated TGP. It is believed that utilization of river habitat by fish below compensation depth downstream of Hugh Keenleyside Dam coincidentally minimizes exposure to elevation TGP levels.

- TGP levels of 115–120 per cent for durations of 20 to 30 days or less may not be harmful to fish in the lower Columbia River in terms of acute or chronic TGP.

- Field studies to assess GBT effects at 120 per cent could be conducted to confirm the use of 120 per cent as an effects threshold.

In addition it was concluded that, although TGP cannot be reliably predicted at the Waneta Eddy area where white sturgeon are known to spawn, TGP is unlikely to be a significant factor in the survival of sturgeon larvae. The magnitude and extent of any impact would be minimized by the vertical cycle of larvae within the water column and the fact that a significant portion of the population would not be exposed to elevated TGP for extended periods.

5.18 LOWER COLUMBIA RIVER STRANDING PROTOCOL

The Columbia Operations Fisheries Advisory Committee (COFAC) and the Columbia River water use planning process identified the need for a protocol to address the risk of fish stranding associated with flow reductions below Hugh Keenleyside Dam. A working draft of the strategy (Vonk, 2003) was submitted and accepted by COFAC, and provided to the Fish Technical Subcommittee for consideration in exploring operating alternatives and design of monitoring programs. The working draft is currently being used for flow reduction management at the dam, with the expectation that it will be revised over time as new information becomes available.

The protocol sets out:

- Procedures for internal BC Hydro communication in response to planned and unplanned flow changes at Hugh Keenleyside Dam.
- A communication strategy for external agency notification and consultation in response to planned and unexpected flow changes.
- A flow reduction decision-making framework.
- Strategies for flow reduction monitoring and mitigation activities in relation to fish stranding risk (based on queries of BC Hydro's Fish Stranding Database).
- Requirements for information collection, post flow reduction reporting, and annual audits.

5.19 LOWER COLUMBIA RIVER FISH PERFORMANCE MEASURES

The Consultative Committee acknowledged that there was significant uncertainty around the implications of operating alternatives in the lower Columbia River on the ecosystem. Specifically, it was unclear how flow alternatives might affect productivity and which aspects of productivity should be considered when evaluating possible flow changes. A desktop exercise was undertaken to identify the factors limiting fish populations in the lower Columbia River, and identify opportunities to benefit these populations through seasonal changes in the shape of the hydrograph (Failing, 2003).

Through work of the Fish Technical Subcommittee, interim performance measures and flow options were developed for the lower Columbia River. Based on preliminary review, it was concluded that the greatest opportunities to influence a population level response was probably for rainbow trout (through provision of a stable or rising limb during egg incubation) and sculpins/dace (through reduction in the magnitude of daily/weekly flow fluctuations). Opportunities to influence other species (bull trout, burbot) were also identified, but it was acknowledged that they were either of lower probability or simply uncertain because there is a possibility that other factors may limit their population. Based on specific fish objectives for the lower Columbia River, impact hypotheses were developed to help define how each of the flow options could affect the fish endpoints. This provided the basis for subsequent prioritizing of the flow options based on the expected impact on each of the endpoints and learning.

5.20 WILDLIFE HABITAT PERFORMANCE MEASURE FOR THE LOWER COLUMBIA RIVER

A study was undertaken to assess whether total surface area of the gravel bars at Genelle was a suitable performance measure to use in evaluating impacts of incremental flow changes in the lower Columbia River on river riparian habitat (Robertson Environmental, 2001). It was determined that the only riparian habitat that could be significantly affected by operational changes is located on the gravel bars, and that this habitat has become established as a result of current river discharge patterns and associated sediment transport.

Based on a review of available information and limited field assessment of the biophysical characteristics of the gravel bars, it was determined that minor changes to flow rates and water levels would not have a measurable impact on these bars or wildlife use of the riparian vegetation. Provided that operating changes involving flows in excess of 160 kcfs are not considered, it is likely that vegetation succession will continue towards the development of more mature and complex habitats.

6 OPERATING ALTERNATIVES

6.1 INTRODUCTION

In Step 6 of the *Water Use Plan Guidelines*, the Consultative Committee created various operating alternatives for satisfying the Columbia River water use planning objectives described in Section 4. *An operating alternative is an explicit, discrete set of operating rules or constraints applied to each hydraulic component of the system, which is then modelled as a combined set of operating instructions for BC Hydro's Columbia River hydroelectric facilities.*

The BC Hydro project team simulated the operating alternatives using several interrelated computer models of the Columbia River hydroelectric facilities. The Consultative Committee used the modelling results and performance measures to compare how well each alternative performed in satisfying the Columbia River water use planning objectives.

This section describes the specifications of the Columbia River Water Use Plan alternatives and the modelling process.

6.2 MODELLING OPERATING ALTERNATIVES

Once the Consultative Committee developed an alternative, BC Hydro used several Power Operations Models developed for BC Hydro's Water Use Plan Program to simulate operations of the Columbia River hydroelectric facilities according to the specified constraints of each operating alternative. As alternatives evolved and became more refined, the power studies methodology was updated to capture the effects of those refinements.

For each operating alternative, the Power Operations Models provide statistics for reservoir elevations, dam discharges, river flows and value of power generation for the years of simulated flow operation. These outputs serve as inputs to the Environmental Model to calculate the performance measures for each alternative.

The Environment Model is a Visual Basic program that calculates 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.

Dam discharge flow data and reservoir elevations are routed through a Value of Energy Model to calculate the annual value of the power generation that will be produced under each operating alternative.

Figure 6-1 illustrates the Columbia River Water Use Plan operating alternative modelling process.

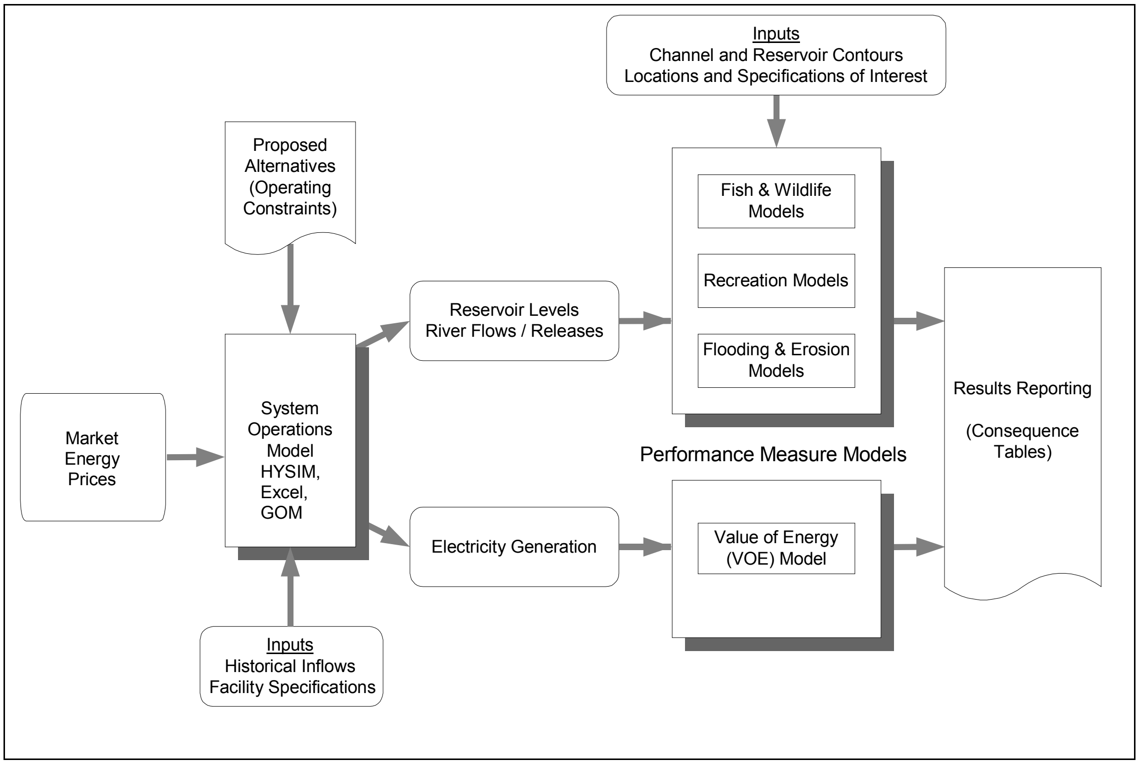

Figure 6-1: Columbia River Water Use Plan Operating Alternative Modelling Process

6.2.1 Columbia River Treaty

The provincial government's *Water Use Plan Guidelines* specifically mentions the Columbia River Treaty as one of the international agreements to be taken into account when preparing water use plans. The Treaty dictates required weekly flows across the United States border and thus limits the feasible scope of operational changes. However, the Treaty does allow for changes to its default operation provided that both the United States and Canadian Entities agree to such changes.

In response to a request from the Consultative Committee, the BC Hydro project team provided documentation to clarify the scope of the Columbia River Water Use Plan and outline guidelines that could be applied by the Committee in determining which operating alternatives could be considered within the process (refer to Appendix U: Correspondence from the Columbia River Water Use Plan Project Manager to Consultative Committee). At the May 2002 Consultative

Committee meeting, the Committee distinguished between three types of operating flexibility.

- Operating alternative(s) that involve incremental changes to existing operations that BC Hydro can implement unilaterally, without agreement from the United States. A partial list includes some flex operations (i.e., balancing reservoir levels between Kinbasket and Arrow Lakes reservoirs), constraints on reservoir maximum and minimum elevations which can be accommodated within the Columbia River Treaty operations, minimum flows and ramping rates at Mica and Revelstoke dams, and incremental use of the BC Hydro portion of non-Treaty storage.

- Operating alternative(s) that deviate from the Treaty but have been agreed to by the United States on previous occasions. The Consultative Committee's role with respect to these alternatives is to make recommendations to BC Hydro on flow alternatives to pursue in negotiations with the United States Entity (affecting Detailed Operating Plans and Supplemental Operating Agreements developed under the Treaty). However, BC Hydro's ability to secure such an alternative is uncertain, depending upon successful negotiations with the United States and, possibly, other affected parties following implementation of the Columbia River Water Use Plan.

- Operating alternative(s) that deviate from the Treaty that have not been agreed to by the United States on previous occasions. As noted above, the Consultative Committee adopted the role of making recommendations to BC Hydro around its negotiating objectives. However, the Committee also recognized that, given a limited budget and time frame, this water use planning process would put the investigation of proposals that were not likely to be acceptable to the United States as a low priority throughout the process.

Within the operating flexibility that could be considered, a number of issues were highlighted to the Consultative Committee.

- Under the Treaty, storage swaps between Kinbasket and Arrow Lakes reservoirs are possible, provided that flow requirements at the border are met. (Kinbasket and Revelstoke reservoirs can be de-coupled.)

- The ratio of storage space for flood control between Arrow and Kinbasket is currently 5:2. While this ratio could be changed, the U.S. would have interest in this due to flood control issues (but could not veto this change).

- Under the Non-Treaty Storage Agreement with the U.S., flow changes less than 2000 cfs can be made unilaterally by BC Hydro.

- The Consultative Committee could set limits between Koocanusa and Arrow/Kinbasket reservoirs swaps. While the U.S. could veto this, it is considered unlikely.

- In recent years, BC Hydro has negotiated non-power use agreements with the U.S., including:
  - Flow management for rainbow trout spawning in the Canadian Columbia River to maintain river levels at Norns Creek Fan between 1 April and 30 June.
  - The Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the 1–15 January period to reduce Arrow outflow by 20 kcfs for enhancement of whitefish spawning.
  - The Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir during the September–October period in compensation to the U.S. for lost energy benefits associated with maintaining stable minimum flows to minimize the dewatering of whitefish eggs until 31 March.

If the preferred alternative(s) of the Consultative Committee requires agreement with the United States, the Committee may recommend that BC Hydro seek such agreement. However, the Committee recognized that it must recommend a preferred alternative that can be implemented unilaterally by BC Hydro in the event that no agreement with the United States is reached.

In making recommendations about operating alternatives, the Consultative Committee limited its scope to assessing domestic power generation (financial) impacts, as well as domestic social and environmental benefits and costs. U.S. power generation and other social and or environmental benefits and costs associated with an alternative were not modelled during the Columbia River water use planning process. In all cases, Columbia River Water Use Plan operating alternative(s) would recognize and adhere to local and downstream flood control operations, as required by the Columbia River Treaty.

6.2.2 Power Operations Models

By the summer of 2002, the BC Hydro project team had segmented the analyses of operating alternatives into three different, but interrelated models of the Columbia River system. These modelling approaches addressed:

1. The overall operations of the Columbia River system, including all reservoir elevations, dam releases and river flows (referred to as HYSIM).
2. Flows immediately below Revelstoke Dam (referred to as GOM).
3. The balance between Arrow Lakes Reservoir and the flows below Hugh Keenleyside Dam, which considered changes to Columbia River Treaty flows (an Excel spreadsheet model described below).

The HYSIM and GOM studies address Columbia River hydroelectric facilities operations that can be implemented unilaterally by BC Hydro, whereas the latter studies address operations that would require agreement with the United States.

Principle requirements or inputs for the models included:

- Hard hydroelectric facility constraints based on physical limits (e.g., turbine capacity, reservoir capacity, spillway rating), licensing, integrated electrical system requirements, and/or Treaty obligations.
- Soft constraints governing daily operational use of water (e.g., timing, magnitude, rate) could be made to meet the different or combined needs of various interests within the range of the hard constraints.

Each proposed package of soft operational constraints represented a unique operating alternative within the bounds of the hard constraints.

Variation in snowpack levels, freshet timing and precipitation events result in different reservoir elevations and facility discharges between years. This variation was reflected in different intra- and inter-annual discharge regimes within a given alternative as the Operations Models attempted to optimize for power generation. In the case of Kinbasket, reservoir storage capacity is sufficient to influence next year operations by supplementing or withholding actual inflows using storage. This characteristic is unique to a multi-year storage reservoir, in that actual discharge is tied to both annual inflow and previous year storage and discharge decisions. For example, two successive drought years may have large implications on how the hydroelectric project behaves in the third year based on soft and hard operating constraints.

The primary output of the Power Operations Models is a set of data describing reservoir elevations and flow releases through time for each facility. These outputs were then used as inputs to generate performance measures based on flow and/or reservoir elevations and to estimate power generation as described in Section 4. The performance measure results were documented in a summary consequence table that was used in the trade-off analysis discussions as described in Section 7.

6.3 HYDRO SIMULATION MODEL

The BC Hydro project team used a Hydroelectric Simulation Model (HYSIM) to capture the operations of the Columbia River system as a whole, including all reservoir levels, reservoir outflows and river flows.

While most other water use planning models focused solely on hydro generation of one watershed, the HYSIM was more broad and represented a detailed hydraulic model of the larger BC Hydro system of electric generation. This approach was needed to capture both the size and importance of the Columbia River system within British Columbia and the fact that operation of the Columbia

River system and the Peace/Williston river systems are co-ordinated to optimize power generation. For a given load and resource portfolio, the HYSIM will determine the most economic dispatch of the generating system, subject to operating constraints and objectives, under a range of streamflow sequences.

The HYSIM simulates operation of BC Hydro's integrated electric generation system on a monthly time-step. As such, it is able to provide end-of-month reservoir elevations, mean monthly flows, monthly generation and mean monthly operating costs. It does not reflect any variability of these outputs within the month (e.g., daily and/or hourly).

HYSIM simulations were based on inflow data sets using the time series between 1940 and 2000 (60 years) with an annual load approximating the system Firm Energy Load Carrying Capability (FELCC). This is defined as the annual generation that the system can reliably sustain under all water conditions. Based on the existing and planned resources, an annual firm load of 64 000 GWh with the same load shape as the BC Hydro domestic load was determined to be the FELCC. These results reflected a single continuous sequence of reservoir inflows in which the initial conditions (e.g., Kinbasket Reservoir elevations) for each year were carried forward from the end of the previous year starting in 1940. Electricity prices were varied depending on water conditions in the Pacific Northwest.

6.3.1 HYSIM Assumptions and Methodology

Table 6-1 summarizes the assumptions built into the HYSIM.

Table 6-1: HYSIM Assumptions

• FELCC load ~ 64,000 GWh/year (as required by planning criteria)
• Streamflow sequence is from October 1940 to September 2000
• September 2001 gas and electricity price forecast (Henwood model) • Market prices are based on average monthly prices for heavy load and light load periods • Energy limit is based on the estimated monthly transmission availability • The market prices are adjusted by water year to reflect the impact due to varying streamflow conditions at British Columbia and Pacific Northwest (at The Dalles)
• Resources • Existing BC Hydro resources and Independent Power Producers • Hugh Keenleyside generation (185 MW) • Seven Mile generation, including Unit 4 (200 MW) • Additional Independent Power Producers • Island Cogeneration Project (240 MW) • Vancouver Island Generation Project (265 MW)
• Columbia River Operations • Treaty operation based on 2006 Assured Operating Plan (AOP) • Flood control storage requirements based on 4.08/3.60 MAF flood control split at Kinbasket and Arrow Lakes reservoirs • Fixed Bonneville Power Administration non-Treaty operation, varying by water year • Meet operating objects to the extent possible through the use of Flex operation and, when required, the British Columbia non-Treaty operation.

Table 6-1: HYSIM Assumptions (cont'd)

- Peace River Water Use Plan Constraints
  - Williston Reservoir operating range as per water licence
  - Peace Canyon flows constraints
    - 52 kcfs from January to February for base case
    - Minimum 30 kcfs in March
    - Minimum 10 kcfs from April to November
    - Minimum 40 kcfs in December

6.3.2 BC Hydro Operations under HYSIM

The Peace and mainstem Columbia river systems account for approximately 65 per cent of BC Hydro's total generating capacity. Their large storage capacity provides BC Hydro with a significant amount of operating flexibility to co-ordinate their operations to meet the various demands on the system and to take advantage of market opportunities. Therefore, any constraints on either system will reduce this flexibility and may also impact on the other system.

The modelling for the Columbia River water use planning process included assumptions for the Peace River system operations. In the summer of 2003, as the Peace River water use planning process neared completion, the BC Hydro project teams undertook a high level assessment of the proposed Peace and Columbia river systems operations to determine whether there were any cross-system impacts. The conclusion was that some of the more extreme scenarios for constraining Arrow Lakes Reservoir could change the costs of achieving the Peace River Water Use Plan constraints (and vice versa). This concern was brought forward to the Consultative Committee members, and the BC Hydro project team committed to follow up with more precise measures of cross-system impacts if the Committees chose extreme constraints on either of the systems.

The Columbia River system operation is modelled in accordance with the Columbia River Treaty and the Non-Treaty Storage Agreement. The Columbia River Treaty operation is computed based on the 2006 Assured Operating Plan, while the United States non-Treaty operation is assumed to be a fixed operation, which varies by water year. Downstream flood control requirements are based on the 4.08/3.60 MAF split at Kinbasket and Arrow Lakes reservoirs. Non-power operations are not based on any long-term agreements and are currently agreed upon on a year-to-year basis. As a result, they were not included in the HYSIM modelling assumptions but were assessed separately as alternatives that require negotiations with the United States as described under Section 6.4. Constraints on the Columbia River system are achieved, first with any flexibility that BC Hydro has to shift water between Kinbasket and Arrow Lakes reservoirs, and then with the BC Hydro portion of the Non-Treaty Storage Agreement.

For all operating alternatives modelled using HYSIM, Columbia River Treaty operations and flows below Hugh Keenleyside Dam to the border are identical.

The Consultative Committee recognized that alternatives requiring agreement with the United States would require a different modelling approach.

6.3.3 Streamflow Record for HYSIM

The 60-year streamflow sequence used in the HYSIM modelling was based on the October 1940 to September 2000 historical streamflow. This period includes a wide range of streamflow conditions and is considered to provide a sufficiently large sample to be representative of future streamflow. Early in the process, while the modelling approach was still under development, the inflow data set only included years to 1985. However, the larger data set was used in all HYSIM modelling from May 2002 onwards.

Each operating alternative was run continuously over the 60 years of streamflow data using initial conditions (at the beginning of October 1940) that match the conditions at the end of the streamflow period (September 2000). This ensured that the same amount of water was used in each alternative.

Some interests in the lower Columbia River are affected both by flows out of Arrow Lakes Reservoir and the Kootenay River system. Since the Kootenay River system has hydroelectric facilities that are owned by entities other than BC Hydro, operational changes on the Kootenay River system were outside of the scope of the Columbia River water use planning process. To assess the impact of changing constraints on the lower Columbia River, the same set of monthly flow averages for the Kootenay River system were paired with each operating alternative on the Columbia River, yielding average monthly flows for the lower Columbia River that varied with each alternative.

During the Columbia River water use planning process, several changes occurred on the Kootenay River system including:

- The imposition of a minimum flow on Brilliant Dam.
- The expansion of Brilliant Dam (completion 2006).
- A change in operating policy on Libby Reservoir (Libby VarQ).
- An expected change to the Duncan Dam operation due to the water use planning process.

While the flow file for the Kootenay River system was not updated for the Columbia River water use planning process, an assessment was made as to whether these changes would affect the performance measures for interests in the lower Columbia River. As outlined in Appendix V: Impact of Flow on Recreation and Infrastructure on the Lower Columbia River, none of these changes on the Kootenay River system were large enough to affect the interests as they were defined for the Columbia River water use planning process.

6.3.4 Market Modelling under HYSIM

Import and export markets are modelled based on the September 2001 electricity price forecast and are limited by an estimated monthly transmission availability. In the Pacific Northwest, electricity prices tend to vary depending on the runoff volumes in the Northwest. Therefore, the electricity price forecast is adjusted for each of the 60-year streamflow conditions used in the study based on the runoff volumes at The Dalles. The assumed price variations due to streamflow conditions ranged from about +45 per cent of the mean for a dry year to -25 per cent of the mean for a wet year.

Due to the flexibility of the hydroelectric system, BC Hydro is able to take advantage of market price variability by shaping the generation to enable market purchases during low price periods and sales during higher price periods. Any constraints on the system may reduce this flexibility, thereby increasing the cost of operating the system.

The price forecast used by the HYSIM provides a single view of the market based on certain assumptions. In real time, there may be much more volatility due to a range of different factors, as the early years of this decade have shown. This volatility will tend to increase the value of the operating flexibility, and hence, increase the cost of alternatives that restrict operating flexibility.

6.3.5 Operating Alternative Costs for HYSIM

The BC Hydro project team developed Alternative 0 – Base Case as a reference base case that minimized the cost of meeting the FELCC load using the provincial hydroelectric system subject to Columbia River Treaty constraints. The costs of each alternative were expressed as the change in the average annual cost of meeting the same FELCC with the added constraints relative to Alternative 0 – Base Case.

6.4 MODELLING ARROW LAKES RESERVOIR AND FLOWS BELOW HUGH KEENLEYSIDE DAM

Operating alternatives modelled using the HYSIM specified similar monthly flow averages crossing the United States and British Columbia border in the lower Columbia River, consistent with the 2006 Assured Operating Plan Columbia River Treaty flows. As the Columbia River water use planning process progressed, it became evident that several interests below Hugh Keenleyside Dam could not be addressed through this modelling approach. In response, the BC Hydro project team used an Excel spreadsheet analysis to modify flows below Hugh Keenleyside Dam to address operations that would require agreement with the United States Entity (i.e., rainbow trout flows, mountain whitefish flows, and Arrow/Libby swaps).

Each HYSIM operating alternative specified a unique set of reservoir elevations and flows for the entire Columbia River system. As outflows at Hugh Keenleyside Dam were modified through the Excel spreadsheet analysis to meet interests in the lower Columbia River, storage in Arrow Lakes Reservoir was modified. It was assumed that Kinbasket Reservoir levels, Mica Dam outflows, Revelstoke Reservoir elevations, and Revelstoke Dam outflows remained constant. For example, Alternatives 11D and IC were modelled using the HYSIM. An Excel spreadsheet analysis was then used to append negotiated flows onto each alternative resulting in Alternative 11D+Rbt and Alternative IC+Rbt (refer to Section 6.8).

6.4.1 Assumptions and Methodology for Changes to Treaty Flows

While agreements with the United States vary from year to year, a "typical agreement profile" was constructed for rainbow trout flows, mountain whitefish flows, and Arrow/Libby swaps. These agreement profiles were applied to each year of the 60-year inflow data set, with the recognition that the change to river flows and reservoir storage may vary under each annual agreement depending on inflows and market conditions. This modelling approach was refined over the course of the Columbia River water use planning process. The different approaches used to model the fish flow agreements in the lower Columbia River are outlined in the following sections, and are described in Appendix W: Evolution of Lower Columbia River Fish Flows.

6.4.2 Streamflow Record for Changes to Treaty Flows

Each negotiated flow alternative used end of month elevations and average monthly flows over the 60-year data set (October 1940 to September 2000) generated by the HYSIM for that alternative. Monthly average outflows from the Kootenay River system remained constant for all alternatives.

6.4.3 Market Modelling

The prices used for evaluating the change in value of power generation were the same as those used for the HYSIM study described above. These prices have a seasonal component to them, and also vary according to the volume of inflow for that year. Consequently, they capture the value of shifting power generation from month to month.

6.4.4 Operating Alternative Costs

Changes to Arrow Lakes Reservoir elevations and outflows to achieve the negotiated flows in the lower Columbia River affects the amount of power generated at the Arrow Lakes Generating Station. An Excel spreadsheet analysis was used to calculate the value of the power generation loss/gain using estimated electricity prices.

A second cost to providing these fish flows is through its impact on market prices. As outlined in Section 6.3.4, BC Hydro generates profits through its flexibility in providing electricity selectively when prices are fluctuating. One of the flow changes sought by the United States parties through the fish flow agreements allows the United States entities to change flow patterns from Arrow Lakes Reservoir during the fall months which would moderate price fluctuations. This, in turn, reduces BC Hydro's profitability. A more thorough description of this is provided in the Power Studies Report for the Columbia River water use planning process (BC Hydro, in prep.).

6.5 MODELLING FLOWS BELOW REVELSTOKE DAM

Several interests related to fish objectives in the mid Columbia River were affected by fluctuating flows from Revelstoke Dam. Since the HYSIM provides only monthly flow averages as output, a more refined approach was needed to explore operating alternatives that constrained these flow releases. The Generalized Optimization Model (GOM) simulated operations of Revelstoke Dam on a short (bi-hourly) time step, which allowed changes to these flow fluctuations to be studied in greater detail. The GOM was partially available to address alternatives in the second round of the trade-off analysis. Discussions regarding constraints on Revelstoke operations were based on the GOM output from the third round of trade-offs onwards.

6.5.1 BC Hydro Operations under GOM

Electricity prices vary over the short term on a daily and weekly basis. BC Hydro uses its system's flexibility to maximize its hydroelectric revenues in response to these fluctuating electricity prices. Facilities on both the Columbia River and the Peace River system are used in co-ordination to achieve this flexibility.

The Consultative Committee developed operating alternatives that specified constraints on Revelstoke Dam operations, including minimum flows, maximum flows, maximum magnitude changes, and ramping rates. In general, these constraints reduce BC Hydro's operating flexibility and ability to respond to electricity market prices. The way in which the Peace and the Columbia river systems were modelled to capture the impact of constraints on Revelstoke flows is outlined in the following section.

6.5.2 GOM Assumptions and Methodology

The General Optimization Model (GOM) was used to capture the way in which the entire BC Hydro system was co-ordinated to maximize revenues over the short term and guided by the monthly HYSIM simulations.

Table 6-2 summarizes the GOM assumptions.

Table 6-2: **GOM Assumptions**

- Water Years: uses 10 years of streamflow data from 1 October 1964 to 30 September 1973.
- BC Hydro September 2001 gas and electricity price forecast for Alberta and the United States.
  - Estimated hourly market prices and transmission availability.
  - The market prices adjusted by water year to reflect the impact due to varying streamflow conditions at British Columbia and Pacific Northwest.
- The initial forebay and ending elevations were set to match those derived by the HYSIM results for the corresponding water years.
- The monthly total energy production from the G.M. Shrum and the Mica generating plants were restricted to deviate by no more than a certain percentage from those derived by the HYSIM.
- The average monthly inflows for the studies were set to the inflows used in the HYSIM. Within each month, daily inflows are assumed to be constant for the Peace River system, while the Columbia River system used inflows that vary daily.
- The minimum plant outflows for the base case were assumed to be:
  - G.M. Shrum 1.5 kcfs
  - Peace:
    - January to February 51 kcfs
    - March 30 kcfs
    - April to November 10 kcfs
    - December 40 kcfs
  - Mica 0 kcfs
  - Revelstoke 0 kcfs
  - Forebay limit:
    - Peace = 9 ft
    - Revelstoke = 5 ft
- Different maximum and minimum plant outflows may be used as required by each alternative.

Note: Plant unit outages were scheduled during the spring for two weeks each unit. The unit outages for each plant in a river system were co-ordinated so that a unit outage at an upstream plant coincides with a unit outage at the downstream plant.

Since the Peace and the Columbia river systems are interdependent, there was the possibility that short-term constraints at one location could affect the flows and/or costs of operations at the other facilities. These cross-system impacts were apparent under some of the more extreme constraints imposed at Revelstoke Dam (e.g., minimum flows at or above 15 kcfs), and this was highlighted to the Consultative Committee and the Technical Subcommittees. The BC Hydro project team committed to exploring these system-wide impacts in more detail if required. As outlined in the following sections, the adoption of the lowest possible minimum flow at Revelstoke Dam meant that cross-system impacts were not a large consideration.

6.5.3 Streamflow Record for GOM

Due to the detailed nature of the model, the GOM does not employ the entire 60-year streamflow period used in the HYSIM. Instead, it uses 10 years of flow conditions from 1 October 1964 to 30 September 1973. This period was selected to capture a wide variation in inflow conditions and electricity prices.

Since monthly average HYSIM flows vary by alternative, constraints on Revelstoke operations were modelled using the HYSIM results from the Alternative 0 – Base Case (the least constrained alternative), and Alternative 11B (a relatively more constrained alternative) for the 10-year period noted above. While the underlying HYSIM alternative did change the absolute level of the environmental and financial performance measures derived from the GOM output, it did not change their relative differences, making the underlying HYSIM alternative irrelevant from a decision-making perspective. Treating the constraints at Revelstoke Dam as independent from the constraints on the whole system greatly simplified the modelling and trade-off process. As a result, the final GOM alternatives were modelled using only Alternative 0 – Base Case as the underlying HYSIM alternative.

6.5.4 Operating Alternative Costs for GOM

The costs of constraints on Revelstoke Dam were generated by comparing the costs of constrained operations to an unconstrained, “power-optimal” alternative. These were presented as averages over the 10 years of inflow data. Note that this reference case contained no minimum flows at Revelstoke Dam, whereas BC Hydro’s practice at the time had been to provide daytime minimum flows of 5 kcfs when practical. As well, this power-optimal alternative included an informal restriction on the drawdown in Revelstoke Reservoir, although no formal constraints exist within BC Hydro’s water licence.

As the Consultative Committee focused its interest on a range of minimum flows, additional detailed modelling was required. At this point, interpolations between previously modelled results were used to provide approximations of flows and costs. These interpolated flows were then used to calculate the environmental performance measures, and interpolation between previous modelled outcomes were also used to generate costs.

Table 6-3 summarizes the relative monthly cost of a minimum flow constraint on Revelstoke Dam. In the high cost months, a minimum flow provides power generation at times of low electricity prices instead of conserving this water for higher value times. Thus, the highest cost periods come when low (light load hour) electricity prices are at their lowest.

Table 6-3: Relative Monthly Costs of a Minimum Flow Constraint on Revelstoke Dam

Month	Percent of Annual Cost of Minimum Flow
March	9%
April	16%
May	25%
June	16%
July	6%
August to February	4%

6.6 ROUND 1 OPERATING ALTERNATIVES

Creating and evaluating operating alternatives is an iterative process. The Round 1 alternatives demonstrated how the Columbia River hydroelectric facilities could achieve the specified minimum reservoir elevations and the minimum river flows 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 evaluated alternatives in Rounds 2, 3, 4, and 5. In Round 3, non-operational physical works in lieu of operational changes were introduced.

Table 6-4 summarizes the specifications of the Round 1 operating alternatives for the Columbia River water use planning process developed by the Consultative Committee during the June 2001 Committee meeting. The performance measures for these alternatives were reviewed at the February 2002 Committee meeting.

Table 6-4: Round 1 Operating Alternatives

Alternative	Description	Constraints
0	**Base Case.**	Unconstrained Treaty operation.
1	**Kinbasket Reservoir Rec-Friendly.** This alternative is generally a "recreation-friendly" alternative on Kinbasket Reservoir. Kinbasket Reservoir elevations are held higher through the recreation season.	Minimum elevation of 730 m (2395 ft) by 24 May. Maintain elevation between 749 and 751 m (2457 ft and 2464 ft) 1 August to 30 September.
2	**Kinbasket Reservoir Min Elev.** This alternative generally supports fish, navigation and recreation on Kinbasket Reservoir. It maintains a minimum elevation of 730 m year round.	Minimum elevation of 730 m (2395 ft) year round.
5	**Mid Columbia River No-Go Zone.** This alternative is designed to be recreation-friendly in mid Columbia River. It avoids Arrow Lakes Reservoir elevations at which neither shoreline nor water-based activities are possible on mid Columbia River during the recreation season.	Minimize the number of days with reservoir elevations between 432 and 437 m (1417 and 1433 ft) 1 May to 30 September.

Table 6-4: Round 1 Operating Alternatives (cont'd)

Alternative	Description	Constraints
7	**Lower Columbia River Fish Friendly.** This alternative would achieve the preferred fish hydrograph on lower Columbia River through modifications to Arrow Lakes Reservoir elevations.	Adjustments made to Arrow Lakes Reservoir first, and to Kinbasket Reservoir only when required, according to hydrograph specified by the Fish Technical Subcommittee.
10	**Arrow Lakes Reservoir Consistently High.** This alternative is similar to Base Case on average, but raises summer elevations of wet/dry years through June to August. The goals are to increase pelagic productivity for fish and improve recreational quality.	Minimum elevation of 431 m (1414 ft) 1 May to 31 May. Minimum elevation of 437 m (1433.8 ft) 30 June to 30 September.
11	**Arrow Lakes Reservoir Low.** This alternative holds Arrow Lakes Reservoir lower until mid July for various recreational benefits to allow vegetation to extend into lower elevations, and increase the length of flowing river.	Maximum elevation of 435 m (1427.2 ft) 1 May to 30 June. Maximum elevation of 439 m (1433.8 ft) 31 July to 31 August.
3a	**Mid Columbia River Min Flow 5000 All Year.** This alternative provides a minimum flow through Revelstoke of 5000 cfs year round.	Maintain a minimum flow of 5000 cfs year round.*
3b	**Mid Columbia River Min Flow 5000 Summer Only.** This alternative provides a minimum flow through Revelstoke of 5000 cfs for the growing and recreation season.	Maintain a minimum flow of 5000 cfs 1 May to 30 August.*
4a	**Mid Columbia River Ramp 500 All Year.** This alternative restricts ramping rates (the rate at which flow rate is allowed to change) to 500 MW per hour year round.	Reduce ramp rate to 500 MW/hr (15 kcfs/hr) year round.
4b	**Mid Columbia River Ramp 100 Summer Only.** This alternative restricts ramping rates (the rate at which flow rate is allowed to change) to 100 MW per hour for the growing and recreation season.	Reduce ramp rate to 100 MW/hr (3 kcfs/hr) 1 May to 30 August.

* Minimum flow represents turbine discharge (no leakage assumed).

Alternative 0 – Base Case maximized power generation subject to Columbia River Treaty constraints. Alternatives 1, 2, 5, 10 and 11 specified different ways of operating Kinbasket and Arrow Lakes reservoirs. Alternatives 3a, 3b, 4a, and 4b specified minimum flows and ramping rate restrictions on the mid Columbia River, respectively. Alternative 7 specified an alternative hydrograph for the lower Columbia River. Alternative 7 violated the Columbia River Treaty flows and therefore, could not be unilaterally implemented by BC Hydro.

The HYSIM was used to model Alternatives 0, 1, 2 and 5, but was not available to complete modelling of Alternatives 7, 10 and 11 during Round 1 of the trade-off analysis. These latter alternatives were approximated using an Excel spreadsheet analysis. The Excel spreadsheet analysis for modelling changes to Columbia River Treaty flows as specified in Alternative 7 was only implemented by the third round of alternatives. At this time, the GOM was not fully developed, and costs of the Revelstoke Dam flow alternatives were estimated using an Excel spreadsheet analysis without any detailed flow modelling. Moreover, a full set of inflows was not yet available and therefore included only years up to 1985.

6.7 ROUND 2 OPERATING ALTERNATIVES

Table 6-5 summarizes the specifications of the Round 2 operating alternatives for the Columbia River water use planning process previously considered by the Consultative Committee during the February 2002 Committee meeting. The alternatives attempt to balance flows and reservoir elevations across the system. The HYSIM model was used to model the alternatives. The performance measures for these alternatives were reviewed at the May 2002 Committee meeting.

Table 6-5: Round 2 Operating Alternatives – System-wide

Alternative	Description	Constraints
0	**Base Case.**	Unconstrained Columbia River Treaty operation.
1	**Kinbasket Reservoir Rec-Friendly.** This alternative is generally a "recreation-friendly" alternative on Kinbasket Reservoir. Kinbasket Reservoir elevations are held higher through the recreation season.	Minimum elevation of 730 m (2395 ft) by 24 May. Maintain elevation between 749 and 751 m (2457 and 2464 ft) 1 August to 30 September.
2	**Kinbasket Reservoir Min Elev.** This alternative generally supports fish, navigation and recreation on Kinbasket Reservoir. It maintains a minimum elevation of 730 m year round.	Minimum elevation of 730 m (2395 ft) year round.
5	**Mid Columbia River No-Go Zone.** This alternative is designed to be recreation friendly in mid Columbia River. It avoids Arrow Lakes Reservoir elevations at which neither shoreline nor water-based activities are possible on the mid Columbia River during the recreation season.	Minimize the number of days with reservoir elevations between 432 and 437 m (1417 and 1433 ft) 1 May and 30 September.
10	**Arrow Lakes Reservoir Consistently High.** This alternative is similar to Base Case on average, but raises summer elevations of wet/dry years through June to August. The goals are to increase pelagic productivity for fish and improve recreational quality.	Minimum elevation of 431 m (1414 ft) 1 May to 31 May. Minimum elevation of 437 m (1433.8 ft) 30 June to 30 September.
11	**Arrow Lakes Reservoir Low.** This alternative holds Arrow Lakes Reservoir lower until mid July for various recreational benefits to allow vegetation to extend into lower elevations, and increase the length of flowing river.	Maximum elevation of 435 m (1427.2 ft) 1 May to 30 June. Maximum elevation of 439 m (1433.8 ft) 31 July to 31 August.

No new operating alternatives designed to balance flows in the lower Columbia River and Arrow Lakes Reservoir were developed for the Round 2 trade-off analysis. However, subsequent to this meeting, the Fish and Wildlife Technical Subcommittee gained further clarity around specific elements of the preferred hydrograph in the lower Columbia River that would benefit fish interests. This led to modifications to Alternative 7 that involved using 1 MAF and 2 MAF of extra storage in Arrow Lakes Reservoir through the non-power use agreement to achieve:

- Higher summer flows in July.
- Lower flows and reduced variability in February.
- Rainbow trout protection flows in April to June.

Table 6-6 summarizes the specifications of the two new alternatives, Alt 7-1MAF and Alt 7-2MAF. The modelling results of these alternatives were reviewed by the Fish and Wildlife Technical Subcommittee but were not presented to the Consultative Committee for consideration during subsequent rounds of trade-off discussions.

Table 6-6: Round 2 Operating Alternatives – Lower Columbia River Flows and Arrow Lakes Reservoir

Alternative	Constraint
7-B-1MAF 7-B-2MAF	Alt 7-B-1MAF and 7-B-2MAF use 1 and 2 MAF respectively from non-power uses agreement to achieve, in order of priority: • Stable or ascending hydrograph limb April to May (for rainbow trout incubation). • Decreased variability in February (to reduce energetics requirements for all fish species). • Higher summer flow all of July (predator avoidance for white sturgeon and general benefits to all fish species).

Table 6-7 summarizes the specifications of the Round 2 operating alternatives for Revelstoke Dam that were designed to improve flow conditions in the mid Columbia River.

Table 6-7: Round 2 Operating Alternatives – Flows at Revelstoke Dam

Description	Constraint
Ramp Rate	200 MW/hr (6 kcfs/hr) at Revelstoke Dam year round
	200 MW/hr (6 kcfs/hr) at Revelstoke Dam and Mica Dam year round
Maximum Flow Change	± 10 kcfs above and below average June, July flows 1 June to 31 August at Revelstoke Dam
	± 10 kcfs above and below average June, July flows 1 June to 31 August at Revelstoke Dam and Mica Dam
Minimum Flow	5000 cfs at Revelstoke Dam 1 June to 31 August
	10 000 cfs at Revelstoke Dam year round
	15 000 cfs at Revelstoke Dam year round

Note: Minimum flow represents turbine discharge (no leakage assumed).

6.8 ROUND 3 OPERATING ALTERNATIVES

Table 6-8 summarizes the specifications of the Round 3 operating alternatives for the Columbia River water use planning process developed by the Consultative Committee during the May 2002 Committee meeting. The performance measures for these alternatives were reviewed at the June 2003 Committee meeting.

Table 6-8: Round 3 Operating Alternatives – System-wide

Alternative	Description	Constraint					
		Maximum Month-End Elevations					
		May	June	July	August	September	October
Base Case	Base Case is the unconstrained Columbia River Treaty operation. It will be somewhat different from the original Base Case due to modelling refinements, and is sometimes referred to as Base Case B.	–	–	–	–	–	–
11-B	Alt 11-B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in spring to improve vegetation potential, large river habitat, and bird habitat.	436 m 1430 ft	436 m 1430 ft	–	437 m 1434 ft	436 m 1430 ft	436 m 1430 ft
11-D	Designed to reduce costs of 11-B by relaxing the June constraint and allowing earlier fill, but pushing Arrow Lakes Reservoir down faster than 11-B in the fall.	436.5 m 1432 ft	438.3 m 1438 ft	–	436.5 m 1432 ft	435.3 m 1428 ft	–

By the June 2003 Consultative Committee meeting, the BC Hydro project team had developed an approach that reshaped the Arrow Lakes Reservoir elevation files and outflow files using an Excel spreadsheet analysis to achieve the desired cross-border flows.

Table 6-9 summarizes the modelled changes to the 2006 Assured Operating Plan Treaty flows below Hugh Keenleyside Dam and across the Canada/United States border.

Table 6-9: Alternatives Addressing Changing Treaty Flows

Alternative	Description	Constraint
HYSIM alternatives from Table 6-8 above "+ Rbt"	Flows below Hugh Keenleyside Dam shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement (including flow changes in lower Columbia River and storage changes in Arrow Lakes Reservoir). Kinbasket Reservoir is unchanged.	Cap January outflows to 60 kcfs. February to March: Target smooth discharge over period while storing 1 MAF for flow augmentation subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than 1 MAF flow augmentation. April and May: Target smooth discharge over period subject to reservoir flood control as per above and with a discharge floor of 15 kcfs. June: Release up to one-half of stored flow augmentation, subject to Arrow Lakes Reservoir flood control. July: Release remaining flow augmentation. August: Draft additional 220 ksfd[1] (equal to swapping 10 feet of Libby Reservoir water) October to December: Return August draft at rate of 55 ksfd per month.

[1] ksfd (thousand second-foot days) is the volume of water sufficient to provide a flow of 1,000 cfs for a 24-hour period

Table 6-10 summarizes the Revelstoke Dam minimum flow constraints specified for the Round 3 operating alternatives. The GOM was used to model all the alternatives.

Table 6-10: Round 3 Operating Alternatives – Flows at Revelstoke Dam

Minimum Flow[1]	Description
0 kcfs	Estimated leakage flows are in the range of 1.8–3.2 cfs[2]
Status Quo	5 kcfs during daylight hours, when power values are not extremely high
5 kcfs	Year-round
10 kcfs	Year-round
15 kcfs	Year-round
5 to 0 kcfs	5 kcfs from May to September, 0 kcfs from October to April
5 to 10 kcfs	5 kcfs from May to September, 10 kcfs from October to April
10 to 5 kcfs	10 kcfs from May to September, 5 kcfs from October to April

[1] Minimum flow represents turbine discharge (no leakage assumed).
[2] Estimates of combined seepage through the dam include both the concrete and earthfill dams (and abutments).

6.9 ROUND 4 OPERATING ALTERNATIVES

Table 6-11 summarizes the specifications of the Round 4 operating alternatives for the Columbia River water use planning process developed by the Consultative Committee during the June 2003 Committee meeting. The performance measures for these alternatives were reviewed at the November 2003 Committee meeting.

Table 6-11: Round 4 Operating Alternatives – Columbia River System

Alternative	Description	Constraint					
		Maximum Month-End Elevations					
		May	June	July	August	September	October
Base Case	Base Case is the unconstrained Treaty operation. It will be somewhat different from the original Base Case due to modelling refinements, and is sometimes referred to as Base Case B.	–	–	–	–	–	–
11-B	Alt 11-B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in the spring to improve vegetation potential, large river habitat, and bird habitat.	436 m 1430 ft	436 m 1430 ft	–	437 m 1434 ft	436 m 1430 ft	436 m 1430 ft
11-D	Designed to reduce costs of Alt 11-B by relaxing June constraint and allowing earlier fill, but pushing the reservoir down faster than Alt 11-B in the fall.	436.5 m 1432 ft	438.3 m 1438 ft	–	436.5 m 1432 ft	435.3 m 1428 ft	–
11-F	Compromise between Alt 11-B and Alt 11-D in the spring/summer, with no constraints after June.	435 m 1427 ft	437 m 1434 ft	–	–	–	–
Inundation Control (IC)	Performance based constraint limits inundation duration directly (not through Arrow Lakes Reservoir elevations). Derived from recent conditions that produced current vegetation.	Arrow Lakes Reservoir cannot exceed 436 m for more than 36 weeks over any consecutive 2-year period; or cannot exceed this level for more than 48 weeks over any consecutive 3-year period. Arrow Lakes Reservoir cannot exceed 438 m for more than 10 weeks in any one year, more than 19 weeks over any 2 consecutive years; or more than 25 weeks over any 3 consecutive years.					

Table 6-12 summarizes the modelled changes to the 2006 Assured Operating Plan Treaty flows below Hugh Keenleyside Dam and across the Canada/United States border. These were achieved by reshaping the Arrow Lakes Reservoir elevation files and outflow files using an excel spreadsheet analysis to achieve the desired cross-border flows.

Table 6-12: Alternatives Addressing Changing Treaty Flows

Alternative	Description	Restrictions
HYSIM alternatives from Table 6-11 above "+ Rbt"	Flows below Hugh Keenleyside Dam shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement, including flow changes in lower Columbia River and storage changes in Arrow Lakes Reservoir. This includes the "Arrow/Libby swap." Kinbasket Reservoir is unchanged.	Cap January outflows to 60 kcfs. February to March: Target smooth discharge over period while storing 1 MAF for flow augmentation subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than 1 MAF flow augmentation. April to May: Target smooth discharge over period subject to reservoir flood control as per above and with a discharge floor of 15 kcfs. June: Release up to one-half of stored flow augmentation, subject to reservoir flood control. July: Release remaining flow augmentation. August: Draft additional 220 ksfd (equal to swapping 10 feet of Libby water) October to December: Return August draft at rate of 55 ksfd per month.

Table 6-13 summarizes the Revelstoke Dam minimum flow constraints specified in the Round 4 operating alternatives.

Table 6-13: Round 4 Operating Alternatives – Flows at Revelstoke Dam

Minimum Flow	Description
0 kcfs	Leakage flows are approximately 2 cfs
Status Quo	5 kcfs during daylight hours, when power values are not extremely high
5 kcfs	Year-round
10 kcfs	Year-round
15 kcfs	Year-round
5 to 0 kcfs	5 kcfs from May to September, 0 kcfs from October to April
5 to 10 kcfs	5 kcfs from May to September, 10 kcfs from October to April
10 to 5 kcfs	10 kcfs from May to September, 5 kcfs from October to April

Note: Minimum flow represents turbine discharge (no leakage assumed).

6.10 ROUND 5 OPERATING ALTERNATIVES

Table 6-14 summarizes the specifications of the Round 5 operating alternatives for the Columbia River water use planning process developed by the Consultative Committee during the November 2003 Committee meeting. The performance measures for these alternatives were reviewed at the June 2004 Committee meeting.

Table 6-14: Round 5 Operating Alternatives – Columbia River System

Alternative	Description	Maximum Month-End Elevations					
		May	**June**	**July**	**August**	**September**	**October**
11-B	Alt 11-B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in the spring to improve vegetation potential, large river habitat, and bird habitat.	436 m 1430 ft	436 m 1430 ft	–	437 m 1434 ft	436 m 1430 ft	436 m 1430 ft
11-D	Designed to reduce costs of Alt 11-B by relaxing June constraint and allowing earlier fill, but pushing the reservoir down faster than Alt 11-B in the fall.	436.5 m 1432 ft	438.3 m 1438 ft	–	436.5 m 1432 ft	435.3 m 1428 ft	–
11-D2	Designed to retain environmental benefits of Alt 11-D while reducing fluctuations in costs.	436.8 m 1433 ft	438.6 m 1439 ft	–	436.8 m 1433 ft	435.3 m 1428 ft	435.3 m 1428 ft
11-D3	Designed to retain the environmental benefits of Alt D2 while providing more habitat for migratory birds in Arrow Lakes Reservoir during the late summer months.	436.8 m 1433 ft	438.6 m 1439 ft	–	436 m 1430.4 ft	434.4 m 1425.3 ft	434.3 m 1425.3 ft
Inundation Control (IC)	Performance based constraint limits inundation duration directly (not through Arrow Lakes Reservoir elevations). Derived from recent conditions that produced current vegetation.	Arrow Lakes Reservoir cannot exceed 436 m for more than 36 weeks over any consecutive 2-year period; or cannot exceed this level for more than 48 weeks over any consecutive 3-year period. Arrow Lakes Reservoir cannot exceed 438 m for more than 10 weeks in any one year, more than 19 weeks over any 2 consecutive years; or more than 25 weeks over any 3 consecutive years.					

Table 6-15 summarizes the modelled changes to the 2006 Assured Operating Plan Treaty flows below Hugh Keenleyside Dam and across the Canada/United States border. These were achieved by reshaping the Arrow Lakes Reservoir elevation files and outflow files using an Excel spreadsheet analysis to achieve the desired cross-border flows. This approach was based on discussions at the November 2003 Consultative Committee meeting and subcommittee meetings during the winter of 2004.

The Rbt2 variations were presented to the Fish and Wildlife Technical Subcommittee in February 2004, and then revised for the spring 2004 subcommittee meetings and the final Committee meeting in June 2004. As discussions within the Committee began to focus on individual elements of the rainbow trout and mountain whitefish flows, the package of flow changes in the lower Columbia River was given the more accurate title “Fish Friendly Flows (FFF)” to convey the message that it included both rainbow trout and mountain whitefish flow agreements.

Table 6-15: Alternatives Addressing Changing Treaty Flows

Alternative	Description	Restrictions
HYSIM alternatives from Table 6-14 above "+ Rbt2"	Flows below Hugh Keenleyside Dam shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement (including flow changes in the lower Columbia River and storage changes in Arrow Lakes Reservoir. No Libby swap is included, and Kinbasket Reservoir is unchanged.	January: Cap January outflows to no greater than 60 kcfs unless higher flow required to meet January flood control level or to limit the January volume reduction to no greater than 400 ksfd. February and March: Target smooth discharge over period while storing 1 MAF for flow augmentation for years where the January to July runoff at The Dalles is less than average. Flow augmentation storage further subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than target flow augmentation. April and May target smooth discharge over period subject to reservoir flood control with a discharge floor of 15 kcfs. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 438.8 m (1438 ft) at the end of May. June: Release 20 per cent of stored flow augmentation, subject to reservoir flood control. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 439.5 m (1442 ft) at the end of June. July: Release remaining flow augmentation. August: No additional activity (no assumed Libby swap). September to December: No additional activity (no assumed Libby swap).
HYSIM alternatives from Table 6-14 above "+ FFF"	Flows below Hugh Keenleyside Dam shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement (including flow changes in lower Columbia River and storage changes in Arrow Lakes Reservoir. No Libby swap is included and Kinbasket Reservoir is unchanged.	January: Cap January outflows to no greater than 60 kcfs unless higher flows required to meet January flood control level or to limit the January volume reduction to no greater than 400 ksfd. February and March: Target to store 1.0 MAF for United States flow augmentation when the 95 per cent confidence inflow volume (January to July) at the Dalles is below 90 MAF (this translated into flow augmentation required in about 60 per cent of the time) while target smooth discharge over period. Flow augmentation storage further subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent months to preserve flow augmentation. Therefore, some years will show less than target flow augmentation.

Table 6-15: Alternatives Addressing Changing Treaty Flows (cont'd)

Alternative	Description	Restrictions
HYSIM alternatives from Table 6-14 above "+ FFF" (cont'd)		April and May: Target smooth discharge over period subject to reservoir flood control with a discharge floor of 15 kcfs. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 438.3 m (1438 ft) at the end of May. Some Flow augmentation may be released due to this operation but no additional flow augmentation would be stored. June: Release 20 per cent of remaining (May) flow augmentation, subject to reservoir flood control. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 439.5 m (1442 ft) at the end of June. July: Release remaining flow augmentation. August: No additional activity (no assumed Libby swap. September: For years when September electricity price > October and November price assume United States draft 400 ksfd due to Whitefish Agreement. October: For years when September electricity price > October and November price assume United States returns 200 ksfd due to Whitefish Agreement. November: For years when September electricity price > October and November price assume United States returns 200 ksfd due to Whitefish Agreement.

Table 6-16 summarizes the Revelstoke Dam minimum flow constraints specified in the Round 5 operating alternatives.

Table 6-16: Round 5 Operating Alternatives – Flows at Revelstoke Dam

Minimum Flow	Description
5 kcfs	
Alt F – 5 kcfs	Maintain 5 kcfs except when Arrow Lakes Reservoir is at or above 438 m.

7 TRADE-OFF ANALYSIS AND CONSENSUS AGREEMENTS

7.1 INTRODUCTION

As required under Step 7 of the provincial government's *Water Use Plan Guidelines*, the Columbia River Water Use Plan Consultative Committee conducted a formal analysis of the trade-offs associated with the operating alternatives described in Section 6. The intent of the trade-off analysis was to seek the combination of operating and non-operating alternatives that best balance the impacts on the range of water use objectives specified in Section 4.

In addition to the general guidance provided for all of BC Hydro's water use planning programs in the provincial government's *Water Use Plan Guidelines* and related documents[1], the provincial government also directed the Columbia River Water Use Plan Consultative Committee to consider the following during their trade-off discussions.

In a letter dated 19 February 2001, the Chair of the Water Use Plan Steering Committee[2] provided the following direction to the Columbia River Water Use Plan Consultative Committee: "*The Province has made a policy decision that the magnitude of change it is willing to accept on the Peace and Columbia is smaller compared to other systems undergoing water use planning. In addition government by policy has set a cap on the funding to support the implementation of water use plans, so it is important to ensure funds are available for a wide range of projects. Government recognition of the high values of these river for power generation was articulated in its 1998 response to the BC Heritage River*

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[1] The interagency Water Use Plan Management Committee prepared a number of documents designed to build on the general guidance provided in the provincial government's *Water Use Plan Guidelines* and to provide specific guidance for BC Hydro's water use planning processes. Documents included: Principles of Water Use Planning for BC Hydro; Financing Water Use Plans (Background Paper); and Creating Water Use Plan Alternatives: Identifying Appropriate Issues and Developing Preferred Strategies.

[2] The *Water Use Plan Steering Committee* was one of the interagency committees responsible for managing BC Hydro's water use planning process. The Water Use Plan Management Committee was responsible for overall program co-ordination, while the Steering Committee guided the Management Committee and resolved outstanding process issues. The Water Use Plan Steering Committee provided policy and direction on public interests in the process of making trade-offs. The original membership of the Steering Committee included: the Assistant Deputy Minister of the Ministry of Environment, Lands and Parks, the Assistant Deputy of the Ministry of Fisheries, the Assistant Deputy Minister of the Ministry of Employment and Investment; the Executive Director of the Department of Fisheries and Oceans; the Director of the Crown Corporations Secretariat; and the Senior Vice President of Executive Operations and Senior Vice President of Power Supply at BC Hydro. Representation on the committee changed over the course of the water use planning process with re-organization of provincial government ministries and within BC Hydro.

Board, in which it endorses the Columbia and Peace remaining as working rivers compatible with natural heritage and recreational values."[1]

There was significant debate by the Columbia River Water Use Plan Consultative Committee over whether the water use planning process should be limited by the provincial government's estimated cost of the program (i.e., $50 million/year in lost revenue across of all BC Hydro's facilities). Committee members wished to know how the System Operating Fund (SOF) would be allocated across the 25 Water Use Plans, and what proportion they should assume to be available for the Columbia River Water Use Plan. A number of proposals for reasonable limits for this Water Use Plan were put forward, ranging from $1/25^{th}$ ($2 million/year) to 45 per cent of the SOF (corresponding to the percentage of BC Hydro's energy that is produced at the Columbia River facilities. Some members did not agree with limiting the process by the SOF because they felt that the federal government has a fiduciary responsibility to protect First Nations interests, as well as legal obligations with respect to heritage, fisheries and international agreements. Moreover, it was felt that the SOF is a notional figure developed for the purposes of internal accounting and should not constrain the work of the Committee, given the need to prepare for future renegotiation of the Columbia River Treaty, importance of local resources, and the need to articulate a long-term vision for the Basin. Other Committee members agreed with a funding cap and the notion of the Columbia River as a "working river", recognizing the incremental nature of the process and the need to ensure that the work of the Consultative Committee is not ignored at the end of the process. These participants felt that the Committee needs some idea as to the budget for alternatives as a way of focusing efforts on those changes that have the best chance of being implemented. The BC Hydro project team indicated the practical difficulties associated with modelling major changes to operations, since this would require co-ordination with associated changes on the Peace River system.

In the end, the Consultative Committee agreed to the following:

- The Committee recognizes that there are legal obligations that will need to be considered and, therefore, it is impossible at this time to set a firm upper bound on cost.

- The Committee may define alternatives that reflect participant's longer-term vision for the future of the Basin, unconstrained by budget considerations.

- The Committee recognizes that the provincial government designed the water use planning process with an upper limit on cost, and the Committee should consider the value of the SOF in developing its recommendations to

1 O'Riordon (February 19, 2001). *Letter to the Peace and Columbia River Water Use Plan Consultative Committees.* Refer to Appendix X: Correspondence from J. O'Riordan, Chair, Water Use Plan Steering Committee.

maximize the probability that their work and recommendations will be implemented.

- There should be two categories of alternatives, which are treated differently in the process: alternatives that likely fall outside the scope of water use planning that will receive qualitative assessment; and alternatives that are likely within scope that will receive more rigorous analysis.

The following sections describe the decision analysis and trade-off process and the resultant consensus agreements reached by the Consultative Committee regarding flow changes, reservoir constraints, monitoring studies, and physical works in lieu of operational changes. As noted in Section 6, the Committee conducted iterative rounds of alternative development and refinement. Initial efforts at defining alternatives, objectives, performance measures, and modelling approaches were exploratory in nature and did not involve any substantive trade-offs. The first substantive trade-offs made by the Committee occurred during their February 2002 meeting. The trade-off process is documented in a chronological sequence covering the February 2002, May 2002, June 2003, November 2003 and June 2004 Committee meetings (Sections 7.3–7.7). The reader is referred to Sections 4 and 6 for detailed definitions and rationale for modifications to the performance measures and operational alternatives, respectively.

Within each section, the discussion is structured around the geographic/operational focus of the trade-offs employed by the Consultative Committee table:

- Kinbasket/Arrow Lakes Reservoir balance.
- Arrow Lakes Reservoir/lower Columbia River balance.
- Flow constraints at Revelstoke Dam.

In addition to making recommendations around flow and reservoir constraints, the Consultative Committee also identified physical works to the system where these were a more cost-effective way of achieving an objective than constraining water management decisions. The Committee also put forward a set of monitoring recommendations to address uncertainties regarding operational impacts that were identified during the issue scoping phase and decision analysis. These monitoring programs recommended by the Committee were evaluated using the eligibility criteria for Water Use Plan monitoring studies (Stumborg, 2003; refer to Appendix Y: Eligibility Criteria for Water Use Plan Monitoring Studies). These non-operational alternatives and monitoring recommendations are highlighted throughout this section in the context of the trade-off discussions.

7.2 OVERVIEW OF ALTERNATIVE EVALUATION AND TRADE-OFF TOOLS

7.2.1 Hydrographs

For each proposed operating alternative, a set of hydrographs was developed to assist the Consultative Committee in understanding how specific reservoir constraints would impact the hydrological behaviour of the system in terms of monthly reservoir elevations and outflows. These were developed for each key region of interest in the Columbia River system, and included Kinbasket and Arrow Lakes reservoir elevations, Revelstoke and Arrow Lakes reservoir outflows, and flows at Trail (Arrow Lakes Reservoir outflows summed with Kootenay discharges).

As illustrated in Figure 7-1, use of a toggle tool allowed the Consultative Committee to compare any two alternatives at a specific location of interest, using a range of statistics for elevation or flow levels. These statistics included the 90th percentile, 50th percentile and 10th percentile to provide an indication of how an alternative would affect reservoir elevations or flow. These statistics do not represent a year of operation, but rather the probability that the reservoir will be at or lower than this level at that time of year.

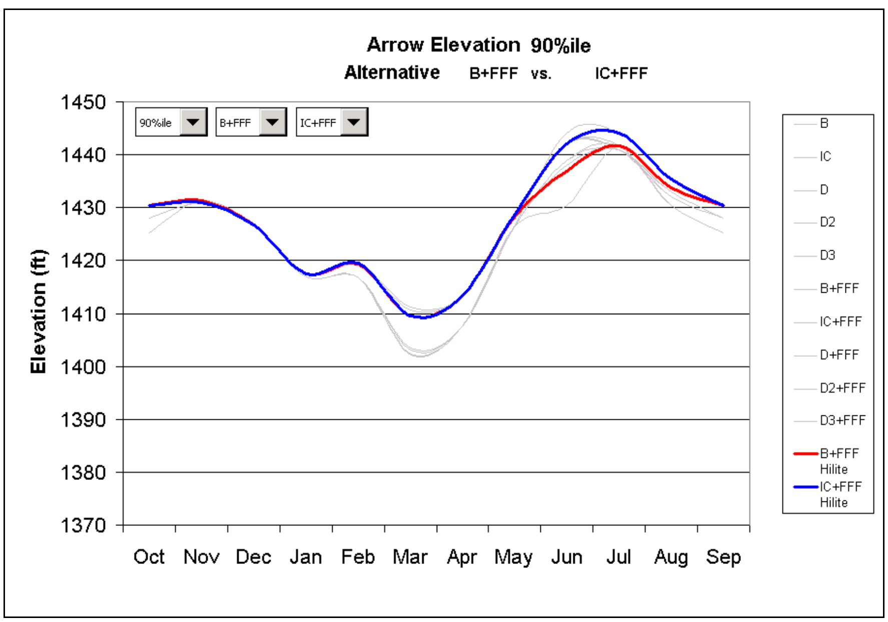

Figure 7-1: Example of Alternative Hydrographs

7.2.2 Consequence Tables

To assist the Consultative Committee in making value-based trade-offs, an explicit and systematic method was used to link the impact of the alternative hydrographs to the issues of interest identified by the Committee. As shown in

Table 7-1, consequence tables were used to present the impact of each operating alternative on the performance measures developed for each key objective.

Table 7-1: Example of a Consequence (Alternatives by Objectives) Table

Objective/Performance Measure	Units	What's Good	Signif. Diff	11B + FFF	11D + FFF	IC + FFF	11D2 + FFF	11D3 + FFF	Historic
Birds									
Summer/spring nesting (Short-eared Owl) (average)	% nesting habitat available	more	3	28	18	11	18	17	20
Shorebird Fall Migration (10%ile)	% habitat available	more	4	13	20	9	16	23	0
Fish									
Average annual minimum river length (average)	km	more	2	8	8	6	8	7	8
Lower Columbia River Whitefish flows	yes/no	yes		yes	yes	yes	yes	yes	no
Lower Columbia River Rainbow flows	yes/no	yes		yes	yes	yes	yes	yes	no
Littoral (see vegetation Performance Measure)	(see "Vegetation" Performance Measure)								

The first column of the consequence table lists the high-level objectives identified by the Consultative Committee that would help choose amongst operating alternatives (e.g., birds, fish). The second and third columns define the performance measure(s) for that objective, and the units by which performance is measured. These measures were developed at the Technical Subcommittee level and were, in many cases, further informed by studies conducted during Step 5 of the process (refer to Sections 4 and 5). In this example, measures of "what is good for birds" included spring/summer nesting habitat, and shorebird fall migration habitat. The fourth column "What's Good" shows the direction of preferred change for each performance measure. For Shorebird Fall Migration, providing a larger percentage of available habitat is better for the high-level objective of birds. The "Significant Difference" is the minimum amount by which any two alternatives must differ on a performance measure score before one alternative can be considered to perform significantly better than the other.

Subsequent columns of the consequence table show either the average or 10th percentile values of the performance measures over the period of simulation used for each operating alternative. As illustrated in Table 7-1, the assumed level of significant difference for percent habitat availability for shorebird fall migration is 4. For this performance measure, Alternatives 11D2+FFF and 11B+FFF could be considered tied since their scores (16 and 13, respectively) differ by less than the minimum significant difference. However, 11D2+FFF would be considered to provide significantly more habitat for fall migrants than IC+FFF since its score (16) is more than four units higher than that of IC+FFF (9).

The Technical Subcommittees were requested to report levels of significant difference for each performance measure within their area of expertise. The goal was to eliminate information that would not be useful in decision making, and thus more clearly highlight the important impacts and trade-offs for the Consultative Committee. In establishing the significant difference thresholds, consideration was given to:

- Statistical variation in inflows.
- Potential data quality limitations or measurement error.
- Potential modelling uncertainty.
- Confidence in the relationship between the performance measure (e.g., length of river) and the overall objective (fish abundance in the mid Columbia River).

In some cases, additional statistics and/or methods of presenting performance measure results were used at the technical subcommittee level. As shown in Figure 7-2, the Wildlife Technical Subcommittee was provided with more in-depth information around the impact of the proposed alternatives on nesting and fall migration habitat, using a range of statistics for those performance measures (e.g., 10th, 50th and 90th percentile).

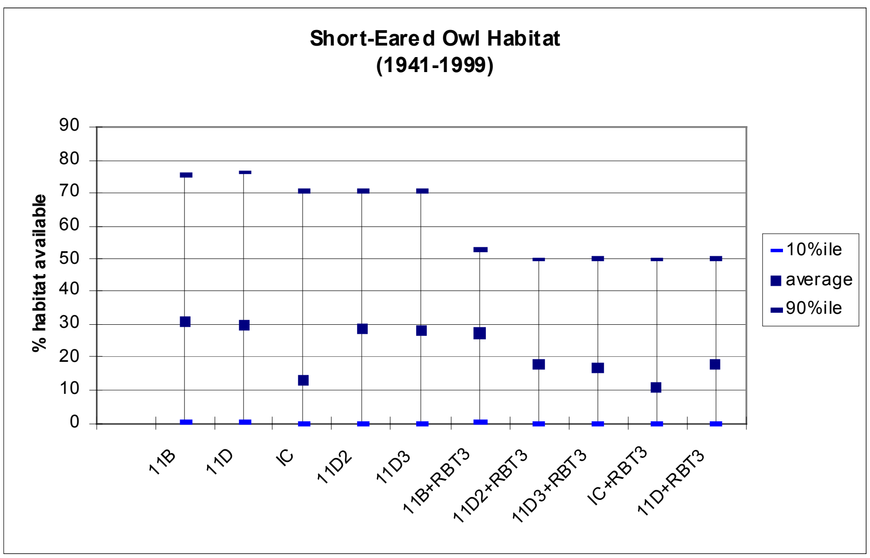

Figure 7-2: Detailed Performance Measure Information

For each performance measure, the Technical Subcommittees selected the statistic most useful for the Consultative Committee in its trade-off analysis based on the description of the objective and the performance measure. In cases where key trade-offs existed, the subcommittees were requested to provide additional information around impacts to further assist the Consultative Committee in their decision-making task.

For each Consultative Committee meeting, a brief description of the objectives and performance measures and a consequence table for those proposed alternatives being considered by the Committee was provided as background reading. In cases where the issues were complex or the trade-offs difficult, additional briefing notes were prepared by the BC Hydro project team to provide further insights from the Technical Subcommittee meetings. (Refer to Appendix C: List of Documents Generated during the Columbia River Water Use Planning Process.)

7.2.3 Interactive Consequence Table

Interactive consequence tables were also employed to assist the Consultative Committee in assessing trade-offs across alternatives for all performance measures simultaneously. As shown in Table 7-2, Committee members could highlight an alternative of interest and determine its strengths and weaknesses relative to all other alternatives. This technique used the definition of a significant difference to code alternatives that performed worse than the alternative of comparison (indicated in red), better than the alternative of comparison (indicated as green), and close to the alternative of comparison (indicated as yellow). It is readily apparent that 11D3+FFF dominates several other alternatives for the objective of birds, since the performance of other alternatives is tied with (yellow) or significantly worse than (red) 11D3+FFF. However, the chart also shows that the choice between 11D3+FFF and 11B+FFF requires a trade-off between some bird sub-objectives.

Table 7-2: Example of Interactive Consequence Table

Performance Measure	Alternative				
	11B+ FFF	11D+ FFF	IC+ FFF	11D2+ FFF	11D3+ FFF
Grassland Nesting Waterfowl (ave)	36	29	25	29	28
Ground Nesting (ave)	25	16	12	16	16
Late Nesting Waterfowl (ave)	20	13	8	13	12
Short-eared Owl (ave)	28	18	11	18	17
Shrub Nesting (ave)	49	39	29	38	38
Fall Migration (10%ile)	32	36	29	34	43
Shorebird Migration (10%ile)	13	20	9	16	23

7.3 ROUND 1 TRADE-OFF ANALYSIS, FEBRUARY 2002

During the June 2001 meeting, the Consultative Committee reviewed a broad range of alternatives that addressed a diverse set of interests across the Columbia River basin. At that time, the HYSIM modelling approach was still in development (see Section 6.6 for more details), and the performance measures used to assess these alternatives were in a preliminary stage of development. Consequently, the February 2002 meeting was the first opportunity for the Committee to review the modelling results in a comprehensive way.

The following section documents the results of these trade-off discussions, including a high-level description of the nine Round 1 operating alternatives modelled for the Consultative Committee, lessons learned from the performance measure results regarding the range of impacts associated with the alternative constraints, and the subsequent trade-off decisions made by the Committee.

7.3.1 Kinbasket/Arrow Lakes Reservoir Balance – Round 1

Alternatives 1, 2, 5, 10 and 11 were designed to explore alternative ways of operating Kinbasket and Arrow Lakes reservoirs through imposing different maximum and minimum elevations. Table 7-3 briefly describes these alternatives and the intended key objective of their constraints. Alternative 0 was used as a reference case representing Columbia River Treaty operations, with no further constraints.

Table 7-3: Alternatives for Kinbasket/Arrow Lakes Reservoir Balance – Round 1

No.	General Description
0	**Base Case.** Unconstrained reservoir and river operations to minimize the cost of power production, subject to Columbia River Treaty obligations.
1	**KIN Rec-Friendly.** This alternative is generally a "recreation-friendly" alternative on Kinbasket. Kinbasket Reservoir elevations are held higher through the recreation season.
2	**KIN Min Elev.** This alternative generally supports fish, navigation and recreation on Kinbasket Reservoir. It maintains a minimum elevation of 730 m year round.
5	**MCR No-Go Zone.** This alternative is designed to be recreation friendly in the mid Columbia River. It avoids Arrow Lakes Reservoir elevations at which neither shoreline nor water-based activities are possible on the mid Columbia River during the recreation season.
10	**ARR Consistently High.** This alternative is similar to Base Case on average, but raises summer elevations of wet/dry years through June-August. The goals are to increase pelagic productivity for fish and improve recreational quality.
11	**ARR Low.** This alternative holds Arrow Lakes Reservoir lower until mid July for various recreational benefits and to allow vegetation to extend downward and increase the length of flowing river.

Table 7-4 presents a consequence table highlighting the performance measure results for these Round 1 alternatives. Performance measure scores are presented for an average inflow year. Additional information for wet and dry years was also provided in tabular and chart format for review by the Consultative Committee.

Table 7-4: Consequence Table for Round 1 Operating Alternatives – Kinbasket/Arrow Lakes Reservoir Balance

Loc	Obj	Performance Measure	Units	What's Good?	Alt 1 Average Year	Alt 2 Average Year	Alt 5 Average Year	Alt 10 Average Year	Alt 11 Average Year	Alt 0 Average Year
Kinbasket Reservoir										
	Fish									
		Pelagic Productivity	kg carbon/year	more	5777	6096	5777	5505	5782	5777
		Littoral Productivity	kg carbon/year	more	480	664	480	396	479	480
	Wildlife/Aesthetics									
		Riparian Vegetation	ha	more	515	477	515	592	515	515
	Recreation									
		All Activities Total	Days met	more	209	231	209	174	209	209
	Flooding									
		Frequency of Surcharge > Full Pool	Days exceeded	less	0	0	0	0	0	0
	Navigability									
		All Sites Total	Days met	more	790	809	788	727	788	788
Revelstoke Reservoir										
	All									
		Probability of Emergency Drawdown	%	less	0	0	0	0	0	0
		Normal Drawdown	Min elevation	more	1880	1880	1880	1880	1880	1880
	Recreation									
		All Activities Total	Days met	more	108	108	108	108	108	108
	Flooding									
		Frequency of Surcharge > Full Pool	Days exceeded	less	0	0	0	0	0	0
Arrow Lakes Reservoir and Mid Columbia River										
	Fish									
		Pelagic Productivity	kg carbon/year	more	16540	16332	16577	16925	16339	16577
		Littoral Productivity	kg carbon/year	more	554	477	561	601	568	561
		Large River Habitat (Quantity)	km-weeks	more	449	445	447	405	511	447
		Large River Habitat (Quality) – Minimum Cont. Summer Flow cfs (May to August)	cfs	more	0	0	0	0	0	0
		Large River Habitat (Quality) – Minimum Cont. Winter Flow	cfs	more	0	0	0	0	0	0
		White Sturgeon Recruitment	Scale	more	0	0	0	0	0	0
	Wildlife/Aesthetics									
		Riparian Vegetation	ha	more	2539	2046	2539	2046	2934	2539
		Revelstoke Wetlands Bird Access	Days available	more	18	18	18	18	28	18
	Recreation									
		ARR All Activities Total	Days met	more	257	244	256	258	257	256
		MCR All Activities Total	Days met	more	153	153	153	153	153	153
	Flooding									
		Frequency of Surcharge > Full Pool	Days exceeded	less	11	12	12	15	0	12
Lower Columbia River										
	Fish									
		Diversity (Winter Flows: 1 December to 28 February)	Average cfs	less	63	61	63	63	63	63
		Rainbow Trout (Spring Flows Increase: 1 April to 30 June)	Yes/no	yes	yes	no	yes	no	yes	yes
		White Sturgeon (Summer Flow: 1 July to 31 August)	Average cfs	more	107	110	108	111	106	108
		Total Gas Pressure Threshold	Days at risk	less	47	57	52	70	14	52
	Flooding									
		Impacts at Genelle	Days exceeded	less	0	0	0	0	0	0
	Recreation									
		All Activities Total	Days met	more	443	421	443	358	506	443
System-wide										
	Power Generation									
		Annual Power Value Loss	$million/year	less	-16	-25	-2	-12	-23	0
		Columbia River Treaty Violated	Yes/no	no	no	no	no	no	no	no

To help the Consultative Committee in discerning overall differences in impacts across the range of operating alternatives, the consequence table provided an aggregation of some performance measures for a particular objective. However, in some cases, consolidation into a summary metric resulted in no apparent significant net gain or loss under the proposed alternatives. Consequently, there was a need to disaggregate the data to reveal information about specific impacts of the alternatives on the Committee's interests. Table 7-5 presents the disaggregated results for the recreation performance measures for each recreation activity/attribute tracked under each alternative.

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

- Alternative 5 was initially designed to be recreation friendly in the mid Columbia River by keeping Arrow Lakes Reservoir out of its middle elevation zone that benefits neither shore-based nor water-based recreation. However, as the Recreation Technical Subcommittee refined their understanding of desirable thresholds for recreation, it became apparent that recreation benefits were ambiguous. There was little change in recreation quality in the mid Columbia River under this alternative, there were no large benefits discernible for other interests, and the cost of annual foregone power was approximately $2 million. **Consequently, the Consultative Committee decided to eliminate this alternative from further consideration.**

- While Alternative 10 was designed to improve pelagic productivity, littoral productivity and recreation quality in Arrow Lakes Reservoir, the modelling results indicated only a small increase in productivity, and no significant difference in the number of recreation days in Arrow Lakes Reservoir relative to the Base Case. However, in a wet year, boat access increased significantly under Alternative 10. Recreation conditions in Kinbasket Reservoir were worse for all activities in all years , and navigability also decreased at all sites in the reservoir. On the lower Columbia River, there were fewer shoreline use and boat access days under this alternative. Much of the $12 million annual cost of this alternative is the result of bringing a few exceptionally dry years into compliance with the elevation targets**. Given that the main goals of improving pelagic and littoral productivity in Arrow Lakes Reservoir were not met, there were no other large unintended benefits and the costs of implementing Alternative 10 would be high, the Consultative Committee agreed to eliminate this alternative from further consideration.**

Table 7-5: Disaggregated Performance Measure Scores for Kinbasket Reservoir Recreation

Loc	Obj	Performance Measure	Units	What's Good?	Alt 1			Alt 2			Alt 5			Alt 10			Alt 11			Alt 0		
Kinbasket Reservoir					Dry Year	Avg Year	Wet Year	Dry Year	Avg Year	Wet Year	Dry Year	Avg Year	Wet Year	Dry Year	Avg Year	Wet Year	Dry Year	Avg Year	Wet Year	Dry Year	Avg Year	Wet Year
	Recreation																					
		Viewshed Quality	Days met	more	0	0	15	0	0	16	0	0	13	0	0	0	0	0	21	0	0	15
		Shoreline Use	Days met	more	17	52	72	26	56	72	0	52	70	0	40	62	0	52	72	0	52	72
		Boat Access (General)	Days met	more	96	95	97	108	108	108	90	95	97	86	85	91	96	95	97	96	95	97
		Boat Access (South Kinbasket)	Days met	more	40	62	77	51	67	78	21	62	75	5	49	72	40	62	77	37	62	77
		All Activities Total	Days met	more	153	209	261	185	231	274	111	209	255	91	174	225	136	209	267	133	209	261

- The main benefits of Alternative 1 were improved shoreline use in dry years, and slightly better boat access in the south of Kinbasket Reservoir in the worst years. Because Alternative 1 tends to hold Kinbasket Reservoir higher, and therefore Arrow Lakes Reservoir lower, it also resulted in an increase in large river habitat in the mid Columbia River and a loss of recreation-days on Arrow Lakes Reservoir through impacts on viewshed quality. The annual cost of this alternative was estimated at about $16 million.

- Alternative 2 resulted in improvements to pelagic and littoral productivity, as well as recreation and navigability benefits. As it does not significantly alter the upper elevations of Kinbasket Reservoir, the recreation benefits were realized in increased boat access rather than in improvements to view quality or shoreline use. This alternative also resulted in improvements in large river habitat and riparian vegetation in the mid Columbia River. Its main drawback was the financial cost, which was estimated at $25 million per year. There was also a slight reduction in recreation days in Arrow Lakes Reservoir and on the lower Columbia River.

- While both Alternatives 1 and 2 provided benefits that are valued by the Consultative Committee, the foregone power generation was a concern for Committee members. It was agreed that the benefits of these alternatives did not justify the costs of achieving them through changing the management of the reservoirs. The Committee instructed the BC Hydro project team to determine whether most of the benefits could be delivered and most of the costs avoided if the constraints could be removed in a few expensive years. If this was not possible, the Committee agreed that these alternatives should be dropped. This question of cost variability and flexibility in imposing the constraints of Alternatives 1 and 2 was reviewed at the May 2002 Consultative Committee meeting, and was explored again in the context of Arrow Lakes Reservoir operating alternatives in later meetings.

- By keeping Arrow Lakes Reservoir lower for longer in the spring and early summer, Alternative 11 increased the length of the mid Columbia River, provided more available habitat for nesting birds, and enhanced vegetation establishment in the Revelstoke Wetlands. However, a number of Consultative Committee members felt that many of these benefits could be delivered at a much lower cost than the estimated $23 million if the constraints around Alternative 11 could be refined. These changes were modelled subsequent to the February 2002 meeting, and reviewed at the May 2002 Consultative Committee meeting.

7.3.2 Arrow Lakes Reservoir/Lower Columbia River Balance – Round 1

While the balance between Kinbasket and Arrow Lakes reservoirs was modelled with a cross-border flow fixed by the Columbia River Treaty, a number of Consultative Committee members expressed a desire to explore flows in the lower Columbia River (from Hugh Keenleyside Dam to the International Boundary) that deviated from Treaty flows. Alternative 7 was defined broadly as a "fish friendly" flow alternative that involved modifying the flow regime in the lower Columbia River by increasing summer flows and decreasing winter flows for the primary purpose of achieving fish benefits (refer to Table 7-6).

Table 7-6: Alternatives for Arrow Lakes Reservoir/Lower Columbia River Balance – Round 1

No.	General Description
7	**LCR Fish Friendly.** This alternative would achieve the preferred fish hydrograph on the lower Columbia River through modifications to Arrow Lakes Reservoir elevations. These flows would depart from Columbia River Treaty flows and would require a negotiated agreement from the United States.

Table 7-7 presents the consequence table highlighting the performance measure results for this Round 1 alternative.

Table 7-7: Consequence Table for Round 1 Operating Alternatives – Arrow Lakes Reservoir /Lower Columbia River Balance

Loc	Obj	Performance Measure	Units	What's Good?	Alt 0 Average Year	Alt 7 Average Year
Kinbasket Reservoir						
	Fish					
		Pelagic Productivity	kg carbon/year	more	5777	5742
		Littoral Productivity	kg carbon/year	more	480	490
	Wildlife/Aesthetics					
		Riparian Vegetation	ha	more	515	515
	Recreation					
		All Activities Total	Days met	more	209	205
	Flooding					
		Frequency of Surcharge > Full Pool	Days exceeded	less	0	0
	Navigability					
		All Sites Total	Days met	more	788	783
Revelstoke Reservoir						
	All					
		Probability of Emergency Drawdown	%	less	0	0
		Normal Drawdown	Min elevation	more	1880	1880
	Recreation					
		All Activities Total	Days met	more	108	108
	Flooding					
		Frequency of Surcharge > Full Pool	Days exceeded	less	0	0

Table 7-7: Consequence Table for Round 1 Operating Alternatives – Arrow Lakes Reservoir /Lower Columbia River Balance (cont'd)

Loc	Obj	Performance Measure	Units	What's Good?	Alt 0 Average Year	Alt 7 Average Year
Arrow Lakes Reservoir and Mid Columbia River						
	Fish					
		Pelagic Productivity	kg carbon/year	more	16577	17361
		Littoral Productivity	kg carbon/year	more	561	675
		Large River Habitat (Quantity)	km-weeks	more	447	225
		Large River Habitat (Quality) – Minimum Cont. Summer Flow cfs (May to August)	cfs	more	0	0
		Large River Habitat (Quality) – Minimum Cont. Winter Flow	cfs	more	0	0
		White Sturgeon Recruitment	Scale	more	0	0
	Wildlife/Aesthetics					
		Riparian Vegetation	ha	more	2539	2046
		Revelstoke Wetlands Bird Access	Days available	more	18	27
	Recreation					
		ARR All Activities Total	Days met	more	256	255
		MCR All Activities Total	Days met	more	153	153
	Flooding					
		Frequency of Surcharge > Full Pool	Days exceeded	less	12	22
Lower Columbia River						
	Fish					
		Diversity (Winter Flows: 1 December to 28 February)	Average cfs	less	63	50
		Rainbow Trout (Spring Flows Increase: 1 April to 30 June)	Yes/no	yes	yes	yes
		White Sturgeon (Summer Flow: 1 July to 31 August)	Average cfs	more	108	122
		Total Gas Pressure Threshold	Days at risk	less	52	169
	Flooding					
		Impacts at Genelle	Days exceeded	less	0	0
	Recreation					
		All Activities Total	Days met	more	443	307
System-wide						
	Power Generation					
		Annual Power Value Loss	$million/year	less	0	?
		Columbia River Treaty Violated	Yes/no	no	no	yes

Since Alternative 7 was not fully defined by the Fish Technical Subcommittee and the performance measures needed to assess this alternative were preliminary in nature, the Consultative Committee was not able to arrive at any conclusions. However, general discussions around achieving rainbow trout flow agreements drew the Consultative Committee's attention to the negotiated link between flows that benefit rainbow trout in the summer in the lower Columbia River and the storage of extra water in Arrow Lakes Reservoir for higher cross-border flows in July to August to benefit U.S. salmon. The Committee raised the possibility that this extra storage in Arrow Lakes Reservoir might lead to additional spilling at Hugh Keenleyside Dam, thereby increasing TGP production downstream.

The BC Hydro project team was subsequently tasked with exploring the impact of Arrow Lakes Reservoir operations and the lower Columbia River "fish friendly flows" on TGP production. In addition, the Fish Technical Subcommittee was tasked with further defining fish performance measures for the lower Columbia River and its "fish friendly flow" alternative to determine how much of the desired hydrograph could be achieved within the constraints of the Columbia River Treaty. Several Committee members were also interested in exploring flow changes that would benefit white sturgeon in the lower Columbia River. The modelling results of Alternative 7 made it clear that rainbow trout flows would not significantly benefit their interests for sturgeon.

Discussions at the Committee table led to the identification of three types of flow constraints in the lower Columbia River that would be used to guide the Committee's focus for the remainder of the water use planning process.

1. Flow changes that can be achieved unilaterally by BC Hydro. These included operations that flex water between Kinbasket and Arrow Lakes reservoirs, while maintaining Columbia River Treaty Flows, and flow changes in the lower Columbia River achieved through non-Treaty storage operations. The Consultative Committee agreed that these flow changes would be the focus of this water use planning process, and that discussions, agendas and study budgets would reflect this.

2. Flow changes that require agreement from the U.S. These may violate the Treaty but have a reasonable probability of being successfully negotiated. These would include previous agreements such as the rainbow trout flows and the mountain whitefish flows.

3. Flow changes that require agreement from the U.S., but that do not have a significant probability of being agreed to. These would include flow changes that Canada would want but would be contrary to United States interests, or new flow change proposals that have not been proven in previous negotiations.

For the first category, the Consultative Committee adopted the assumption that consensus recommendations would become constraints on BC Hydro's water licence when ordered by the Water Comptroller. For the second and third categories, the Committee accepted that the nature of annual negotiations meant that these would remain as recommendations and not become licence constraints. For the third category, the Committee expressed an interest in outlining a vision to assist in BC Hydro's discussions with the United States, but agreed that more detailed studies, modelling and consideration around such alternatives would not be pursued within the water use planning process.

7.3.3 Flow Constraints at Revelstoke Dam – Round 1

The Consultative Committee examined opportunities for constraining operations at Revelstoke Dam to achieve fish and wildlife benefits in the mid Columbia River. As outlined in Table 7-8, the Round 1 flow alternatives involved the provision of year-round and seasonal minimum flows and reduced ramp rates.

Table 7-8: Revelstoke Dam Alternatives – Round 1

Alternative	General Description
3a	**MCR Min Flow 5000 all year.** This alternative provides a minimum flow through Revelstoke of 5000 cfs all year.
3b	**MCR Min Flow 5000 Summer Only.** This alternative provides a minimum flow through Revelstoke Dam of 5000 cfs for the growing and recreation season.
4a	**MCR Ramp 500 All Year.** This alternative restricts ramping rates at Revelstoke Dam (the rate at which flow rate is allowed to change) to 500 MW per hour all year.
4b	**MCR Ramp 100 Summer Only.** This alternative restricts ramping rates at Revelstoke Dam (the rate at which flow rate is allowed to change) to 100 MW per hour for the growing and recreation season.

Table 7-9 presents the consequence table highlighting the performance measure results of the Round 1 flow alternatives for Revelstoke Dam.

Table 7-9: Consequence Table for Round 1 Flow Alternatives – Revelstoke Dam

Loc	Obj	Performance Measure	Units	What's Good?	Alt 0 Average Year	Alt 3a Average Year	Alt 3b Average Year	Alt 4a Average Year	Alt 4b Average Year
Kinbasket Reservoir									
	Fish								
		Pelagic Productivity	kg carbon/year	more	5777	Performance measure scores for Alt 3a–4b are the same as under Alt 0 status quo			
		Littoral Productivity	kg carbon/year	more	480				
	Wildlife/Aesthetics								
		Riparian Vegetation	ha	more	515				
	Recreation								
		All Activities Total	Days met	more	209				
	Flooding								
		Frequency of Surcharge > Full Pool	Days exceeded	less	0				
	Navigability								
		All Sites Total	Days met	more	788				
Revelstoke Reservoir						Performance measure scores for Alt 3a–4b are the same as under Alt 0 status quo			
	All								
		Probability of Emergency Drawdown	%	less	0				
		Normal Drawdown	Min elevation	more	1880				
	Recreation								
		All Activities Total	Days met	more	108				
	Flooding								
		Frequency of Surcharge > Full Pool	Days exceeded	less	0				
Arrow Lakes Reservoir and Mid Columbia River									
	Fish								
		Pelagic Productivity	kg carbon/year	more	16577				
		Littoral Productivity	kg carbon/year	more	561				
		Large River Habitat (Quantity)	km-weeks	more	447				
		Large River Habitat (Quality) – Minimum Cont. Summer Flow cfs (May to August)	cfs	more	0				
		Large River Habitat (Quality) – Minimum Cont. Winter Flow	cfs	more	0	5000	5000	0	20000
		White Sturgeon Recruitment	Scale	more	0	5000	0	0	0

Table 7-9: Consequence Table for Round 1 Flow Alternatives – Revelstoke Dam (cont'd)

Loc	Obj	Performance Measure	Units	What's Good?	Alt 0 Average Year	Alt 3a Average Year	Alt 3b Average Year	Alt 4a Average Year	Alt 4b Average Year
Arrow Lakes Reservoir and Mid Columbia River (cont'd)									
	Wildlife/Aesthetics					Performance measure scores for Alt 3a–4b are the same as under Alt 0 status quo			
		Riparian Vegetation	ha	more	2539				
		Revelstoke Wetlands Bird Access	Days available	more	18				
	Recreation								
		ARR All Activities Total	Days met	more	256				
		MCR All Activities Total	Days met	more	153				
	Flooding								
		Frequency of Surcharge > Full Pool	Days exceeded	less	12				
Lower Columbia River									
	Fish								
		Diversity (Winter Flows: 1 December to 28 February)	Average cfs	less	63				
		Rainbow Trout (Spring Flows Increase: 1 April to 30 June)	Yes/no	yes	yes				
		White Sturgeon (Summer Flow: 1 July to 31 August)	Average cfs	more	108				
		Total Gas Pressure Threshold	Days at risk	less	52				
	Flooding								
		Impacts at Genelle	Days exceeded	less	0				
	Recreation								
		All Activities Total	Days met	more	443				
System-wide									
	Power Generation								
		Annual Power Value Loss	$million/year	less	0	-2.5	-1.8	-8.3	-13.0
		Columbia River Treaty Violated	Yes/no	no	no				

Alternatives 3a and 3b were developed with the primary goal of increasing the quality of large river fish habitat in the mid Columbia River by implementing a continuous minimum flow, with possible additional aesthetic and recreational benefits. While the Consultative Committee valued the improvements achieved through these alternatives, the annual costs of implementing these flow constraints ($1.8 million – $2.5 million) were considered high. The Fish Technical Subcommittee was tasked with refining both the performance measures, and exploring whether minimum flows need to be provided year round.

Alternatives 4a and 4b were developed with the aim of increasing the quality of large river habitat through imposing ramping rates at Revelstoke Dam. While Alternative 4a reduces the ramp rate year round to about half of what it is under the Base Case, it provided little biological benefit since flows still varied from 0 to 60 kcfs on a daily basis. Further, implementation of this flow alternative would cost about $8.3 million per year. Alternative 4b reduces the ramp rate to about one tenth of what it is under the Base Case, but only for a critical summer season (beginning of May to end August). Notwithstanding the cost of implementing Alternative 4b ($13 million per year), the Consultative Committee expressed some interest in this option because of the benefits it would provide through reducing the magnitude of the daily flow fluctuation as a result of the reduced ramp rate. The Committee tasked the Fish Technical Subcommittee with further exploring alternatives that impose a constraint on the maximum flow as opposed to the ramp rate, with the objective of achieving most of the benefits at a lower cost.

At this stage in the trade-off analysis, the Consultative Committee viewed the exploration of flow regimes in the mid Columbia River as a high priority for the Columbia River Water Use Plan. However, the Committee expressed concerns that changes in operations at Revelstoke Dam might cause unacceptable negative impacts on the productivity of Revelstoke Reservoir. Consequently, the Committee requested that further study be undertaken to identify potential effects of the flow alternatives on reservoir water retention time and thermocline, and related implications to reservoir productivity.

Information gained from this preliminary trade-off exercise was used to help focus the Consultative Committee's discussions and efforts in areas where opportunities for gains were most likely to exist. In preparation of the next Committee meeting on May 2002, the BC Hydro project team, in collaboration with the Technical Subcommittees, drafted a series of study proposals aimed at addressing the information gaps highlighted during the February 2002 meeting. The results of these studies were then used to further refine alternatives and performance measures (refer to Section 5).

7.4 ROUND 2 TRADE-OFF ANALYSIS, MAY 2002

During the second round of the trade-off analysis, the Consultative Committee reviewed the four Round 1 operating alternatives for Kinbasket and Arrow Lakes reservoirs (Alts 0, 1, 2 and 11), and evaluated five new Round 2 alternatives developed for Revelstoke Dam. These trade-off discussions assisted the Committee in evaluating the alternatives in light of new information gained through the Step 5 studies, eliminating those alternatives that were clearly dominated by other alternatives, and developing new alternatives for Round 3 that would better meet Committee member's values and balance the competing objectives.

7.4.1 Kinbasket/Arrow Lakes Reservoir Balance – Round 2

As no new alternatives were modelled for Kinbasket or Arrow Lakes reservoirs for the May 2002 meeting, the Round 2 trade-off discussions focused on reviewing queries of the Consultative Committee posed during their February 2002 meeting.

The Consultative Committee expressed an interest in determining whether the high costs of Alternatives 1, 2 and 11 were being driven by a small number of years, and whether it was possible to relax the constraints in these years to achieve approximately the same benefits at a much lower cost. The BC Hydro project team reported that, under Alternatives 1 and 11, there are single years when a large portion of the cost is incurred. This was not the case for Alternative 2. Furthermore, even if the most expensive year for each alternative could have its costs adjusted down to average, each alternative would still be delivering small benefits at a large cost. A summary of these costs is presented below in Table 7-10.

Table 7-10: Costs of Alternatives With and Without Extreme Cost Years

Alternative	Average Annual Cost ($ million)	Adjusted Average Annual Cost ($ million)
1	$16	$10
2	$25	$20
11	$23	$19

Based on these results, the Consultative Committee confirmed that the benefits delivered by Alternatives 1 and 2 for recreation, navigation, pelagic and littoral productivity in Kinbasket Reservoir and large river habitat in the mid Columbia River did not justify the cost of foregone power. **Consequently, the Committee agreed that these alternatives should be eliminated from further consideration, and that it was more effective to stop exploring water management options for Kinbasket Reservoir and start to look for more cost effective non-operational works to achieve these environmental and social benefits.**

Consultative Committee's Recommendations Regarding Restrictions on Kinbasket Reservoir

Recommendation	Comments
The Consultative Committee recommended that no additional operating constraints be placed on Kinbasket Reservoir.	None.

Since the costs for Alternative 11 were not likely to be reduced by selectively relaxing the constraints in high cost years, the Consultative Committee requested that the constraints for Alternative 11 be refined to achieve the same benefits at a lower cost.

7.4.2 Arrow Lakes Reservoir/Lower Columbia River Balance – Round 2

During the May 2002 Consultative Committee meeting, no new alternatives or modelling information was introduced for this portion of the Columbia River system. Discussions at the Committee table focused on identifying ways of achieving specific elements of the preferred hydrograph to benefit fish interests in the lower Columbia River. The Committee agreed that efforts should focus on alternatives that could either be achieved unilaterally by BC Hydro, or alternatives that would require negotiation with the United States but have a reasonable probability of being accepted. It was recognized that the Columbia River Water Use Plan could provide direction to BC Hydro about priorities to pursue in negotiations with the United States, but the success of achieving these flow agreements would be uncertain.

Subsequent to the May 2002 meeting, the Fish and Wildlife Technical Subcommittee gained further clarity around specific flow alternatives for the lower Columbia River, and concluded that the primary interests included:

- Reducing the magnitude of daily/weekly flow fluctuations.
- Stabilizing or increasing flows in April–June.
- Reducing the magnitude and variability of winter flows.
- Providing high June–July flows.

Two new alternatives were modelled using 1 and 2 MAF of extra storage in Arrow Lakes Reservoir through the non-power use agreement to achieve these hydrograph improvements (Alt 7-1MAF, Alt 7-2MAF). It became apparent to the Technical Subcommittee that it was not possible to derive any meaningful performance measures linking flows in the lower Columbia River to the fish objectives. Subsequent work of the subcommittee focused on identifying and prioritizing a set of flow options that could be negotiated by BC Hydro and could be placed on any of the operating alternatives being considered for the Kinbasket/Arrow Lakes Reservoir balance. Consequently, the modelling results of Alt 7-1MAF and Alt 7-2MAF were not presented to the Consultative Committee.

7.4.3 Flow Constraints at Revelstoke Dam – Round 2

Four new alternatives were modelled for the May 2002 Committee meeting. These are briefly described below in Table 7-11.

Table 7-11: Flow Constraints at Revelstoke Dam – Round 2

Alternative	General Description
1a	**MCR Ramp 200 All Year.** This alternative restricts ramping rates to 200 MW per hour for the growing and recreation season.
2a	**MCR and Mica Ramp 200 All Year.** This alternative restricts ramping rates to 200 MW per hour for the growing and recreation season for both Revelstoke and Mica dams.
3a	**Max Flow Change of ± 10 kcfs.** This alternative sets the maximum range of flow change to 20 kcfs during June to August, centred around the monthly flow averages, for Revelstoke Dam.
4a	**Max Flow Change of ± 10 kcfs.** This alternative sets the maximum range of flow change to 20 kcfs during June to August, centred around the monthly flow averages, for Revelstoke and Mica dams.
5a	**Summer Min Flow of 5 kcfs at Revelstoke.** This alternative restricts summer minimum flows at Revelstoke Dam to 5 kcfs from June through August.

Alternatives 1a and 2a were developed as a compromise to Round 1 Alternative 4b that provided some benefits but was very expensive and Alternative 4a that did not deliver any benefits. Based on discussions of the Fish Technical Subcommittee, it was concluded that these intermediate ramping rates would not deliver any discernible benefits to the river downstream of Revelstoke Dam, since they still allowed daily flows to fluctuate from 0 kcfs to 60 kcfs. Further, it was concluded that the absolute change in flows is most likely the determinant of habitat quality, not ramp rates. Since ramping restrictions were an expensive way to manage river flows, did not directly address the link between flow fluctuations and fish habitat, and did not deliver any significant benefits at their lower ranges, **the Consultative Committee recommended that ramping restrictions be eliminated from further consideration.**

The Fish Technical Subcommittee hypothesized that the range of flow change in the river below Revelstoke Dam was a significant factor affecting the quality of fish habitat. Alternatives 3a and 4a were developed to address this directly by limiting the maximum flow change during the growing season. These alternatives were also designed to specifically address whether matching constraints at both Revelstoke and Mica dams would be required to avoid significant changes in water level fluctuations in Revelstoke Reservoir. The primary concern of the Subcommittee was possible implication on water retention time and thermocline and related impacts on productivity of the reservoir. Alternative 3a imposed restrictions at Revelstoke Dam only, while Alternative 4a imposed restrictions at both Revelstoke and Mica dams. Table 7-12 presents the key outcomes of a high-level discussion at the Consultative Committee table about these impacts.

Table 7-12: Impacts of Revelstoke Dam Operating Constraints on Revelstoke Reservoir and Costs

Impact	Base Case	Alt 1a	Alt 2a	Alt 3a	Alt 4a	Alt 5a
Change in flows below Revelstoke Dam	na	No improvement	No improvement	Significant Improvement	Same as Alt 3a	Improvement
Change in elevation in Revelstoke Reservoir	na	Not decided by Fish Technical Subcommittee	Not decided by Fish Technical Subcommittee	Possible improvement, impact on retention and thermocline is unclear	Same as Alt 3a, impact on retention and thermocline is unclear	Same as Base Case
Annual Power Value Impact or Loss ($ million)	na	$3.1	$6.2	$3.8	$10.9	$0.5

As shown in Table 7-12, the addition of flow constraints on Mica Dam operations provides no benefit to Revelstoke Reservoir or flows below Revelstoke Dam. However, such restrictions impose large costs on the operations. The Consultative Committee agreed that, unless there were some impacts on water retention time and the thermocline of Revelstoke Reservoir, additional constraints at Mica Dam would not be required in the context of constraining flows at Revelstoke Dam.

This issue was addressed through a study undertaken during Step 5 of this water use planning process (Leake, 2002; refer to Section 5.8), which concluded that neither retention time or thermal characteristics of the reservoir would be affected by flow constraints at Revelstoke Dam. On review of these results by the Fish and Wildlife Technical Subcommittee in the fall of 2002, the Consultative Committee agreed to drop this as an issue and that further constraints on Mica Dam operations would not be required.

Consultative Committee's Recommendations on Ramping Rate Restrictions at Revelstoke Dam

Recommendation	Comments
Based on recommendations of the Fish Technical Subcommittee, the Consultative Committee agreed that ramping rate restrictions should not be placed on Revelstoke Dam operations.	The Committee wished to continue exploring minimum flow constraints at Revelstoke Dam.

A high-level assessment by the Fish Technical Subcommittee suggested that a reduction in flow fluctuations downstream of the dam (Alternative 3a) and a summer minimum flow constraint (Alternative 5a) both had the potential to deliver fish habitat improvements in the mid Columbia River. Further, Alternative 3a could result in a reduction in Revelstoke Reservoir fluctuations. As a result, the Consultative Committee agreed that both alternatives merited further detailed consideration.

7.5 ROUND 3 TRADE-OFF ANALYSIS, JUNE 2003

Refined modelling requests and new study results allowed the Consultative Committee to make more substantive trade-off decisions at the June 2003 Committee meeting. Round 3 of the trade-off analysis involved evaluating two new alternatives for Arrow Lakes Reservoir, a new modelling approach for exploring fish friendly flows in the lower Columbia River, and six new minimum flow alternatives for Revelstoke Dam.

7.5.1 Kinbasket/Arrow Lakes Reservoir Balance – Round 3

At the request of the Consultative Committee at their May 2002 meeting, constraints of Alternative 11 were modified based on input from the Fish, Wildlife, Recreation, and Culture and Heritage subcommittees with the goal of providing the same environmental and social benefits within the Arrow Lakes Reservoir drawdown zone at a lower cost. With information gained through Step 5 studies, further clarity was gained around preferred monthly maximum elevations to benefit these interests. Table 7-13 summarizes the Round 3 alternatives for Arrow Lakes Reservoir that were evaluated by the Consultative Committee.

Table 7-13: Alternatives for Kinbasket/Arrow Lakes Reservoir Balance – Round 3

		Maximum Month End Arrow Lakes Reservoir Elevations					
Alternative	**Description**	**May**	**June**	**July**	**August**	**September**	**October**
Base Case	Base Case is the unconstrained Columbia River Treaty operation. It is somewhat different from the original Base Case due to modelling refinements.	–	–	–	–	–	–
11B	Alt 11B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in the spring to improve vegetation potential, large river habitat, and bird habitat.	436.0 m 1430.0 ft	436.0 m 1430.0 ft	–	437.0 m 1434.0 ft	436.0 m 1430.0 ft	436.0 m 1430.0 ft
11D	Designed to reduce costs of Alt 11B by relaxing the June constraint and allowing earlier fill, but pushing the reservoir down faster than Alt 11B in the fall.	436.5 m 1432.0 ft	438.3 m 1438.0 ft	–	436.5 m 1432.0 ft	435.3 m 1428.0 ft	–

Alternatives 11B and 11D were achieved primarily through flexing of water between Kinbasket and Arrow Lakes reservoirs. While the impact of imposing these Arrow Lakes Reservoir constraints on Kinbasket were relatively small, these constraints had a marked impact on the rising and falling limbs of the hydrograph for Arrow Lakes Reservoir. As illustrated in Figure 7-3, the constraints of Alternatives 11B and 11D can change the monthly average elevations by almost 10 feet in wet years. Although not shown in this figure, these same constraints had no discernible impact on monthly average elevations in years when water levels are low.

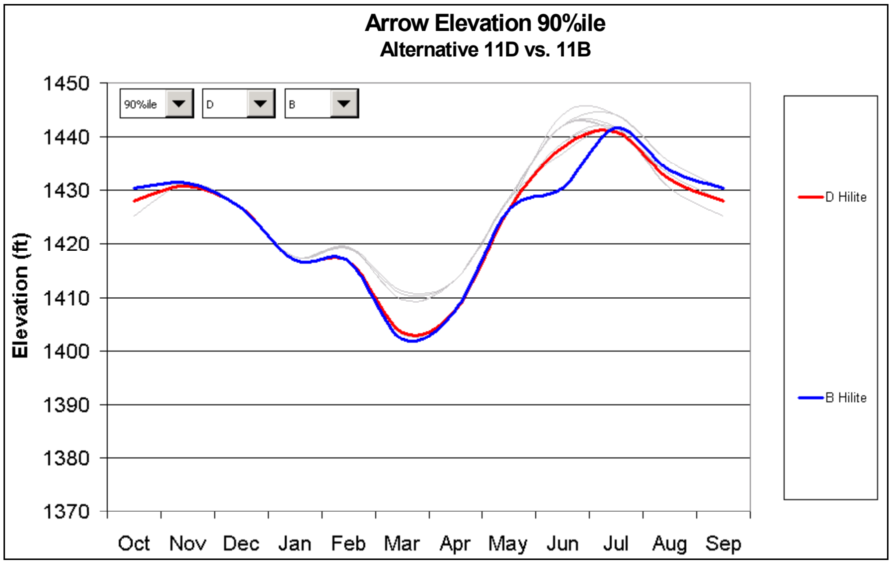

Figure 7-3: Arrow Lakes Reservoir Monthly 90th Percentile Elevations, Alternative 11D vs. 11B

Table 7-14 presents the consequence table highlighting the performance measure results for Round 3 alternatives (11B, 11D and Base Case). Comparisons between the alternatives were made based on a number of performance measures that were refined based on the Consultative Committee's objectives for the Arrow Lakes Reservoir drawdown zone and the mid Columbia River, and information gained through Step 5 studies. A detailed description of these measures is provided in Section 4.

Performance measure results for fish interests in the lower Columbia River are not presented in the consequence table, as they did not show any significant difference across the range of alternatives. Further, the Fish Technical Subcommittee recognized that there was considerable uncertainty around the meaning of the performance measures to the fish objectives. It was agreed that these performance measures should be removed and set as flow options that could be placed on any alternative.

For most of the performance measures, the consequence table presents median values to simplify evaluation of the alternatives, since ranking of the alternatives was the same regardless of whether the 10th, 50th or 90th percentile values were used. The Recreation Technical Subcommittee determined that the most relevant statistic for reporting on the recreation performance measures was the 10th percentile values.

Table 7-14: Consequence Table for Round 3 Operating Alternatives – Kinbasket/Arrow Lakes Reservoir Balance

Loc Obj Performance Measure	Units	What's Good?	Alt 0B (Base Case)	Alt 11B	Alt 11D
Arrow Lakes Reservoir/Mid Columbia River Vegetation					
Grass Area (430–434)	Hectare lost/gained	more	0	0	0
Grass Biomass (434–437)	Scale	more	-1	1	0
Shrub Growth (>437)	Scale	more	-1	1	1
Fish					
MCR Prod Area (Reach 3)	Hectare-weeks	more	14400	16800	15600
LCR Whitefish and Rainbow Flows	Yes/no	yes	no	no	no
Littoral	See "Vegetation Grass Biomass"				
Recreation					
KIN REC	Thousands $/year	more	0	64	134
MCR REC	Thousands $/year	more	2974	5905	5309
ARR REC	Thousands $/year	more	0	0	0
LCR REC	Thousands $/year	more	1484	1208	1371
KIN NAV	Site-days/year	more	740	733	768
Heritage					
ARR Water Erosion	# days above 1430	less	147	91	84
ARR Wind Erosion	See "Vegetation Grass Area"	less			
Flood					
ARR Surcharge	# days surcharge	less	1	0	0
LCR Flooding	# days at Genelle	less	0	0	0
Power Generation					
Annual Power Value Loss	Millions $/year	less	0.0	10.0	2.8

*Note: Bird performance measure scores were not presented to the Consultative Committee, as it became clear that modifications to the performance measures were needed to better reflect the impacts of reservoir operations on fall migratory bird habitat and nesting mortality. Further, it was recognized that physical works in lieu should be explored as a cost-effective means of minimizing impacts on bird habitat.

The following summarizes the highlights of the Round 3 trade-off discussions.

- Alternative 11B delivered the greatest benefits for wildlife (vegetated area), fish (productive area), heritage (water erosion and vegetated area), and flooding (inundation) in Arrow Lakes Reservoir and the mid Columbia River because it was the most restrictive in monthly maximum reservoir elevations during the spring and fall periods. Through limiting the timing and duration of inundation in the upper portions of the drawdown zone during the growing season, the area would be allowed to act as a wetland, encouraging expansion of vegetation and thus promoting wildlife and fish values, reducing erosion and dust storms, and protecting existing archaeological sites. However, because this alternative would impose the strictest constraints on reservoir operations, its cost ($10 million per year) was also the highest.

- As Alternative 11D imposed less severe restrictions on maximum reservoir elevations, it delivered fewer environmental benefits than 11B but at a substantially lower cost ($2.8 million per year).

- The Base Case alternative imposed no constraints on Arrow Lakes Reservoir operations and therefore delivered the fewest environmental and social benefits, and risked losing the existing levels of vegetation that have become established within the drawdown zone.

It became apparent that there was no "win-win" solution for environmental, social and economic interests in Arrow Lakes Reservoir and the mid Columbia River, and the Consultative Committee was faced with a trade-off. The Committee indicated that no one alternative commanded universal support by Committee members, and no one alternative was universally disliked by members.

During discussions around the apparent trade-off between power generation and vegetation in the Arrow Lakes Reservoir drawdown zone, a better understanding of reservoir operations and vegetation emerged. Based on input from the vegetation specialist for the Wildlife Technical Subcommittee, it became apparent that the vegetated areas in the drawdown zone did not need to remain exposed during the growing season every year. In fact, eliminating full pool events permanently through maximum reservoir constraints would destroy the wetland nature of the upper drawdown zone and cause a shift to a more terrestrial environment. The vegetation in these areas could withstand prolonged inundation provided that reservoir operations allowed for drier conditions in subsequent years.

Because the understanding around vegetation interests was still evolving, the Consultative Committee postponed making decisions around balancing Kinbasket and Arrow Lakes reservoirs. The BC Hydro project team and the Wildlife Technical Subcommittee were tasked with creating an alternative that would maintain the current level of vegetation (i.e., that which became established in response to recent historic water levels, 1990–1999) in Arrow Lakes Reservoir from elevation 434 to 440 m (1424 to 1444 ft) through flexible constraints that would allow the reservoir to occasionally inundate its upper elevation zones. The constraints of this new "inundation control" alternative were discussed at the Committee meeting, and are presented in Table 7-15. In developing these constraints, it was explicit that vegetation establishment below 434 m (1424 ft) was the result of a unique period of low water events in Arrow Lakes Reservoir between 1990 and 1999, and that this could not be guaranteed across all water conditions in the future.

Table 7-15: Definition of the Inundation Control Alternative

Alternative	Description	Constraints
Inundation Control (IC)	Performance-based constraint limits inundation duration directly (not through Arrow Lakes Reservoir elevations). Derived from recent conditions (1990–1999) that produced current vegetation.	Arrow Lakes Reservoir cannot exceed 436 m for > 36 weeks over any 2 years; or > 48 weeks over any 3 years. Arrow Lakes Reservoir cannot exceed 438 m for > 10 weeks over any 1 year; > 19 weeks over any 2 years; or > 25 weeks over any 3 years.

The Consultative Committee also requested that a new alternative (11F) be modelled to deliver greater benefits in the drawdown zone than Alternative 11D but at a lower cost than Alternative 11B. This compromise was sought by imposing a stricter May constraint, reducing the June constraint of Alternative 11D, and removing all fall constraints.

Given the value of foregone power generation associated with the alternatives developed for the Arrow Lakes/Kinbasket Reservoir balance, the Consultative Committee recognized that physical works in lieu of operational changes may be a more cost-effective means of achieving environmental and social benefits. A list of proposed physical works were brought forward for discussion by the Committee. These included:

- Boat ramps on Kinbasket and Arrow Lakes reservoirs.
- Debris management on Kinbasket Reservoir.
- Archaeological protection within the drawdown zones of Kinbasket and Arrow Lakes reservoirs.
- Bird islands and other works for wildlife interests in the Revelstoke Wetlands.
- Revegetation of the drawdown zones of Kinbasket and Arrow Lakes reservoirs.

The Consultative Committee tasked the relevant Technical Subcommittees and the BC Hydro project team to develop proposals around these issues, including high-level estimates of costs and benefits.

Preliminary work on developing strategies for revegetation of the drawdown zones of Kinbasket and Arrow Lakes reservoirs (AIM Ecological and CARR Environmental, 2003a, 2003b) was presented to the Consultative Committee. This highlighted areas around the reservoirs and the mid Columbia River that are potentially suitable for vegetation establishment or enhancement, and the estimated costs of implementing these works. It was recognized that planting options might change as more information is gained around site suitability, the interaction between revegetation and other interests (e.g., presence of archaeological sites, recreational use of the drawdown zone), and selection of a final operating alternative. Table 7-16 summarizes the preliminary estimates for planting and enhancement works and associated costs. A more detailed description of the planting programs is provided in Appendices Z and AA).

Table 7-16: Description of Proposed Revegetation Programs

Area	Area for Potential Planting (ha)	Area for Potential Vegetation Enhancement (ha)	Total Cost over 5 Years (undiscounted) ($million)
Kinbasket Reservoir	1800	1500	$2.0
Mid Columbia River	530	1000	$0.6
Arrow Lakes Reservoir	700	500	$1.5

The Consultative Committee agreed that the planting program should be designed to benefit all of the interests, and that a distinction needs to made between this program and the current dust control programs. It was noted that while there will be a need to continue planting fall rye for dust control at the lower elevations, the need to plant/seed for dust control will eventually diminish as more stable permanent vegetation becomes established.

The Consultative Committee supported the general scope and magnitude of the proposed planting programs, and agreed that the estimated costs would form a financial envelope to undertake these works subject to the caveats noted above. The Committee also placed some strict guidelines around the revegetation program by establishing the following criteria.

- The goal of the program is to achieve a self-sustaining vegetated area within five years of treatment. Areas that do not have this potential will not be considered for treatment. [1]
- The funds are specifically allocated to each geographic region and should not be moved between areas.
- Respect for archaeological sites containing First Nations' artifacts must be observed. A protocol will need to be developed to ensure that revegetation efforts do not harm archaeological sites.
- Dust control is a high priority.

[1] Later in the Columbia River water use planning process, the Consultative Committee recognized the need for public consultation to ensure that recreational use of the drawdown zone did not threaten the success of the revegetation program. The cost of public consultation was not included in the estimated costs of the revegetation program.

Consultative Committee's Recommendations Regarding Revegetation Efforts in Kinbasket and Arrow Lakes Reservoirs, and the Mid Columbia River

Recommendation	Comments
The Consultative Committee recommended that revegetation efforts be undertaken in the drawdown zone of Kinbasket and Arrow Lakes reservoirs, and the mid Columbia River to achieve self-sustaining vegetated areas within five years of treatment.	The Committee agreed to a maximum funding cap of approximately $4.1 million over five years, and set out principles by which the planting programs should be implemented. The Committee also agreed that the current dust control program in the mid Columbia River will need to be maintained.

7.5.2 Arrow Lakes Reservoir/Lower Columbia River Balance – Round 3

The Fish and Wildlife Technical Subcommittee developed a set of seasonal flow management options for the lower Columbia River aimed at achieving a number of fish objectives identified by the Consultative Committee. As the Committees gained a clearer understanding about what was achievable through operational changes and the Columbia River Treaty, and around the links between operational changes and the end points of interest, a number of the flow options were dropped from consideration. Discussions at the June 2003 Committee meeting focused on flow management for mountain whitefish, rainbow trout and white sturgeon, and ramping rates at Hugh Keenleyside Dam (refer to Figure 7-4). Other key interests that were highlighted as priorities earlier in the process such as sculpins and dace were set aside as topics that should be addressed through life history studies and other monitoring programs to provide better information for future decision-making.

As requests for white sturgeon flows and the possible approaches to examining ramping and stranding issues in the lower Columbia River were still at a conceptual stage, no specific alternatives were discussed by the Consultative Committee. The Fish Technical Subcommittee was tasked with developing a detailed plan around testing possible flow changes to address these issues for the following Consultative Committee meeting.

By the June 2003 Consultative Committee meeting, the BC Hydro project team had developed a new approach to modelling preferred flow options for the lower Columbia River. This replaced the former approach where the Columbia River alternative (Alt 7) was treated separately from the rest of the system. The rainbow trout and mountain whitefish flows were modelled in such a way that they could be appended as one flow change package to any of the HYSIM alternatives run for the Kinbasket/Arrow Lakes reservoirs balance. This was accomplished by reshaping flows below Hugh Keenleyside Dam to provide a more accurate representation of how actual flow agreements with the United States impact other interests upstream in Arrow Lakes Reservoir and the mid Columbia River. A description of the "+Rbt" alternative is provided below in Table 7-17.

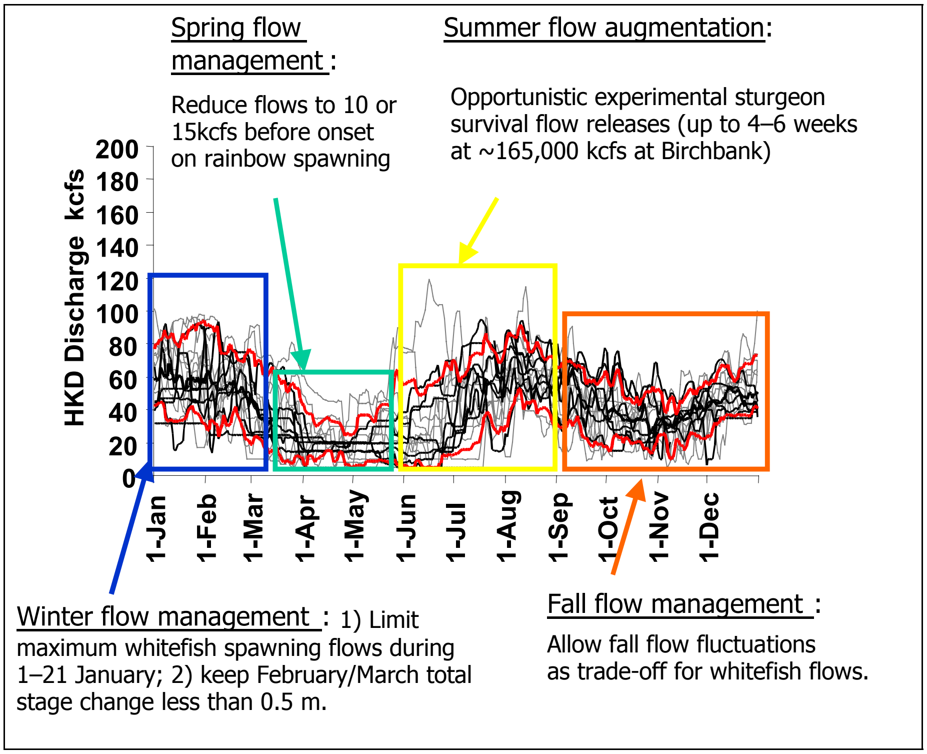

Figure 7-4: Seasonal Flow Management Options on the Lower Columbia River

Table 7-17: Definition of the Lower Columbia River Flows ("+Rbt") – Round 3

Alternative	Description	Detailed Specification
Any HYSIM alternative "+ Rbt"	Flows below Hugh Keenleyside Dam are shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement (including flow changes in the lower Columbia River and storage changes in Arrow Lakes Reservoir). Kinbasket Reservoir is unchanged.	Cap January outflows to 60 kcfs for the mountain whitefish agreement. February to March: Target smooth discharge over period while storing 1 MAF for flow augmentation subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than 1 MAF flow augmentation. April to May: Target smooth discharge over period subject to reservoir flood control as per above and with a discharge floor of 15 kcfs for the rainbow trout agreement. June: Release up to one-half of stored flow augmentation, subject to reservoir flood control. This is for the rainbow trout agreement. July: Release remaining flow augmentation for the rainbow trout agreement. August: Draft additional 220 ksfd (equal to swapping 10 feet of Libby water) for the Libby/Arrow swap. October to December: Return August draft at rate of 55 ksfd per month for the Libby/Arrow swap.

The modelling results of these alternatives highlighted a new issue of concern for the Consultative Committee. To minimize potential egg losses of mid-timed rainbow trout spawners, the objective is to provide stable, non-decreasing flows from 1 April to 30 June. Since this flow change deviates from Treaty flows, this must be negotiated with the United States. In previous years, BC Hydro has secured these flows by providing up to 1 MAF of storage in Arrow Lakes Reservoir for higher cross-border flows in May to July for United States salmon flow augmentation. As shown in Figure 7-5, the addition of rainbow trout and mountain whitefish flow agreements to Alternative 11B +Rbt results in the reservoir being approximately 7 ft higher in the early spring period during high water years. This is due to the need to store 1 MAF of water by early April as part of the rainbow trout agreement, which causes the maximum elevation constraints in the spring to be exceeded. Because of potential gains that could be achieved for environmental and social interests in Arrow Lakes Reservoir by holding the reservoir elevation lower in the spring, this highlighted a key trade-off for the Consultative Committee. The imposition of the mountain whitefish flows, which caps the January (whitefish spawning period) Arrow Lakes Reservoir outflows, must also be negotiated with the United States. BC Hydro has in recent years been able to secure this flow by providing the United States with additional flow flexibility during the September to December period. Because the effects of this flow flexibility were not modelled for the Round 3 analysis (only in Round 5), the whitefish flows appeared to have little impact on the hydrograph of Arrow Lakes Reservoir.

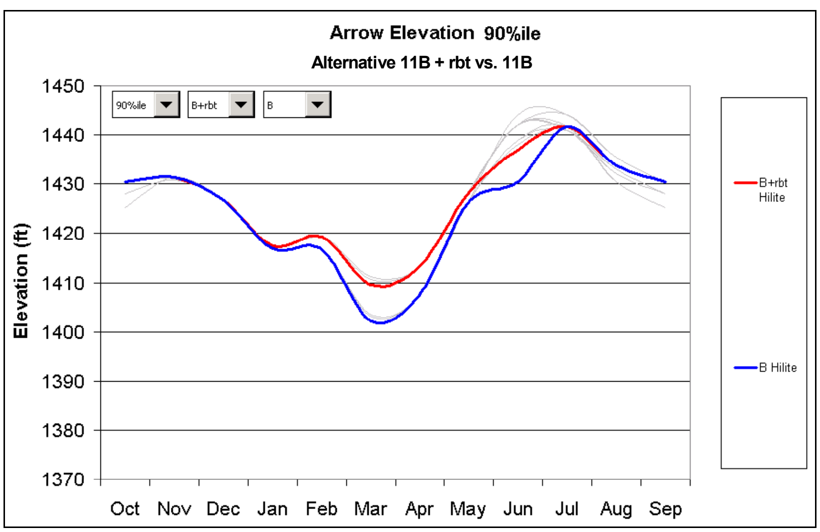

Figure 7-5: Response of Arrow Lakes Reservoir Elevations to Storage for Rainbow Trout Flows

Since specific flow conditions around the rainbow trout agreement differ from year to year, no quantitative performance measures could be developed linking flow changes to the endpoints of interest. Rather, the Consultative Committee was presented with a more qualitative chain of reasoning to assess the expected outcome of continuing these flows.

The performance measures derived for the Arrow Lakes Reservoir drawdown zone, however, allowed the Committee to track the impact of these lower Columbia River flow agreements on interests in Arrow Lakes Reservoir. Table 7-18 presents the consequence table highlighting the impacts of the +Rbt alternatives.

Table 7-18: Consequence Table for Round 3 Operating Alternatives – Arrow Lakes Reservoir/Lower Columbia River Balance

Performance Measure	Units	What's Good?	0B (Base Case)	11B	11D	0B+ RBT	11B+ RBT	11D+ RBT
Arrow Lakes Reservoir Wildlife and Vegetation								
Grass Area (430–434)	Hectare lost/gained	more	0	0	0	-1000	-1000	-1000
Grass Biomass (434–437)	Scale	more	-1	1	0	-1	-1	-1
Shrub Growth (>437)	Scale	more	-1	1	1	-1	1	1
Fish								
MCR Prod Area (Reach 3)	ha-weeks	more	14400	16800	15600	13300	15600	15600
LCR Whitefish and Rainbow Flows	Yes/no	yes	no	no	no	yes	yes	yes
Littoral	See "Veg Grass Biomass"							
Recreation								
KIN REC	Thousands $/year	more	0	64	134	0	64	134
MCR REC	Thousands $/year	more	2974	5905	5309	3609	5742	5451
ARR REC	Thousands $/year	more	0	0	0	1067	0	1067
LCR REC	Thousands $/year	more	1484	1208	1371	1233	1127	1213
KIN NAV	Site-days/year	more	740	733	768	740	733	768
Heritage								
ARR Water Erosion	# days above 1430	less	147	91	84	Not calculated		
ARR Wind Erosion	See "VEG Grass Area"	less						
Flood								
ARR Surcharge	# days surcharge	less	1	0	0	1	0	0
LCR Flooding	# days at Genelle	less	0	0	0	0	0	0
Power								
Annual Power Value Loss	Millions $/year	less	0.0	10.0	2.8	0.0	10.0	2.8

The BC Hydro project team estimated that there would be a power cost in implementing the mountain whitefish flow agreement but a power benefit in implementing the rainbow trout flow agreement. Although there is a high degree of uncertainty in the financial impacts due to the assumed negotiated outcomes of these agreements, the project team concluded that the net financial impact would be approximately zero. However, as shown in the consequence table, approximately 1000 ha of vegetated area within the drawdown zone between elevations 430 and 434 m (1411 and 1424 ft)and an unquantified area of vegetation between 434 and 437 m (1424 and 1434 ft) would be lost to achieve the lower Columbia River fish flow agreements.

The Consultative Committee deferred making decisions around the lower Columbia River flows until the Fish Technical Subcommittee developed a monitoring program to accompany these flow changes. Although it was agreed by the subcommittee that rainbow trout flows have been a key policy success for fish interests below Hugh Keenleyside Dam, it is unclear whether these flows are required every year to maintain or enhance the population. A long-term commitment to monitoring was considered critical to acceptance of this assumption. The link between whitefish flow implementation and changes in populations is even less defined, and the Fish Technical Subcommittee agreed that longer term data are needed to determine limiting factors to this population and establish relationships between the flow policy and population levels. As a result, the Consultative Committee tasked the subcommittee with developing an adaptive management approach to inform on these critical data gaps.

The Consultative Committee also requested that the Wildlife Technical Subcommittee and the BC Hydro project team further refine the vegetation and wildlife performance measures for Arrow Lakes Reservoir to assist in further evaluating the trade-off between flow management for rainbow trout in the lower Columbia River and operating strategies for vegetation and other interests in Arrow Lakes Reservoir.

7.5.3 Flow Constraints at Revelstoke Dam – Round 3

In the months following the May 2002 Consultative Committee meeting, the Fish Technical Subcommittee met several times to discuss flow constraints at Revelstoke Dam, define performance measures that would address fish interests in the mid Columbia River, and review the modelling results. The subcommittee reviewed hypotheses around what factors could be limiting fish populations in the mid Columbia River, and concluded that evaluations should focus on:

- Alternative minimum flow policies at Revelstoke Dam rather than restrictions on maximum flows or the range of flow change as it is believed that fish energetic requirements may be driven more by the difference in daily/weekly velocity than by the absolute maximum velocity. A minimum flow would reduce the difference in velocity and provide continuously wetted habitat. A reduction in maximum flow would reduce velocity differences, but would not provide continuously wetted habitat.

- Exploring a set of year-round minimum flow constraints as opposed to part-year flow policies (e.g., minimum flows for summer only or winter only), as the latter would provide for colonization of wetted habitat for only a portion of the year.

Recommendation	Comments
The Fish Technical Subcommittee, on behalf of the Consultative Committee, recommended that maximum flow change restrictions should not be placed on Revelstoke Dam operations.	The subcommittee agreed to focus their efforts on exploring a set of year-round minimum flow constraints at Revelstoke Dam.

Four new alternatives were modelled to determine the impact of implementing a 0, 5, 10 and 15 kcfs minimum flow at Revelstoke Dam[1]. These alternatives were modelled under Arrow Lakes Reservoir operating Alternatives 0B (Base Case) and 11B to determine whether the reservoir operating regime had any effect on the impacts of minimum flow constraints and vice versa.

At its April 2003 meeting, the Fish Technical Subcommittee concluded that the performance measure scores were approximately 15 per cent greater (better) when Arrow Lakes Reservoir was operated under more severe constraints (Alternative 11B) compared to Base Case. This small difference led the Subcommittee to conclude that the benefits to the mid Columbia River from keeping Arrow Lakes Reservoir low were relatively minor, and that the large river benefits in the mid Columbia River should not drive decisions around reservoir operations. Further, the *relative* difference between the minimum flow alternatives remained unchanged from Alternative 11B to Alternative 0B – Base Case. In other words, the Consultative Committee could make decisions around minimum flow constraints independently of any decisions around the operating regime of Arrow Lakes Reservoir.

Modelling results of the year-round minimum flow alternatives revealed that there would be greater fish habitat gains in the mid Columbia River when Arrow Lakes Reservoir is low and backwatering is minimal during the winter-spring period. Smaller gains would be realized when the reservoir is at near full pool and backwatering affects the majority of the mid Columbia River. Further, the greatest effects of a minimum flow would occur in the 10 km reach of the river immediately below Revelstoke Dam where there is neither the distance, influence of tributary inflow, nor influence of reservoir backwatering to attenuate the impact of dam operations. Benefits achieved through a minimum flow would be greatly reduced in the lowest 30 km of the river due to the effect of tributary inflows and reservoir elevations.

To address this reach and seasonal variation in habitat response to a minimum flow, the Fish Technical Subcommittee developed three seasonally adjusted flow

[1] The Fish Technical Subcommittee also requested that a 20 kcfs minimum flow alternative be modelled. However, preliminary modelling indicated that this alternative would affect the operation of Williston Reservoir, a factor that indicates large costs. For the purpose of the next round of analysis, only the 0, 5, 10 and 15 kcfs alternatives were modelled.

alternatives (A, C, E) to explore ways to maximize gains while minimizing cost. These alternatives are described below in Table 7-19.

Table 7-19: Specifications for Revelstoke Dam Minimum Flow Constraints by Season – Round 3

Alternative	October to April (kcfs)	May to September (kcfs)
0	0	0
5	5	5
10	10	10
15	15	15
A	5	0
C	5	10
E	10	5

Using performance measure results based on wetted area, productive area and maximum velocity difference (refer to Section 4.10.2.3) and expert judgment, the Fish Technical Subcommittee evaluated each of the minimum flow alternatives. Each alternative was scored against the ecological and learning objectives using the scale defined in Table 7-20 as a means of determining whether some alternatives could be eliminated from further consideration.

Table 7-20: Scoring Scales for Revelstoke Dam Minimum Flow Alternatives – Round 3

	Ecological Scale	Learning Scale
Objectives	● Maximize Ecological Productivity ● Increase Juvenile Habitat Use ● Maximize Adult Abundance/ Condition/Growth/Fecundity ● Trigger Rainbow Trout Spawning	Maximize learning about fish response to flow
Scale		
-2	Negative and detectable effect on the population likely (>75 per cent)	N/A
-1	Negative effect on population likely (>75 per cent) but likely not detectable	N/A
0	No net change	No learning
1	Habitat benefits possible, population response unlikely	Information sufficient to provide supportive arguments, but insufficient to justify flow decisions in absence of other data
2	Habitat benefits likely (>75 per cent), population response moderately likely (>50 per cent) but not detectable	Information quality sufficient to make qualitative inferences and inform decisions
3	Population response likely (>75 per cent) and detectable	Information quality sufficient to distinguish quantitatively among competing hypotheses and provide strong rationale for decisions

Table 7-21 presents the consequence table highlighting the ranking of each minimum flow alternative against the ecological and learning objectives.

Table 7-21: Ranking of Revelstoke Dam Minimum Flow Alternatives – Round 3

ALT	Productive Area (ha-days)	Max Daily Velocity Difference (m^3/s)	Cost [1] (millions $/year)	ECOL PROD	JUV	ADULT	RBT	LEARN
0	14 387	0.64	0	0	0	0	0	0
5	17 917	0.46	1.5	3	1–2	2	1	1
10	19 183	0.34	3.2	3	2–3	2	1	N/A
15	20 300	0.25	6.4	3	3	2–3	2–3	3
A 5-0	16 990	0.50	0.8	1–2	0–1	1	-1–0	0
C 5-10	18 316	0.42	2.5	3	2	2	1	2
E 10-5	18 784	0.38	2.2	3	1–2	2	1	N/A

[1] Due to a modelling error, these costs are only 50 per cent of the properly estimated costs. This error was corrected for the November 2003 Consultative Committee meeting.

Note: Shaded rows are alternatives that are dominated or practically dominated by at least one other alternative that scores better on all other performance measures.

A number of lessons emerged from a detailed analysis of these data.

- Investigations undertaken prior to the Columbia River water use planning process suggested that a minimum flow of 2500 cfs posed some threshold, beyond which greater flows produced diminished benefits to fish habitat in the mid Columbia River. More detailed flow modelling using unsteady flow analysis[1] indicated that no such breakpoint existed. Rather, a relatively linear relationship existed between minimum flows and performance measure scores.

- Some of the flow alternatives were dominated by others. For example, a 10 kcfs minimum flow provided approximately the same environmental benefits as Alternative C (5–10 kcfs) but at a higher cost. Since the 10 kcfs flow alternative was dominated by Alternative C, it could be removed without any trade-offs being made. Similarly, Alternative E (10–5 kcfs) was dominated by Alternative C (5–10 kcfs), and could be removed from consideration.

[1] Steady flow analysis assumes that the discharge at each cross-section of the river is the same as what is released at the dam, but does include the effects of local discharge (tributary input). The steady flow analysis does not include effects of wave attenuation. The unsteady flow analysis includes the effects of both tributary inputs and wave attenuation.

A figure of the remaining alternatives was presented to the Consultative Committee. As illustrated in Figure 7-6, increasing the environmental benefits of a minimum flow alternative comes at an increasing cost.

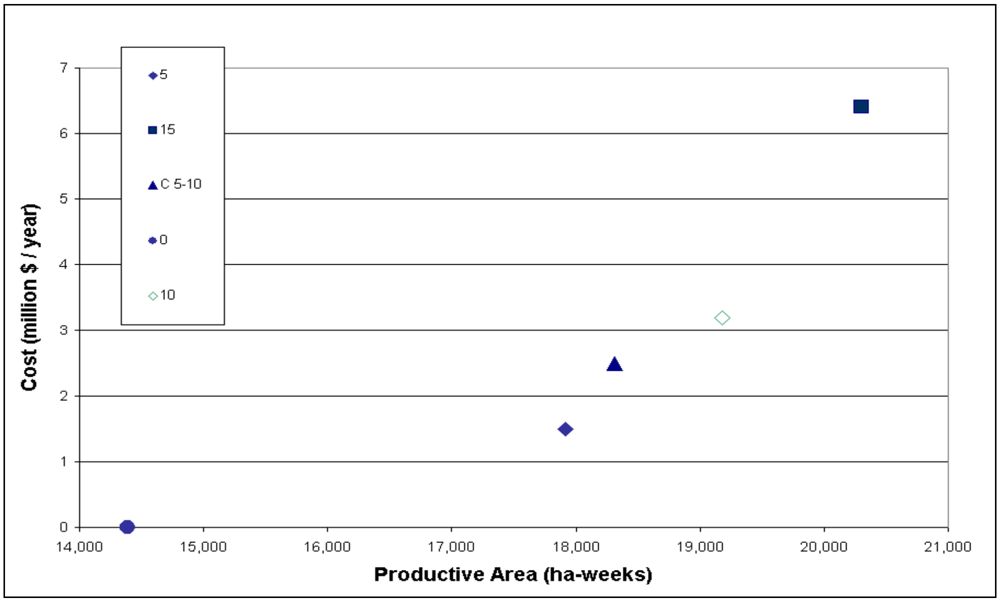

Figure 7-6: Costs vs. Benefits of the Revelstoke Dam Minimum Flow Alternatives

During these discussions, it was highlighted that the Fish Technical Subcommittee had a high degree of confidence that there would be a beneficial response in primary productivity (Productive Area performance measure) to a minimum flow, which would have benefits for a number of fish species. However, knowledge of the relationship between fish and flow in the mid Columbia River is limited, and there is uncertainty about the response of specific species, the magnitude of the response, and the ability of monitoring programs to detect the response. Given the range of expected outcomes and uncertainty in the predictions, the Consultative Committee was faced with a trade-off regarding the value of power generation they thought should be given up to achieve environmental benefits. The Committee formally ranked the alternatives based on their perception of the best value for fish benefits for cost. The results of this poll are presented in Table 7-22. Based on these results, it became apparent that neither a high minimum flow (10 kcfs of higher) or low minimum flow (less than 5 kcfs year round) could form the basis of a consensus agreement.

Table 7-22: Level of Support for Revelstoke Dam Minimum Flow Constraints – Round 3

Member	0	5-0	5	5-10	10	15
1	3	2	1	3	3	3
2	1	2	3	4	4	4
3	1	2	3	4	4	4
4	6	4	3	1	2	5
5	5	1	2	3	4	6
6	6	4	2	1	2	5
7	1	2	3	4	4	4
8	4	4	2	4	1	3
9	1	2	3	3	3	3
10	2	5	1	3	4	5
11	5	3	1	2	3	5
12	1	3	3	3	2	3
13	6	5	4	2	2	1
14	6	5	2	4	1	3
15	6	5	3	4	1	2
16	6	5	2	4	1	3
17	5	5	3	4	2	1
18	5	4	1	1	1	5
19	3	2	1	4	5	6
20	1	3	3	3	2	3
21	6	4	3	1	5	2
22	6	4	5	2	1	3
23	1	3	4	2	5	6
24	2	1	3	4	5	6
25	1	2	2	2	2	2
26	4	4	1	2	3	4
27	5	6	3	2	1	3
28	3	2	3	1	3	3
29	1	4	2	3	4	4
30	1	2	3	6	4	5

While a 5 kcfs minimum flow received the greatest support from the Consultative Committee, some members questioned the value of enhancing fish habitat in the mid Columbia River and felt that efforts should be focused elsewhere in the system. Other Committee members did not support the 5 kcfs minimum flow either because of the high costs and uncertain benefits, or because they preferred a higher flow to increase the chance of delivering and detecting a change.

It was recognized by the Consultative Committee that development of a robust monitoring program to assess the effectiveness of flow treatment would be critical to acceptance of the 5 kcfs flow alternative. Moreover, given the cost of implementing this minimum flow constraint, the monitoring program would need to be conducted within a reasonable time frame and within a reasonable cost to inform on its success or failure. The Committee agreed that a suitable period of baseline monitoring would be required prior to implementation of the minimum flow, and that post-treatment monitoring should be conducted for a length of time required to deliver reasonable information about fish response. **Subject to an acceptable monitoring program being developed, the Consultative Committee agreed to a 5 kcfs minimum flow constraint at Revelstoke Dam.**

During discussions, it was highlighted that any flow alternatives to benefit white sturgeon recruitment in the mid Columbia River would be of a much greater magnitude than the year-round minimum flow alternatives being considered by the Consultative Committee. While the Fish Technical Subcommittee was still working with the Upper Columbia White Sturgeon Recovery Team in defining a recommended flow treatment for sturgeon, results of Step 5 modelling studies indicated that a seasonal minimum flow of at least 30 kcfs would be required to provide suitable habitat conditions for spawning and rearing.

7.6 ROUND 4 TRADE-OFFS, NOVEMBER 2003

During Round 4 of the trade-off analysis, the Consultative Committee reviewed two new operating alternatives for balancing Kinbasket and Arrow Lakes reservoirs (Alt 11F and IC) along with Round 3 Alternatives 11B and 11D. The Committee also evaluated the impacts of these alternatives with appended flow agreements for rainbow trout and mountain whitefish to assist in trade-off discussions around the ecological benefits/costs in the lower Columbia River versus Arrow Lakes Reservoir. Round 4 discussions also involved re-evaluation of the minimum flow constraint at Revelstoke Dam, as well as a review of an operating protocol to address fish stranding issues in the lower Columbia River.

7.6.1 Kinbasket/Arrow Lakes Reservoir Balance – Round 4

Two new alternatives were modelled for the Round 4 trade-off analysis. These alternatives were developed with the objective of achieving greater social and environmental benefits in the drawdown zone of Arrow Lakes Reservoir than Alternative 11D at a lesser cost than Alternative 11B. These included:

- Alternative 11F, which is a compromise between Alternatives 11B and 11D in terms of maximum Arrow Lakes Reservoir elevation constraints in May and June. No fall constraints were imposed on this alternative as a means of reducing cost.

- Inundation Control (IC) alternative, which imposes inundation duration constraints in the upper 4 m of the Arrow Lakes Reservoir drawdown zone that are as restrictive or more restrictive than the historical period under which the existing vegetation became established.

Table 7-23 provides a description of the Round 4 alternatives.

Table 7-23: Alternatives for Kinbasket/Arrow Lakes Reservoir Balance – Round 4

		Maximum Month End Elevations					
Alternative	**Description**	**May**	**June**	**July**	**August**	**September**	**October**
Base Case	Base Case is the unconstrained Treaty operation. It will be somewhat different from the original Base Case due to modelling refinements, and so sometimes will be referred to as Base Case B.	–	–	–	–	–	–
11B	Alt 11B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in the spring to improve vegetation potential, large river habitat, and bird habitat.	436.0 m 1430.0 ft	436.0 m 1430.0 ft	–	437.0 m 1434.0 ft	436.0 m 1430.0 ft	436.0 m 1430.0 ft
11D	Designed to reduce costs of Alt 11B by relaxing June constraint and allowing earlier fill, but pushing the reservoir down faster than Alt 11B in the fall.	436.5 m 1432.0 ft	438.3 m 1438.0 ft	–	436.5 m 1432.0 ft	435.3 m 1428.0 ft	–
11F	Compromise between Alts 11B and 11D in the spring/summer, with no constraints after June.	435.0 m 1427.0 ft	437.0 m 1434.0 ft	–	–	–	–
Inundation Control (IC)	Performance-based constraint limits inundation duration directly (not through Arrow Lakes Reservoir elevations). Derived from recent conditions that produced current vegetation.	Arrow Lakes Reservoir cannot exceed 436 m for > 36 weeks over any 2 years; or > 48 weeks over any 3 years. Arrow Lakes Reservoir cannot exceed 438 m for >10 weeks over any 1 year; > 19 weeks over any 2 years; or > 25 weeks over any 3 years.					

The impact of imposing these constraints on the profile of Arrow Lakes Reservoir is illustrated in Figure 7-7, which shows the end of month reservoir elevations under Alternatives 11B and IC for periods when the reservoir is full. As Alternative 11B has the strictest constraints in the early summer, it keeps the reservoir the lowest during this period. However, Alternative IC does not impose large constraints in any one particular year and therefore allows the reservoir to be higher on occasion. Using the 90th percentile statistics, Alternative IC allows the reservoir to reach full pool 440.1 m (1444 ft) in some years, while Alternative 11B maintains the reservoir at 436 m (1430 ft) in May and June.

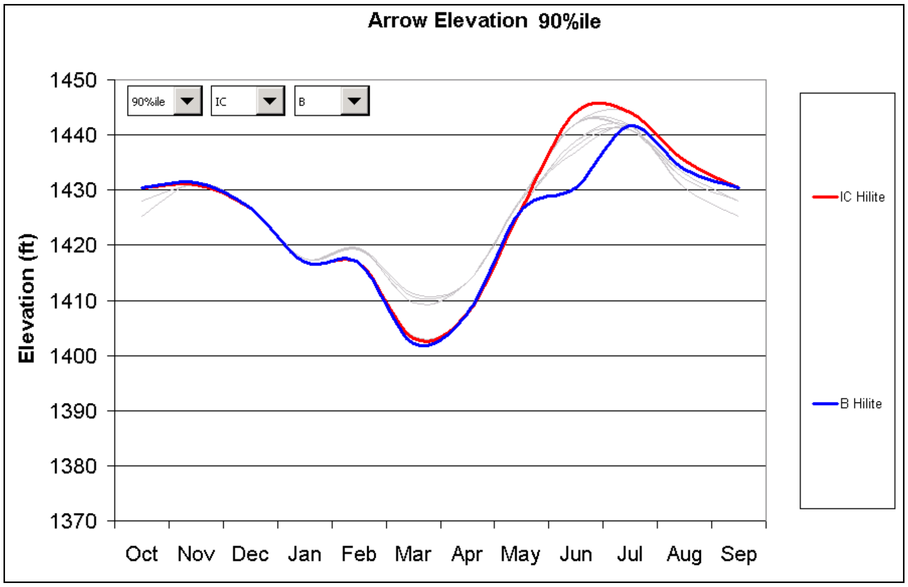

Figure 7-7: Arrow Lakes Reservoir 90th Percentile Monthly Elevations, Alternative 11B vs. IC

Based on median monthly elevations, there is little difference (~ 3 ft) in reservoir levels under these two most extreme alternatives (refer to Figure 7-8). This highlighted a key discovery by the Consultative Committee, which was that major changes in water management were occurring mostly when the reservoir was full, not when it was at low or average water elevations.

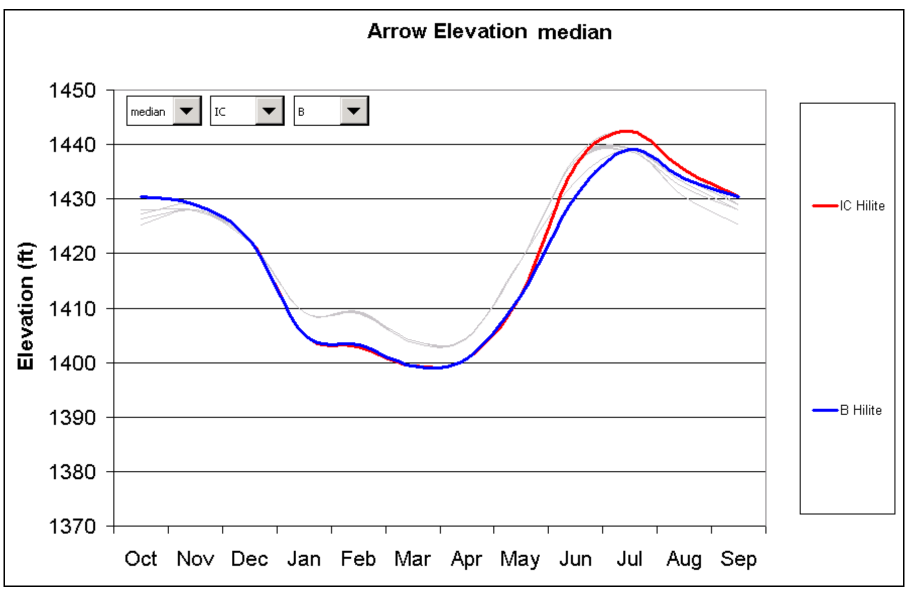

Figure 7-8: Arrow Lakes Reservoir Median Monthly Elevations, Alternative 11B vs. IC

Table 7-24 presents the consequence table highlighting the performance measure results for Round 4 alternatives. While many of the measures used to evaluate the performance of the alternatives are the same as those used during the Round 3 trade-off, substantial changes were made to the way in which impacts on birds and vegetation in Arrow Lakes Reservoir and the mid Columbia River were measured. The rationale for these changes is provided in Section 4.

Table 7-24: Consequence Table for Round 4 Operating Alternatives – Kinbasket/Arrow Lakes Reservoir Balance

Performance Measure	Units	What's Good?	Significant Difference	Base Case	11B	11D	11F	IC
Wildlife and Vegetation								
Vegetation (area, biomass and diversity)	Index	more	0.5	-2	1	1	-1	1
Birds								
Summer/spring nesting (Short-eared Owl) (average)	% nesting habitat available	more	3%	13	31	30	18	13
Fall Migration (10th percentile)	% habitat available	more	4%	5	23	30	12	19
Fish								
Average annual minimum river length (average)	km	more	tbd	6	9	9	8	7
LCR Whitefish and Rainbow	Yes/no	yes		no	no	no	no	no
Littoral	See "Vegetation" Performance Measure							
Recreation								
Total Recreation Economic Activity (10th percentile)	Thousands $/year	more	$300k	4458	7177	6814	5988	6435
KIN NAV (average)	Site-days/year	more	tbd	781	767	767	781	795
Heritage								
Heritage archaeological impacts from water (average)	# days above 436 m	less	tbd	96	73	67	90	81
Heritage archaeological impacts from wind	See "Vegetation" Performance Measure	more						
Flood/Erosion								
High Arrow Lakes Reservoir Elevations (average)	# days elevation > 439 m	less	tbd	36	2	2	9	23
LCR Flooding	# days at Genelle > 165 kcfs	less		0	0	0	0	0
Revenue								
Power/Financial (average)	Power Value Loss Millions $/year	less	10%	0	10	3	7	1

During discussions of the performance measure scores, the representative of the Columbia Power Corporation (CPC) distributed a 26 November 2003 letter to the Consultative Committee clarifying CPC's interest and role in the Columbia River Water Use Plan (refer to Appendix G: Correspondence related to the Columbia Power Corporation and the Columbia Basin Trust). He noted that CPC's interest is to maintain benefits produced by ALH and other CPC/CBT joint venture projects on the Kootenay River (Brilliant Dam and powerplant, and the Brilliant Expansion Project, which is currently under construction). While ALH is included in the overall power calculations, the performance measure does not specify estimated power impacts at ALH. Accordingly, to date, there has not been sufficient analysis of the proposed operating alternatives to determine potential adverse impacts on CPC/CBT interests. CPC has been working with BC Hydro to better understand these potential impacts but there has been no further clarity on this issue. It was further noted that any adverse financial impacts on CPC/CBT joint venture projects would have a direct impact on the Columbia Basin Trust, which receives 50 per cent of the net income from CPC/CBT joint venture projects. The Trust's share of power project returns is used to provide benefits to the people of the region. CPC is not prepared to support any of the operating alternatives until there is better clarification of the impacts on the joint venture projects. It was agreed that CPC's decision would be deferred until a later date.

At this point in the discussion, there was considerable debate around whether foregone power values at ALH should be included in the modelling of power costs associated with the proposed operating alternatives. There was concern that consideration of this lost power generation opportunity at ALH in the trade-off analysis might be beyond the scope of the water use planning policy framework and the November 1998 government policy directive to BC Hydro. Additionally, both DFO and MWLAP representatives maintained that the ALH Project Approval Certificate (PAC) recognized the value of flexibility in flows at Hugh Keenleyside Dam for fish and fish habitat management, and specifically included provisions.[1] to ensure that operation of ALH would not preclude beneficial

[1] Condition 8(1) of the ALH PAC provided that CPC must to the reasonable satisfaction of the Comptroller of Water Rights, enter into an agreement with BC Hydro for the diversion and use of water from the Arrow Reservoir, and demonstrate how the agreement provides details of how:

"(a) storage operations required by the Columbia River Treaty will be satisfied, supported by a letter from the Canadian Entity, including operational arrangements for the (ALH) Project to ensure that all existing requirements for minimum flows and ramping rates will be implemented and that the (Hugh) Keenleyside Dam will continue to be operated such that water not discharged through the (ALH) Powerplant will continue to be discharged through the (Hugh) Keenleyside Dam preferentially throughout the north low level outlets rather than the spillway and the south level outlets, or in such other manner as is determined to minimize the level of Total Dissolved Gasses in the Columbia River downstream; and

(b) current opportunities to implement beneficial operations for fish and other environmental objectives will not be diminished."

These provisions were included in a Release Co-ordination Agreement approved by the Comptroller of Water Rights on 15 March 1999.

opportunities for fish and wildlife. DFO and MWLAP were of the opinion that ALH costs may be: a) questionable as to whether they represented true "costs" (as compared to lost opportunities); and/or b) outside the scope of this Water Use Plan. As a result, they requested that a new performance measure be developed to separate out the value of power generation in the lower Columbia River (i.e., at ALH) from power generation at the Mica and Revelstoke projects.

It was noted that HYSIM modelling of the proposed operating alternatives considers the Canadian Columbia River system as a whole, and has been designed to determine the most economic dispatch of the generating system, subject to the operating constraints and objectives under a range of streamflow sequences. Optimization of the system is achieved through flexibility of storage in Kinbasket and Arrow Lakes reservoirs, and does not affect how the water is being released. Both the Base Case and the alternatives include ALH in the optimized system. The model therefore calculates the sum of power costs at Mica, Revelstoke and ALH. However, removing ALH will not likely change how the system is operated in a significant way because this facility is a small contributor to overall power generation.

While some Consultative Committee members felt that the focus of discussions should be on whether the benefits to interests are worth the cost as a whole (irrespective of who is bearing the costs), the DFO and MWLAP representatives still felt that the ALH power costs should not be included in the modelling.[1] The Committee agreed that this issue was most appropriately resolved at the policy level. Although the issue of whether the ALH PAC restrictions had any implication for the Columbia River Water Use Plan was not resolved at the Consultative Committee table, a June 2004 government policy directive to BC Hydro directing it to save CPC/CBT power projects harmless from any adverse effects resulting from implementation of the Water Use Plan meant that the financial impacts at ALH were included in the power cost calculations of the proposed operating alternatives.

As a means of possibly eliminating some operating alternatives from the trade-off analysis, the Consultative Committee evaluated whether there were any alternatives that, clearly performed worse than others and were not providing good value. The facilitator proposed eliminating Alternatives 11F and Base Case.

[1] On 11 June 2004, representatives of DFO, MWLAP and CCRIFC met with staff of the Environmental Assessment Office (EAO) and Water Management Branch (WMB) to seek clarification on the ALH Project Approval Certificate (PAC), specifically Condition 8 which precludes operation of ALH from diminishing "current opportunities to implement beneficial operations for fish and other environmental objectives". Clarification was provided, at least in part, by references in the EAO Recommendations Report to potential flow requirements for mountain whitefish, rainbow trout and kokanee spawning. It was acknowledged that resolution of the intent of this clause would be made by the Comptroller of Water Rights, as stipulated in Condition 8 of the PAC.

As illustrated in Table 7-25, a comparison of performance measures revealed that Alternative 11F performs significantly worse for vegetation, summer and fall bird interests, littoral productivity, recreation, and heritage in the Arrow Lakes Reservoir drawdown zone when compared to Alternative 11D. It also costs approximately $4 million more per year on average. Alternative F also performs significantly worse than Alternative IC for all interests in Arrow Lakes Reservoir with the exception of spring/summer nesting birds. **Based on this comparison, the Consultative Committee agreed to eliminate Alternative 11F from further consideration.**

Table 7-25: Comparison of Alternative 11F to other Round 4 Alternatives

Objective	Performance Measure	Base Case	11B	11D	11F	IC
Wild and Veg	Vegetation (area, biomass and diversity)	-2	1	1	-1	1
BIRDS	Summer/spring nesting (Short-eared Owl)	13	31	30	18	13
	Fall Migration (10%ile)	5	23	30	12	19
FISH	Ave annual minimum river length (ave)	6	9	9	8	7
	LCR Rainbow	no	no	no	no	no
	Littoral (veg PM)	-2	1	1	-1	1
RECREATION	Total Rec Economic Activity (10%ile)	4458	7177	6814	5988	6435
	KIN NAV (ave)	781	767	767	781	795
HERITAGE	Heritage arch impacts (water)	96	73	67	90	81
	Heritage arch impacts (wind) (veg)	-2	1	1	-1	1
Flood/Erosion	High Arrow Elevations (ave)	36	2	2	9	23
	LCR Flooding	0	0	0	0	0
Revenue	Power / Financial (UNDER DISCUSSION)	0	10	3	7	1

A similar comparison with the Base Case revealed that it differentiated itself from the others in its negative impacts on vegetation, summer/spring nesting birds, fall migratory birds, large river habitat, littoral productivity, heritage and flooding in Arrow Lakes Reservoir. Despite the Base Case being the least expensive alternative under consideration, the Consultative Committee agreed by consensus that the negative impacts from frequently using the full drawdown zone outweighed the financial benefits from doing so. **As a result, the Consultative Committee agreed to eliminate the Base Case from further consideration, and use it only in future discussions as the financial benchmark against which other alternatives were compared.**

Table 7-26: Comparison of the Base Case Alternative to other Round 4 Alternatives

Objective	Performance Measure	Base Case	11B	11D	11F	IC
Wild and Veg	Vegetation (area, biomass and diversity)	-2	1	1	-1	1
BIRDS	Summer/spring nesting (Short-eared Owl)	13	31	30	18	13
	Fall Migration (10%ile)	5	23	30	12	19
FISH	Ave annual minimum river length (ave)	6	9	9	8	7
	LCR Rainbow	no	no	no	no	no
	Littoral (veg PM)	-2	1	1	-1	1
RECREATION	Total Rec Economic Activity (10%ile)	4458	7177	6814	5988	6435
	KIN NAV (ave)	781	767	767	781	795
HERITAGE	Heritage arch impacts (water)	96	73	67	90	81
	Heritage arch impacts (wind) (veg)	-2	1	1	-1	1
Flood/Erosion	High Arrow Elevations (ave)	36	2	2	9	23
	LCR Flooding	0	0	0	0	0
Revenue	Power / Financial (UNDER DISCUSSION)	0	10	3	7	1

At this point, the Consultative Committee felt that it could not proceed any further in the trade-off of alternatives without further considering how the rainbow trout flow agreements interact with operating constraints on Arrow Lakes Reservoir.

7.6.2 Arrow Lakes Reservoir/Lower Columbia River Balance – Round 4

During the Round 4 trade-off analysis, the modelling method used to capture the impact of rainbow trout and mountain whitefish flow agreements on the operating regime of Arrow Lakes Reservoir remained unchanged from that presented to the Consultative Committee during their June 2003 meeting (refer to Section 7.5.2). This allowed the Committee to explore how operating alternatives that could be implemented unilaterally by BC Hydro and flow policies that would require annual negotiation with the United States could impact objectives developed for Arrow Lakes Reservoir and the lower Columbia River.

Table 7-27 presents the consequence table for Round 4 alternatives developed to balance Arrow Lakes Reservoir and the lower Columbia River. The performance measure scores presented below differ from that presented to the Consultative Committee at the June 2003 meeting, as a number of modifications were made to the performance measures during this intervening period based on recommendations of the Committee

Table 7-27: Consequence Table for Round 4 Operating Alternatives – Arrow Lakes Reservoir/Lower Columbia River Balance

Performance Measure	Units	What's Good?	Significant Difference	11B	11D	IC	11B + Rbt	11D + Rbt	IC + Rbt
Wildlife and Vegetation									
Vegetation (area, biomass and diversity)	Index	more	0.5	1	1	1	0	0	0
Birds									
Summer/spring nesting (Short-eared Owl) (average)	% nesting habitat available	more	3%	31	30	13	29	17	10
Fall Migration (10th percentile)	% habitat available	more	4%	23	30	19	33	37	28
Fish									
Average annual minimum river length (average)	km	more	tbd	9	9	7	9	8	6
LCR Whitefish and Rainbow	Yes/no	yes		no	no	no	yes	yes	yes
Littoral	See "Vegetation" Performance Measure								
Recreation									
Total Recreation Economic Activity (10th percentile)	Thousands $/year	more	$300k	7177	6814	6435	6933	7785	8532
KIN NAV (average)	Site-days/year	more	tbd	767	767	795	767	767	795
Heritage									
Heritage archaeological impacts from water (average)	# days above 436 m	less	tbd	73	67	81	60	59	75
Heritage archaeological impacts from wind	See "Vegetation" Performance Measure	more							
Flood/Erosion									
High Arrow Lakes Reservoir Elevations (average)	# days elevation > 439 m	less	tbd	2	2	23	2	9	24
LCR Flooding	# days at Genelle > 165 kcfs	less		0	0	0	0	0	0
Revenue									
Power/Financial (average)	Power Value Loss Millions $/year	less	10%	10	3	1	10	3	1

To assess the level of interaction between operating alternatives for Arrow Lakes Reservoir and fish flows in the lower Columbia River, the Consultative Committee was presented with a series of pair-wise comparisons. As the mountain whitefish flows were shown to have little to no impact on the hydrograph of Arrow Lakes Reservoir, this comparison focused on potential gains/losses to interests in the reservoir and the lower Columbia River as a result of implementing the rainbow trout agreements.

Table 7-28 presents the performance measure scores for Alternative 11B with and without the rainbow trout flows, with the former as the basis of comparison.

Table 7-28: Comparison of Alternative 11B and 11B+Rbt

Objective	Performance Measure	11B	11B+ Rbt
Wild and Veg	Vegetation (area, biomass and diversity)	1	0
BIRDS	Summer/spring nesting (Short-eared Owl)	31	29
	Fall Migration (10%ile)	23	33
FISH	Ave annual minimum river length (ave)	9	9
	LCR Rainbow	no	yes
	Littoral (veg PM)	1	0
RECREATION	Total Rec Economic Activity (10%ile)	7177	6933
HERITAGE	Heritage arch impacts (water)	73	60
	Heritage arch impacts (wind) (veg)	1	0
Flood/Erosion	High Arrow Elevations (ave)	2	2
	LCR Flooding	0	0
Revenue	Power / Financial (UNDER DISCUSSION)	10	10

The highlight from this pair-wise comparison is that there would be potential gains in vegetation, nesting bird habitat and protection of archaeological sites sensitive to wind erosion in Arrow Lakes Reservoir by not implementing the rainbow trout flows in the lower Columbia River. However, this would also result in losses to rainbow trout, fall migratory bird habitat and archaeological site protection from water erosion. There would be no significant difference to recreation interests or flooding erosion.

As shown in Table 7-29, removing rainbow trout flows from Alternative 11D would result in losses to rainbow trout, fall migratory birds, heritage and recreation interests. However, this would result in gains to vegetation, which would in turn benefit protection of archaeological sites through increased vegetative cover, littoral productivity, and spring/summer nesting habitat.

On comparison of Alternative IC with and without rainbow trout flows, approximately the same pattern emerged (refer to Table 7-30). There is a trade-off between vegetation interests in Arrow Lakes Reservoir and fish interests in the lower Columbia River, as well as a trade-off between summer nesting habitat and fall migration habitat. The only notable difference among the pairs of alternatives is in the magnitude by which these effects vary.

Table 7-29: Comparison of Alternative 11D and 11D+Rbt

Objective	Performance Measure	11D	11D+ Rbt
Wild and Veg	Vegetation (area, biomass and diversity)	1	0
BIRDS	Summer/spring nesting (Short-eared Owl)	30	17
	Fall Migration (10%ile)	30	37
FISH	Ave annual minimum river length (ave)	9	8
	LCR Rainbow	no	yes
	Littoral (veg PM)	1	0
RECREATION	Total Rec Economic Activity (10%ile)	6814	7785
HERITAGE	Heritage arch impacts (water)	67	59
	Heritage arch impacts (wind) (veg)	1	0
Flood/Erosion	High Arrow Elevations (ave)	2	9
	LCR Flooding	0	0
Revenue	Power / Financial (UNDER DISCUSSION)	3	3

Table 7-30: Comparison of Alternative IC and IC+Rbt

Objective	Performance Measure	IC	IC+ Rbt
Wild and Veg	Vegetation (area, biomass and diversity)	1	0
BIRDS	Summer/spring nesting (Short-eared Owl)	13	10
	Fall Migration (10%ile)	19	28
FISH	Ave annual minimum river length (ave)	7	6
	LCR Rainbow	no	yes
	Littoral (veg PM)	1	0
RECREATION	Total Rec Economic Activity (10%ile)	6435	8532
HERITAGE	Heritage arch impacts (water)	81	75
	Heritage arch impacts (wind) (veg)	1	0
Flood/Erosion	High Arrow Elevations (ave)	23	24
	LCR Flooding	0	0
Revenue	Power / Financial (UNDER DISCUSSION)	1	1

The Consultative Committee recognized there was a trade-off around recommending the negotiated flow agreements for the lower Columbia River and an operating alternative for Arrow Lakes Reservoir. Table 7-31 summarizes the highlights of the analysis around the potential benefits/losses from implementing the rainbow trout flow agreements.

Table 7-31: Implications of Not Pursuing the Rainbow Trout Flow Agreements

Gains	Losses	Comments
Increased vegetation in Arrow Lakes Reservoir drawdown zone (area, biomass, and diversity).		
Decreased wind erosion impacts on heritage sites (from increased vegetated area).	Increased water erosion impacts on heritage sites in the Arrow Lakes Reservoir.	Net impact on First Nations' interests is unclear, since the relative efficacy of protecting archaeological sites through vegetation cover or through lower water levels is unknown.
Increased nesting habitat for spring and summer nesters.	Decreased habitat for migratory fall birds.	Net impact to birds is unclear, since the relative magnitude of impacts on summer nesters and fall migrants is not known.
Decreased erosion at the upper range of the Arrow Lakes Reservoir drawdown zone.	Decreased recreational activity in Arrow Lakes Reservoir and the lower Columbia River.	
Increased littoral zone productivity (from increased vegetated cover).	Decreased benefits to rainbow trout in the lower Columbia River.	The Fish Technical Subcommittee indicated that the magnitude and certainty of the benefits to the lower Columbia River rainbow trout and mountain whitefish agreements exceeded those from increases in littoral productivity.

At this point, the facilitator requested that each Consultative Committee member verbally state their level of support for the rainbow trout flow agreements and to describe any concerns and how they could be addressed. The Committee was not requested to express their level of support for the whitefish flow agreements at this point in the trade-off discussions, as there was no apparent trade-off between implementation of these flows and other expressed interests of the Committee upstream in Arrow Lakes Reservoir or in the lower Columbia River.

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 7-32 presents the results of this exercise.

Table 7-32: Level of Support for Rainbow Trout Flow Agreements in the Lower Columbia River

Consultative Committee Member	Level of Support	Notes
Gordon Boyd, BC Hydro	A	These flows have improved rainbow trout populations. Rainbow trout are important in themselves and are an important indicator species.
Doug Robinson, BC Hydro	A	The rainbow trout flows are a win-win for these fish and BC Hydro. Hydro would find providing rainbow trout flows in only some years acceptable as well.
Ian MacLean, BC Hydro	A	BC Hydro accepts these flows from a high level perspective. We have other options for birds. There is limited control over Arrow Lakes Reservoir drawdown zone. Given what we have created here, are we ever going to achieve success for this area?
Llewellyn Matthews, Columbia Power Corporation	–	**Abstained*** Rainbow trout flows are aligned with Columbia Power Corporation's (CPC) interests. CPC is disappointed that the Canadian Wildlife Service (CWS) is not at the table to voice their interests and regulatory concerns around the impacts of these flows on birds.
Steve Macfarlane, Fisheries and Oceans Canada	E	Rainbow trout and mountain whitefish also serve as a proxy for other species, so protecting rainbow trout benefits other interests. Physical works could alleviate some impacts on summer nesters, but proposals of $1.2 million seem too expensive. Making these trade-offs will be difficult for DFO in Step 11 when CWS is not at the table. They should have been here themselves.
Steve McAdam, Ministry of Water, Lands and Air Protection	E	Further explore things to mitigate impacts to birds.
Fred Fortier, Secwepemc Fisheries Commission	E	Same comments that Mark Thomas expressed (below).
Chris Beers, Columbia Kootenay Fisheries Renewal Partnership	E	Some suitable mitigation to bird habitat is needed. As well, I would like to see a modification of rainbow trout agreement in high water years to avoid impacts to nesting birds.
Pat Wilcox, Castlegar Power Squadron/ Arrow Yacht Club/Safe Moorage Committee	E	Some physical works to avoid impacts to birds are needed.
Bill Green, Canadian Columbia River Inter-tribal Fisheries Commission	A	Accept subject to mitigation to nesting of bird habitats to 30 per cent survival rate. Need to see the physical works.
Mark Thomas, Ktunaxa Kinbasket Tribal Council	E	Endorse with guarantee that cultural heritage sites are protected. Rainbow trout agreements seem to enhance heritage values across all alternatives.
Loni Parker, Columbia Shuswap Regional District	A	I accept the rainbow trout flows, but would like to see physical works for nesting birds. I would like to see the cost of all of these proposed changes. People in the basin would not want to see any decrease of value of Arrow Lakes Generating Station. When considering costs, it is important to remember the total economic value of the system.

Table 7-32: Level of Support for Rainbow Trout Flow Agreements in the Lower Columbia River (cont'd)

Consultative Committee Member	Level of Support	Notes
Gord DeRosa, City of Trail	E	I endorse this, but would also like to see some attention paid to the nesting areas in Genelle flats, the strength of the fish population in the lower Columbia River, and to predator birds in lower Columbia River.
Webb Webster, West Kootenay Naturalists	A	Same concerns as Janice for physical works for bird mortality.
Janice Jarvis, North Columbia Environmental Society/ Friends of Mt. Revelstoke & Glacier	A	I accept this, but would like to see with physical works for other species and mitigation for lost heritage values.
Susan Hall, Parks Canada	A	I can accept rainbow trout flows with mitigation of bird mortality and other values that are affected. With the rainbow trout storage, it will cost more to achieve the same level of benefits.
Bill Duncan, TeckCominco Ltd.	E	I endorse, but I need to figure out how to address the other trade-offs. I want to get down to three alternatives and better understand them.
Penny Dewar, Area Resident	E	I endorse this because it enhances the Columbia River system. I don't think the trade-offs should be environmental in any other system and I don't consider the financial considerations large given the revenue generated by the system.
Helmut Klughammer, Area Resident	A	I accept this, but I am looking at the birds and fish and the erosion factors.
Gail Bernacki, City of Revelstoke	A	I am really concerned about costs of monitoring and physical works, and about rainbow trout. I think birds are more endangered than rainbow trout. I would like to see money available for all these other things that we have to do. If we have RBT with Alt 11D, then we can have money to do other things.
Bob Taylor, Louisiana-Pacific Canada Ltd.	A	I would like to see if there is opportunity for alternate water levels to between helping bird nesting and the rainbow trout. I would also like to know more about works in lieu (physical works).
Warren Ward, Mica Marina	A	I accept this, but I have concerns for birds.
Maureen Weddell, Illecillewaet Greenbelt Society	A	I accept with information on how it impacts migratory birds and recreation. Some consideration for mitigation will be needed in order to get consensus.
Shelley Murphy, Ministry of Energy and Mines	A	I would like to hear more about the trade-off between rainbow trout and nesting in some years. I have some process questions on the rainbow trout flows since they will not be constraints on BC Hydro's licence. I accept because the rainbow trout flows provide lots of benefits over the base case, even for their impact to nesting habitat.
Kindy Gosal, Columbia Basin Trust	A	Need better information of what is going to happen on the power impacts side. Is there a conflict between mountain whitefish and rainbow trout flows, or a conflict between rainbow trout flows and sturgeon?

* CPC abstained due to concerns around potential impacts of the rainbow trout flows on its revenues at the Arrow Lakes Generating Station (refer to Appendix G: Correspondence related to the Columbia Power Corporation and the Columbia Basin Trust).

Consultative Committee's Recommendation related to Rainbow Trout Flows in the Lower Columbia River

Recommendation	Comments
With exception of CPC's representative who abstained, the Consultative Committee recommended that BC Hydro continue to pursue the rainbow trout flow agreements with its United States counterparts every year.	The Committee accepted that the negative impacts of the additional storage in Arrow Lakes Reservoir were outweighed by the benefits that the agreements have achieved for rainbow trout in the lower Columbia River. However, the Committee wanted to see this agreement fulfilled with as little impact as possible on the interests in the Arrow Lakes Reservoir drawdown zone.

Three operating alternatives for Arrow Lakes Reservoir remained for consideration by the Consultative Committee (11B+Rbt, 11D+Rbt, and IC+Rbt). Table 7-33 summarizes the understanding of the Committee around the potential for physical works in lieu of other operational changes, and provides a rough comparison to recent historic (i.e., past 15 years of flow data and professional judgment from the Technical Subcommittee members).

Table 7-33: Comparison of Alt 11B+Rbt, 11D+Rbt and IC+Rbt

Performance Measure	11B+ Rbt	11D+ Rbt	IC+ Rbt	Potential for Physical Works	Comparison to Historic (after Physical Works)
Wildlife and Vegetation					
Vegetation (area, biomass and diversity)	0	0	0	high	better
Birds					
Summer/spring nesting (Short-eared Owl)	29	17	10	small	depends?
Fall Migration (10th percentile)	33	37	28	small	better?
Fish					
Average annual minimum river length (average)	9	8	6	none	better?
LCR Rainbow	yes	yes	yes		
Littoral (Vegetation Performance Measure)	0	0	0		
Recreation					
Total Recreation Economic Activity (10th percentile)	6933	7785	8532	large	better
Heritage					
Heritage archaeological impacts (water)	60	59	75	medium	better?
Heritage archaeological impacts (wind) (vegetation)	0	0	0		
Flood/Erosion					
High Arrow Lakes Reservoir Elevations (average)	2	9	24	?	?
LCR Flooding	0	0	0		
Revenue					
Power/Financial (Under Discussion)	10	3	1	none	?

While all three of the operating alternatives offer improvements to key interests of the Consultative Committee, some alternatives provide larger gains due to stricter constraints on reservoir operations. A key trade-off for the Consultative Committee was what level of potential benefits are justifiable given the value of foregone power generation. The average annual costs of the alternatives ranged from $1 million for Alternative IC+Rbt to $10 million for Alternative 11B+Rbt.

The Consultative Committee was requested to indicate their support for the alternatives by specifying their first, second and third preferences. Their responses and comments are presented in Table 7-34.

Table 7-34: Level of Support for Round 4 Alternatives – Kinbasket/Arrow Lakes Reservoir Balance – Round 4

Name	Alt 11B+	Alt 11D+	Alt IC +	Notes
Gordon Boyd, BC Hydro	3	2	1	The differences in cost across the alternatives are large, and the cost of foregone power generation will be borne by the ratepayers. BC Hydro has some concern over the level of confidence in benefits that these alternatives provide. Moreover, the costs are averages but there is a large range. Is there a way to narrow the range? I would have difficulty in accepting 11B+Rbt given the high costs. Could do much better for the cost of the alternative.
Doug Robinson, BC Hydro		2	1	The annual variability in costs is large. The upper annual range of Alt 11B+Rbt is $50 million per year. I can accept Alt IC+Rbt and with revisions to reduce cost variations, Alt 11D+Rbt. Suggest soft constraints in some years with compensation fund for violating constraints.
Ian MacLean, BC Hydro		2	1	The Water Use Plan is about looking at incremental changes. But looking at $10 million for only operational changes makes me think we could do a lot better. For birds, we are in a drawdown zone, so delivering bird benefits are difficult given the natural variability of the system. We should be looking more at fish and recreation benefits instead.
Llewellyn Matthews, Columbia Power Corporation				**Abstained**[1] Do not have enough information to accept any of the alternatives.
Steve Macfarlane, Fisheries and Oceans Canada	1	2		Alt IC+Rbt has little value compared to Alt 11D+Rbt. Having said that, in consideration of all values, the only alternative that I can endorse is Alt 11B+Rbt. However, if rainbow trout flows can be tweaked to improve nest survival, then could accept 11D+Rbt.
Steve McAdam, Ministry of Water, Lands and Air Protection	1	1		I have the least interest in Alt IC+Rbt. Alternatives 11B+Rbt and Alt D+Rbt are tied. The ability to tweak the rainbow trout flows for nesting birds will help me decide between these two alternatives.
Fred Fortier, Secwepemc Fisheries Commission	1	2		I would not support IC+Rbt. 11D+Rbt with physical works to protect arch values would be acceptable.

Table 7-34: Level of Support for Round 4 Alternatives – Kinbasket/Arrow Lakes Reservoir Balance – Round 4 (cont'd)

Name	Alt 11B+	Alt 11D+	Alt IC +	Notes
Chris Beers, Columbia Kootenay Fisheries Renewal Partnership	1	2		Endorse 11B+Rbt and feel that 11D+Rbt is acceptable. I would like to see some modifications for protection of birds and archaeological sites.
Pat Wilcox, Castlegar Power Squadron/Arrow Yacht Club/Safe Moorage Committee		1	2	
Bill Green, Canadian Columbia River Inter-tribal Fisheries Commission	1	2		I have serious reservations for IC+Rbt. It is no better than Base Case for a number of interests. Alt 11D+Rbt is acceptable, but with need to address concern about nesting birds.
Mark Thomas, Ktunaxa Kinbasket Tribal Council	1	2		Concerned about $9 million difference across the range of alternatives. Alt IC+Rbt has financial basis, but no ecological and social values. Protection of archaeological sites is of importance to me. Alt 11D+Rbt addresses the erosion issue.
Loni Parker, Columbia Shuswap Regional District	1	2		I would reject IC+Rbt given the concern for nesting birds and fish. Alt 11D+Rbt is workable if it could be tweaked. I endorse Alt 11B+Rbt, but it is already a compromise to what people want. I am concerned over monetary constraint. We have been flooded. I can see no reason why rates cant be increased for benefits back to the system.
Gord DeRosa, City of Trail	1		2	Need to consider habitat for birds.
Webb Webster, West Kootenay Naturalists	2	1		Reluctantly accept 11D+Rbt, but I have serious concerns over bird losses.
Janice Jarvis, North Columbia Environmental Society/Friends of Mt. Revelstoke & Glacier	1	2		I prefer Alt 11B+Rbt with the potential fisheries benefits. I reject Alt IC+Rbt. Alt 11D+Rbt I reluctantly accept. It needs some tweaking before I could accept.
Susan Hall, Parks Canada	1	2		Alt 11B+Rbt performs best so endorse that. Alt 11D+Rbt would need substantive physical works to be acceptable. I would not support Alt IC+Rbt, as bird mortality could not be mitigated.
Bill Duncan, TeckCominco Ltd.		1	1	We are making significant decisions with limited information. The caveat on both alternatives that we need to learn a lot more, and we need to spend more money on learning. Alt 11B+Rbt makes assumptions that we are going to get a lot of benefits.
Bob Munro, Town of Golden	1	2		I choose Alt 11B+Rbt, but would want boat ramps for recreation. This addresses the environmental damage caused by the dams. I have no sympathy for taxpayers. I am not concerned with the $10 million cost. I am reluctant on Alt 11D+Rbt.
Penny Dewar, Area Resident	1			I still have a hard time with the costs. Should there be a dollar value on the benefits? Alt 11B+Rbt is the best of the three.

Table 7-34: Level of Support for Round 4 Alternatives – Kinbasket/Arrow Lakes Reservoir Balance – Round 4 (cont'd)

Name	Alt 11B+	Alt 11D+	Alt IC +	Notes
Helmut Klughammer, Area Resident	1	2		My big concern is erosion, and Alt 11B+Rbt addresses this most. I could live with Alt 11D+Rbt if some physical works are undertaken; spend the $7 million on physical works.
Gail Bernacki, City of Revelstoke	2	1		I am trying to be practical. We do not have the perfect information. We keep on hearing about the uncertainty. We may need to spend $10 million, but dollars need to be spent on other things, not just 11B+Rbt. Mortality rate for birds is high and needs to be addressed. We need to ensure that we get the information for decision making in the future. Alt 11D+Rbt is my first choice given the costs.
Bob Taylor, Louisiana-Pacific Canada Ltd.	2	1		I am torn between Alt 11D+Rbt and Alt 11B+Rbt. One provides economic benefits, while the other provides environmental benefits.
Warren Ward, Mica Marina	2	1		I endorse Alt 11D+Rbt. There is a lot of uncertainty. We should spend the money on monitoring and studies to make better decisions.
Maureen Weddell, Illecillewaet Greenbelt Society	1	1		I don't accept Alt IC+Rbt. I would like benefits of Alt 11B+Rbt but at a lower cost, so I would like to see groups come up with a creative solution.
Shelley Murphy, Ministry of Energy and Mines		1	1	I am leaning towards Alt 11D+Rbt but concerned what the total package cost would be. I also have concerns about the distribution of costs of Alt 11D+Rbt. Most frequently occurring cost is $11 million annually.
Kindy Gosal, Columbia Basin Trust	1	1		Alt IC+Rbt not a huge improvement over Base. Would weight 11B+Rbt and 11D+Rbt equally. We need to implement and monitor to determine whether we get what we are expecting. We also need to look at compatibility between fish flows and nesting birds. Works in lieu will have a big impact on how we review Alt 11B+Rbt and Alt 11D+Rbt. When looking at optimizing range of values, cost is only one aspect.

[1] CPC abstained from supporting any operating alternative before the Consultative Committee until further information was available with which to measure the potential impacts on CPC/CBT facilities (Letter dated November 26, 2003, Appendix G).

Note: Numbering of alternatives refers to Consultative Committee members' first, second and third choices.

Results of the exercise revealed a difference in Consultative Committee members' willingness to forego power generation in favour of more environmental benefits. For many Committee members, Alternative 11D+Rbt was barely acceptable because it did not deliver enough environmental benefits, particularly for birds. This group wanted the more restrictive and expensive constraints of Alternative 11B+Rbt. The other group felt that Alternative 11D+Rbt was at the upper range of what they were willing to accept in foregone power generation.

Although many Consultative Committee members selected Alternative 11D+Rbt as their second preference, it was not clear that this alternative could form the basis of a consensus agreement. Consequently, the Committee tasked the Technical Subcommittees with exploring new alternatives that would outperform

Alternative 11D+Rbt by a) providing greater environmental benefits, and b) reducing costs either on average or at least in the highest cost years. The Committee also tasked the subcommittees with exploring physical works options that would deliver environmental benefits at a lesser cost than the operating alternatives.

7.6.3 Flow Constraints at Revelstoke Dam – Round 4

During Round 3 of the trade-off analysis, the Consultative Committee provisionally agreed to a 5 kcfs minimum flow constraint on Revelstoke Dam operations, subject to a monitoring program being developed to inform on the effectiveness of this change. Subsequent to the June 2003 meeting, it became apparent that there had been an oversight in using the bi-hourly modelling results, which led to the reported costs of the minimum flow alternatives being 50 per cent of the actual modelled values. As a result, the actual cost of the minimum flows doubled, and the trade-offs process had to be revisited.

The Round 4 minimum flow alternatives presented to the Consultative Committee were the same as those presented in June 2003, plus the addition of a status quo alternative. BC Hydro's current (2003) operations include a minimum daytime flow of 5 kcfs to avoid stranding boaters and reduce stranding of fish in pools. These alternatives are listed below in Table 7-35.

Table 7-35: Specifications for Revelstoke Dam Minimum Flow Constraints – Round 4

Flow Alternative	Details	Rationale
0 kcfs	Leakage flows are approximately 2 cfs	
Status Quo	5 kcfs during daylight hours, when power values are not extremely high	Reduces risk of stranding for boaters, and predation on fish in pools.
5 kcfs	5 kcfs minimum flow, year round	
10 kcfs	10 kcfs minimum flow, year round	
15 kcfs	15 kcfs minimum flow, year round	
5–0 kcfs	5 kcfs from October to April, 0 kcfs from May to September	Tributary inflows and Arrow Lakes Reservoir levels increase after April, reducing benefits of the minimum flow. Few benefits for 4 km of river above the Hwy 1 bridge.
5–10 kcfs	5 kcfs from October to April, 10 kcfs from May to September	Similar to above, greater minimum flows are provided to offset lower reservoir levels and lower inflows.
10–5 kcfs	10 kcfs from October to April, 5 kcfs from May to September	Minimum flow more resembles natural conditions with higher flows occurring during freshet. Lesser benefits for 4 km of river above the Hwy 1 bridge.

During a November 2003 Fish Technical Subcommittee meeting, there were further discussions around the learning potential of each minimum flow alternative, which led to revisions to the rankings assigned to each flow. This revised prioritization by the subcommittee was presented to the Consultative

Committee to assist in their trade-off discussions. Table 7-36 provides the performance measure and scoring results for each minimum flow alternative, as well as the final benefit score and ranking assigned by the Fish Technical Subcommittee. Shaded rows indicate those alternatives that were eliminated as dominated or practically dominated alternatives (i.e., options for which there is at least one other alternative that scores better on all other performance measures).

Table 7-36: Ranking of the Revelstoke Dam Minimum Flow Alternatives – Round 4

ALT	Prod Area (ha-days)	Vmax (m^3/s)	Cost (million $/year)	ECOL PROD	JUV	ADULT	RBT	LEARN	Total Score
0	14 387	0.64	0	0	0	0	0	0	0
Status Quo	14 387	0.64	0.2	0	0	0	0	0	0
5	17 917	0.46	3.0	3	1–2	2	1	1	7.5
10	19 183	0.34	6.4	3	2–3	2	1	2	8.5
15	20 300	0.25	12.8	3	3	2–3	2–3	3	11
A 5-0	16 990	0.5	1.6	1–2	0–1	1	-1–0	0	2.5
C 5-10	18 316	0.42	5	3	2	2	1	2	8
E 10-5	18 784	0.38	4.4	3	1–2	2	1	1	7

* Costs of the seasonally adjusted flow alternatives (A, C and E) are pro-rated annual costs based on the relative monthly costs of a minimum flow constraint on Revelstoke Dam (refer to Table 6-3, Section 6.5.4).

A figure outlining the environmental benefits versus the cost of each minimum flow alternative was presented to the Consultative Committee. As illustrated in Figure 7-9, the trade-off between the flow alternatives is similar to that presented during Round 3; the measure of environmental benefits generally increases with larger, more costly minimum flows.

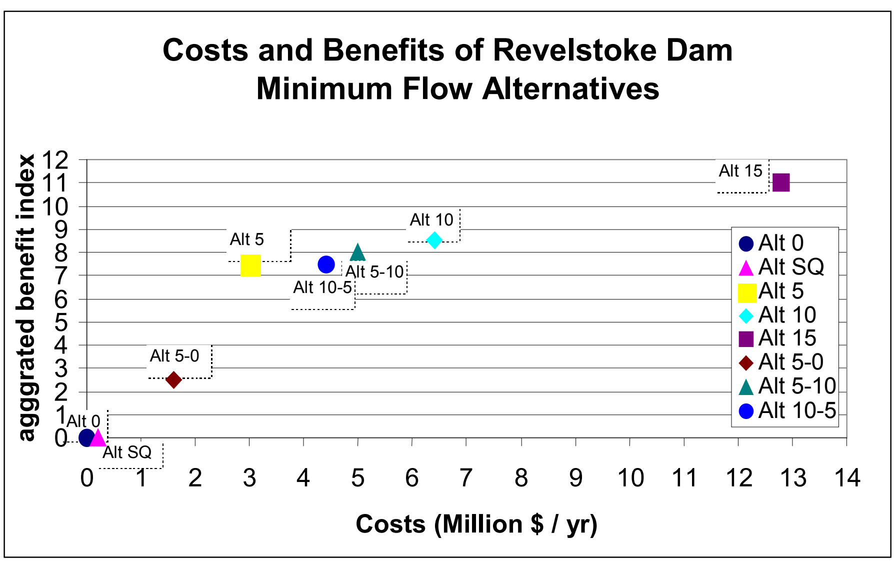

Figure 7-9: Costs vs. Benefits of the Revelstoke Minimum Flow Alternatives – Round 4

The Consultative Committee had discussions around the merit of each flow alternative given the uncertainty around eliciting a detectable response at the fish population level, and seasonal and reach variation in physical habitat response to the minimum flow constraints. The Committee agreed by consensus that the 5 kcfs year-round minimum flow provided the best value. Some highlights from the discussions were as follows:

- Restoring large river habitat to this section of the Columbia River was of high value as this would lead to benefits for other endpoints of interest such as fish and wildlife.
- A monitoring program needs to accompany the change in flows so that the effectiveness of this operation can be measured.
- Committee members would be much less willing to support a 5 kcfs flow if it was determined to have negative impacts on wildlife in the mid Columbia River.
- Committee members would change their support for this decision if monitoring program results indicated that the environmental benefits were less than what was expected.

The BC Hydro Committee members noted that unusual circumstances (e.g., loss of transmission) might force an outage at Revelstoke Dam, which would cause the cessation of flows to the mid Columbia River. While BC Hydro could partially mitigate this by free spilling down the spillway, this would be expensive and might cause damage to the bank adjacent to the spillway. The financial costs associated with spilling and slope damage were not included in the estimated costs of any of the flow alternatives. The DFO representative indicated that it recognizes that forced outages could occur and would accept deviations from the minimum flow under the circumstances, as described by BC Hydro.

During ensuing discussion, the DFO representative raised a question regarding the efficacy of the minimum flow when Arrow Lakes Reservoir was at full pool. It was noted that backwatering of Arrow Lakes Reservoir to the mid Columbia River might enable lowering the minimum flow at certain times during the summer months if it could be demonstrated that it would provide little to no benefit. It was requested that the BC Hydro project team determine the frequency of backwatering, and explore whether the 5 kcfs minimum flow could be modified to reduce costs.

BC Hydro requested the Consultative Committee to consider whether this 5 kcfs minimum flow constraint should also apply after installation of a fifth generating unit at Revelstoke Dam. The Consultative Committee, and in particular DFO, indicated that consideration of Revelstoke Unit 5 was outside the scope of this Water Use Plan, and that the Committee was not prepared to speak on behalf of those that will be responsible for reviewing this project.

Consultative Committee's Recommendation for a Minimum Flow Constraint at Revelstoke Dam

Recommendation	Comments
The Consultative Committee conditionally agreed to recommend a 5 kcfs year-round minimum flow constraint on Revelstoke Dam operations, pending review of the scope and cost of the final water use planning package.	The Committee was clear that this flow constraint needed to be accompanied by a robust monitoring plan to assess the effectiveness of this change. The Committee understood that forced outages may cause the minimum flow to be temporarily disrupted.

7.6.4 Mid Columbia River White Sturgeon Flows

Based on studies conducted during Step 5 of the Columbia water use planning process, the Fish Technical Subcommittee concluded that the best way to improve white sturgeon recruitment in the mid Columbia River through flow changes would be through provision of a periodic flow augmentation during the period of spawning and larval deposition. Physical works options were also considered as a way of providing benefits for white sturgeon in lieu of the natural freshet (i.e., 60 kcfs maximum plant capacity or higher minimum flow) during the spawning and incubation period. A feasibility study was undertaken on behalf of the Fish Technical Subcommittee (Hildebrand et al., 2003) to assess the likely benefits and costs of providing a minimum spawning/incubation flow and turbidity augmentation in the mid Columbia River.

The proposed experimental plan was first presented to the Consultative Committee in November 2003 as a means of addressing possible limitations of the current operating regime on egg/larval survival and juvenile recruitment. The plan was presented as having two options. The first option involved providing four weeks of a minimum flow of 30 kcfs during mid July to mid August, with the exact dates dependant on the availability of hatchery fertilized sturgeon eggs. The second option involved providing a 30 kcfs minimum flow plus a turbidity agent (bentonite) to the river to increase survival of sturgeon larvae through reducing predation pressures. Over a 10-year period, BC Hydro could select three years in which to provide an experimental treatment of either the flow or the flow plus turbidity intervention.

The Consultative Committee discussed the costs and potential benefits of the experimental plan. It was highlighted that, while the probability of successful recruitment to Year 1 class was low with either option, the flow plus turbidity experiment provided the best chance of success. However, Committee members expressed concern over the high cost of this option and that addition of bentonite to the river could have negative effects on other interests (e.g., recreational fishing success).

At this point in the discussion, the BC Hydro project team put forward a revised proposal based on recommendations of the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) for consideration by the Consultative Committee.

- The Recovery Team was not supportive of an experimental flow treatment with the release of large numbers of eggs or larvae, but was supportive of conducting the minimum flow treatment in years when pre-spawning females are identified as present in the system. This would help determine whether a 30 kcfs flow is sufficient to improve spawning conditions and performance for natural spawners in the mid Columbia.

- Due to the high costs associated with a flow + turbidity experiment, it was recommended that turbidity augmentation not be implemented in the mid Columbia River. This was based on the likelihood that predation rates are not as high and therefore likely not as much of a limiting factor in juvenile recruitment as in the lower Columbia River, where the likelihood of producing a detectable recruitment signal through increased turbidity is much higher (50 per cent).

- In lieu of the turbidity experiment or a higher minimum flow, the Recovery Team recommended the development of an experimental hatchery-based supplementation program involving the release of either larvae or 1-year old juvenile sturgeon. It was felt that there is not sufficient genetic diversity or number of individuals in the Arrow Lakes Reservoir sturgeon population to support a unique stock rebuilding effort, and best chances for development of a self-sustaining population would require conservation fish culture.

The Consultative Committee agreed in principle with the revised experimental plan, but highlighted the need to further define the experiment with respect to frequency of flow treatment, and cost of hatchery supplementation, flow release and monitoring. In principle, the Committee agreed to the following main components of the plan:

- A $5 million water budget over 10 years to provide a 30-day minimum flow of 30 kcfs during the spawning period when spawners are detected in the area.

- Monitoring at an estimated cost of $190,000 (annualized over 25 years).

Subsequent to this meeting, the Fish Technical Subcommittee worked with the UCWSRI to develop final recommendations related to treatment options and monitoring within the maximum funding cap recommended by the Consultative Committee. This revised plan was presented to the Committee at their final June 2004 meeting.

7.6.5 Ramping and Stranding Protocol in the Lower Columbia River – Round 4

Early on in the water use planning process, fish stranding in the lower Columbia River as a result of daily and weekly flow changes at Hugh Keenleyside Dam was raised as an important issue to be addressed through the Columbia River Water Use Plan. As outlined in Section 4.10.1.3, preliminary modelling indicated that none of the alternatives modelled had the potential to significantly impact short-term flow fluctuations in the lower Columbia River. As a result, potential fish stranding was not a decision variable in the trade-off process. However, the Consultative Committee wanted to explore how Hugh Keenleyside Dam could be operated to reduce stranding impacts. It was recognized that limiting flow ramping rates within the constraints of the Treaty would not incur a power cost and would not negatively impact other interests in the area. Consequently, there were no trade-offs to be explored related to this issue.

Concerns of the Consultative Committee related to ramping rates and stranding impacts provided further impetus for development of a stranding protocol by the Columbia Operations Fish Advisory Committee (COFAC)[1]. This protocol provides a communication strategy and a standardized method for data collection and environmental response actions related to planned flow changes at Hugh Keenleyside Dam. It also provides interim ramping rates to reduce the incidence of pool stranding until further information is available (refer to Table 7-37). A working draft of the strategy is currently being used to manage flow reductions at Hugh Keenleyside Dam (Vonk, 2003), and is expected over time to reduce fish stranding impacts, reduce the frequency and level of effort required in response activities, and provide a common understanding between BC Hydro and the regulatory agencies around what are acceptable practices and outcomes around these ramping and stranding issues.

Table 7-37: Interim Ramping Rates for Hugh Keenleyside Dam

Stranding Risk Period	Ramp Rate	Comments
High risk period	For discharge changes ≤ 5 kcfs, use a 1.25–2 kcfs/h ramp rate (though some situations may require a higher ramp rate).	For discharge changes greater than 5 kcfs, query the stranding database for risk, select a rate depending on risk, and consult DFO as required.
Low-moderate risk period	For discharge changes ≤ 10 kcfs, use a ≤ 5 kcfs/h ramp rate (though some situations may require a higher ramp rate).	For discharge changes greater than 5 kcfs, query the stranding database for risk, select a rate depending on risk, and consult DFO as required.

1 The Columbia Operations Fisheries Advisory Committee (COFAC) serves as a high-level forum for review of hydro-fisheries conflicts and co-operative opportunities in the Columbia River Basin. It offers the opportunity for BC Hydro, DFO, MWLAP and CCRIFC to exchange information on operational plans, effects or benefits and alternatives, where practical to maximize overall benefits to British Columbia and Canada within the terms of prevailing laws, treaties and agreements.

A study plan to address the consequence of ramping rates on interstitial stranding in the lower Columbia River was presented to the Fish Technical Subcommittee during their September 2003 meeting (Golder Associates, 2003). BC Hydro is currently undertaking the first phase of this study, which was initiated in the winter of 2003 and will likely continue for three years. Based on similar studies that have extended over a 10 to 15 year period, the subcommittee recommended that planned and opportunistic tests/monitoring to establish ramping impacts and appropriate mitigation continue under the Columbia River Water Use Plan.

The Consultative Committee agreed by consensus that the stranding protocol was an acceptable interim measure to addressing fish stranding issues in the lower Columbia River while monitoring and the ramping rate study are carried out. It was noted that, once appropriate ramp rates have been established, accepted by the fisheries regulatory agencies and implemented by BC Hydro, response activities (including fish salvage efforts) would be reduced (i.e., salvage would occur if BC Hydro deviates from these accepted rates). Any further work would entail maintenance of recontouring work undertaken in high stranding risk areas.

Consultative Committee's Recommendation related to Fish Stranding and Ramping Rates in the Lower Columbia River

Recommendation	Comments
The Consultative Committee recommended interim ramping operations, data collection and long-term operating protocols designed to address ramping and stranding issues in the lower Columbia River.	The Consultative Committee recognized that there will be a need to undertake further study under the Columbia River Water Use Plan to continue with current efforts to establish ramping rates for interstitial stranding in the lower Columbia River.

7.7 ROUND 5 TRADE-OFF ANALYSIS, JUNE 2004

A substantial amount of modelling and work at the technical subcommittee level occurred between the November 2003 and June 2004 Consultative Committee meetings to assist in final decision making around operational and non-operational changes for the Columbia River facilities. During the Round 5 trade-off analysis, the Committee evaluated the modelling results of refined operating alternatives for Arrow Lakes Reservoir and the lower Columbia River, along with proposed physical works and monitoring programs associated with these operational decisions[1]. The Committee also reviewed physical works and monitoring proposals for Kinbasket Reservoir, and revisited decisions made for Revelstoke Reservoir and Dam made during Round 4 trade-off discussions.

[1] During the June 2004 meeting, the estimated costs of physical works and monitoring were presented to the Consultative Committee as annual costs (in real dollars), as well as annualized costs over 15 years (i.e., present value using an 8 per cent discount rate levelized in equal payments) to allow for a balanced comparison across proposals. Prior to this, the costs were not reported over one consistent time horizon and were presented as annualized costs over 10, 20 and 25 years at the request of the various technical subcommittees.

Given the integrated nature of the system, there is a substantial degree of overlap between the proposed operations, physical works and monitoring programs among the geographic areas. These will be noted in the text and tables below.

7.7.1 Kinbasket/Arrow Lakes Reservoir Balance – Round 5

At the November 2003 Consultative Committee, it was agreed that the likely path towards consensus involved the creation of a new alternative that would deliver greater environmental benefits than Alternative 11D+Rbt (particularly for birds and vegetation interests) at lesser variable and lower average costs. In 10 per cent of the years, Alternative 11D+Rbt imposes power value losses of at least $13 million, which far exceeds its estimated average annual cost of $3 million. The BC Hydro project team was tasked with finding a way to reduce overall costs and cost variability of constraints by devising a system that would trigger the relaxation of these constraints when they would lead to extremely expensive years. After several modelling attempts, the project team concluded that such an approach was not possible. The Columbia River hydroelectric system, when tied in with the Peace River hydroelectric system, is complex and is optimized over a multi-year horizon. Examination of the high cost years in the previous modelling efforts did not reveal a simple set of triggers that could be used to predict when system constraints would yield high costs. As a result, it was not possible to devise a set of Arrow Lakes Reservoir constraints that could be applied in most years, but relaxed when conditions suggested that they would be very expensive.

The BC Hydro project team created two additional sets of alternatives, based on variations of Alternative 11D. There are listed below in Table 7-38.

Table 7-38: Alternatives for Kinbasket/Arrow Lakes Reservoir/Lower Columbia River Balance – Round 5

		Maximum Month End Elevations					
Alternative	**Description**	**May**	**June**	**July**	**August**	**September**	**October**
11B	Alt 11-B is a refinement of Alt 11. This alternative holds Arrow Lakes Reservoir lower for longer than the Base Case in the spring to improve vegetation potential, large river habitat, and bird habitat.	436.0 m 1430.0 ft	436.0 m 1430.0 ft	–	437.0 m 1434.0 ft	436.0 m 1430.0 ft	436.0 m 1430.0 ft
11D	Designed to reduce costs of Alt 11B by relaxing June constraint and allowing earlier fill, but pushing the reservoir down faster than Alt 11B in the fall.	436.5 m 1432.0 ft	438.3 m 1438.0 ft	–	436.5 m 1432.0 ft	435.3 m 1428.0 ft	–
11D2	Designed to retain environmental benefits of Alt 11D while reducing fluctuations in costs.	436.8 m 1433.0 ft	438.6 m 1439.0 ft	–	436.8 m 1433.0 ft	435.3 m 1428.0 ft	435.3 m 1428.0 ft

Table 7-38: Alternatives for Kinbasket/Arrow Lakes Reservoir/Lower Columbia River Balance – Round 5 (cont'd)

		Maximum Month End Elevations					
Alternative	**Description**	**May**	**June**	**July**	**August**	**September**	**October**
11D3	Designed to retain the environmental benefits of Alt 11D2 while providing more habitat for migratory birds in Arrow Lakes Reservoir during the late summer months (August, September, October) by drawing down Arrow Lakes Reservoir.	436.8 m 1433.0 ft	438.6 m 1439.0 ft	–	436.0 m 1430.5 ft	434.4 m 1425.3 ft	434.3 m 1425.3 ft
Inundation Control (IC)	Performance-based constraint limits inundation duration directly (not through Arrow Lakes Reservoir elevations). Derived from recent conditions that produced current vegetation.	Arrow Lakes Reservoir cannot exceed 436 m for > 36 weeks over any 2 years; or > 48 weeks over any 3 years. Arrow Lakes Reservoir cannot exceed 438 m for > 10 weeks over any 1 year; > 19 weeks over any 2 years; or > 25 weeks over any 3 years.					

Alternative 11D2 imposes a slightly less restrictive month end constraint on Arrow Lakes Reservoir during the spring and fall periods relative to Alternative 11D. Alternative 11D3 matches the spring constraints of Alternative 11D2 but drafts the reservoir more quickly in fall than Alternative 11D. The rationale for the more extreme fall constraints was two-fold: it would provide more habitat for fall migratory birds, and would provide some exposure for vegetation in the drawdown zone during the latter part of the growing season at a less expensive time than spring. It was noted by the vegetation specialist working for the Wildlife Technical Subcommittee that, while the best growing time is during the spring, fall exposure would help to maintain some plants that were inundated for a period of time.

Following the November 2003 Consultative Committee meeting, several important changes were made to the performance measures for vegetation, bird habitat and financial costs. Details and rationale for these modifications are provided in Section 4, and are briefly described below.

- Discussions of the Wildlife Technical Subcommittee led to the use of four separate vegetation performance measures to qualitatively track changes in biomass, diversity and presence of vegetation in the drawdown zone arising from changes in water management regimes.

- New performance measures were developed for nesting and fall migratory bird habitat to reflect both the effects of water levels and vegetation cover on availability and suitability of habitat.

- Several new issues arose around the measurement and interpretation of financial impacts. Some Consultative Committee members felt that the acceptability of the alternatives should also be driven by how expensive these alternatives could be in a high cost year. To capture this interest, the 90th percentile of costs was reported along with average annual costs. Some Consultative Committee members felt that the regulatory agreements around construction of the Arrow Lakes Generating Station (ALH) precluded consideration of financial impacts to this project. To accommodate this interpretation, the total average annual costs of the alternatives excluding impacts at ALH were also included in the consequence table. Finally, BC Hydro raised a concern that the selection of any specific set of constraints around the operation of Arrow Lakes Reservoir would negatively impact Hydro's ability to renegotiate the Non-Treaty Storage Agreement. This was captured in a qualitative way.

- The Consultative Committee had agreed to the rainbow trout flows during the November 2003 meeting, but were uncertain about the whitefish flows and were not prepared to support them at that time. Therefore, it was necessary to present the potential financial impacts of the two flow agreements separately. This allowed the Committee to explore the financial impacts directly associated with implementation of the mountain whitefish agreements on Arrow Lakes Reservoir.

As noted earlier in Section 7.5.1, the impact of the operating alternatives on the profile of Arrow Lakes Reservoir depends on the amount of water in the system in any given year. As illustrated in Figure 7-10, the constraints of Alternatives 11B+FFF[1] and 11D3+FFF result in little difference in monthly reservoir elevations in low water years (10th percentile). However, as illustrated in Figure 7-11, these same two alternatives result in very different reservoir profiles in high water years. Alternative 11D3+FFF differs from 11B+FFF in that it imposes less restrictive constraints in the spring, but stricter constraints in the fall.

[1] Modelling of the lower Columbia River flows was modified for the Fish and Wildlife Technical Subcommittee meeting in February 2004 to account for the low probability of implementing the Libby/Arrow swap. It was revised again for the May 2004 Subcommittee meeting and June 2004 Consultative Committee meeting to account for the fall provisional draft, which the U.S. requires in return for agreeing to cap January flows for mountain whitefish (refer to Section 6.10 and 7.7.8). The new modelled flow agreements were relabelled as "Fish Friendly Flows (+FFF)" as opposed to "Rainbow Trout Flows (+Rbt)" to convey the message that they more accurately reflect the mountain whitefish and rainbow trout agreements in their entirety.

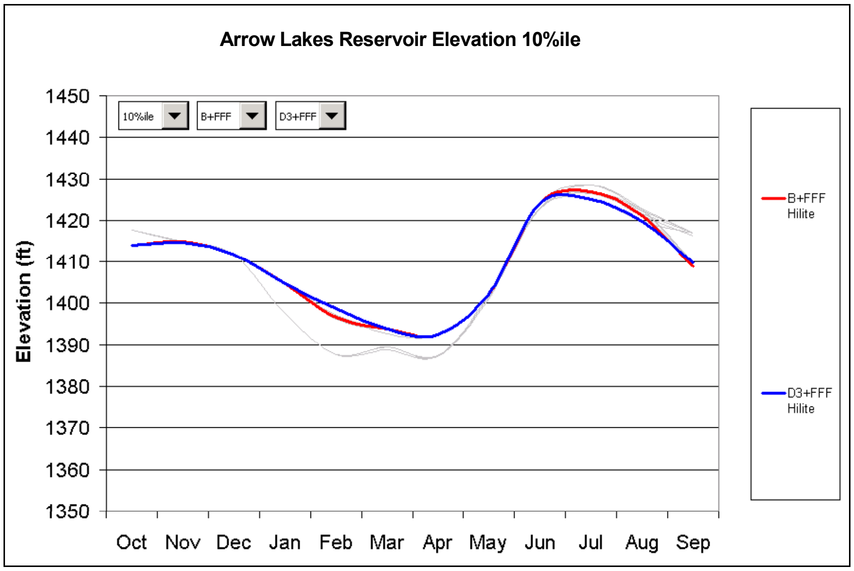

Figure 7-10: Arrow Lakes Reservoir Monthly 10th Percentile Elevations, Alternative 11B+FFF vs. 11D3+FFF

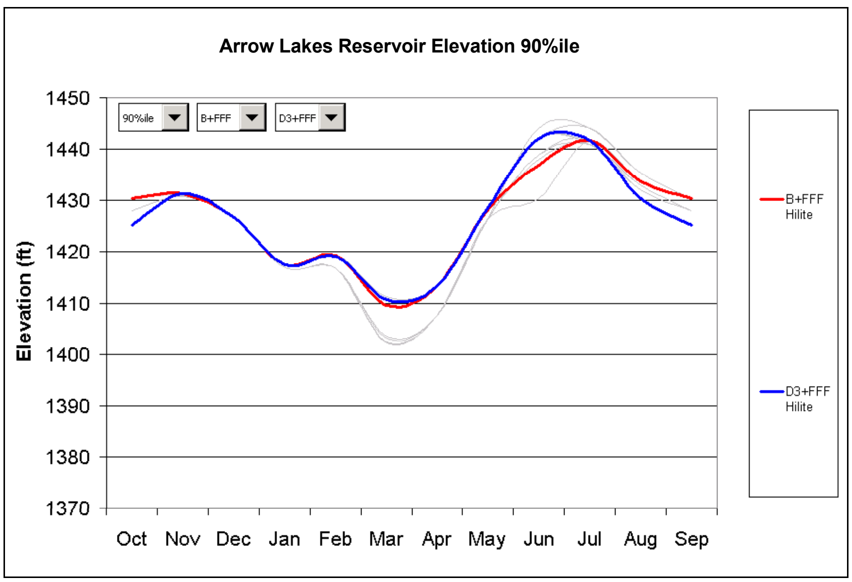

Figure 7-11: Monthly 90th Percentile Elevations, Alternative 11B+FFF vs. 11D3+FFF

To place the constraints of these operating alternatives into the context of actual reservoir elevations, a comparison to recent (1990–1999) historic was presented to the Consultative Committee. This comparison is presented in Figure 7-12. In low water years, Alternative 11D3+FFF would operate the reservoir substantially lower from May through September than that experienced over this 10-year period.

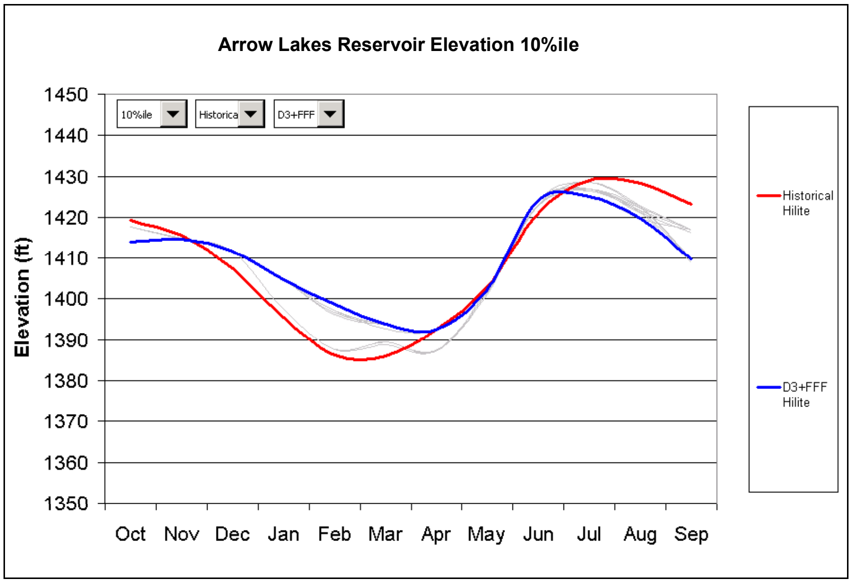

Figure 7-12: Arrow Lakes Reservoir Monthly 10th Percentile Elevations, Alternative 11D3+FFF vs. Recent (1990–1999) Historic

In years when the reservoir is relatively full, Alternative 11D3+FFF would substantially reduce the reservoir level relative to recent historic conditions (refer to Figure 7-13). At the end of September, this would equate to almost a 20-foot difference in elevation.

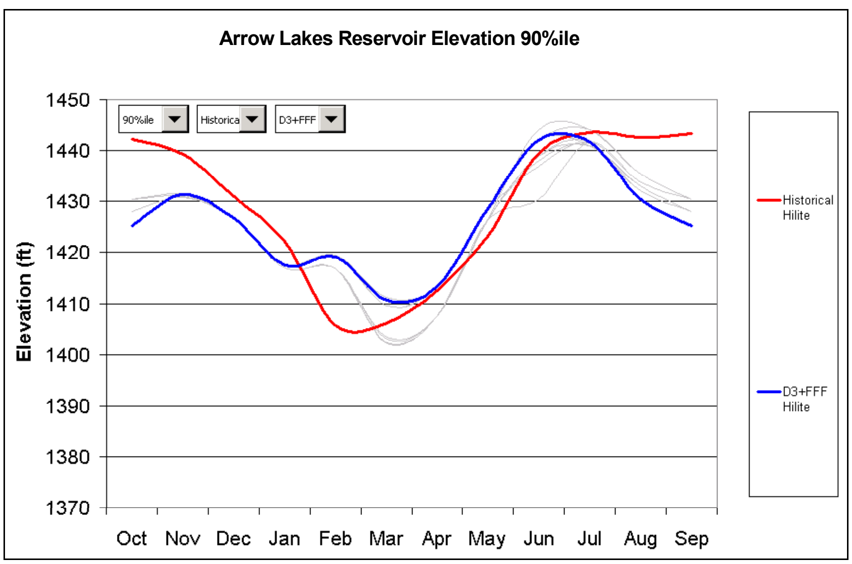

Figure 7-13: Arrow Lakes Reservoir Monthly 90th Percentile Elevations, Alternative 11D3+FFF vs. Recent (1990–1999) Historic

Table 7-39 presents the consequence table highlighting the performance measure results for the Round 5 operating alternatives and recent historic conditions.

Table 7-39: Consequence Table for Round 5 Operating Alternatives – Kinbasket/Arrow Lakes Reservoir/Lower Columbia River

Performance Measure	Units	What's Good?	Significant Difference	11B+ FFF	11D+ FFF	IC+ FFF	11D2 +FFF	11D3 +FFF	Historic
Wildlife and Vegetation									
Vegetation biomass (434–438 m)	Index	more	0.5	-1	-1	-1	-1	-1	0
Vegetation diversity (436–438 m)	Index	more	0.5	1	-1	-1	-1	0	0
Vegetation presence (434–436 m)	Index	more	0.5	-1	-1	-1	-1	0	0
Vegetation presence (436–440 m)	Index	more	0.5	0	0	0	0	0	0
Birds									
Summer/spring nesting (Short-eared Owl) (average)	Rank	less	na	1st	3rd	5th	3rd	2nd	4th
Shorebird Fall Migration (10th percentile)	Rank	less	na	2nd	3rd	4th	3rd	1st	5th
Fish									
Average annual minimum river length (average)	km	more	1 km	8	8	6	8	7	8
LCR Whitefish flows	Yes/no	yes		yes	yes	yes	yes	yes	no
LCR Rainbow flows	Yes/no	yes		yes	yes	yes	yes	yes	no
Littoral (see Vegetation Performance Measure)	See "Vegetation presence"								
RECREATION									
Total Recreation Economic Activity ($ Million)	Thousands $/year	more	$300k	6.4	6.0	5.4	6.7	6.5	3.9
KIN NAV (average)	Site-days/year	more	7 site-days/yr	722	741	734	740	746	
Heritage									
Heritage archaeological impacts from water (average)	# days at or above 436 m	less	7 days	85	78	89	78	68	132
Heritage archaeological impacts from wind (see Vegetation Performance Measure)	See "Vegetation presence"	more							
Flood/Erosion									
High Arrow Lakes Reservoir Elevations (# days > 439)	# days elev 439 m	less	7 days	2	8	25	9	9	37
LCR Flooding	# days/year Genelle 165 kcfs	less		0	0	0	0	0	0
Financial									
Cost of mountain whitefish flows	Power Value Loss M$/year	less	10%	2.3	2.2	2.2	2.2	2.3	
Cost (benefit) of rainbow trout flows	Power Value Loss M$/year	less	10%	(3.0)	(3.0)	(3.2)	(3.0)	(3.0)	
Total Power Costs (gains) (ALH subtracted)	Power Value Loss M$/year	less	10%	9.9	1.9	1.2	1.0	2.0	
Total Power Costs (gains)	Power Value Loss M$/year	less	10%	9.3	2.0	0.0	0.9	2.8	
High Cost Year (90th percentile)	Power Value Loss M$/year	less	10%	31.6	13.3	7.5	10.4	13.6	
Potential Impacts to BC Hydro NTSA negotiations	Index	more	0.5	-2	-2	-1	-2	-2	

The following summarizes the highlights of discussions related to performance of the operating alternatives and how they compare to recent historic conditions.

Vegetation

- All of the alternatives would maintain some vegetation presence at or above elevation 436 m (1430 ft), but would also pose a risk of losing vegetation values from 434 to 438 m (1424 to 1437 ft) relative to historic levels. Note that this conclusion is different from that reached during Round 4 trade-off discussions for the same set of alternatives (Alternatives 11B+FFF, 11D+FFF and IC+FFF). This difference highlights the difficulty in making succinct, qualitative statements about complex issues such as vegetation growth in the drawdown zone. It also highlights the level of uncertainty around the measurement of vegetation impacts.

- There was a wide divergence in the level of trust of Consultative Committee members that the performance measure values were accurate predictors of how the vegetation would respond under the different sets of constraints. Many Committee members felt that the assumptions underlying the vegetation performance measures were too optimistic, and that the vegetation would die back much more than the performance measure scores suggested. However, a number of Committee members felt that the vegetation performance measures were too pessimistic, and that policies that restricted the reservoir elevations significantly more than in the past would lead to more vegetation growth.

Birds

- There is an apparent trade-off between operations that favour summer nesting bird habitat and fall migratory habitat. To minimize financial impacts, the Consultative Committee had to choose between restricting reservoir elevations in the spring or fall, which translated into providing bird habitat (exposed, vegetated areas) between these two seasonal periods. Given that vegetation was an important input into this performance measure, and there was a high level of uncertainty around the vegetation performance measures, the range of uncertainty around the bird measures was also large.

Erosion

- All of the alternatives would provide significant improvements in shoreline erosion and protection of archaeological sites over historical (1990–1999) conditions.

Financial Costs

- The rainbow trout agreement reduces the cost of electricity production by approximately $3 million per year on average, with this impact being largely independent from the operating restrictions placed on Arrow Lakes Reservoir. The mountain whitefish agreement increases the cost of power production by over $2 million per year on average, with this largely unaffected by the operating restrictions on Arrow Lakes Reservoir. While Round 4 modelling efforts had indicated that the cost of the two flow agreements approximately netted out to zero, this more detailed analysis shows that the total package of "fish friendly flows" actually poses a net reduction in the average cost of power production.

- Eliminating the financial impacts at ALH from the total cost of the alternatives slightly alters the ranking of these alternatives with respect to cost.

- Alternative 11D3+FFF has approximately the same average and extreme costs as Alternative 11D+FFF while delivering slightly greater environmental benefits. Alternative 11D2+FFF has slightly lower costs while delivering approximately the same environmental benefits. General discussions of the Consultative Committee suggested that neither of the two new alternatives provided an obvious basis for a consensus agreement, since neither delivered both lower costs and greater environmental benefits compared to 11D+FFF. In fact, some Committee members suggested that another round of modelling would be needed, perhaps exploring more flexible alternatives like IC+FFF to achieve consensus.

Just prior to the final June 2004 meeting, the BC Hydro Project Team and Consultative Committee was informed that the Non-Treaty Storage Agreement between BC Hydro and Bonneville Power Authority (BPA) would expire by end of June 2004, and negotiations with the U.S. had failed to produce a replacement agreement. This posed a change to the way in which the process would be able to consider operating alternatives for Arrow Lakes Reservoir. Consequently, the Committee was not requested to choose amongst the Arrow alternatives.

7.7.2 The Non-Treaty Storage Agreement and the Columbia River Water Use Planning Process

The Non-Treaty Storage Agreement (NTSA) is a commercial agreement that allows for the co-ordination of additional storage at Kinbasket and Arrow Lakes reservoirs that is not governed by the Treaty.

The BC Hydro modelling team assumed that there were several mechanisms through which it could unilaterally change flows, and this included flexibility within the NTSA. This was particularly important in achieving the rapid drawdown of Arrow Lakes Reservoir in the later summer and early fall periods. All of the alternatives developed to balance Kinbasket and Arrow Lakes reservoirs (Alternatives 11B, 11D, 11D2, 11D3, and IC) used the NTSA to some extent to achieve this fall constraint. This allowed the alternatives to be treated as options that BC Hydro could implement unilaterally without agreement with the United States.

Without a new NTSA in place, it would not be possible for BC Hydro to unilaterally implement all of the monthly constraints on Arrow Lakes Reservoir under the alternatives across all water years. In the absence of a negotiated agreement, there will be no mechanism to deliver flows to draft Arrow Lakes Reservoir on an assured basis. Reservoir water levels could be kept lower by storing more water in Kinbasket Reservoir during low water years. However, meeting the constraints during high water years would not be possible, as the Treaty would restrict downstream flows. Further, all of the alternatives would have significantly higher financial costs and perhaps impose a different balance between Kinbasket and Arrow Lakes reservoir levels. The impact of a new NTSA on the cost of the alternatives will not be known until negotiations are completed.

The Consultative Committee was informed that BC Hydro would be working towards having an agreement in place by the end of 2004; however, there is no guarantee that a new agreement would be signed by this time. In the meanwhile, imposing any of the alternative constraints within the Columbia River Water Use Plan would undermine BC Hydro's bargaining position with the United States. There was substantial discussion of the Committee around how water use planning decisions would impact upcoming negotiations, and possible options for the Committee to proceed with the water use planning process. During these discussions, Committee members expressed several issues and concerns.

- During previous meetings, the Consultative Committee had discussed the NTSA, and some members had expressed a strong interest in being consulted in the renegotiations, particularly those that lived in the Kinbasket Reservoir area. This issue was highlighted again by some members.

- Committee members expressed frustration related to the interruption posed by the NTSA negotiations on progress of the consultative process. They noted that significant time and effort had gone into working towards consensus, but that they were now being told that a final decision might have to be postponed for half a year or longer to accommodate BC Hydro's negotiating agenda.

- Some members noted that there has been an inconsistency in the way that the interaction between the NTSA and Columbia River water use planning processes has been viewed. Expiration of the NTSA was delayed for one year until the water use planning process was complete, and yet now there is an inability to complete the process without a NTSA in place.

- Several Committee members reiterated their desire to have input into BC Hydro's long-term planning processes if these processes will impact their interests. These comments were expressed by both Kinbasket Reservoir residents, as well as the First Nations representatives.

The Consultative Committee expressed an interest in adapting the Columbia River water use planning process to assist BC Hydro in its negotiations with the United States. In particular, Committee members understood and accepted the need not to undermine BC Hydro's position by proceeding with recommendations for constraints on Arrow Lakes Reservoir operations. The Committee struggled with ways that it could make agreements on the many areas where consensus was possible, while leaving open the possibility of revisiting some decisions once the

NTSA was renegotiated. Unfortunately, it was not clear to the Committee whether these approaches would fit into the scope of water use planning. As this issue became apparent at the last minute, the representative for the Water Comptroller's Office was unable to respond definitively to their questions during the meeting.

The Consultative Committee initially discussed five possible options the process could follow.

- Option 1: Review materials presented, but defer making final decisions until negotiations for a new agreement have been completed.
- Option 2: Leave BC Hydro to represent the Committee's objectives. Risk that there is no certainty to operations for Arrow Lakes Reservoir. There would be no additional Committee meetings.
- Option 3: Move forward with making decisions for the Mica and Revelstoke projects only. Once a new NTSA is completed, convene an additional Committee meeting to finalize decisions around Arrow Lakes Reservoir and the lower Columbia River.
- Option 4: Select a shorter term for review of the Water Use Plan (e.g., 3 years).
- Option 4a: Select a shorter term review for the Arrow Lakes Reservoir component of the Water Use Plan, with clearly stated objectives and review in 3 years.

Based on the information presented, the Consultative Committee agreed in principle to Option 3 assuming that potential outcomes of a new NTSA would not impact operation of Kinbasket Reservoir. It was agreed that a final decision related to proceeding with the Water Use Plan could not be made until further information was presented by BC Hydro.

This issue was revisited on the third day of the meeting, with a number of options being presented for discussion by the Committee. The Committee accepted that there were three options that could be followed.

- Option 1: Review materials presented, but defer making final decisions until a meeting in the new year (March 2005), by which time BC Hydro felt it would have completed negotiations. In the event that a new NTSA is not in place, present a viable plan for Arrow Lakes Reservoir that would fit into the scope of water use planning.
- Option 2: Agree to Water Use Plans for Mica and Revelstoke projects, but defer final discussions around Arrow Lakes Reservoir operations until the NTSA is renegotiated. Once a new agreement has been negotiated, complete

a second Water Use Plan for Hugh Keenleyside, Arrow Lakes Reservoir, and the lower Columbia River.

- Option 3: Complete decision making for the water use planning process now, but leave constraints for Arrow Lakes Reservoir operations as “soft” constraints.

The discussion that followed amongst the Consultative Committee members embodied several themes.

- The Committee had worked hard and achieved consensus agreement on most elements of the Water Use Plan.
- The Committee had a strong desire to have timely completion of this process in order to proceed with implementation as soon as possible.
- Making a decision around Arrow Lakes Reservoir operations was going to be difficult because of the lack of certainty around vegetation and bird impacts, and the view that a more flexible alternative was required but had not been modelled.
- The Committee did not want to hamper BC Hydro’s negotiating efforts.

At the end of its deliberations, the Consultative Committee was asked to express its support for these three options. Table 7-40 presents the results of this poll and comments made by the Committee members.

The representative from the Columbia Power Corporation (CPC) took this opportunity to note the general difficulty facing CPC regarding the Columbia River Water Use Plan. CPC had been in discussions with the Province and BC Hydro to ensure that any decisions coming out of the water use planning process will not adversely impact the Arrow Lakes Generating Station and other CPC/CBT joint venture projects. In the absence of greater clarity around this policy issue, CPC is unable to support any decisions that might reduce its revenues and the ability to project finance. However, CPC is prepared to conditionally accept the consensus recommendations of the Consultative Committee subject to receiving assurance from BC Hydro that CPC/CBT joint venture projects would be saved harmless or appropriately compensated for any adverse impacts resulting from implementation of the Water Use Plan. CPC’s position was outlined in a 18 June 2004 letter to the BC Hydro project manager of the Columbia River water use planning process (refer to Appendix G: Correspondence related to the Columbia Power Corporation and the Columbia Basin Trust).

The representative of the Columbia Basin Trust supported this position. As the CBT receives one-half of joint venture net income, which in turn is spent on programs for the social, economic and environmental benefit of the region, any financial impact to these joint venture projects would impact the benefits CBT delivers to Columbia River Basin residents. As such, the CBT could not support any alternative that may have negative financial impacts on the CPC/CBT joint venture projects.

Table 7-40: Level of Support for Three Options for Completing the Columbia River Water Use Planning Process

Committee Member	Option 1 (Postpone, and meet by March, 2005)	Option 2 (Complete one Water Use Plan now and one later)	Option 3 (Complete the Water Use Plan now, with soft constraints on Arrow)	Comments
Bill Green	E			
Bob Taylor			E	
Chris Beers		E		
Doug Robinson			E	
Fred Fortier			E	I support Option 3 if we are dealing with hard constraints. We haven't talked about the soft constraints.
Gail Bernacki			E	
Gordon Boyd			E	
Helmut Klughammer			E	
Ian MacLean			E	We are trying to move forward and get the work going. Recognize soft constraints are conflicting coming out of the water use planning process. Need to determine what the review period is.
Janice Jarvis			E	With the agreement that if there is a non-consensus, then a Consultative Committee meeting happens in the near future.
Jim Forbes			E	
Judy Bosh			E	
Kindy Gosal			E	
Llewellyn Matthews			E	I support options 3, 2 and 1 in that order, subject to previously stated conditions.
Loni Parker			E	
Mark Thomas	E			Provided an impact assessment on the delay of the NTSA signing from 6 month to 7 years is undertaken.
Maureen Weddell			E	
Pat Wilcox			E	
Paul Peterson			E	Subject to implementation of physical works.
Randy Priest			E	
Shelley Murphy	E			
Steve Macfarlane			E	With the proviso that further refining of the performance measures for Arrow Lakes Reservoir is done.

Table 7-40: Level of Support for Three Options for Completing the Columbia River Water Use Planning Process (cont'd)

Committee Member	Option 1 (Postpone, and meet by March, 2005)	Option 2 (Complete one Water Use Plan now and one later)	Option 3 (Complete the Water Use Plan now, with soft constraints on Arrow)	Comments
Susan Hall	A	A	E	Endorse 3. Accept 1 or 2 with completion of Kinbasket and Revelstoke with interim operating agreement tied to performance standard. Maintain vegetation diversity and biomass and extent. Maintain access to habitat for migratory birds (20–30 ha week summer migration and nesting – average). Identify and preserve heritage sites. Fully funded monitoring to document compliance. Endangered species work (sturgeon). 3-year review period when opportunity to re-open Water Use Plan based on monitoring and public input.
Terry Anderson		E		

To summarize, the Consultative Committee agreed in principle to recommend soft constraints on Arrow Lakes Reservoir operations. It was agreed that:

- Soft constraints were to help inform the BC Hydro operators on impacts.
- Soft constraints would be reflected in the System Operating Orders for Arrow Lakes Reservoir.
- No new maximum or minimum constraints would be placed on BC Hydro's water licences for Arrow Lakes Reservoir.
- No compliance monitoring would be required by the Water Comptroller's office.

The Consultative Committee subsequently discussed a review period for the Water Use Plan and agreed that a longer review period would be beneficial for several reasons.

- Monitoring plans will be better able to inform on performance measures.
- There is little public appetite to participate in meetings again soon.
- Funding another set of meetings would be difficult in the near future.
- There would be no point in setting a date that may occur before the NTSA discussions are completed.

However, the Consultative Committee was also reluctant to agree to a lack of hard constraints on Arrow Lakes Reservoir operations for a long period of time.

The Committee agreed to a 5-year review for Arrow operations to evaluate the effectiveness of the soft constraints, report out on the results of a concluded NTSA, and determine whether there is a need to review Arrow operations. While it was explicitly agreed that signing of a new NTSA agreement would not be a trigger for a review, it was recommended that there be annual reporting of progress on monitoring and physical works, and performance in meeting the soft constraints.

Consultative Committee's Recommendation for the Review Period Regarding Constraints on Arrow Lakes Reservoir Operations

Recommendation	Comments
The Consultative Committee recommended a 5-year review period upon the Water Use Plan's implementation for Arrow Lakes Reservoir operations to evaluate the effectiveness of the soft constraints, to report out on the results of the concluded NTSA discussions, and to determine whether there is a need to review Arrow Lakes Reservoir operations.	The Committee agreed that the completion of the Non-Treaty Storage Agreement discussions was not a trigger for a review of the Water Use Plan. However, the Committee wished to see BC Hydro undertake an impact assessment to determine how the NTSA will affect BC Hydro's ability to achieve the soft constraints and meet the objectives of the system.

Decisions related to soft constraints on Arrow Lakes Reservoir operations and a 5-year review period were made at the end of the meeting. Prior discussions around monitoring and physical works for Arrow Lakes Reservoir and the mid Columbia River had produced recommendations for longer term programs (i.e., greater than 5 years). Time did not permit a consideration of how a mid-term review of operations would fit with longer term monitoring and physical works programs. It was recognized that results of the monitoring studies and effectiveness of the physical works would help inform on how well the objectives of the Committee were being met with the soft constraints.

The Consultative Committee discussed the impacts of the modelled alternatives on objectives for Arrow Lakes Reservoir and the mid Columbia River to examine trade-offs in the system and structure the discussion of soft constraints. The following constraints were recommended by the Committee for consideration by the BC Hydro operators.

Vegetation

The Consultative Committee recognized early on that operating alternatives for Arrow Lakes Reservoir could not restrict the reservoir from reaching full pool in July. Since vegetation within the drawdown zone requires exposure during the growing season to survive, the operating question focused on how much exposure was required, and the relative importance of this exposure in the spring versus the fall. Modelling of the reservoir and the vegetation performance measures highlighted these uncertainties, but was unable to resolve them. As a result, the Committee's recommendation to the BC Hydro operators around this interest was to **maintain the current level of vegetation in the drawdown zone. No specific operating targets were discussed around this general objective of maintaining lower reservoir levels.**

Birds

The Consultative Committee suggested that the goal for BC Hydro operators should be to **ensure that inundation of nesting bird habitat by rising reservoir levels is no worse than it has been historically**. The Committee suggested that BC Hydro match historic spring/summer habitat for short-eared owls on average performance measure scores. In general, this means that lower reservoir levels in the early summer are better for nesting birds.

For fall migrating birds, the Consultative Committee recommended that BC Hydro ensure that performance measure scores are as good or better than historic performance measure scores suggest. This could be accomplished by drafting the reservoir quickly after full pool is reached. As a specific target, the group wanted to **reduce water elevations to 1438 ft by 7 August**.

Fish

The Consultative Committee recognized that fish interests were not directly affected by Arrow Lakes Reservoir constraints but may benefit indirectly through improvements in vegetation and wildlife. However, concern was expressed that drafting Arrow Lakes Reservoir below 1425 ft in the fall may cause small tributaries in the reservoir to become inaccessible to kokanee spawners. It was acknowledged that this issue required further verification[1].

Recreation

Those Consultative Committee members representing recreation interests on Arrow Lakes Reservoir reiterated that the **ideal operating range for recreation was between 1435 and 1440 ft**. It was acknowledged that, with the construction of new boat ramps and upgrades to existing ramps, **a lower level of 1425 ft would be acceptable**. However, there is a strong preference for interests not served by these few formal access points to maintain the reservoir levels between 1435 and 1440 ft during the recreation season.

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[1] Subsequent to the Consultative Committee meeting, results of a tributary access study were reviewed by the Fish Technical Subcommittee (refer to Appendix BB: Briefing Note – MCA WUP Fish Technical Subcommittee Teleconference, November 2004). While this study provided further information related to reservoir and streamflow conditions required to provide upstream fish passage, it was recognized that more comprehensive observations under a range of reservoir operating levels and streamflow conditions would be required to inform future water use planning reviews. The subcommittee recommended that a monitoring study be undertaken as part of the Columbia River Water Use Plan to assess fish migration tributary access.

In addition, there is an interest in **minimizing the time the reservoir is at full pool, and avoiding sudden drawdown once full pool has been reached (particularly if high runoff has saturated the banks).** It was felt that these measures would reduce erosion and bank slumpage into the reservoir.

Erosion

Although not intended as soft constraints for operation of Arrow Lakes Reservoir, some Consultative Committee members identified other constraints that should be considered by BC Hydro in its operations.

On behalf of the representative of the City of Trail (who was not in attendance), it was noted that there is a desire to keep flows below 165 kcfs at Genelle. If BC Hydro is taking actions that cause damage at Trail, then the City will seek compensation.

A number of Committee members also highlighted the need to avoid surcharging of Kinbasket Reservoir whenever possible.

Heritage

Those Consultative Committee members representing First Nations interests emphasized the need to **maintain reservoir levels at or below 436 m (1430 ft) for as long as possible**, based on archaeological work undertaken on Arrow Lakes Reservoir. Ideally, the reservoir would be at or below this level for 80 per cent of the time. While this need to maintain lower reservoir levels might be reduced as physical works are undertaken, the First Nations representatives viewed this as a priority in the immediate future.

The Consultative Committee recognized that some of the soft constraints identified for Arrow Lakes Reservoir are in conflict. As illustrated in Figure 7-14, operations to benefit recreation interests conflict with vegetation, bird and archaeological site protection in early summer. In the fall, there is a small elevation band from 1435 ft to 1438 ft where recreation and wildlife interests are met. However, water levels lower than this are needed to protect eroding archaeological sites in Arrow Lakes Reservoir. It was highlighted that there are areas of common ground, and some potential conflicts could be removed through implementation of physical works. However, the Committee agreed that these trade-offs would always exist, and the degree to which they occur will vary by water year.

Rather than prioritizing the soft constraints, the Consultative Committee agreed that BC Hydro would need to balance these trade-offs internally through choosing its water management strategy. This balance would be informed by the expressed values of the Committee members, the performance measures calculated to date, the efficacy of the physical works, and knowledge gained from the monitoring plans to guide its operational decisions.

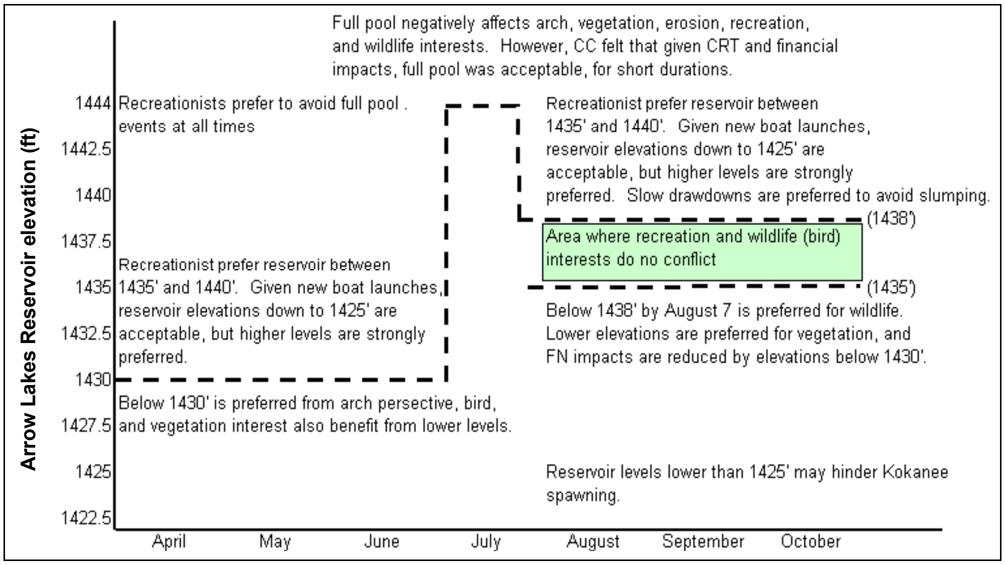


Figure 7-14: Soft Constraints for Arrow Lakes Reservoir Operations

7.7.3 Physical Works for Arrow/Kinbasket Balance – Boat Ramps

7.7.3.1 Kinbasket Reservoir

Due to the high costs associated with implementing operational constraints on Kinbasket Reservoir ($10 million to $20 million per year for Alternatives 1 and 2), the Consultative Committee explored physical works in lieu of operational changes for recreation interests on the reservoir. Four boat ramp proposals were developed to address recreational boat access during different times and reservoir elevations (Valemount, Bulldog Creek, Nixon Creek and Bush Harbour). These proposals are described in Table 7-41, and their locations are shown in

Figure 7-15. The Committee indicated a high degree of support for these proposals.

Table 7-41: Boat Ramp Proposals for Kinbasket Reservoir

Location	Issue/Action	Benefits	Construction Costs (amortized over 15 years + maintenance)
Kinbasket Reservoir			
Bulldog Creek	A new ramp from 2405 ft to 2375 ft	3 weeks/summer 7 weeks/year of extra use, 32 km from Valemount (1250 people)	$87,000 ($9,400/year + $3,000 annual maintenance)
Valemount Marina	Ramp is dry every year. Extend ramp from 2404 ft to 2395 ft	1 week/summer, 3 weeks/year extra use Closest access to Valemount (1250 people)	$30,000 ($3,250/year + $12,500 annual maintenance)
Nixon Creek	Ramp is stranded 1/6 years. Extend ramp from 2400 ft to 2340 ft	2 summer weeks/60 years, 49 weeks/ 60 years extra use. Would be 1st site available to Golden end	$136,000 ($14,700/year + $12,500 annual maintenance)
Bush Harbour	Ramp is stranded every years. Extend ramp from 2410 ft to 2385 ft	1.5 weeks/summer, 5 weeks/year of extra use	$46,290 ($5,000/yr + $12,500 annual maintenance)

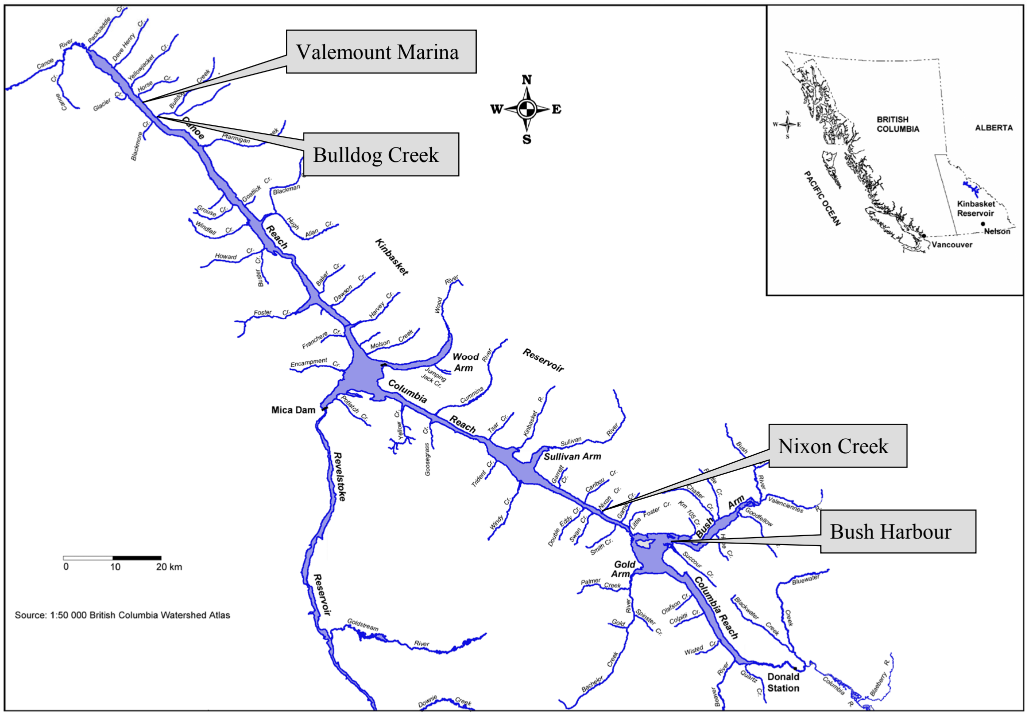


Figure 7-15: Location of Proposed Boat Ramp Projects on Kinbasket Reservoir

7.7.3.2 Mid Columbia River

At the final Recreation Technical Subcommittee meeting in May 2004, the representative from the City of Revelstoke presented a proposal for construction of a boat ramp in the mid Columbia River. Boaters launching from the current site face a number of hazards, including high currents (when Revelstoke Dam is releasing large flows) and hazardous low water conditions (when Arrow Lakes Reservoir is low). Due to the late nature of this proposal, no alternatives were modelled to address these issues, and no examination of the existing model runs was made to explore the impact of flows on these issues. However, in principal, it was argued that improved boat access in this area would be in lieu of lower, more stable flows from Revelstoke Dam and higher water levels in Arrow Lakes Reservoir during the recreation season.

The proposal for the mid Columbia River boat ramp consisted of three parts: a feasibility study to examine the most suitable location for the ramp; a weir to deflect currents from high flows, and a ramp (or ramp extension if the current site is used) that would accommodate access across a wide range of reservoir levels. The benefits and estimated construction costs are summarized in Table 7-42.

Table 7-42: Initial Proposal for Boat Access for the Mid Columbia River

Location	Issue/Action	Benefits	Construction Costs (amortized over 15 years + maintenance)
Mid Columbia River			
Revelstoke	Low water and high flows pose hazardous launch conditions at exposed end of ramp	Alternative to those that don't want the year-round access at Revelstoke Reservoir (10 km away)	$950,000 ($111,000 + $12,500 annual maintenance)

At the June 2004 meeting, the Consultative Committee discussed this proposal at length. Some members felt that access for boating was an important issue, and the current location was not functioning properly. Given the size of the town of Revelstoke and tourist traffic through the area, a well-functioning boat ramp could be a valuable asset. Committee members were clear that access to the Arrow Lakes Reservoir system was important.

There were several Consultative Committee members, however, that did not support the proposal. BC Hydro representatives felt that the river section was a hazardous stretch of water, with levels fluctuating due to dam releases, reservoir levels, and a shifting river bottom. BC Hydro did not want to encourage more boating in an area where these dangers existed, but would prefer boaters use safer reservoir access points, particularly tourists who would be less familiar with these hazards.

The DFO representative noted that a breakwater of sufficient size to ensure access to the river would be a substantial structure, and would require regulatory approval. It would be more preferable from the Department's perspective if a location could be found that does not require such a structure.

7.7.3.3 Arrow Lakes Reservoir

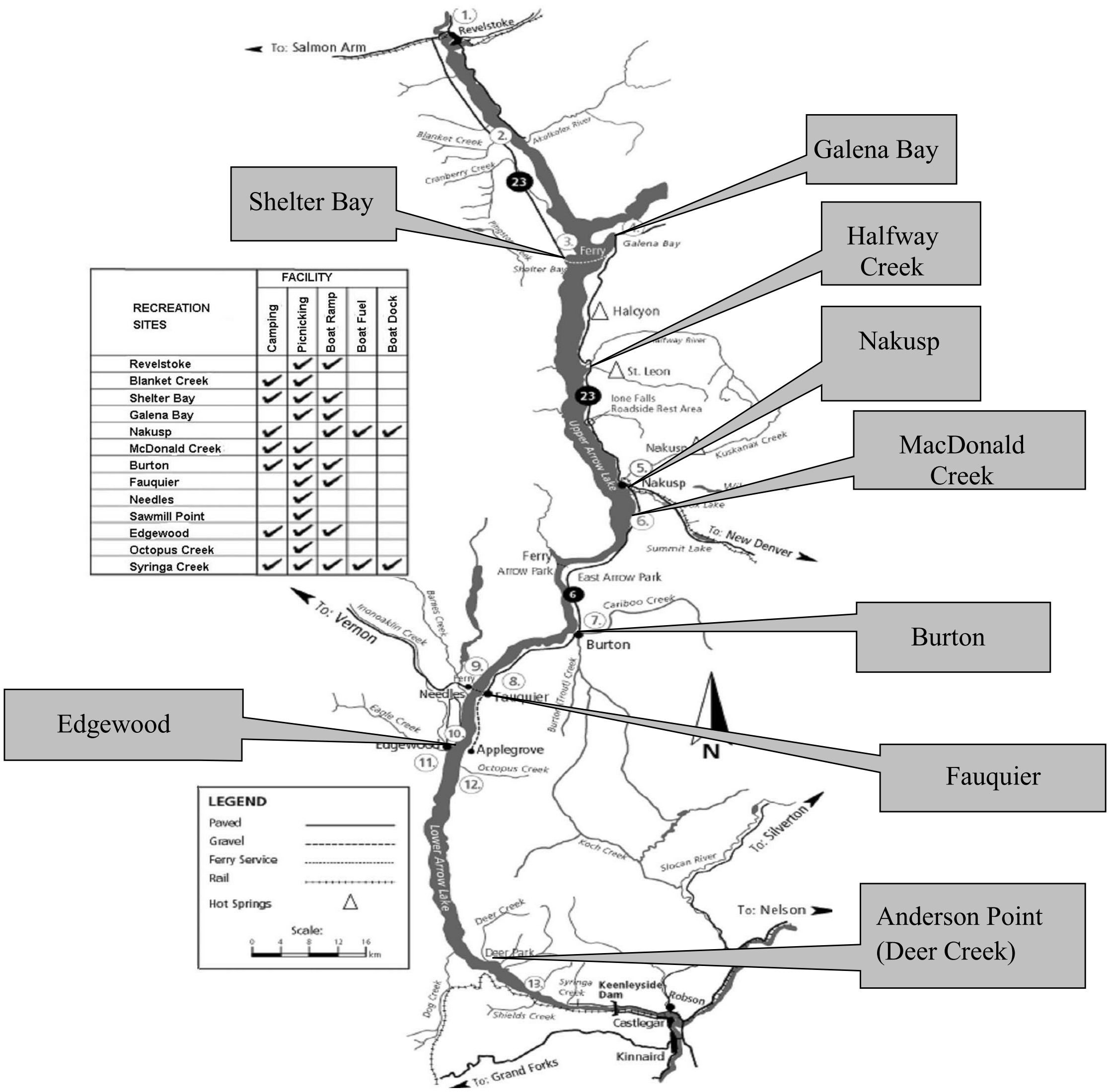
The Consultative Committee tasked the Recreation Technical Subcommittee to explore boat ramp proposals for Arrow Lakes Reservoir that would provide access to the reservoir at a lower cost than implementing an operational policy that would maintain a minimum elevation of 1434 ft during the recreation season (i.e., $10 million per year for Alternative 10). The subcommittee developed nine boat ramp proposals (Galena Bay, Anderson Point, Edgewood, Fauquier, Burton (upgrade), Burton (new), MacDonald Creek Park, Nakusp and Shelter Bay). A further proposal, Halfway Creek, was added to this list during the Consultative Committee meeting. Table 7-43 describes the benefits of the boat ramps when compared against modelled data, and their estimated construction and maintenance costs. Figure 7-16 shows the location of the proposed works.

The Committee discussed the 10 proposals, and whether these works fit within the scope of water use planning. With the assistance of a representative from the Water Comptroller's office, the Committee established an approximate guideline that new points of access do not fit within the scope of water use planning.

Table 7-43: Proposed Boat Ramps for Arrow Lakes Reservoir

Location	Issue/Action	Benefits	Construction Costs (amortized over 15 years + maintenance)
Edgewood	Ramp stranded in 16 of 60 years. Extend ramp from 1397 ft to 1390 ft	Additional 24 weeks/60 years of summer access, 133 weeks/60 years of year-round access	$868,000 ($94,000/year + $12,500 annual maintenance)
Fauquier	Boat ramp extension. Ramp stranded in 13 of 60 years	Provides access for local residents (250), 25 km from Edgewood site	$508,000 ($55,000/year + $12,500 annual maintenance)
Burton (new ramp)	Ramp for low water periods proposed (1420 ft to 1390 ft)	Serves Burton residents and visitors. Provides substitute for Fauquier Ferry terminal (20 km) and MacDonald Creek Park (20 km). Additional use of 28 weeks/year, all outside of summer months	$350,000 ($38,000/year + $12,500 annual maintenance)
MacDonald Creek Park	Ramp strands in almost all years. Extend ramp from 1431 ft to 1427 ft	Serves locals, park visitors to east side of lake. Substitute to Nakusp (15 km away) Arrow Park (10 km away). Extra 2 weeks/summer, 9weeks/year of use	$520,000 ($56,250/year + $12,500 annual maintenance)
Nakusp	Current ramp of poor design, in poor repair. Build a new ramp adjacent to old ramp	Benefits to Nakusp residents (3000) and visitors. 50 km to shelter Bay, 10 km to MacDonald Creek Park	$1.4 million ($151,450/year + $12,500 annual maintenance) [1]
Galena Bay	New ramp, size and location tbd	Alternative to Galena Bay Ferry launch, closest substitute is Nakusp	$868,000 ($101,000 + $12,500 annual maintenance)
Halfway Creek	New ramp, size and location tbd	Reduces distance for boaters to return to their launch, which may increase safety during rough weather	$868,000 ($101,000 + $12,500 annual maintenance)
Anderson Point (Deer Park)	New ramp, down to 1380 ft	Alternative launch to Scotties marina and newly upgraded Syringa Creek (15 km) facilities	$695,000 ($81,000 + $12,500 annual maintenance)
Burton (existing ramp)	Current ramp needs maintenance and upgrade.	Serves local residents and visitors; would improve service.	$8,000 ($1,000 + $12,500 annual maintenance)
Shelter Bay	Low water strands ramp in about 4 of 60 years. Extend ramp from 1390 ft to 1386 ft	Serves residents in Upper Arrow Lake and visitors Extra 4 summer weeks/60 years, 21 weeks/60 years in extra use	$585,000 ($68,000 + $12,500 annual maintenance)

[1] Construction and maintenance costs for Nakusp were updated prior to the Consultative Committee meeting.



RECREATION SITES	FACILITY Camping	Picnicking	Boat Ramp	Boat Fuel	Boat Dock
Revelstoke		✔	✔		
Blanket Creek	✔	✔			
Shelter Bay	✔	✔	✔		
Galena Bay		✔	✔		
Nakusp	✔		✔	✔	✔
McDonald Creek	✔	✔			
Burton	✔	✔	✔		
Fauquier		✔	✔		
Needles		✔			
Sawmill Point		✔			
Edgewood	✔	✔	✔		
Octopus Creek		✔			
Syringa Creek	✔	✔	✔	✔	✔

Figure 7-16: Location of Proposed Boat Ramps for Arrow Lakes Reservoir

The following summarizes key decisions of the Consultative Committee related to each boat ramp proposal.

Shelter Bay

The Recreation Technical Subcommittee considered this proposed project a low priority. The Consultative Committee agreed to remove it from the list of projects.

Galena Bay

Currently, boaters use the ferry slip to launch their boats. However, a recent change in ownership raised the possibility that new owners may restrict access of private boaters to this launch due to safety reasons. In such a circumstance, boaters would not have access to this portion of the reservoir and their closest launch would be Nakusp. A sentiment expressed by several Committee members was that BC Hydro is responsible for providing access to Arrow Lakes Reservoir as a part of its water licence. While the Consultative Committee agreed that there is a risk that boaters may lose access to the reservoir in this area, no operational change would reduce this risk and, therefore, it was agreed that this was not a water use planning issue.

Halfway Creek

The lack of boat access points in this area raised a concern that boaters on this stretch risked not being able to return to their launch site if weather conditions turned foul. While the Committee recognized this risk, they agreed that no operational change would reduce the risk to boaters arising from sudden bad weather conditions. Consequently, the Committee agreed that this project was not within the scope of water use planning.

Nakusp

The current boat ramp at Nakusp is in poor condition and of poor design. The ramp is a steep, narrow, fixed angle ramp with no turnaround at the bottom. Committee members familiar with this ramp stated that it is difficult to use because of its overall design and a lack of maintenance. It is particularly difficult to navigate at low water levels due to the angle and length of the ramp. Members of the Recreation Technical Subcommittee considered replacement of the existing ramp the highest priority.

Several Consultative Committee members questioned whether a change in reservoir operations would change the usability of the ramp in its current design. If safety of the ramp could not be improved by operational changes, removal of the old ramp and construction of a new ramp would not fit within the scope of water use planning. Not all of the Committee members agreed on whether the Nakusp boat ramp fits within the scope of water use planning, and decided to leave this judgment to the Comptroller of Water Rights.

Macdonald Creek Park

The Consultative Committee identified that operations that hold the reservoir at or above 1431 ft during the recreation season would provide access to boats at this site. In lieu of this, the ramp could be extended to 1427 ft to provide access during the recreation season under all water conditions modelled. Committee members acknowledged the link with operation of the reservoir but questioned the high cost of the proposal. However, it was explained that the cost estimates were high level only, and that detailed designs based on site visits would be conducted once the water use plan is approved.

Burton (upgrade)

The Consultative Committee acknowledged that the existing ramp at Burton requires maintenance and upgrading, but agreed that there is no operational link to fixing this ramp. Consequently, the Committee agreed that this project was outside the scope of water use plans.

Burton (new)

The existing boat ramp at Burton is stranded when water levels are below 1420 ft. As it is not cost effective to extend the ramp to provide access at these low reservoir levels (ramp is 1 km from the water's edge), a new ramp was proposed as a lower cost alternative. This ramp would be usable at low water levels, providing access to the reservoir during the shoulder season. After reviewing this line of reasoning, the Consultative Committee agreed that this project appeared to be within the scope of water use planning.

Fauquier

The lower end of the boat ramp is left dry during the recreation season in more than 20 per cent of the years of the modelled data. The Consultative Committee acknowledged extending the boat ramp would be a more cost-effective means of improving access than maintaining higher reservoir levels. The Committee noted, however, that the nearby ferry launch site is preferable to most boaters in the area, and would be an ideal location for a boat launch if the ferry is replaced with a bridge. If the bridge is not constructed, work would be required to the existing ramp.

Edgewood

The Consultative Committee identified that operations that maintain reservoir levels at or above 1397 ft during the recreation season would provide boat access at this site. In lieu of this, the existing ramp could be extended to 1390 ft, which would provide access to the reservoir during the recreation season under all water conditions modelled. This would require dredging to remove the accumulation of sediment caused by erosion. Alternatively, it may be possible to construct a rock breakwater at the south of the bay that would protect the ramp and beach and provide vehicle access to a new deep water launch site. The Committee agreed that there is no operational alternative that could be tied to dredging.

Anderson Point (Deer Park)

The Consultative Committee could not establish an operational link between reservoir management and the building of a new boat launch in this area. As a result, this item was dropped from the list of boat ramp projects.

Based on discussions of the Consultative Committee, a total of five boat ramp proposals remained on the list for consideration, including Edgewood, Fauquier, Burton (new), MacDonald Creek Park and Nakusp. Several members of the Committee requested that those proposals that could not be linked to operation of the reservoir be put forward by the Committee as non-water use planning recommendations.

7.7.3.4 Lower Columbia River

The Recreation Technical Subcommittee discussed how proposals for flow changes on the lower Columbia River fit within the scope of water use planning. These discussions and their conclusions are provided in Appendix V: Impact of Flow on Recreation and Infrastructure on the Lower Columbia River. Flow changes considered within the scope of water use planning and for which the Consultative Committee could make recommendations included:

- Seasonal flow policies for rainbow trout, mountain whitefish and white sturgeon.
- Changes in ramping rates at Hugh Keenleyside Dam.
- Changes in the day on which flow changes at Hugh Keenleyside Dam occur to meet Treaty requirements at the border.

Based on an examination of monthly average modelled flows, all of the alternatives, with the exception of white sturgeon flows, were expected to reduce the impact of extreme flows on the lower Columbia River. The conclusion reached by the Recreation Technical Subcommittee was that only physical works to mitigate high flows for white sturgeon interests would fit within the scope of water use planning.

One important issue related to the lower Columbia River that could not be addressed through water use planning was the impact of daily flow fluctuations on recreation and boat access. The Consultative Committee member from Trail noted that daily fluctuations are highly erosive and cause the removal of sand from Gyro Park Beach and subsequent deposition at the boat ramp at Indian Eddy. This requires the replacement of sand at the beach, and dredging at Indian Eddy to maintain access to the river for recreational boats and emergency rescue boats. The cost of sand replacement is approximately $150,000 per occurrence, and the cost of dredging is approximately $50,000 per occurrence.

The Consultative Committee was unable to resolve whether this issue was within the scope of water use planning, as it was not clear to what extent the erosion is caused by ramping at Hugh Keenleyside Dam. It was noted that most of the change in flows experienced at Trail arise from load shaping at Kootenay Canal on the Kootenay River system[1], which is outside the scope of the Columbia River water use planning process. Most fluctuations over the summer months occur at a time when Hugh Keenleyside Dam discharges are constant, which acts to smooth flow fluctuations from Brilliant Dam. However, the representative from Trail noted that most of the water passing Trail comes through Hugh Keenleyside Dam, and therefore it must be at least partially responsible for the impacts caused by these flow changes. Given constraints of the Columbia River Treaty, it was not clear what operational change could be considered. Some Committee members expressed frustration that this issue could not be addressed through the Columbia River water use planning process, as it is related in part to operations on the Kootenay River system. The representative from Trail noted that the City continues to incur the costs for sand replacement and dredging, and believes that BC Hydro should compensate the City as it is responsible for these impacts.

Questions related to the scope of water use planning were usually put forward to the Water Use Planning Interagency Management Committee. However, as this committee no longer existed at the time of the June 2004 Consultative Committee meeting, there was no mechanism for resolution of this issue. The Consultative Committee tabled the Trail representative's request to fund the ongoing dredging at Indian Eddy for an estimated cost of $50,000 per occurrence (refer to Table 7-44). However, it was agreed that the decision whether this fits within the scope of water use planning would need to be determined by the Comptroller of Water Rights. If it does not meet the criteria for inclusion, the Committee agreed that this project should be included as a non-water use planning recommendation to undertake some remedial action.

Table 7-44: Proposed Boat Access Projects for the Lower Columbia River

Location	Issue/Action	Benefits	Construction Costs (amortized over 15 years + maintenance)
Lower Columbia River			
Indian Eddy	Sand deposited at Gyro Park beach eroding away and being deposited on boat ramp at Indian Eddy.	Indian Eddy boat ramp access is critical for emergency craft since it is the only local point of access to the river.	$50,000 per dredging event. (Frequency of these activities was not discussed.)

[1] Load shaping occurs at Kootenay Canal, and the effects of this can be passed through Brilliant Dam. Under a certain range of flows, the downstream effects of the load shaping are reduced as the Brilliant headpond re-regulates the flow out of Kootenay Canal to keep Brilliant fully loaded.

7.7.3.5 Consultative Committee Support – Boat Ramps/Access

The Consultative Committee considered the proposed projects to improve boat access to the reservoirs and river in lieu of operational changes:

Package 1 – Kinbasket
Package 2 – Mid Columbia River (Revelstoke)
Package 3 – Arrow Lakes Reservoir
Package 4 – Lower Columbia River

The results of the Consultative Committee's recommendations are presented in Table 7-45.

Table 7-45: Consultative Committee's Recommendations for Boat Access

Committee Member	**Level of Support/Comments** **Package 1 (4 Kinbasket Projects)**	**Package 2 (Revelstoke Ramp)**	**Package 3 (5 Arrow Projects)**	**Package (Dredging Indian Eddy)**
Bill Green	Accept all. Qualifications similar to Fred Fortier. Environmental study, analysis and full implications including impact of new facilities on archaeological sites. #4 subject to research and monitoring program to feed next Water Use Plan.			
Bill Duncan	E	A	A Some concerns over Arrow Lakes Reservoir costs compared to Kinbasket Reservoir	E
Bob Taylor	E	A Huge range of costs.	E	E
Chris Beers	E	A With feasibility study.	A	A Needs to be tied to Water Use Plan operations, if not then needs to be included as non-Water Use Plan recommendation.
Don Bennett	E	A With feasibility study.	E	A If you can find a link to Water Use Plan, if not then needs to be included as non-Water Use Plan recommendations.
Doug Robinson	Same as Ian	Same as Ian	Same as Ian	Same as Ian
Fred Fortier	E	A	E	E Conditions for all 4 packages. Need review of the maintenance. First Nations involvement in habitat referral process.
Gail Bernacki	E	E	A Reservations regarding proposals, costs.	E

Table 7-45: Consultative Committee's Recommendations for Boat Access (cont'd)

Committee Member	**Level of Support/Comments**			
	Package 1 (4 Kinbasket Projects)	**Package 2 (Revelstoke Ramp)**	**Package 3 (5 Arrow Projects)**	**Package (Dredging Indian Eddy)**
Gord DeRosa	E	A I don't know how big the ramp is to be.	E	E
Gordon Boyd	Same as Ian	Same as Ian	Same as Ian	Same as Ian
Helmut Klughammer	E	A Needs additional feasibility study.	E	E
Ian MacLean	E	As submitted would block. Very low usage and high cost. Concerned about boater safety. We know who will be called if there were any other issues. If it were only a feasibility study and marginal improvement we would accept that. But 950K not our choice.	A Concerned about fit within Water Use Plan and costs (e.g., Macdonald Park).	Block* We do not see the operational link based on treaty flows, erosion effect part of treaty operation. If Water Comptroller approves this as part of Water Use Plan, we would consider.
Kindy Gosal	E	A Need information on the Revelstoke proposal.	A Budgetary issue – need to sharpen our pencils.	E
Janice Jarvis	E	A With a feasibility study.	A Other Consultative Committee members reasons.	E
Jim Forbes	E	E	A I need some things to go ahead such as the erosion questions.	E
Judy Bosh	E	A With feasibility study.	A Need to look at cost savings.	E
Llewellyn Matthews				
Loni Parker	E	A Needs additional feasibility study.	E	E
Mark Thomas	E	A Needs additional feasibility study.	E	E
Maureen Weddell	E	A With feasibility study as to where this ramp should be located.	A The fact there could be project partners for Burton and Nakusp, there should be issues that Hydro is addressing because of operations.	E

Table 7-45: Consultative Committee's Recommendations for Boat Access (cont'd)

Committee Member	Level of Support/Comments			
	Package 1 (4 Kinbasket Projects)	**Package 2 (Revelstoke Ramp)**	**Package 3 (5 Arrow Projects)**	**Package (Dredging Indian Eddy)**
Pat Wilcox	E	A Needs additional feasibility study.	E	E
Paul Peterson	E	E	E	E
Randy Priest	E	A Needs additional feasibility study.	E	E
Shelley Murphy	E	Block In sufficient information, too much uncertainty on what the project involves. Do not understand what is being proposed costs, etc.	A With strong reservations on how Nakusp fits within Water Use Plan criteria and costs. Costs need to be looked at. Do not support if it does not fit within Water Use Plan.	Block* Support doing study, but do not think it fits within the Water Use Plan. If Water Comptroller supports, then likely would remove the block.
Steve Macfarlane	Accept all. Need to determine the potential habitat impacts. Concerned with ongoing maintenance issues. Do not like to see projects that are going to be long-term maintenance projects. All works need to be subject to design specific structures acceptable to regulatory agencies such as DFO. Breakwaters – I don't think they are non-starters, but we will need to look at. Need DFO authorizations for some of these structures.			
Susan Hall	E	A	A Other Consultative Committee members' reasons.	E
Terry Anderson	E	A Location concerns, feasibility study needs to come first.	A Concerned about the costs. Needs to be as cost effective as possible.	E I would like to see the engineering study done first.

* These levels of support are conditional on a link being found between the proposed physical works and the water use planning process. If the Water Comptroller feels that these proposals fit, then these responses are taken as indications of support.

In summary, the Consultative Committee members felt that the potential benefits of the projects for Kinbasket and Arrow Lakes reservoirs, and the lower Columbia River all had benefits that outweighed their costs and risks. Some members highlighted particular concerns related to the detailed implementation plans (e.g., environmental impacts, regulatory approval, cost control, and impact to archaeological sites). Others were unsure whether these projects fit within the scope of water use planning and conditionally supported them pending a decision by the Comptroller of Water Rights. Nevertheless, the support for these projects was unanimous.

7.7.3.6 Consultative Committee Discussions and Proposed Refinements

Dredging at Indian Eddy

Several Consultative Committee members that questioned whether the dredging project at Indian Eddy met the criteria for inclusion within water use planning suggested that a study be undertaken to determine the influence of Hugh Keenleyside Dam operations on the erosion process at Gyro Park Beach and whether there is an operational change that could affect this. No formal study was tabled during the meeting and therefore the Consultative Committee was never canvassed for their views on whether such a study was worthwhile.

Boat Ramp at Revelstoke

The proposal for improving access in the mid Columbia River area received a great deal of support from the Consultative Committee; however, a number of members suggested that a feasibility study should be completed prior to any work being undertaken. The representative from the Ministry of Energy did not support the proposal due to the high level of uncertainty. The BC Hydro representatives were the only Committee members that felt that the costs and risks to increasing boat access in this area outweighed the benefits of the project, and therefore did not support this proposal.

Several Consultative Committee members, including BC Hydro and the representative from Revelstoke convened to discuss the proposal further. A refined proposal was put forward later in the meeting to address concerns of the participants (refer to Table 7-46). It was proposed that a study be undertaken to determine:

- The need for a substitute site.
- The best location for a substitute boat ramp, considering proximity to the city and potential hazards in the river.
- The level of use if a new ramp is constructed.
- Design and costs of a new site.

It was acknowledged that this revised plan has three possible outcomes.

- If a suitable site is found that will provide benefits without creating boating hazards and the ramp could be constructed at a cost less than $200,000, the boat ramp will be built.
- If a suitable site is found but it would cost more than $200,000 to build the ramp, plans would be reviewed when the Arrow Lakes Reservoir component of the Water Use Plan is reviewed at the end Year 5.

- If a suitable site is not found, up to $50,000 would be spent to upgrade the existing site to improve access for car-top boats, but not for larger boats (since BC Hydro feels that the current location is not suitable for launching larger boats due to hazards in the area).

Table 7-46: Final Proposal for Boat Access to the Mid Columbia River

Location	Issue/Action	Benefits	Construction Costs (amortized over 15 years + maintenance)
Mid Columbia River			
Revelstoke	Low water poses hazardous launch conditions and exposed end of ramp. A location, feasibility study, and review to take place with three outcomes: build new ramp, defer building, upgrade existing ramp.	Alternative to those that don't want the year-round access at Revelstoke Reservoir (10 km away).	Up to $200,000 ($23,500 + $12,500 maintenance)

The Consultative Committee unanimously agreed that this feasibility study (which may lead to the construction of a $200,000 boat ramp) was worth the benefits and the risks. The representative from the Ministry of Energy was not clear that constructing a new access point fit within the scope of water use plans, but was willing to support the proposal if the Comptroller of Water Rights felt that this was a legitimate water use planning proposal.

7.7.3.7 Final Consultative Committee Support – Boat Ramps/Access

The Consultative Committee made the following recommendations related to boat access issues on Kinbasket and Arrow Lakes reservoirs and the mid and lower Columbia River.

Recommendation	Comments
The Consultative Committee recommended that Packages 1–4 be carried out as physical works in lieu of operational changes for boat access to Kinbasket Reservoir, the mid Columbia River, Arrow Lakes Reservoir, and the lower Columbia River.	The level of support for many of the elements of these packages was contingent on the Comptroller of Water Rights agreeing to the link made by the Committee between these items and the water use planning process, and feasibility and environmental studies being undertaken. If the Water Comptroller does not agree that these projects meet the criteria of water use planning, these elements of the packages are not supported by the Committee.

The Consultative Committee was also interested in access issues to the reservoirs for areas or projects that did not fit within the scope of water use planning. Local residents felt that providing access to these bodies of water is important and would be a worthwhile investment. To this end, the Committee recommended the following non-water use planning recommendation.

Non-Water Use Plan Recommendation	Comments
The Consultative Committee (except for the BC Hydro and Ministry of Energy representatives, all of whom abstained) wished to seek clarification from the Comptroller of Water Rights as to what constitutes access to the reservoirs. Once clarification has been sought, the Committee wants the Comptroller to identify how provisions will be made and then to direct appropriate parties responsible to improve access.	None.

Finally, the Consultative Committee (except for the representative from the Ministry of Energy, who abstained) suggested that any proposals to improve boat access that are subsequently ruled as outside of the scope of water use planning by the Water Comptroller be put forward as non-water use planning recommendations.

Non-Water Use Plan Recommendation	Comments
The Consultative Committee (except for the representative from the Ministry of Energy) recommended that BC Hydro and other parties consider funding the boat access proposals that do not fit within the scope of water use planning.	None.

7.7.4 Physical Works for Arrow/Kinbasket Balance – Debris Management

The Consultative Committee recognized that debris problems in Kinbasket and Arrow Lakes reservoirs are fewer than historically; however, concern was expressed around new debris that enters the system either from tributaries or sloughing of the reservoir banks during high water events. This debris tends to become stranded in a “bathtub ring” around the reservoir, and re-introduced into the reservoir during subsequent high water events. In any given year when reservoir water levels are expected to be high, BC Hydro may have some flexibility to maintain lower levels to delay refloating previously stranded debris. However, maintaining the reservoir at successively lower levels is only a short-term solution, as eventually large inflows will cause the reservoir to reach full pool. The Committee agreed that, while operations might avoid refloating of debris in the short term, this is not a cost-effective long-term solution to debris management.

A debris management plan was put forward by the Recreation Technical Subcommittee as a more cost-effective means of managing debris on Kinbasket and Arrow Lakes reservoirs. This is summarized below in Table 7-47.

Table 7-47: Detailed Summary of Debris Management Program for Kinbasket and Arrow Lakes Reservoirs

Program 1, 2, 3	Debris Field Survey and Debris Management Strategy, Kinbasket and Arrow Lakes Reservoirs
Scope	1. Debris Management Study: A multi-interest group will develop strategies and targets for debris management activities on the Kinbasket and Arrow Lakes reservoirs. The intent is to identify site-specific targets and identify best practices. 2. Debris Field Survey: Comprehensive inventory of existing debris fields and sources of current new recruitment will be undertaken on each system. Presently, it is assumed that the source of the debris fields come from: • Standing timber submerged during impoundment. • New recruitment of timber and debris from the foreshore associated with avalanches and timber harvesting activities. • New recruitment of timber and debris from the mainstem and tributary systems. At the completion of the survey, it is expected that the rate of contribution from these sources be quantified, and an estimate made of the quantity of existing debris. These data will assist in estimating realistic management costs associated with ongoing debris maintenance and/or removal and the relative responsibility of different parties to the ongoing problems. This survey will also be of value in prioritizing annual collection and removal efforts on the two systems. 3. Annual Activity Reporting: Report annually to interested stakeholders pre and post annual debris removal, including location, expenditure and monitoring and target updates.
Budget and Schedule	1. Debris Targets and Management Strategy — Year 1 — $20,000 2. Distribution and Amount Inventory ($20,000/year biannually) — Years 1, 3–15 — $160,000 3. Annual Reporting ($5,000/year) — Years 2–15 — $70,000 • **Total** — **$250,000** • **15 Year Levelized Annual Cost** — **$17,361**

Program 4	Targeted Annual Shoreline Debris Removal, Kinbasket and Arrow Lakes Reservoirs
Scope	This work supports the recreation access projects by targeting debris removal at key locations where boat ramps are being extended or built, or of high visual importance. This should significantly improve the functionality and quality of recreation on the Kinbasket and Arrow Lakes reservoirs. Once debris is collected, it would either be 1) piled and burned 2) removed and salvaged, or 3) barged or boomed to another beach for burning or salvage. The proposed Debris Removal Project will not replace any existing debris management that BC Hydro undertakes in support of dam safety and facility maintenance. The proposal for this project is to expand the scope of debris removal to include non-power interests.
Budget and Schedule	The duration and number of sites targeted debris removal depends on the results of the Debris Field Survey and Management Strategy. Previous estimates have suggested an annual program of up to $150,000 for the first five years, with up to $100,000 allocated to Kinbasket and up to $50,000 allocated to Arrow. If the debris targets are met in the future then the costs could be considerably less. • Debris Collection and Burning ($150,000/year for 5 years) ($75,000/year for 10 years) — Years 1–15 — $1,500,000 • **Total** — **$1,500,000** • **15 Year Levelized Annual Cost** — **$100,000**

Table 7-47: Detailed Summary of Debris Management Program for Kinbasket and Arrow Lakes Reservoirs (cont'd)

Program 5	**Periodic Floating Debris Removal, Kinbasket**		
Scope	This work supports recreation interests by activating a Kinbasket Reservoir floating debris removal program immediately following a full-pool event (at or above 2470 ft). Expected on an infrequent basis, the funding estimate is expected to be made available on an as needed basis reflecting a return period of approximately five per cent of years across the operating alternatives, or approximately 1:20 years. Note that while this is an average return period, this event can happen in adjacent years, although the second year debris program will likely be less intensive, as the between year accumulation will be minimal. Once debris is collected, it would either be 1) piled and burned 2) removed and salvaged, or 3) barged or boomed to another beach for burning or salvage. The proposed Debris Removal Project will not replace any existing debris management that BC Hydro undertakes in support of dam safety. The proposal for this project is to expand the scope of debris removal to include non-power interests.		
Budget and Schedule	The periodic debris removal effort is expected to require an infrequent but higher level of effort than the annual program. The frequency is dependent upon high reservoir levels.		
	• Periodic Floating Debris Removal ($200,000/year)	Years 1, 10	$400,000
	• **Total**		**$400,000**
	• **15 Year Levelized Annual Cost**		**$32,458**

The Recreation Technical Subcommittee recommended that stakeholders (regulatory agencies, local community members) be involved in annual prioritization of the debris collection/removal activities for Kinbasket and Arrow Lakes reservoirs. The intent of the multi-interest group will be to develop site-specific targets and strategies for debris management on an annual basis.

The Subcommittee also recommended that a specific percentage of the budget for annual shoreline debris removal to be set aside for Kinbasket Reservoir to ensure that adequate funding is available to manage debris on this reservoir. It was suggested that the annual cost be set at approximately $150,000 for the first five years, with $100,000 earmarked for Kinbasket Reservoir and the balance for Arrow Lakes Reservoir. After the fifth year of the program, funds could be spent in either of the two areas, on an as needed basis. Funding of approximately $400,000 was also recommended to address floating debris removal needs in response to high reservoir levels in Kinbasket Reservoir (expected occurrence of 2 events over 15 years).

The Consultative Committee questioned whether there was a need for a debris management plan for the lower Columbia River. It was noted that about $2,000 per year was required to maintain access at the Indian Eddy boat ramp.

The Consultative Committee was asked to express its level of support for the Debris Management Plan. The results of this poll are presented in Table 7-48.

Table 7-48: Consultative Committee's Level of Support for Debris Management Plan

Committee Member	Kinbasket	Arrow	Lower Columbia River (ramp clearing)	Comments
Bill Green	A	A	A	Conditional on an environmental feasibility study of the debris program.
Bill Duncan	E	E	E	
Bob Taylor	E	E	E	
Chris Beers	A	A	A	Debris is good for fish. Need to consider maintenance of fish habitat.
Don Bennett	E	E	E	
Doug Robinson	A	A	A	With the reservation that it is linked to operations and that the Water Comptroller accepts this link.
Fred Fortier	A	A	A	Need to consider that debris is good for wildlife values.
Gail Bernacki	E	A	A	In 2 and 3 need to increase habitat.
Gord DeRosa	E	E	E	
Gordon Boyd	A	A	A	With the reservations that it is linked to operations and that the Water Comptroller accepts this link.
Helmut Klughammer	E	E	E	
Ian MacLean	A	A	A	With the reservations that it is linked to operations and that the Water Comptroller accepts this link.
Kindy Gosal	E	E	E	If we could get to the point in Kinbasket Reservoir. Identify areas to create wetlands great, but you will have to change operations.
Janice Jarvis	A	A	A	Subject to an environmental review, fish habitat and re-vegetation efforts and archaeological works. Could be used to create wetland habitat and for archaeological site protection.
Jim Forbes	E	E	E	
Judy Bosh	A	A	A	
Llewellyn Matthews	A	A	A	We don't have any real concerns with Kinbasket and Arrow Lakes reservoirs, but I hesitate if they aren't operational but rather footprint issues. For the lower Columbia River, I have concerns. Would not want to block BC Hydro from spending money, however, there are benefits of debris. It is a natural occurrence through Brilliant, and in the lower river there is a lack of woody debris. That is one of the big ecological issues. Not sure if this is an appropriate use of provincial money.
Loni Parker	E	E	E	

Table 7-48: Consultative Committee's Level of Support for Debris Management Plan (cont'd)

Committee Member	Kinbasket	Arrow	Lower Columbia River (ramp clearing)	Comments
Mark Thomas	A	A	A	With a habitat assessment to identify whether it is possible to harvest the timber.
Maureen Weddell	E	A	A	In 2 and 3 need to increase habitat. Accept as long as habitat enhancement is done in Arrow Lakes Reservoir and lower Columbia River.
Pat Wilcox	E	E	E	
Paul Peterson	E	E	E	
Randy Priest	E	E	E	
Shelley Murphy	A	A	A	With the reservations that it is linked to operations and that the Water Comptroller accepts this link.
Steve Macfarlane	A	Same as 1	A	DFO is supportive of strategy and assessment. Problem that we are going to remove all debris. DFO likes debris. In some cases we put it into river. We want to be part of those discussions. May look at alternatives to removal. If it is part of the wetland/grasslands, we may want re-location. Looking at cabling, securing that debris as opposed to taking out. For the lower Columbia River, there may be a concern about taking woody debris out of a river, but I am not sure that this is a big issue.
Susan Hall	A	A	A	Subject to environmental review, fish habitat and re-vegetation efforts and archaeological works. Create wetland habitat and vegetation.
Terry Anderson	A	A	A	Same comments as Steve.

A Consultative Committee member expressed concern that the debris strategy does not address surcharging of Kinbasket Reservoir. While it is a rare occurrence (i.e., the reservoir has only surcharged twice since it was built), it should be considered in the management plan as it can contribute to the debris problem. The BC Hydro Corporate Representative noted that BC Hydro operates the reservoir to stay within flood control and minimize downstream impacts. Under its water licence, BC Hydro has the ability to surcharge under emergency situations (i.e., for routing of large floods); however, this requires discussion with the Comptroller of Water Rights and has included funds to compensate for impacts to infrastructure.

Consultative Committee's Recommendation Regarding Debris Management Issues

Recommendation	Comments
The Consultative Committee recommended debris management programs for Kinbasket and Arrow Lakes reservoirs, and the Indian Eddy boat ramp in the lower Columbia River. The Consultative Committee recommended that BC Hydro avoid surcharging Kinbasket Reservoir if at all possible, and that compensation/ funding be provided to address infrastructure damage and additional debris management needs in the event of surcharge.	The Committee's support of the debris management efforts was conditional on a) an environmental review being undertaken, and b) the Comptroller of Water Rights accepting the link between these issues and the water use planning process. It was acknowledged that DFO would be involved in the review/approval of the debris management plan. The Committee acknowledged that on rare occasions BC Hydro needs to surcharge the reservoirs for flood control under emergency conditions.

7.7.5 Physical Works for Arrow/Kinbasket Balance – Vegetation Management and Monitoring

As discussed earlier in Section 7.5.1, the Consultative Committee reviewed revegetation plans for Kinbasket and Arrow Lakes reservoirs and the mid Columbia River as part of Round 3 of the trade-off analysis process. It was agreed that these plans would provide a more cost-effective means of providing benefits to wildlife and vegetation interests than imposing operating constraints and therefore should form part of the final package of recommendations for the Columbia River Water Use Plan. It was noted that, while these physical works were tied to Kinbasket/Arrow Lakes reservoirs operations, they were also tied to decisions around the lower Columbia River rainbow trout flows through the requirement for additional storage in Arrow Lakes Reservoir during the spring/summer period.

During the Round 3 trade-off discussions, it was recognized that a monitoring program would be required to evaluate the effectiveness of the revegetation efforts, and gain a better understanding about plant survival and establishment within the drawdown zone. The importance of this was subsequently underscored by the Committee given the uncertainties around the predicted impacts of different water regimes on existing vegetation.

The Wildlife Technical Subcommittee was tasked with developing a monitoring program that would assess the effectiveness of the planting program and also improve knowledge around the impacts of water management on vegetation and other interests in the reservoirs. Seven vegetation and wildlife-related studies were proposed by the subcommittee to help inform the status of vegetation establishment and its effects on wildlife habitat use. Four additional studies were included to address concern related to the potential impact of increased vegetation on mosquito production in the Revelstoke area. The total annualized cost of the monitoring program was estimated at about $239,000. Details regarding the proposed studies and their estimated costs are presented in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

The Consultative Committee was asked to indicate its level of support for the monitoring program. Their responses are provided below in Table 7-49.

Table 7-49: Consultative Committee's Level of Support for the Vegetation Monitoring Program

Committee Member	Kinbasket Reservoir	Mid Columbia River and Arrow Lakes Reservoir	Comments
Bill Green	E	E	Same as Mark's conditions (see below).
Bill Duncan	A	A	Some concern about the low priority studies.
Bob Taylor	E	E	
Chris Beers	E	E	
Don Bennett	E	E	
Doug Robinson	A	A	Concern with the costs.
Fred Fortier	E	E	Same as Mark's conditions.
Gail Bernacki	E	E	
Gord DeRosa	E	E	
Gordon Boyd	A	A	Concern with the costs.
Helmut Klughammer	E	A	A lot of areas in the Arrow Lakes Reservoir and mid Columbia River do not need extra vegetation. There are a lot of places where public use is very high and there is potential for a conflict.
Ian MacLean	A	A	Concern with the costs.
Kindy Gosal	E	E	
Janice Jarvis	E	E	
Jim Forbes	E	A	Some reservation about the revegetation efforts
Judy Bosh	E	E	
Llewellyn Matthews	A	A	
Loni Parker	E	E	
Mark Thomas	E	A	Accept based on stringent monitoring of known archaeological sites with vegetation efforts to ensure success. There must be a trigger to revisit the program if sites are determined to be jeopardized. The Digital Elevation Model (DEM) is needed in this monitoring to complement the archaeological overview process and the areas with a high probability of having sites need to be researched prior to vegetation efforts.
Maureen Weddell	E	E	
Pat Wilcox	E	E	
Paul Peterson	E	E	

Table 7-49: Consultative Committee's Level of Support for the Vegetation Monitoring Program (cont'd)

Committee Member	Kinbasket Reservoir	Mid Columbia River and Arrow Lakes Reservoir	Comments
Randy Priest	E	A	Why can't the Columbia Shuswap Regional District deal with mosquito issues?
Shelley Murphy	A	A	I look at whole package and it seems expensive. We need to ensure that each study is linked to water use planning and that there will be a potential for learning from each study.
Steve Macfarlane	E	E	
Susan Hall	E	E	
Terry Anderson	E	A	I am concerned about the costs of this package in the Arrow. The DEM should be done first to determine the high priority sites for planting.

The Consultative Committee unanimously supported the monitoring program for vegetation interests in Kinbasket and Arrow Lakes reservoirs. However, Committee members noted several caveats including the need for co-ordination with the local community to maintain pristine beaches, and the need to co-ordinate vegetation efforts with archaeological site protection. This latter issue is addressed in Section 7.7.6.

The DFO representative noted that removal of vegetation from the drawdown zone would require consultation with the regulatory authorities, since these areas are considered fish habitat. The representative sent the project team a note outlining the approach that would likely be followed in response to such a request. These included the need to:

- Determine what is an acceptable area to remain unvegetated and assess possible impacts to critical vegetation sites or critical fish habitat sites in adjacent areas.

- Zone the approved areas as unvegetated and state that they can remain unvegetated (i.e., not creating new unvegetated areas).

  It was noted that, within the unvegetated sites, any works in and about water other than beach grooming will still require approvals. Further, any works in and about water outside of the zoned areas must be approved by Land and Water BC, Ministry of Water, Lands and Air Protection, and Fisheries and Oceans Canada.

Consultative Committee's Recommendation Regarding the Monitoring of Vegetation Interests

Recommendation	Comments
The Consultative Committee recommended a monitoring program for vegetation interests in Kinbasket Reservoir, the mid Columbia River, and Arrow Lakes Reservoir.	The Committee raised concerns that revegetation efforts need to be carried out in such a manner that they do not impact other interests, including First Nations' archaeological sites, recreation and wildlife habitat.

7.7.6 Physical Works for Arrow/Kinbasket Balance – Archaeological Site Protection

Early in the Columbia River water use planning process, alternatives were developed for Kinbasket Reservoir to explore the potential impacts of imposing different maximum and minimum elevations on key interests of the Consultative Committee. Modelling of these alternatives showed that imposing these restrictions would be very costly and provide little benefit to the interests they were designed to address. Rather than use the limited time and budget of the process on exploring more extreme alternatives, the Committee agreed to task the Culture and Heritage Subcommittee with developing physical works in lieu of operations to protect sensitive archaeological sites within the drawdown zone of the reservoir.

A high-level archaeological survey completed for Arrow Lakes, Revelstoke and Kinbasket reservoirs (Choquette, 2002) determined that significant, intact archaeological sites are likely to exist in Arrow Lakes Reservoir at elevations 436 m (1430 ft) and above. An operating alternative that keeps the reservoir at elevation 436 m (1430 ft) or below as much as possible to minimize erosion of archaeological sites was estimated to cost approximately $20 million per year. Given the high cost associated with this operational change, the Culture and Heritage Subcommittee focused on physical works in lieu as a more cost-effective means of protecting sensitive archaeological sites.

The Consultative Committee agreed that the best protection for existing archaeological sites would be achieved through revegetation of the drawdown zone, which would stabilize the soils against wind erosion, wave action, and runoff. In addition, revegetation of exposed areas would also help to conceal sites from pot hunters and protect surface archaeological materials from foot and vehicular traffic. As some forms of planting (i.e., drill seeding by tractor) have the potential to damage sensitive sites, it was recognized that a broad survey would be required to identify areas with potential for containing archaeological material so that revegetation efforts could be co-ordinated with site protection needs.

In addition to the revegetation work, a set of physical works and monitoring was proposed for archaeological site protection in Kinbasket and Arrow Lakes reservoirs:

- Address the four known sites.
- Survey the system for sites yet to be discovered.
- Monitor the effectiveness of the physical works at the first four sites.
- Implement physical works to protect newly discovered sites, based on knowledge gained at the first four sites.

The strategy consists of two programs to manage the known and yet to be discovered archaeological sites within the drawdown zones. The individual program components of this plan are detailed in Table 7-50 and Table 7-51 below.

Program 1

- Designed to deal with four known sites in Arrow Lakes Reservoir in Years 1–5.
- Annualized cost of $130,000 (levelized over 15 years), representing approximately $1.4 million in spending.

Program 2

- Designed to deal with the potential existence of other archaeological sites that may be actively modified, with some work starting in Years 1–5 to confirm location , composition and priority of sites, but with most work occurring in Years 6–10.
- Annualized cost of $750,000 (levelized over 15 years), representing up to $12 million in spending. Assumes potential for discovering up to 50 additional sites.

Table 7-50: Program 1 – Management and Monitoring Plan for the Four Known Archaeological Sites in Arrow Lakes Reservoir

Study	Description	Amount of Learning Expected From Monitoring	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Determine First Nation preferences for treatment options for discovered archaeological sites and develop an effective, acceptable management plan.	Each approach to addressing archaeological sites has different drawbacks, benefits and long term consequences. Interested First Nations will need to be involved in developing the approaches.	N/A	Years 1 and 2	$10,000	$1,000
Determine the archaeological importance of each site, the appropriate approach to protecting site, and implement mitigation. Applied to four known archaeological sites in Arrow Lakes Reservoir.	The extent of the archaeological information and the dynamics of the erosion process will determine the best approach to protecting archaeological sites. Mid-level estimates suggest that over $220,000 per site would be required to mitigate impacts. Mitigation could range from hand planting vegetation to geotextile cover/riprap excavations.	High	Years 1–5	$220,000 per site	$103,000
Determine the dynamic between reservoir activity and the stability of the scarps and terraces containing archaeological sites.	A set of transects at archaeological sites and in other areas could determine the link between reservoir operations, erosion by wind, waves, and underwater action.	High	Years 1–5	$33,000	$26,000
Effectiveness monitoring at sites of mitigation.	Transects and ongoing monitoring will be required to assess the effectiveness of mitigation. This will allow knowledge to be transferred to additional works as new sites are discovered.	High	Years 1–5	$6,000 per site to establish transects, $3,000 per site per year data collection, done intermittently.	$10,000

Table 7-51: Program 2 – Management and Monitoring Plan for Yet-to-be-Discovered Archaeological Sites

Study	Description	Amount of Learning Expected From Monitoring	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Stratified Survey and Inventory of potential sites (and sites of all physical works) for archaeological sites at risk by BC Hydro operations – Kinbasket and Revelstoke Reservoirs.	Reservoir operations and physical works (revegetation, boat ramp building) may impact archaeological sites. Number, location and characteristics of sites are unknown.	Moderate	1–3 years	$35,000 (in total)	$4,000
Survey and Inventory of potential sites (and sites of all physical works) for archaeological sites at risk by BC Hydro operations – Arrow Lakes Reservoir.	Reservoir operations and physical works (revegetation, boat ramp building) may impact archaeological sites. Number, location and characteristics of sites are unknown.	Moderate	1–3 years	$75,000 (in total)	$9,000
Exploratory excavations to determine archaeological importance of additional sites.	Visible scatter of archaeological materials may be the last of an archaeological site, or the “tip of the iceberg.” Determining how much material exists will help prioritize physical works approaches. Monitoring of these sites will develop link between operations and will assess the effectiveness of protection strategies.	High	Years 5–10	$90,000 per year for Years 6, 7 and 8 for excavation. $12,000 per year for 3 years for monitoring	$21,000
Determine First Nation preferences for treatment options for discovered archaeological sites and develop an effective, acceptable management plan.	Each approach to addressing archaeological sites has different drawbacks, benefits and long term consequences. Interested First Nations will need to be involved in developing the approaches.	N/A	Years 5–7	$10,000	
Determine the archaeological importance of each newly discovered site, the appropriate approach to protecting site, and implement mitigation.	The extent of the archaeological information and the dynamics of the erosion process will determine the best approach to protecting archaeological sites. The number of yet-to-be-discovered sites is unknown. An upper estimate was 50 sites.	High	To start after inventories are completed, management plan in place, and sites prioritized. No later than Year 6.	$220,000 per site for up to 50 sites.	$700,000 (net present value at Year 1)

Several themes emerged during the Consultative Committee's discussion of the archaeological site protection plan. It was agreed that physical works for vegetation, wildlife habitat, boat ramps and archaeological site protection and its associated monitoring program would need to be co-ordinated and sequenced to ensure compatibility with site protection needs. The proposed approach is outlined below in Table 7-52.

Table 7-52: Proposed Sequencing of Monitoring and Physical Works Activities

Project Sequence	Rationale for Sequencing
1. Digital Elevation Model (DEM) for the mid Columbia River and Arrow Lakes Reservoir	Determines more accurate elevations of landforms. Useful for identifying areas for potential revegetation. Useful for identifying areas where potential archaeological sites that are being actively modified may exist.
2. Stratified Archaeological Inventory	Based on DEM output, an inventory of the reservoirs will take place, starting with highest potential areas.
3. Revegetation Work	Using input from archaeological findings and DEM, revegetation efforts can be tailored to a) not disturb archaeological sites, b) reduce erosion and assist in protecting archaeological sites.
4. Other physical works	Using input from archaeological findings, other physical works (boat ramps, wildlife works) can be designed to avoid disturbing existing archaeological sites.
5. Monitoring Mitigation Works at Four Known Sites	Physical works (or operational changes) to assist yet-to-be-discovered sites will be based on lessons learned from scarp stability monitoring and effectiveness monitoring of four existing and treated sites.

While the Consultative Committee was discussing the relative merits of the two programs, the First Nations representatives noted that their view of this matter lay outside a weighing of costs and benefits and felt that there was an obligation on the part of both the Province and BC Hydro to protect these sites. While discussions amongst the First Nations, the Province and BC Hydro about the source of this funding may be ongoing, the First Nations representatives reiterated their view that this work needed to be done. Moreover, the possible 50 additional sites was an estimate based on a high level assessment and that the actual number of sites and thus cost of protection could be higher. The First Nations representatives were clear that this upper level estimate should not be viewed as a cap on spending.

Table 7-53 presents the level of support expressed by the Consultative Committee for the proposed physical works and monitoring for archaeological sites.

Table 7-53: Consultative Committee's Level of Support for Physical Works for Sensitive Archaeological Sites

Committee Member	Level of Support		Comments
	Program 1	Program 2	
Bill Green	E	E	
Bill Duncan	E	A	Uncomfortable with the open endedness of Program 2.
Bob Taylor	E	A	
Chris Beers	E	E	With Fred's comments.
Don Bennett	E	E	
Doug Robinson	A	Defer*	Agree with concept. There are unknown sites. We would like to defer the decision until after we know what is happening on Arrow. There may be an operation that we would rather do that would be more beneficial.
Fred Fortier	E	E	I would like to see it co-ordinated with revegetation program.
Gail Bernacki	E	E	
Gord DeRosa	E	E	
Gordon Boyd	A	Defer*	Same as Doug's comments.
Helmut Klughammer	E	E	
Ian MacLean	A	Defer*	Same as Doug's comments.
Kindy Gosal	E	E	
Janice Jarvis	E	E	Condition that there is ample money for vegetation plans.
Jim Forbes	E	E	
Judy Bosh	E	E	
Llewellyn Matthews	A	A	
Loni Parker	E	E	
Mark Thomas	E	E	
Maureen Weddell	E	A	I think that the province and federal governments need to be more involved in this. Do not think that the investigation is all within Water Use Plans.
Pat Wilcox	E	E	
Paul Peterson	E	E	
Randy Priest	E	A	Program 2 needs to have more definition (i.e., whether it is within the Water Use Plan or not). May be other ways that this could be looked at. Could not endorse at this point in time.
Shelley Murphy	E	A	Concerned about how this fits within water use planning? How to manage this open ended issue? Needs to be a process that ensures value for money. For Arrow Lakes Reservoir we need to look at operational alternatives related to impacts.
Steve Macfarlane	E	E	
Susan Hall	E	E	
Terry Anderson	E	A	Program is the right thing to do. The Province should be at the table on this. However, I have a concern about the open endedness of this as well for Program 2.

* The BC Hydro representatives later accepted a package of proposed flow changes, monitoring and physical work, which included Programs 1 and 2.

The decision around physical works to protect archaeological sites was the first of several long-term recommendations that the Consultative Committee made in the mid Columbia River and Arrow Lakes Reservoir. These decisions were reached on the second day of a three-day meeting. On the third day of the meeting, the Committee decided on the approach of soft constraints for Arrow Lakes Reservoir operations with a 5-year review. Time did not permit a discussion regarding how a 5-year review of Arrow Lakes Reservoir operations would fit with longer term commitments around monitoring and physical works.

The Consultative Committee unanimously supported Program 1 to address the four known archaeological sites in Arrow Lakes Reservoir. Although no Committee members blocked Program 2, a number of members expressed some reservations about its open-endedness. The BC Hydro representatives deferred their decision on the monitoring and physical works program until a decision was made regarding operations of Arrow Lakes Reservoir.

Consultative Committee's Recommendation for Monitoring and Physical Works for Archaeological Sites

Recommendation	Comments
The Consultative Committee recommended that monitoring and physical works should be carried out to protect existing and yet-to-be-discovered archaeological sites that are at risk from reservoir operations.	The BC Hydro representatives originally chose to defer their decision on this element of the Water Use Plan. However, in accepting the whole package of flow changes, physical works and monitoring, they indicated that they accepted the physical works and monitoring of archaeological sites.

7.7.7 Physical Works for Arrow/Kinbasket Balance – Wildlife Habitat Physical Works

As discussed earlier in Section 7.6.2, the Consultative Committee recognized that Alternative 11B provided the most protection to nesting birds in the Revelstoke Wetlands by maintaining lower reservoir levels in the spring/early summer period. However, this alternative would not fully protect nests from inundation, particularly those of late-season breeding species. Moreover, an alternative that would follow the preferred hydrograph for nesters (i.e., imposing a maximum reservoir elevation of 435 m (1427 ft) until 15 July) would not be practical given the Columbia River Treaty and substantial costs associated with its constraints (about $23 million per year on average in lost storage). The Consultative Committee agreed that the costs of this alternative exceeded the level of benefits it could provide. It was acknowledged that the inundation of some bird habitat was inevitable under any operating alternative being considered, and that physical works should be investigated as a way of mitigating these impacts.

Several lessons were learned through the process of exploring physical works that would mitigate the impact of changing water levels on wildlife in the drawdown zone of Arrow Lakes Reservoir. The first is that, given the vast area over which these impacts occur, complete mitigation of impacts such as nest inundation would not be possible. To avoid nest inundation, low lying areas in the reservoir would need to be raised, and this is not possible across all parts of the drawdown zone. Moreover, large-scale efforts to raise even small areas of the drawdown zone would be expensive. Cost estimates for nesting bird islands and berm structures were in the order of $0.5 to $1.2 million per hectare of elevated land. These costs were high both because of the height to which they would have to be built to avoid inundation, and the robustness that would be needed for these structures to endure in the harsh, high current environment. Moreover, there was some evidence that even building durable, elevated land masses may not benefit the targeted species, but may provide habitat for other species (such as geese), or may attract predators.

During the June 2004 Consultative Committee meeting, the Wildlife Technical Subcommittee proposed an adaptive approach to improving conditions for nesting and migratory bird habitat, and wildlife habitat in general, in the Revelstoke Wetlands. This plan focused on a variety of physical works aimed at:

- Stabilizing areas through development of berms.
- Creating pocket wetland habitat and backchannel habitat through installation of water control structures.
- Protecting nesting habitat through creation of higher elevation points of land.
- Small-scale experimental terracing to create wetland habitat.

Given the preliminary nature of these proposals, discussions with technical experts would be required to further define possible treatments. Feasibility and risk assessments, detailed planning studies and public consultation would also be required to address engineering design, questions around soil permeability and potential impacts on other interests (i.e., private lands, recreation, vegetation, wildlife, fish, mosquito production), and regulatory and permitting issues.

Table 7-54 provides a description of these works and their estimated costs. Refer to Appendix DD: Physical Works for Wildlife in the Revelstoke Wetlands, for detailed information regarding the physical works projects.

Table 7-54: Proposed Physical Works for Wildlife Habitat in Revelstoke Wetlands

Physical Works	Objective	Potential Benefits/ Potential Risks	Estimated Cost [1]
Berms	Delay ingress of water by about two weeks until late June/early July to provide more stable water levels in areas of known or suspected nesting.	• Enhance small areas of nesting habitat and improve nest survival for early to mid season breeding birds. • Provide for a diversity of wildlife habitat through creation of both elevated lands and productive ponds/riparian habitat behind the berm. • Potential impacts on other interests (recreation, fish habitat). • Feasibility questionable given permeability of substrates and effectiveness of holding water back as reservoir rises. • Permitting requirements and other regulatory issues associated with construction. • High risk option for regulatory compliance.	Implementation: $4–6 million/km Feasibility Study: 1–2 % of total capital cost (5–6 % if assessed as individual projects)
Water control structures	Retain water in natural backchannel areas that tend to dewater during low water periods and low water years using a variety of water control structures (e.g., culverts and other passive designs).	• Enhance wetland, riparian and large river habitats for birds, fish and other wildlife species. • Would provide productive wetland areas only if adjacent grasslands continue to survive and provide the needed associated habitat (i.e., an annual reservoir operation that maintains existing grasslands).	Implementation: $25,000–35,000 per site Feasibility Study: 1–2 % of total capital cost (5–6 % if assessed as individual projects)
Creation of high elevation lands	Create source nesting habitat by increasing elevation of existing high points of land by several metres.	• Estimated 1–2 breeding pairs of Northern Harriers or Short-eared Owl, or 5–6 pairs of smaller waterbird species per site.	Implementation: $20,000–30,000 per 1,000 m^2 per 1 m height Feasibility Study: 1–2 % of total capital cost (5–6 % if assessed as individual projects)
Non-traditional terracing	Experimental small-scale terracing to create wetland habitat.		Implementation: $30,000–45,000 per site Feasibility Study: 1–2 % of total capital cost (5–6 % if assessed as individual projects)

[1] BC Hydro provided cost estimates based on hard-engineered structures and, therefore, are considered conservative (refer to Appendix DD: Attachment 1).

This approach recognizes that this first phase of mitigation would be small scale and experimental in nature, and at best would only partially offset the negative impacts of reservoir operations on wildlife. However, this proposal uses an approach of soft engineering that will exploit the existing landforms in the drawdown zone to improve the functioning of the existing areas of habitat. Sites considered to have a high probability of success were identified as potential candidates for experimental trials; however, it was recognized that alternate more preferable areas might be identified through the planning and feasibility studies.

Discussions of the Consultative Committee focused on cost-effective ways that small-scale soft engineered works could be implemented. The BC Hydro representative noted that the corporation is very risk averse and would not be willing to build projects that have a significant risk of failure. BC Hydro would need to consider the liability of the works and construct the projects as hard-engineered structures. It was noted that, while effective lower cost options might be identified through the planning and feasibility studies, implementing these physical works for substantially lower costs would only be possible if a third party was to assume responsibility for the construction, maintenance and liability of these works. The benefits of a third party agreement would be that the works could be implemented for a much lower cost, there would be community-based input into the project, and the structures would be soft engineered.

The Consultative Committee agreed that, if a third party was to assume responsibility for the construction, maintenance and liability of these works, some experimental projects could be a cost-effective way to test out these options. While all of the proposed options were considered reasonable approaches to mitigating operational impacts on wildlife habitat, it was noted that the berm concept would only be acceptable if existing structures were used (i.e., railway and roadbeds in the drawdown zone) as opposed to the creation of new berms where landforms do not already exist.

The Consultative Committee agreed to a funding level that would allow the delivery of these projects over a 10-year period (refer to Table 7-55). Several Committee members expressed concern that project tracking and performance monitoring would need to be implemented to ensure that the goals of the program were being achieved. The BC Hydro project team pointed out that monitoring studies are being proposed to evaluate how well these works perform. Much of this has been included as elements of other studies undertaken in support of operational/non-operational changes being proposed for Arrow Lakes Reservoir (i.e., nest mortality study, amphibian and reptile life history study, and revegetation monitoring). One study specific to this program is a survey of high value wildlife habitat sites to determine additional opportunities for protection and enhancement. The estimated cost of this study is $100,000/year over a 4-year period.

Table 7-55: Physical Works Program for Wildlife Habitat in the Revelstoke Wetlands

Program	Arrow Lakes Reservoir Wildlife Physical Works in Lieu		
Scope	Based on further discussions with technical expert, further define possible treatment options to enhancement wildlife habitat. Undertake feasibility and risk assessments, detailed planning studies and public consultation to address engineering design, questions around soil permeability and potential impacts on other interests. Implement feasible enhancement options.		
Budget and Schedule	• Feasibility and planning studies	Year 1	$100,000
	• Administration, planning and implementation ($250,000/year)	Years 2–10	$2,225,000
	• **Total**		**$2,325,000**

The Consultative Committee did not review this proposal in light of the five-year review of soft constraints on Arrow Lakes Reservoir operations.

In the event that a third party cannot be found to undertake the wildlife physical works, the Consultative Committee acknowledged that substantially less could be done if BC Hydro were to undertake these works for the agreed upon budget.

Table 7-56 presents the level of support expressed by the Consultative Committee members for the proposed physical works for wildlife in the Revelstoke Wetlands.

Table 7-56: Consultative Committee's Level of Support for Wildlife Physical Works

Committee Member	Level of Support	Comments
Bill Green	E	
Bill Duncan	E	
Bob Taylor	E	
Chris Beers	E	
Doug Robinson	A	Subject to performance measures being in place to demonstrate success.
Fred Fortier	E	
Gail Bernacki	E	
Gord DeRosa	E	
Gordon Boyd	A	Subject to performance measures being in place to demonstrate success.
Helmut Klughammer	E	
Ian MacLean	A	Subject to performance measures being in place to demonstrate success.
Kindy Gosal	E	
Janice Jarvis	E	
Jim Forbes	E	

Table 7-56: Consultative Committee's Level of Support for Wildlife Physical Works (cont'd)

Committee Member	Level of Support	Comments
Judy Bosh	E	
Llewellyn Matthews	E	
Loni Parker	E	
Mark Thomas	E	
Maureen Weddell	E	
Pat Wilcox	E	
Paul Peterson	E	
Randy Priest	E	
Shelley Murphy	A	Subject to confirmation of final package. My concern around acceptance of this strategy is that the design of the program has checks and balances to ensure value for money.
Steve Macfarlane	E	
Susan Hall	E	
Terry Anderson	E	

Consultative Committee's Recommendation for Wildlife Physical Works

Recommendation	Comments
The Consultative Committee recommended that an adaptive approach be taken to implementing physical works for wildlife interests in the mid Columbia River.	The Committee acknowledged that substantially less could be done for the agreed upon budget if BC Hydro undertakes implementation of the wildlife physical works.

7.7.8 Arrow Lakes Reservoir/Lower Columbia River Balance – Round 5

During the Round 5 trade-off analysis, the modelling approach used to capture a "typical" set of rainbow trout and mountain whitefish agreements with the United States was modified from that presented to the Consultative Committee during their November 2003 meeting (refer to Section 7.6.2). For the November meeting, some elements of the flow shaping were included to capture the Libby Co-ordination Agreement (the Arrow/Libby swap). The Arrow/Libby swap had a substantial impact on reducing Arrow Lakes Reservoir elevations during late summer to the extent that it had the potential to impact some performance measure scores. However, as the expansion of the Brilliant power plant has proceeded, the likelihood of BC Hydro pursuing this agreement in the future has decreased. Consequently, the project team was advised to remove this low probability event from the modelling assumptions.

Modelling of the lower Columbia River flows was also modified to account for the fall provisional draft, which the United States requires in return for agreeing to capping of January flows for mountain whitefish. This option involves the drafting of 400 ksfd from Arrow Lakes Reservoir in September in years when September energy prices are greater than the October/November prices. This occurs in approximately half of the years in the data set (27 out of 60 years), and appears to coincide with years when the reservoir is low. Adding the mountain whitefish flow agreement was shown to have little to no impact on fall reservoir levels in average water years, but lowers fall water levels in low years by approximately 7 to 8 ft by the end of September. The reservoir is about 3 to 4 ft lower by the end of October due to the fall provisional draft, and returns to average levels by the end of November. Since the impacts on water levels were outside of the sensitive elevation ranges for the recreation and fall migratory bird performance measures, the mountain whitefish agreement had no impact on any of the calculated performance measure scores for Arrow Lakes Reservoir.

Table 7-57 provides a detailed description of how the rainbow trout and mountain whitefish agreements were included in the modelling of the Arrow Lakes Reservoir alternatives.

Table 7-57: Definition of the Lower Columbia River Flows ("+FFF") – Round 5

Alternative	Description	Detailed Specification
Any HYSIM alternative "+ FFF"	Flows below Hugh Keenleyside Dam shaped in every water year to achieve more favourable outcomes for mountain whitefish (by capping January flows), rainbow trout (by providing non-decreasing flows starting in April), and to approximate flow variations required for United States agreement (including flow changes in LCR and storage changes in Arrow Lakes Reservoir). No Libby swap in included here, and Kinbasket is unchanged.	January: Cap January outflows to no greater than 60 kcfs unless higher flows required to meet January flood control level or to limit the January volume reduction to no greater than 400 ksfd. Due to whitefish agreement. February/March: Target to store 1.0 MAF for United States flow augmentation when the 95 per cent confidence inflow volume (January to July) at The Dalles is below 90 MAF (this translated into flow augmentation required in about 60 per cent of the time) while target smooth discharge over period. Flow augmentation storage further subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent months to preserve flow augmentation. Therefore, some years will show less than Target flow augmentation. Due to Rainbow Trout agreement. April and May: Target smooth discharge over period subject to reservoir flood control with a discharge floor of 15 kcfs. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 1438 ft (438.3 m) at the end of May. Some Flow augmentation may be released due to this operation but no additional flow augmentation would be stored. Due to Rainbow Trout agreement. June: Release 20 per cent of remaining (May) flow augmentation, subject to reservoir flood control. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 1442 ft (439.5 m) at the end of June. Due to Rainbow Trout agreement.

Table 7-57: Definition of the Lower Columbia River Flows ("+FFF") – Round 5 (cont'd)

Alternative	Description	Detailed Specification
Any HYSIM alternative "+ FFF" (cont'd)		July: Release remaining flow augmentation. Due to Rainbow Trout agreement. August: No additional activity (no assumed Libby swap). September: For years when September energy price > October/November price assume United States draft 400 ksfd due to Whitefish Agreement. October: For years when September energy price > October/November price assume United States returns 200 ksfd due to Whitefish Agreement. November: For years when September energy price > October/November price assume United States returns 200 ksfd due to Whitefish Agreement.

Separate modelling of the financial impacts of the mountain whitefish flows suggested that there were two major sources of losses arising from these agreements. The mountain whitefish flow agreement provides the United States with the option to draft additional water during September, which is expected to result in energy losses from Arrow Lakes Generating Station due to increased spills and head losses. These flows also reduce the volatility of the market prices, which reduces BC Hydro's ability to profit from its system's flexibility. As shown in Table 7-58, the net cost of these flows varies little across the range of alternatives for Arrow Lakes Reservoir.

Table 7-58: Financial Impact of the Rainbow Trout and Mountain Whitefish Agreements Across Alternatives

Performance Measure	11B + FFF	11D + FFF	IC + FFF	11D2 + FFF	11D3 + FFF
Financial (Million $/year)					
Cost of mountain whitefish flows	2.3	2.2	2.2	2.2	2.3
Cost (benefit) of rainbow trout flows	(3.0)	(3.0)	(3.2)	(3.0)	(3.0)

7.7.8.1 Mountain Whitefish Flows

Past agreements for mountain whitefish have focused on reducing outflows from Arrow Lakes Reservoir during the peak spawning period (1 January to 21 January) and maintaining stable flows during the incubation periods (21 January to 31 March) to minimize the dewatering of whitefish eggs. The target is to minimize the difference between the maximum peak spawning flow (Qs) and minimum incubation flow (Qi).

Table 7-59 and Table 7-60 show the flow regimes and predicted egg losses below Hugh Keenleyside Dam prior to and since implementation of the whitefish flow agreements.

Table 7-59: Lower Columbia River Flows and Predicted Whitefish Egg Losses Without the Whitefish Flow Agreement (1984 to 1993)

Historic Flows			Historic Egg Losses		
Qs-Qi kcfs	% Frequency	# Years over 5 Years	Egg Loss (%)	% Frequency	# Years over 5 Years
0–20	0.00	0	0–20	0.00	0
20–40	0.00	0	20–40	0.00	0
40–60	0.36	2	40–60	0.36	2
60–80	0.18	1	60–80	0.18	1
80–100	0.45	2	80–100	0.45	2

Table 7-60: Lower Columbia River Flows and Predicted Whitefish Egg Losses With the Whitefish Flow Agreement (1994 to 2003)

Whitefish Flows			Recent Egg Losses		
Qs-Qi kcfs	% Frequency	# Years over 5 Years	Egg Loss (%)	% Frequency	# Years over 5 Years
0–20	0.33	2	0–20	0.66	3
20–40	0.44	2	20–40	0.33	2
40–60	0.22	1	40–60	0.11	0
60–80	0.11	0	60–80	0.00	0
80–100	0.00	0	80–100	0.00	0

Based on the whitefish egg loss computer model, it is predicted that the whitefish flow regime has reduced egg losses at representative spawning locations relative to that which occurred under the historic (pre-1994) flow regime. However, counter to the hypothesis that the flows conserve the whitefish population, monitoring data collected between 1991 and 1996, and 2001 and 2002 implies that there has been a 35 per cent decline in adult numbers since implementation of these flows. Given the critical gaps in time series of monitoring, changes in monitoring objectives and protocol and inherent natural variation in whitefish survival rates, there was considerable uncertainty regarding the reliability of inferences that have been made from the data. While the Consultative Committee was presented with a plausible link between whitefish flows and whitefish population levels, no clear link could be established. Given the financial implications of continuing the whitefish flow policy, the Committee tasked the Fish Technical Subcommittee with devising an experimental approach that would address these issues.

The Fish Technical Subcommittee put forward an adaptive management plan that would test the effectiveness of the current flow regime to ensure that it is achieving its goal of protecting the whitefish population. Table 7-61 summarizes the adaptive experimental plan.

Table 7-61: Adaptive Experimental Plan for Mountain Whitefish in the Lower Columbia River

Phase 1		
Scope	1. Continue the current whitefish flow regime for five years to provide a total of 10 continuous years of systematic baseline data under implementation of whitefish flows (Years 1–5 pre-Water Use Plan; Years 6–10 Water Use Plan). This would maintain the current pattern of egg mortalities within the range since implementation of these flows. If flow releases are expected to result in greater than 40 per cent mortality, BC Hydro will undertake consultation with DFO prior to implementation of these flows.. 2. Continue annual monitoring of the whitefish population for five years, and analyze the data to determine population status and trends in recruitment and abundance as they may relate to winter flow regime. Monitoring results will either show that stronger recruitment noted in 2001/2002 has led to the rebuilding of the adult population, or that there has been no detectable increase in adult numbers, suggesting that there may be other factors implicated in high adult mortality. . (Years 1-5 assumed to be 2001 through 2005, with CWR order for 2006; Year 2001 selected as this represents the first year of systematic data collection through the Large River Index Program). 3. Decide whether to increase contrast (and thus learning potential) to test the historical flow regime (invoking egg mortality rates as high as 80 per cent), or maintain status quo whitefish flows to protect the population.	
Schedule	White Fish flows + Pre-Water Use Plan Index Monitoring (assumes Comptroller of Water Rights Order by end of Year 5)	Years 1–5
	White Fish Flows + Water Use Plan Index Monitoring	Years 6–10
	Interim Analysis and Decision for Optional Testing [1]	End of Year 10
Phase 2		
Scope	1. Implement the flow treatment decision made from Phase 1 (i.e., continue status quo or allow a broader range of flow deviation based on the historical flow regime). 2. Continue annual monitoring and analyse the data to test for trends in abundance and recruitment as they relate to winter flow regime. 3. Make a final assessment of the links between flows and whitefish indices.	
Schedule	Optional Flows Tests + Water Use Plan Index Monitoring	Years 11–15

[1] A joint BC Hydro and fish regulatory agency team of Fish Technical Subcommittee members will be appointed to review and analyze the results of monitoring conducted in Years 1 to 10, and provide recommendations regarding optional flow testing in Years 11 to 15 for broader approval.

The two-phase program will be implemented over a 15-year period to assess the benefits of the whitefish flow. As illustrated in Figure 7-17, this will involve building on existing baseline data from 2001, and obtaining additional data over the review period of the Columbia River Water Use Plan assumed to be 10 years.

While this approach is based on re-creating (as close as possible) predicted egg loss rates based on the egg loss model, the Consultative Committee recognized that the target treatment will need to be operationalized using a distribution of flow targets similar to the past 10 years, as outlined earlier in Table 7-59.

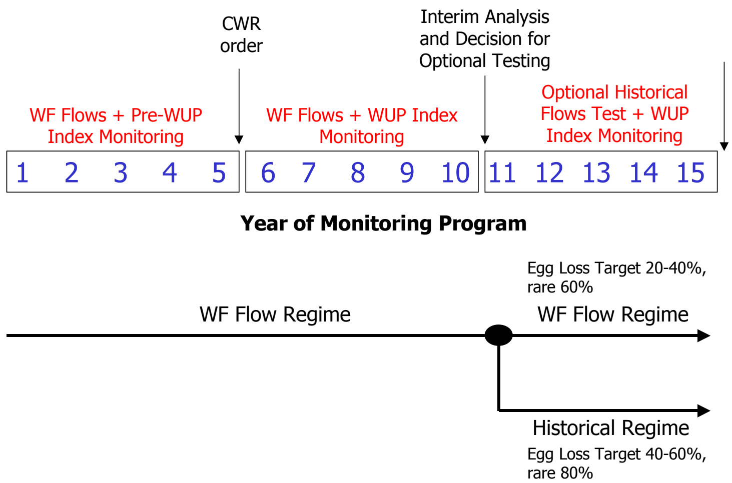


Figure 7-17: Implementation Schedule for the Lower Columbia River Whitefish Experiment

The implementation of the adaptive experimental plan as an outcome of the Columbia River Water Use Plan was an area of concern for some Consultative Committee members. While the Committee could make recommendations around operations in the lower Columbia River, these were subject to negotiations with the United States and would not become water licence constraints. DFO representatives wanted some assurance that BC Hydro would deliver on the flows over the term of the Water Use Plan. They were willing to accept an experiment that tested the effectiveness of the seasonal flow targets (Qs–Qi) provided that they were maintained at the same magnitude and frequency as recent historic (1994 to 2003) over the first five years of the Water Use Plan, and thus maintain the current pattern of egg mortalities. This would provide the opportunity to continue monitoring to better inform on the relationships between flow and egg mortality, and egg mortality and population levels, and the acceptability of implementing a broader range of flow deviations in the future.

In response to this request, BC Hydro provided DFO with a letter of commitment to negotiate mountain whitefish (and rainbow trout flows) with the United States (refer to Appendix EE: Commitment to Negotiate Mountain Whitefish and Rainbow Trout Flows). In efforts to maintain status quo conditions over the first five years of the Water Use Plan, BC Hydro stated that it would endeavour to provide flow reductions that are predicted to result in 30 to 40 per cent egg mortality only once over the five years. Further, it is recognized that these modelled egg losses could hit the 40 to 60 per cent range in 1 year out of 5, but this was being masked in the predicted 5-year frequencies by the way in which the data were rounded. In the event that flow releases are expected to deviate from the target flow treatments and result in greater than 40 per cent (estimated) egg mortality, it was agreed that BC Hydro would undertake consultation with DFO prior to implementation of these flows.

To address each of the hypotheses regarding the relationship between flow conditions and whitefish population levels, the Fish Technical Subcommittee recommended a substantial monitoring program to accompany the mountain whitefish experimental plan. This included whitefish spawning ground topographic surveys, egg monitoring and a whitefish life history study, as well as two additional studies to assess the effects of the whitefish flows on the use of wintering habitat at Waldie Island by Great Blue Heron. The total annualized cost of the monitoring program was estimated at $122,540 (levelized over 15 years). A description of each of these studies and their estimated costs is provided in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

The Consultative Committee was asked to indicate its level of support for the whitefish experimental plan and monitoring program. Table 7-62 shows the level of support expressed by the Consultative Committee for adaptive experimental plan and monitoring for whitefish.

Table 7-62: Consultative Committee's Level of Support for Mountain Whitefish Flows and Related Monitoring Activities

Committee Member	Level of Support	Comments
Bill Green	E	
Bob Taylor	A	Providing that CPC and CBT are successful in negotiation, so that they are kept whole.
Chris Beers	E	May change to accept if there was substantial impact to CPC/CBT.
Doug Robinson	A	BC Hydro supports MWF and monitoring. Blue Heron monitoring is not consistent with how we have done monitoring on other programs. Heron should be included in some other section.
Fred Fortier	E	I would change to accept if CPC/CBT were impacted. We asked CPC, we are missing some facilities outside of the water use planning process. One of the recommendations to the Water Comptroller will be to help facilitate Water Use Plans for Kootenay River systems into the Columbia River Water Use Plan.
Gail Bernacki	E	
Gord DeRosa	A	
Gordon Boyd	A	BC Hydro supports MWF and monitoring. Blue Heron monitoring is not consistent with how we have done monitoring on other programs. Heron should be included in some other section.
Helmut Klughammer	A	Same conditions as CPC and CBT. Also have concerns the drawdown of water earlier in the year when you get sloughing that could cause problems.
Ian MacLean	A	BC Hydro supports MWF and monitoring. Blue Heron monitoring is not consistent with how we have done monitoring on other programs. Heron should be included in some other section.
Kindy Gosal	A	Similar to CPC conditions.
Janice Jarvis	B*	Blocking any fish flows given their negative impact on vegetation and wildlife is detrimental. I did not realize that I had accepted Rbt flows previously. I would have blocked.

Table 7-62: Consultative Committee's Level of Support for Mountain Whitefish Flows and Related Monitoring Activities (cont'd)

Committee Member	Level of Support	Comments
Jim Forbes	A	In consideration that it does not hamper CPC.
Judy Bosh	A	Providing that CPC and CBT are successful in negotiation.
Llewellyn Matthews	A	Subject to the conditions that CPC/CBT are saved harmless or appropriately compensated for any adverse impacts resulting from the implementation of the Water Use Plan.
Loni Parker	A	Same condition as CPC/CBT.
Mark Thomas	A	Based on information regarding wildlife impacts.
Maureen Weddell	A	Providing that CPC and CBT are successful in negotiation. I know how much CPC and CPT puts into the basin and a loss of revenue would be detrimental to the basin.
Paul Peterson	A	Providing that CPC and CBT are successful in negotiation.
Randy Priest	A	Providing that CPC and CBT are successful in negotiation.
Shelley Murphy	–	**Abstained.**
Steve Macfarlane	E	I wish CPC and CBT were more open regarding the real impacts to the community.
Susan Hall	A	Conditional on those larger overall impacts on vegetation and Rbt flows.
Terry Anderson	E	

* This block was later removed, with the understanding that BC Hydro would work towards satisfactorily resolving the recreation user conflict in the Arrow Lakes Reservoir drawdown zone.

With resolution of concerns regarding recreational use conflicts in Arrow Lakes Reservoir, the Consultative Committee unanimously supported the proposed whitefish experiment and monitoring program. However, many Committee members stated that their level of support would be reduced if implementation of the whitefish flows reduced the Columbia Basin Trust's funds for the region. In addition, BC Hydro representatives were uncertain whether there was an operational link between the mountain whitefish flows and impacts to herons on Waldie Island. While they understood the importance of this issue to other members around the table and would support the heron studies, this support was conditional on the Comptroller of Water Rights accepting the linkage to the water use planning process.

Consultative Committee's Recommendation Regarding Mountain Whitefish Flows and Related Monitoring

Recommendation	Comments
The Consultative Committee recommended that BC Hydro pursue the mountain whitefish flow agreements every year, and carry out the experimental plan and associated monitoring program to assess the effectiveness of this flow policy.	The Committee's level of support for the package of flow changes and monitoring would be reduced if the Columbia Power Corporation and the Columbia Basin Trust were not kept whole from any financial costs imposed by the Columbia River Water Use Plan.

7.7.8.2 Rainbow Trout Flows

During the June 2003 meeting, the Consultative Committee agreed to recommend that BC Hydro continue pursuing the rainbow trout flow agreements with its United States counterparts. However, given the negative impact of the flow policy on interests in the Arrow Lakes Reservoir drawdown zone and the unconfirmed linkage between flow conditions and rainbow trout populations, the Committee requested that a long-term monitoring program be developed to address these key uncertainties.

The Fish Technical Subcommittee presented the Consultative Committee with a proposed monitoring program to better define the link between rainbow trout flow implementation and the change in population levels in the lower Columbia River. This included rainbow trout spawning assessments, physical habitat monitoring, ecological productivity monitoring, and population index survey.[1] (The latter three studies are also required to support the implementation of the whitefish experimental plan.) The total annualized cost of these studies was estimated to be about $310,000.

The Consultative Committee was asked to express their level of support for the monitoring program to accompany the lower Columbia River rainbow trout flows. The results of this are presented below in Table 7-63.

Table 7-63: Consultative Committee's Level of Support for the Rainbow Trout Flows and Monitoring Program

Committee Member	Level of Support	Comments
Bill Green	E	
Bill Duncan	E	
Bob Taylor	A	I would like to see if there are other government agencies to fund.
Chris Beers	E	
Doug Robinson	A	Subject to review of the total package for Arrow Lakes Reservoir.
Fred Fortier	E	
Gail Bernacki	E	
Gord DeRosa	E	
Gordon Boyd	A	Subject to review of the total package for Arrow Lakes Reservoir.
Helmut Klughammer	E	
Ian MacLean	A	Subject to review of the total package for Arrow Lakes Reservoir.

[1] During meetings of the Fish Technical Subcommittee, it was noted that redd salvage efforts would likely be reduced once appropriate ramp rates have been established and accepted by the regulatory agencies. However, some salvage may need to continue to some extent (i.e., if BC Hydro deviates from these ramp rates). The cost of ongoing redd salvage has not been included in the estimated costs of the proposed monitoring studies.

Table 7-63: Consultative Committee's Level of Support for the Rainbow Trout Flows and Monitoring Program (cont'd)

Committee Member	Level of Support	Comments
Kindy Gosal	A	
Janice Jarvis	A	Subject to study addressing if flows could be reduced or eliminated in some years or all years to address Arrow Lakes Reservoir concerns.
Jim Forbes	E	
Judy Bosh	E	
Llewellyn Matthews	A	Need to monitor if there are flows.
Loni Parker	E	
Mark Thomas	E	
Maureen Weddell	E	
Pat Wilcox	E	
Paul Peterson	E	
Randy Priest	A	I like that it is not open ended and that it will be reviewed to ensure that flows are being effective.
Shelley Murphy	–	**Defer** given that it is not part of the water use planning process.
Steve Macfarlane	E	
Susan Hall	A	Subject to focus of study on the utility of these flows, supporting general biodiversity as well as prolific sport fish with end of being able to back-off or modify delivery for vegetation and wildlife habitat interests in Arrow Lakes Reservoir (migratory bird habitat use, nest mortality).
Terry Anderson	E	

Consultative Committee's Recommendation for the Rainbow Trout Flows and Monitoring Program

Recommendation	Comments
The Consultative Committee recommended that BC Hydro continue to pursue the rainbow trout flow agreements with its United States counterparts every year and undertake effectiveness monitoring of these flows.	None.

7.7.8.3 Ramping and Stranding Protocol

During the November 2003 Consultative Committee meeting, the Committee agreed by consensus that the stranding protocol was an acceptable means of addressing fish stranding issues in the lower Columbia River while monitoring and the ramping rate study are carried out (Section 7.6.5). The plan as presented to the Committee was reviewed again during the Round 5 trade-off analysis to ensure Committee support for the protocol, monitoring studies and associated budget.

It was noted that once further information is available regarding stranding risk at various flows and locations in the river, BC Hydro will be reviewing the protocol with the agencies and looking for opportunities not to salvage and to undertake physical works in areas prone to fish stranding. As the existing budget for the ramping rate study ($150,000/year) did not include funding for physical works or its maintenance, the Consultative Committee agreed that the annual cost of continuing the ramping rate experiments under the Columbia River Water Use Plan should be increased to $180,000 to cover these costs.

Some Consultative Committee members expressed concern regarding the duration of the ramping rate study and whether interim review of the study results was possible. It was suggested that the Committee could recommend that COFAC review this issue each year.

The Consultative Committee agreed that implementation of the stranding protocol and interim ramping rate criteria, in conjunction with planned ramping rate tests, monitoring and appropriate mitigation, were an acceptable approach to addressing fish stranding in the lower Columbia River until further information is gained through ongoing fish salvage, survey activities and the ramp rate study to develop a defined ramping rate matrix to the satisfaction of BC Hydro and the fisheries regulatory agencies.

7.7.9 Revelstoke Reservoir – Round 5

Early in the Columbia River water use planning process, the Consultative Committee agreed that specific objectives related to Revelstoke Reservoir did not need to be developed, as no operating alternatives would be considered that significantly alter the timing, depth or duration of normal drawdown or the frequency of emergency drawdown. While it was acknowledged that there are potentially negative impacts on fish, wildlife, recreation and property interests associated with normal current operations (1.0 to 1.5 m drawdowns), these were not considered significant to warrant exploring operating alternatives for the reservoir. During the November 2003 meeting, the Committee identified the need to include specifications for current operating rules for Revelstoke Reservoir in the Water Use Plan to ensure that it continues to be operated in its current manner.

During the June 2004 meeting, the Consultative Committee reviewed the operation requirements for Revelstoke Reservoir as specified in BC Hydro's System Operating Order (SOO) 4P30. The BC Hydro representatives noted that there are economic incentives to maintain the reservoir close to its upper levels. As stated in the SOO, the reservoir is typically kept within elevations 571.50 and 573.02 m (full pool) (1875.0 and 1879.99 ft), except during unusual system conditions or hydrology. Because of this relatively stable operating regime, the Committee generally agreed that status quo operations are acceptable, and there would be no requirement for additional studies or monitoring during the term of the Water Use Plan provided that the current operations are maintained. Any change in operation of the reservoir from status quo or a change in the physical structure of Revelstoke or Mica dams would trigger a review of this portion of the Water Use Plan.

One Consultative Committee member expressed concern related to the infrequent need for deep drawdown of the reservoir. After some discussion, the Committee agreed that, in the event of an emergency, other priorities would take precedence over the Water Use Plan.

The Consultative Committee agreed to build these conditions into the review period of the Columbia River Water Use Plan.

Consultative Committee's Recommendation Regarding Operation of Revelstoke Reservoir

Recommendation	Comments
The Consultative Committee recommended that no additional restrictions be placed on operation of Revelstoke Reservoir.	The Committee emphasized that current operations are acceptable, and that the System Operating Order governing these operations (SOO 4P30) should be reflected in the Water Use Plan. The Committee also acknowledged that, under unusual or emergency conditions, the reservoir might be drafted outside of its normal operating range.

7.7.10 Monitoring of Revelstoke Minimum Flows – Round 5

During the November 2003 meeting, the Consultative Committee provisionally agreed to a 5 kcfs year-round minimum flow constraint on Revelstoke Dam operations at an annual cost of $3 million. However, as discussed earlier in Section 7.6.4, the Committee requested that the BC Hydro project team explore the option of relaxing the minimum flow when backwatering of Arrow Lakes Reservoir could possibly negate any benefits gained through an increase in base flow, and thus reduce the cost of providing the minimum flow. The project team found that, when the reservoir was at or above 438 m (1437 ft), the additional wetted width of the river attained by a 5 kcfs minimum flow was negligible. However, further examination of this by the Fish Technical Subcommittee led to the conclusion that the minimum flow would still deliver some benefits to the reach of river closest to the dam even when the reservoir was at full pool. Consequently, there was no ability to modify the year-round minimum flow to reduce costs while still providing the same magnitude of benefits to fish habitat.

While providing a minimum flow of 5 kcfs would create more stable habitat in the mid Columbia River, the Fish Technical Subcommittee was uncertain about the response of fish communities and the magnitude of this response given the large daily fluctuations in flows from Revelstoke Dam (5 to 60 kcfs). A number of studies were therefore proposed by the subcommittee to monitor the effectiveness of the minimum flow in meeting the fish objectives developed for the mid Columbia River. The annualized cost of this monitoring program was estimated at approximately $423,000 over 15 years. The details of this program are provided in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

Some Consultative Committee members expressed concern over the high cost of the monitoring, and questioned whether there was the opportunity to reduce costs either through exclusion of lower ranked studies or bundling of studies. Members of the Fish Technical Subcommittee pointed out that each of the studies focus on specific species or require different approaches. Further, each of these studies is critical to developing a logical chain in assessing the biological effectiveness of the minimum flow. This information will be essential to inform future decision making around an suitable minimum flow.

The Consultative Committee was asked to express its level of support for the Revelstoke minimum flow and monitoring program. The results of this are provided below in Table 7-64.

Table 7-64: Consultative Committee's Level of Support for the Revelstoke Minimum Flow and Monitoring Program

Committee Member	Level of Support	Comments
Bill Green	E	
Bill Duncan	E	
Bob Taylor	E	
Chris Beers	E	
Doug Robinson	A	Subject to review of the entire package.
Fred Fortier	E	
Gail Bernacki	E	
Gord DeRosa	E	
Gordon Boyd	A	Subject to review of the entire package.
Helmut Klughammer	E	
Ian MacLean	A	Subject to review of the entire package.
Kindy Gosal	E	
Janice Jarvis	A	Need to ensure that the most effective flow regime through the monitoring studies.
Jim Forbes	E	
Judy Bosh	E	
Llewellyn Matthews	A	I have some reservations about the costs.
Loni Parker	E	
Mark Thomas	E	
Maureen Weddell	E	
Pat Wilcox	E	
Paul Peterson	E	
Randy Priest	A	With conditions that monitoring has some upper limit. If you find information, the monitoring may need to be changed. Secondly, when Unit 5 goes in, the minimum flow ends. Rev Unit 5 would trigger a new Water Use Plan.
Shelley Murphy	A	Concerns with overall costs and hoping to see good contract management.
Steve Macfarlane	E	
Susan Hall	E	I would like to look at the overall value of that stretch of the river. Because of the extreme flow variability, the monitoring studies may not show the benefits of the minimum flow. Need ongoing analysis of the data. A 5 kcfs flow is a small minimum flow relative to what comes down the river.
Terry Anderson	E	

The Consultative Committee unanimously supported the 5 kcfs minimum flow and associated monitoring program, but recommended that the minimum flow be implemented two years after initiation of the Columbia River Water Use Plan to allow sufficient time to collect additional baseline data.

Consultative Committee's Recommendation for a Revelstoke Minimum Flow and Related Monitoring

Recommendation	Comments
The Consultative Committee recommended a year-round 5 kcfs minimum flow constraint at Revelstoke Dam and the proposed monitoring program.	The Committee recommended that the 5 kcfs minimum flow be implemented two years after the Water Use Plan is implemented to collect additional baseline data.

7.7.11 Flow Decisions, Monitoring and Physical Works for White Sturgeon in the Mid Columbia River – Round 5

During the November 2003 meeting, the Consultative Committee agreed to the provision of a seasonal minimum flow for white sturgeon, with a maximum funding cap of $5 million over 10 years. Subsequent to this meeting, the Fish Technical Subcommittee worked with members of the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) to develop final recommendations related to treatment options within this funding envelope and monitoring.

The proposed workplan was presented to the Consultative Committee at their final June 2004 meeting. This involved a 4-phase plan extending over 10 years to better understand juvenile habitat capabilities in the mid Columbia River, and begin rebuilding the population through flow treatments and conservation aquaculture. The plan was designed to inform on key hypotheses regarding potential habitat changes in the mid Columbia River that may have contributed to recruitment failure, and focuses on early life history habitat requirements (spawning and rearing) where bottlenecks to production are thought to be occurring. Flow treatments were proposed as a possible means of improving spawning condition and performance, and the survival of naturally spawned individuals during the egg and larval stages. It was also proposed that the sturgeon population be augmented through a hatchery program involving the release of juvenile sturgeon. The intent of this latter program would be to help address key uncertainties regarding the availability/suitability of juvenile rearing habitat in the mid Columbia River, and assess the effectiveness of flow treatments on larval and juvenile survival over the short term. Over the long term, a conservation aquaculture program would help to support the population until such a time as stock abundance/age structure and habitat conditions can support a self-sustaining population. It would also address residual impacts of providing lower than optimal spawning, incubation and rearing flows.

The experimental workplan was designed specifically to allow the necessary flexibility in annual fund allocations for research, experimental treatments and monitoring to ensure that the program is responsive to future learnings and related changes in priorities. This would be facilitated through comprehensive reviews at the end of each phase of the program, and an option to discontinue flow tests in the mid Columbia River (if monitoring supports this decision) and direct all or part of the conservation aquaculture effort in Kinbasket Reservoir.

The Consultative Committee was also informed that effective and dedicated co-ordination would be essential, as this program is both substantial and complex. The Committee was presented with a proposed annual budget of $115,000 to enable co-ordination of all elements of the mid Columbia River white sturgeon recovery program supported by the Columbia River Water Use Plan.

A summary of the workplan, schedule and budget is presented below in Table 7-65, and is described in more detail in Appendix FF: Development of the Mid Columbia River White Sturgeon Experimental Plan.

Table 7-65: Mid Columbia River White Sturgeon Experimental Workplan

Option A	**Develop Self-sustaining Population in Arrow Lakes Reservoir**		
Flow Treatment	Selection of minimum flow treatment based on feasibility of using underwater videography as a means of detecting potential spawners. If videography trials successful: • 30 kcfs (four weeks in August) in years when probable spawning detected up to $5 million cap over 10 years. If videography not feasible: • 15 kcfs (eight weeks in July and August) every year, or • 24 kcfs (four weeks in August) every year. (The maximum attainable minimum flows within the $5 million cap plus the 5 kcfs Revelstoke minimum flow.) [1]		
Arrow Lakes Reservoir Experimental Aquaculture	Experimental release of juveniles and yearlings near Revelstoke to determine juvenile habitat suitability in the mid Columbia River, and assess effectiveness of flow treatments on larval and juvenile survival over the short term.		
Arrow Lakes Reservoir Conservation Aquaculture	Conservation aquaculture implemented if wild production detected. This program would help to support the population until such a time as stock abundance, age structure and habitat conditions can support a self-sustaining population.		
Budget and Schedule	1. Flow Treatment	Years 3–10	$5,000,000
	2. Experimental Aquaculture ($370,000/year)	Years 2–4	$1,110,000
	3. Conservation Aquaculture ($370,000/year)	Years 6–10	$1,850,000
	One-time hatchery facility upgrade[2]	Year 6	$500,000
	4. Program Co-ordination ($115,000/year)	Years 1–10	$1,150,000
	Total		**$9,610,000**

Table 7-65: Mid Columbia River White Sturgeon Experimental Workplan (cont'd)

Option B	**Develop Failsafe Population in Kinbasket and/or Arrow Lakes Reservoirs or Self-sustaining Population in Kinbasket Reservoir**		
Arrow Lakes/ Kinbasket Reservoirs Conservation Aquaculture	If no wild production and no egg/larval benefit conclusively demonstrated, discontinue flow treatment and initiate conservation aquaculture program for Kinbasket and/or Arrow Lakes reservoirs failsafe population(s), or Kinbasket Reservoir recovery area. A decision to go to Option B could be made as early as end of Year 5 or as late as end of Year 8, depending on results of monitoring.		
Budget and Schedule[3]	1. Flow Treatment ($500,000/year)	Years 3–8	$3,000,000
	2. Experimental Aquaculture ($370,000/year)	Years 2–4	$1,110,000
	3. ARR Conservation Aquaculture ($370,000/year)	Years 6–8	$1,110,000
	One-time Hatchery Facility Upgrade	Year 6	$500,000
	4. ARR/KIN Conservation Aquaculture ($370,000/year)	Years 9–10	$740,000
	5. Program Co-ordination ($115,000/year)	Years 1–10	$1,150,000
	Total		**$7,610,000**

1 These minimum flows include the 5 kcfs year-round minimum flow agreed to by the Consultative Committee for Revelstoke Dam. Flows of 10 kcfs (July–August) and 19 kcfs (August) are estimates of what could be achievable (on average) within the $5 million, 10-year ceiling agreed to by the Committee.

2 Estimated costs of conservation aquaculture have assumed upgrade of existing facilities at the Kootenay Hatchery. Costs could be reduced, depending on the outcome of proposed hatchery developments in the U.S., which might be used to support a portion of the culture requirements for releases downstream of Hugh Keenleyside Dam.

3 Estimated costs of program assume that flow treatments could conceivably continue from Year 3 until the end of Year 8 before it is conclusively demonstrated that there are no detectable benefits to wild production or egg/larval survival, and that aquaculture efforts should be shifted to an alternate recovery area in Year 9. These cost estimates differ from those presented at the final Consultative Committee meeting, which assumed that flow treatments could continue for seven years (i.e., Years 1–7) with aquaculture efforts being initiated in Kinbasket in Year 8. These latter estimates were in error, as they did not capture changes that were made to the proposed workplan to reflect the need to undertake research and monitoring in the first two years of the program before flow treatments could be initiated in Year 3.

The Fish Technical Subcommittee and Recovery Team identified a number of research and monitoring studies that are essential to supporting decision making around flow treatments and hatchery supplementation in the mid Columbia River. In particular, they recommended to the Consultative Committee specific studies to define sturgeon spawning and rearing habitat capability in the mid Columbia River and Kinbasket Reservoir/upper Columbia River, determine reasons for recruitment failure, and assess the effectiveness of treatment options in eliciting a detectable recruitment signal. The annualized cost of the monitoring program was estimated at about $235,000 (levelized over 15 years). Details of these proposed studies and the estimated costs associated with Options A and B of the workplan are provided in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

The Consultative Committee discussed the package of proposed flow changes, monitoring and physical works for white sturgeon in the mid Columbia River. The Committee was then asked to provide their level of support for this plan. The results of this are provided below in Table 7-66.

Table 7-66: Consultative Committee's Level of Support for the Mid Columbia River White Sturgeon Experimental Plan

Committee Member	Level of Support	Comments
Bill Green	E	
Bill Duncan	E	
Bob Taylor	E	
Chris Beers	E	
Doug Robinson	A	Concern that decision points are built into the process and get into what will work in the long term.
Fred Fortier	E	
Gail Bernacki	E	
Gord DeRosa	E	
Gordon Boyd	A	Concern that decision points are built into the process and get into what will work in the long term.
Helmut Klughammer	E	
Ian MacLean	A	Concern that decision points are built into the process and get into what will work in the long term.
Kindy Gosal	E	
Janice Jarvis	E	
Jim Forbes	E	
Judy Bosh	E	
Llewellyn Matthews	A	A good work plan. But concerned about designing a cadillac version.
Loni Parker	E	
Mark Thomas	E	
Maureen Weddell	E	
Pat Wilcox	E	
Paul Peterson	E	
Randy Priest	E	
Shelley Murphy	A	Reservations on cost of the studies.
Steve Macfarlane	E	
Susan Hall	E	
Terry Anderson	E	

The Consultative Committee unanimously supported the mid Columbia River white sturgeon experimental plan, including the recommended flow changes, physical works in lieu and monitoring program.

Consultative Committee's Recommendations for White Sturgeon Flows, Physical Works and Monitoring in the Mid Columbia River

Recommendation	Comments
The Consultative Committee recommended implementation of the proposed experimental plan for white sturgeon in the mid Columbia River, including provision of a seasonal minimum flow, physical works in lieu of operations and monitoring.	None.

7.7.12 Flow Decisions, Monitoring and Physical Works for White Sturgeon in the Lower Columbia River – Round 5

Given uncertainty about responses of white surgeon to a higher base flow in the lower Columbia River, the Fish Technical Subcommittee felt that one of the best opportunities for improving conditions for sturgeon through the Columbia River Water Use Plan might be to examine a flow augmentation strategy. A feasibility assessment was undertaken on behalf of the subcommittee (Hildebrand et al., 2003) to examine the ability of delivering experimental flows within existing physical, operational and flood control constraints, the likelihood of eliciting a detectable recruitment signal, and the estimated costs of conducting an experimental program over a 10-year period.

Based on substantial discussion by the Fish Technical Subcommittee, consideration was given to an experimental treatment involving a flow target of 200+ kcfs at the Canada/United States border for one month during the late June to late July period to reduce predation pressures on sturgeon larvae and juveniles. This assumed a maximum flow of 165 kcfs at Birchbank to remain below flooding thresholds at Trail and Genelle. While the likelihood of achieving the 200 kcfs target was considered high provided that upstream storage could be used to supplement high flows from the Pend d'Oreille River, it became apparent that this would require a large shift in current operation of Arrow Lakes Reservoir in most years, and could be very costly ($15–20 million) due to implications on spill downstream on the United States side of the border in high flow years.

During the June 2004 meeting, the Consultative Committee recognized that the high flow option carried with it uncertainty around BC Hydro's ability to deliver the required high flow dependably, the willingness of the United States to accept extra water from Canada during a high water period (freshet), and risks associated with damage to infrastructures in and around the Genelle/Trail area. As such, the Committee recommended that opportunistic assessments of high flow events be undertaken in years when they occur naturally (expected frequency of two years out of 10), as opposed to through an operational change. There were discussions around the need to develop a decision rule to trigger the opportunistic assessment. Details around the decision rule and scope of the opportunistic assessment was subsequently explored by the Fish Technical Subcommittee during a November 2004 meeting (refer to Appendix BB: Briefing Note – MCA WUP Fish Technical Subcommittee Teleconference, November 2004).

Given the low frequency and high costs of achieving a 200 kcfs flow target at the border (i.e., in lost power generation, damage to infrastructure), the Fish Technical Subcommittee recommended turbidity augmentation as a physical works in lieu. This plan involves the delivery of bentonite (clay-like substance or other turbidity agents) to the lower Columbia River during low flow periods (i.e., when discharge at the border is below 90 kcfs), and when sturgeon larvae are known to be hatching and undergoing their downstream drift phase. This was based on the premise that sturgeon spawn every year regardless of discharge, but larvae would be most vulnerable to predation when flows are low and clear. Consequently, the benefits of increased turbidity to survival should be maximized during these low flow periods. A 10 Nephelometer Turbidity Unit (NTU) increase in turbidity was considered to have a reasonable likelihood of achieving recruitment benefits (25−35 per cent probability of successful recruitment to year 1 class), as turbidity is typically between 1 and 2 NTU during the June to July period. The use of bentonite to increase water turbidity was considered to be a safe additive as it poses low human health or environmental risks. The frequency of achieving a 30-day period of flows at or above 90 kcfs at the Canada/United States border was expected to be three years out of 10. The annual cost of providing the target turbidity levels was estimated at approximately $3 million per occurrence. The annualized cost of the turbidity experiment was estimated at $607,000 (over 15 years).

While members of the UCWSRI supported the recommended strategy for opportunistic high flow assessments and turbidity augmentation, they highlighted the need for a fallback option in the event that the turbidity treatment is found to be unfeasible. The Recovery Team recommended that the Consultative Committee consider a provisional contribution to the existing lower Columbia River sturgeon aquaculture program. This additional element to the proposal would require an annual contribution of $188,000.

The Consultative Committee recognized that review and consultation will be required to ensure that legal and regulatory issues around adding turbidity to the river are fully considered. Further, feasibility assessments will be required to address impacts on other interests in the river. If this option is found to be feasible and is implemented, monitoring the response of the sturgeon population will be critical to informing on the effectiveness of this action. A monitoring program was proposed by the Fish Technical Subcommittee to accompany the management plan for white sturgeon in the lower Columbia River. This included juvenile and adult sturgeon monitoring, planning and assessment studies, and the opportunistic assessment of high flow events. The annualized cost of this program was estimated at about $274,000 (over 15 years)[1]. Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs provides a description and estimated costs for each of the proposed studies.

The Consultative Committee discussed the proposed physical works and monitoring package for lower Columbia River white sturgeon. The following summarizes key discussion points of the group.

[1] The estimated cost of the program includes broodstock collection. These costs are included within the $150,000 annual budget for the adult sturgeon population monitoring (refer to Appendix CC).

- One Committee member questioned why the plan did not focus more on aquaculture. The CCRIFC representative noted that white sturgeon will soon be listed under the Species at Risk Act (SARA). Neither this act nor the Columbia River White Sturgeon Recovery Team consider aquaculture to be an acceptable substitute to wild production. The conservation hatchery program is viewed as a stopgap until issues related to wild production are resolved.

- Several Committee members highlighted the need for flexibility in the program to consider other physical works in the event that turbidity is not found to be feasible or appropriate. While turbidity is considered to be a likely factor in recruitment failure of white sturgeon in the lower Columbia River, the MWLAP representative noted that there might be other more appropriate actions that should be investigated in the future.

- Concern was expressed by a number of Committee members related to the potential negative impacts that turbidity augmentation could have on other fish species in the lower Columbia River. The MWLAP representative noted that the Columbia River would have historically been turbid. The 10 NTU increase that is being proposed would have likely occurred prior to dam construction. Nevertheless, it was agreed that an ecological assessment of the turbidity experiment would need to be undertaken to determine the impacts on other interests in the river as part of the approval process.

- There was considerable discussion around whether the proposed turbidity plan fits within the scope of water use planning. It was noted that turbidity augmentation is a works in lieu of a flow change, which would require negotiation with the U.S. since it would violate the Treaty. As this flow change could not be ordered as part of the Water Use Plan, there was uncertainty around whether a physical ordered by the Comptroller of Water Rights.

The Consultative Committee was asked to express its level of support for this package of feasibility studies, physical works and monitoring. The results of this are presented in Table 7-67.

Table 7-67: Consultative Committee's Level of Support for Monitoring and Physical Works for Lower Columbia River White Sturgeon

Committee Member	Level of Support	Comments
Bill Green	E	With the flexibility in the program. Expressed thanks to the table.
Bill Duncan	E	
Bob Taylor	E	Comment that acceptance of the United States for the bentonite experiment is not too likely.
Chris Beers	E	
Doug Robinson	A	Similar concerns as Llewellyn regarding the open-endedness of the program. If the bentonite experiment is not feasible, then what moves forward?
Fred Fortier	E	
Gail Bernacki	A	
Gord DeRosa	E	If the high flow events have negative impacts on Trail, there will need to be some mitigation. Accept conditional on this.
Gordon Boyd	A	Similar concerns as Llewellyn regarding the open-endedness. If the bentonite experiment is not feasible, then what moves forward?
Helmut Klughammer	A	I have a bit of a problem with the flow in the back of my mind.
Ian MacLean	A	Similar concerns as Llewellyn regarding the open-endedness. If Bentonite does not work, then what moves forward?
Kindy Gosal	E	
Janice Jarvis	A	Same reservations as Llewellyn.
Jim Forbes	E	
Judy Bosh	E	
Llewellyn Matthews	A	There is a reservation with the open-endedness regarding the bentonite. If it does not work we will do something else? We are doubling the RT budget; there should be re-evaluation if bentonite does not turn out to be a reasonable option?
Loni Parker	E	
Mark Thomas	E	
Maureen Weddell	E	I would like to thank the people working on this, explaining the proposal, and helping to get our heads around this.
Pat Wilcox	E	
Paul Peterson	E	
Randy Priest	A	If sturgeon are listed as a critical species and other money comes available it should be explored. If walleye are eating sturgeon, then do not continue.
Shelley Murphy		**Abstained.** It is not clear that there is an operational alternative under the Water Use Plan for this.
Steve Macfarlane	E	
Susan Hall	E	With all the same comments related to the need for flexibility.
Terry Anderson	E	

Consultative Committee's Recommendation Regarding Monitoring, and Physical Works for Lower Columbia River White Sturgeon

Recommendation	Comments
The Consultative Committee recommended the proposed physical works and monitoring plan for white sturgeon in the lower Columbia River.	While some Committee members highlighted the need for flexibility within the program, this was an area of concern for other members as there was no clarity around the scope of the program in the event that turbidity was found to be unfeasible. Others highlighted the need to clarify whether the proposed plan could be considered under the Water Use Plan.

Post-Meeting Note

Subsequent to the June 2004 meeting, it became apparent that there was a lack of clarity around the nature of the consensus decision for the lower Columbia River white sturgeon plan. The two principal issues of concern expressed by some members of the Consultative Committee related to flexibility in the approach to physical works in lieu, and annual contributions to the conservation aquaculture program as a fallback option.

Representatives of MWLAP, DFO and CCRIFC pointed out that the need for flexibility to explore other physical works was explicitly highlighted during discussions of the Consultative Committee. Accordingly, they believe that the plan was revised to include this as a key element of the experiment plan in the event that feasibility was found to be inappropriate or unfeasible. This view is supported by the level of support expressed by some Committee members (i.e., conditions of support, and acceptance with reservations regarding the open-endedness of the program). Moreover, the MWLAP and CCRIFC representatives believe that the revised plan included the flexibility to re-direct the funds allocated for the turbidity augmentation to other physical works options. However, this view is not supported by other Committee members. The DFO representative believes that the scope of the program was not adequately defined prior to expressing level of support and that further clarity around budget is required prior to implementation of the plan. Other Committee members believe they were expressing support only for the turbidity experiment, as it was presented to the Committee in the pre-meeting briefing notes and during the meeting.

Based on recommendations of the UCWSRI, the annual contribution to the conservation aquaculture program was presented to the Consultative Committee as a fallback option in the event that turbidity was found to be unfeasible. However, representatives of DFO, MWLAP and CCRIFC do not view this as a fallback position but rather a works in lieu of the high flow option. It is their view that the annual contribution was proposed to address the fact that turbidity augmentation would, at best, only be possible in 3 out of 10 years while the lack of freshet flow volumes is likely to have an impact of sturgeon recruitment in every year. However, the representatives of BC Hydro and the Ministry of Energy and Mines believe that they had agreed to the annual contribution as an option in lieu of turbidity.

7.7.13 Monitoring Impacts of Arrow Lakes Reservoir Operations

The Consultative Committee acknowledged that long-term data collection will be critical to assessing the impacts of Arrow Lakes Reservoir operations on fish, vegetation/wildlife, heritage and recreation interests, and its performance in meeting the objectives for the reservoir. Given considerable uncertainties around the response of vegetation/wildlife and fish resources to operation of the reservoir, a number of assumptions were built into the modelling of constraints and performance measures, which require verification through ongoing monitoring. Specifically, there is substantial uncertainty around the relative importance of timing, duration and depth of inundation on the distribution, biomass and diversity of vegetation within the drawdown zone, and around multi-year stresses on vegetation survival. In addition, the lack of data on the relative abundance, distribution and seasonal patterns of habitat use by nesting and migrating shorebirds in the reservoir drawdown zone limited the predictive capability of the modelling.

The Fish and Wildlife Technical Subcommittee proposed a substantial monitoring program for Arrow Lakes Reservoir. This included a burbot life history study, vegetation monitoring and research, and tool development for assessing the status of vegetation establishment, as well as a monitoring to assess the impacts of reservoir operations on wildlife habitat use, mosquito production, recreation demand and erosion of cultural sites. The annualized cost of this program was estimated at $689,579 (over 15 years). A description of the proposed studies and costs are provided in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

The Consultative Committee discussed the monitoring studies, and some Committee members expressed concern about the overall cost of the program and whether the objectives of some studies were not already addressed through monitoring proposed for other elements of the Water Use Plan (e.g., mosquito studies, nesting bird studies). Further, there was some concern related to whether the neotropical and waterbird studies were linked to operations and therefore could be considered as part of the overall package. The BC Hydro project team assured the Committee that each of these studies had been vetted through the Technical Subcommittees and were considered essential to addressing outstanding data gaps. There are several cases where information collection and effectiveness monitoring programs overlap between management plans, and some study elements have been integrated into other monitoring for cost efficiencies. The observer from the Water Comptroller's office agreed that the link between water management decisions and these studies will need to be clearly demonstrated in the Water Use Plan.

The representative from MWLAP suggested that the scope of the burbot study be revised to include other species to address uncertainty around the operational impacts on reservoir fish populations. It was noted that some concern has been identified around the large piscivorous species of rainbow trout. The BC Hydro project team was tasked with following up on this item after the final Consultative Committee meeting.[1]

Some Consultative Committee members viewed this monitoring package as very important to implement. The representative of the Illecillewaet Greenbelt Society/North Columbia Environmental Society blocked the recommendation for mountain whitefish flows in the lower Columbia River because of concern that the flow agreements were negatively affecting interests in the Arrow Lakes Reservoir drawdown zone. She agreed to remove this block provided that BC Hydro ensure that the physical works and monitoring program for Arrow Lakes Reservoir were designed and delivered in a way that would alleviate the negative impacts. The BC Hydro project team pointed out that a number of the studies were explicitly designed around this question. The team was tasked with following up on this request.

The Consultative Committee was asked to express its level of support for the proposed monitoring package. The Committee unanimously agreed to support this recommendation.

Consultative Committee's Recommendation for the Arrow Lakes Reservoir Monitoring Program

Recommendation	Comments
The Consultative Committee recommended the proposed monitoring program to assess the impact of reservoir operations on interests within the drawdown zone of Arrow Lakes Reservoir.	None.

[1] During a Fish Technical Subcommittee meeting held on 5 November 2004, there was discussion of a proposal to better understand the importance of Revelstoke Reach to piscivorous rainbow trout production. Specifically, this involved conduct of a telemetry study to determine the location of spawning grounds and the degree to which habitats within the Revelstoke Reach are used for rearing. It was agreed that these data gaps would be adequately addressed through studies recommended for the mid Columbia River (i.e., juvenile and adult habitat use assessments), and that additional study was not required (refer to Appendix BB: Briefing Note – MCA WUP Fish Technical Subcommittee Teleconference, November 2004).

7.7.14 Kinbasket Information Plan

Early on in the Columbia River water use planning process, the Fish and Wildlife Technical Subcommittee recognized that there was a great deal of uncertainty regarding whether the lack of constraints on operation of Kinbasket Reservoir was having a significant impact on littoral and pelagic productivity and riparian habitat. Although a number of key hypothesized impacts were identified (e.g., interruption of natural sturgeon recruitment processes, entrainment of bull trout at Mica), a general lack of data on the relative abundance, distribution, life history and seasonal patterns of habitat uses in the upper Columbia River and Kinbasket Reservoir precluded incorporation of these concerns into water use planning assessments. Further, the subcommittee recognized that any operational changes to improve Kinbasket Reservoir for non-power interests were very expensive and the benefits uncertain as a result of initial modelling. As discussed earlier in Section 7.3.1, the cost of implementing the constraints of Alternatives 1 and 2 were not commensurate with the benefits they would provide to recreation, fish and wildlife interests in the reservoir and, therefore, were dropped from further consideration. However, the group acknowledged the importance of better understanding the reservoir ecology and influence of current operations as an outcome of the water use planning process.

The operational link to many of the proposed monitoring studies developed to address these data gaps was considered tenuous given that there are no operational changes being recommended for Kinbasket Reservoir. However, it was recognized that a large stumbling block to making recommendations (operational or physical works) for the reservoir was the lack of quantitative data for fish and wildlife populations. Inferences about impacts of the proposed operational changes on littoral and pelagic productivity of Kinbasket Reservoir were developed based on limited site-specific information and professional judgment. Proposed monitoring studies were, therefore, accepted as meeting the water use planning monitoring criteria, as they are the only tool to validate the assessments used to make decisions about the proposed operating changes and provide the necessary information for making decisions around possible operational and non-operational changes during the next water use planning process.

Although no operating changes were considered for Revelstoke Reservoir, the Fish and Wildlife Technical Subcommittee recommended that many of the fish-related studies in Kinbasket Reservoir be linked to studies in Revelstoke Reservoir to provide a comparison of trends. The subcommittee discussed the possibility of separating out these studies, as the operational link in Revelstoke is even more uncertain than in Kinbasket. However, it was agreed that there would be cost efficiencies by keeping the study components together.

During the June 2004 meeting, the Consultative Committee was presented with a proposed fish and wildlife information collection plan for Kinbasket and Revelstoke reservoirs. The annualized cost of this plan was estimated at $403,254 (over 15 years). A description of the proposed studies and costs are provided in Appendix CC: Proposed Columbia River Water Use Plan Monitoring Programs.

During discussion of the proposed plan, it was noted that information gained through the monitoring studies would be used in future decision making around operational/non-operational changes for Kinbasket Reservoir during the next Water Use Plan. Given the high costs of the information collection plan, the representative of the Ministry of Energy highlighted the need for good oversight in the implementation of these studies. It was also pointed out that efforts should be made to ensure that these studies are not addressing work that should be funded through other programs.

The Consultative Committee was asked to express its level of support for the Fish and Wildlife Information Collection Plan for Kinbasket/Revelstoke reservoirs. The Committee unanimously supported this plan.

Consultative Committee's Recommendation for the Kinbasket Reservoir Information Plan

Recommendation	Comments
The Consultative Committee recommended the Fish and Wildlife Information Collection plan for Kinbasket and Revelstoke reservoirs.	None.

7.7.15 Columbia River Water Use Plan Review Period

The Consultative Committee discussed the review period for the Columbia River Water Use Plan. As the Committee had already agreed to a 5-year review for Arrow Lakes Reservoir operations, the discussion focused on Kinbasket and Revelstoke operations.

Several Consultative Committee members felt that the duration of the monitoring studies was the primary driver in selection of a review period. It was noted that sufficient time would be required to ensure that the longer-term studies could be completed and the data analyzed. Of all the proposed monitoring programs, studies associated with the Revelstoke Dam minimum flow had the longest duration (12 years). Once the Water Comptroller orders BC Hydro to implement the Water Use Plan, this will consist of collecting two years of baseline data plus 10 years of post-treatment data under the 5 kcfs minimum flow. It was felt that the review period should also allow for one additional year to assimilate all of the information gained through the monitoring programs. This would make for a 13-year review period once the Water Use Plan is implemented.

Several Consultative Committee members noted that the first opportunity for BC Hydro to notify its United States counterparts of its intent to renegotiate the Columbia River Treaty will be in 2014. The Committee was urged to consider the interaction of these two events in selection of a review period.

The representative of the Secwepemc Fisheries Commission pointed out that, over such a long period of time, several things will need to change in the relationship between the First Nations and the process for managing water in the province. The First Nations disagreed with the water use planning process from the outset, but went along with the process in the end because negative impacts to the aquatic environment were already occurring. First Nations came to the table prepared to give consent to this Water Use Plan. However, some of the high priority impacts that the First Nations highlighted (e.g., entrainment) have not been addressed in the water use planning process. The First Nations feel strongly that a province-wide entrainment strategy needs to be developed and supported. This is one of the conditions that the First Nations will be putting on the entire water use planning program before they can support it. Within the next 10 years, the First Nations will want to change how they deal with BC Hydro and other parties within water use planning. In particular, an approach needs to be found that will deal with grievance issues. Finally, if the Columbia River Treaty is renegotiated in 2024, there will be a redistribution of benefits. The First Nations need information around these discussions and these changes; the First Nations need to know what the federal government is going to say about the First Nations' rights to the water.

After discussing these issues and formally considering proposals around a 10-year, 12-year and 15-year review period, the Consultative Committee unanimously agreed to a 13-year review period, which would involve 12 years of implementation and an additional year for assimilation and summarization of all study data. The Committee also recommended that BC Hydro undertake annual reporting of progress on the monitoring studies, physical works and performance of the soft constraints.

Consultative Committee's Recommendation for the Columbia River Water Use Plan Review Period

Recommendation	Comments
The Consultative Committee recommended that the review period for the Kinbasket and Revelstoke portions of the Water Use Plan (including the Revelstoke Dam minimum flow) be 13 years after implementation of the Water Use Plan. The Committee recommended that there be annual reporting of progress on monitoring studies and physical works, and performance of the soft constraints for Arrow Lakes Reservoir. The Committee also recommended that Arrow Lakes Reservoir operations be reviewed five years after the implementation of the Water Use Plan to review the results of the monitoring studies and evaluate the effectiveness of the soft constraints and physical works in meeting the Committee's interests in the reservoir and the lower Columbia River. If a new Non-Treaty Storage Agreement is negotiated within this 5-year period, it is also recommended that the outcomes of this agreement be reviewed in the context of its implications to operational flexibility and ability to meet the Committee's objectives for Arrow Lakes Reservoir.	The Committee recommended that the conclusions reached in this consultative process be reviewed in the event that operation of Revelstoke Reservoir changes, or additional units are installed at Revelstoke or Mica dams.

7.7.16 Consideration of the Total Package for the Columbia River Water Use Plan

During the November 2003 and June 2004 meetings, the Consultative Committee was asked to express their level of support for flow changes, monitoring studies and physical works. The Committee expressed some discomfort with making decisions around specific elements of the Water Use Plan without knowing what the "total package" would look like. The BC Hydro project team presented the total package of proposed flow changes, monitoring and physical works with their estimated costs to the Committee at the end of the June 2004 meeting. The estimated total annual cost of the package, as presented to the Committee, is shown below in Table 7-68. A summary of all recommendations with the revised costs made by the Consultative Committee is provided in Section 8.

Table 7-68: Estimated Annual Cost of the Columbia River Water Use Plan

Change in Operations		**Cost (Million $/Year)**
Soft Arrow Lakes Reservoir Constraints		0
Revelstoke 5 kcfs Minimum Flow		3
Mid Columbia River White Sturgeon Minimum Flows		0.5[1]
Rainbow Trout Flows for Lower Columbia River		-3[2]
Mountain Whitefish Flows		2.2[2]
Physical Works		**Million $/Year (annualized over 15 years)**
Arrow Lakes Reservoir Wildlife		0.18[1]
Mid Columbia River White Sturgeon Aquaculture		0.26
Lower Columbia River White Sturgeon Aquaculture		0.16[1]
Lower Columbia River Turbidity Experiment		0.61[3]
Arrow Lakes Reservoir Revegetation		0.19[1]
Kinbasket Reservoir Revegetation		0.19[1]
Kinbasket Reservoir Boat Ramps (4 Ramps)	0.07	
Revelstoke Boat Ramps (1 Ramp)	0.06	
Arrow Lakes Reservoir Boat Ramps (5 Ramps)	0.80	
Boat Ramps (Total)		0.92
Debris Management		0.14
Addressing Known Archaeological Site Issues	0.14	
Addressing Unknown Archaeological Sites	0.46	
Archaeological Protection (Total)		0.67
Total Physical Works		*3.25*
Monitoring		
Kinbasket Reservoir Fish and Wildlife		0.40
Kinbasket/Arrow Lakes Reservoirs Heritage		0.04
Archaeological Impacts		0.04
Kinbasket/Arrow Lakes Reservoirs Recreation		0.03
Mid Columbia River White Sturgeon		0.23
Lower Columbia River White Sturgeon		0.27
Lower Columbia River Fish Flows		0.62
Arrow Lakes Reservoir Revegetation Plan		0.02
Kinbasket Reservoir Revegetation Plan		0.22
Arrow Lakes Reservoir Wildlife Physical Works		0.04
Arrow Lakes Reservoir Impacts		0.69
Revelstoke Minimum Flow		0.42
Total Monitoring		*3.03*
Total Cost ($ Million)		**$ 8.97**

[1] Costs represent a maximum financial cap agreed to by the Consultative Committee

[2] BC Hydro currently pursues the rainbow trout and mountain whitefish flow agreements through annual negotiations with the United States. As BC Hydro cannot implement these flows unilaterally, they can not be written into BC Hydro's Water Licences and therefore do not represent a generation benefit/cost to the Columbia River Water Use Plan.

[3] Subject to regulatory approval in Canada and agreement by the U.S.

The Consultative Committee was asked to express its level of support for the total package of flow changes, physical works and monitoring and the review period. The results of this are presented in Table 7-69.

Table 7-69: Consultative Committee' Support for Implementation of the Columbia River Water Use Plan

Committee Member	Level of Support	Comments
Bill Green	E	Endorse subject to conditions First Nations have specified: An acceptable Provincial entertainment strategy; BC Hydro enters into Columbia Basin First Nations grievance strategy; BC Hydro enters into a suitable agreement for First Nations involvement in monitoring implementation.
Bob Taylor	E	Subject to a 5-year review of the Arrow Lakes Reservoir Water Use Plan.
Chris Beers	E	Subject to BC Hydro satisfactory resolving recreation users conflict. I also strongly support community participation in implementation.
Doug Robinson	E	
Fred Fortier	A	Accept subject to comment related to Janice's issue on drawdown management plan. First Nations have stated to BC that it is a land use plan and we would like to have the final say in that activity. We would also support non-motorized use in the drawdown zone that needs to be co-ordinated with our heritage committee in that Water Use Plan. Information on heritage sites will not be presented to a multi-stakeholder process. We would have to have an acceptable consultation process with the Water Comptroller and federal agencies for review of the Water Use Plan.
Gail Bernacki	E	I agree with the comments regarding recreation in the Arrow Lakes Reservoir drawdown zone. Thanks to everyone. I think this is a great result.
Gordon Boyd	E	
Helmut Klughammer	E	
Ian MacLean	E	
Janice Jarvis	E	Subject to conditions stated earlier regarding resolution of motorized vehicle conflict with vegetation in Arrow Lakes Reservoir drawdown zone and maximizing community benefits.
Jim Forbes	E	
Judy Bosh	E	
Loni Parker	E	Same comments as Janice, including rural residents and general community benefits.
Mark Thomas	A	Subject to there being a process to address footprint issues for First Nations and we develop an entrainment strategy.
Maureen Weddell	E	Subject to resolution of motorized vehicle conflict with vegetation in Arrow Lakes Reservoir drawdown zone.
Paul Peterson	E	
Randy Priest	E	
Shelley Murphy	A	Subject to previously stated conditions.
Steve Macfarlane	E	
Susan Hall	E	Endorse with recommendation for an implementation strategy that maximizes First Nations, and community benefits.
Llewellyn Matthews	A	Subject to the conditions that the CPC/CBT project joint ventures are either saved harmless or appropriately compensated for any potential adverse impacts arising from implementation of the Columbia River WUP.[1]
Terry Anderson	E	

[1] Llewellyn Matthews was not in attendance at the time that the Consultative Committee was asked to express its level of support for implementation of the Columbia River Water Use Plan. CPC's confirmation of its conditional acceptance was made subsequent to the Consultative Committee meeting.

In summary, the Consultative Committee unanimously supported the total package of recommendations put forward for operational changes, monitoring, physical works and the review periods. However, several Committee members noted concern around details of implementing the Water Use Plan, and issues in the watershed. Their support for the Committee's recommendations was conditional on one or more of the following actions being implemented.

- Resolving the conflict in the Arrow Lakes Reservoir drawdown zone between environmental interests and recreational interests.
- Protection of sensitive archaeological sites in the drawdown zone.
- Need for control over implementation of the activities and spending given the large cost of the program.
- Participation of local communities and First Nations in implementation of monitoring studies and physical works projects.
- Indemnification of CPC/CBT joint venture projects from any adverse impacts arising from implementation of the Columbia River Water Use Plan[1].

Consultative Committee's Recommendation for Implementation of the Columbia River Water Use Plan

Recommendation	Comments
The Consultative Committee unanimously recommended the package of proposed flow changes, monitoring studies, physical works and review periods as summarized above in Table 7-69.	

[1] In June 2004, a government policy directive from the Minister of Energy and Mines was issued to BC Hydro directing BC Hydro to save CPC/CBT harmless from the effects of BC Hydro water use planning where it 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 costs for a CPC/CBT facility. BC Hydro confirmed in a letter to Columbia Power Corporation of 20 October 2004 its commitment to implementing and abiding by the government policy directive and a May 2004 approval of indemnity issued by the Minister of Finance. Subsequent to receiving this BC Hydro letter of commitment, Columbia Power Corporation, on behalf of Columbia Power Corporation and the CPC/CBT power project joint venture companies, and Columbia Basin Trust each issued letters to BC Hydro stating that, relying on the government policy directive and BC Hydro's letter of commitment, they were now willing to remove their objections to recommendations of the Consultative Committee for the Columbia River Water Use Plan (Refer to Appendix G: Correspondence related to the Columbia Power Corporation and the Columbia Basin Trust).

8 SUMMARY OF CONSULTATIVE COMMITTEE RECOMMENDATIONS

8.1 INTRODUCTION

Following the final trade-off analysis at the June 2004 Consultative Committee meeting, the Committee reached consensus on a package of recommended operating and non-operating alternatives, a monitoring program and review period for BC Hydro's Columbia River Water Use Plan.

The Consultative Committee did not accept all of the proposals put forward for physical works, as it was recognized that they did not meet the criteria of water use planning, and therefore could not be recommended as part of the Columbia River Water Use Plan. However, in recognition of their importance to the region, the Committee recommended that BC Hydro and other parties consider funding these activities independently of the Water Use Plan. These proposals took the form of non-Water Use Plan recommendations.

8.2 WATER USE PLAN RECOMMENDATIONS

To ensure meaningful decision making for the Columbia River water use planning process, relevant information was gathered as part of Step 5 of the process to help refine estimates of flow-related impacts. In several cases, however, the process did not have adequate resources to fully scope specific water use issues. Some of these data gaps were significant given the large geographic scope of the project and complexity of issues, and the time period and funds allocated for the water use planning process. This resulting uncertainty precluded some issues from being effectively addressed through the process.

Two strategies were developed to address critical uncertainties and ensure that better information would be available for future decision making.

- Information Plans
- Management Plans

Information Plans are a strategy developed to collect information in a timely manner to address critical areas of remaining uncertainties and data gaps related to key Consultative Committee interests. The Technical Subcommittees proposed these plans either when there were no quantitative data available to make informed decisions, or when existing data demonstrated a need for further study. The goal of each plan is to provide sufficient information for decision making around possible operational and non-operational physical works during the next Columbia River Water Use Plan review.

Management Plans use an adaptive approach to investigating operational and non-operational changes by integrating studies and effectiveness monitoring. The goals of the plans are to collect sufficient information to responsibly implement the operational change and physical works to address impacts (implementation projects), and subsequently monitor their effectiveness before the next Columbia River Water Use Plan review (effectiveness monitoring). Each management plan has several components, including:

- Information collection to study impacts, identify and prioritize areas, and assess works or measures to be implemented (e.g., feasibility studies).
- Implementation of the physical works or operational changes to address key operational impacts.
- Effectiveness monitoring programs to audit the effectiveness of the physical works or mitigation.
- Interim technical reviews to assess the monitoring results and use the insights gained to improve the design and implementation of operational changes, physical works or other mitigation measures.

There are several cases where information collection and effectiveness monitoring programs overlap between Management Plans. The Consultative Committee recognized that there could be cost efficiencies if multiple plans are approved.

The following section summarizes the Information and Management Plans that were recommended by the Consultative Committee. Estimated costs for the operational changes and non-operational physical works and associated monitoring are presented as real dollars. Note: The costs of all proposals presented to the Consultative Committee were provided in real dollars, as well as annualized costs levelized over a 15-year period during the final trade-off analysis. The 15-year levelized annual costs were used in the trade-off discussions to ensure that the Committee was making balanced comparisons when considering the cost effectiveness of the non-operating alternatives relative to the operating alternatives, and to allow more direct comparisons to be made across plans. The annualized costs are, therefore, not repeated in this summary section.

The Consultative Committee recognized that some elements of the recommended Management Plans could not be considered by the Comptroller of Water Rights for inclusion in BC Hydro's Water Licences for the Columbia River facilities. BC Hydro acknowledged that these issues were important to the Committee, and committed to considering these recommendations when making water management decisions. These include the following.

- Arrow Lakes Reservoir Operations Management Plan – Implement soft constraints on operation of Arrow Lakes Reservoir.

- Kinbasket and Arrow Lakes Reservoir Debris Management Plan – Propose mitigation and/or compensation measures for impacts associated with reservoir surcharge.
- Lower Columbia Fish Management Plan – Implement the Hugh Keenleyside fish stranding protocol and interim ramping rate criteria. Pursue annual negotiations with the U.S. Entity for lower Columbia River rainbow trout flows and mountain whitefish flows.

8.2.1 Fish and Wildlife Information Plan

An obstacle to making recommendations around operational changes or physical works in lieu of operational changes for Kinbasket Reservoir was the lack of quantitative data for fish and wildlife populations. The Consultative Committee acknowledged the importance of better understanding reservoir ecology and the influence of current operations as an outcome of the water use planning process.

The Consultative Committee supported the Fish and Wildlife Information Collection Plan as summarized in Table 8-1.

Table 8-1: Fish and Wildlife Information Plan for Kinbasket Reservoir

Study	Year	Estimated Annual Cost
Mica Dam Total Gas Pressure (TGP) Monitoring and Abatement Program	Years 1–5	$20,000
Kinbasket and Revelstoke Reservoirs Kokanee Population Monitoring	Years 1–15	$50,000
Kinbasket and Revelstoke Reservoirs Ecological Productivity Monitoring	Years 1–15	$200,000
Kinbasket Reservoir Fish Stranding Surveys	Years 1–2	$50,000
Kinbasket Reservoir Burbot Life History and Habitat Use Assessment	Years 1–3	$100,000
Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment	Years 1–3	$100,000
Kinbasket Reservoir Rainbow Trout Life History and Habitat Use Assessment	Years 1–3	$100,000
Kinbasket Reservoir Sturgeon Inventory and Habitat Use Assessment	Years 1–3	$125,000
Kinbasket Reservoir Monitoring and Stabilization of Peatland near Valemount	Years 1–2	$5,000 (Year 1) $50,000 (Year 2)

8.2.2 Revegetation Management Plan

8.2.2.1 Implementation Project

The Consultative Committee supported reservoir-wide planting programs compatible with both the current operating regime and proposed operating alternatives to maximize vegetation growth in the drawdown zones of Kinbasket and Arrow Lakes reservoirs. The Committee agreed to a maximum funding cap of about $4.1 million over five years, and set out principles by which the planting programs should be implemented.

- Revegetation will be undertaken only in areas that have a good potential to become self-sustaining in five years.
- Any revegetation activity must be done in a manner that is respectful of existing First Nation archaeological sites.
- Revegetation efforts are to be directed on Arrow Lakes Reservoir above elevation 434 m (1424 ft). Areas below this elevation are still to be addressed as required by the BC Hydro dust control program.
- Above Arrow Lakes Reservoir elevation 434 m (1424 ft), planting efforts to address erosion and dust control issues are a high priority.
- Planting will not occur where efforts will be disrupted by or interfere with other forms of public use. This will require consultation with local stakeholders.

The revegetation program is a multi-year program requiring intervention over five years to facilitate long-term vegetative cover. Table 8-2 summarizes the schedule and preliminary cost estimates for revegetation efforts in Kinbasket and Arrow Lakes reservoirs, and Revelstoke Reach.

Table 8-2: Revegetation Management Plan Implementation Project

Location	Year	Estimated Cost (over 5 years)
Kinbasket Reservoir	Years 1–5	$2.0 million
Mid Columbia River	Years 1–5	$600,000
Arrow Lakes Reservoir	Years 1–5	$1.5 million
Total Cost		**$4.1 million**

The areas proposed to be vegetated are considered preliminary, and will be refined once a digital elevation map (DEM) is completed to assist in prioritizing treatment areas. Development of a final revegetation program will require public consultation to ensure that the plan is not in conflict with other land uses (e.g., motorized and non-motorized recreation, beach areas). Specifically, it will require co-ordination and integration of information collected through BC Hydro's Arrow Lakes Reservoir Drawdown Management Plan. Further, it will require that planting prescriptions are compatible with First Nation archaeological site protection requirements. Development of specific treatments and selection of planting mechanisms will need to be linked with information gained through the archaeological inventory to ensure that existing sites or areas considered to have a high potential for the presence of archaeological information are adequately protected.

8.2.2.2 Monitoring Program

The Consultative Committee recommended a number of studies to inventory vegetation resources, and monitor the effectiveness of planting efforts on vegetation communities and wildlife habitat use, as outlined below in Table 8-3.

Table 8-3: Revegetation Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Kinbasket Reservoir Monitoring of Revegetation Efforts	Years 1–5, 10	$50,000
Kinbasket Reservoir Inventory of Vegetation Resources	Years 1–5, 10	$150,000 (Year 1) $100,000 (Years 2–5 and 10)
Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works	Years 1–2, 4, 6, 8, 10, 12	$250,000 (2 years baseline followed by monitoring every other year over 10 years)
Arrow Lakes Reservoir Monitoring of Revegetation Efforts	Years 1–5, 10	$25,000 (Years 1–4) $50,000 (Years 5 and 10)
Mid Columbia Monitoring of Mosquito Distribution in Revelstoke Area	1	$15,000
Mid Columbia Monitoring of Mosquito Populations	1	$15,000
Mid Columbia Monitoring and Management of Potential West Nile Virus Hotspots	1	$25,000
Mid Columbia Monitoring of Effects of Hydrologic Regime on Mosquito Production	**Study costs included under the monitoring program for Arrow Lakes Reservoir operations**	
Arrow Lakes Reservoir Inventory of Vegetation Resources		
Arrow Lakes Reservoir Aerial Photographs		
Arrow Lakes Reservoir Complete Digital Elevation Model		

8.2.3 Recreation Management Plan

8.2.3.1 Implementation Projects

The Consultative Committee recognized that addressing recreational issues on Kinbasket and Arrow Lakes reservoirs through operational changes was not cost effective. Moreover, it would divert the process away from focusing on areas where operational changes showed the greatest chance of providing cost-effective benefits. During their final June 2004 meeting, the Committee supported non-operational means to address recreation interests around Kinbasket Reservoir and mitigate the effects of low water impacts on Arrow Lakes Reservoir. The Committee recommended the following implementation projects as part of the Recreation Management Plan.

- Kinbasket/Arrow Lakes Reservoirs and Lower Columbia Boat Access Improvement.
- Kinbasket and Arrow Lakes Reservoir Debris Management.
- Lower Columbia River Debris Management.

A. Kinbasket/Arrow Lakes Reservoir and Lower Columbia Boat Access Improvement Project

As discussed in Section 7.6.3, 15 boat access/ramp proposals for Kinbasket Reservoir, the mid Columbia River and Arrow Lakes Reservoir were presented to the Consultative Committee for their consideration. During the trade-off discussions, the Committee accepted 10 of the proposals (refer to Table 8-4) conditional on the Comptroller of Water Rights confirming that each project meets the criteria for Water Use Plans (i.e., new points of access are within the scope of water use planning, and there is a demonstrated operational link to the project). Acceptance of these works was also conditional on a feasibility study being undertaken to ensure that these works are undertaken in the most cost-effective manner, and that impacts on other interests (e.g., fish habitat, archaeological sites) are taken into consideration. It was acknowledged that BC Hydro would require an authorization or letter of advice from DFO prior to implementation of the boat ramp improvement projects. Provincial and federal regulatory review will be required prior to approval and re-designs may be required as a result of the review process.

A proposal to dredge sand from Indian Eddy to maintain boat access to the lower Columbia River was also discussed by the Consultative Committee. The Committee supported this works, pending completion of an engineering study to confirm the link between flow fluctuations from Hugh Keenleyside Dam, and sand erosion from Gyro Park beach and subsequent deposition downstream at Indian Eddy. If results of this study indicate that this is being caused by Hugh Keenleyside Dam operations, the Committee acknowledged that an environmental impact assessment would be required to gain the necessary approvals prior to undertaking the dredging project. It was acknowledged that the dredging program would require provincial and federal regulatory review prior to approval.

Table 8-4: Kinbasket/Arrow Lakes Reservoir and Lower Columbia Boat Access Project

Location	Action	Construction Costs
Kinbasket Reservoir		
Bulldog Creek	A new ramp from 2405 ft to 2375 ft.	$87,000 + $3,000 annual maintenance
Valemount Marina	Ramp is dry every year. Extend ramp from 2404 ft to 2395 ft.	$30,000 + $12,500 annual maintenance
Nixon Creek	Ramp is stranded 1 out of 6 years. Extend ramp from 2400 ft to 2340 ft.	$136,000 + $12,500 annual maintenance
Bush Harbour	Ramp is stranded once every 15 years. Extend ramp from 2410 ft to 2385 ft.	$46,290 + $12,500 annual maintenance

Table 8-4: Kinbasket/Arrow Lakes Reservoir and Lower Columbia Boat Access Project (cont'd)

Location	Action	Construction Costs
Mid Columbia River		
Revelstoke [1]	Low water poses hazardous launch conditions and exposed end of ramp.	If conditions are met, $200,000 capital cost to build boat ramp. + $12,500 annual maintenance If capital cost exceeds $200,000, wait until the 5-year review for potential additional funds. If no substitute site, $50,000 to upgrade existing ramp.
Arrow Lakes Reservoir		
Edgewood	Ramp stranded in 16 out of 60 years. Extend ramp from 1397 ft to 1390 ft. Cost estimate includes possible option of constructing a rock breakwater that would protect the ramp and beach, and provide vehicle access to a new deepwater launch site.	$868,000 + $12,500 annual maintenance
Fauquier	Boat ramp extension. Ramp stranded in 13 of 60 years.	$508,000 + $12,500 annual maintenance
Burton (new ramp)	Ramp for low water periods proposed (1420 ft to 1390 ft).	$350,000 + $12,500 annual maintenance
MacDonald Creek Park	Ramp strands in almost all years. Extend ramp from 1431 ft to 1427 ft.	$520,000 + $12,500 annual maintenance
Nakusp[2]	Current ramp of poor design, in poor repair. Build a new ramp adjacent to old ramp.	$1.4 million + $12,500 annual maintenance
Lower Columbia River		
Indian Eddy[3]	Sand deposited at Gyro Park beach eroding away at high flows and being deposited in Indian Eddy. Dredging required to maintain boat access to river.	$50,000 per dredging event every 3–5 years ($200,000)

[1] Subsequent to the final Consultative Committee meeting, the Comptroller of Water Rights assessed the boat access proposals and concluded that there is an operational link to the Revelstoke ramp. That is, fluctuations in flow from Revelstoke Dam impair access at this ramp; therefore there is an operational change that could be made to improve access. However, due to the swift moving and fluctuating nature in this section of the river, there are concerns regarding public safety. Therefore, a feasibility study is required to determine if access can be provided in the Revelstoke area in a safe manner. The results of this study will be considered and a recommendation with respect to a ramp put forward thereafter.

[2] The Water Comptroller reviewed the Nakusp boat ramp proposal, and concluded that the current ramp provides access at all Arrow Lakes Reservoir elevations. As the proposed physical works project is not in lieu of a change to operations, it does not fit within the scope of water use planning. Subsequent to this decision, BC Hydro committed, in a letter dated 2 November 2004 (Appendix GG: Correspondence from BC Hydro to Columbia Basin Trust and the Regional District of Central Kootenay), to discuss possible partnerships with local government, Columbia Basin Trust and others towards construction and maintenance of a new ramp at Nakusp.

[3] The Water Comptroller reviewed the proposal to dredge at the Indian Eddy boat ramp and concluded that there is currently insufficient information to determine whether these works fit within the scope of water use planning. Prior to making a recommendation with respect to its inclusion in the Columbia River Water Use Plan, further information would be required (i.e., mechanism causing transport of sediment from the Gyro Park Beach to Indian Eddy, extent of transport and deposition affected by Hugh Keenleyside Dam operations vs. Brilliant operations, and whether there is an operating alternative that could be implemented to prevent sediment transport if this can be attributed to Hugh Keenleyside Dam operations). If there is a possible operating alternative to reduce sediment transport, a physical works in lieu could be considered. It would need to be demonstrated that dredging is the best non-operational alternative to alleviate the problem.

B. Kinbasket and Arrow Lakes Reservoir Debris Management Project

The Consultative Committee supported a proposal for an ongoing debris management program on Kinbasket and Arrow Lakes reservoirs to address debris issues related to reservoir operations, provided that an environmental review be undertaken to ensure that impacts on other interests (e.g., fish and wildlife habitat, revegetation efforts, archaeological site protection) are addressed, and potential uses of debris for fish habitat and wetland habitat restoration are identified. It was acknowledged that the debris management program would require provincial and federal regulatory review prior to approval. The Committee's support was also conditional on the Comptroller of Water Rights accepting that the debris management plan is within the scope of the water use planning process.

The debris management plan consists of three elements, which provide the necessary flexibility around the level of response depending on the type of water year (refer to Table 8-5). In particular, it will allow BC Hydro to fund larger clean up efforts as needed when full pool events occur. The plan also provides the opportunity for stakeholder involvement in annual prioritization of the debris collection/removal activities for Kinbasket and Arrow Lakes reservoirs. The intent of the multi-interest group will be to develop site-specific targets and strategies for debris management on an annual basis

The Consultative Committee agreed to the debris management program as presented, acknowledging that on rare occasions, BC Hydro needs to surcharge the reservoirs for flood control under emergency situations. It was recommended by the Committee that BC Hydro avoid surcharging Kinbasket Reservoir if at all possible, and that funding/compensation be provided to address infrastructure damage and additional debris management activities in the event of surcharge.

The Consultative Committee agreed to a debris management project that sets specific budgets for annual shoreline debris removal in Kinbasket Reservoir ($100,000 per year) and Arrow Lakes Reservoir ($50,000 per year) in Years 1 to 5, with funds targeted as needed after this period. The Committee also agreed to a periodic floating debris removal program in Kinbasket Reservoir to be implemented immediately following a full pool event (at or above 2470 ft). Table 8-6 presents the annual estimated costs of the debris management programs for Kinbasket and Arrow Lakes reservoirs.

Table 8-5: Kinbasket and Arrow Lakes Reservoirs Debris Management Project

<table>
<tr><th>Program 1, 2, and 3</th><th colspan="3">Debris Field Survey and Debris Management Strategy, Kinbasket and Arrow Lakes Reservoirs</th></tr>
<tr><td>Scope</td><td colspan="3">1. Debris Management Study: A multi-interest group will develop strategies and targets for debris management activities on the Kinbasket and Arrow Lakes reservoirs. The intent is to identify site-specific targets and identified best practices.
2. Debris Field Survey: A comprehensive inventory of existing debris fields and sources of current new recruitment will be undertaken on each system. Presently, it is assumed that the source of the debris fields come from:
• Standing timber submerged during impoundment.
• New recruitment of timber and debris from the foreshore associated with avalanches and timber harvesting activities.
• New recruitment of timber and debris from the mainstem and tributary systems.
At the completion of the survey, it is expected that the rate of contribution from these sources will be quantified, and an estimate made of the quantity of existing debris. These data will assist in estimating realistic management costs associated with ongoing debris maintenance and/or removal and the relative responsibility of different parties to the ongoing problems. This survey will also be of value in prioritising annual collection and removal efforts on the two systems.
3. Annual Activity Reporting: Report annually to interested stakeholders pre and post annual debris removal, including location, expenditure and monitoring and target updates.</td></tr>
<tr><td>Budget and Schedule</td><td>1. Debris Targets and Management Strategy</td><td>Year 1</td><td>$20,000</td></tr>
<tr><td></td><td>2. Distribution and Amount Inventory ($20,000/per biannually)</td><td>Years 1, 3–15</td><td>$160,000</td></tr>
<tr><td></td><td>3. Annual Reporting ($5,000 per year)</td><td>Years 2–15</td><td>$70,000</td></tr>
<tr><td></td><td>Total Cost</td><td></td><td>$250,000</td></tr>
</table>

<table>
<tr><th>Program 4</th><th colspan="3">Targeted Annual Shoreline Debris Removal, Kinbasket and Arrow Lakes Reservoirs</th></tr>
<tr><td>Scope</td><td colspan="3">This work supports the recreation access projects by targeting debris removal at key locations where boat ramps are being extended or built, or of high visual importance. This should significantly improve the functionality and quality of recreation on the Kinbasket and Arrow Lakes reservoirs.
Once debris is collected, it would either be 1) piled and burned, 2) removed and salvaged, or 3) barged or boomed to another beach for burning or salvage.
The Debris Removal Project will not replace any existing debris management that BC Hydro undertakes in support of dam safety and facility maintenance. This project will expand the scope of debris removal to include non-power interests.</td></tr>
<tr><td>Budget and Schedule</td><td colspan="3">The duration and number of sites targeted for debris removal depends on the results of the Debris Field Survey and Management Strategy. Previous estimates have suggested an annual program of up to $150,000 for the first five years, with up to $100,000 allocated to Kinbasket Reservoir and up to $50,000 allocated to Arrow Lakes Reservoir. If the debris targets are met in the future, the costs could be considerably less.</td></tr>
<tr><td></td><td>• Debris Collection and Burning</td><td>Years 1–15</td><td>$1,500,000</td></tr>
<tr><td></td><td>Total Cost</td><td></td><td>$1,500,000</td></tr>
</table>

Table 8-5: Kinbasket and Arrow Lakes Reservoirs Debris Management Project (cont'd)

Program 5	**Periodic Floating Debris Removal, Kinbasket Reservoir**		
Scope	This work supports recreation interests by activating a Kinbasket Reservoir floating debris removal program immediately following a full pool event (at or above 2470 ft). Expected on an infrequent basis, the funding estimate is expected to be made available on an as needed basis reflecting a return period of approximately five per cent of years across the operating alternatives, or approximately 1:20 years. Note that while this is an average return period, this event can occur in adjacent years, although the second year debris program will likely be less intensive, as the between-year accumulation will be minimal. Once debris is collected, it would either be 1) piled and burned, 2) removed and salvaged, or 3) barged or boomed to another beach for burning or salvage. The Debris Removal Project will not replace any existing debris management that BC Hydro undertakes in support of dam safety. This project will expand the scope of debris removal to include non-power interests.		
Budget and Schedule	The periodic debris removal effort is expected to require an infrequent but higher level of effort than the annual program. The frequency is dependent upon high reservoir levels.		
	• Periodic Floating Debris Removal ($200,000/year)	Years 1, 10	$400,000
	Total Cost		**$400,000**

Table 8-6: Annual Estimated Costs of the Kinbasket and Arrow Lakes Reservoirs Debris Management Project

Year		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Debris Strategy		20														
Bi-annual Inventory		20		20		20		20		20		20		20		20
Annual Reporting			5	5	5	5	5	5	5	5	5	5	5	5	5	5
Shoreline Debris Removal		150	150	150	150	150	75	75	75	75	75	75	75	75	75	75
Floating Debris Removal		200									200					
Total Annual Cost	**$**	390	155	175	155	175	80	100	80	100	280	100	80	100	80	100

C. Lower Columbia River Debris Management Project

During the final June 2004 meeting, the Consultative Committee discussed the need for debris management in the lower Columbia River. It was noted that, at present, there is no management program being undertaken in this section of river. The City of Trail currently budgets about $2,000 each year to remove debris that accumulates in Indian Eddy. This is required to maintain access to the river for emergency boats.

The Consultative Committee supported an annual expenditure of $2,000 for debris removal at Indian Eddy, subject to an environmental review and acceptance by the Comptroller of Water Rights that it fits within the scope of water use planning (Table 8-7).

Table 8-7: Annual Estimated Costs of the Lower Columbia River Debris Management Project

Program	Debris Removal at the Indian Eddy Boat Launch Site		
Scope	This work is required to maintain access at the launch		
Budget and Schedule	Debris removal from Indian Eddy is expected to be required on an annual basis.		
	• Debris Removal ($2,000/year)	Years 1–15	$30,000
	Total Cost		**$30,000**

8.2.3.2 Monitoring Program

Table 8-8 summarizes the studies recommended by the Consultative Committee in support of the Recreation Management Plan.

Table 8-8: Recreation Management Plan Monitoring Program

Study	Year	Estimated Cost
Engineering Study in Support of Dredging at Indian Eddy	Year 1	$5,000[1]
Environmental Assessment of Dredging at Indian Eddy	Year 1	$50,000[1]
Environmental Review of Debris Removal in Kinbasket and Arrow Lakes Reservoirs/Assessment of Potential Uses	Year 1	$50,000[1]
Environmental Review of Debris Removal from Indian Eddy	Year 1	$25,000[1]
Feasibility Study of Boat Ramps (new/upgrades)	Years 1–2	$135,000[1, 2]
Boat Ramp Use Study	Years 1–15	$20,000 (Year 1) $10,000 (Years 2–15)

1 Cost estimates for these studies were developed subsequent to the final Consultative Committee meeting based on recommendations of the Committee. These costs were not considered by the Committee.

2 Cost estimate includes the $50,000 for assessing the feasibility of the Revelstoke Reservoir boat ramp.

8.2.4 Heritage Management Plan

The Consultative Committee agreed that revegetation of the drawdown zone would provide protection (i.e., stabilization of soils, cover to conceal sites from pothunters) of archaeological sites around Kinbasket and Arrow Lakes reservoirs. However, the Committee also supported a management plan specifically aimed at reducing operational impacts to sites in Kinbasket, Revelstoke and Arrow Lakes reservoirs. The management program puts forward a strategy to addressing the four known archaeological sites in Arrow Lakes Reservoir from Years 1 to 5, and building on the knowledge from the first four interventions and data collected from Kinbasket, Revelstoke and Arrow Lakes reservoirs to address the remaining, as yet undiscovered sites (Table 8-9). It was acknowledged that the archaeological site protection plans would require provincial and federal regulatory review prior to approval.

While the Consultative Committee supported all elements of the Heritage Management Plan, there were some reservations expressed about the open-endedness of Program 2 directed at yet to be discovered archaeological sites.

Table 8-9: Annual Estimated Costs of Archaeological Site Mitigation

Program 1	Arrow Lakes Reservoir Plan for Actively Eroding Archaeological Sites (Years 1 to 5)		
Scope	• Develop an archaeological management strategy with First Nation community participation for the four known sites. • Determine the importance of the four archaeological sites, and design and implement intervention at these sites. • Monitor the impact of wave and wind erosion on scarp stability. • Effectiveness monitoring at the four archaeological sites.		
Budget and Schedule	• Full remediation of 4 known sites ($220,000/site)	Years 1–5	$880,000
	Total Cost		**$880,000**

* Costs of site remediation are mid level estimates, and could include interventions such as hand planting vegetation, geotextile wrapping or excavation.

Program 2	Addressing Impacts on Yet-To-Be-Discovered Archaeological Sites		
Scope	Archaeological site protection is to be implemented once a full inventory is complete, the management plan is in place, and all of the sites have been prioritized (i.e., no later than Year 6). **Years 1 to 5** • Stratified archaeological inventory for Kinbasket and Revelstoke reservoirs. • Complete archaeological inventory for Arrow Lakes Reservoir. **Years 6 to 10** • Exploratory excavations to determine archaeological importance of newly discovered sites. • Develop management strategy around newly discovered archaeological sites with First Nation participation. • Mitigation at newly discovered archaeological sites (20 to 50 sites). • Effectiveness monitoring at new archaeological sites.		
Budget and Schedule	• Protection of as yet undiscovered sites ($220,000/site)	Years 6–10	$11 million*
	Total Cost		**$11 million**

* Cost estimate based on assumption that 50 sites will be discovered in Kinbasket, Revelstoke and Arrow Lakes reservoirs during the archaeological inventories. First Nations do not view this as a maximum cap on the cost of the program as there may be more than 50 additional sites discovered through the inventory work.

8.2.4.1 Monitoring Program

Inventory and excavation work will be required to determine the number of actively eroding archaeological sites in the Kinbasket and Arrow Lakes reservoirs, their importance in terms of quantity of intact archaeological materials, and First Nation preferences around intervention at these sites (refer to Table 8-10). The depth of the archaeological information and dynamics of the modification processes will determine the best approach to protecting these archaeological sites.

The Consultative Committee recognized the importance of sequencing and co-ordination between the archaeological site inventories and implementation of the Revegetation and Recreation Management plans. The intent is that the revegetation strategy and boat access project will be integrated with the archaeological site plan to ensure that these activities are compatible with site protection needs.

Table 8-10: Heritage Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Program 1		
Arrow Lakes Reservoir – Development of a management strategy for the four known archaeological sites	Years 1–2	$10,000
Arrow Lakes Reservoir – Monitor wave and wind impacts on scarp stability	Years 1–5	$33,000
Arrow Lakes Reservoir – Effectiveness monitoring at sites of active intervention	Years 1–5	$6,000/site to establish transects $3,000/site per year data collection, done intermittently
Program 2		
Kinbasket and Revelstoke Reservoirs – Archaeological Site Survey and Inventory	Years 1–3	$35,000 (in total)
Arrow Lakes Reservoir – Archaeological Site Survey and Inventory	Years 1–3	$75,000 (in total)
Kinbasket and Arrow Lakes Reservoirs – Exploratory Excavations and Monitoring	Years 6–8	$90,000 (in total)
Effectiveness Monitoring of Active Intervention at Newly Discovered Archaeological Sites	Years 5–10	$90,000 (Years 6–8 for excavation) $12,000 (3 years of monitoring)
Kinbasket, Revelstoke, and Arrow Lakes Reservoirs – Multi-Year Management Strategy to Address Access to and Monitoring of Significant Sites	Years 5–7	$10,000

8.2.5 Revelstoke Flow Management Plan

8.2.5.1 Implementation Project

The Consultative Committee supported a 5 kcfs year-round minimum flow constraint at Revelstoke Dam to meet the fish objectives for the mid Columbia River (refer to Table 8-11). It was recommended that the minimum flow be implemented two years after implementation of the Columbia River Water Use Plan to allow for collection of baseline data.

The Consultative Committee recognized that forced outages due to extreme or emergency situations might cause the minimum flow to be temporarily disrupted. The Committee accepted that deviations from the minimum flow could occur under these extreme circumstances.

Table 8-11: Annual Estimated Costs of the Revelstoke Flow Management Plan

Program	Minimum Flow Constraint		
Scope	Provide a 5 kcfs year-round minimum flow to the mid Columbia River		
Budget and Schedule	• Minimum flow (average $3 million/year)	Years 3–15	$39 million
	Total Cost		**$39 million**

8.2.5.2 Monitoring Program

The Consultative Committee supported a number of study proposals to monitor the effectiveness of the minimum flow (refer to Table 8-12). While it was noted that the cost of the Revelstoke monitoring program was high relative to other management plans, the Committee recognized the uncertainties that exist around the benefits of a 5 kcfs minimum flow to fish populations and the need to assess its effectiveness for future decision making.

Table 8-12: Revelstoke Flow Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Mid Columbia River Physical Habitat Monitoring	Years 1–15	$40,000
Mid Columbia River Ecological Productivity Monitoring	Years 1–15	$125,000
Mid Columbia River Fish Population Index Surveys	Years 1–15	$150,000
Mid Columbia River Juvenile Fish Habitat Use	Years 1–5	$70,000
Mid Columbia River Adult Habitat Use Assessment	Years 1–5	$150,000

8.2.6 Mid Columbia River White Sturgeon Management Plan

8.2.6.1 Implementation Project

The Consultative Committee supported a 4-phase workplan aimed at better understanding juvenile white sturgeon habitat capabilities in the mid Columbia River, and building a self-sustaining population in Arrow Lakes Reservoir through flow treatments and conservation aquaculture (refer to Table 8-13).

The experimental workplan is designed specifically to allow the necessary flexibility in annual fund allocations for research, experimental treatments and monitoring to ensure that the program is responsive to future learnings and related changes in priorities. This will be facilitated through comprehensive reviews at the end of each phase of the program, and an option to discontinue flow tests in the mid Columbia River (if monitoring supports this decision) and direct all or part of the conservation aquaculture effort in Kinbasket Reservoir (refer to Appendix FF: Development of the Mid Columbia River White Sturgeon Experimental Plan for more details on the decision structure and workplan).

If it were conclusively demonstrated that wild reproduction is not possible within Arrow Lakes Reservoir, the workplan could follow one of three possible directions.

1. Initiate a conservation aquaculture program for development of an Arrow Lakes Reservoir failsafe population.
2. Develop a self-sustaining (in the long term) population in a Kinbasket Reservoir/upper Columbia River recovery area.
3. Initiate a conservation aquaculture program for development of a Kinbasket Reservoir failsafe (non-reproducing) population.

It is unlikely, within the term of the Columbia River Water Use Plan, that a determination could be made around whether spawning and early lifestage survival is possible within the Kinbasket Reservoir/upper Columbia River area. Therefore, the conservation aquaculture strategy will have to be robust enough to determine whether (I) wild production is possible, or (ii) wild production is not possible over the 10 year program. It should be possible to determine within the term of this Water Use Plan whether recovery efforts should be made in either Arrow Lakes or Kinbasket reservoirs, or both.

Given that the mid Columbia River white sturgeon experimental workplan is both substantial and complex, the Consultative Committee also supported an annual budget of $115,000 to enable co-ordination of all elements of the program supported by the Columbia River Water Use Plan.

Table 8-13: Mid Columbia River White Sturgeon Experimental Workplan

Option A	**Develop Self-sustaining Population in Arrow Lakes Reservoir**		
Flow Treatment	Flow treatments as a possible means of improving spawning condition and performance, and the survival of naturally spawned individuals during the egg and larval stages. Selection of minimum flow treatment based on feasibility of using underwater videography as a means of detecting potential spawners. If videography trials successful: • 30 kcfs (4 weeks in August) in years when probable spawning detected up to $5 million cap over 10 years. If videography not feasible: • 15 kcfs (8 weeks in July to August) every year, or • 24 kcfs (4 weeks in August) every year. (The maximum attainable minimum flows within the $5 million cap plus the 5 kcfs Revelstoke minimum flow.) [1]		
Arrow Lakes Reservoir Experimental Aquaculture	Experimental release of juveniles and yearlings near Revelstoke to determine the suitability of juvenile rearing habitat in the mid Columbia River, and assess the effectiveness of flow treatments on larval and juvenile survival over the short term.		
Arrow Lakes Reservoir Conservation Aquaculture	Conservation aquaculture implemented if wild production is detected. This program would help to support the population until such a time as stock abundance and age structure and habitat conditions can support a self-sustaining population. It would also address residual impacts of providing lower than optimal spawning, incubation and rearing flows.		
Budget and Schedule	1. Flow Treatment	Years 3–10	$5,000,000
	2. Experimental Aquaculture ($370,000/year)	Years 2–4	$1,110,000
	3. Arrow Lakes Reservoir Conservation Aquaculture ($370,000/year)	Years 6–10	$1,850,000
	One-time cost for Hatchery Facility Upgrade[2]	Year 6	$500,000
	4. Program Co-ordination ($115,000/year)	Years 1–10	$1,150,000
	Total Cost		**$9,610,000**

Table 8-13: Mid Columbia River White Sturgeon Experimental Workplan (cont'd)

Option B	**Develop Failsafe Population in Kinbasket and/or Arrow Lakes Reservoirs or Self-sustaining Population in Kinbasket Reservoir**		
Kinbasket and Arrow Lakes Reservoirs Conservation Aquaculture	If no wild production and no egg and larval benefit conclusively demonstrated, discontinue flow treatment and initiate conservation aquaculture program for Kinbasket and/or Arrow Lakes reservoirs failsafe population(s), or Kinbasket Reservoir recovery area. A decision to go to Option B could be made as early as end of Year 5 or as late as end of Year 8, depending on results of monitoring.		
Budget and Schedule[3]	1. Flow Treatment ($500,000/year)	Years 3–8	$3,000,000
	2. Experimental Aquaculture ($370,000/year)	Years 2–4	$1,110,000
	3. Arrow Lakes Reservoir Conservation Aquaculture ($370,000/year)	Years 6–8	$1,110,000
	One-time cost for Hatchery Facility Upgrade	Year 6	$500,000
	4. Arrow Lakes/Kinbasket Reservoirs Conservation Aquaculture ($370,000/year)	Years 9–10	$740,000
	5. Program Co-ordination ($115,000/year)	Years 1–10	$1,150,000
	Total Cost		**$7,610,000**

1 These minimum flows include the 5 kcfs year-round minimum flow agreed to by the Consultative Committee for Revelstoke Dam. Flows of 10 kcfs (July–August) and 19 kcfs (August) are estimates of what could be achievable (on average) within the $5 million, 10-year ceiling agreed to by the Committee.

2 Estimated costs of conservation aquaculture have assumed upgrade of existing facilities at the Kootenay Hatchery. Costs could be reduced, depending on the outcome of proposed hatchery developments in the United States, which might be used to support a portion of the culture requirements for releases downstream of Hugh Keenleyside Dam.

3 As a worst-case, estimated costs assume flow treatments and conservation aquaculture in the mid Columbia River continue until end of Year 8 before a decision is made to discontinue and go to Option B (although this decision could be made as early as end of Year 5).

8.2.6.2 Monitoring Program

The Consultative Committee supported a number of research and monitoring studies integral to supporting decision making around flow treatments and hatchery supplementation in the mid Columbia River. Table 8-14 summarizes the monitoring program for the Mid Columbia River White Sturgeon Management Plan.

Table 8-14: Mid Columbia River White Sturgeon Management Plan Monitoring Program

Study	Years	Estimated Annual Cost
Option A		
Mid Columbia River – White Sturgeon Spawning Habitat Assessment	Years 1–2	$80,000
Mid Columbia River – Juvenile Sturgeon Detection and Habitat Use Program	Years 1–10	$125,000
Mid Columbia River – Tracking of existing sonic tagged sturgeon[1]	Years 1–2	$55,000
Mid Columbia River – Sturgeon Egg Substrate Mat Monitoring and Underwater Videography Feasibility Study	Years 1–10	$80,000 (Years 1–2) (egg mat monitoring) + $55,000 (videography feasibility) $30,000 to $80,000 (Years 3–10) (depending on use of egg monitoring or videography to detect spawning)
Mid Columbia River – Sturgeon Genetic Assessment[2]	Year 1	$30,000
Kinbasket Reservoir – Sturgeon Recolonization Risk Assessment and Habitat Suitability Study	Years 3–5	$50,000
Mid Columbia River – Sturgeon Incubation and Rearing Study	Years 1–2	$90,000
Mid Columbia River – Temperature and TGP Monitoring during periods of normal and experimental flow treatment operations	**Study included in scope of physical habitat monitoring associated with Revelstoke Dam Minimum Flow**	
Option B – If decision is made to go to Option B, the following additions and modifications would be made to the monitoring program		
Mid Columbia River – Juvenile Sturgeon Detection and Habitat Use Program	Years 1–8	$125,000
Mid Columbia River – Sturgeon Egg Substrate Mat Monitoring and Underwater Videography Feasibility Study	Years 1–8	$80,000+ $55,000 (Years 1–2) $30,000 to $80,000 (Years 3–8)
Kinbasket Reservoir – Juvenile Sturgeon Detection and Habitat Use Program	Years 8–10	$125,000

1 Represents continuation of existing tracking program

2 Genetic assessment currently underway; expected completion in spring 2004. However, inconclusive results may require additional sampling and/or lab work. Assumed one additional year for completion under the Columbia River Water Use Plan.

8.2.7 Arrow Lakes Reservoir Operations Management Plan

8.2.7.1 Implementation Project

With the Non-Treaty Storage Agreement expiring in June 2004 and negotiations with the U.S. having failed to produce a replacement agreement, the Consultative Committee was presented with a modification as to how the Columbia River water use planning process must consider the Arrow Lakes Reservoir alternatives. While several options for completing the Columbia River Water Use Plan were discussed by the Committee (refer to Section 7.6.2), consensus agreement was reached around developing soft constraints for Arrow Lakes Reservoir to meet the interests and stated objectives of the Committee.

In supporting soft constraints for Arrow Lakes Reservoir, the Consultative Committee recommended a 5-year review period upon initiation of the Water Use Plan to evaluate the effectiveness of the soft constraints, report out on the results of the concluded NTSA discussions, and determine whether there is a need to review Arrow Lakes Reservoir operations.

The Consultative Committee agreed that there are a number of conflicting interests and the degree to which they occur will vary by water year. The Committee acknowledged that BC Hydro would need to balance these trade-offs internally by choosing its water management strategy. This balance would be informed by the expressed values of the Committee members, the performance measures calculated to date, the efficacy of the physical works, and the evolution of knowledge arising from the monitoring programs to guide operational decisions.

Table 8-15 summarizes soft constraints for Arrow Lakes Reservoir.

Table 8-15: Soft Constraints for Arrow Lakes Reservoir

Interest	Constraint
Vegetation	• Maintain current level of vegetation in the drawdown zone through maintaining lower reservoir water levels during the growing season. No specific operating targets were identified to meet this general objective. • If vegetation is showing signs of stress as a result of inundation during the early part of the growing season (May-July), target lower reservoir levels in the fall to allow exposure of plants during the latter part of the growing season. • Preservation of current levels of vegetation at and above elevation 434 m (1424 ft) is considered a priority.
Wildlife	• Ensure that inundation of nesting bird habitat by rising reservoir water levels in early summer is no worse than that which occurred on average over recent history (1984-1999). Match operating levels to inundation statistics for elevations 434 m (1424 ft) and above over the 1984-1999 period, which were used to produce the average historic performance measure score for spring/summer nesting short-eared owl habitat. • Ensure that availability of migratory bird habitat in the fall is as good or better than that which has been provided on average over recent history (1984-1999). Draft the reservoir quickly after full pool is reached, targetting a reservoir level of 438 m (1437 ft) or lower by 7 August.
Fish	• Ensure appropriate reservoir elevations for tributary access during the kokanee spawning period (late August to early November). Reservoir levels of 434 m (1424 ft) could cause tributary access to be restricted in some streams under certain conditions. Proposed monitoring study aimed at determining reservoir level thresholds under a range of tributary streamflow conditions below which spawner access becomes a problem.
Recreation	• Target reservoir water levels between 437.4 m and 438.9 m (1435.0 ft and 1440.0 ft) from 24 May to 30 September. • Flexibility to achieve lower reservoir levels of 434 m (1424 ft) during the recreation season would be acceptable with proposed construction/upgrade of boat ramps for recreation interests served by these formal access points.
Culture and Heritage	• Maintain reservoir water levels at or below 436 m (1430 ft) for as long as possible. • First Nations willing to accept water levels above this 20 per cent of the time (or for 2.5 months) provided that it is timed in accordance with the vegetation efforts. First Nations would be willing to relax this constraint if the archaeological site protection plan is underway.
Erosion	• Minimize duration of full pool events. Reservoir water levels of 439 m (1440 ft) are ideal. • Avoid sudden drawdown once full pool has been reached (particularly if high runoff has saturated the reservoir banks) to avoid slumping of the shores.
Power Generation	• Optimize power values.

8.2.7.2 Monitoring Program

In accepting a package of soft operational constraints for Arrow Lakes Reservoir, the Consultative Committee recommended a data collection plan to evaluate its performance in meeting the stated objectives for the reservoir. Table 8-16 summarizes the monitoring program for the Arrow Lakes Reservoir Operations Management Plan.

Table 8-16: Arrow Lakes Reservoir Operations Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Arrow Lakes Reservoir – Burbot Life History and Habitat Use Assessment	Years 1–5	$100,000
Arrow Lakes Reservoir – Tributary Fish Migration Access Assessment and Monitoring*	Years 1–12	$24,000
Arrow Lakes Reservoir – Complete Digital Elevation Model (including 1:10,000 black and white aerial photography)	Year 1	$280,000
Arrow Lakes Reservoir – 1:50,000 Colour Aerial Photography for Baseline Vegetation Mapping	Years 1–5 and 10	$35,000
Arrow Lakes Reservoir – Inventory of Vegetation Resources	Years 1–5 and 10	$125,000 (Year 1) $100,000 (Years 2–5 and 10)
Arrow Lakes Reservoir – Vegetation Composition and Analysis	Years 1–5 and 10	$100,000 (Years 1, 5 and 10) $50,000 (Years 2–4)
Arrow Lakes Reservoir – Plant Response to Timing and Duration of Inundation	Years 1–5	$25,000 (Years 1–4) $50,000 (Year 5)
Kinbasket and Arrow Lakes Reservoirs – Nest Mortality of Migratory Birds due to Reservoir Operations	Years 1–10	$300,000
Kinbasket and Arrow Lakes Reservoirs – Amphibian and Reptile Life History and Habitat Use Assessment	Years 1–5	$75,000
Arrow Lakes Reservoir – Fall Migrating Shorebird Use of the Drawdown Zone	Years 1–10	$125,000
Arrow Lakes Reservoir – Neotropical Migrant Use of the Drawdown Zone	Years 1–10	$80,000
Arrow Lakes Reservoir – Waterbird Monitoring	Years 1–10	$20,000
Arrow Lakes Reservoir – Monitoring of effects of hydrologic regime on mosquito production	Year 1	$20,000
Arrow Lakes Reservoir – Recreation Demand Study	Years 1–5	$24,000 (Years 1 and 5) $85,000 (Years 2–4)

* In response to concerns expressed during the final Consultative Committee, the Fish Technical Subcommittee met on 5 November 2004 to discuss the need for a study to assess the impact of low reservoir elevations on fish access to spawning tributaries.

8.2.8 Arrow Lakes Reservoir Wildlife Management Plan

8.2.8.1 Implementation Project

The Consultative Committee supported implementation of wildlife physical works in the mid Columbia River. The Committee agreed to a maximum annual budget, which was based on a third party assuming responsibility for construction, maintenance and liability of these works. If a Memorandum of Understanding (MOU) cannot be developed with a third party, it was acknowledged that substantially less could be undertaken by BC Hydro within the agreed upon budget.

An annual budget of $100,000 was recommended for Year 1 to undertake feasibility studies, and $250,000 for Years 2 to 10 for administration, planning and implementation of the wildlife physical works (refer to Table 8-17). It was acknowledged that provincial and federal regulatory review of the wildlife physical works would be required prior to approval, and that re-design of these works may be required as a result of the review process.

Table 8-17: Arrow Lakes Reservoir Wildlife Physical Works in Lieu

Program	Arrow Lakes Reservoir Wildlife Physical Works in Lieu		
Scope	Based on further discussions with technical expert, further define possible treatment options to enhancement wildlife habitat. Undertake feasibility and risk assessments, detailed planning studies and public consultation to address engineering design, questions around soil permeability and potential impacts on other interests. Implement feasible enhancement options.		
Budget and Schedule	• Feasibility and planning studies	Year 1	$100,000
	• Administration, planning and implementation ($250,000/year)	Years 2–10	$2,250,000
	Total Cost		**$2,350,000**

8.2.8.2 Monitoring Program

Significant uncertainties remain about the feasibility of physical works for wildlife in Revelstoke Reach, and whether implementation of these works will provide a level of benefit to wildlife that is commensurate with the cost. The Consultative Committee recognized the importance of effectiveness monitoring to assess the benefits to wildlife, as well as potential impacts on other interests. Much of the required monitoring has been included as elements of other studies undertaken in support of operational and non-operational changes in Arrow Lakes Reservoir.

The Consultative Committee agreed that any feasibility studies undertaken in support of proposed wildlife physical works would need to identify potential impacts on private lands, vegetation, wildlife habitat, fish habitat and mosquito production, as well as any incompatibility risks with recreational use of the drawdown zone. In addition, any wildlife physical works activities must be done in a way that is respectful of existing First Nation archaeological sites. This would require co-ordination between activities undertaken for wildlife habitat and the Heritage Management Plan to ensure compatibility with archaeological site protection.

Table 8-18 summarizes the monitoring program for the Arrow Lakes Reservoir Wildlife Management Plan.

Table 8-18: Arrow Lakes Reservoir Wildlife Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Arrow Lakes Reservoir – Study of High Value Wildlife Habitat Sites for Potential Enhancement	Years 1–4	$100,000
Mid Columbia – Monitoring of Mosquito Distribution in Revelstoke Area	**Need to address mosquito issue to enable habitat enhancement works to go forward. Study costs included under the monitoring program for the Revegetation Management Plan and Arrow Lakes Reservoir Operation Plan.**	
Mid Columbia – Monitoring of Mosquito Populations		
Mid Columbia – Monitoring and Management of Potential West Nile Virus Hotspots		
Mid Columbia – Monitoring of Effects of Hydrologic Regime on Mosquito Production		
Kinbasket and Arrow Lakes Reservoirs – Nest Mortality of Migratory Birds due to Reservoir Operations	**Effectiveness monitoring of physical works on nesting success included within this study. Study costs included under the monitoring program for Arrow Lakes Reservoir Operation Plan.**	
Kinbasket and Arrow Lakes Reservoirs – Amphibian and Reptile Life History and Habitat Use Assessment	**Effectiveness monitoring of physical works on amphibians and reptiles included within this study. Study costs included under the monitoring program for Arrow Lakes Reservoir Operation Plan.**	
Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works	**Effectiveness monitoring of physical works on wildlife habitat utilization included within this study. Study costs included under the monitoring program for the Revegetation Management Plan.**	

8.2.9 Lower Columbia Fish Management Plan

8.2.9.1 Implementation Projects

The Consultative Committee agreed that the greatest potential to provide gains to wild, indigenous fish populations in the lower Columbia River was through the following actions.

- Development of a flow reduction protocol and standard methods for assessment, data collection and mitigation responses to manage fish stranding impacts.
- Conduct of flow ramp studies to determine appropriate ramping rates to minimize interstitial fish stranding.
- Implementation of seasonal changes in the shape of the hydrograph to induce population responses by key fish species (mountain whitefish, and rainbow trout).
- Implementation of physical works in lieu of operational changes to increase natural recruitment of juvenile white sturgeon (refer to Section 8.2.10).

A. Strategy for Managing Fish Impacts associated with Flow Reductions

The Consultative Committee recommended the following strategy and associated monitoring program as an acceptable approach to addressing impacts of flow reductions from Hugh Keenleyside Dam on fish stranding in the lower Columbia River.

Stranding Protocol

In response to ongoing concerns by the Columbia River Operations Fisheries Advisory Committee, Fisheries and Oceans Canada, and the Columbia River Water Use Plan Consultative Committee, a stranding protocol was developed for the lower Columbia River. This protocol provides a communication strategy, interim flow reduction strategies (i.e., flow ramping) and environmental response actions (i.e., fish salvage, monitoring) relating to planned flow changes from Hugh Keenleyside Dam (Vonk, 2003). Through proper planning, it is expected that this will:

- Reduce fish stranding impacts of flow reductions.
- Reduce the frequency and level of effort required in response activities.
- Provide a common understanding between BC Hydro and the fish regulatory agencies around what are acceptable practices and outcomes around these ramping and stranding issues.

A working draft of the strategy is currently being used to manage flow reductions at Hugh Keenleyside Dam, and is expected to be revised over time as new information becomes available through ongoing survey and salvage efforts. It is the intent that BC Hydro will work with this strategy over the next year to ensure that the processes and procedures are working to the satisfaction of Hydro and the fisheries regulatory agencies, and will undertake a review at that time.

Ramping Rates

Ramping rates recorded since 2000 were assessed relative to the numbers of isolated fish observed below Hugh Keenleyside Dam. Due the limited available information and potentially confounding effects (i.e., area dewatered, time of day, time of year, flow history), this has neither provided conclusive results nor established a clear link between ramping rates and pool stranding of fish. Further, it does not address interstitial fish stranding. Until further information is available, the following ramping rate criteria are combined with a review of past data to determine appropriate ramping rates for an individual flow reduction event to minimize the incidence of pool stranding.

Table 8-19 summarizes the Hugh Keenleyside Dam ramping rate selection criteria.

Table 8-19: Hugh Keenleyside Dam Ramping Rate Selection Criteria

Risk Period	Ramping Rate Criteria
Moderate to High Risk Period: Spring, Summer and Fall	For discharge changes ≤ 5 kcfs, use a 1.25 to 2 kcfs per hour ramp rate (though some situations may require a higher ramp rate). For discharge changes greater than 5 kcfs, query the stranding database for risk, select a rate depending on risk, and consult DFO as required.
Low to Moderate Risk Period: Winter	For discharge changes ≤ 10 kcfs, use a ≤ 5 kcfs per hour ramp rate (though some situations may require a higher ramp rate). For discharge changes greater than 5 kcfs, query the stranding database for risk, select a rate depending on risk, and consult DFO as required.

Qualitative data on interstitial stranding (i.e., when fish become trapped in the spaces among substrate) have only recently been collected at key pool stranding sites during field surveys. As these fish are not easily salvaged or observed, the only practical mitigation is by altering the rate of flow change. However, there are currently insufficient data to develop a ramping rate strategy to address this issue.

In response to this, BC Hydro initiated a study in the winter 2003/04 to examine ramping rates during declining flows from Hugh Keenleyside Dam to determine the biological significance of interstitial fish stranding. Hydro has committed to undertake the first phase of the study, which is expected to continue for three years. As this is a pilot program, it is expected that there may be a need to undertake further study under the Columbia River Water Use Plan to continue with these efforts. The Consultative Committee recommended an annual budget of $180,000 for undertaking subsequent phases of this work, as well as implementation and maintenance of physical works required to mitigate fish stranding (e.g., recontouring) over the term of this Water Use Plan.

Once appropriate ramp rates have been established, accepted by the fisheries regulatory agencies and implemented by BC Hydro, it is expected that response activities (including fish salvage efforts) will be reduced (i.e., salvage would occur if BC Hydro deviates from these accepted rates). Any further work would entail maintenance of recontouring work undertaken in high stranding risk areas.

B. Mountain Whitefish Flow Strategy

The Consultative Committee recommended an active approach to implementing and monitoring whitefish flows in the lower Columbia River to provide more information for future decision-making. However, the level of support expressed by some Committee members for this flow strategy was conditional on the CPC and the CBT being saved harmless or appropriately compensated for any financial costs imposed by the Columbia River Water Use Plan. Subsequent to the final June 2004 meeting, conditions of support for recommendations of the Committee were removed pursuant to BC Hydro's October 2004 Letter of Commitment to the Columbia Power Corporation.

The objective of this program will be to assess the biological effectiveness of whitefish flows, with the intent of maintaining or improving current populations of whitefish below Hugh Keenleyside Dam.

The whitefish flow experiment and associated monitoring program is designed to test specific hypotheses and inform on critical data gaps regarding the relationship between flows and whitefish population levels.

- Do whitefish flows reduce egg dewatering in the lower Columbia River?
- Do whitefish flows provide conditions to maintain and improve young-of-the-year recruitment? What is the functional relationship between young-of-the-year recruitment to surviving eggs?
- Do whitefish flows maintain a stable adult population abundance? What is the functional relationship between adult population and recruitment?

A two-phase program will be implemented over a 15-year period to assess the benefits of the whitefish flow. This will involve building on existing baseline data from 2001, and obtaining additional data over the review period of the Columbia River Water Use Plan.

Table 8-20 summarizes the Adaptive Experimental Plan for Mountain Whitefish in the lower Columbia River.

Table 8-20: Adaptive Experimental Plan for Mountain Whitefish in the Lower Columbia River

Phase 1	**Maintenance of Status Quo Flow Conditions for Mountain Whitefish**	
Scope	1. Continue the current whitefish flow regime for five years to provide a total of 10 continuous years (Years 1–5 Pre-Water Use Plan, Years 6–10 Water Use Plan) of systematic baseline data under implementation of whitefish flows. This would maintain the current pattern of egg mortalities within the range since implementation of these flows. If flow releases are expected to result in greater than 40 per cent egg mortality, BC Hydro will undertake consultation with DFO prior to implementation of these flows. 2. Continue annual monitoring of the whitefish population for five years, and analyze the data to determine population status and trends in recruitment and abundance as they may relate to winter flow regime. Monitoring results will either show that stronger recruitment noted in 2001/2002 has led to the rebuilding of the adult population, or that there has been no detectable increase in adult numbers, suggesting that there may be other factors implicated in high adult mortality. (Years 1–5 assumed to be 2001 through 2005, with CWR order for 2006; Year 2001 selected as this represents the first year of systematic data collection through the Large River Index Program). 3. Decide whether to increase contrast (and thus learning potential) to test the historical flow regime (invoking egg mortality rates as high as 80 per cent), or maintain status quo whitefish flows to protect the population.	
Budget and Schedule	• White Fish flows	Years 1–5
	• Pre-Water Use Plan Index Monitoring (assumes Comptroller of Water Rights Order by end of Year 5)	Years 1–5
	• White Fish Flows	Years 6–10
	• Water Use Plan Index Monitoring	Years 6–10
	• Interim Analysis & Decision for Optional Testing*	End of year 10

Table 8-20: Adaptive Experimental Plan for Mountain Whitefish in the Lower Columbia River (cont'd)

Phase 2	**Optional Testing of Historical Flow Regime for Mountain Whitefish**	
Scope	1. Implement the flow treatment decision made from Phase 1 (i.e., continue status quo or allow a broader range of flow deviation based on the historical flow regime). 2. Continue annual monitoring and analyse the data to test for trends in abundance and recruitment as they relate to winter flow regime. 3. Make a final assessment of the links between flows and whitefish indices.	
Budget and Schedule	• Optional Flows Tests	Years 11–15
	• Water Use Plan Index Monitoring	Years 11–15

* Note: A joint BC Hydro and fish regulatory agency team of Fish Technical Subcommittee members will review and analyze the results of monitoring conducted in Years 1 to 10, and provide recommendations regarding optional flow testing in Years 11 to 15 for broader approval.

Figure 8-1 outlines the schedule for implementation of the whitefish experiment.

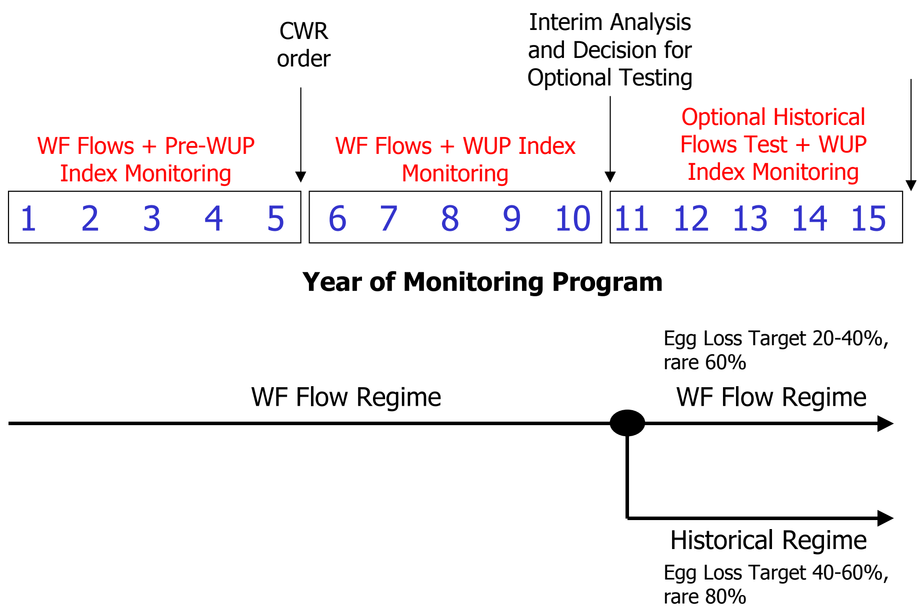


Figure 8-1: Implementation Schedule for the Lower Columbia River Whitefish Experiment

The objectives of the experimental plan will be to test the effectiveness of the current flow regime to ensure that it is achieving its goal of protecting the whitefish population. While this approach is based on re-creating (as close as possible) predicted egg loss rates based on the egg loss model, the target treatment will need to be operationalized using a distribution of flow targets similar to the past five years. The flow target is the difference between the maximum peak spawning flow (Qs) over the 1 to 20 January period and minimum incubation flow (Qi) over the 21 January to 31 March period.

Flows Agreed To: (1994–2003)			Expected Egg Losses: (1994–2003)		
Qs–Qi kcfs	**% Frequency**	**# Year /5 Years**	**Egg Loss**	**% Frequency**	**# Year/ 5 Years**
0–20	0.33	2	0–20	0.66	3
20–40	0.44	2	20–40	0.33	2
40–60	0.22	1	40–60	0.11	0
60–80	0.11	0	60–80	0.00	0
80–100	0.00	0	80–100	0.00	0

Pursuant to the June 2004 Letter of Commitment from BC Hydro to DFO, BC Hydro commits to pursuing the whitefish flow agreements as a high priority. Efforts will be made to maintain recent historical flow reductions and associated pro-rated occurrences (i.e., last 10 years) over the first five years of the Columbia River Water Use Plan. BC Hydro will endeavour to provide flow reductions that are predicted to result in 0–30 per cent egg mortality with 30 to 40 per cent egg mortality occurring only once over this period. Further, it is recognized that predicted egg losses could hit the 40 to 60 per cent range in one year out of five, but this was being masked in the predicted 5-year frequencies by the way in which the data were rounded. In the event that flow releases are expected to deviate from the target flow treatments and result in greater than 40 per cent egg mortality, it was agreed that BC Hydro would undertake consultation with DFO prior to implementation of these flows.

C. Rainbow Trout Flow Strategy

The Consultative Committee recommended that BC Hydro continue to pursue the rainbow trout protection flows each year through annual negotiations with the United States. The Committee highlighted a number of high priority items for consideration in future operations.

- Achieve rainbow trout flows as specified, targeting a start date of 1 April, but consulting with the fish regulatory agencies on an annual basis regarding timing of rampdown from whitefish flows in March to rainbow trout protection flows in April.
- Minimize the volume of water stored in Arrow Lakes Reservoir for the United States.
- Delay the onset of storage for as long as possible.
- Release the additional storage of water in Arrow Lakes Reservoir as quickly as possible.

Pursuant to the June 2004 Letter of Commitment from BC Hydro to DFO, BC Hydro commits to pursuing the rainbow trout flow agreements with the U.S. Entity as a high priority. Efforts will be made to negotiate typical Arrow flow smoothing operations to achieve a sustainable base Arrow release that can be maintained during the 1 April to 30 June period.

8.2.9.2 Monitoring Program

The Consultative Committee recommended a substantial monitoring program to address existing uncertainties around operational impacts on key fish resources in the lower Columbia River.

Table 8-21 summarizes the Lower Columbia Fish Management Plan Monitoring Program.

Table 8-21: Lower Columbia Fish Management Plan Monitoring Program

Study	Year	Estimated Annual Cost
Lower Columbia River – Fish Stranding Assessment and Ramping Protocol Development	Years 1–15	$180,000
Lower Columbia River – Sculpin and Dace Life History Assessment	Years 1–5	$75,000
Lower Columbia River – Physical Habitat Monitoring	Years 1–15	$25,000
Lower Columbia River – Ecological Productivity Monitoring	Years 1–15	$100,000
Lower Columbia River – Fish Population Index Surveys	Years 1–15	$150,000
Lower Columbia River – Rainbow Trout Spawning Assessments	Years 1–15	$35,000
Lower Columbia River – Whitefish Spawning Grounds Topographic Surveys	Years 1–2	$100,000
Lower Columbia River – Whitefish Egg Monitoring	Years 1–5	$75,000
Lower Columbia River – Whitefish Life History Study	Years 1–5	$75,000
Lower Columbia River – Effect of Whitefish Flows on Great Blue Heron Winter Use of Waldie Island	3 years (opportunistically when elevation at Waldie Island expected to exceed 421 m)	$30,000
Lower Columbia River – Winter Use of Waldie Island by Great Blue Herons Nesting adjacent to Revelstoke Reach	Years 1–5	$50,000

8.2.10 Lower Columbia River White Sturgeon Management Plan

8.2.10.1 Implementation Project

The Consultative Committee considered an experimental treatment involving a flow target of 200,000 cfs at the Canada/United States border for one month during the late June to late July period to reduce predation pressures on larvae and juveniles. However, it became apparent that achieving this target would require a large shift in current operations of Arrow Lakes Reservoir to supplement flows in most years, and could be very costly ($15–20 million) due to implications on spill downstream in high flow years. The Committee, therefore, recommended the high flow option only on an opportunistic basis, as opposed to through an operational change, and undertaking an assessment in those years when it occurs naturally.

Given BC Hydro's limited capability in predicting flow volumes based on runoff forecasts, the Fish Technical Subcommittee agreed that the studies should be undertaken whenever April to July runoff forecasts for the Columbia River at the International boundary are 10 per cent above normal and a decision to "go or no-go" on the studies should be based on consultation with other stakeholders. In the event that there has not been a high runoff year for 4 to 5 years, consideration should be given to reducing the "threshold value" in consultation with other stakeholders.

Given the practical and financial impediments to substantially increasing flows at the border (i.e., in lost power generation, damage to infrastructure), the Consultative Committee supported a physical works in lieu to improve conditions for white sturgeon in the lower Columbia River. This plan involves the delivery of bentonite or another turbidity agent to the lower Columbia River during low flow periods (i.e., when discharge at the United States boundary is below 90 kcfs) when sturgeon larvae are known to be hatching and undergoing their downstream drift phase and are vulnerable to predation. The Committee accepted this experiment plan, recognizing that it would first require a feasibility study to address regulatory concerns around introducing a turbidity agent to the river and associated fisheries and related ecosystem issues.

The Consultative Committee also supported a provisional annual contribution to the existing lower Columbia River sturgeon aquaculture program. The Committee recommended an annual contribution of $188,000.

Subsequent to the June 2004 meeting, it became apparent that there was a lack of clarity around the nature of the consensus decision for the lower Columbia River white sturgeon plan. The two principal issues of concern expressed by some members of the Consultative Committee related to flexibility in the approach to physical works in lieu, and annual contributions to the conservation aquaculture program as a fallback option.

In supporting the lower Columbia River white sturgeon plan, some Consultative Committee members believe that they accepted the annual contribution to the aquaculture program as a fallback option in the event that turbidity augmentation was found to be unfeasible. Other members believe that they supported a program that included both options and the necessary flexibility within the program to explore other physical works if the turbidity experiment does not proceed.

Table 8-22 summarizes the management plan recommended by the Consultative Committee for white sturgeon in the lower Columbia River.

Table 8-22: Lower Columbia River White Sturgeon Management Plan

Option 1	**Turbidity Augmentation Experiment**		
Scope	Bentonite introduced to the lower river during the late June to late July period (i.e., hatching and drift phase) for 30 days when flows at the Canada/United States border are expected to be at or below 90 kcfs (expected frequency of 3 years out of 10). Target a 10 NTU increase in turbidity to reduce predation pressures on sturgeon larvae and juveniles. Expected 25–35 per cent probability of successful recruitment to year one age class. Feasibility study required to address legal, regulatory and environmental concerns, and logistics prior to implementation.		
Budget and Schedule	• Bentonite addition (average $3 million/treatment)	3 Years	$9 million
Option 2	**Fallback Option: Lower Columbia White Sturgeon Aquaculture Program**		
Scope	Provisional contribution to the existing aquaculture program for white sturgeon in the lower Columbia River, if turbidity augmentation is deemed unfeasible.		
Budget and Schedule	• Annual contribution ($188,000/year)	Years 1–10	$1.88 million

8.2.10.2 Monitoring Program

The Consultative Committee recognized that review and consultation will be required to ensure that legal and regulatory issues around adding turbidity to the river are fully considered. Further, feasibility assessments will be required to address impacts on other interests in the river. If this option is found to be feasible and is implemented, monitoring the response of the sturgeon population will be critical to informing on the effectiveness of this action and ensuring that adopted changes do not result in a decline in population abundance.

Table 8-23 summarizes the monitoring program for the Lower Columbia White Sturgeon Management Plan.

Table 8-23: Lower Columbia White Sturgeon Management Plan Monitoring Program

Study	**Year**	**Estimated Annual Cost**
Lower Columbia River – Adult Sturgeon Population Monitoring[1]	Years 1–15	$150,000
Lower Columbia River – Juvenile Sturgeon Detection Program	Years 1–10	$125,000
Lower Columbia River – Planning and Assessment of White Sturgeon Turbidity Experiment	Years 1–2	$50,000
Lower Columbia River – Opportunistic Assessment of High Flow Events at the Canada/United States Border	Years 1–2	$75,000

1 Cost of the adult sturgeon population monitoring includes $25,000/year for broodstock collection.

8.3 NON-LICENCE WATER USE PLAN RECOMMENDATIONS OF THE CONSULTATIVE COMMITTEE

The Consultative Committee recognized that several of their recommendations could not be considered by the Comptroller of Water Rights for inclusion within BC Hydro's Water Licences for the Columbia River hydroelectric facilities. BC Hydro acknowledged that these issues were important to the Committee, and committed to considering these recommendation when making water management decisions.

8.3.1 Reservoir Surcharge

The Consultative Committee acknowledged that, on rare occasions, BC Hydro may need to surcharge Kinbasket, Revelstoke and Arrow Lakes reservoirs for flood control under emergency conditions.

On rare occasions, BC Hydro may also wish to surcharge the reservoir to address other environmental or economic considerations. The Committee recommended that BC Hydro avoid reservoir surcharge if at all possible, and that compensation be provided to address infrastructure damage and additional debris control in the event of its occurrence.

8.3.2 Boat Access Proposals

Several physical works proposals to improve boat access were deemed outside of water use planning, as there was no link to operations of the Columbia River facilities. Given the importance of these works for safety and maintenance reasons, the Consultative Committee recommended that BC Hydro and other parties consider funding these projects (Table 8-24).

It was also suggested that any proposals recommended by the Committee as part of the Columbia River Water Use Plan that are subsequently ruled as outside of the scope of water use planning by the Water Comptroller be put forward as non-water use planning recommendations.

Table 8-24: Non-Water Use Plan Recommendations for Boat Access

Location	Issue/Action	Comments	Construction Cost (+ annual maintenance)
Arrow Lakes Reservoir			
Galena Bay	New ramp, size and location to be determined. Needs to be contingency in place if public do not have access to Galena Bay ferry slip to launch their boats. If boats are allowed to launch from ferry landing, there would be no need for a new boat launch.	Rationale for proposal was around BC Hydro's obligation to provide access. Not supported by the Consultative Committee, as the licence review is a separate process from water use planning. No tie to operations.	$868,000 + $12,500 annual maintenance
Anderson Point (Deer Park)	New ramp, accessible down to 1380 ft.	No operational link.	$695,000 + $12,500 annual maintenance
Burton (existing ramp)	Current ramp needs maintenance and upgrade.	Maintenance issue. No link to operations.	$8,000 + $12,500 annual maintenance
Halfway Creek	Ramp between Galena Bay and Nakusp to provide shelter/safety for boaters in case of extreme weather. Currently, 50 km open water between Galena and Nakusp with no access point.	No operational link that allows a new boat ramp to be built using this line of reasoning. Therefore, does not fit within the scope of water use planning.	$868,000 + $12,500 annual maintenance
Shelter Bay	Low water strands ramp in about 4 of 60 years. Extend ramp from 1390 ft to 1386 ft.	Considered a very low priority; dropped from list of proposals by the Consultative Committee.	$585,000 + $12,500 annual maintenance
Nakusp	Current ramp of poor design, in poor repair. Build a new ramp adjacent to old ramp.	Considered the highest priority site. To include breakwater and removal of old ramp. Deemed outside of water use planning by the Comptroller of Water Rights.	$1.4million + $12,500 annual maintenance

8.3.3 Other Non-Water Use Plan Recommended Actions

During the trade-off discussions, the Consultative Committee accepted a number of operating changes, physical works and monitoring packages conditional on further information being sought by BC Hydro. These conditions were put forward by the Committee as non-Water Use Plan recommendations, as follows.

- Many of the Consultative Committee members wished to seek clarification from the Comptroller of Water Rights as to what constitutes access to the reservoirs. Once clarification has been sought, the Committee wants the Comptroller to identify how provisions will be made and then to direct appropriate parties responsible to improve access.

- Prior to the 5-year review of Arrow Lakes Reservoir operations, the Consultative Committee recommended that BC Hydro undertake an impact assessment to determine how the Non-Treaty Storage Agreement will affect BC Hydro's ability to achieve the soft constraints and meet the objectives of the system. This would include the current and new agreements, as well as a scenario with no NTSA in place. The Committee also recommended that the NTSA impact assessment include an assessment of whether there is an increased likelihood of surcharging Kinbasket and Arrow Lakes reservoirs and the impacts associated with this.

8.4 EXPECTED CONSEQUENCES

Table 8-25 summarizes the expected consequences of the recommendations for the Columbia River Water Use Plan.

Table 8-25: Expected Consequences of the Columbia River Water Use Plan

Water Use Interest		Consequences
Culture and Heritage		
Kinbasket Reservoir Revelstoke Reservoir Arrow Lakes Reservoir	+	Increase in knowledge of the distribution, susceptibility and characteristics of archaeological sites within the drawdown zone with implementation of monitoring studies. Increase in protection of archaeological sites with implementation of physical works.
Arrow Lakes Reservoir	+	Increase in protection of archaeological sites with implementation of soft operational constraints.
Kinbasket Reservoir Arrow Lakes Reservoir	+	Increase in protection of archaeological sites with implementation of revegetation in the drawdown zone.
Flood Erosion Control		
Arrow Lakes Reservoir	+	Decrease in shoreline erosion and dust control problems in the mid Columbia River and Arrow Lakes Reservoir by revegetation of the drawdown zone and soft operational constraints.
Power Generation		
Mica, Revelstoke and Hugh Keenleyside facilities	–	Decrease in the annual average power value of approximately $3.5 million per year.
Other Licensed Uses of Water		
Kinbasket Reservoir Revelstoke Reservoir Arrow Lakes Reservoir Mid and Lower Columbia River	**0**	No effects on other current licensed uses of water associated with Kinbasket, Revelstoke and Arrow Lakes reservoirs, or the mid and lower Columbia River.[1]

Table 8-25: Expected Consequences of the Columbia River Water Use Plan (cont'd)

Water Use Interest		Consequences
Fish and Aquatic Resources		
Arrow Lakes Reservoir	+	Increase in overall aquatic productivity with revegetation of the drawdown zone and implementation of soft constraints.
Kinbasket Reservoir Revelstoke Reservoir Arrow Lakes Reservoir Mid and Lower Columbia River	+	Increase in knowledge and understanding of ecological health, fish habitat capability, fish populations and operational-related impacts on aquatic productivity with implementation of monitoring studies.
Kinbasket Reservoir	+	Increase in littoral productivity through revegetation efforts in the drawdown zone of the reservoir.
Mid Columbia River	+	Increase in overall aquatic productivity with implementation of the minimum flow constraint at Revelstoke Dam.
Kinbasket Reservoir Mid Columbia River Arrow Lakes Reservoir	+	Increase in understanding of juvenile white sturgeon habitat capabilities in the mid Columbia River. Improved chance of building a self-sustaining population in Arrow Lakes Reservoir with implementation of flow treatments and conservation aquaculture. If wild reproduction is not possible, then increase chance of building a self-sustaining population in Kinbasket or failsafe population(s) in Kinbasket and/or Arrow Lakes Reservoir through conservation aquaculture.
Lower Columbia River	+	Increase in the abundance of wild, indigenous fish populations with implementation of a flow reduction protocol, physical works and monitoring studies.
	+	Maintain or improve current populations of rainbow trout below Hugh Keenleyside Dam with implementation of the rainbow trout agreement, which BC Hydro will pursue through annual negotiations with the United States
	+	Maintain or improve current populations of mountain whitefish below Hugh Keenleyside Dam with implementation of the whitefish flow agreement, which BC Hydro will pursue through annual negotiations with the United States
	+	Increased probability of successful natural recruitment of white sturgeon with implementation physical works..
Recreation		
Arrow Lakes Reservoir	+	Increase in opportunities for water-based recreation through improved access to the reservoir as a result of soft constraints.
Kinbasket Reservoir Arrow Lakes Reservoir Mid Columbia River	+	Increase in understanding of recreational use patterns with implementation of monitoring studies.
	+	Improved accessibility and increase in opportunities for water-based recreation with improvements to existing boat ramps and the construction of new ramps.
Kinbasket Reservoir Arrow Lakes Reservoir Lower Columbia River	+	Improved accessibility and increase in opportunity for water-based recreation through implementation of debris management program.
Mid Columbia River	+	Increase in navigational safety for water-based recreation in the mid Columbia River as a result of the year-round minimum flow release and the seasonal sturgeon minimum flow from Revelstoke Dam, as this will reduce daily flow variation below the dam.
Lower Columbia River	+	Increase in knowledge and understanding of environmental impacts associated with dredging the debris removal at Indian Eddy.

Table 8-25: Expected Consequences of the Columbia River Water Use Plan (cont'd)

Water Use Interest		Consequences
Wildlife and Vegetation		
Kinbasket Reservoir Mid/Lower Columbia River Arrow Lakes Reservoir	+	Increase in knowledge and understanding of wildlife habitat capability, wildlife populations and operational-related impacts with implementation of monitoring studies.
Kinbasket Reservoir Mid Columbia River Arrow Lakes Reservoir	+	Increase in wildlife and wildlife habitat with implementation of revegetation project and physical works.
Arrow Lakes Reservoir	_	Maintain lower than optimal vegetation and wildlife habitat values with implementation of the rainbow trout flow agreements in the lower Columbia River.
Arrow Lakes Reservoir	o	Maintain historic vegetation with implementation of soft constraints.
Learning		
Mica, Revelstoke and Hugh Keenleyside facilities	+	Increase in knowledge and understanding with implementation of monitoring studies, physical works and experimental management plans.

[1] Pursuant to the June 2004 government policy directive issued by the Ministry of Energy and Mines, the May 2004 Approval of Indemnity issued by the Ministry of Finance, and the October 2004 Letter of Commitment from BC Hydro, CPC/CBT joint venture power companies will be saved harmless or appropriately compensated for any adverse impacts resulting from implementation of this Water Use Plan.

8.5 REVIEW PERIOD

The Consultative Committee recommended that the Columbia River Water Use Plan be reviewed 13 years after implementation unless results from the monitoring program suggest an earlier review is appropriate. The Committee recommended that a review of the Plan be completed within two years.

The Committee also recommended a review of Arrow Lakes Reservoir operations five years after implementation of the Columbia River Water Use Plan to review the results of monitoring studies conducted in Arrow Lakes Reservoir and evaluate the effectiveness of the soft constraints and physical works in meeting the Committee's interests. If a new Non-Treaty Storage Agreement is negotiated within this 5-year period, it is also recommended that the outcomes of this agreement be reviewed in the context of its implications to operational flexibility and ability to meet the Committee's objectives for Arrow Lakes Reservoir. The outcomes of the 5-year review will be used to assess the need to recommend to BC Hydro a review of the Arrow Lakes Reservoir component of this Water Use Plan.

9 REVIEW PERIOD

The Consultative Committee recommended a review of Arrow Lakes Reservoir operations five years after implementation of the Columbia River Water Use Plan to review the results of monitoring studies and evaluate the effectiveness of the soft constraints and physical works in meeting the Committee's interests in Arrow Lakes Reservoir and the lower Columbia River. If a new Non-Treaty Storage Agreement is negotiated within this 5-year period, it is also recommended that the outcomes of this agreement be reviewed in the context of its implications to operational flexibility and ability to meet the Committee's objectives for Arrow Lakes Reservoir. The outcomes of the 5-year review will be used to assess the need to recommend to BC Hydro a review of the Arrow Lakes Reservoir operations.

The Consultative Committee recommended that the Columbia River Water Use Plan be reviewed 13 years after implementation unless results from the monitoring program suggest an earlier review is appropriate.

The Consultative Committee recommended that there be annual reporting of progress on the monitoring studies and physical works, and performance of the soft constraints for Arrow Lakes Reservoir.

10 IMPLEMENTATION OF RECOMMENDATIONS

The preferred operating alternative, the non-operational projects and the monitoring program recommended by the Consultative Committee will be implemented once the Comptroller of Water Rights approves the Columbia River Water Use Plan and issues direction to BC Hydro. 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 changes. Until that time, BC Hydro will operate according to its current licence conditions for the Columbia River hydroelectric facilities.

Figure 10-1 illustrates the next steps in the Columbia River water use planning process.

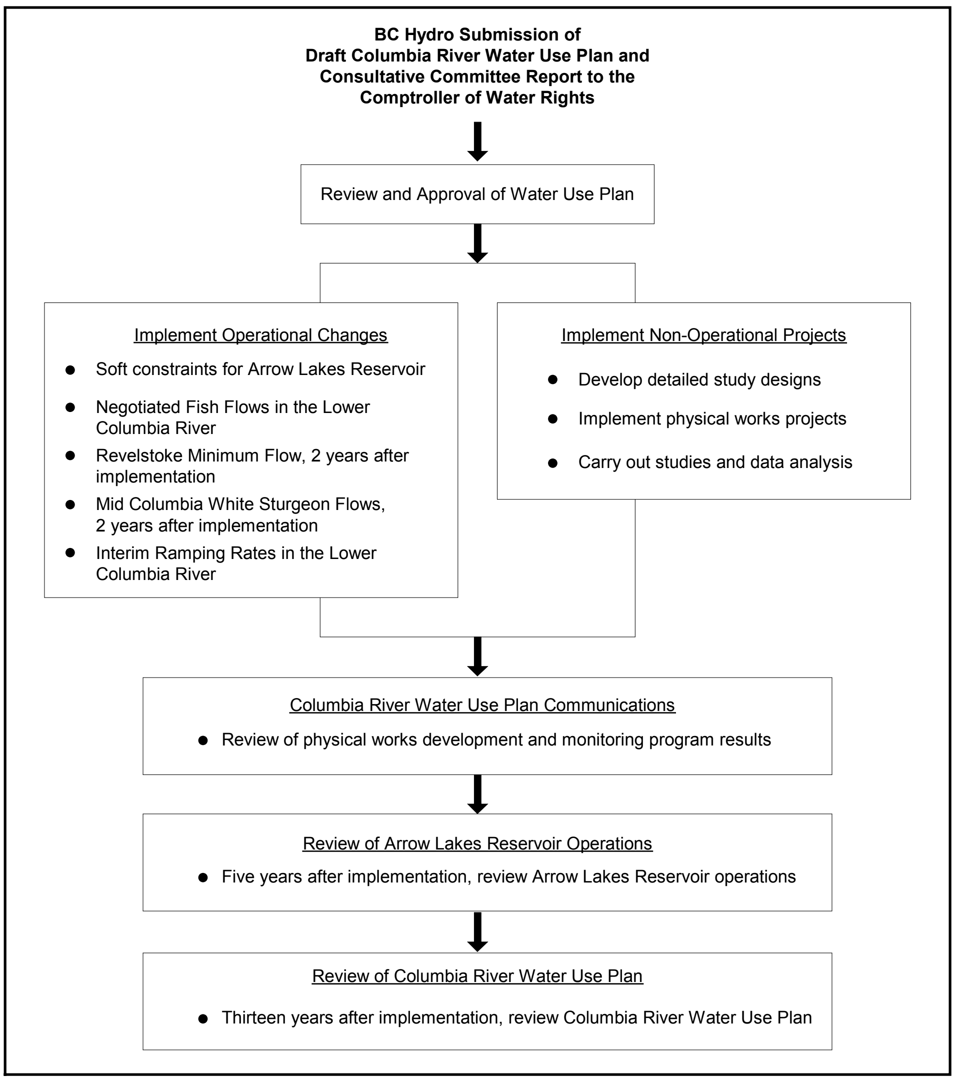


Figure 10-1: Next Steps in the Columbia River Water Use Planning Process

The following is a summary of the review, approval and implementation process for the Columbia River Water Use Plan.

- Submission to government: BC Hydro will submit two documents for government review:

    1. The Columbia River Water Use Plan Consultative Committee Report.

    2. The Columbia River Draft Water Use Plan.

- Review and Approval of the Water Use Plan: As described in Step 10 of the provincial government's *Water Use Plan Guidelines*, the government will review and issue a decision on the Draft Columbia River Water Use Plan under provisions of the *Water Act*. This process involves referring the draft Plan for review and comment by 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 six to 12 months once it 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 Columbia River Water Use Plan and the Comptroller of Water Rights has provided BC Hydro with direction, BC Hydro will implement the approved operational changes.

- Implement Non-Operational Projects: Once the Comptroller of Water Rights has provided BC Hydro with direction on the Columbia River Water Use Plan, BC Hydro will:

    1. Develop detailed terms of reference for all approved non-operational projects (monitoring studies and physical works in lieu of operations).

    2. Begin implementation of the projects and programs. The detailed terms of reference will be reviewed with appropriate government agencies, First Nations, and interested parties.

- Columbia River Water Use Plan Communications: BC Hydro will work with the appropriate parties in development of the physical works, and implementation of the experimental plans and monitoring studies:

    - Fisheries and Oceans Canada – the rainbow trout and mountain whitefish flow agreements for the lower Columbia River, and feasibility and implementation of the lower Columbia River white sturgeon experimental plan.

    - First Nations – the Arrow Lakes Reservoir and mid Columbia River revegetation plans, archaeological survey and site protection needs/prioritization, and inclusion of traditional ecological knowledge.
    - Upper Columbia White Sturgeon Recovery Initiative – the mid and lower Columbia River white sturgeon experimental plans.
    - Local Community and Stakeholders – the Arrow Lakes Reservoir and mid Columbia River revegetation plans and wildlife physical works, communication of study results regarding boat ramp proposals and debris management plans, and priorities for debris management.
    - Joint BC Hydro/Fish Regulatory Agency Team – testing of whitefish flows in the lower Columbia River.

- Review of Arrow Lakes Reservoir Operations: Arrow Lakes Reservoir operations will be reviewed five years after the implementation of the Plan. The results of the review will be used to assess the need to recommend to BC Hydro a review of the Arrow Lakes Reservoir operations.
- Review of the Columbia River Water Use Plan: The Columbia River Water Use Plan will be reviewed 13 years after implementation of the Plan.

11 REFERENCES

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Consultative Committee Report

Volume 2 of 2

July 2005

Prepared on behalf of:

The Consultative Committee for the Columbia River Water Use Plan

Columbia River Water Use Plan

A Project of BC Hydro

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APPENDICES

Appendix T	Eligibility Criteria for Studies Conducted during the Columbia River Water Use Planning Process
Appendix U	Correspondence from the Columbia River Water Use Plan Project Manager to the Consultative Committee
Appendix V	Impact of Flow on Recreation and Infrastructure on the Lower Columbia River
Appendix W	Evolution of Lower Columbia River Fish Flows
Appendix X	Correspondence from J. O'Riordan, Chair, Water Use Plan Steering Committee
Appendix Y	Eligibility Criteria for Water Use Plan Monitoring Studies
Appendix Z	Proposed Revegetation Plan for Kinbasket Reservoir
Appendix AA	Proposed Revegetation Plan for Arrow Lakes Reservoir
Appendix BB	Briefing Note – MCA WUP Fish Technical Subcommittee Teleconference, November 2004
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Appendix DD	Physical Works for Wildlife in the Revelstoke Wetlands
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APPENDIX A: COLUMBIA RIVER WATER USE PLAN CONSULTATIVE COMMITTEE, ALTERNATES, OBSERVERS AND SUBCOMMITTEES

Table A-1: Columbia River Water Use Plan Consultative Committee

Member	Affiliation	Notes
Terry Anderson	Ministry of Water, Land and Air Protection	
Andreas Artz	Little Shuswap Indian Band	
Chris Beers	Columbia Kootenay Fisheries Renewal Partnership	
Don Bennett	Valemount Marina Association	
Arnold Benty	Golden District Rod & Gun Club	Participated in first meeting only
Gail Bernacki	City of Revelstoke	
Judy Bosh	Village of Valemount	
Gordon Boyd	BC Hydro	
Clayton Brooks	Village of Nakusp	Resigned in 2003
Gord DeRosa	City of Trail	
Penny Dewar	Area Resident	Joined in 2003
Bill Duncan	TeckCominco Ltd.	
Bruce Duncan	Columbia Power Corporation	
Paul E. Feuz	Esplanade Bay Society	
Jim Forbes	Timeless Tours	
Fred Fortier	Secwepemc Fisheries Commission	
Willi Friml	BC Hydro	Replaced by Gordon Boyd in 2003
Kindy Gosal	Columbia Basin Trust	
Bill Green	Canadian Columbia River Inter-tribal Fisheries Commission	
Susan Hall	Parks Canada	
Janice Jarvis	North Columbia Environmental Society/ Friends of Mt. Revelstoke & Glacier	
Alan Karges	West Kootenay Sailing Club	Participated in first meeting only.
Helmut Klughammer	Area Resident	
Steve Macfarlane	Fisheries and Oceans Canada	
Ian MacLean	BC Hydro	
Francis Maltby	Area Resident	

Member	Affiliation	Notes
Don Munk	Downie RV Resorts Ltd.	
Bob Munro	Town of Golden	Did not participated in any meetings
Shelley Murphy	Ministry of Energy and Mines	
Tim Newton	BC Hydro	Replaced by Doug Robinson in 2002
Loni Parker	Columbia Shuswap Regional District	
Paul Peterson	Regional District of Central Kootenay	
Randy Priest	Kinbasket property owners, Columbia Reach	
Doug Robinson	BC Hydro	
Bob Taylor	LP Engineered Wood Products	
Fred Thiessen	BC Forest Service	
Mark Thomas	Ktunaxa Kinbasket Tribal Council	
Warren Ward	Mica Marina	
Webb Webster	West Kootenay Naturalists	
Maureen Weddell	Illecillewaet Greenbelt Society	
Pat Wilcox	Castlegar Power Squadron/Arrow Yacht Club/Safe Moorage Committee	

Table A-2: Columbia River Water Use Plan Water Use Plan Alternates

Name	Alternate for	Affiliation
Tola Coopper	Steve Macfarlane	Fisheries and Oceans Canada
Paul E. Feuz	Warren Ward	Esplanade Bay Society, property owner
Willi Friml	Ian MacLean Doug Robinson	BC Hydro
Llewellyn Matthews	Bruce Duncan	Columbia Power Corporation
Thomas Munson	Mark Thomas	Ktunaxa Kinbasket Tribal Council
Ron Oszust	Loni Parker	Columbia Shuswap Regional District
Mark Tiley	Bill Green	Canadian Columbia River Inter-tribal Fisheries Commission
Les Tisdale	Paul E. Feuz	Fantasy Island Causeway Society, property owner

Table A-3: Columbia River Water Use Plan Water Use Plan Observers

Registered Observer	Affiliation
Administrator	Fraser Fort George RD
Administrator	City of Revelstoke
Jim Abbott	MP, Kootenay - Columbia
Aimee Ambrosone	CBT Energy
Steve Arndt	Columbia Basin Fish and Wildlife Compensation Program
Cam Barlow	Pope and Talbot
Julia Beatty	MWLAP – Head, Environmental Quality Section
Art Benzer	Village of Montrose
Ron Blaue	Mistaya Lodge
Karen Bray	CBFWCP biologist
Mindy Brugman	Area Resident
Dennis Butchart	BC Assets & Lands Corp
Jubilee Cacaci	Area Resident
Chris Carroll	Canadian Pacific Railway
Ric Chartraw	Kinbasket Resort owner
Bob Clarke	Revelstoke Community Forest Corp
Steve Day	Slocan Forest Products
Don De Gagne	City of Revelstoke, admin.
Richard & Barb Dehnke	Valemount Marina Society
Joan Dolinsky	East Kootenay Environmental Society
Tina Donald	North Thompson Indian Band
Jim Doyle	Mayor, Town of Golden
Pam Doyle	Parks Canada
Loretta Eustache	Spallumcheen Indian Band
Denise Gurney	Secwepemc Fisheries Commission
Jim Gustafson	City of Castlegar
Shannon Hammond	Earth Matters
Dick Harris	MP, Prince George - Bulkley Valley
Paul Higgins	BC Hydro
Steven Hui	Revelstoke Chamber of Commerce
Stephen Hureau	Canadian Wildlife Services – replaced by Greg Mallet in 2004
Rhondi Hurlbut	Area Resident
Bob Kruisselbrink	Area Resident
Jayson Kurtz	Fisheries and Oceans Canada
William Leithwood	Area Resident
Lisa Longinotto	MacPherson Lodge
Tahl Lunoch	LP Engineered Wood Products
Deana Machin	Okanagan Nation Alliance
Harald Manson	CBFWCP
Alan Mason	Revelstoke Economic Development Commission
Steve McAdam	Senior Hydroelectric Impacts Biologist - Ministry of Water, Lands and Air Protection
Laura McCoy	Ktunaxa-Kinbasket Tribal Council
Judy McQuary	CPC
Ron Mitchell	Valemount Rod & Gun Club

Registered Observer	Affiliation
Mike Monroe	Fraser Fort George RD director
Ken Nishida	Area Resident
Colin Pike	Bell Pole Company
Jan Rodman	Golden Chamber of Commerce
Janet Spicer	Area Resident
Bob Sturgeon	Salmon Arm Metis Association
Greg Switenky	Town of Golden, admin.
Lee Taylor	Revelstoke Rod & Gun Club
Philip Tonnellier	Area Resident
Christine Torgerson	Area Resident
Roberta Van Steinburg	KKTC
Barrie Wagner	Downie Timber Limited
Ted White	MoELP, Water Management Branch
Jon Wilsgard	Economic Development Officer - Town of Golden
Lewis Zambon	Area Resident
Ellen Zimmerman	East Kootenay Environmental Society

Table A-4: Columbia River Water Use Plan Subcommittees

Member	Affiliation	Fish Technical Committee	First Nation Archaeology and Heritage	Wildlife Technical Committee	Transportation	Recreation
Terry Anderson	Ministry of Water, Land and Air Protection	✓				
Andreas Artz	Little Shuswap Indian Band	✓	✓	✓		
James Baxter	BC Hydro	✓				
Chris Beers	Columbia Kootenay Fisheries Renewal Partnership	✓				
Don Bennett	Valemount Marina Association					✓
Arnold Benty	Golden District Rod & Gun Club			✓		
Gail Bernacki	City of Revelstoke		✓			
Gary Birch	BC Hydro	✓				
Gordon Boyd	BC Hydro	✓		✓		
Clayton Brooks	Village of Nakusp			✓		✓
Tola Coopper	Fisheries and Oceans Canada	✓				
Gord DeRosa	City of Trail					✓
Penny Dewar	Area Resident					✓
Bill Duncan	TeckCominco Ltd.	✓				
Loretta Eustache			✓	✓		
Jim Forbes	Timeless Tours	✓				
Fred Fortier	Secwepemc Fisheries Commission	✓	✓			✓
Bill Green	Canadian Columbia River Inter-tribal Fisheries Commission	✓	✓			
Susan Hall	Parks Canada	✓	✓	✓		
Janice Jarvis	North Columbia Environmental Society/Friends of Mt. Revelstoke & Glacier		✓	✓		
Helmut Klughammer	Area Resident					✓
Steve Macfarlane	Fisheries and Oceans Canada	✓				
Ian MacLean	BC Hydro	✓		✓		✓

Member	**Affiliation**	**Fish Technical Committee**	**First Nation Archaeology and Heritage**	**Wildlife Technical Committee**	**Transportation**	**Recreation**
Francis Maltby	Area Resident	✓		✓		
Llewellyn Matthews	Columbia Power Corporation	✓				
Steve McAdam	Ministry of Water, Land and Air Protection	✓				
Don Munk	Downie RV Resorts Ltd.					✓
Bob Munro	Town of Golden					✓
Loni Parker	Columbia Shuswap Regional District				✓	✓
Paul Peterson	Regional District of Central Kootenay					✓
Colin Pike	Bell Pole Company				✓	
Randy Priest	Kinbasket property owners, Columbia Reach					✓
Doug Robinson	BC Hydro	✓		✓		
Fred Thiessen	BC Forest Service					✓
Mark Thomas	Ktunaxa Kinbasket Tribal Council		✓	✓		
Mark Tiley	Canadian Columbia River Inter-tribal Fisheries Commission	✓	✓	✓		
Barrie Wagner	Downie Timber Limited				✓	
Warren Ward	Mica Marina					✓
Maureen Weddell	Illecillewaet Greenbelt Society					✓
Pat Wilcox	Castlegar Power Squadron/Arrow Yacht Club/Safe Moorage Committee	✓				✓

APPENDIX B: SCHEDULE OF CONSULTATIVE COMMITTEE MEETINGS AND ACTIVITIES

Step 1: Initiate Water Use Plan	**30 August 2000** • Public announcement
Step 2: Issues Scoping	**19, 20, 21, 26, 27, and 28 September 2000** • Host Open Houses and Information Sessions in Valemount, Golden, Revelstoke, Nakusp, Castlegar and Trail. **16–17 February 2001** • Present overview of water use planning process • Introduce terms of reference and workplan • Introduce and discuss issues list
Step 3: Determine the Consultative Process	• Present overview of Columbia River System • Review issues list and introduce objectives • Present value-based decision making process
Step 4: Develop Objectives and Performance Measures	**27–28 June 2001** • Confirm Consultative Committee Members, terms of reference, and workplan • Confirm issues list, continue work on objectives and preliminary performance measures • Present overview of Columbia River facility operations • Development of Preliminary Operating Alternatives
Step 5: Additional Information Gathering	**28 February 2002** • Discuss Round 1 operating alternatives • Identify Round 2 operating alternatives for modelling
Step 6: Creating Alternatives	• Review objectives and performance measures • Discuss candidate Step 5 studies **8–9 May 2002** • Prioritize Step 5 study proposals and approve studies • Discuss Round 2 operating alternatives • Review objectives and performance measures • Identify Round 3 operating alternatives for modelling **11–13 June 2003** • Discuss Round 3 operating alternatives • Review and confirm objectives and performance measures • Identify Round 4 operating alternatives for modelling • Review relevant Step 5 study findings • Review water use planning monitoring principles

Step 7: Assess Trade-Offs Step 8: Document Areas of Agreement and Disagreement	**26–28 November 2003** • Discuss Round 4 operating alternatives • Conduct trade-offs and document areas of agreement and disagreement • Identify Round 5 operating alternatives for modelling • Discuss monitoring and physical works in lieu of operational changes **21–23 June 2004** • Discuss Round 5 operating alternatives • Conduct trade-offs and document areas of agreement and disagreement • Discuss recommended monitoring program, physical works in lieu of operations, review period, and Water Use Plan triggers

APPENDIX C: LIST OF DOCUMENTS GENERATED DURING THE COLUMBIA RIVER WATER USE PLANNING PROCESS

This appendix summarizes the documents prepared during the Columbia River water use planning process. These documents are available in either hard copy or digital file format.

1.0 Meeting Documentation

Pre-reading material and meeting notes summarizing presentations, discussions and agreements at Columbia River Water Use Plan Consultative Committee and Subcommittee meetings are presented below. These documents are posted on the Columbia River Water Use Plan web site and can be made available through royal mail as required. In most cases draft notes were circulated for review followed by notes marked "final." Meeting notes were distributed as digital files and hard copies.

Meeting Date	Documents
Consultative Committee	
16–17 February 2001	Minutes
27–28 June 2001	Minutes
	Briefing Note 1 – Preliminary Objectives and Performance Measures
	Hugh Keenleyside Water Use Plan Preliminary Issues Report
	Columbia River Water Use Plans, Upper Columbia Preliminary Issues Report, Mica and Revelstoke Projects
	Columbia Overview Document – 31 May 2001
27–28 February 2002	Minutes
	Briefing Note 1(b) – Objectives and Performance Measures
	Briefing Note 3 – Summary of Performance Measures and Preliminary Alternatives
	Consequence Tables: a. PMs for the Reservoir-based Alternatives (Average Years Only) b. PMs for Reservoir-based Alternatives (Wet, Dry, Average Years) c. PMs for MCR-based Alternatives (Wet, Dry, Average Years)
	Detailed Tables: Recreation KIN, Navigation KIN, Recreation ARR/MCR, Recreation LCR, Flooding LCR
	PM Charts (separate Powerpoint attachment)
	Hydrology (separate Powerpoint attachment)
	Letter from J. O'Riordan – 19 February 2001
	Comments on Performance Measures by S. Hall and J. Jarvis
	Draft Mica Water Use Plan Terms of Reference
	Plots, 93, 96, 97
	Basics of Electricity Supply
	Operating Flexibility
	Introduction to Mica Water Use Plan Preliminary Alternatives
8–9 May 2002	Minutes
	Summary of Modelling
	Explaining the Costs of Alternatives 1, 2, and 11
	Overview of Impacts Arising from Ramping and Flow Restrictions at Mica and Revelstoke Dams.
	Summary of Environmental Studies Proposed For Mica-Revelstoke WUP
	Columbia River Treaty Information
	Summary of Learnings from the Weighting and Ranking Questionnaire
	Proposed Process for Evaluating Studies under Step 5

Meeting Date	Documents
11–13 June 2003	Minutes
	Briefing Note 1 – Overview of Phase 2 Work Components and Decisions
	Briefing Note 2 – Arrow Lakes Reservoir Alternatives
	Briefing Note 3 – Middle Columbia River Flow Alternatives
	Briefing Note 4 – Middle Columbia River White Sturgeon Flow Treatment
	Briefing Note 5 – Lower Columbia River Flow Components
	Briefing Note 6 – Kinbasket Reservoir Fish and Wildlife Monitoring
	Briefing Note 7 – Monitoring Proposals
	Briefing Note 7b – Details of Monitoring Programs for Lower Columbia River and Middle Columbia River
	Briefing Note 9 – Planting/Revegetation Options for Arrow and Kinbasket Reservoirs
	14 May 2003 Memo from Lee Failing
	Hydrographs
	Kinbasket Reservoir Community Group Summary Presentation
26–28 November 2003	Minutes
	Briefing Note 2 – Roadmap to Decisions for the Columbia River Water Use Plan
	Briefing Note 3 – Alternatives Descriptions
	Briefing Note 4 – Hydrographs
	Briefing Note 5 – Performance Measure Descriptions for Arrow/Lower Columbia River/Kinbasket Reservoir Balance
	Briefing Note 6 – Consequence Table for Arrow/Kinbasket/Lower Columbia River Balance
	Briefing Note 7 – Arrow Impacts on Nesting and Migrating Birds
	Briefing Note 8 – Arrow Impacts on Vegetation
	Briefing Note 9 – Flow Options for the Lower Columbia River
	Briefing Note 10 – Lower Columbia River Rainbow Trout Flows
	Briefing Note 11 – Lower Columbia River Whitefish Flows
	Briefing Note 12 – Fish Stranding in the Lower Columbia River
	Briefing Note 13 – Arrow/Lower Columbia River Tradeoff Summary
	Physical Works in Lieu of Operational Changes
	Briefing Note 15 – Mid and Lower Columbia White Sturgeon
	Briefing Note 16 – Revelstoke Minimum Flows
	Briefing Note 17 – Monitoring Proposals
	Briefing Note 18 – Reducing Financial Costs and Maintaining the Benefits of Alternatives
	Revelstoke Mosquito Issue Briefing Note
21–23 June 2004	Minutes
	Briefing Note 3 – Roadmap to Decisions for the Columbia River Water Use Plan
	Briefing Note 4 – Alternatives Descriptions
	Briefing Note 5 – Hydrographs
	Briefing Note 6 – Performance Measure Descriptions for Arrow/LCR/Kinbasket Reservoir Balance
	Briefing Note 7 – Performance Measure Results for MCA WUP Arrow Operating Alternatives
	Briefing Note 8 – Revised Stat Comparison Tool
	Briefing Note 9 – The Non-Treaty Storage Agreement and Arrow Alternatives
	Briefing Note 10 – Vegetation Performance Measure Summary
	Briefing Note 11 – Arrow Impacts on Nesting and Migrating Birds (June 2004)
	Briefing Note 12 – Proposals for Boat Ramps on Kinbasket and Arrow Reservoirs
	Briefing Note 13 – Proposal for Debris Management in Kinbasket and Arrow
	Briefing Note 14 – Proposal for Revegetation Works in Kinbasket and Arrow
	Briefing Note 15 – Proposal for Physical Works to Address Eroding Archaeological Sites
	Briefing Note 16 – Proposed Physical Works for Wildlife in the Mid Columbia River
	Briefing Note 17 – Lower Columbia White Sturgeon Experimental Plan
	Briefing Note 18 – Mid Columbia White Sturgeon Experimental Plan
	Briefing Note 19 – Lower Columbia River Rainbow Trout Flows
	Briefing Note 20 – Proposal for Revelstoke Minimum Flow Monitoring

Meeting Date	Documents
21–23 June 2004 cont'd	Briefing Note 21 – Impact of Flows on the Lower Columbia River's Recreation and Infrastructure
	Briefing Note 22 – Lower Columbia River Whitefish Flows
	Briefing Note 23 – Arrow Reservoir Operations
	Briefing Note 24 – Proposed Information Plans
	Briefing Note 25 – Fish Stranding in the Lower Columbia River
	Briefing Note 26 – Revelstoke Reservoir Operations
	Briefing Note 27 – Discussion of Financial Impacts of Arrow Operations
	Briefing Note 28 – Total Cost of WUP Package
	Assessment of Eligibility of Columbia River WUP Boat Ramp Projects
	Letter from Upper Columbia White Sturgeon Recovery Initiative to the Columbia River Water Use Plan Consultative Committee
Recreation Technical Subcommittee	
11 April 2001	Meeting Notes
	Pre-reading document prepared by Graham Long, Compass Resource Management
11 April 2002	Conference Call Meeting Notes
4 April 2003	Conference Call – Performance Measure Definitions for Access Days (Review)
	Pre-reading Package
	Mica Water Use Plan Hydrology Overview – March 2003 (revised)
	Mica-Revelstoke-Keenleyside (MCA) Water Use Plan Recreation Study – Final Report
	Mica Water Use Plan Information Sheet – Recreation Performance Measure – Recreational Quality
29 May 2003	Conference Call
	Overall Approaching for Assessing Alternatives during Mica Water Use Plan June Consultative Committee Meeting
	Note on Overall Summary and Trade-offs for Recreation Interests in the Columbia Water Use Plan
	Recreation Performance Measure Trade-offs
	Overall Alternatives and Performance Measures
	Bulldog Ramp Proposal – Cost Estimate
	Notes on Proposed Bulldog Creek Boat Ramp for Kinbasket Reservoir
8 October 2003	Briefing Note 1 – Alternatives Descriptions
	Briefing Note 3 – Performance Measure Descriptions
	Performance Measure Results
	Briefing Note 5 – Physical Works Overview – Boat Ramps
	Briefing Note 7 – Impacts of Sturgeon Experiments on Recreational Interests
24 March 2004	Minutes
	Pre-reading Package prepared by Siobhan Jackson, BC Hydro
	Arrow Boat Launch – Preliminary Assessment
	Arrow Reservoir Boat Launch Ramps – Preliminary Cost Estimates
27 May 2004	Minutes
	Briefing Note 3 – Alternatives Descriptions
	Briefing Note 4 – Hydrographs for June 2004 Consultative Committee meeting
	Briefing Note 5 – Performance Measure Descriptions for Arrow/Lower Columbia River/Kinbasket Reservoir Balance
	Briefing Note 6 – Consequence Table for Mica Water Use Plan
	Briefing Note 7 – Statistics Comparison Tool
	Briefing Note 8 – Impact of Flows on the Lower Columbia River's Recreation and Infrastructure
	Briefing Note 9 – Total Cost of Proposed Package
	Briefing Note 10 – Prioritizing of Proposed Boat Launch Extensions/Additions
	Briefing Note 10 – Prioritizing of Proposed Boat Launch Extensions/Additions – Addition
	Briefing Note 12 – MacDonald Creek Park Revisions
	Briefing Note 13 – Details Around Recreation Performance Measures
	Briefing Note 15 – City of Revelstoke Boat Launch Proposal
	Briefing Note 16 – Update on Debris Removal Strategy

Meeting Date	Documents
27 May 2004 cont'd	Briefing Note 17 – Impact of Rapid Drawdowns in Arrow on Recreational and Social Issues
Fish and Wildlife Technical Subcommittee	
24–25 October 2002	Minutes
10–11 April 2003	Minutes
	Alternatives and Performance Measure Descriptions
	MCA WUP Performance Measures Summary
	Consequence Tables Showing Performance Measure Values for each Alternative
	Performance Measure Charts
	Hydrology Overview, March 2003
	Alternatives Affecting Arrow Lakes Reservoir Outflow Regime
	Update on Bird Habitat Performance Measure Computation for Migratory Shorebirds
	Methodology for Shore and Breeding Bird Performance Measure Computation
	Lower Columbia Fish Performance Measures
	Description of Results for Middle Columbia River Minimum Flow Analysis
	Documentation of Preliminary White Sturgeon Spawning Habitat Suitability Model for the Middle Columbia River
	Literature Review of Load-Following Impacts on Stream Biota
	Mid Columbia River Hypotheses
	Alt 7 Notes: Alternates Affecting Arrow Lakes Reservoir Outflow Regime
	Water Use Planning Monitoring Program: Principles, Decision Tree, and Required Information
	MCR WUP Monitoring Presentation
	Monthly Breakdown of Minimum Flow Restrictions on Revelstoke Flows
	Preliminary Analysis of Minimum Flow Impacts on Revelstoke Reservoir
	TGP Performance Measures for the Mica Water Use Plan – A Derivation Summary
	TGP Performance Measures for the Columbia River – Water Use Planning Process – A Review and Evaluation of Relevant Information and Data
	Fish Habitat Performance measures to Evaluate Minimum Discharge Requirements for Revelstoke Canyon Dam
	Upper Columbia White Sturgeon Recovery Initiative Hypotheses to Water Flows, Reservoir Levels and Water Quality – October 2002
	Pelagic Carbon Production in Kinbasket, Revelstoke and Arrow Lakes Reservoirs – Final Report – October 2002
28–29 April 2003	Minutes
	Alternatives and Performance Measure Descriptions
	Consequence Tables Showing Performance Measure Values for each Alternative
	Performance Measure Charts
	Total Gas Pressure Performance Measure Results: Summary Note
	Lower Columbia River Summer Magnitude Performance Measure Charts
	Study 24 Briefing Note: Lower Columbia River Fish Performance Measures
	Lower Columbia River Flow Option Summary – Hypotheses
	Strategy for Managing Fish Impacts Associated with Flow Reductions at Keenleyside Dam, Lower Columbia River (working protocol)
	Hydrology Alt 11C Charts
	Middle Columbia River Performance Measure Results
21–22 May 2003	Arrow Lakes/Kinbasket Reservoir Alternatives
	Middle Columbia River Flow Alternatives
	Middle Columbia River White Sturgeon Flow Treatment
	Lower Columbia River Flow Components
	Inundation Statistics for the Revelstoke Reach and Implications for Riparian Vegetation
	Estimates of Mountain Whitefish Egg Stranding Mortality for Potential Columbia River Flow Reductions in 2002–2003
4 November 2003	Minutes
	Briefing Note 2 – Rainbow Trout Flows and Impacts on Arrow Wildlife/Vegetation
	Briefing Note 3 – Mid and Lower Columbia White Sturgeon
	Consequence Table for Arrow, Revelstoke, Kinbasket, Keenleyside Operations
	Middle Columbia River Monitoring 4 November 2003, Round 3

Meeting Date	Documents
4 November 2003 cont'd	Aquatic Monitoring Program Proposal
	Mica/Revelstoke Total Gas Pressure
	Revelstoke Total Gas Pressure Measurements Summary
	Total Gas Pressure Monitoring Downstream of the Revelstoke Dam
16–18 February 2004	Minutes
	Briefing Note 1 – Roadmap to Decisions for the Columbia River Water Use Plan, Spring 2004
	Briefing Note 3 – Alternatives Descriptions
	Briefing Note 4 – Hydrographs
	Briefing Note 5 – Performance Measure Descriptions for Arrow/Lower Columbia River/Kinbasket Reservoir Balance
	Briefing Note 6 – Performance Measure Results for Arrow/Kinbasket/Lower Columbia River Alternatives
	Briefing Note 7 – Lower Columbia River White Sturgeon Experimental Plan
	Briefing Note 7b – Mid Columbia River White Sturgeon Experimental Plan
	Briefing Note 8 – Revisions to the Rainbow Trout Flows
	Briefing Note 9 – Proposed Physical Works for Wildlife in the Mid Columbia River
	Briefing Note 9b – Proposed Wildlife Physical Works
	Briefing Note 11 – Arrow Impacts on Nesting and Migrating Birds
	Briefing Note 12 – Impact of Arrow Reservoir Backwatering on 5 kcfs Min Flow
	Kinbasket Reservoir Revegetation Studies
	Briefing Note 15 – Variability and Distribution of Costs
	Assessment of Effectiveness of Whitefish Flows for Conserving Mountain Whitefish Populations in Lower Columbia River, Revised Proposal 16 February 2004
18–19 May 2004	Minutes
	Briefing Note 3 – Alternatives Descriptions
	Briefing Note 4 – Hydrographs for June 2004 Consultative Committee Meeting
	Briefing Note 5 – Performance Measure Descriptions for Arrow/Lower Columbia River/Kinbasket Reservoir Balance
	Briefing Note 6 – Consequence Table
	Briefing Note 8 – A Summary of Modelling Fish Friendly Flows in the Lower Columbia River
	Briefing Note 10 – Vegetation Performance Measure Summary
	Briefing Note 11 – Arrow Impacts on Nesting and Migrating Birds (May 2004)
	Briefing Note 12 – Impact of Arrow Reservoir Backwatering on 5 kcfs Min Flow (Revised and Updated with an Addendum)
	Briefing Note 12 – Lower Columbia River Whitefish Flow Experiment
	Briefing Note 13 – Lower Columbia River White Sturgeon Experimental Plan
	Proposed Physical Works for Wildlife in the Mid Columbia River
	Briefing Note 17 – Operationalizing Arrow Reservoir Constraints
	Briefing Note 18 – Mosquito Production Issue
	Briefing Note 19 – Total Cost of Proposed Package
Wildlife Technical Subcommittee	
11 April 2001	Minutes
	Fish and Wildlife Performance Measures
30 September – 1 October 2003	Minutes
	Briefing Note 1 – Alternatives Descriptions
	Briefing Note 2 – Hydrographs
	Briefing Note 3 – Performance Measure Descriptions
	Performance Measure Results
	Revised Planting Options
	Assessment of Floating Vegetation in Arrow Reservoir
	Briefing Note 7 – Nesting Birds in Revelstoke Reach (Upper Arrow Reservoir)
	Briefing Note 10 – Rate of Predicted Vegetation Responses to Altered Hydrology
	Briefing Note 13 – Columbia River Nesting Bird Summary
	Evaluation of the Impact of Reservoir Operations on Nesting Birds in the Revelstoke Reach
	Information Sheet

Meeting Date	Documents
30 September – 1 October 2003 cont'd	Great Blue Herons at Waldie Island (Castlegar)
	MCA WUP Wildlife Monitoring
	Canadian Wildlife Service Presentation
	Arrow Vegetation Monitoring Recommendations
28 October 2003	Minutes
	Briefing Note 1 – Arrow Impacts on Vegetation
	Briefing Note 2 – Arrow Impacts on Nesting Birds
	Briefing Note 3 – Reducing Financial Costs and Maintaining the Benefits of Alternatives
	Briefing Note 4 – Water Use Planning Monitoring Program: Principles, Decision Tree, and Required Information
	Briefing Note 5 – Vegetation Monitoring Program Proposal
	Briefing Note 6 – Wildlife Monitoring Program Proposal
	Arrow Vegetation Monitoring Recommendations – Projected Cost summaries Over Time
	Arrow Planting Prescriptions
	Briefing Note 8 – Potential Physical Works to Benefit Migratory Birds in Lieu of Operational Changes
	Revelstoke Mosquito Issue Briefing Note
Fish Technical Subcommittee	
12 April 2001	Minutes
	Fish Wildlife Performance Measures
	Performance Measure Backgrounder
30–31 May 2001	Minutes
	Ecosystem Management, Ecological Integrity, and Ecosystem Health Backgrounder
	Draft Performance Measure Information Sheets
	Management Priorities Discussion Papers
	Letter from MCA WUP Project Manager on Project Budget and Step 5 Study Criteria
	Fish Subgroup Draft Terms of Reference
	Fish Life History Periodicity Charts
	Memo: Flushing Flow Rates
	Memo: Habitat Modelling Limitations below Keenleyside
	Memo: Tourism Action Society of the Kootenays
	Periodicity Tables for Arrow Lakes Reservoir, Kinbasket Reservoir, Revelstoke Reservoir, Lower Columbia River
	Revelstoke Dam Unit 5 Project Aquatic Resources Scoping and Potential Impact Review
	Arrow Tributary Access
14–15 February 2002	Minutes
27 January 2003	Lower Columbia TGP Conference Call Notes
11 July 2003	Minutes
	Middle Columbia River White Sturgeon Flow Treatment
	Pre- and Post Regulation Flows over Steamboat Rapids
	Lower Columbia River White Sturgeon Flow Treatment
	Lower Columbia River Erosion/Flooding Thresholds
	Upper Columbia White Sturgeon Recovery – Implementation Plan, 2004–2006
	Upper Columbia White Sturgeon Recovery Initiative Project Tracking 1 April 2003 – 31 March 2004
9 September 2003	Minutes
	Strategy for Managing Fish Stranding Impacts Associated with Flow Reductions at Keenleyside Dam, Lower Columbia River
	Review of Interstitial Stranding Assessment Study Design
22–23 September 2003	Minutes
	Briefing Note 1 – Alternatives Descriptions
	Briefing Note 2 – Alternative Hydrographs
	Briefing Note 3 – Performance Measure Descriptions
	Briefing Note 4 – Performance Measure Results
	Briefing Note 5 – White Sturgeon Conservation Fish Culture Information Sheet
	Briefing Note 6 – Revelstoke Emergency Drawdown

Meeting Date	Documents
22–23 September 2003 cont'd	Briefing Note 7 – Entrainment (Kinbasket, Revelstoke, Arrow Lakes Reservoirs)
	Briefing Note 8 – Monitoring Program
	Briefing Note 9 – White Sturgeon Experimental Plans
	Briefing Note 10 – Great Blue Herons at Waldie Island (Castlegar)
	Briefing Note 11 – Revised Cost of Revelstoke Minimum Flows
5 November 2004	Minutes
Cultural and Heritage Subcommittee	
7 June 2001	Minutes
12 July 2001	Minutes
21 February 2002	Conference Call Notes
18 November 2002	Site Visit to Arrow Lakes Reservoir
18–19 November 2002	Minutes
24 April 2003	Conference Call Notes
7 October 2003	Minutes
4 May 2004	Briefing Note 1 – Physical Works Table
	Briefing Note 2 – Monitoring Table
	Briefing Note 3 – Alternatives Descriptions
	Briefing Note 4 – Hydrographs
	Briefing Note 5 – Consequence Table
	Briefing Note 6 – Performance Measure Descriptions
	Draft MCA Information Sheet – 3 November 2003
	Draft Information Matrix for Water Use Plan Monitoring Requests
	Draft Integrating Traditional Ecological Knowledge and Traditional Use Information in the Columbia Water Use Planning Process
	Parking Lot Mica Water use Plan – Modified
	Heritage Alternatives Update – Modified
	Alternatives and Performance Measures – April 2003 – Modified
	MCA Information Sheet – 30 April 2003
	Terms of Reference for the Archaeological and Heritage Overview of the Columbia Reservoirs
	Cultural Research Proposal – Running Horse Consulting
	Terms of Reference for the Columbia Archaeological Inventory Proposal
Revegetation Workshop	
26 May 2003	Minutes
	Vegetation Change in the Arrow Lakes Reservoir
	Arrow Planting Costs
	Potential Areas for Vegetation Establishment in Kinbasket Reservoir
	Selected Plants of Past Importance To First Nations in the Columbia Basin.
Financial Technical Meeting	
1 June 2004	Briefing Note 1 - Variability of Costs
	Briefing Note 2 - High Cost Years
	Briefing Note 3 – Financial Impact on LCR Power Generation
	Briefing Note 4 – Discounting Costs over Time

2.0 Other Documents Prepared for the Columbia River Water Use Planning Process

The following outlines documents that were prepared for the Columbia River Water Use Plan. This includes studies that were undertaken as part of Step 5 of the process, as well as other documents required to support work of the Technical Subcommittees and decision making of the Consultative Committee.

Author	Date	Document
AIM Ecological Consultants	2005	Mica-Revelstoke-Keenleyside Water Use Plan – Potential Areas for Vegetation Establishment in Arrow Lakes Reservoir
AIM Ecological Consultants Ltd.	2004	Vegetation Change in the Arrow Lakes Reservoir – A Summary of Past Studies.
AIM Ecological Consultants and CARR Environmental Consultants	2003	Mica-Revelstoke-Keenleyside Water Use Plan – Potential Areas for Vegetation Establishment in Kinbasket Reservoir
Aspen Applied Sciences	2002	TGP Performance Measures for the Columbia River Water Use Planning Process – A Review and Evaluation of Relevant Information and Data
Aspen Applied Sciences	2003	TGP Performance Measures for the Mica Water Use Plan – A Derivation Summary
Axys Environmental Consulting and Manning Cooper & Associates	2002	Mica-Revelstoke-Keenleyside (MCA) Water Use Plan – Breeding Bird and Migratory Shorebird Use of the Revelstoke Wetlands
Axys Environmental Consulting and Gustavson Ecological Resource Consulting	2002	Mica-Revelstoke-Keenleyside (MCA) Water Use Plan – Recreation Study
BC Hydro	November 2000	Hugh Keenleyside Preliminary Issues Report
BC Hydro	February 2001	Mica/Revelstoke Preliminary Issues Report
BC Hydro	August 2002	Proposed Consultation Process Report: Columbia River Water Use Plan
Carr	2003	Draft Conceptual Proposal for Mica-Revelstoke-Keenleyside Water Use Plan Fish and Wildlife Technical Subcommittee – Creation of Elevated Habitat Enhancement Islands in Revelstoke Reach
Choquette	2002	Archaeological Component of Arrow, Mica and Revelstoke Reservoirs. Water Use Planning Process.
Clough and Gillespie	2003	Spallumcheen (Splatsin) Traditional Use Study – Columbia River
Cooper, D. and Korman, J.	2003	Literature review of load-following impacts on Stream Biota. Report prepared for BC Hydro by Ecometric Research Inc. 18pp.
Ernst, A., Running Horse Consulting	December 2001	Columbia WUP Literature Review Report
Ernst, A., Running Horse Consulting	2002	Columbia WUP Culture and Heritage Report (Upper Columbia Region)
Failing, Lee. Compass Resource Management	2001	Review by Fish Technical Subcommittee
Failing, Lee. Compass Resource Management	June 2001	Briefing Note 1 - Preliminary Objectives and Performance Measures
Failing, Lee. Compass Resource Management	January 2002	Briefing Note 1b - Mica Water Use Plan Objectives and Performance Measures
Failing, Lee. Compass Resource Management	January 2002	Briefing Note 2 - Fish and Wildlife Performance Measures and Preliminary Operating Alternatives
Failing, Lee. Compass Resource Management	January 2002	Briefing Note 3 - Summary of Performance measures and Preliminary Alternatives

Author	Date	Document
Lee Failing. Compass Resource Management	October 2002	Study 24 Briefing Note. Lower Columbia River Fish Performance Measures
Failing, Lee. Compass Resource Management	2003	Study 24 Briefing Note. Lower Columbia River Fish Performance Measures
Failing, Lee. Compass Resource Management	February 2003	Briefing Note 4 - Summary of Phase 1
G.G. Oliver	2001	2001 Fish Access Assessment of Selected Tributaries to Kinbasket Reservoir
Golder Associates	2003	A Feasibility Assessment of Proposed Water Use Plan Flow and Turbidity Experiments to Increase Natural Recruitment of White Sturgeon
Green	2002	Upper Columbia White Sturgeon Recovery Initiative Hypotheses to Water Flows, Reservoir Levels and Water Quality
Keefer	2002	Ktunaxa-Kinbasket Treaty Council Columbia River Water Use Planning Traditional Use Study
Korman and Lin	2003	Description of Results for Middle Columbia River Minimum Flow Analysis
Korman and Lin	2003	Documentation of Preliminary White Sturgeon Spawning Habitat Suitability Model for the Middle Columbia River
Korman et al.	2002	Fish Habitat Performance Measures to Evaluate Minimum Discharge Requirements for Revelstoke Canyon Dam
Leake	2002	Preliminary Analysis of Minimum Flow Impacts on Revelstoke Reservoir
Perrin	2001	Implications of Reservoir Operational Changes to Littoral Productivity in Arrow Reservoir
RL&L Environmental Services, et al.	2001	Environmental Information Review and Data Gap Analysis. Volume 1: Upper Columbia. Volume 2: Lower Columbia
Robertson Environmental	2001	Habitat Associated with the Genelle Gravel Bars, Columbia River
Stockner	2001	Some Implications of Reservoir Operation on Littoral and Pelagic Production in Upper Columbia Reservoirs
Stockner and Korman	2002	Pelagic Carbon Production in Kinbasket, Revelstoke and Arrow Lakes Reservoirs
Vonk	2003	Strategy for Managing Fish Impacts Associated with Flow Reductions at Keenleyside Dam – Working Draft

APPENDIX D: REVIEW COMMENTS AND SIGNOFF ON THE DRAFT CONSULTATIVE COMMITTEE REPORT

Comments were provided by the following Consultative Committee members:

Name	Organization
Terry Anderson	Ministry of Water, Land and Air Protection
Chris Beers	Columbia-Kootenay Fisheries Renewal Partnership
Judy Bosh	Village of Valemount & Property Owner
Mindy Brugman	MCI & Environment Canada
Penny Dewar	Area Resident
Bruce Duncan	Columbia Power Corporation
Jim Forbes	Times Tours Owner
Fred Fortier	Secwepemc Fisheries Commission
Kindy Gosal	Columbia Basin Trust
Bill Green	Canadian Columbia River Inter-Tribal Fisheries Commission
Helmut Klughammer	Area Resident
Francis Maltby	Area Resident
Shelley Murphy	Ministry of Energy
Ron Oszust	Columbia Shuswap Regional District
Paul Peterson	Regional District of Central Kootenay, Director, Area K
Randy Priest	Property Owner on Kinbasket Reservoir
Jason Quigley/ Steve Macfarlane	Fisheries and Oceans Canada
Bob Taylor	Louisiana-Pacific Canada Ltd.
Warren Ward	Mica Marine Ltd.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

WATER LAND & AIR PROTECTION
#401 - 333 VICTORIA ST
NELSON BC V1L 6A2

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process. WITH THE PROVISO THAT THE CONCERNS OUTLINED IN THE ATTACHED LETTER ARE ADDRESSED.

Name & Organization: WATER LAND & AIR PROTECTION

Signature: [signature]
TERRY ANDERSON

BRITISH COLUMBIA

File: 200-20/BCH-CWUP
34270-20/CRS

BC Hydro
E16 – 6911 Southpoint Drive
Burnaby BC V3N 4X8

Dear Sue Foster:

RE: Comments on Columbia Water Use Plan Consultative Committee Report

I am writing to provide comments on behalf of the Ministry of Water, Land and Air Protection with regard to the Columbia Consultative Committee report that was provided February 25, 2005. Please accept my apologies for the delay in our response, however, it is a large document and some of the elements of that report have complicated our review.

My general impression is that the report is well written and BC Hydro put a lot of effort into the report. The Columbia WUP was a long and complicated process, and the BCH project team should be commended for their work on this project.

As you are aware from conversations and e-mails between MWLAP and BC Hydro personnel, my office has a number of concerns with respect to this report, which I shall detail in this letter. MWLAP comments on the CC report are split into three sections A) Lower Columbia River white sturgeon, B) incorporation of ALGS and, C) general comments.

A) LCR white sturgeon

As you may be aware white sturgeon recovery is a very significant concern for my ministry, and the discrepancies regarding the CC report may create future implications for white sturgeon funding. Consensus was an important part of the WUP process, however, it appears that the nature of the consensus decision that MWLAP participated in has been altered within the CC report. This is quite a significant concern. An e-mail has already been provided to your office detailing concerns about LCR white sturgeon and also providing background information corroborating the views expressed here.

Ministry of Water, Land and Air Protection | Kootenay Region Environmental Stewardship | Mailing/Location Address: #401 333 Victoria Street Nelson BC V1L 4K3 | Telephone: 250 354-6344 Facsimile: 250 354-6332

There are two principle issues of concern:

a- Flexibility in the approach to non-operational alternatives for lower Columbia white sturgeon, and;

b- Contributions to the conservation fish culture program in conjunction with contribution to non-operational alternatives.

a) Flexibility in the approach to non-operational alternatives for lower Columbia River white sturgeon

This issue arises throughout the document, but particularly on page 9 and pages 7-125,126, and 8-27, because the CC report does not capture the need for flexibility regarding the turbidity experiment that is proposed for the LCR white sturgeon.

Given the time that has passed since this meeting it is certainly a challenge to evaluate the details of what was, or was not, agreed to. However, I have referred back to my extensive notes, as well as e-mails sent both by me and Steve McAdam shortly after the June 2004 CC meeting in order to clarify the nature of the decisions we had made. The meeting minutes are also referenced since there are a number of points where the interpretation presented in the CC report does not agree with the meeting minutes.

The minutes indicate on page 48 that the need for flexibility in the lower Columbia planning was discussed at the June 2004 meeting. The comments recorded for CC members are very informative regarding whether flexibility with respect to non-operational alternatives was agreed to. Two CC members who endorsed the plan commented specifically about the flexibility. One thanked the table for granting the flexibility, the other is reported to have said "with all the same comments on the need for flexibility". Another 5 participants accepted the plan, but expressed reservations about its "open endedness". As you are well aware one of the options regarding WUP recommendations was to accept them, but state the cause of reservations preventing full endorsement. These 5 respondents apparently stated that they had reservations about the flexibility that had been requested, since the need for flexibility did not clearly define alternatives to turbidity tests. However, even with this uncertainty they accepted the proposal. This clearly indicates that there was consideration of flexibility within the discussions and within the consensus decision.

MWLAP is very concerned that the agreement that we thought we had achieved at the June 2004 meeting is significantly different when presented in the text of the CC report (due to its failure to mention the need for flexibility). The absence of this provision could lead to a lack of funding for other more suitable non-operating alternatives such as was discussed, and in our view agreed to, at the June 2004 meeting. We would therefore like to see the text of the CC report altered, or an addendum issue with respect to this concern. In the reports present form, without acknowledging the need for flexibility to undertake suitable non-operational mitigation, the CC report presents an apparent consensus decision which MWLAP does not feel it agreed to at that time.

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b) Contributions to the conservation fish culture program for lower Columbia River white sturgeon.

This aspect of my concerns relates to whether the CC agreement regarding a contribution to conservation fish culture operations is in addition to the funding for non-operational options (turbidity or a better option), or whether, as stated in the draft CC report (e.g. page 9, 7-126 and 8-27), the contribution to the conservation fish culture program was in lieu of contributions to a non-operational solution (i.e. is it the non-operational option **and** fish culture, or is in the non-operational solution **or** fish culture). The CC report is internally inconsistent with regard to this matter, but I understand that BC Hydro suggests that contributions to fish culture are in lieu of contributions as suggested on page 9 and page 8-27.

Again the written records of e-mails sent shortly after the meeting and my detailed notes indicate that both components were agreed to, as do the minutes and some of the text in the CC report. Comparison of page 50 in the minutes and page 7-126 in the CC report indicates that the decision was outlined to include both elements (and) in the minutes, but this has been changed to indicate fish culture as an alternate activity (or) within the CC report. Given that the minutes are the written record of the meeting it seems inappropriate that the CC report should alter the nature of a decision recorded in those minutes.

Table 7-68 on page 7-132 indicates the total annual costs for the Columbia WUP, and the committee's level of support for this package is presented in Table 7-69. In this table both the annualized cost of the turbidity experiment and the contribution to fish culture are included, indicating that the committee did indeed consider both annualized costs together, and unanimously approved of both together, rather than one in lieu of the other. Similarly page 7-125 indicates that the conservation fish culture is an additional element to the proposal.

Based upon the attached e-mails and my notes, and the noted internal inconsistency in the CC report it seems fairly apparent that a contribution to the conservation fish culture program was to be done in conjunction with non-operational alternatives, and not in lieu of them. I hope that the draft CC report can be amended, or an addendum issued to correct this discrepancy.

B) Arrow Lakes Generating Station

The issue of how the Arrow Lakes Generating Station would be incorporated into this WUP was a challenge throughout this process, and information provided by BC Hydro reps appeared to shift over the course of the WUP. Although the document appears to provide a reasonable representation of the ultimate decisions that were made with respect to the ALGS plant, the CC report does not accurately represents the discussions regarding this facility that occurred throughout the process.

During the initial phases of this WUP some participants inquired whether impacts to the ALGS plant would be included within this WUP. My recollection is that they were told that it would not, because it was not a BC Hydro facility. There was a relatively laborious transition from that to the ultimate decision that owners of the ALGS facility must be made whole for any losses incurred as a result of the WUP (which basically means that the WUP fully includes impacts at

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ALGS). Unfortunately the CC report presents issues with respect to the ALGS facility only in the context of the later half of the WUP process, and does not indicate any of the challenges that were presented to this interpretation.

The CC report also presents the ALGS facility along side the BC Hydro facilities. It is very important to clarify that the WUP process was designed to address BC Hydro water licences, and even addressing the ALGS facility represents an anomaly for the WUP process. The business relationship between BC Hydro and the owners of ALGS create clear economic links between the operations of the BC Hydro system and ALGS operations. However, the CC report fails to mention the conflicts that exist between this sort of operational arrangement and the project approval certificate for the ALGS facility which contains some wording regarding operational restrictions. These concerns certainly formed part of the discussion within the WUP process, but are not reflected in the CC document, which, if the CC document is intended to fully reflect the nature of the discussions, they should be. As stated previously the CC report does provide a sufficiently accurate representation of the final outcomes with respect to this facility.

C) General Comments

Other than those two larger issues I have a couple of concerns regarding the CC document that I would like to address.

On page 5 the report indicates that there would be no compliance monitoring for Arrow operations, however, various aspects of the program will require reporting. I would appreciate it if BC Hydro could identify how we will achieve such reporting, if they will not be subject to compliance monitoring. Consultation with agencies perhaps through COFAC may also be required.

Another apparent discrepancy in the document is how it addresses emergency conditions. For example, page 7-57 indicates that a minimum flow at Revelstoke might be disrupted under extreme or emergency situations. Emergencies have been clearly stated to be outside of WUPs, and are therefore circumstances when WUP requirements may not be met. That was established as an early policy, and the kinds of factors considered to be emergencies have been outlined. While some may equate the terms extreme and emergency, we have no definition of what may constitute extreme conditions. MWLAP certainly agrees that this recommendation applies to emergency conditions. However, I do not feel that we agreed that it should apply to extreme conditions. I hope that the wording could be changed accordingly so that extreme conditions are not included as grounds for not achieving the minimum flow or other recommendations made by the CC.

In addition, there is a discrepancy with the Physical Works section of Table 7-132 (also Table 3). The funding for the LCR white sturgeon hatchery should be $0.19 ($188,000) as per the last sentence in paragraph 2 page 7-125.

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Where appropriate, and not included, I would like to see the tables in Chapter 8 also reflect the annualized costs.

Thank you for the opportunity to comment on the Columbia Consultative Committee report.

Yours truly,

Terry Anderson
Ecosystem Officer

TA:ar
cc: Ted Down
Steve McAdam
Wayne Stetski, MWLAP, Regional Manager, Kootenay Region, Cranbrook

To:

Sue Foster
.Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

ANDREAS ARTZ

ABORIGINAL INTEREST ADVISOR

LITTLE SHUSWAP INDIAN BAND

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: ANDREAS ARTZ LITTLE SHUSWAP INDIAN BAND

Signature:

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

CHRIS BEERS

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: CHRIS BEERS COLUMBIA KOOTENAY FISHERIES RENEWAL PARTNERSHIP

Signature:

Columbia Kootenay Fisheries Renewal Partnership

Sue Foster
Project Manager
Water Use Planning
BC Hydro
E16-6911 Southpoint Drive
Burnaby, BC
V3N 4X8
April 8, 2005

Dear Ms. Foster,

Thank you for the opportunity to review the draft Columbia River Water Use Plan Consultative Committee Report. Overall, I found the report reflects the Consultative Committee (CC) discussions and decisions for the Columbia River Water Use Plan (WUP). There are two comments I would like to have added through this letter:

1) The role of operations on entrainment was considered by the Fisheries Technical Committee and was not included in this WUP because of the indication that a provincial multi-agency team would be reviewing entrainment on a province wide basis. I would like to ensure that the issue of entrainment is identified as important. The Columbia-Kootenay Fisheries Renewal Partnership hope that by the end of this WUP there will be sufficient information available to make better decisions regarding the balance between upstream losses and potential downstream benefits of entrainment and the role of operations on magnitude of entrainment. Note, an assessment of spawning bull trout in Kinbasket Reservoir using radio telemetry located 3 of 30 radio tags downstream of Mica Dam. This indicates that entrainment may have substantial impacts on adult bull trout in Kinbasket Reservoir, though it is unknown if this rate was related to operations. Hence, our concern that entrainment may have substantial impacts to a blue listed species and efforts to reduce those effects are needed.
2) Throughout the process and reflected in the draft report, some Consultative Committee members indicated concerns regarding the high cost of implementing changes to operations (e.g., through foregone revenues) and monitoring. CC members requested that these costs be put in context through an indication of the percent of overall revenue from Columbia River facilities relative to the costs that would be incurred if various alternatives were implemented. This information was never provided; therefore the high costs of alternative operations and monitoring are never placed in context with the revenues generated by Columbia River facilities. I recognize that the costs of alternatives and monitoring are substantial and this additional information may not have changed the decisions of

MAIN OFFICE
#7468 Mission Road, Cranbrook, British Columbia V1C 7E5
Phone (250) 417-FISH (3474) Fax (250) 489-5760

REVELSTOKE OFFICE
#200 Suite C, Campbell Avenue
P.O. Box 2008, Revelstoke, British Columbia V0E 2S0
Phone (250) 837-2124 Fax (250) 837-2190

the CC. However, I believe that if the proportional changes in revenue were presented, it would have increased the comfort level of some CC members concerned with high costs associated with these recommendations.

Thank you for the opportunity to participate in this process. It was very interesting to hear the values and concerns of people throughout the Columbia Basin representing a range of interests on how water should be managed. It also was an exciting opportunity to provide input on how to incorporate non-Power values into management of flows and reservoir levels in the Columbia River.

Finally, congratulations to the BC Hydro team - this was a large undertaking and I think they did an excellent job in obtaining and presenting information clearly and in a timely manner.

Sincerely,

Chris Beers
CKFRP Stewardship Coordinator

From: Chris Beers [chris.beers@telus.net]
Sent: Friday, April 08, 2005 4:12 PM
To: sue.foster@bchydro.bc.ca
Cc: Bill Green
Subject: WUP Comments

Importance: High

Hi Sue,

Thanks for the opportunity to review the WUP CC draft report. I have attached a letter that I would like included in the appendix with a couple of comments from CKFRP related to this WUP. I will fax the sign off sheet today and mail a hard copy of the sign off sheet and a signed copy of this letter for your files. Below, I have a few specific comments. These are not meant to be gramatical, but where I felt the wording was not clear with the intent I recall.

- Excecutive Summary (Page 6) Table 2 - wildlife - bring Arrow to 438 m or lower for migrating birds - not fowl - this is correct in body of report
- Executive Summary & throughout the report, can the units be standardized, or both presented. Frequently one place metres are used and others feet.
- Page 3-9 Columbia Indian Bands - should be Columbia Lake Indian Band & they have changed their name to Akisq'nuk First Nation since this process was initiated.
- Page 4-8 Table 4-4 Down-E Timber - the name is Downie Timber and actually Wood River Forest Products in Kinbasket area
- Page 4-19 I thought the importance of mud flats here was questionable - not the same productivity as costal mudflats. The comments on 5-12 and 5-13 are consistent with my recollection.
- Page 4-31 - I think kokanee are indigenous to Arrow Lakes, probably not Kinbasket
- Page 5-16 - fish behaviour to avoid elevated TGP - can this be reworded? My understanding of this aspect is fish can't detect TGP, it is other aspects of behaviour that incidentally reduce exposure to TGP.
- Page 5-17 & 5-18 "Opportunities to influence other species were also identified, but it was acknowledged that they were either of lower probability or simply uncertain because there is a possibility that other factors may limit their population (e.g., bull trout, burbot, white sturgeon)." Can this be reworded as it seems to me to imply that bull trout, burbot and sturgeon are limiting other species. That is not the case, it was a combination or other factors may be limiting bull trout, burbot & sturgeon (as I recall).
- Page 7-27 footnote - the concern was to limit impacts of recreation, not to limit planting.
- Page 7-28 - "key interest... sculpins and dace could be addressed through a more passive approach consisting of life history studies and monitoring..." I thought the life history and monitoring were because we couldn't recommend flow options or impacts because of limited information on these species.
- Page 7-38 Table 23. 11F - compromise between 11-B and 11-D
- Page 7-52 - comments and scoring for Bob Taylor don't match - can this be checked?
- Page 7-77 Benefits for Mid Columbia Boat Ramp. Not sure why access to Revelstoke Reservoir is mentioned - Revelstoke Reservoir is not connected to mid-Columbia (for recreation use - water passes through turbines or over spillway, very infrequently), very different recreation options in the two areas. The other options for boat launches for mid Columbia access are informal access within the Revelstoke Wetlands (that I believe we would like to discourage) or formal launch 50 km away at Shelter Bay.
- Page 7-94 7.7.5 should this read "Vegetation Monitoring"?
- Page 7-114 - is the level of support "S" a typo. If not, what does it stand for - didn't see it within the list or anywhere else.
- Page 7-131 - Fred is listed as "Shuswap Fisheries Nation" - should be "Secwepemc Fisheries Commision"
- Pages 4-34 & 7-129 juvenile bull trout entrainment. should get rid of juvenile part, adults are entrained as well - through Mica - in a study with tagged adult bull trout, 3 of 30 tags were relocated downstream of the dam. I highly doubt the adults would survive passage through the turbines, or that a mechanism other than entrainment caused the tags to end up downstream of the dam.

Again, thank you for the opportunity to participate in this process. It was very interesting and congratulations to the BCH team - this was a large undertaking and I think they did a very good job in obtaining and presenting information clearly and in a timely manner.

Cheers,
Chris Beers, Aquatic Ecologist
Columbia-Kootenay Fisheries Renewal Partnership &
Canadian Columbia River Inter-Tribal Fisheries Commission
Phone: (250) 837-2124 Fax: 250-837-2190
chris.beers@telus.net

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

DON BENNETT
Box 628 Valemount BC
V0E 2Z0

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Valemount Marina Association.

Signature: DK Bennett

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

GAIL BERNACKI
PO BOX 2699
Revelstoke, BC V0E 2S0

Columbia River Water Use Plan Consultative Committee Report

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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 Columbia River water use planning process.

Name & Organization: CITY OF REVELSTOKE

Signature: Gail Bernacki

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

JUDY BUSH

VILLAGE OF VALEMOUNT

Columbia River Water Use Plan Consultative Committee Report

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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 Columbia River water use planning process.

Name & Organization: JUDY BUSH, VILLAGE OF VALEMOUNT

Signature: Judy Bush

I would like the following verbatim comments, in addition to what is noted in the draft Columbia River Water Use Plan Consultative Committee Report, to be captured within an appendix within the Report. (Preference is to have this done by e-mail to sue.foster@bchydo.bc.ca if possible)

Mention should be made that money needs to be allocated annually by BCH for debris management.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:
Gordon Boyd
Keenleyside

9 March 2005

Columbia River Water Use Plan Consultative Committee Report

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Name & Organization: Gordon Boyd, BCH Corp. Rep.

Signature:

Mmb comments for Columbia water use plan April 8 2005
Comments on the final draft Volume 2 comments followed by volume 1.

By Dr. Mindy Brugman, Revelstoke resident

1. I note through letters in Volume 2… the apparent frustration that the CWS has not participated as much as desired in the WUP although efforts have been initiated. It seems to me that due diligence on the part of BCHydro WUP committee was made. The information included in this report addresses the major concerns. When reviewing this document each of us involved look carefully to what is being presented and hopefully through this involvement we have identified and evaluated the issues that CWS would have done if they had time to work closely on the project. I hope that is the case. That is the premise that I am reviewing this material on. Staff and personnel are limited and it is difficult for people stationed in Vancouver or Victoria to come to Revelstoke or regions for a meeting. . It is understandable to me that if this material was being prepared properly they should only have to review the material. From the literature I have seen from Steven Hureau that the CWS has been kept abreast of information they were concerned with related to migratory birds and potential for vegetation reestablishment. Patricia Vonk in 2003 also gave a very thoughtful letter – and I agree with her concerns about specie tradeoffs based on models that are poorly informed. Basically the sensible approach is stable areas during spring nesting and migration and also be low during fall migration to provide places for feeding and rest. I see no mention though of the impact of the airport on the planning for migratory birds and water levels. I am not sure if the CWS is aware of the growing development in the region and the progressive stress the area around the airport will have in future years…and the likely push for expansion of the airport runway. This seems not be adequately considered…but I will examine all the documents. If it was there would be islands make for resting places for birds that are away from motorized vehicles and also the airport, and near food sources – and located for effective use for water levels planned.. Feb 17 2003 bird islands were emphasized originally for the CC and should be followed up.

2. Conflicting concerns about – and still exist. The goal here is to find the best way to obtain a solution so one may move ahead in a proper manner which will hold up to the test of time and scientific scrutiny and is cost effective. Concerns regarding – requests that are misguided in their goal…may be biased to create funding opportunities in an economically disadvantaged are. May be aimed at pleasing local residents without proper care for the environment. Note there are many conflicting interests in the region. Boaters want more ramps, fisherman want more access to fish - more and larger fish, environmentalists want much the same thing as fisherman – but want fishing access limited to preserve stocks and environmental quality, property owners want more shoreline stability, local residents want less air pollution due to wind blown dust and better vistas and fewer fluctuations in water level and less dramatic drawdown, motorized recreationists want more access to dry floodplain regions, environmentalists want access by horses and motorized vehicles limited to save wildlife, some fisheries

experts want more chemicals and turbidity compounds introduced in an attempt to return the river to natural conditions, other scientists and knowledgeable resident disagree with adding more compounds and chemicals and more hatchlings to the waterways when there are other options available and there is not international independent recognition by scientific communities that these compounds and chemical would help the fish more than other means which are less invasive.

3. From this huge document it is hard to find exactly what we have done that is progressive and what is simply due to those who keep pounding desks to have their views heard. The final decision should not be by those who are the most persistent- or have the time/support to keep going to endless meetings - – it should be by those who have the best solutions and the best contributions to a well designed water use plan for the economy, environment, local population and wildlife.

4. 4. CBT comments Jan 31 2005 regarding negative impacts on Duncan and other joint ventures in the Columbia Kootenay systems is noted. Adverse impacts on CBT activities from operation changed by the WUP of BY Hydro are not desired – and should be clearly stated – and be accounted for . These impacts were very vague. It seems to me that BC Hydro has agreed on May 6, 2004 to be responsible for any adverse effects on power entitlements and other benefits to CBT. I wish this was more clearly stated. Seems like a black box of responsibility – and for a reason for not addressing the main issues of the WUP .. More clarity on the impacts of this agreement are required.

5. It is somewhat unfortunate that there is so much politics in this endless process – such as the letter form the regional district of Central Kootenay Cct 3, 2003 . But perhaps in their region there was no public consultation. But I am glad they are concerned that the biological issues must be balanced with the human and social issues. I should add the hydrological issues and non-biological environmental issues as well need a better balance. But consultation is important the WUP BC Hydro personnel did their job effectively as best they could under the circumstances.

6. I felt Lee failing and Basil Stumborg did a very fine job in this effort, as well as Sue Foster.

7. I share the concern that adequate funds be allocated for monitoring – and that the monitoring be properly planned. Also that the Columbia River treaty violations are not well stated as to how they affect possible choices. I know this is an iterative procedure..but I agree with the concerns of WLAP stated by Steve Mcaddam Nov. 2002, and supported by Tola Coopper DFO.

8. Very good summary M1-26 to address the Columbia Treaty and history of the Columbia River and context to questions posed above by Al Geissler BC Hydro. This only mentioned snow melt and not glacier melt – and did not mention

climate change impacts on the region. The climate variability was suggested by the plots indicating that 1945-1973 time periods had about twice the discharge in the Columbia that the time period 1975 to 2005 (page M10 Feb 17 2005 report) . Variability in the 30 percent inflow at Revelstoke is from local sources – with 70% above is likely ok…but does not address seasonal and decadal variations in variability. The loss is glacier ice mass was not mentioned – and comprises an important impact on the sustainability of river flow levels in the summer – and timing and duration of freshet. The value of the river flow at a various times in the year for users downstream was underemphasized. They will undoubtedly put a large strain on any agreement in the WUP. It is critical to know their legal right to this water in a changing climate. There is a proposal to build another water storage dam near Yakima for water retention(pumping water up from the Columbia for their storage use) – and this may present large problems for those of us on the Canadian side of the Columbia River if the WUP does not hold strong to environmental, social and economic values in Canada. The water temperature of the entire Columbia river may be affected but such a dam in Washington state- and further limit our options to adjust to climate and weather variability for a healthy fish and wildlife population. These issues should be included in the 5 to 30 year planning climate, weather and development on the US side of the border related to new dams and water use pressures). Impacts on the temperature of the water is critical – probably more so than the turbidly or nitrate levels. Anadromous and local native fish populations require proper water temperatures – as well as water levels. I see little discussion regarding impacts on water temperatures.

9. pg N1-4! Should include the impact of debris along the shoreline and in mouths of streams on fish migration. Also negative impact of barren sediment flats on aquatic habitat and fisheries especially in Kinbasket but also the upper Arrow. Pg N4 fish stranding should be emphasized a swell as fish egg stranding. All along the areas where water levels have dropped the mixed us and over use by recreational vehicles compromises any positive effect one does for fish , wildlife or environmental improvement. There are very serious land use issues in the region. There is no point to hire consultants to help improve the fisheries, reptile or bird habitat if you allow recreational motorized vehicles and bikes and horses to destroy the habitat. In addition it is propose to have a refuge from the airport to REV (the dam)as indicated on page N6– but that makes no sense if the are is also affected by concentrated human usage from boats, to horses to people and bikes to motorized vehicles. There ahs to be some very decent planning in this matter - and all I see is a great collision of users. Agreed land use planning must be done in conjunctions or in consideration of WUP constraints. All I see is conflict now and destroyed habitat – and the environmentalist minded folks not wanting any access for the recreationists in motorized vehicles. I think a solution must be found – or the problem clearly outlined in the WUP and timelines set up for the community or government agencies to set rules.

10. Hydraulic models appear useful and thoughtful and reasonable. The Illecillewaet and Akolkolex should be spelled properly on the graphs on page O21 . The

average and max/min and std deviation should also be plotted on the graph on page O-20. If the glacier input is further greatly reduced in the next 20 to 30 years then the August and September flow minimum may approach even lower levels on this plot and should be considered. What is the input from the city of Revelstoke and then new development on each of these rive stretches? The greatest effect is likely on the Ilecillewaet Ak streach.The link between width(wetted perimeter) and discharge in each area can be modified by making islands . What about the region S of the AK river inflow? It can be included as well - since there is fish habitat in that region. The Revelstoke canyon? Strange term.

11. Surgeon critical habitat flows need more work before further tests are done.

12. High water flows for sturgeon should be linked with high flows for fish along the entire length of the river including Chinook and Sockeye salmon – so that they may return to the headwaters as well. The costs for this may then be shared to return the fish populations for several species. This would be a moot point though if new dams and water extraction along the Columbia River in Washington causes river temperatures to rise higher than fish can survive though. I noted that the costs responsibility and concerns were emphasized pt T-14 – but I have not yet found these costs clearly outlines. I do not understand why the sturgeons need high flows. I do know why Chinook fingerlings need a high flow to help them flush to the sea before they are eaten or die of heat or fatigue or starvation.

13. Vegetation reestablishment in Keenleyside sectionX-2. No field sites were visited near Mica dam…I am surprised they did not find any fireweed. Despite the great draw down and public use there- does this mean there is no reasonable mitigation planned there for low water levels? I appreciate the concern for introducing reed canary grass that may expand and affect the natural biodiversity. The use of natural wind conditions and stream flow in floods , as well as birds for distribution of seeds was not adequately investigated – and may provide more near natural distribution of seed species. I am not sure what the conclusions are but it paper as that rye grass is needed to get the revegetation started. Then I would suggest get clumps of willows started and then introduce other species. I believe that soil stabilization with a non-invasive species is much better than more fertilization. Great care must be taken to not add more compounds to these very naturally clean waterways. Overall nice clear studies on limited budgets. The sedges showed best survivability – but speci3es can be planted to vary with elevation and tolerance of flooding. It is not clear to me what the wildlife can eat of this . It would be helpful to the fish of course through stabilization of soils and for habitat for insects. Over and over again it was stated that planting over vegetation is a costly process. I did not see a budget though. Maybe options for planting have not been completely investigated. I am completely against again enhanced fertilization. Before nay such thing is done there must be a complete environmental impact assessment done with proper federal and provincial approvals..as well as international approval since this contaminant is being introduced to an international waterway. I strongly believe that any new

components including fertilization for fish presently done must be stopped and a proper environmental impact assessment be done prior to any more addition of such unnatural and expensive contaminants. I do not accept any scientific results done on the Columbia to date on fertilization. I find all the studies flawed, and biased. Habitat enhancement can be done without pollution our waterways through intelligent planting, and timing this revegetation with water levels and weather forecasting. I do not condone a program that spends money to appear to be doing something positive when if you do nothing except limit access to these dust flats by motorized vehicles – and provide proper seeing at proper times of the year that the plants my survive and eventually thrive..That way the fish may be much better off. It is not acceptable to make an illusion of success – one must have it proven to the most demanding scientific investigators– and not just try to please those who want an immediate result – when it is based in fancy more than fact. Revegetation can be done – but needs to be progressive – and affordable. Why not take funds from fertilization of the reservoirs and put into revegetation? I think that would be a much better application of funds for fish and habitat enhancement along the Columbia waterways. But the fertilization and promotion goes on. Do not make this a part of the seeding unless it is for initial establishment – and if so then reduce the fertilization put in for fisheries downstream. All targets should be to eventually restore native vegetation and that should be planned as best as possible to be self regenerating within 10 years. It must be started ASAP – it is unacceptable to have such vast barren dust flats when solutions are available. This will help everything from tourism, recreation, fisheries, wildlife to air quality. But it will take time. It will be a careful balance between cost and success. Several years of low water levels may benefit plants greatly in their re-establishment (pg Y45-46). This should be considered and taken advantage of in planting programs. I t is a waste of time to plant without the best water levels and weather forecasting also considered so the funds used for planting are most effectively used. I saw no mention as to planning for optimal planting conditions – or wait a few years to get the best conditions for reestablishment then go full force for the best effect. It seems this was done accidentally on the Arrow and it had good results.

14. I know nothing about burbot – glad someone else does.

15. Arrow lake tributary access Z4. Linking stream flow discharge to fish migration is important – for the upper arrow and should be included. A continuous stream discharge with turbidity meter could be established on a local smaller stream in t the upper arrow that is representative –of both glacier fed and not glacier fed – such as Begbie or Blanket – and include water temperature, turbidity, conductivity and stream discharge. This will be important for a baseline in future water studies and stream studies, and may be used to help vary the water flow in the main stem for the WUP. It is crucial to have hydrology as well as biology done – and not simply focus on the biology when considering the proper habitat in streams for fish. This was not budgeted in -cost for three monitoring site in arrow and three in Kinbasket would be capital of 60k and basic monitoring of about 30k/year- with about 10 k for summary and collaboration. Fish migrations

are critically linked to water discharge of course – but also even more so to turbidity and temperature – which in turn is strongly dependent on the summer glacial water influx – thus careful timing and understanding of the local hydrology in these stream is very important for survivability of the fish – and how easily then can migrate to their spawning beds. If you really want to do proper fish enhancement then a better understanding of local hydrology and glacial hydrology is required. You do not need to dump bentonite clay into the river or streams when they have a tremendous amount naturally – you just need to understand this fluctuation and allow the fish to better use their natural environments along the side of Keeleyside as well as Arrow reservoir. I also think that it should be considered to make fish ladders so the fish can enter into the upper Jordon and Tumkwatla streams – or at least these large habitats should be better studied. It seems nuts to me to exclude these potentially great fish spawning areas when we have messed up much of the other streams they naturally use- and because non-native fish species have already been planted in these headwaters. The WUP should not have to ignore these drainages..and pursue costly options that are not as good.

16. Sonic and electronic tracking of fish and animals should only be done if those biologist will allow the same torture be done to them during the entire duration of the experiments. When I see fish biologists with sutures in their tummies with an antenna then I will agree that more funds should be put to put these invasive devises into our few remaining sturgeon. Funds should be spent on less invasive procedures. How do you know that the biologists and their boat- and the fact fish can not migrate up and down stream past dams.. are not doing more damage to the sturgeon than the water fluctuations the dams present. Limited tracking fine – but not a long term torture supported by the WUP. Sonic sounders in submarines negative effect dolphins how do you know these fish trackers are not part of what is destroying our fish in these reservoirs too by causing them pain a confusion. Has any one studied the impact of sonic finders on fish ? Would you want it to impinge on your infant all day everyday? I think not. We must rethink our methods – and be sure that the Hippocratic oath is observed. DO NO HARM must be the guiding rule of any funding for this WUP or I will not support it.. Sometimes we get used to certain methods when we forget solutions are at hand. Any funding for improved water for fish must be connected to improved assessment of other pollutants coming into the waterway from road clearing, salt, sewage, antibacterial soaps, hospital waste, herbicides and pesticides, oil, garbage site leakage. Videography is a great idea – it is in invasive hopefully and can be remotely maintained. Fixed cameras are a good idea and not a roving vehicle. AA8. But any attempt to put in more clay I completely disagree with.

17. page AA17. legal issues should be a complete environmental impact before one adds any bentonite into the river and regardless sit is an idea that I soundly and perpetually reject…why even waste time studying the legalities. Throw it out and spend funds studying other more fruitful means to help these fish. Such as study drainages with natural glacial turbid discharges and understand how they are linked to the fish survivability. That would be a better application of the

50k./year. I am sure people mean well but I am plumb tired arguing this point which I find so lacking any hydrology , sediment – and glacial expertise – and too biology laboratory oriented. We are dealing with a natural system – we must first take steps that optimize on our understanding of self sustaining natural systems. Focus on studying sturgeon at the outflow of Illecillewaet, and Jordon and Begbie and blanket stream as compared to Tum tum, AK and other mainly non glacial sourced stream in the same area… That is an non-invasive study that would do the same thing and derive much better results as to the impact of turbidity on sturgeon. Then we may find we must spend more effort making sure the surgeon can survive near those outflow stream – and we will know where we should modify land use in hat region to help them.

18. I like the opportunistic in assessment of high flow events AA17 that will be very useful if we are ever to help fish runs return to the sea, or help floods modify the habitat to meet our needs (i.e. islands, create sand bars, moving plants and seeds or soil or whatever we want). Use of nature to our advantage should be optimized in the WUP and support to forecast these events should be included. – what about weather? Isn't that critical for forecasting these effects. No mention of how we will forecast these events. I think we can do a lot better in this regard if we include improved flood weather forecasting – as well as drought weather forecasting to help meet our WUP goals. The studies should include how to include weather and water forecasting seasonal and short term in the region to help resolve these mitigation issues (fish, habitat, water levels, migration, recreation).

19. Constructed wetlands are a good idea – I am not sure the costs need to be that high – I think that properly dumped loads combined with natural and human enhanced floods could create some fine islands and berms that would look natural and be cheaper to make. The choice of sites should be away from places that recreation occurs from motorized vehicles. Also I think emphasis around the air strip should be minimized except areas to help the turtles…and more effort be placed to the sw of the airport . Also one must adapt to the fact that the airport will be lengthened someday – or changed in orientation. I suggest zone 7 be moved elsewhere. There needs to be more areas on the w side of the river as well. This also has a better chance for animal survival since there are fewer people and no vehicles there. One suggestion is the area below Begbie creek. This could also be a great place to enhance or sturgeon, kokanee and dolly with less conflict with other users. More enhancements near Blanket and other creeks might be useful as well..if they impact fisheries. They have substantial turbidity influxes. Why not help optimize the (tidal) flats so help the fish use these water ways more effectively and the birds as well. Btu I suppose some thought has been put to making a great place for birds to rest and eat up all the migrating fish. Hmm that will require some analysis I suppose. Wow the expenses of these land alterations is huge. They should be carefully planned. Seems like you could create a never ending cycle of make work and make environmental disasters. I suggest use natural floods and careful studies prior to any work.

20. SS1. Strike out the turbidity augmentation part. Do not do for even a 30 day period. You will introduce more contaminants as you do for the present fertilization. It is much better to study how the fish use the natural turbidity that is already there in abundance each year NOW…much the same as it was in the past. DD@- indicates flo+turbidity experiment will not be implemented. But do not even implement a turbidity experiment….except using what natural variations already exist. Well controlled aquaculture might be acceptable –BUT only after a thorough detailed environmental impact assessment has been done…We have already conducted a terrible experiment on our native populations without any impact assessment prior – by having fish hatcheries all over the place. It was a failure. Why not learn from these. Hatcheries are fun for biologists and scientists – but bad for nature. Ask Dick Beamish – he will scream as loud at I on fish introduction – we destroy natural variability – and we must first know how to help the fish naturally enhance. ..If we have time. I be the answer is right in front our face – if we just have the time, the staff and consistent funding to study it. Do not resort to old solutions due to lack of time – be innovative – especially when the old solutions did not solve our fisheries problems– but instead created more problems. Substrate mats may be a great idea and are worthy of investigation. Genetics assessment and videography is a great idea.. as is sonic tagging the biologists during the experiments. To keep them aware of the pain they are inflicting and increase their innovation to avoid personal pain. Conservation improvements (stopping poaching and people driving through spawning beds or horses walking in areas where they impact critical fish) are also a very important measure as is land use planning and identification and enforcement of conservation areas. I have seen local politicians children doing damage to our streams in the Tum Tum region – and could do nothing. Some education would possibly go a long way as well with enforcement – and community involvement in the policing – through education. That needs support, and might be a lot cheaper than changing water flows.

21. ON the final draft plan I saw no mention as to consideration for the return of wild salmon – and I think this should be included. We may lose all the sturgeon as well as the genetic stock of the wild salmon. No one is doing anything about the salmon. Large pulses of water to help the surgeon if planned properly would help could help the salmon as well. I think that any study to help fish in the WUP should help with enhancements to bring back all native fish. We can have these runs back if we just want. They will not return if we do not evaluate them – and stop increases in water temperatures along the path of the river. I think any further impacts for water storage along the river will effect our ability to help the local fish – and the ocean going fish return. I find it a great mishap not to even mention this issue in this document. It was important to the natives and to many local residents and the public – it should be considered for a 5 to 30 year water use plan…just as much as the sturgeon, burbot, and kokanee and rainbow enhancement planning.

22. page 4-20 wetlands are also impacted by glacier melt – and this is critical for this region of the upper arrow and Kinbasket and should be mentioned in addition to snow melt.

23. pg 4-31 How do you know Kokanee were not indigenous to the system. Sure some have been introduced . But Kokanee may have been a small percentage in the past but they likely did exist to some degree in the past. Are you certain about this statement?   Kokanee presently exist in the Shuswap along side wild salmon I see no reason why they did not also exist in the Columbia in the past..They probably thri8ved in years when the salmon could not make it to the headwaters.

24. 4-32. Food lost through entrainment is not a well defined issue. I think you should strike any mention of successful boosting of pelagic production by fertilization in Arrow reservoir. Do you have a good insurance policy to pay for the deformed children downstream? If not then do you really know this is doing any good? And what else is being introduced into the waterways with this "pure" fertilizer?

    I completely disagree with the fish technical committee statement that we agreed that fertilization of lower arrow might provide greater benefits than operational changes. I think habitat improvement and conservation will provide better results. I am very upset this keeps getting pushed into these results. Did they all agree with this result? What is pushed past them as an easy solution..to support and confirm ongoing studies?   Would we accept this being done to a waterway if the US dumped it upstream from us? NO they could not. It would be against their EPA regulations . It would be considered pollution of waterways. Please step forward instead of backwards and stop supporting this. Use this proactive WUP to do something proactive – such as the many other great ideas in this report. Get outside reviews from those like me opposing fertilization – such as the Wash Dept of Ecology or many other top scientists (biologist, hydrologist s, ecologists) world wide. The WUP must ensure that what they do doe no harm. Opposing views must be examined before this contaminant is supported – and present studies must be stopped. The impact of water temperature , the actual pathways the killing off of mysid by this "fertilizer" the cost must be examined before any more experiments are done. I find this terribly irresponsible. Water temperature is known to be a major cause of fish survivability in the Fraser WHY IS IT NOT ALSO CONSIDERED A MAJOR IMPACT HERE!!! If you follow water temperature and fish abundance in nearby waterways they can be explained by natural conditions that are not related to the fertilizer. If someone other than a biologist was hired to do these studies they would not continue to support these efforts for fertilize? And I thought we had gotten somewhere in their WUP planning..and now I see the nasty head of someone's pet project rises again. It is disappointing you would be taken in by this still, and dissenting views silenced by lack of funding. Just because they have done it the past in this water way does not mean it is acceptable. That is likely why I was not invited on that committee.

25. 4-39 . Fish stranding is emphasized good. As well as white sturgeon juvenile recruitment. We need to know WHY high flows improved requirement. Was it because fish could migrate? A good source was obtained? Habitat flushed? Competing species killed off? We need to know why.

26. 4-46 I would add that benefits also achieved through fertilization are not worthwhile or proven. Habitat and riparian enhancements are best way to improve pelagic productivity. I do not see where any temperature variations have been separated from fertilizer effects on pelagic production. This is poor science .

27. Do not make claims that can to be supported it is dangerous.

28. 4-55 Learning more for improved management decision making is critical --very good points. The public must learn too – but not be brainwashed. Spending signs telling them how good fertilization is or minimizing the impact of introduction of invasive species such as mysid shrimp seems for like Nazi propaganda than science. Education of the public should not be so one sided. Learning and education to help meet these WUP goals should be well balanced and subject to unbiased outside review. It is ok to admit our mistakes – and then learn from them.

29. 4/59 Green house gas emission considerations. One must also consider methane production and release in these lakes – and acknowledge it may have an effect on greenhouse gas contribution. But no one has really looked at this critically. Maybe a one ton challenge should be applied to the impact and cost of these changed water levels in the WUP.

30. One might also consider the mercury that is also released and if it significantly changes due to these operations. The mercury content in fish may be changed by these fluctuations and the public should know – perhaps fishing will be limited due to this. Does any one really know the mercury content of the fish and ho it varies with water level in the Columbia? Does anyone really want to know – if so they may not want to eat so much of the fish! Could this be impacting the survivability of the juvenile sturgeon? Has anyone looked at this? It affects fish elsewhere (see Quebec Hydro..Ross lake..others) . It seems to me such analyses should be included in these studies.

31. Recreational use – there are many conflicting uses in the region – some totally environmentalists and others just wanting the region as their personal fisheries pond or hot rod race course, or horse feeding area, or bike touring area, water-ski, motorboat, …. I see no way all these conflicting desires can co-exist. Good luck.

32. Boy it is hard to get through all this documentation.

33. 1425 and impact of kokanee in the Arrow it is good it will get addressed. 7-73.

34. Focus of stranded debris management should be at the outflow of streams where fish feed and migrate should be noted. There is no real need to do this debris

management everywhere. 7-90. Needs study to determine where debris is harmful and where helpful. Some action is better than none. Some streams are hopelessly blocked presently.

35. Archeology is critical and poorly known. Good it will be addressed or at least protected.

36. 7-121 The term flow treatment is vague and should be better defined. Good to have decision point built into the process – I agree. Good effort to help the sturgeon as long as fertilization is not uses as a water treatment.

37. Oh No. 7-124 the return of the bentonite. NO. not a good idea . I thought this had been rejected over and over. NO a 10 NTU increase in turbidity. Spare me. Stop it. Please. Does someone have a futures in this company or something. I do not approve of this for even one month. There are other natural tests one can do. And in the long run this is never feasible. Feed poor children, reduce electrical costs, but this is not acceptable. Note that the acceptance by the US for a bentonite experiment is not too likely. In fact it would need a proper EPA env impact assessment as we should do as well..and it is a ridiculous expense for no benefit. Quit tweaking with nature – and instead use her natural turbidity. Why can not you see this?!!I think the cc is just exhausted.

38. 8-27 take out all reference to bentonite and eliminate this experiment. Save 9 million dollars. Hire local people to remove debris and reduce local pollution a misuse of waterways, and revegetate the flats. Much better use of the money.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: **604 528-2905**
Phone: **604 528-2737**

From:

G. DeRosa
1487-3RD AVE
TRAIL, B.C. V1R-1P5

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: CITY OF TRAIL.

Signature: G. DeRosa

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Penny Dewar (email: penelopedewar@gmail.com)
Box 8, Nakusp
BC, V0G 1R0

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Old Arrow Park

Signature: Penelope L Dewar

I would like the following verbatim comments, in addition to what is noted in the draft Columbia River Water Use Plan Consultative Committee Report, to be captured within an appendix within the Report. (Preference is to have this done by e-mail to sue.foster@bchydo.bc.ca if possible)

I joined the Consultative Committee because of concerns over severe erosion at a few key locations on the Arrow Reservoir shore. I recommended that erosion control measures be considered for these areas, to preserve the land, for its heritage and wildlife values, and to keep it from constantly silting the reservoir. I would appreciate such a consideration.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Bill Duncan
Teck Cominco Metals Ltd.
Trail BC V1R4L8

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Bill Duncan, Teck Cominco Metals Ltd.

Signature: ______________________

From: Duncan, Bruce [mailto:Bruce.Duncan@columbiapower.org]
Sent: Tuesday, July 05, 2005 2:39 PM
To: sue.foster@bchydro.com
Cc: Matthews, Llewellyn; David Bursey (Bursey, David); Les.MacLaren@gov.bc.ca; Sivertson, Lorne; Jmaeff, Victor; Freeman, Bill; Penner, Wally; Josh Smienk (Smienk, Josh); Shelley.Murphy@gems2.gov.bc.ca
Subject: FW: Final Draft - Columbia River WUP Consultative Committee Report

Sue, further to your e-mail of June 29th, thank you for providing Columbia Power Corporation the opportunity to make comments on the final draft of the Columbia River WUP Consultative Committee Report ("the Report"). I only have a few additional comments, which are enumerated below:

1. Page 6, paragraph 3, line 11, of the Executive Summary - change "DFO and WLAP representatives noted that the ALH Project Approval Certificate (PAC) recognized" to "the DFO and WLAP representatives maintained that the ALH Project Approval Certificate (PAC) recognized". As you know, the statement ascribed to DFO and WLAP representatives is not consistent with the actual wording of the ALH PAC Condition 8(1) which states that CPC must, to the reasonable satisfaction of the Comptroller of Water Rights, enter into an agreement with BC Hydro (i.e. the Release Coordination Agreement approved by the Comptroller of Water Rights on 15 March 1999) for the diversion and use of water from the Arrow Reservoir, and demonstrate how the agreement provides details of how "current opportunities to implement beneficial operations for fish and other environmental objectives will not be diminished." As stated previously, it is CPC's position that "current opportunities" refers to opportunities that were current at the time the PAC was issued. We appreciate that, as requested by CPC's on June 28th, you have included the actual wording of ALH PAC condition 8(1) as a footnote on page 7-43. However, on further consideration, since the clarifying footnote is not included in the Executive Summary, we believe it is necessary to properly characterize the DFO and WLAP representatives position as a subjective assertion, rather than an objective fact. We believe replacing the word "noted" with "maintained" is the easiest way to do this, and avoids the need to include a footnote on page 6 of the Executive Summary. As you know, our previous attempt to redraft the subject sentence so it was consistent with the wording of the ALH PAC was rejected on the basis that this is what the DFO and WLAP representatives maintain they actually said.

2. Page 7-43, paragraph 1, line 10, of Section 7.6.1 - remove footnote 1 from paragraph 1 and insert it in paragraph 2, line 10 (i.e. the last line on the page), after the word "provisions". The footnote is simply in the wrong place.

3. Page 7-43, paragraph 2, line 7, of Section 7.6.1 - change "DFO and WLAP representatives noted that the ALH Project Approval Certificate (PAC) recognized" to "the DFO and WLAP representatives maintained that the ALH Project Approval Certificate (PAC) recognized", for the reasons discussed above.

4. Page 7-43, footnote 1, line 1, change "satisfction" to "satisfaction".

5. Page 7-44, paragraph 3, line 6, of Section 7.6.1 - remove footnote 1 from the end of the second sentence, line 6, and insert it at the end of the first sentence in the paragraph, in line 4 after the word "modelling." The footnote is in the wrong place. It is incorrect to associate the footnote (which describes the 11 June 2004 meeting between representatives of DFO, MWLAP and CCFRIC and staff of the EAO and WMB) with resolving the issue of whether to include ALH power costs in the modelling "at the policy level". The next sentence clarifies that the policy level resolution was "a June 2004 government policy directive". This policy directive was approved by Treasury Board on 6 May 2004 and was subsequently approved by Cabinet and incorporated in the 24 June 2004 letter from the Minister of Energy and Mines to the Chair of BC Hydro, with copies to the Comptroller of Water Rights and the BC Utilities Commission, among others. The staff level meeting of 11 June 2004 had nothing to do with the resolution of policy in this matter.

6. Page 7-44, footnote 1, change "MWLAP" to "WLAP", for consistency with the body of the text.

Please give me a call if you have any questions in this regard.

Thank you.

Bruce Duncan
Vice President
Strategic Planning & Regulatory Affairs
Columbia Power Corporation
Tel: (250) 387-9697; Fax: (250) 356-2819
E-mail: Bruce.Duncan@columbiapower.org

From: Duncan, Bruce [Bruce.Duncan@columbiapower.org]
Sent: Monday, May 30, 2005 5:23 PM
To: Foster, Sue
Cc: Matthews, Llewellyn; Vonk, Pat; Sivertson, Lorne; Ken Epp (E-mail); Jmaeff, Victor
Subject: RE: CPC's COMMENTS ON THE DRAFT COLUMBIA RIVER CONSULTATIVE COMMITTEE REPORT

Introduction

Further to my e-mail comments of March 18, 2005, the purpose of this e-mail is to provide Llewellyn Matthews' and my additional comments and suggested further edits regarding the draft Columbia WUP Consultative Committee (CC) Report. These are in addition to my e-mail comments of March 18, 2005, CPC's letter of March 18, 2005 (also attached for ease of reference) and CPC's comments of December 24, 2004 on the draft June 2004 CC Meeting Minutes. For ease of reference, I am also repeating my e-mail comments of March 18, 2005 below. As discussed, we would be pleased to have a conference call with BC Hydro staff working on the Draft Columbia WUP CC Report to go over our comments and provide any further explanations/elaborations if that would be helpful. It avoid any misrepresentations from paraphrasing, I would suggest that, where references are being made to the position of CPC (on behalf of CPC and Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation), specific quotes be used from either the letters we have provided or the corrected Final June 2004 CC Meeting Minutes.

* Our December 24, 2004 detailed comments and line edits on the Draft June 2004 Columbia WUP CC Meeting Minutes, while included in the final June 2004 CC Meeting Minutes e-mailed on February 25, 2005 by Sue Heaton, were not reflected in the Draft Columbia WUP CC Report mailed out to the CC by you the same day. The effect of this oversight was compounded by BC Hydro's decision to reorder the Draft Columbia WUP CC Report so that the discussion of issues in sections 7 and 8 did not follow the same chronology as the June 2004 CC Meeting and Meeting Minutes.

* While CPC's participation and interest in the Columbia WUP and our letters of November 26, 2003 and June 18, 2004 are briefly described in section 3.3.2, the absence of CPC's December 24, 2004 corrections to the June 2004 CC Meeting Minutes captured in section 7 and 8, and the re-ordering of the topics in the section 7 combine to create an inaccurate/misleading record of CPC's interests and involvement. The result is that CPC's concerns and our conditional acceptance of the consensus recommendations of the CC appear in the Draft CC Report to be limited to the discussion of mountain whitefish flows at pages 7-113 through 7-115. Thus, even though CPC's June 18, 2004 letter of interest pre-dated the June 21-23, 2004 CC meeting and was clearly general in its scope, and despite the changes in the Final June 2004 Minutes taking this into account, there is no mention of CPC's conditional acceptance of the consensus reached by the CC on "a package of recommended operating and non-operating alternatives" in the first paragraph of section 8.1 on page 8-1, where the enumerated conditions upon which the "acceptance

of these proposed plans was conditional" is limited to only "robust monitoring programs being implemented". The potential adverse impacts on CPC/CBT power projects from the Columbia WUP were not limited to mountain whitefish flows, nor was CPC's statement of position of June 18, 2004 narrow in its scope. Proposals for Arrow Lakes Reservoir levels and resulting Keenleyside Dam and Arrow Lakes Generating Station (ALH) operations had the potential to generate very substantial adverse impacts (up to $10 million per year). BC Hydro's position regarding the Non-Treaty Storage Agreement (NTSA) and the introduction of the concept of so-called "soft constraints" still had the potential for significant adverse impacts on CPC/CBT in the absence of the BC Hydro indemity of October 20, 2004. Our letter of objection of June 18, 2004, conditional support at the June 2004 CC Meeting, and our subsequent reliance on the BC Hydro Letter of Indemnity of October 20, 2004 in CPC's attached letter of March 18, 2005 supporting the Columbia WUP CC "package of recommended operating and non-operating alternatives" should be clearly stated in the first paragraph of section 8.1 on page 8-1.

* In addition to the discussion in section 3.3.2, there should also be a clear statement in Section 7.1, regarding third party impacts and the government policy directive and approval of indemnity related to CPC/CBT power projects and joint ventures, and the Columbia Basin Initiative. Without references to the May 6, 2004 approval of indemnity under the Financial Administration Act, the June 24, 2004 government policy direction to BC Hydro, and the BC Hydro October 20, 2004 letter of indemnity (all of which are attached to CPC's letter of March 18, 2005), the current discussion of the WUP policy framework and government WUP guidelines and directions, at pages 7-1 to 7-3 of the Columbia WUP Report, are deficit. CPC could not have supported the Columbia WUP CC recommendations would a change to the WUP policy framework. CPC undertook its initial due diligence work in this regard in the spring and summer of 2003. This led to a series of meetings with government officials and a confidential letter from CPC (Bruce Duncan) to BC Hydro (Gary Rodford) dated September 11, 2003 stating CPC's position and seeking assurances from BC Hydro. Following this letter, CPC worked with BC Hydro and government officials to clarify the policy framework underpinning BC Hydro's Columbia (and Duncan) WUP as they relate to potential third party impacts on CPC/CBT and the Columbia Basin Initiative. Potential third party impacts on holders of downstream water rights were not addressed in the WUP Guidelines and November 1998 WUP governemnt policy directive to BC Hydro. The Treasury Board Submission of May 2004, the approval of indemnity of May 6th, the government policy directive of June 24th and the subsequent BC Hydro letter of indemnity of October 20th to CPC/CBT effectively amended the 1998 government directive regarding WUP as it relates to CPC/CBT power projects and joint venture companies. This should be clearly stated in the WUP policy discussion in section 7.1; without this clarification CPC's general and specific positions regarding the issues and recommendations set out in sections 7 and 8 do not have a proper policy context. (With respect, it would not be sufficient to simply add CPC's March 18, 2005 letter of support to CPC's other correspondence in Appendix F of Volume 2.)

* Similarly: there is no reference to CPC's November 26, 2003 statement of position to clarify CPC abstaining in Table 7-34, at page 7-51; CPC's endorsement of Option 3 and the enumerated "soft constraints" on Arrow in Table 7-40 at page 7-70 make no mention of CPC's conditions for acceptance (recorded at page 68 of the Final June 2004 CC Minutes); CPC's position and conditional endorsement of the "Total Package" do not even appear in Table 7-69 at page 7-132 (despite being recorded at page 84 of the Final June 2004 CC Minutes); and there is no mention in the Expected Consequences, section 8.4, Table 8-25 at page 8-30, under Power Generation, that CPC and the CPC/CBT joint venture power companies are being indemnified by BC Hydro from any adverse impacts, pursuant to BC Hydro's Letter of Commitment of October 20, 2004. Indeed, it is incorrectly stated in the comment box at page 7-115 and in the first paragraph of section B at page 8-22 that it is the responsibility of the provincial government, as opposed to BC Hydro, to make CPC and the CBT "whole". No reference is made to Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation, and the discussion at pages 7-115 and 8-22 is limited to the "CC's Recommendations Regarding Mountain Whitefish Flows and Related Monitoring".

Comments of Llewellyn Matthews

Bruce:

I have conducted a review of the Columbia WUP Draft Consultative Committee Report. Due to time constraints, the review was restricted to those portions of the report that seemed most relevant to our participation in the WUP process.

Our interests are mainly affected by WUP recommendations that apply to management of the Arrow Lakes Reservoir and the lower Columbia River. An important outcome of the WUP is that because of the NTSA issue that was thrown in at the last minute by BCH, no recommendations for restrictions were placed on Arrow levels. BCH will have no additional restrictions placed on their water licenses for Arrow operations. Instead they will operate as they see fit, taking into account the expressed interests of the stakeholders. The interests will be expressed as "soft constraints" that will be worked into system operating orders. Given that there is some conflict between the soft constraints, and that actual operations in any given year will be driven by water supply and a host of other factors, it will be difficult to tell what, if any, impact the WUP will have on future Arrow operations. The main impact we will likely see is a desire to see less time spent at full pool and an increased focus on keeping the reservoir at lower levels in general through the spring/summer period. In the absence of the BC Hydro indemnity of October 20, 2004, the "soft constraints" had the potential to result in significant adverse impacts on CPC/CBT. The only other recommendation that, in the absence of the BC Hydro indemnity of October 20, 2004, could have an adverse effect on CPC/CBT (through ALH generation) was the Mountain Whitefish (MFW) flows issue.

Specific comments follow:

P. 4 Footnote 1
Our letter of March 18, 2005 should also be referenced here.

Global comment
It would be preferable to use "ALH" instead of "ALGS" as the abbreviation for Arrow Lakes Generating Station throughout the document as it is the official station code.

P. 2-17, Sect. 2.6.1, 2nd para
change the 2nd sentence to read: "...to the Brilliant Terminal Station splitting the transmission line into 15 km 2L290 from ALH to BTS and 35 km 2L289 from BTS to SEL. In this arrangement ALH delivers its power..."

P. 2-17 Sect 2.6.2, 2nd para
ALPC has contract with BCTC, not BCH, for the remote dispatch and operation services.

P. 2-18, Sect. 2.6.4.1 1st para
it should be BCTC's Southern Interior Control Center

P. 2-18, Sect 2.6.4.1 2nd para
* delete the 2nd sentence.
* the min res el for 1 unit operation is 425.08 m
* the min res el for 2 unit operation is 426.83 m at a total flow of 292 m3/s
* The min net operating head is 4.6 m and the maximum operating head is 20 m.

P. 2-18, Sect 2.6.4.1 3rd para
It is Project Approval Certificate.

P. 2-18, Sect 2.6.4.2 1st para
* HLK is staffed 364 days per year (not Xmas)
* change the end of the last sentence "...day-today basis to meet the Facility Discharge Requirement."

P. 2-19, top para
It is the BCTC dispatchers, not BC Hydro operators that remotely open HLK.

P. 2-19, Sect 2.6.4.3
* Title should be Approach Channel Operating Parameters
* Delete the first sentence and replace with "The approach channel operating parameters include maximum flow rates for a given reservoir level. These parameters are included in the operating range of ALH and are controlled in the plant control system."
* Delete the last two sentences (starting "On 30 April ...").

P. 2-20 Sect 2.6.5.3
This section should be included within Sect. 2.6.5.1

P. 2-20, Sect 2.7 1st para
The last sentence should be changed to "... the water license holder for half of the Kootenay Lake storage..." [The other half is held by Brilliant Power Corporation.]

P. 4-12, Sect 4.7.1.1
Change the last sentence to "... generation at Arrow Lakes Power Corporation's Arrow Lakes Generating Station ..."

P. 4-13, Table 4-7
The use of the term "revenue" is incorrect in the Total Power Cost (ALGS subtracted) PM. Actual revenue is not used or calculated and could be misleading. A better term would be "power value".

P. 4.14, Sect 4.7.2.1 1st para
Same comment as above. Revenue losses to specific companies are not used, rather you are referring to provincial power values.

P. 7-82, Sect. 7.7.3.4, bottom para
This paragraph is very misleading. It is incorrect to say load shaping occurs at Brilliant Dam. Load shaping occurs at Kootenay Canal. The effects of this upstream load shaping can be passed through Brilliant. Often the effects downstream of Brilliant are reduced as the Brilliant Headpond, under a certain range of flows, reregulates the flow out of KCL in order to keep Brilliant fully loaded.

P. 7-113, 3rd para
This paragraph should be changed to reflect the wording in the final minutes of the June 2004 CC meeting. It should also indicate our subsequent acceptance contained in the CPC March 18th, 2005 letter, which should also be noted in the footnote.

P. 7-134
The comments box should contain reference to CPC's Notice of Objection as stated in our letter of June 18th, 2004. I assume I was no longer in attendance at the meeting when the level of support registered in Table 7-69 was polled. That however does not negate the effect of the letter.

P. 8-1, Sect. 8.1
CPC's conditional acceptance should be mentioned as stated in the March 18th, 2005 letter.

I trust these coments are helpful.

From: Duncan, Bruce [Bruce.Duncan@columbiapower.org]
Sent: Friday, March 18, 2005 1:31 PM
To: Heaton, Susan
Cc: Sue Foster (E-mail); Matthews, Llewellyn; Sivertson, Lorne; Ken Epp (E-mail); Jmaeff, Victor; Freeman, Bill
Subject: RE: Final June 2004 CRWUP CC Meeting Minutes & Draft CC CRWUP Report

Sue, thank you for sending me a copy of the Final June 2004 Columbia River WUP Consultative Committee ("CC") Meeting Minutes on February 28, 2004. I have reviewed this Final version and confirm that it incorporates CPC's blackline edits of December 24, 2004, as requested. Accordingly, I am now able to send a letter to BC Hydro clarifying CPC's conditional acceptance of the CC's Columbia River WUP recommendations as recorded in the Final June 2004 CC Minutes, similar to that for the Duncan WUP. I hope to send that letter to Sue Foster by the end of business today. My one comment on the Final June 2004 CC Minutes is that the footer is wrong, as it refers to meetings on June 21, 22 and 23 of 2003, not 2004.

I have also had an opportunity to undertake an initial review of the Draft Columbia River WUP CC Report, which I received on February 28, 2005. I will be away on holidays from today until April 4, 2005, and will provide more detailed comments on a best efforts basis on my return. My major comment at this point, however, is that the Draft CC Report does not appear to take into account the blackline edits that CPC provided to the Draft June 2004 CC Meeting Minutes, which have been incorporated in the Final June 2004 CC Minutes. There are other significant discrepancies in the ordering of the discussion in the Draft CC Report (primarily section 7) and the Final June 2004 CC Minutes, the result being that CPC's concerns (on behalf of CPC and Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation) and our conditional acceptance of the consensus recommendations of the CC appear in the Draft CC Report to be limited to the discussion of mountain whitefish flows at pages 7-113 through 7-115. Thus, even though CPC's June 18, 2004 letter of interest pre-dated the June 21-23, 2004 CC meeting and was clearly general in its scope, and despite the changes in the Final June 2004 Minutes taking this into account, there is no mention of CPC's conditional acceptance of the consensus reached by the CC on "a package of recommended operating and non-operating alternatives" in the first paragraph of section 8.1 on page 8-1, where the enumerated conditions upon which the "acceptance of these proposed plans was conditional" is limited to "robust monitoring programs being implemented". Similarly: there is no reference to CPC's November 26, 2003 statement of position to clarify CPC abstaining in Table 7-34, at page 7-51; CPC's endorsement of Option 3 and the enumerated "soft constraints" on Arrow in Table 7-40 at page 7-70 make no mention of CPC's conditions for acceptance (recorded at page 70 of the Final June 2004 CC Minutes); CPC's position and conditional endorsement of the "Total Package" do not even appear in Table 7-69 at page 7-132 (despite being recorded at page 86 of the Final June 2004 CC Minutes); and there is no mention in the Expected Consequences, section 8.4, Table 8-25 at page 8-30, under Power Generation, that CPC and the CPC/CBT joint venture power companies are being indemnified by BC Hydro from any adverse impacts, pursuant to BC Hydro's Letter of Commitment of October 20, 2004 and the Minister of Energy and Mines Letter of Direction of June 24, 2004. Indeed, it is incorrectly stated in the comment box at page 7-115 and in the first paragraph of section B at page 8-22 that it is the responsibility of the provincial government, as opposed to BC Hydro, to make CPC and the CBT "whole". No reference is made to Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation, and the discussion at pages 7-115 and 8-22 is limited to the "CC's Recommendations Regarding Mountain Whitefish Flows and Related Monitoring".

I trust these initial comments will suffice for now, and hope they are helpful. As noted, I will follow-up with more detailed comments on my return in April. Regards.

Bruce Duncan
Vice President
Strategic Planning & Regulatory Affairs
Columbia Power Corporation
Tel: (250) 387-9697; Fax: (250) 356-2819
E-mail: Bruce.Duncan@columbiapower.org

BRITISH COLUMBIA

MAY 0 6 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
Mailing Address:
PO Box 9048 Stn Prov Govt
Victoria BC V8W 9E2
Telephone: 250 387-3751
Location:
Parliament Buildings
Victoria

BRITISH COLUMBIA

VANCOUVER 2010

RECEIVED
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.

.../2

Ministry of Energy and Mines
Office of the Minister
Mailing Address:
PO Box 9060 Stn Prov Govt
Victoria BC V8W 9E2
Telephone: 250 387-5896
Facsimile: 250 356-2965
Location:
Parliament Buildings
Victoria
Website: www.gov.bc.ca/em/

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

- 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.

BChydro

Bob G. Elton
President & Chief Executive Officer

RECEIVED
OCT 28 2004
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

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

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

March 18, 2005

Ms. Sue Foster
Columbia Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C.
V3N 4X8

Dear Ms. Foster:

Subject: Columbia River Water Use Plan

I am writing to you to clarify Columbia Power Corporation's ("CPC") position regarding the recommendations of the Columbia River Water Use Plan Consultative Committee ("CC") as recorded in the Final June 2004 CC Meeting Minutes provided to us on February 25, 2005.

On June 18, 2004, prior to the June Consultative Committee ("CC") meeting, I wrote setting out CPC's interest in BC Hydro's Mica/Revelstoke/Keenleyside Water Use Plan ("Columbia River WUP") deliberations. This interest stems from CPC's position as joint venture owner, 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 Columbia River 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 Columbia River WUP.

Ms. Sue Foster
March 18, 2005
Page 2

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, without appropriate compensation. As recorded on page 58 (and referenced on pages 60, 70 and 86 of the Final June 2004 Columbia River WUP CC Meeting Minutes distributed February 25, 2005):

> *CPC on behalf of CPC and CPC/CBT power project companies Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation (collectively "CPC/CBT") cannot support or accept any alternative other than the status quo 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 implementation of this WUP taking into account the year to year variability of the impacts. CPC registered a similar position to the Duncan Dam WUP CC. As with the Duncan WUP, CPC is prepared to conditionally accept the consensus recommendations of the CC with the strict proviso that CPC/CBT are saved harmless or appropriately compensated. CPC will continue to work diligently with the Province and BC Hydro to resolve this issue and will update the CC as appropriate.*

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.

Ms. Sue Foster
March 18, 2005
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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, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation, can now accept the implementation of the recommended Columbia River WUP "Total Package", as recorded on page 86 of the Final June 2004 Columbia River WUP CC Meeting Minutes.

As holders of water licences and water rights who might be affected by the changes stemming from a decision on the Draft Columbia River WUP by the Comptroller of Water Rights under the provisions of the *Water Act*, Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation reserve their right to provide comments directly to the Comptroller of Water Rights regarding the Draft Columbia River WUP as part of the review and approval process (described in Step 10 of the provincial government's Water Use Plan Guidelines).

Yours truly,

Bruce Duncan

Bruce Duncan
Vice President Strategic Planning
Columbia Power Corporation

Attachments

cc: Columbia WUP Consultative Committee

Gary Rodford, BC Hydro

Lorne Sivertson, Columbia Power Corporation

Ken Epp, CBT Energy Inc.

Josh Smienk, Columbia Basin Trust

Glen Davidson, Water Management Branch
Land and Water BC Inc.

Pieter Bekker, Water Use Planning and Utilities Branch
Land and Water BC Inc.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

JIM FORBES
BOX 98 EDGEWOOD, B.C.
V0G - 1J0

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: JIM FORBES - TIMELESS TOUR'S

Signature:

I would like the following verbatim comments, in addition to what is noted in the draft Columbia River Water Use Plan Consultative Committee Report, to be captured within an appendix within the Report. (Preference is to have this done by e-mail to sue.foster@bchydo.bc.ca if possible)

PAGE 7-81 EDGEWOOD BOAT RAMP;
IT WAS MY UNDERSTANDING THAT THE
EXISTING RAMP COULD NOT BE EXTENDED.
BECAUSE DREDGING WOULD SPEED UP
THE EROSION IN THE BAY
B.C.'HYDRO'S PUBLICATION; REVIEW OF ARROW
RESIVOUR BOAT RAMPS; JUNE 2001. BY. MARK JOHNSTON
AND JAMIE MAIR; THAT RECOMENDATION WAS
TO STABILIZE THE PENINSULA. AND PUT THE
RAMP OFF THE END. THIS WOULD OFFER
YEAR ROUND ACCESS TO THE LAKE!

Secwepemc Fisheries Commission
274-A Halston Connector Road, Kamloops, BC V2H 1J9
PH: (250) 828-2178 FAX: (250) 828-2756

April 26, 2005

Ms. Sue Foster
Project Manager
Columbia River Water Use Plan
BC Hydro
E16- 6911 Southpoint Drive
Burnaby BC V3N 4X8

Dear Ms. Foster,

Subject: Columbia River Water Use Plan Consultative Committee Report

The SFC has reviewed the 2005 'Draft Consultative Committee Report – Columbia River Water Use Plan'. The SFC agrees that the consultation report does accurately summarize the discussions within the Columbia River Water Use Plan Consultative Committee. This of course is subject to the final report addressing the changes requested in the 'Detailed Technical Report Comments' put forward by CCRIFC staff in their letter dated April 11th, 2005.

We would also like to support the three conditions as put forward by the First Nations participants at the conclusion of the Consultative Committee process that:

1) BC Hydro develops and implements, in consultation with First Nations and governments agencies, a strategy to assess, mitigate and compensate for entrainment related to operations of their dams, diversions and generating stations;
2) BC Hydro enters into preliminary grievance negotiations with Columbia Basin First Nations affected by the construction of their Columbia River facilities; and
3) BC Hydro develops an acceptable strategy for an agreement with First Nations regarding participation in the implementation of the Columbia Basin Water Use Plans.

We look forward to consultation with the Comptroller of Water Rights and DFO on a draft Water Use Plan in the near future for the Columbia WUP and look forward to participation on the Columbia WUP monitoring program in the future.

The SFC would like to thank the Staff of BC Hydro for their hard work and commitment on the completion of the Columbia WUP and hope that the good work is not lost in moving forward.

Sincerely,

Fred Fortier, Director
Secwepemc Fisheries Commission

cc: Jayson Kurtz, DFO
John Emery, BC Hydro
CCRIFC Board
SFC Communities
SNTC

COLUMBIA BASIN TRUST

445 13 Avenue
Suite 300
Castlegar, BC
V1N 1G1

Toll Free: 1-800-505-8998
Tel: (250) 365-6633
Fax: (250) 265-2246
Email: cbt@cbt.org
www.cbt.org

May 1st, 2005

Ms. Sue Foster
Columbia Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster,

Re: BC Hydro Columbia River Water Use Planning Processes

Thank you for the opportunity to provide comments on the Draft Consultative Committee Report for the Columbia River Water Use Plan (Columbia WUP).

The Columbia Basin Trust (CBT) participation on the Columbia River Water Use Plan Consultative Committee (Columbia WUP CC) was undertaken with the objectives of ensuring that individuals with 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 would like to commend BC Hydro and the process team for their efficiency and professionalism throughout this four-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 had difficulty 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

Page 1 of 7

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 CC 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 a consequently 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 the Columbia River Treaty (CRT) 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 the CRT in place, and without it, so we can effectively analyze at the next WUP review if any of these operations are worth pursuing in negotiations 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 to understand how they are affected on an on-going basis by the proposed changes in 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.

There was significant progress made at the CC table and many productive recommendations produced. The CBT encourages the Comptrollers office to ensure that these recommendations are implemented in a timely manner. However, there are a number of outstanding issues with respect to the information contained in Section 8 of the Columbia WUP Draft CC report that need to be addressed prior to the CBT endorsing this draft document.

Page 2 of 7

Please refer to Appendix 1 of this document for detailed comments on the Draft CC report.

Thank you for the opportunity to comment on this document.

Sincerely yours,

Kindy Gosal
Manager, Water Initiatives
Columbia Basin Trust

CC:
Josh Smienk, Chair/interim CEO Columbia Basin Trust
Ken Epp, CEO CBT Energy
Garry Merkel, Vice Chair Columbia Basin Trust

Page 3 of 7

Appendix 1

The following is a list of specific comments on the Draft CC Report for the Columbia WUP:

Section 7 Trade-off Analysis and Consensus Agreements

- While the process used by the BC Hydro Process team provided a logical pathway that lead to decision-making on some very complex issues, the time that elapsed between each of the CC meetings (and thus the trade-off and analysis sessions) made it difficult for CC members to ensure continuity and effective engagement.
- In particular, because of time constraints imposed by the Comptroller's office and BC Hydro to complete the process, many very complex and contentious issues needed to be addressed at the last CC meeting in June 2004. This meeting was very rushed and there was not adequate time for the CC to effectively deal with many of the issues at hand. As such, many decisions were not adequately debated, nor were the CC members able to discuss an adequate trade-off scenario for the decisions that were made.
- This is particularly true for the recreation interests. In a number of CC meetings the recreation issues were left to the end of agendas and in some cases deferred to the next meetings. Many of the recreation issues were left to the last CC meeting and, with all of the other complex issues on the table, these issues were not adequately debated.
- A key component of the Trade-off Analysis was the "face to face" discussion and debate that occurred at the CC table. This gave members the opportunity to listen to each others' views on these matters and vote accordingly. The CC was not given adequate time to undertake this process on many issues at the last CC meeting.
- Many of the recreation issues that were referred to the Comptroller's office and the BC Hydro Process team for further clarification did not come back to the CC group as a whole for consideration and comment.
- Requests made to the BC Hydro Process team and the Comptroller's office for an additional CC meeting to address these issues was not granted.

Section 7.7 Round 5 Final Trade-off Analysis

7.7.2 The Non-Treaty Storage Agreement and the Columbia River Water Use Planning Process

- There is an inconsistency in recording the outcomes from this discussion item. See page 8 of the MCA WUP meeting minutes June 21st, 22nd, 23rd, 2004. A number of options were discussed for the CC to move forward on this issue. As noted in the meeting minutes, the CC members agreed to *Option 3: Move forward with the MCA/Kinbasket, Revelstoke and MCA only. Additional CC meeting once NTSA is completed to finalize, unknown date.*
- Subsequent discussions were held on this issue over the duration of the CC meeting. On the third day this issue was revisited with a number of options being presented again in light of new discussion. Once again, as indicated on Page 69 and 70 of MCA WUP meeting minutes June 21st, 22nd, 23rd, 2004, CC members agreed to *Option 3: One WUP with soft constraints for Arrow Reservoir (with trigger/review when NTSA is in place).*
- Subsequently the CC discussed a review period for the WUP. See page 73 MCA WUP meeting minutes June 21st, 22nd, 23rd, 2004. It was agreed that "*A 5-year review period*

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upon WUP implementation for Arrow Operations to evaluate the effectiveness of soft Constraints, Report out on the results of a concluded NTSA, and determine whether there is a need to review Arrow Operations. NTSA is not a trigger for review." "CC Recommended annual reporting of progress on monitoring studies, physical works and soft constraints performance".

- Thus further clarification is required in the Columbia WUP Draft CC report under section 7.7.2 page 7-72 "Consultative Committee's Recommendation for Review Period Regarding Constraints on Arrow Lakes Reservoir Operations" and section 9 "Review Period". The Recommendation contained here should clearly state that while the signing of the NTSA agreement is not an immediate trigger for opening the WUP recommendations on the Arrow Lakes Reservoir Operations, there will be an annual reporting of progress in meeting the soft constraints. In addition, should BC Hydro be unable to meet the soft constraints under any new NTSA, BC Hydro has committed to reporting back to the CC, and reviewing Arrow Lakes Reservoir operations with this body. If the new operating agreement fails to meet the soft constraints, then the CC should be re-convened to look specifically at this issue and re-evaluate our support for either:
  - The new operations (reflecting the new operating agreement between BC Hydro and the US);
  - The soft constraints that cannot be met;
  - Or the entire portion of the WUP that covers Arrow operations.
- In addition the CBT would recommend that BC Hydro keep the Columbia WUP CC updated on the status of negotiations with respect to the NTSA and utilize this body as an "advisory body" in formulating any new NTSA to ensure the new agreement has the WUP operating constraints built into it.

Section 8.2.2 Re-vegetation Management Plan

8.2.2.1 Implementation Project & 8.2.2.2 Monitoring Program

- There are references in both these sections to requiring "public consultation" to implement the re-vegetation plan and monitoring program. This was in accordance with the wishes at the CC table. However more detail is required to ensure that this consultation occurs and is meaningful.

Section 8.2.3 Recreation Management Plan

8.2.3.1 Implementation Projects

Kinbasket Reservoir

- Clarification is required for the Nixon Creek and Bush Harbour boat ramp projects. BC Hydro will hold the "license" for these facilities and have the responsibility for maintenance.

Mid-Columbia River

- The CC emphasized the importance of ensuring there was a boat ramp in this area for recreational access. The CBT would encourage BC Hydro and the Comptroller's office to expedite the feasibility study to determine the location of this boat ramp.

Arrow Reservoir

Nakusp Boat Ramp

Page 5 of 7

- The logic used by the Comptroller's office indicating that the Nakusp boat ramp may not fit within the scope of the WUP is not clear. The discussions around this boat ramp at the CC table indicated that at lower elevations the boat ramp is not usable because of its steepness and basic disrepair. Thus, when operations lower the Arrow reservoir, the ramp becomes increasingly unusable and unsafe. There is, therefore, a clear operational link. In addition, due to the fact that the boat ramp is a wooden structure, continued operational fluctuation of Arrow reservoir has an impact on the structural integrity of the ramp. Of more importance, both BC Hydro and the Comptroller's office should by now understand the regional significance and importance of this particular recreation facility. Residents of the area have been requesting that both BC Hydro and the Comptroller's office deal with the issues at this facility. The Columbia WUP provides a mechanism to address this outstanding issue. Discussions around the CC table over the Columbia WUP process have repeatedly indicted that there was overwhelming support to address issues around the Nakusp boat rámp by the Columbia WUP CC. BC Hydro and the Comptroller should re-evaluate their decision on eligibilitry of this particular facility within the WUP.

Edgewood

- This project was identified as a regional priority by the CC and the budget allocated should be included in the final physical works package. However local community representatives have indicated that there may be feasible alternatives to look at improving recreational access at this location that include "building up" the adjacent peninsula to protect the boat ramp extension from sedimentation build up that may render the boat ramp extension unusable. Further consultation with the local community representatives is recommended to ensure that the allocated funds are used in the most effective manner.

<u>Lower Columbia River</u>

Indian Eddy

- The Comptroller's office has provided a very clear list of questions that need to be addressed before a decision can be made as to whether this project is eligible under the WUP. This information-gathering needs to be expedited and funding from the WUP process should be used to get the required information. In the interim, Indian Eddy should be considered part of the final physical works package until a determination and clarification of its eligibility is completed.

<u>Kinbasket and Arrow Lakes Reservoir Debris Management Project</u>

- On page 7-89 of the CC Draft report it is stated "*Issues related to wood debris in Kinbasket and Arrow Lakes reservoirs caused by clearing of the land and inundation have largely been resolved by BC Hydro.*" While this statement may be correct with respect to Arrow Lakes Reservoir, the CC members from the Kinbasket area clearly indicated that this was not the case on the Kinbasket Reservoir. They have indicated there are outstanding issues with respect to debris management on the Kinbasket.
- The CBT commends the Columbia WUP CC and BC Hydro for putting in place a strong and well thought out debris management strategy, as well as the resources to implement this strategy. This issue has been long standing and this plan begins a process to bring some resolution to this outstanding issue.
- Table 8-5 (page 8-8) makes reference to setting up multi-stakeholder interest groups to develop strategies and targets for debris management activities on the Arrow and

Page 6 of 7

Kinabsket Reservoirs. Given the fact that debris management issues have been an outstanding and unresolved issue on the Kinbasket reservoir, the CBT requests that the Comptrollers Office direct BC Hydro to expedite the process of forming these multi-stakeholder interest groups in advance of the completion of the Columbia WUP process in accordance with the wishes of the community groups.

Monitoring and Physical Works Package

- With respect to the Monitoring Package and Physical Works Package there was discussion around the CC table about ensuring the involvement (consulting with), and contracting with Columbia Basin Community Groups and First Nations. The essence of the discussion was to make sure some of the financial benefits from the work are distributed to local communities and people in the region. This should be captured in the meeting minutes from the last CC report (June 21st, 22nd, 23rd, 2004) and the Draft Report.

8.3.2 Other Non-Water Use Plan Recommended Actions

Access to the reservoirs

- The CBT supports the recommendations that there needs to be clear and immediate clarification by the Comptroller's office as to "what constitutes access to the various reservoirs". In addition, clarification needs to be provided on how the Comptroller plans to ensure these provisions will be made, and direction needs to be given to the appropriate parties responsible to improve access.

Surcharge events

- CC members from the Kinabsket had requested that compensation for impacts to roads and other infrastructure resulting from surcharging the reservoirs be incorporated into any surcharge event authorized by BC Hydro and the Comptroller. In addition, the Comptroller should require BC Hydro to notify impacted communities and interest groups about impending surcharge operations.

Reporting out on all WUP activities

- It is not clear how BC Hydro intends to "report out" on the activities and follow-up recommended under this WUP. A detailed reporting out plan should be provided to the CC for comment.

April 11th, 2005

Ms. Sue Foster,
Project Manager,
Columbia River Water Use Plan,
BC Hydro
E16 - 6911 Southpoint Dr.,
Burnaby, B.C.
V3N 4X8

Via mail and fax: 604-528-2905:

Dear Ms. Foster,

Subject: ***Columbia River Water Use Plan Consultative Committee Report***

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 draft Consultative Committee report is undertaken without prejudice to the aboriginal title and rights of CCRIFC member nations and communities.

We have reviewed the February 17th, 2005 'Draft Consultative Committee Report – Columbia River Water Use Plan.' Subject to the final report addressing the changes requested in the attached 'Detailed Technical Comments', I agree that the consultation report accurately summarizes the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee, including the context for, and the committee's recommendations for the future operations of the Columbia River storage and hydroelectric facilities. I note that, with a few exceptions (some of which have subsequently been resolved), the committee's recommendations were made by consensus.

Canadian Columbia River Inter-Tribal Fisheries Commission

Cranbrook Office
#7468 Mission Rd.
Cranbrook, BC V1C 7E5
Phone (250) 417-FISH (3474)
Fax (250) 417-3475

Revelstoke Office
#200 Suite C Campbell Ave.
P.O. Box 2008
Revelstoke, BC V0E 2S0
Phone (250) 837-2154
Fax (250) 837-2190

I hereby confirm that, subject to addressing the technical comments summarized in the attachment to this letter and the following conditions noted at the conclusion of the Consultative Committee process, this draft Consultative Committee report adequately describes the water use interests, objectives and associated values expressed by the Consultative Committee members during the Columbia River water use planning process:

Condition One: That BC Hydro develops and implements, in consultation with First Nations and government agencies, a strategy to assess, mitigate and compensate for entrainment related to operation of their dams, diversions and generating stations.

Condition Two: That BC Hydro enters into preliminary grievance negotiations with Columbia Basin First Nations affected by the construction of their Columbia River facilities.

Condition Three: That BC Hydro develops and acceptable strategy for, and agreement with First Nations regarding participation in implementation of Columbia Basin Water Use Plans.

I understand that the next step in the Columbia River WUP process is the preparation of a draft Water Use Plan by BC Hydro, based on the recommendations of the Consultative Committee, for review by First Nations' governments and government agencies and approval by the Comptroller of Water Rights and Fisheries and Oceans Canada. Pursuant to the WUP decision-making process adopted by Columbia Basin First Nation governments, I hereby request that you distribute copies of the draft WUP to concerned Columbia Basin First Nation governments and CCRIFC for review.

In closing, I would like to commend you and your project team for an excellent job in conducting the Columbia River WUP consultative committee process. I found the process to be fair, thorough and effective. In particular, I think you and your staff have done an excellent job in summarizing the recommendations from the process in section 8 of the draft report.

Yours truly,

William Green
Director

Encl (1)

Cc: CCRIFC board
Jayson Kurtz, DFO
Fred Fortier, Secwepemc Fisheries Commission
Dan Paradis, Ktunaxa Land and Resource Agency
John Emery, BC Hydro

Canadian Columbia River Intertribal Fisheries Commission

Detailed Technical Comments on:

DRAFT Columbia River Water Use Plan Consultative Committee Report

By

Mark Tiley, CCRIFC Hydro Impacts Biologist, and

Bill Green, CCRIFC Director, Columbia River WUP CC member

The red text identifies requested/recommended changes.

Executive Summary

P. 1 under Revelstoke Project: "The reservoir formed by the construction of Revelstoke Dam is known as Revelstoke Reservoir. It is fed largely by the flow discharged from the Mica Project (delete 'discharges', repetitive) and local inflow.

P. 3, para. 1, first sentence: "The Consultative Committee members included representatives of BC Hydro, provincial and …."

P. 3, para. 2: This paragraph currently doesn't make sense. It notes 35 started, some dropped out, 39 ended. Suggest adding a note to the effect that additional members joined.

Table 1:

Cultural Heritage

- Provide access to traditional plants

Remove the bullet between "…to support.." and "First Nations harvesting".

Flood and erosion: Minimize damage to property and injury to people.

Page 4, Kinbasket Reservoir Fish and Wildlife Information Plan, first sentence: "…quantitative data for fish and wildlife populations and supporting ecosystem processes."

Page 5, Mid Columbia River White Sturgeon Management Plan, sentence 2: "…annual fund allocations for research, experimental flow treatments and monitoring…." Last sentence: "…or part of the conservation aquaculture effort to Kinbasket Reservoir."

Re table 2:

Wildlife: first bullet is very difficult to understand

Fish: fourth bullet also difficult to understand. Proposed revision: "Monitor and assess sturgeon early life stage survival on occasions when flows (at boundary) meet or exceed 200 kcfs during sturgeon spawning and incubation period."

Page 8: Kinbasket and Arrow Lakes Reservoir Heritage Management Plan, sentence 2: "…a strategy to address the four known archaeological sites in Arrow Lakes Reservoir from Years 1 to 5, and build on the knowledge…" Sentence 3: "Inventory and excavation work and consultation will be required…" (This change is needed to make consistent with last clause of sentence.)

Page 8. Arrow Lakes Reservoir Wildlife Management Plan

Second sentence

"The committee agreed to ……$100,000 in year 1 for feasibility studies and $250,000 in years 2 to 10 for implementation……..

Page 9: White Sturgeon Experimental Plan, para. 2, sentence 2: "This plan involves the delivery of bentonite or other turbidity agent to the river …and when sturgeon eggs are known to be hatching and larvae undergoing their downstream…" Last sentence: "The Committee also supported monitoring to inform on the effectiveness of this action (delete last clause as not appropriate in the current circumstances of this population).

Page 2-1, Columbia River Treaty, sentence 1: Suggest re-wording as follows: "The Columbia River Treaty between Canada and the United States of America was signed in 1961…."

Page 2-7, 2.3.1.1. Please check if the reference to "Conditional Water Licenses No. 27068 and 39432 and 27068(?) is accurate or repetitive.

Page 2-20, section 2.7, para. 1, sentence 1: "The Kootenay River originates in the Rocky Mountains southeast of Golden (delete 'near the source of the Columbia River at Canal Flats' as inaccurate)…" Last sentence: Isn't the Kootenay Lake Order held jointly by FortisBC and CPC/CBT?

Para. 2, sentence 1: "In the central part of the Kootenay Basin…" (Northern is inaccurate)

Table 4-6

For local and tourist $, indicate units is 1000's of $ as per Table 4-5 if that is the case, or clarify exact amount. Provide calculation details for average $/Access days within text or appendix. Reference appendix in text on page 4-11. Page 4-14; 4.7.2.1 Total Power Cost.

Define "levelized" in context to levelized dollars per year.

Define “unconstrained” in second paragraph for unfamiliar reviewers. Wasn’t Columbia River Treaty and minimum flow/maximum flow and rule curve constraints incorporated into the model?

Provide a General Optimization Model summary, including assumptions and formula in appendix, reference its’ page or reference the summary description provided on page 6-10 and 6-11.

Page 4-15; 4.8.1 Culture and Heritage

1st paragraph
“……known historical trails and archaeological sites within reservoir drawdown zones or between minimum and maximum operational elevations…..

2nd paragraph
“……operations are most likely to affect sites within and around Arrow Lakes Reservoir

“A high level landform study………………..identified four sites within the Arrow Lakes Reservoir drawdown zone…………

Page 4-16; 4.8.2

- Provide access to traditional plants

Page 4-32, 4.10.1.1.2, para. 1, last sentence: “Although under current conditions some littoral-feeding sport fish ……”

Keep in mind that species occupying the lower trophic levels (omnivorous bottom feeders such as suckers) generally out-number sport fish. Such species are important ecologically and provide a link between low trophic communities and top predators such as burbot, bull trout, sturgeon, raptors etc.

Table 4-12

Entrainment.

While the statements presented reflect some of the discussion and content presented at FTC and CC meetings, it should also be stated that the impact of entrainment is a significant outstanding issue, at least for FN. There was (is) almost no data or applicable study with which to base any decisions upon specific to Mica, Revelstoke or Keenleyside Dams and that no satisfactory study design could have been implemented in step 5 that would have provided conclusive results given the very short time-frame available for study completion (approximately 6 months). It was therefore deferred to the Fisheries Advisory Team (FAT) to initiate a process whereby an effective monitoring program would be implemented during the review period.

The statement "fish that do not die contribute to downstream populations" is a gross assumption. Many species or populations that are entrained downstream of Keenleyside Dam may not be able to spawn, in which case they should not be considered contributions to downstream populations.

Page 4-36, 4.10.1.2.2

Provide references for spawning events in 1999 and 2003, population estimate of 50 individuals.

The references are as follows:

R.L.&L. Environmental Services Ltd. 2000. White Sturgeon Investigations in Arrow Reservoir and Columbia River, B.C., 1999 study results. Report prepared for B.C. Ministry of Environment, Lands and Parks, Nelson, B.C. R.L.&L. Report No. 754F: 38p. + 4 app.

RL&L (2000) provided the first documentation of spawning downstream of Revelstoke Dam

Tiley, M.H. 2003. Lower Arrow Adult White Sturgeon Assessment: Final Summary Report prepared for The World Wildlife Fund Under the Endangered Species Recovery Fund. 12p.

Tiley (2003) provided the population estimate: 46 (95% CI= 28 to 87) which is the most up-to-date population estimate for the Arrow Lakes Reservoir population based on mark-recapture data up to 2002. RL&L(2000) provided an estimate of 50 individuals based on mark-recapture data up to 1999.

Tiley, M.H. 2004. White sturgeon (Acipenser transmontanus) egg and larval development in response to summer temperature conditions observed downstream of Revelstoke Dam. Final Summary Report prepared for The World Wildlife Fund Under the Endangered Species Recovery Fund 29p.

The likelihood of delayed spawning based on empirical temperature data and spawning events was first provided in the above Tiley (2004).

In addition to high clarity and low flow resulting in predation, other potential factors contributing to recruitment failure include the following:

- Low productivity due to low nutrient levels and peaking operations
- High imbededness due to lack of scouring flows further reducing productivity and refuge from predation and high velocity
- Stranding of embryos, larvae and juveniles
- and cold temperature which may interact synergistically with the above.

I would consider adding these potential impacts given the possibility that recruitment failure in not being caused solely by predation.

Page 4-38, table 4-13: I would indicate that the Fish Technical Subcommittee (FTS) is synonymous with the Fisheries Technical Committee (FTC) or the Fish and Wildlife Technical Committee (FWTC) early in the report as many emails and documents were distributed addressing the later This would increase clarity for future reviewers.

Page 4-39: 4.10.1.3.3, para. 1, last sentence: "This occurred in another downstream sub-population on the United States side of the border…"

Page 4-40; second paragraph.

"Further, individual fish……………indicating that food and habitat is available". Please provide a reference(s). Please indicate that the size and age of fish are approximately 200g and approximately 1 year old at the time of release (get details from Ron Ek of the Kootenay Sturgeon Hatchery at Wardner, or from someone from the RT). One-year-old white sturgeon habitat, food requirements, and susceptibility to stranding may be radically different from post hatch larvae and early juvenile stages. Although predation is certainly a potential cause of recruitment failure, other potential factors should also be listed.

Page 4-45

Second paragraph referring to HYSIM Model.

Provide information on the model (applications, formula, assumptions) in the appendix section and reference page here in the text. I note that this info is provided in chapter 6. I suggest providing a page reference in order to allow a reviewer to address model details in this section.

Page 4-46

First paragraph, last sentence referring to Integrated Response Model (Korman, 2002).

Provide information on the model (applications, formula, assumptions) in the appendix section and reference page here in the text).

Same comment above for the ELZ model described under 4.10.2.2. I suggest providing an entire appendix chapter devoted to summarizing the various models used.

Page 4-51

First sentence,
Specify which spawning events you are referring to, as there were two spawning events in 1999 (July 31 and August 20, RL&L, 2000) and two in 2003 (August 02/03 and August 13/14, Tiley, 2004). I suspect the 1999 spawning events are being referred to here.

Page 4-52

Fourth bullet: reduce embeddedness?

Page 5-16

Second bullet under key conclusions:

"It is believed that fish behaviour (use of water depth) to avoid TGP ……." This comment might suggest to some that fish can detect and actively avoid TGP.

The study by Westslope Fisheries did not find such an avoidance type of behaviour in rainbow trout radio-tagged downstream of Keenleyside Dam. Other literature I have reviewed has observed or suggested the same. If there is a study that provides such evidence, I suggest referencing it here. Otherwise, I would rephrase this comment.

I suggest the following: It is believed that the utilization of river habitat by fish below compensation depth downstream of Keenleyside Dam coincidentally minimizes exposure to elevated TGP levels.

Page 6-7, 6.3.2., fourth Paragraph.

Since the HYSIM model incorporates operational flexibility under the NTSA, state potential error in outputs as the costs of alternatives may increase, as a result of the NTSA no longer being in effect, and the accounts being returned in the Arrow and Kinbasket potentially over the next 7 years. I acknowledge that the NTSA would have been needed primarily for Alternatives 11B or the alt 11D's, but given the CC's decision to accept soft constraints and BC Hydro to make best efforts for Arrow until a new agreement is reached, this may be a non-issue. However, it should still be clarified here.

Page 6-18; Table 6-9.

Define ksdf as for all units

Page 6-18; Table 6-10.

I have been informed that leakage flows from the dam are closer to 500cfs, but it may be worth confirming. Perhaps provide a reference that indicates leakage flow from Revelstoke Dam is 2cfs – I believe previously referenced as 200 cfs.

Page 7-14, clause 2: Indicate that the alt 7's or FFF depart from (I would use the work violate if that is what is meant) the CRT but an agreement with the US is likely (?) (Rainbow trout flows) or possible (white fish flows).

Page 7-30

Figure 7-5. The excel figure states Alt B. It should read Alt 11B.

Page 7-34; Table 7-21,

The table categories and associated units need to be defined and clearly presented. Future reviewers will not know what they mean. Explain the N/As for alts 10 and E 10-5.

Page 7-37, second paragraph

" ……results of Step 5 modelling studies indicated that a seasonal minimum flow of at least 30 kcfs would be required to provide suitable habitat conditions for spawning and rearing.

Page 7-38, last sentence.

"……while alt 11B targets a maximum reservoir elevation of 436m in May and June". Alt 11B does not hold the reservoir at 436m throughout the growing season. Full pool must generally be reached under CRT requirements.

Page 7-51, Table 7-34

Explain what the numbers 1, 2, 3 or no number means under the Arrow Reservoir alternatives.

Page 7-109, Table 7-58

Indicate units ($1,000,000/year) to clearly illustrate cost of whitefish flows.

Page 8-17, table 8-15: Soft constraints for Arrow Lakes Reservoir

- Wildlife first bullet is far from clear
- Wildlife fourth bullet also very unclear
- Reword fish third bullet as follows, for clarity: Monitor and assess sturgeon early life stage survival on occasions when flows (at boundary) meet or exceed 200 kcfs during sturgeon spawning and incubation period.

Page 8-27, first para: "This plan involves the delivery of bentonite or other turbidity agent to the lower Columbia River…"

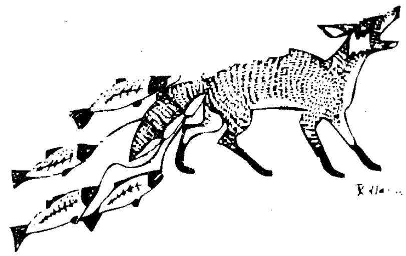
Table 8-25: Culture and heritage, Arrow Lakes Reservoir, second item: "…with implementation of soft constraints and physical works."

Kinbasket Reservoir, Revelstoke, Arrow Lakes Reservoir (2nd row): Add new item: "Increase in knowledge of distribution and sensitivity of archaeological sites with implementation of monitoring studies."

Page 8-31

Foot note number 1 under table 8-25: “ subject to negotiations with the US” needs to be clarified with specifics. Is a re-negotiated NTSA or similar agreement being referred to here and/or are the whitefish and rainbow trout flows being referred to? State the specific agreements or context of future agreements as they relate to specific operations.

Page 10-3, first bullet: First Nations need to be involved in many of the physical works, experimental plans and monitoring studies. Please add to the list “fish and wildlife information plan for Kinbasket Reservoir, Kinbasket and Arrow Lakes Reservoir Debris Management Project, Revelstoke Flow Management Plan, Mid-Columbia River White Sturgeon management plan, Arrow Lakes Reservoir Operations Management Plan; Arrow lakes Reservoir Wildlife Management Plan, Lower Columbia River Fish Management Plan, Lower Columbia River White Sturgeon management Plan.



May 4th, 2005

Ms. Sue Foster,
Project Manager,
Columbia River Water Use Plan,
BC Hydro
E16 - 6911 Southpoint Dr.,
Burnaby, B.C.
V3N 4X8

Via mail and fax: 604-528-2905:

Dear Ms. Foster,

Subject: ***Additional Comment: DRAFT Columbia River Water Use Plan Consultative Committee Report***

I am writing to correct an oversight in our previous comprehensive comments (April 11th, 2005) on the draft Consultative Committee report. Sections 7.7.12 and 8.2.10 do not, in my opinion, accurately reflect the discussions and decisions of the consultative committee with respect to 'physical works in lieu' for the lower Columbia River white sturgeon population.

During the final CC meeting, members (who are also members of the Upper Columbia White Sturgeon Recovery Team) recognized a deficiency in UCWSRI recommendations with respect to the lower Columbia population segment. They recommended to the CC that: (i) the proposed contribution for the conservation aquaculture program was not a 'fallback' position in the event of the infeasibility of the experimental turbidity augmentation program; rather it attempted to address the fact that turbidity augmentation would at best only be possible in approximately 3 out of 10 years, whilst the lack of freshet flow volumes is likely to have an impact on white sturgeon reproduction and recruitment in every year; and (ii) if the proposed experimental turbidity augmentation program proved infeasible, the funds for this program should be re-directed towards programs to address other impacts related to BC Hydro operations.

Canadian Columbia River Inter-Tribal Fisheries Commission

Cranbrook Office
#7468 Mission Rd.
Cranbrook, BC V1C 7E5
Phone (250) 417-FISH (3474)
Fax (250) 417-3475

Revelstoke Office
#200 Suite C Campbell Ave.
P.O. Box 2008
Revelstoke, BC V0E 2S0
Phone (250) 837-2154
Fax (250) 837-2190

There was considerable discussion of the requested change – as indicated in the concluding paragraph on page 7-125 of the draft CC report. Moreover, as indicated in table 7-67, BC Hydro corporate representatives (and CPC's representative) only accepted the proposed program (as opposed to endorsed) because of concerns about the 'open-endedness of the program.' Their comments were clearly not related to the idea of a conservation aquaculture contribution as the only fall-back requirement in the event that the experimental turbidity augmentation program proved infeasible. Moreover, my comments, as recorded on table 7-67, attempted to clarify that the proposal being voted upon was one 'with flexibility' to re-direct turbidity augmentation funds should it prove infeasible.

Finally, I believe that table 3 in the executive summary accurately captures the final recommendations of the CC (as summarized in the meeting either on a flip chart or through the digital projector), indicating contributions to both the Lower Columbia River White Sturgeon Hatchery ($160,000 annualized) AND the Lower Columbia River Turbidity Experiment ($610,000 annualized), as opposed to the hatchery contribution being in lieu of the turbidity experiment.

Thank you for your consideration of this matter.

Yours truly,

William Green
Director

cc. Colin Spence, UCWS Recovery Team
Steve McAdam, UCWS Recovery Team
Gary Birch, UCWS Recovery Team
Jayson Kurtz, DFO

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Susan Hall
Conservation Biologist
Mount Revelstoke & Glacier National Parks

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Parks Canada Mount Revelstoke & Glacier National Parks

Signature: Susan I Hall

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Helmut Klughammer
RR-1, Site-11, C-1
Nakusp, B.C. V0G1R0

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Area Resident, Nakusp Rod+Gun Club

Signature: H. Klughammer

Helmut
Klughammer

Hi Sue

Some of these items are of concern to me and I don't know if anything can be done at this stage. But anyway here are the items:

Sec.4.4.2.2. In this paragraph only the metric system is used. It would be helpful to have the imperial system in brackets throughout the document.

.

Page 7-80 Nakusp Boat Ramp
The Committee Members from this area agreed that the Nakusp Boat Ramp. fits within the WUP
In 2001 Westmar Consultants did a survey of that ramp and stated that the fluctuation of the water deteriorated the structure.
Therefore it definitely fits in the WUP

Table 8-4 The paragraph below under Nakusp
As said above the deterioration of the ramp is caused by the rise and fall of the reservoir and the impact fit in the WUP.

Page 7-78 Last sentence before Table 7-43
New ramps do not fit within the scope of the WUP
Replacing a ramp that has deteriorated because of the operation of the Reservoir is not a new ramp as it replaces the one that is no longer safe ie: the Nakusp ramp

Table 7-43 Shelter bay under benefits should read, "serves **residents** in upper Arrow Lake and visitors".

Figure 7-16 Map shows 16km as the Crow flies. This is misleading, as it is 27km by road.

Page 7-81 Fauquier
It looks like the bridge is on hold, therefore work on the existing ramp is Required.

Page 7-81 Edgewood
It seems to me that it was the members from BC Hydro on the Committee that felt that the dredging could not fit in the Operational alternative.
This ramp fills in with sediment as the reservoir rises and falls and therefore is affected by the operation of the system.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

IAN F. MACLEAN

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River hydroelectric facilities. Minor comments and corrections reviewed with Pat Vonk 2005 APRIL 5.

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 Columbia River water use planning process.

Name & Organization: IAN F. MACLEAN B.C. HYDRO

Signature: IFMacLean

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

FRANCIS L. MALTBY
BOX 2687
REVELSTOKE, B.C.
V0E 2S0

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process:*

Name & Organization: INDEPENDENT/LOCAL REP.

Signature: Francis L Maltby

* 3 PAGE LETTER TO SUE FOSTER DATED APRIL 8, 2005
RE: COMMENTS ON DRAFT CC REPORT AND THE WUP PROCESS

April 8, 2005

Attn: Sue Foster
Project Manager
BC Hydro - Water Use Planning

Re: Comments on DRAFT CC Reports and the WUP Process

Dear Sue;

Thank you for the reminder regarding deadline for CC Report comments. I have quickly reviewed the reports A & B and would make the following observations and comments:

1. Good work on the analysis and suggestions for expansion of what I prefer to call the semi-aquatic vegetation (the report calls it "wetland vegetation", which it is), that is the vegetation that is temporarily flooded during seasonal fluctuation of the reservoir.
2. I am very disappointed that little progress was made during the process to identify and establish a process to evaluate permanently wetted areas or what I prefer to call "permanent wetlands", those with true emergent and submerged vegetation. These are some of the most valuable areas for migratory and resident waterbirds and other wetland dependant organisms using habitats within the reservoir area.
3. I am disappointed that more progress was not made toward refining the very long and broad list of candidate areas for restoration or creation of additional permanent wetlands. This process could have been significantly advanced had there been more willingness to collaborate and utilize local expertise. I will expand on these two comments below. With only a small amount of additional field work a much more refined, cost effective, and practical list of candidate areas could have been presented to the CC.
4. The CC report is largely about fish and semi-aquatic areas and fails to recognize the current status of permanent wetlands that have developed or persisted since the creation of the Arrow Reservoir. There are many examples or remarkably modest physical changes that have produced very impressive results in relation to increased wetted area and increased wetland productivity. All this information passed below the radar screen of the CC, and unfortunately was not fully developed or considered.

Now at the risk of sounding bitter, let me assure you I am not, just disappointed. I will clarify my two comments above regarding <u>collaboration</u> and <u>utilization of local expertise</u>.

Collaboration:

Perhaps you recall a meeting in Revelstoke during which a list of "proposals" for physical works / wetland enhancement was presented to a F&W Committee by Sue Hall and Janice Jarvis, the development of which was supported by Brian Gadbois. Revelstoke is a small town, so it should be no surprise that we are all aware of each other and our respective interests and expertise. I should make it clear that I respect each of these people and the work that they do. Perhaps you also recall that I objected rather firmly, on technical grounds, to some of the major and most costly "proposals", i.e. a 24 million-dollar dike.

A bit of a background: To my knowledge, as of 1998, I was the only person that had actually developed a formal proposal for creation of a wetland within the Arrow Reservoir[1]. Also, I worked with Sue Hall on a Beaver Maintained Wetland Education and Wetland Assessment project[2]&[3]. Also, I have done extensive professional work and continuing education projects related to wetland and wetland dependant species[4]&[5]. Additionally, I have spent approximately $15,000 dollars of my own money on post-secondary education (continuing education and distance learning) and have personal reference library that would make many earth scientists and biologist drool. Simply put "I know my stuff" very well, and my stuff is wetland ecosystems, particularly those within hydro reservoirs such as the Arrow.

1

Now to the point, problems with Collaboration: At Some point during CC deliberations a sub-committee of the F&W Committee was struck to prepare "proposals" for physical works / wetland enhancement (referred to above). In spite of the fact that I had an extensive knowledge of the Arrow Res. and a strong educational background to support the works of this sub-committee I was not informed of its creation or invited to participate. Honestly, this is not "sour grapes", just making a point. At the Revelstoke F&W Committee meeting where I was critical of the "proposals" presented I approached one of the participants of that sub-committee, and offered to meet with them and work to refine and improve the proposals. I later followed up with a telephone call with the same offer. I regret to say that I never was contacted by these folks. Personally that is unfortunate as well as unscientific, and not in the spirit of effective collaboration. To this day, I remain willing to work with this or any other group on this or any other initiatives.

Utilization of Local Expertise:

This should more correctly be "the failure" to utilize local expertise. Let me be clear here that I am most certainly speaking about myself as well as such people as Janis Jarvis and likely others. By utilize I mean recognize their skills, knowledge and availability, and provide compensation for their efforts, yes that means pay us for our services please. It is interesting to me that BC Hydro and the WUP process was and is willing to spend huge funds to import "experts" from "away" rather than support the development and growth of a strong locally based pool of experts. At a very fundamental level, the most obvious benefit would be significant cost savings for BC Hydro with absolutely no sacrifice in the quality of work produced. Again, I am disappointed that it appears at least some in BC Hydro are not prepared to accept that there are some local "experts" that they could perhaps learn from. My own expertise are in the areas of wetland ecology, soils, hydrology (ground water of particular interest), and management planning, multi-disciplinary, which is just common sense if you wish to do habitat restoration. The lack of letters behind someone's name does not a dummy make, but that appears to be what some in BC Hydro persist in thinking.

I am not ashamed to say that this is about my personal interests. I have made major investments in post secondary education, I have contributed thousands of hours in volunteer efforts to learn about and conserve local wetlands. I see BC Hydro prepared to spend millions of dollars near my home area researching, developing plans, and implementing projects in a field of endeavor that I am very knowledgeable about and quite qualified to work in. I see distant "experts" building their careers around works related to reservoirs and reservoir restoration and I would like to be given a fair chance at the same opportunities. Simply put, BC Hydro should support the local, skilled expertise!

I will close for now, these are just brief comments, ultimately my objective is to be more involved with the actual projects and works as a very knowledgeable and skilled independent professional. I have many good ideas for modest projects and suggestions for assessment works that I would like to develop with BC Hydro. I look forward in the future to furthering the work of the WUP CC "on the ground" and "in the water".

Thanks for the opportunity to participate in the WUP process, I have met many good people and it has been educational in many ways. I am emailing this letter to you today and will put a hard copy and the CC Report Sign Off Form in the mail to you today as well. Finally, I will be forwarding this letter to others in BC Hydro.

Take Good Care!

Sincerely

Francis L. Maltby

2

Reference Documents:

1. 1999, Maltby, F.L., Illecillewaet Greenbelt Society Wetland/Fisheries Habitat Restoration and Creation Project Proposal Summary, at Revelstoke, B.C., Submitted to: Columbia Basin Fish and Wildlife Compensation Program, Nelson, B.C. (unpublished)
2. 2001. Maltby, F.L., *Education for Beaver Maintained Wetlands Project (Maltby Management),* Developed for: Senior Secondary (classroom and outdoors) *(Three Educational Units),* Prepared for: Columbia/Kootenay Fisheries Renewal Partnership (Ktunaxa/Kinbasket Tribal Council)
3. 2001, Maltby, F.L., *Field Inspection Manual and Field Inspection Checklist, Education for Beaver Maintained Wetlands Project,* Prepared for: Columbia/Kootenay Fisheries Renewal Partnership (Ktunaxa/Kinbasket Tribal Council)
4. 1998, 1999 & 2000, Maltby, F.L., *Painted Turtle Nest Site Assessment, Enhancement and Monitoring, Red Devil Hill Nest Site* at Revelstoke, Prepared for: Columbia Basin Fish and Wildlife Compensation Program
   2002, Maltby, F.L., *A) Preliminary Evaluation of Painted Turtle Habitat and Ecological Factors at Burnaby Lake B) Potential Impacts on Painted Turtles and Proposed Mitigation Strategies for the Burnaby Lake Rejuvenation Program* Prepared for: City of Burnaby, At: Burnaby Lake Regional Park
5. 1998, Maltby, F.L., *Illecillewaet Greenbelt Society - Wetland Restoration and Creation Project Proposal Biophysical Description and Project Summary* (volunteer/education), (Continuing Studies - Physical Geography, U Vic.)
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   2000, Maltby, F.L., *Towards a Conservation Plan for Painted Turtles at Revelstoke, B.C.* (volunteer/education) (Continuing Studies - RNS, University of Victoria)

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

DON MUNK

Box 520

Revelstoke BC

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: DOWNIE R.V. RESORTS LTD

Signature: Donald Munk

From: Murphy, Shelley EM:EX [mailto:Shelley.Murphy@gov.bc.ca]
Sent: Wednesday, July 06, 2005 9:22 AM
To: 'Foster, Sue'
Subject: RE: Final Draft - Columbia River WUP Consultative Committee Repor t

Hi Sue.

Unfortunately, I was not able to meet your deadline. I know you said "as discussed" but I don't recall having talked to anyone at BCH about next steps on the report, so wasn't expecting this short re-review period. When did we talk/email? Apologies if I have just forgotten.

I glanced through the document to see what has changed since the one I previously reviewed, and note that there are quite a few changes and additions. In order to review completely, I would need to re-read the entire document, and, as I had other deadlines and commitments in this time, I not able to fit in the review of a 300 page document in 2.5 working days (I was away on Monday).

I did do a quick scan to see how my previous comments were addressed. Thank you for addressing some of my comments. However, I did note that several of my previous comments had not been addressed, and I am not sure why. Many of those were comments related to the portrayal and calculation of costs. As one example, on Revelstoke boat ramp on page 16, this is listed an annualized cost over 15 years of $.06 million. $0.06 million * 15 years = $0.9 million. The CC did not agree to spend this much. The CC agreed to up to $200k in capital cost, plus up to $12.5k in maintenance, which, over 15 years is (max) only $0.026, not $0.06. My earlier comments also raised similar questions about other items. What is it that I am not understanding about the table and the cost calculations?.

I did start to read through the revised document and did pick up a couple of things. On the discussion on the Treaty in the exec summary - the sentence on the termination of the treaty - should read "There is no specified termination date for the Treaty, however, the earliest the Treaty may be terminated by either party is 2024, provided notice is given 10 years prior.

On the soft constraints table on page 10, I note that others have added explanation to that which was provided at the last meeting. So for power values, add the sentence "Operate system to obtain maximum value for power" - which just explains "optimize". Doug R. may want to review this.

On page 5, last bullet - delete the rest of the sentence after "Violating the Columbia River Treaty is outside of the scope of water use planning". There are more reasons than financial to respect a Treaty, and I don't think this statement needs any qualifiers.

Shelley

From: Murphy, Shelley EM:EX [Shelley.Murphy@gov.bc.ca]
Sent: Wednesday, June 01, 2005 5:34 PM
To: Sue Foster (E-mail)
Subject: wup comments

Sue, here are my comments on the draft Columbia WUP CC report. I am sorry for the delay in responding. We have been very busy here, and have been fitting it in on weekends/evenings. It took a fair bit of time to go through such a large document - particularly given I haven't looked at for 10 months. However, I finally finished it last night.

First, a comment on the sign off sheet. I am not sure how I can sign off that the CC report is acceptable, when I don't know how the document has changed in response to others' comments or how my comments will be addressed. Is it okay to put a caveat on the sign off sheet - saying this is based on the draft reviewed, assuming comments I provided were addressed, and that subsequent changes to address others comments are acceptable as well?

As a general comment/question, the report wasn't entirely clear (or maybe it is me who is not entirely clear) on how the CC recommendations that can't be written into a water license (or works in lieu of that) and related monitoring studies - the ones that require US agreement or change to Treaty flows (which I thought was the MWF, RBT and lower Columbia sturgeon (which I abstained on)) - fit in the WUPs. As I understand it, these are separate recommendations to BC Hydro, but not something included in the plan (and subject to water rental remissions) ?

In terms of specific comments:

Page 7 - boat ramp discussion. This section should note in the text or in a footnote the outcome of the Comptrollers view on the fit of the boat ramps.

Page 7 - Kinbasket and Arrow Lakes Reservoir Debris Management - I believe that in addition to needing the Comptroller to accept that the plan is within the scope of WUPS, I there was also a stipulation that the program be designed such that it only dealt with debris issues related to operations.

Page 8 - Kinbasket and Arrow Lakes Reservoir Heritage Management Plan - for the 'unknown sites', I think there was a need to design the program to link it to operational issues.

Page 10 - summary of costs (note that I think this is the same table as 7-68, so same comments apply) - this table states that it reflects the CC supported the costs as noted in the table. However the table has the wrong numbers for the Arrow and Revelstoke boat ramps - does not reflect final CC decision and CWR decision on which ramps fit.

LCR white sturgeon hatchery - this is a fallback option to the turbity experiment. It is one or the other, as I understand it and described in section 8, so both should not be noted in the cost column.

Generally, I found that the numbers in table 3 often didn't match exactly with the numbers in section 8 for physical works and monitoring. I didn't go through and check each one, but there were enough differences to leave me wondering how the ave annual costs were calculated (I thought they would simply be the total cost divided by 15 years), and which numbers were correct. For example:

* revegetation physical works numbers (KIN and ARR) - if the total cost of the revegetation is $4.1 million (per section 8) over 4 years, then the ave. annual cost over 15 years is $273 k. But in table 3 the combined ARR KIN programs is 380k in Table 3.
*
* Archaeological sites - the numbers in the table don't seem to line up with the numbers in the discussion in section 8
*
* Revelstoke monitoring - again ave annuals for monitoring in table don't seem to match those in section 8. I calculate the 0.39 from section 8 (without discounting), not 0.42. .
*
* Same sort of concern with the MCR White Sturgeon numbers for the experimental workplan.

Page 7-41 - I don't know that the characterization to eliminate the base case from further consideration is completely correct; more that we agreed that it was not a preferred outcome. Also, it was kept in place as a reference for all values, not just financial.

Page 7-58 - white sturgeon monitoring - why would this be annualized over 25 years? Should be over 15 years like all the other studies.

7-73 (and 8-18) - I don't recall agreeing to the tributary fish study, to be decided after the last WUP. If this wasn't agreed to at the June meeting, then I do not support adding it in after the fact. But if indeed the CC did say, yes to this in June, then I guess it is okay, but I am concerned about including a study the CC did not get a chance to question.

7-77 - the issue of the Revelstoke boat ramp being not in the scope of WUPs was also raised in the discussion.

7-80 Nakusp - should note that subsequently, the Comptroller said this doesn't fit.

7-83 LCR Boat Access - should note that this had not yet been determined if its within the scope or not.

7-90 - Similar to my comment above, I didn't check the math throughout the document, but in some cases I found that the average annual cost did not seem to fit with the total.

I thought it was simply the total divided by 15, (see calculation under Program 4), but for example, for program 3 in table 7-47, 250/15=16.7, not 17.361. Similarly for Program 5 on page 7-91, 400/15=26.7, not 32.458. The numbers should all be checked and confirmed.

7-107 - the comment attributed to me. Please delete the last sentence. I would not have questioned doing a feasibility study prior to implementation. The previous sentence captures my view sufficiently.

Section 8 - it would be helpful if there was some consistency in the presentation of the different items - i.e. all had cost by year, total cost and average annual cost.

8-8 - debris management, top of page - also need to stipulate that the condition was that the program be designed to address only reservoir operation related issues (s.t. agreement from the CWR that it is in the scope).

8-10 - LCR debris management - need to specify this is subject to the CWR saying it is in he scope of WUPs

8-11 - heritage sites; the unknown sites need similar caveats to those noted in section 7 of the report.

Table 8-13 - there seems to be some difference in the description of this compared to the briefing note for the CC in June (Arrow conservation aquaculture Option A was 4 years not 5 - $ calculation reflects 5); flow treatment is 7 years, not 6 in Option B; years 6-8 for aquaculture in Option B didn't seem to be in the briefing note.

8-22 - 150k not 180k./year as per briefing note Or was this changed at the meeting

8-26 couldn't find the sculpin study in the briefing note. Was this added in post-meeting? Or did I just miss it in my review?

Email or call me with any questions. Apologies again for the delay

Shelley

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Loni Parker
Director
Columbia Shuswap Regional District

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River hydroelectric facilities.

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Name & Organization: Loni Parker CSRD

Signature:

-----Original Message-----
From: Ron & Carmen Oszust [mailto:rcoszust@cablerocket.com]
Sent: Tuesday, May 17, 2005 7:13 AM
To: sue.foster@bchydro.bc.ca
Subject: CC draft report

HI Sue,

Thank you for your note and I would like to request a copy of the draft Report after it has been reviewed. I have some comments below that I would like to have included in the review process. I understand that these may have already been submitted by Loni Parker, the CSRD representative, and if so please disregard. Thank you.

ron oszust

CSRD

1- There are concerns locally over the Arrow soft constraints.....if they are not met then there is no ability to open the Columbia WUP in this area and turn them into hard constraints..

2- Surcharge wasn't listed as a soft constraint for the Kinbasket and it was suppose to be included.

3- If there is going to be a surcharge then there must be notice given to the Communities as well as the licensees. The minutes indicate that this was discussed around the table with respect to the impact of reservoir surcharge and its impact on debris. If BC Hydro is going to surcharge the reservoir there should be financial resources put into debris management activities the following year. In addition the comptroller should specify compensation for impact to roads and other infrastructure resulting from surcharging the reservoirs. In addition the comptroller should require BC Hydro to notify impacted communities and interest groups about impending surcharge operations.

4- Kinbasket has always been grouped with Arrow and the Kinbasket needs to be separated. Debris Management may have been resolved in the Arrow but not in the Kinbasket (page 789). This still needs to be addressed. In a presentation made to the CC by the Kinbasket groups they clearly articulated their request that the Kinbasket reservoir have its own budget and Community Consultative Committee to deal with debris management. There was no decision made to lump the two together.

5- Debris Management - ensuring that there is an annual budget and the money needs to be allocated. What the Kinbasket folks are saying is that while Debris issues are subsiding on Arrow they are not on Kinbasket and that a focused Kinabasket Program needs to be initiated. Linking with the Arrow reduces focus on the Kinbasket and follows historical patterns of neglect.

5-From the minutes the community groups had requested that BC Hydro set up consultative groups to work with BC Hydro to plan and implement Debris Management programs on the reservoirs. This should be implemented for this coming winter so that there is a plan in place for next years Debris Management activities. The local community group have sent a letter with no response; **they also wanted it as a non WUP recommendation in the report**

From: Paul Peterson [peterson@columbiacable.net]
Sent: Thursday, April 07, 2005 9:25 AM
To: sue.foster@bchydro.bc.ca
Subject: Draft Review

Paul Peterson
DIRECTOR, ELECTORAL AREA K – THE ARROW LAKES
PO Box 128, Burton, BC V0G 1E0 Phone/Fax: 250-265-4451
e:mail: peterson@columbiacable.net
REGIONAL DISTRICT OF CENTRAL KOOTENAY Telephone: 250-352-6665 or
Box 590, 202 Lakeside Drive, Nelson, B.C., V1L 5R4 1-800-268-RDCK(7325)
web: www.rdck.bc.ca e-mail: rdck@rdck.bc.ca Fax: 250-352-9300

April 7 2005

Sue Foster
Project Manager
BC Hydro

Dear Sue

Below please find my comments regarding the Draft Report

Page 7-79 Figure 7-16 Recreation Sites graph should show camping at Burton and Edgewood.

Page 7-80 Nakusp ramp – To say the Committee did not reach agreement on whether the Nakusp boat ramp fits the scope of water use planning is misleading. If memory serves me correctly the recreation committee prioritized Nakusp and Edgewood as number one and the committee as a whole almost unanimously agreed. It was pointed out that Hydro operation's was the cause of the extreme deterioration of the ramp. There were only a few members that did not agree. If three or four do not agree compared the fifteen or so that do then that has to account for something.

Page 7-81 Fauquier ramp – The bridge does not look very promising so therefore focus should be placed alongside the ferry ramp as the old ramp is in a poor spot and the golf club do not want responsibility of it.

Page 7-81 Edgewood ramp – There was a lot of discussion amongst the committee that is not reflected in the text. It was repeated several times that dredging and extension of the ramp would not work as sedimentation would continue and eventually render the ramp unusable. The wave break that is causing the sedimentation mentioned in the text is actually a natural peninsula that created the one and only harbour on the reservoir. Due to Hydro operations of rising and falling water levels this peninsula is being destroyed. It was pointed out several times that the peninsula should be built up and protected so that waves would not go over top of it thus eroding it away. As stated during the meetings the ramp should go down into the lake at the end of the peninsula for year round access and to stop the sedimentation of the harbour and to stop the erosion of the banks of Edgewood Park which is causing even more sedimentation.

(The people of Edgewood are expecting an engineering report any day now that they commissioned to reflect cost and feasibility of this proposal. I don't know exactly why this suggestion was not reflected in the draft text as it was discussed at the meetings). If costs are equal then it would be advisable to go this route instead of the proposal stated.

I think you should call another meeting with the CC as there are a lot of items that should be discussed by the whole.

Sincerely yours

Paul Peterson

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Randy PriesT
Surprise Rapids Collective

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River hydroelectric facilities.

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Name & Organization: ______________________________

Signature: R J Priest

-----Original Message-----
From: Randy.Priest@lpcorp.com [mailto:Randy.Priest@lpcorp.com]
Sent: 2004, December 03 11:33 AM
To: Sue.Heaton@bchydro.bc.ca
Subject: Columbia Water Use Plan June Minutes

Susan: my apologise for being tardy in returning. Actually reviewed some time ago but wanted to meet with the group here in golden so that everyone agreed in principle on the minutes. Well it doesn't seem to be happening.

First the boat ramps, the folks in Naksup will be disappointed with the decision re their boat ramp. Happened to be in Naksup on Sunday/Monday and water level was at 1330 ft? it is terribly rickety when one see it all out of the water and steep. One would want to be very good at backing up a boat and trailer before going down there. Once there a very goof park brake. The others ramps are no big surprise. If you have any ideas or a group should need some assistance in continuing to justify a ramp would be happy to help.

Comments:

- pg 16 re my question who will assume the ongoing owner ship of the ramps? At this time no group has come forward. Is this something that remains to be done?

- pg 20 re the last 5 points and pg 21 4 points regarding compensation. No clear answer is indicated. During various meetings the surcharging was discussed and thought that; a) communities would be notified and a clean-up action plan would be forth-coming. Water Comptroller determines, but what criteria would be used?

- pg 22 re debris, a number of the these comments could be saved and utilised for the establishing parameters for the annual clean-up budget.

- pg 25 re revegetation, Pat Vonk's comment about melding the 3 areas together and then your comment that Kinbasket is a stand alone needs to be confirmed, as Kinbasket does have some other issues because of levels, steep terrain, remoteness, etc. Would be interesting as time goes by to see results of this program maybe published in the news papers or?

- pg 41/42 re the Revelstoke minimum flows, inclusion in any resulting reports from the Water Comptroller that the plan would need to be reviewed if changes are made to Mica or Revelstoke. The minimum flow is important for maintaince of aquatic life and rather than assume my thought would be that 5 kcf is the minimum.

Much of the remainder of the minutes now deal with fish and cannot comment knowledgeably to this. Interesting but....

The temporary ramping rates in Arrow (providing for NTSA negotiation) and results/effects verses any of the proposed WUP initiatives, will be worthwhile monitoring and over time hearing how it turns out, (good-bad or no real change).

My thanks to you and all of the CC participants, it has been educational, interesting and have met a number of people from throughout the region and gained a much better understanding of their concerns and needs as communities and all of our relationships to the water use. As the plan unfolds I personally would be interested in continuing on in some form if I could be of assistance. Look forward to the final report and the implementation of our recommendations.

Regards

Randy Priest
Chief Engineer
Ph 250 344 8848
Fax 250 344 5811

Randy Priest
Surprise Rapids Collective
2483 – Seward Rd
Golden BC, V0A 1H1

Ms Sue Foster
Columbia Water Use Planning
BC Hydro
6911 Southpoint Dr
Burnaby, BC
V3N 4X8

April 19, 2005

Subject: Review and Sign-off of The "Draft" Consultative Committee Report

Dear Susan:

My apologies for the tardiness in responding, wanted to review the report fairly carefully, reflect and also meet with the Kinbasket Group to hear any of their concerns/responses.

First, let me thank you and BC Hydro for leading the various representatives of the communities and interest groups through the CC Process. It was a privilege to participate and the learning's of the Basin is immeasurable.

The process when placed in context with the system as a whole met the need for a first time review of the operations and the license conditions. Placing the Plan in a fixed time frame for resolution limited the perspective of what the system could become as a vision. Understanding that information and baselines need be first established but even the outcome of these would have taken on a different flavor if the long-range vision had been considered.

The length of time that it took to progress from operational changes to non-operational was far too complicated and long. Many of the non-operational changes were obvious and might have been dealt with earlier and put to rest. As it turned out, believe that not making this distinction earlier clouded the final outcome of the operational changes as we rushed to complete the process.

First issues in respect to the Kinbasket Reservoir. If anyone group was left out of the mix, representatives of this reservoir were. From early on in the process the opportunity to make any changes operationally to Kinbasket were not an economic fit.

At issue are items discussed at the CC meetings and generally understood and agreed upon. Such as Surcharging of the reservoir, in that Hydro would endeavor not plan to fill the top meter of the reservoir if possible to avoid debris problems. Then if Surcharged that not only would fees be paid to the Comptroller for the privilege but monies and a plan registered at the same time to deal with issues that resulted. Debris, damage to private structures and servicing of the boat ramps. This was all lost in the draft report and letters forwarded from the Comptroller.

Debris on the reservoir was discussed I believe at every meeting that was held and meaningful discussions had taken place with commitments to form a committee of community people to tour the reservoir annually, and develop a strategy for debris. This was completely lost in the draft report as we are now waiting for environmental reviews to take place. Unfair that in the final vote those who make these requests never paid any attention to previous discussions and now we are waiting to see a resolution through the WUP that had been previously dealt with through the local area manager. The intention of attaching the debris issue to the WUP was to create funding to enhance past efforts and make the reservoir more user friendly for recreation interests.

I am not clear as to the interpretation given in the draft report regarding Arrow and the application of "Soft Constraints" for five years after the implementation of the WUP. An assessment is to be made for operations and progress. Then an opportunity to review all of the Operating Alternatives, considering the impact of a possibly new NTSA and then the selection of an Operating Alternative (and this could be a continuation of the Soft Constraints) that would best suit the needs of Arrow. Or do the Operating Alternatives not apply at that time?

This review could in effect modify the WUP as applied to Kinbasket, as the NTSA applies to this reservoir also, even though no Operating Alternative was selected. Any monitoring efforts and/or physical remediation programs would change as a result of much different water levels.

Next is the Boat Ramp issue in Naksup. There are several concerns here in that long term, safe access to the reservoir has not been provided. If a similar situation arose today, would a steep, wooden ramp be considered appropriate?

There is another more real issue though with this boat ramp in that it is a Creosote structure. An environmental clean-up should be completed and a plan put in place to finally dispose of it.

The final note is the concern that a great deal of funding has been made available over a long period of time. The viability of many of the projects being funded very much in question. There is no mention of a mechanism that would determine an accountability process as to; progress, effectiveness of information or the overall results of any changes made, (though this is documented in the draft CC minutes for Arrow). It is recommended there should be at a minimum an annual report of progress by any group receiving funding to the Comptroller and BC Hydro and then suggest a posting on the Hydro Web-site for the public to access.

Some how I would like to know that these comments have been received and incorporated into the final report document as attachements.

Fisheries
and Oceans

Pêches
et Océans

Pacific Region

June 28, 2005

Jason Quigley,
Regional Water Use Manager
Fisheries and Oceans Canada
200 - 401 Burrard St.
Vancouver BC V6C 3S4

Sue Foster
Project Manager, Water Use Plans
BC Hydro
E16 – 6911 Southpoint Drive, Burnaby, BC
V3N 4X8

Dear Sue:

Please find attached comments from DFO on the Draft Columbia Water Use Plan Consultative Committee Report, Volumes 1 and 2. Generally, BC Hydro has done a very good job of capturing the events and decisions/agreements that took place through this process. As evidenced by the size of the referenced documents, this process was extremely long and complicated. In conducting the review we utilised the minutes of the CC meetings which we had reviewed throughout the process for accuracy and clarity.

Attached you will find a consolidated set of comments that reflect the understanding that DFO had on specific decisions made at the CC table. We will be pleased to endorse the document once two significant points of contention are addressed, specifically the understanding of various CC members concerning the approved White Sturgeon plan for the Lower Columbia and the Arrow Lakes Generating Station (ALGS) (see attached comments for details).

I hope you find these comments constructive and I am happy to discuss any questions you might have.

Sincerely,

Jason Quigley

Canada

Consolidated DFO Comments on the Draft Columbia WUP Consultative Committee Report.

This Report has been very well written and has done a very thorough job of capturing the events, decisions and agreements that happened over three years from February 2001 to June 2004. The system is extremely complicated with three different power facilities and associated infrastructure. The presence of the Columbia River Treaty (CRT) and the Non-Treaty Storage Agreement (NTSA) also made this WUP far more complicated than other WUPs. With the inclusion of the suggestions below, DFO should be able to sign off the CC report as accurate.

Executive Summary

Pg.1:

- Columbia River Treaty: The CRT is discussed in the main body, but isn't in the Exec Summary. Because of its impact, it should be included in the Exec Summary prior to Mica immediately after the Introduction.

- The reference to Mica Dam should actually state Revelstoke Dam.

Pg. 5, Mid Columbia River White Sturgeon Management Plan:

- The flow treatments referred to in this section are flows for White Sturgeon in addition to the 5 kcfs minimum flow to be provided year round d/s of Revelstoke Dam. Again in the same paragraph there is a reference to "discontinue flow tests". Insert "White Sturgeon related" into the sentence.

P6, Table2, Fish:

- As written, the first and third bullets are not constraints, they are monitoring issues. However, they aren't in the monitoring sections. If they are intended to be soft constraints, then they should be re-written (i.e. Maximize average annual river length).

P7, last para:

- There is no discussion in the main body about emergency boats. Either include it in the main body or remove it from here (DFO doesn't recall specific discussion relating to emergency boats in the CC process so suggest removing it).

P9,para 3: no reference to RB redd salvage.

- BC Hydro currently undertakes salvage of RB redds annually. Although not specifically addressed in the WUP it is currently undertaken by agreement with the regional office. Since it is not specifically operational (ie it is undertaken regardless of the flow scenario), DFO expects that salvage will continue.

Pg. 9, White Sturgeon Experimental Plan;

- DFO suggests that "turbidity augmentation" be used rather than" bentonite" (this describes the objective rather than one specific option). Also the section should provide a brief rationale for this (link to habitat requirement).

- The contribution to the hatchery program was intended to be in addition to the turbidity studies not alternative to. The minutes of the last CC meeting refer to the contribution as being in lieu of flows in the Lower Columbia.

Pg.10-11, Table 3 Summary of Costs:

- There seems to be some minor errors to the Summary Costs table:
  - Boat Ramp Costs are $.93m, not $.92m
  - Archeological Protection costs are $.74m not $.67m
  - It appears that the hatchery contribution for LCR is included as an annual cost. This supports the contention that the CC supported this action separate from turbidity.

<u>Main Report, Volume One</u>

Pg. 2-15, Sec. 2.5.3 Fisheries Interests;

- This CC report is released after the Alternative Measures Agreement was signed between BC Hydro and DFO, which does specify some formal agreements. The report should reference the existence of this agreement in the same way that it references the expiry of the NTSA, which also occurred towards the latter part of the process.

Pg. 2-15, Sec 2.5.3.1 Rainbow Trout Spawning.

- This section does not reference the ongoing actions of regional BC Hydro staff to annually salvage dewatered RB redds. This is an ongoing requirement related to but not specific to WUP.

Pg. 2-16, Sec.2.5.3.3, Total Gas Pressure:

- The comment goes to the over all impression left in the report that TGP is a serious problem but is generally accepted by the agencies. It should be pointed out that TGP remains a concern to DFO d/s of Keenlyside and at other sites. The addition of ALGS has however greatly reduced the overall TGP problem in this area and this fact has not been well flagged in the report. TGP remains significant from Keenlyside d/s to the point in the Columbia where flow from ALGS has fully mixed and the appropriate strategies identified in this section are still important to reduce impacts in this area.

Pg. 2-17, Sec. 2-6, ALGS:

- DFO's concerns, with how ALGS operations and the power interests are documented, have been referenced already and will be commented on further. If, however, this detailed description of the project and operations is to be retained then DFO believes that additional information pertaining to the obligations of ALGS specifically as they pertain to fisheries should also be included at a similar level of detail to ensure a balance This would provide readers with an understanding of why DFO and others believe that ALGS should not be part of the WUP.

Pg. 4-12, Sec. 4.7.1.1, Financial Value of Power:

- ALGS was not considered in the power costs at the outset of the WUP and many interests including WLAP and DFO believe that it still should not be included as part of the Power Costs.

- The issue relates to the interpretation of the ALGS Energy Project Certificate where the agencies had strove to include provisions to ensure that ALGS would not preclude beneficial opportunities for fish and wildlife. Including ALGS in the power costs for the Columbia WUP and the Duncan WUP was objected to by the agencies but this decision was not supported at the WUP policy Committee level. At the end of the day, this decision likely had little impact on the final choices but it was a significant discussion point and should be include as such. It will also be important for future WUP discussions or when NTSA is finally resolved.

Pg. 4-14, Sec.4.7.2.1, Total Power Cost.

- DFO comments on the previous section are perhaps more applicable here. The table agreed to separate the power costs of ALGS from the other facilities for the reasons discussed in the last comment. The document should identify the issue and the main points of debate.

Pg. 4-34, Table 4-12, Entrainment:

- This table undervalues the concerns that the regulators place on entrainment. The FTC including DFO was very concerned about entrainment and would very much like to have addressed the issue in the Columbia ASAP. We believe it to be a significant issue regardless of real or perceived impacts. Entrainment was dropped as a PM because the agencies and BC Hydro agreed to undertake the province wide entrainment initiative that would develop a system wide strategy. It was not dropped due to uncertainty regarding the net effect. There is or was uncertainty concerning the net effect of most of the WUP issues raised, fish or otherwise yet PMs were developed for these issues.

Pg. 4-41, Sec. 4.10.1.3.4, TGP:

- Again the operation of ALGS has significantly reduced TGP generation. This is as important if not more so than the operations at Keenlyside.

Pg. 4-61, Table 4-16, Power Generation:

- DFO does not recall the CC accepting or even discussing the last performance measure (Potential Impacts to BC Hydro's NTSA negotiations) in this section. The issue of NTSA negotiations was only discussed in detail at the last meeting. It is not included in Table 4-7 on pg. 4-13.

Pg. 6-7, Sec.6.3.3 Streamflow Record for HYSIM.

- Changes to the Kootenay system was determined to be outside the scope of the Columbia WUP. While the facilities on the lower Kootenay River, other than Kootenay Canal, are owned by other interests, in reality BC Hydro, by agreement with these interests, manages the water on the lower Kootenay River. The Brilliant facility (owned by CPC) has the capacity to make some short term modifications but does not affect average flows. This document should acknowledge BC Hydro's role in Kootenay flow management as it is significant. It would be far more effective if the Kootenay was included in the Columbia WUP. and DFO should recommend that be the approach next time.

Pg.6-18, Sec. 6.8. Table 6-10

- This section identifies leakage flows at Revelstoke Dam as 2cfs. This seems to be very low. Can we confirm this number?

Pg.7-27, Sec. 7.5.1, Table 7-16.

- Does funding for proposed vegetation programs include existing dust management program, or will it continue to be funded separately? It is our understanding that they are separate programs.

Pg. 7-40, Sec. 7.6.1, Table 7-24.:

- There is an error under bird units, $ nesting habitat available should be % nesting habitat available.

Pg. 7-41, last para:

- Alt 11F was dropped in the previous paragraph. Why is Base Case being compared back to 11F? Clarification is required here.

Pg. 7-42, Sec. 7.6.2.

- In the last paragraph it should be the June 2003 meeting not the November 2003 meeting.

- Same paragraph as previous point. This paragraph is unclear, while the impacts of rainbow trout and whitefish flow agreements on the operating regime of Arrow Lakes remained unchanged from the previous round of tradeoffs there are changes in the information in Table 7-27 from that in Table 7-18. These are likely the refinements to Arrow/LCR tradeoffs requested in the future recommendations on p-7-32, section 7.5.2, and this paragraph should say that the information in Table 7-27 are the results of these recommendations.

Pg. 7-56, Sec.7.6.3, mid page:

- Macfarlane did acknowledge that forced outages could result in disruptions to the minimum flow d/s of Revelstoke Dam. DFO acknowledges this and will provide some latitude for these rare instances in any authorization.

Pg. 7-59, Sec. 7.6.5: Ramping and Stranding Protocol in the Lower Columbia River – Round 4

- The interim ramping rate was adopted but what about subsequent modified rates? DFO's expectation is that the results of the ramping rate experiments will be implemented. The document should reflect this or further discussion would be needed as new information came to light. This could well be a WUP trigger (unless it was simply implemented) and would likely be identified as a trigger in any DFO Authorization.

P7-111, Table 7-61, Scope 1:

- While it was agreed that in certain years there may be little recourse but to accept "high egg loss rates" it is understood and should be stated that "If flow releases are expected to result in greater than 40% egg mortality BC Hydro will consult with Fisheries & Oceans Canada." Same changes should be made in Section 8. This section should also refer to the agreement between Hydro and DFO in Appendix CC. The report should identify that the monitoring and assessment in years 1-5 is a continuation of existing studies.

Pg. 7-124, Sec. 7.7.12:

- This section deals with the decisions made concerning White Sturgeon in the Lower Columbia. After a detailed review of the minutes of the last meeting, I believe there are two points that need to be clarified.

- First, with the issue of the annual hatchery contribution, the minutes suggest that it is additive to the turbidity and not a fall back option. On page 49 of 88, Bill Green stated that if turbidity was not successful there would be the need to look at other options (and does not mention hatchery contribution as one of these options). He does however state that the hatchery contribution would be in lieu of flow options that were not considered acceptable.

- Secondly, the RT members indicated the need for flexibility with the LCR plan. Bill Green's commented that if turbidity wasn't successful they would need to look at other options. Steve McAdam also raised it in discussions. Some members of the CC specifically referenced flexibility as a condition of their support for the WUP. The final decision point here is unclear and I believe that is due to the lack of discussion on the topic. The CC spent a considerable amount of time on the issue on the mid-Columbia and agreed to include it along with a cap on funding. It is hard to imagine that the RT would not want the same flexibility in the Lower Columbia. All parties brushed over the issue in the heat of action at the last meeting and generally accepted it. There was no reference in the minutes to a cap on funding in the lower Columbia.

- BC Hydro needs to lay out a course of action to resolve this and it should be resolved prior to implementing the WUP. It is not a significant funding matter compared to the overall costs of the WUP.

Section 7 General Comment:

- This section is often confusing with regards to the Lower Columbia River Flows (+rbt) and when they include both rainbow trout and whitefish flows and when they only refer to rainbow trout flows.

  - p.7-29, Sec. 7.5.2. Table 7-17 provides a description of the +rbt alternative which includes both rainbow trout and whitefish flows.

  - p.7-32. The second paragraph refers only to rainbow trout management in the Lower Columbia River, likely due to the tradeoff.

  - p.7-42, Sec. 7.6.2. First paragraph of section, last of page refers to both rainbow trout and whitefish flows.

  - p.7-43. The last paragraph on this page refers to rainbow trout flows, but could include both as described in Table 7-17.

  - p.7-45 and p. 7-46. References on these two pages to fish interests in the LCR and Table 7-31 on p.7-46 refers to rainbow trout agreements, all of which would suggest both rainbow trout and whitefish agreements as per definition in Table 7-17.

  - p7-46 to 7-49. CC members were asked to provide their level of support for the rainbow trout flow agreements. It was recommended that they continue to be pursued with the US each year.

- p.7-62, Sec. 7.7.1. The 4th bullet on this page explains that the CC agreed to the rbt flow, but not whitefish flows in round 4 tradeoffs (section 7.6.2, November 2003). In fact the CC was uncertain about WF flows and were not prepared at that time to endorse them.

Section 7 needs to be revised to clearly and accurately reflect when both flows, as defined in Table 7-17, are being discussed and when only one flow is being discussed.

Pg. 8-6, Boat Access

- Prior to building boat ramps or improving access, proponents will have to do more than just consider habitat impacts. In most cases they will require an authorization or letter of advice from DFO. Other regulatory requirements will also likely be needed .This was specifically pointed out to the CC and the document should reflect this need so future problems do not arise later.

- This will also be the case for dredging at Indian Eddy in the Lower Columbia.

- In the same vein, wildlife works (Pg. 8-19,Sec. 8.2.8.1) and archeological works will also require the review by DFO.

Pg. 8-22, B. Mountain Whitefish Flow Strategy.

- The CC never stated that the MWF flow strategy was conditional on CPC and CBT being kept whole. It was a condition of CPC and CBT support but the rest of the CC was never asked to support this condition.

- DFO is concerned that we have a WF strategy that is slated to go for 15 years but a WUP that is slated to be reviewed after 13 years. It may not be a big issue if the WUP takes a couple of years to be formally implemented at which time the two would be consistent (MWF assessments are currently underway).

Pg. 8-27, Sec.8.2.10.1

- Again, hatchery contribution is not a fall back option by should be shown to apply immediately upon ratification of the WUP. The contribution is considered an alternative work replacing the release of large flows to promote WS spawning.

- Again, the issue of flexibility has not been addressed. It was discussed and the RT suggested it was critical to have other options in case turbidity did not work or new information suggested another route. The provision of this flexibility in the Mid Columbia would support this element. Why would the RT want it at one location and not at the other location. It is my belief that it was discussed, and was generally supported but it was late in the process at the last meeting and as a result never got the level of discussion it should have.

- A decision point is required and it needs to be resolved prior to implementing the WUP.

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Doug A. Robinson
Corporate Rep
BC Hydro

Columbia River Water Use Plan Consultative Committee Report

This draft Columbia River Water Use Plan Consultative Committee Report records the deliberations of the Columbia River Water Use Plan (WUP) Consultative Committee and provides the context for the Committee's recommendations for the future operations of the BC Hydro's Columbia River 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 Columbia River water use planning process.

Name & Organization: Doug Robinson, B.C. Hydro

Signature: Doug A. Robinson

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Bob Taylor R.P.F.
Administration Forester
Louisiana Pacific Canada Ltd.

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Name & Organization: Bob Taylor Louisiana-Pacific Canada Ltd.

Signature: RJ Taylor

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BUILDING PRODUCTS

April 25,2005

Sue Foster
Columbia Water Use Plan Project Manager
BC Hydro
E16-6911 Southpoint Drive
Burnaby B.C.
V3N 4X8

Dear Sue:

Thank you for providing the opportunity to respond to the draft Columbia Water Use Plan. I appreciated the opportunity to be involved in the water use planning process. I learned a great deal about other resource values and BC Hydro operations.

I apologize for the delay in providing my response. My workload has been busier than anticipated for this time of year.

I would like to provide overall comments as well as provide specific reference to pages in the draft report.

The four year time period from the initial first meeting to the draft plan completion was too long. It necessitated the hiring of a new facilitator mid way through the process and made it very difficult to keep current with the proceedings considering the gap between meetings. I also feel it was a factor that led the group to agree to a soft constraint package as outlined in the draft report, as there was little desire to further extend the process.

It was regrettable that any change of water levels on Kinbasket Lake was too costly to be considered as an operational alternative. In lieu of operational changes, it was decided that non-operational works to provide environmental and social benefits would be pursued.

Louisiana-Pacific Canada Ltd.
ADDRESS Box 170, 800 - 9th Street North
Golden, BC V0A 1H0

TEL 250.344.8800
FAX 250.344.8807
WEB www.lpcorp.com

BUILD WITH US.

One of the soft constraints discussed at the final meeting was to avoid a surcharge of Kinbasket if at all possible. However, nowhere in the report is this mentioned as a soft constraint. It is referred to in other sections of the report. However, it is an issue of significance to all users of Kinbasket Lake and should be listed as a soft constraint to give it more credence.

Of concern with any possible surcharge are damage to existing infrastructure and the potential for a large scale increase in floating debris. When infrastructure damage occurs, a guarantee that sufficient funding will be provided to compensate for any such impacts is needed. The draft report states that previously funds have been provided for infrastructure damage from a surcharge. A surcharge also results in a large amount of additional debris found on the reservoir. If a surcharge is necessary, funding should also be provided to deal with necessary debris control.

Debris clean up was a frequent topic of discussion during the water use planning process. It is surprising to see within the draft report that debris management will be undertaken only if the Comptroller of Water Rights deems it within the scope of water use planning process. It would seem obvious that water levels relate directly to the amount of debris, particularly shoreline debris found on the reservoir.

During the WUP process it appeared that a lot of progress had been made to implement a debris management program for Arrow and Kinbasket reservoirs. A committee of local representatives was to be formed to annually review the reservoir and develop a debris management plan. It was planned that debris control measures would be implemented immediately following sign off of the WUP. Any such measures now require an environmental review.

The rejection of a new boat ramp for Nakusp because it does not fit within the scope of the water use plan is disappointing. The rationale provided is that because the current ramp provides access at all reservoir elevations any proposal for a new boat ramp for Nakusp must be considered as a non-WUP recommendation.

It is unfortunate that the CC was advised that this project did not fall within WUP until after all committee meetings had taken place. The Nakusp boat ramp is the most widely used boat ramp on the Arrow Reservoir. It is in a deteriorating condition and safety is a concern with its use. Safe access rather than access should be criteria for its inclusion in a WUP.
If no replacement structure is planned for, at a minimum, an annual maintenance budget for the existing boat ramp should be included as a WUP recommendation.

Would you please consider this letter as my verbatim comments to be included in the appendix of the report? I have also attached some page specific suggested changes to the draft report.

Sincerely,

Bob Taylor
Administration Forester

Review of Draft Water Use Plan
Executive Summary

Page 5 – One of the soft constraints discussed at the final meeting listed under the Arrow Reservoir – Power Generation was to avoid a surcharge of Kinbasket if at all possible.

This should be listed as a soft constraint for Kinbasket Reservoir operations as was agreed to at the CC meeting of June 21,22, and 23 (page 76 of minutes). It is probably best dealt with under flood erosion control.

Page 2-2

Not a big hitter but there is a large provincial park at Cummins River that is not on the map. – north of Sullivan River.

Page 4-4

It is stated that there are no structures within the surcharge area of Kinbasket Reservoir. This is not the case. The Boulder Creek Bridge south of Sullivan River on the Bush Sullivan Forest Service is within the surcharge area and is subject to subject to flooding with a surcharge. This is also true of the causeway across Bush River. During the last surcharge the causeway was graveled to provide access. Because of wind and water erosion, it is likely that additional surfacing of the causeway will be necessary should there be another surcharge.

Page 4-8

Table 4-4

Should be Downie Timber not Down-E Timber

Page 7-48

Under my name the company name has changed to Louisiana-Pacific Canada Ltd. from LP Engineered Wood Products

Page 7-52

Under my name the company name has changed to Louisiana-Pacific Canada Ltd. from LP Engineered Wood Products

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Fred Thiessen
Recreation Forester
Ministry of Forests, Kamloops

Columbia River Water Use Plan Consultative Committee Report

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Name & Organization: Fred Thiessen
Ministry of Forests, Kamloops

Signature: F. Thiessen

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

WARREN WARD
1402 Spruce Dr
Golden BC V0A1H6

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Name & Organization: WARREN WARD (Mica Marine Ltd)
- Navigation & Recreation

Signature: Warren Ward

7

I would like the following verbatim comments, in addition to what is noted in the draft Columbia River Water Use Plan Consultative Committee Report, to be captured within an appendix within the Report. (Preference is to have this done by e-mail to sue.foster@bchydo.bc.ca if possible)

7.7.4 Physical Work for Arrow/Kinbasket Balance – Debris Management

1 Line #1 "- Issues related to wood debris in Kinbasket & Arrow Lake reservoirs caused by clearing of the land & inundation have largely been resolved by B.C. Hydro."

This statement is not true of the Kinbasket Reservoir & The Revelstoke (Reservoir) the Arrow reservoir were cleared, piled & burned or buried the Kinbasket reservoir was only felled wood & left to float, there has been some collection of debris but there is still a lot of debris left along the upper edges of the reservoir.

2 A Committee from the Kinbasket lake & Arrow (Debris Disposal) was to be formed & have dissucsion with BC Hydro (Ian Mackean) this has not happened, and am woundering if it got put on hold or what is taking place, was to ~~happen~~ be in the spring of each year

3 Feel that the Arrow/Kinbasket catagories should be kept seperate (1) Debris management Plan for Kinbasket, and a seprate (2) Debris management Plan for the Arrow

This would apply to all aspects of the Water use Plan

4 Would like to get a clear understanding of what "Constitutes accesses to the reservoirs" from the water Comptroller (page 7-88) page

5 "Avoidance of a surcharge on Kinbasket lake to be consider as a soft constraint. It is not mention specifically as a soft constraint (7-93) page

6 Environmental Review prior to any debris management on Kinbasket could delay this process and am wounder if it really necessary

2

7 "Nakusp Boat Ramp" should be replaced under the W.U Plan
New Ramps have a yearly Mtc clause to be upgraded
The reservoirs are a on going operation for BC Hydro there fore
the access & maintanec, debris managent are allso Hydro ongoing
problems. (8-29) page

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Mr. S. W. Webster
1833 Connors Rd
Castlegar BC
V1N 2M6

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Name & Organization: S.W. WEBSTER.
WEST KOOTENAY NATURALISTS ASSOC.

Signature:

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Maureen Weddell rep: Illecillewaet Greenbelt Society
PO Box 303
Revelstoke BC V0E2S0

Columbia River Water Use Plan Consultative Committee Report

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Name & Organization: Maureen Weddell Illecillewaet Greenbelt Society

Signature: M Weddell

To:

Sue Foster
Project Manager
Columbia River Water Use Plan

Fax: 604 528-2905
Phone: 604 528-2737

From:

Dr. Pat Wilcox
SS-1, S-13, C-28
FRUITVALE, BC.
V0G 1L0

Columbia River Water Use Plan Consultative Committee Report

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Name & Organization: SAFE Moorage Committee
Castlegar Power Squadron
Arrow Yacht Club.

Signature: [signature]

APPENDIX E: CORRESPONDENCE FROM BC HYDRO REGARDING THE CANADIAN WILDLIFE SERVICE

BC hydro THE POWER IS YOURS

Sue Foster
Project Manager
Water Use Plans
Phone: 604-528-2737
Fax: 604-528-2905
E-mail: sue.foster@bchydro.bc.ca

15 December 2003

Mr. James S. Mattison
Comptroller of Water Rights
PO Box 9340 Stn. Prov. Gvt.
Victoria, British Columbia
V8W 9M1

Dear Mr. Mattison:

This letter is to apprise you of BC Hydro's efforts to date to engage the Canadian Wildlife Service (CWS) in the Columbia River water use planning process. I have attached a chronological list and copies of the recent correspondence between the CWS and BC Hydro.

The Columbia River water use planning process is currently in step 6 – creating operating alternatives and step 7 – assessing trade-offs between operating alternatives of the provincial *Water Use Plan Guidelines*. Over the past two and a half years, the 39-member Columbia River Consultative Committee has met six times since the water use planning process began. Numerous meetings of the Consultative Committee technical subcommittees (fish, wildlife, heritage and recreation) have taken place to address specific issues. The final meeting for the Columbia River Consultative Committee is scheduled for 27, 28 and 29 April 2004.

In closing, BC Hydro has been diligent in encouraging the Canadian Wildlife Service to participate in the Columbia River water use planning process. BC Hydro will continue to invite the Canadian Wildlife Service to discuss their concerns at the Columbia River Consultative Committee meetings which provide a forum to share information and promote understanding of interests, perspectives and values, and explore alternative ways to operate the facilities.

Please contact me if you require any further information.

Regards,

Sue Foster

Attachments
BC Hydro Project Team
Graeme Matthews, BC Hydro WUP Program Manager
Steve Macfarlane, Fisheries and Oceans Canada

SUMMARY OF BC HYDRO'S EFFORTS TO INVOLVE THE CANADIAN WILDLIFE SERVICE IN THE COLUMBIA RIVER WATER USE PLANNING PROCESS

In July 2001, the Canadian Wildlife Service (CWS) was invited to participate in the Columbia River water use planning process, and was provided documentation on the process and background materials. Over the next two months, efforts were made by the Mica Water Use Plan (WUP) Environmental Task Manager (Wayne Duval) to engage CWS in the process.

In September 2001, CWS indicated that they would not participate at the Consultative Committee or technical subcommittee level but, expressed an interest in receiving updates. Monthly communication updates were sent to CWS to keep them informed of progress being made throughout the process.

In March 2002, Wayne Duval was contacted by CWS indicating their desire to be active participants in all ongoing and new Columbia Basin WUPs. The Columbia River WUP Project Team consulted with the CWS representative (Stephen Hureau) regarding migratory bird issues, and sought input/comment on work being undertaken by the Fish and Wildlife Technical Committee (FWTC) and Consultative Committee, specifically the prioritization, design and results of Step 5 wildlife/vegetation studies in Arrow Reservoir. Although CWS did not participate directly in the Columbia River water use planning process, the Project Team made efforts to support their continued involvement by seeking input into the development of operating alternatives and performance measures based on briefing notes, meeting pre-read materials and other documentation prepared for the committees.

In April 2003, Stephen Hureau contacted the Columbia River WUP Environment Task Manager and Ed Hill (BC Hydro) to discuss concerns regarding the potential impacts of a new operating alternative (11B) on nesting migratory birds. Given that Stephen and several of the WTC members were unable to attend an upcoming meeting of the FWTC on April 28–30, he was concerned that the migratory bird issue would not receive due consideration through the Columbia River water use planning process. In response, the Columbia River WUP Project Team met with CWS on 20 May 2003 to provide an overview of the operating alternatives that had been considered by the Consultative Committee to date, and discuss CWS' concerns about the potential impacts of the alternatives on nesting and migratory birds in the Revelstoke Wetlands. Background materials were also provided to Stephen to support his participation in a 21, 22 May 2003 FWTC meeting. A key action item coming out of this meeting was for Stephen to determine the desire and willingness of CWS to participate in the Columbia River water use planning process at both the Consultative Committee and technical committee levels throughout the remainder of the process.

In June 2003, BC Hydro Generation Environment (Kevin Conlin, Ed Hill) and the Columbia River WUP Project Manager (Sue Foster) held a teleconference meeting with CWS (Rick McKelvey, Stephen Hureau) to discuss the level of CWS' participation in the WUP, their regulatory responsibility, and opportunities to ensure effective input into the process. Through subsequent discussions between BC Hydro and CWS, BC Hydro agreed to provide funding to contract an external consultant to prepare a summary of existing migratory bird data for CWS and the Consultative Committee.

CWS agreed to have Stephen represent their interests at the September 2003 WTC meeting, and to provide input into the development of post-WUP monitoring studies and physical works proposals. Rick McKelvey highlighted the importance of post-WUP monitoring in putting perspective on the migratory bird issue in Revelstoke Reach, indicating those insignificant impacts at the population level would not justify large costs in mitigation by BC Hydro. This would be expected to display due diligence in identifying, avoiding, and mitigating impacts to migratory birds. CWS also agreed to try to participate at the Consultative Committee level.

During the fall of 2003, the Project Team scheduled one FWTC and two WTC meetings. Stephen Hureau attended the 30 September 1 October 2003 WTC meeting, and was teleconferenced into the 28 October 2003 WTC meeting for 2 hours. He did not attend the FWTC meeting held in Vancouver on 4 November 2003.

Efforts were made by the current Columbia River WUP Environment Task Manager (Pat Vonk) to encourage CWS' participation in the November Consultative Committee meeting, as significant decisions were to be made by the Consultative Committee around Kinbasket/Arrow and Mid Columbia River operating alternatives. This involved several discussions with Stephen Hureau, as well as a teleconference meeting involving Ken Brock, Kevin Conlin and Pat Vonk to explore ways to allow their participation in the decision making process. CWS declined to participate but indicated that would provide BC Hydro with both a technical response to briefing notes prepared for the November Consultative Committee meeting, as well as a position letter. To date, CWS has not been represented at the Consultative Committee table.

Table 1: Correspondence Re: Canadian Wildlife Service's (CWS) Participation in the Columbia River Water Use Planning Process

Date	Contact	Comments
24 July 2001	Letter from W. Duval to K. Brock (CWS) – *Attachment #1*	Invitation to CWS to participate in the Consultative Committee and wildlife subcommittee of the Columbia River water use planning process. Provided a variety of documents on water use planning, as well as the environmental information review completed for the Columbia River WUP.
10 September 2001	Email from W. Duval to S. Heaton – *Attachment #2*	Based on discussions, CWS indicated that there would not be represented at either the Consultative Committee or technical subcommittee level but, would like to be informed of progress and receive updates.
06 March 2002	Telephone correspondence with CWS and W. Duval	CWS indicated that they wanted to become active participants in all ongoing and new Columbia Basin WUPs.
07 May 2002	Letter from S. Hureau to W. Duval – *Attachment #3*	CWS provided comments on design of Step 5 wildlife/vegetation studies.
04 November 2002	Letter from S. Hureau to W. Duval – *Attachment #4*	CWS provided comments on the results of two wildlife/vegetation studies undertaken as part of Step 5, indicating efforts by Ian Robertson (wildlife contractor) to involve CWS in the development of technical studies
24 April 2003	Email from S. Hureau to W. Duval – *Attachment #5*	CWS expressed concern regarding new Alternative 11B as a means to reduce nesting mortality caused by rising water levels of Arrow Reservoir in spring, and suggests joint effort in development of management plans to address needs of migratory birds. Expressed a desire for BC Hydro to continue efforts to include CWS in Columbia River water use planning process.
05 May 2003	Email from E. Hill to S. Hureau, W. Duval, I. Robertson and P. Vonk – *Attachment #6*	Confirmation that S. Hureau would participate as a corresponding Consultative Committee member but was unable to attend meetings in the Columbia Basin.
08 May 2003	Correspondence between P. Vonk and S. Hureau – *Attachment #7*	Scheduling and provision of materials for a CWS/BC Hydro meeting to discuss recent progress of the Columbia River water use planning process and seek input from CWS.
20 May 2003	CWS/BC Hydro meeting (W. Duval, B. Stumborg, I. Robertson, E. Hill, S. Hureau) – *Attachment #8*	Purpose of meeting was to discuss CWS concerns related to the impacts of Alternative 11 on bird populations and habitat in Revelstoke Reach, and provide any necessary background to Stephen prior to his participation in the May 21–22 FWTC meeting. A key action item coming out of this meeting was for Stephen to determine the desire and willingness of CWS to participate in the Columbia River water use planning process at both the Consultative Committee and technical committee levels throughout the remainder of the process.
04 June 2003	CWS/BC Hydro teleconference call (K. Conlin, R. McKelvey, S. Foster, S. Hureau, E. Hill)	Discussed issues related to CWS' participation in the Columbia River water use planning process, including regulatory responsibility, availability of information, and BCH/CWS co-funding a contractor to prepare a summary of existing migratory bird data for CWS and the Consultative Committee.

Date	Contact	Comments
05 June 2003	Email from S. Foster to R. McKelvey and S. Hureau – *Attachment #9*	Provided workplan for the Columbia River water use planning process, outlining Consultative Committee and WTC meeting commitments and tasks. Request for confirmation regarding CWS's level of participation in the process.
11/20 June 2003	Email correspondence between K. Conlin, E. Hill, R. McKelvey and S. Hureau – *Attachment #10*	Correspondence regarding BC Hydro agreement to provide funding to contract an external consultant to prepare a summary of existing migratory bird data for CWS and the Consultative Committee.
23 June 2003	Discussion between E. Hill and R. McKelvey	Clarify needs for CWS to participate more effectively in Columbia River WUP. External consultant would prepare a summary of existing migratory bird data for CWS and the Consultative Committee. The consultant would not represent CWS at the Committee table.
nd	Letter from CWS to P. Vonk – *Attachment #11*	Provided comments on briefing note material prepared for the 11–13 June 2003 Consultative Committee meeting for distribution to Consultative Committee members
04 July 2003	Telephone correspondence (P. Vonk, S. Hureau)	Discussed outcomes from June Consultative Committee meeting, and next steps
08 July 2003	Correspondence via telephone between E. Hill and S. Hureau	Discussion around issues expressed by S. Hureau related to role of Consultative Committee in trade-off decisions (vs. regulatory responsibility of CWS), lack of information for decision making, need for wildlife expertise at Consultative Committee table.
28 July 2003	CWS/BC Hydro meeting (R. McKelvey, K. Conlin, S. Hureau, P. Vonk, E. Hill)	Purpose of the meeting was to get clarity on CWS' participation in the Columbia River water use planning process, and contractor support to CWS. BC Hydro agreed to fund bird summary. CWS agreed to have S. Hureau attend Sept WTC meeting and to continue providing input into the process (development of WUP monitoring and physical works proposals). CWS would endeavour to participate at the Consultative Committee level.
08 September 2003	Teleconference (P. Vonk, E. Hill, S. Hureau)	To discuss the June 2003 Consultative Committee meeting minutes.
25 September 2003	Teleconference (P Vonk, E, Hill, S. Hureau)	To review John Coopers bird summary report, minutes of the June Consultative Committee meeting, and to discuss presentation on CWS interests and concerns.
17 November 2003	Telephone correspondence (P. Vonk, S. Hureau)	Request for commitment that CWS would be at the Consultative Committee table at the 26–28 November 2003 Consultative Committee meeting. Stephen expressed doubt regarding his willingness to make decisions around Arrow Reservoir operating alternatives and trade-offs. Viewed his participation over the 3 days of meeting as providing little value, and noted that he had other commitments with the Species at Risk Act.
25 November 2003	Teleconference (P. Vonk, K. Conlin, K. Brock)	Explored opportunities for CWS' participation in decision making around operating alternatives. CWS declined to participate but would provide a technical response to the briefing notes.

Date	Contact	Comments
26 November 2003	Email from Ken Brock to P. Vonk – *Attachment #12*	Indicated CWS would provide position letter to MCA WUP Project Team, and expressed desire/willingness to continue working with BC Hydro either as part of the Columbia River water use planning process or through another process.
27 November 2003	Letter from S. Hureau to P. Vonk – *Attachment #13*	CWS provided comments on briefing note material prepared for 26–28 November 2003 Consultative Committee meeting for distribution to Consultative Committee members.
05 December 2003	Letter from P. Vonk to S. Hureau – *Attachment #14*	BC Hydro provided comments and clarification of a number of issues raised in CWS 27 November 2003 letter.

ATTACHMENT #1

BC hydro THE POWER IS YOURS

Wayne Duval
Columbia River Basin – Environmental Coordinator
Power Supply Environment - Water Use Plans
Phone: 604.528.1568
Fax: 604.528.2905
E-mail: wayne.duval@bchydro.com

24 July 2001

Ken Brock
Canadian Wildlife Service
5421 Robertson Road
Delta, BC
V4K 3N2

Dear Mr. Brock

BC Hydro has initiated the Water Use Planning (WUP) process for our Mica, Revelstoke and Hugh Keenleyside facilities on the Columbia River. The purpose of this letter is to invite CWS to participate in this process along with other federal and provincial agencies. At present, agency wildlife interests are only represented by Parks Canada. We would welcome your participation on the consultative committee and wildlife sub-committee established for this WUP

I have included a variety of documents and a video describing Water Use Planning and the process recently initiated in the Columbia River Basin. An Environmental Information Review and Data Gap Analysis was recently completed and I have also included a copy of the final reports for the CWS Library.

I look forward to hearing from you. Please do not hesitate to call or send me e-mail if you want any further information.

Sincerely,

Wayne Duval, Ph.D.

ATTACHMENT #2

-----Original Message-----
From: Duval, Wayne
Sent: 2001, September 10 12:43 PM
To: Heaton, Susan
Subject: MCA WUP -- Canadian Wildlife Service

Sue,

I have been in discussions with CWS over the past few weeks to see if they want to participate in MCA WUP at the CC or technical committee level. They will not be represented in either but would like to be kept in the loop and receive updates etc.

The contact is Stephen Hureau in their Ladner office. His e-mail address is stephen.hureau@ec.gc.ca

Will begin agency pre-scoping later this week.

Take care.

Wayne

ATTACHMENT #3

Environment Canada   Environnement Canada

Stephen Hureau
Canadian Wildlife Service
RR1 5421 Robertson Rd
Delta, BC   V4K 3N2

May 7, 2002

Wayne Duval
Environmental Coordinator – Columbia Basin Water Use Plans
BC Hydro – Power Supply Environment
6911 Southpoint Drive (E04)
Burnaby, B.C.   V3N 4X8

Subject: Columbia Water Use Planning Consultative Committee Meeting #4 on Study Prioritization.

Dear Mr. Duval:

Since our last discussion I have been receiving updates from the Public Affairs Officer of BC Hydro's Kootenay/Lower Columbia Community Relations, and having discussions regarding the proposed studies for the MCA WUP with the other federal agencies involved, as well as Ed Hill of BC Hydro. Included in this letter are comments on the proposed studies of April 30, 2002 which I hope will help refine and prioritize the studies.

The Canadian Wildlife Service (CWS) of Environment Canada handles wildlife matters that are the responsibility of the federal government. These include protection and management of migratory birds and other trans-boundary wildlife, wildlife on federal land, nationally significant habitat, and species at risk. Also, like all federal agencies CWS has fiduciary responsibilities to First Nations for the natural resources covered by our mandate.

In this regard management plans are being prepared that, in part, distinguish priority species for which inventory, research, and stewardship actions are identified. The area covered by the MCA WUP includes some of these species, notably:

Killdeer	Black-bellied Plover	Spotted Sandpiper
Solitary Sandpiper	Least Sandpiper	Common Snipe
Wilson's Phalarope	Western Grebe	Horned Grebe
Pied-billed Grebe	American Dipper	and many species of

songbirds not explicitly noted in the Information Review by RL&L

I have one specific concern for all the studies relating directly to wildlife (which I see as Nos. 5 to 8) and which involve vegetation in the draw down: The time frames for the completion of studies and for the WUP itself seem not to allow for data collection on the ability of vegetation communities to withstand consecutive years of high summer water levels. That is, can the proposed modeling and field trials determine whether the established plants can survive more than one summer of prolonged inundation? Will two or more such summers in a row cause the community to deteriorate?

Study No. 5 – Potential areas for vegetation establishment in KIN

As you are aware the establishment of vegetation in the draw down zone of reservoirs is an ongoing priority for BC Hydro, within and outside of water use planning. Expanding this to the Kinbasket reservoir through the WUP is strongly supported. It seems that the field trials of 5b offer and opportunity to experiment with differing planting methods that may quicken the stabilization of the substrate and allow later seral stage plants to colonize faster than they may otherwise.

Study No. 6 – Wildlife use of the Revelstoke wetlands

I support this study strongly as it attempts to quantify usage of the habitat by many of the species listed above. I note that methods for 6b mention surveys for “occurrence and sign” but do not mention breeding. Including bird nest searches would add to the validity of the survey, and allow a better assessment of how changing the operating regime would impact usage (e.g. loss or gain of nesting opportunities). Surveys of occurrence during the breeding season (upcoming) would be vital as well. Hopefully there would be time to initiate the study to capture the breeding season. Knowing when and where nesting is taking place would also allow the water level to be manipulated in a way that avoids the drowning of nests.

Study No. 7 – Wetland vegetation class

As noted under “Risks” for this study the identification of “true” wetland habitat may be difficult, as it seems a very subjective ranking. I’m gathering from the description that wetland means ponded areas within the seeded/vegetated draw down zone. I would expect that given the proper soil and moisture regime the “true wetland” would develop within the matrix of the sedge-grass-herb community. Therefore field studies to assess where the true wetlands are, and more importantly why they are able to develop there, would give valuable direction for optimizing the seeding program to suitable areas (ones with the proper contours, runoff, sub-surface water etc to allow ponded habitat to form, perhaps with human improvements). I’m not sure how that will affect the goal of assuring existing true wetlands don’t dry out, but again knowing why the wetlands are where they are is vital baseline information for making any future decisions regarding them.

Study No. 8 – Use of the Revelstoke Wetlands by migratory shorebirds.

It is nice to see that fall staging habitat is being given as much attention as spring nesting habitat. Maximizing the amount of habitat in terms of area is supported, but of course the quality (and even continued existence) of that habitat in terms of the growth and survival as per study No. 6 and my comment above regarding inundation must be considered. I am not sure why this study focuses on shorebirds and not all migratory birds, but the observations of bird use in study No. 8 could simply be extended into the fall migration season.

I recently met with Ed Hill of BC Hydro to discuss the bird management plans (mentioned above), the BCH compensation programs, and water use planning. I hope to be able to initiate better communication between BCH and CWS so that the expertise of the Pacific Wildlife Research Center can be accessed more freely and quickly than has been the case. Also, as I am unable to solely represent CWS on the many, time-demanding WUP's I hope to act as a node by which staff can provide input to the studies that will be generated. Therefore, once the studies have been prioritized, I would be happy to teleconference with coordinators, Parks Canada, our scientists, and any other party that wishes to help refine the wildlife/vegetation final study designs so that they best meet the objectives of the Consultative Committee.

Thank you for the opportunity to comment. If you have any questions please feel free to contact me at (604) 940-4722.

Sincerely yours,

Stephen Hureau
Habitat Conservation Biologist
Canadian Wildlife Service

ATTACHMENT #4

Environment Canada Environnement Canada

Stephen Hureau
Canadian Wildlife Service
RR1 5421 Robertson Rd
Delta, BC V4K 3N2

November 4, 2002

Wayne Duval
Environmental Coordinator – Columbia Basin Water Use Plans
BC Hydro – Power Supply Environment
6911 Southpoint Drive (E04)
Burnaby, B.C. V3N 4X8

Subject: MCA Water Use Plans Summer 2002 Study Results

Dear Mr. Duval:

In the months since I last sent comments to you regarding the MCA WUP's Ian Robertson has done a good job in keeping me involved in the development of the technical studies. I have reviewed the two studies which I feel are directly relevant to wildlife in the Columbia Basin, particularly migratory birds and their habitat. These are:

Mica–Revelstoke–Keenleyside (MCA) Water Use Plan Breeding Bird and Migratory Shorebird Use of the Revelstoke Wetlands by AXYS Environmental Consulting Ltd. in association with Manning, Cooper and Associates, and

Mica–Revelstoke–Keenleyside Water Use Plan: Potential Areas for Vegetation Establishment in Kinbasket Reservoir by AIM Ecological Consultants Ltd. and CARR Environmental Consultants.

The AIM report provides some interesting direction for revegetation, which would obviously be beneficial to migratory birds and other wildlife in the reservoir. I hope that this potential is pursued and implemented where shown to be possible.

The Revelstoke Wetlands study (which I will refer to as the AXYS study) is obviously of great interest to the Canadian Wildlife Service (CWS) considering our mandate for the protection and management of migratory birds. While the study uses only a few species as indicators due to a lack of data for the bird population, I find that the recommendation of Alternative 11 to be sound.

You can see from the graph on page 59 of the Axys study the majority of the high quality habitat for the selected species is present between 434 and 436 meters elevation. It is also apparent that the period of use of this habitat extends from the early spring until late July, as can be expected. Restricting the rise of water in the reservoir to below 434 m, and also to later than the middle of July will allow the habitat to be available to the species during the breeding season, and also allow the majority of fledging to occur before the water rises and covers the nesting habitat. Setting such a "timing window" for the rise of water would be very beneficial in managing for optimal productivity for the habitat.

I hope that this feedback on the Axys report will be useful in further development of the operating alternatives. If you have any questions please feel free to contact me. I look forward to being kept apprised of the directions taken in the WUP from this point...

Sincerely yours,

Stephen Hureau
Habitat Conservation Biologist
Canadian Wildlife Service

C.C.

ATTACHMENT #5

From: Hureau,Stephen [PYR] [Stephen.Hureau@ec.gc.ca]
Sent: Thursday, April 24, 2003 5:30 PM
To: Duval, Wayne
Cc: Hill, Edward
Subject: Columbia River Water Use Plan

Hello Wayne:

Its been some time since we've talked. I hope things are going well with you this winter. I wanted to get some comments to you before the FWTC meeting as I hope we can discuss some issues before you attend that session. Based on information I've recieved from Susan Hall (I seem to have fallen off the email list from the coodinators), I have quite a number of questions about the operating alternatives now being discussed. As a background, I'd like to review some of the points I've made previously to yourself and to Ian Robertson on the plan.

* I'm still concerned that there is a possibility that the vegetation at the Revelstoke Wetlands could be critically compromised due to a) too long of an inundation period during the growing season b) possibility of too many consecutive years of inundation.

* It well established that the Revelstoke wetlands are an important staging and breeding area for migratory and non-migratory birds. Rising water in the Spring has been shown to cause nest mortality in the wetlands, and I understood the WUP would be working to minimize that effect, while maintaining and enhancing the quality of the wetlands as bird habitat.

I thought the Axys report commissioned on this topic was rather good, though there were some aspects to the methods that I thought could have been better (using more and more diverse species as indicators, and using a more robust model to classify habitat). I was quite satisfied that the report would allow refinement of the alternatives to meet performance measures relating to migratory birds and other wildlife. What the report says to me is that:

* there is a diversity of habitats supporting a variety of breeding migratory birds,

* the highest hectarage of high suitability habitat is available at the lowest water elevations used in the model (434 and 435 metres) [except for willow flycatcher which I don't think is really the case, as the model uses distance to water as a yes/no criterion, meaning the quality of the shoreline shrub habitat goes down as the water recedes]

* alternative 11 was the "best" of the alternatives as it allowed the most high suitability habitat to be available during the breeding season [even though it would be rising to a level/time when nest mortality would occur]

* essentially, the lower the water is in the spring and early summer, the better it is for wildlife.

I understand that measurements were taken in the past few seasons to quantify the amount of mortality in nests as the waters rise in the spring. Apparently mortality rates were very high in some cases. You can see on page 62 that in the years 2000, 2001, and 2002 the waters reached 435 m around the middle of June, which means at that elevation and timing there will be mortality. Therefore, even the "unrefined" alternative 11 would be unacceptable as it brings the water to 435 m by the middle of June.

In discussions with yourself and Ian Robertson, what I asked for as a follow up to the Axys report was a plan to establish a "timing window" for the filling of the reservoir. That is, an agreement to restrict the water elevation to below that which makes the maximum high suitability habitat available to the birds, then allowing it to rise starting at a date calculated to allow the fledging of nestlings before inundation of the wetlands. Ian and I discussed this date being around the middle of July, but perhaps later.

Now I have been passed a new copy of the Alternative, which reads...

"Alt 11-B is a refinement of Alt 11. This alternative holds ARR lower for longer in the spring to improve vegetation potential, large river habitat, and bird habitat. Specific constraints include:

* max elev of 436 m (1430.4 ft) at end of May and end of June
* max elev of 437 m (1433.7 ft) at end of August
* max elev of 436 m (1430.4 ft) at end of Sep and end of Oct"

Considering my comments above and the material presented in the reports I've been given, I must say I'm confused how the constraints meet their stated objectives. Wouldn't it be more likely that higher water levels in the spring would harm rather than improve the vegetation? Is it not obvious that the 436 m maximum is above that at which birds can breed, or that nests would be drowned? I realize that these are maximum elevations and won't likely be reached on a yearly basis, but I can't see as such a risk to this habitat is acceptable considering the mandate of the Water Use Planning initiative.

Previously I've mentioned to you that there has been correspondence between BC Hydro and the Canadian Wildlife Service in regards to the Migratory Birds Convention Act as it relates to hydro operations. In a letter from CWS to BCH it was stated

"It is clear from the above [see letter] that the CWS cannot issue BC Hydro a permit allowing for the destruction of birds, eggs and nests unless there is a significant, demonstrated risk to public health or safety. As a result of an amendment to the Migratory Birds Regulations in June 2002, the issuance of special permits is no longer possible. A permit could not be issued, therefore, to remove nests that are merely inconvenient, nor could CWS issue a permit to accommodate water management regimes intended to take advantage of high prices in the electricity market" [underline mine]

I include this not to sound critical, but to point out that there seems no way to me that CWS could absolve BC Hydro from the liaibility associated with destroying nests, even if the water use plan suggests a regime that is accepted by other parties or BC Hydro themselves. However the letter also states,

"We would like to suggest that BC Hydro consider an approach that does not involve the issuance of permits under the Migratory Bird Convention Act. CWS would be prepared to assist BC Hydro in the development of management plans that will lay out how BC Hydro will address the needs of migratory birds potentially affected by Hydro's operations. Such plans could include measures to both deal with keeping birds from structures where they will potentially nest and become a nuisance, and with mitigation for up-and downstream impacts of power generation."

I hope that your goodwill and efforts to include CWS in the WUP process thusfar will continue in light of this situation. I would like greatly to discuss the WUP with you, and see if my interpretation is correct and apprehension justified. I appreciate that you are likely busy in preparing for the meeting in Castlegar, but I hope you can contact me tommorrow to review the contents of this note.

Thanks again for all your work and support on this WUP to date, I look forward to speaking with you.

Stephen Hureau
Habitat Conservation Biologist
Canadian Wildlife Service, Environment Canada
RR1 5421 Robertson Rd, Delta BC, V4K 3N2
Phone: (604) 940-4722   Fax: (604) 946-7022
Stephen.Hureau@ec.gc.ca
http://www.pyr.ec.gc.ca/EN/Wildlife/index.shtml
<http://www.pyr.ec.gc.ca/EN/Wildlife/index.shtml>

ATTACHMENT #6

From: Hill, Edward
Sent: Monday, May 05, 2003 3:57 PM
To: Hureau Stephen (E-mail); Robertson Ian (E-mail); Duval, Wayne; Vonk, Pat
Cc: Hill, Edward; Westcott, Bob
Subject: CWS Participation in Columbia WUP

Hello everyone,
I just spoke with Stephen about his participation in the Columbia WUP as a representative of CWS. Stephen confirmed his previous discussion with Wayne that he can participate as a corresponding committee member, but is unable to attend meetings in the Columbia Basin. Stephen will be able to attend a Fish and Wildlife Technical Committee (FWTC) meeting in Vancouver scheduled for May 21 and 22, and is willing to attend a meeting prior to that to review the updated modelling and to discuss migratory bird issues. It would be valuable to have Ian attend if he is available. I will attend the meetings as well.

Wayne and Pat, could you please let us know when the revised modelling will be available and suggest a date to meet and review the status of the wildlife issue prior to the FWTC meeting. Would it also be possible to obtain an agenda for the FWTC meeting – will wildlife be discussed on both days?

Thanks,

Ed.

ATTACHMENT #7

BC hydro THE POWER IS YOURS

8 May 2003

Patricia Vonk
Water Use Planning
BC Hydro
6911 Southpoint Drive, 4th Floor
Burnaby, B.C.
V3N 4X8

Dear Stephen,

As discussed during our telephone conversation yesterday, please find enclosed background information which provides an overview of progress on the MCA Water Use Plan to date. This includes a briefing note, pre-reading packages from the April 9–10 and April 28–30 Fish and Wildlife Technical Committee (FWTC) meetings, and a report on the vegetation and littoral components of the integrated response model. The pre-reading packages may provide more information than you are interested in at this point, but I thought it best to provide with you all of the documentation.

I have scheduled the May 15th meeting for 9:30 am to noon in the WUP Room on the 4th Floor of BC Hydro's Edmonds office. The agenda for this meeting is as follows,

1. Brief presentation on the evolution of Operating Alternative 11
2. Description of new Alternatives 11a, b, c and d
3. Review of the modelling results of the alternatives
4. Non-operating alternatives in lieu of operational changes
5. Discussion period

If you have any questions or comments, please don't hesitate to contact me (604-528-7873).

Sincerely,

Patricia Vonk
MCA Water Use Plan

ATTACHMENT #8

COLUMBIA (MCA) WUP MEETING NOTES

Canadian Wildlife Service,
5421 Robertson Road, Delta
May 20, 2003, 10:00 am – 12:30 pm
DRAFT

PARTICIPANTS

Wayne Duval	BC Hydro
Ed Hill	BC Hydro
Stephen Hureau	Canadian Wildlife Service
Ian Robertson	Robertson Environmental Services
Basil Stumborg	BC Hydro

MEETING PURPOSE

To discuss CWS concerns related to the impacts of Alternative 11 on bird populations and habitat in the Revelstoke Reach area of Upper Arrow Lakes Reservoir, and provide any necessary background to Stephen prior to his participation in the May 21–22 FWTC meeting.

INTRODUCTORY COMMENTS

Wayne provided a brief overview of his Alternative 11 Briefing Note, the genesis of this alternative and revisions that have occurred over the past year or so. The rationale for the alternative was that filling the reservoir later and to a lower elevation would provide benefits to riparian vegetation development and breeding and migratory shorebirds using the Revelstoke Wetlands. However, the original alternative was very expensive ($23 million/year) and so the CC directed the project team and modelers to revise the alternative to reduce its costs but still provide ecological benefits. Basil elaborated on the manner though which elevation constraints were relaxed in May and June, the months which contributed to high cost of this alternative.

POINTS OF DISCUSSION AND CONCERNS RAISED BY CWS

- Discussions quickly focused on the difference between the modeled base case (operating for maximum revenue within limits set by the Columbia River Treaty) and historical reservoir elevations (particularly in the last 10 years when vegetation establishment in Revelstoke Reach has been so successful). Basil emphasized that the difference between the base case and historic levels is due to the number of “dry years” in recent years compared to the 1940–1999 inflows used as input to the base case reservoir elevation simulations. While this issue was raised time and time again throughout the meeting because of the implications of May–June reservoir elevations on nest mortality, the project team believe that it is impossible to accommodate further changes to the ‘base case’ at this late stage in the process.

- While the focus of the PM calculations is currently on riparian habitat and birds utilizing Revelstoke Reach, Wayne noted that BC Hydro has undertaken a study (Anne Moody, AIM Ecological Resources) to assess the potential for vegetation establishment elsewhere on Arrow, and these studies will be the focus of a workshop scheduled for May 26th in Revelstoke.
- Despite the success of the Revelstoke Revegetation Program over the past 10 years, expert opinion (Will Carr and Anne Moody) suggests that high inundation rates for more than two years would cause vegetation in the wetlands to begin to recede.
- Another unanswered question at the time is whether the Revelstoke Wetlands is a source or sink for nesting birds. There is inadequate information to answer this question, and it would need to be an area of further research.
- The benefits of planting programs are also open to question. Are there other options that could achieve the same benefits? Are there some ecological impacts of planting programs that we are as yet unaware of? Are we really selecting the best locations and plant species? How do we measure the net benefits relative to impacts and what are the tradeoffs?
- Considerable discussion focused on the period from May to July 1 in terms of importance to breeding birds. Many of the points that follow were raised as CWS concerns by Stephen.
- Ian noted that the study completed by AXYS confirmed that few migratory shorebirds use the Revelstoke Wetlands, and questioned why they should be considered a management priority and have their own performance measure. There was some discussion of shorebird use compared to other adjacent high-use areas in this part of the province, but no decision was made on the value of maintaining a shorebird PM. Breeding birds are clearly the key issue.
- Stephen had an issue with some of the indicator species used by AXYS in their modeling, but generally seemed to be in support of the report and its overall conclusions (e.g., inclusion of mallards which nest at higher elevations).
- The big issue from Stephen’s perspective is the flooding of nests before July 1 and before young are fledged. Each version of Alternative 11 shows a benefit in terms of hectare-weeks of breeding habitat, but in each case May–June reservoir elevations will flood nests. The reservoir is already reaching an elevation (434 m) that could flood nests by the last week in May. Wayne emphasized that this issue is an agenda item for resolution at the upcoming FWTC meeting.
- In further discussion of non-operational alternatives, the possible merits of grazing and/or haying as a potential means of creating nesting habitat was raised.
- It was suggested that it may be appropriate in future modeling of breeding habitat to ignore the period after July 1st as it really doesn’t matter after this date and is too generous of a timeline (i.e. focus only on May and June).
- There was considerable discussion of the regulatory mandate of CWS (Migratory Bird Convention Act) vs. the agencies participation in this WUP. Stephen indicated that other agencies such as DFO could sign off on a WUP that was generally good for fish in most years (and issue permits or require compensation in those years where target objectives could not be met because of inflows or other factors), CWS

could not adopt such a policy. Drowning of nests would be an issue with CWS regardless of the water year (i.e. on balance is not the way they would look at it). Stephen emphasized that because birds generally have a shorter life span than fish, failure to reproduce in a given year could have population-wide implications.

- There was a brief discussion of the influence of water levels on the Lower Columbia River on the heron populations that utilize Waldes Island. This is another issue that may be raised in the May 21–22 FWTC meeting.

ACTIONS ITEMS

- **ACTION**: Determine months used for breeding period PM calculations with Josh and assess the difference in PM results that might result from restricting the breeding period to May and June (Wayne or Pat),
- **ACTION**: Determine desire and willingness of CWS to participate in the Columbia (MCA) WUP at both the CC and technical committee levels throughout the remainder of the process (Stephen).
- **ACTION**: Re-run the models to compare historic (i.e. last 10 years) vs. base case water level elevations in relation to Alt. 11-B and 11-D (Concluded by project team to be impossible at this stage in the process).

ATTACHMENT #9

From: Foster, Sue
Sent: Thursday, June 05, 2003 9:47 AM
To: McKelvey Rick (E-mail); Hureau Stephen (E-mail)
Cc: Conlin, Kevin; Hill, Edward; Vonk, Pat; Stumborg, Basil
Subject: RE: CWS Participation in Columbia WUP

Hi Rick and Stephen, please see the proposed workplan below that was sent to the Columbia WUP CC in January 2003. This is also available on the Columbia WUP website.

It is expected that significant decisions will be made at the June 2003 Consultative Committee meeting about KIN/ARR and MCR Operating Alternatives and some key Non-Operating Alternatives (first shaded box of Figure 1). After June 2003, the Committee may continue to work on final refinements to operating and non-operating alternatives, but will also focus efforts on Optional Flow Components, Monitoring Priorities and Operating Protocols. After the June Committee meeting, the project team will have a much clearer picture of the remaining work and monitoring programs to be developed.

<u>As discussed yesterday, the following is a summary of the Consultative Committee and subcommittee meetings where your attendance would be desirable</u>:

- Three Consultative Committee meetings tentatively scheduled for June 2003, October 2003 and April 2004 in Revelstoke.

- Two to three more wildlife technical subcommittee meetings – September, December, February. This schedule is dependent upon availability of modelling results, monitoring proposals, subcommittee member schedules. There may be an opportunity to combine these meetings with the fisheries technical subcommittee.

- One more planting/vegetation workshop, sometime in early fall 2003.

Pat Vonk will organize brief conference calls during those months where no technical subcommittee meeting is scheduled to ensure that everyone is kept up to date and has an opportunity to discuss issues.

In addition, Pat Vonk and Bob Westcott will be developing a number of monitoring proposals for the various issues. Your contribution to these would be valuable.

Upon your review, could you please confirm CWS's level of participation in the Columbia WUP with me? I look forward to working with you.

E-mail note sent to Mica Water Use Plan Consultative Committee Members in January 2003:
Thank you for your patience while the project team has worked to develop a revised workplan to successfully conclude the consultative process of the Mica/Keenleyside/Revelstoke Water Use Plan (MCA WUP).

The following is a draft proposed workplan. Although this workplan is similar to the plan that was in place previously, the main difference is the extension of the schedule to accommodate the power modelers schedules and the increase in technical subcommittee meetings to allow for in-depth discussion on operating alternatives and trade-off analysis. The project team will try to work collaboratively with the subgroup members to determine the timing and the content of these meetings leading up to the June CC meeting, and the overall workplan can be reviewed by the CC at that time.

If you have any questions regarding any aspect of the MCA WUP, I encourage you to contact myself at (604) 528-2737 or via email at sue.foster@bchydro.com or Basil Stumborg at (604) 528-8173 or via email at basil.stumborg@bchydro.com to discuss.

Proposed Workplan

- Three Consultative Committee meetings tentatively scheduled for June 2003, October 2003 and April 2004 in Revelstoke.

- The workplan can accommodate a number of subgroup and working group meetings. While the exact mix of these may vary depending on how much effort is required in each issue area, the project team felt that one possible combination of meetings that is in line with the remaining budget is as follows:
  - Five Fisheries Technical Subcommittee meetings
  - Three Wildlife Technical Subcommittee meetings
  - Two Recreational Technical Subcommittee meetings
  - Two First Nations Technical Subcommittee meetings
  - Workshops:
    - First Nations workshop
    - Two planting/revegetation workshops
    - Middle Columbia River fisheries workshop
    - Lower Columbia River fisheries workshop

One of the challenges associated with a consultative process similar to the MCA WUP, is the amount of time required between Consultative Committee meetings in order to conduct the studies and do the power modeling that are necessary to make informed decisions about tradeoffs between operating alternatives for each facility. This can result in Consultative Committee members feeling disconnected from the process.

In order to improve communications with the Consultative Committee and the technical subcommittees a number of actions will be implemented immediately :

- Monthly check-ins with the technical subcommittees to review progress and action items within each area
- Monthly updates will be sent to the Consultative Committee
- Face to Face technical subcommittee meetings
- Any completed studies, and or updates will be posted on the MCA WUP website. The website and password is:

http://www.bchydro.com/wup/columbia/consultative_committee.html
When you enter this above site, please enter the user id and password below.
user id: colwup
password: water122

We are currently updating our contact information. Can you please send the following information to Sue Heaton at sue.heaton@bchydro.bc.ca **on or before February 10, 2003**:

- affiliation/organization
- mailing address
- phone number / cell number
- fax number
- email address

We all look forward to the successful completion of the MCA water use planning process.

Sue Foster
Project Manager, Water Use Planning
BC Hydro
6911 Southpoint Drive
Burnaby, B.C.
V3N 4X8
Phone (604) 528-2737
Fax (604) 528-2905
E-Mail: sue.foster@bchydro.bc.ca

ATTACHMENT #10

-----Original Message-----
From: Hill, Edward
Sent: 2003, June 20 1:10 PM
To: Conlin, Kevin
Cc: Hureau Stephen (E-mail); McKelvey Rick (E-mail)
Subject: Contractor Assistance for CWS Participation in Columbia WUP

Kevin,

Stephen has suggested that John Cooper would be an appropriate consultant to assist CWS to participate more fully in the Columbia WUP. I agree with his suggestion – John is a well respected and knowledgeable contractor.

Can we commit to allocating $5,000.00 to partially defray the costs associated with John providing support to CWS?

Rick, have you been able to identify funding within CWS or possibly from DU to help with this.

Please let me know.

Ed.

-----Original Message-----
From: Hureau,Stephen [PYR] [mailto:Stephen.Hureau@ec.gc.ca]
Sent: 2003, June 11 5:01 PM
To: Ed Hill (E-mail)
Cc: McKelvey,Rick [PYR]
Subject: Thoughts on Contractor to aid Columbia WUP

Hi Ed,

Further to our telephone discussion today regarding having a contractor assist with the Columbia Water Use Plan, as it relates to wildlife (specifically migratory birds), I'm sending the following:

– a very large knowledge gap still exists for wildlife species in the Columbia reservoirs and the Revelstoke wetlands in particular, so much so that it is very hard to We know that the vegetation community is limited, and that it supports a number of species. We know that usage of the vegetated zone could be compromised by high water levels and that nest mortality occurs due to rising water in the Spring. But to make informed decisions on how to manage operations in an appropriate way we need to quantify the impact to the variouis species. That is we need to know more detail on what species are there, the habitat usage of each, where and when they breed, and what the impact of nest mortality is to each species or guild.

– since the Fish/Wildlife Technical Committee has embarked on an idea to "consider habitat islands in lieu of operational changes" there is now a need to explore what options are available. This type of restoration or compensation can be difficult to achieve as you know, and the CC should be aware that impacts won't easily be mitigated without good planning. While there seems to be a study in the works on this, we have to ensure that it will benefit all the species being impacted and we don't know (as stated above) enough about those species.

– part of the WUP process (I believe) is to set up monitoring programs to provide adaptive feedback. The vegetation community itself, the breeding bird population, and the yet-to-be designed or endorsed "nesting islands" will require on-going monitoring and assessment to measure success. This will be quite a large task.

So what we would have to do from this point:

1. see where the CC is going with the development of alternatives for the WUP and the "trade offs" that are taking place. Will these result in an increase, decrease, or no change of the impact to migratory birds, or can that even be assessed.

2. inquire with DUC what kind of projects or ideas they may have for the area and see if those can be complemented by the WUP

3. use the above to try and guage how much of a cross over there would be with CWS programs like migration monitoring or waterfowl management or species at risk to combine resources.

I hope this helps in trying to understand the need to have more information and someone to collect and analyze it. This would allow me to participate more actively and more effectively in the WUP than currently, as I realize much of my feedback is that there isn't enough data to make recommendations on. Let me know if you have any questions.

Regards,

Stephen Hureau
Conservation Biologist
Canadian Wildlife Service, Environment Canada
RR1 5421 Robertson Rd, Delta BC, V4K 3N2
Phone: (604) 940-4722   Fax: (604) 946-7022
Stephen.Hureau@ec.gc.ca
http://www.pyr.ec.gc.ca/EN/Wildlife/index.shtml

ATTACHMENT #11

Stephen Hureau
Canadian Wildlife Service
RR1 5421 Robertson Rd
Delta, BC V4K 3N2

Patricia Vonk
Environmental Coordinator
Columbia Water Use Plan
6911 Southpoint Drive, Burnaby BC

Re: Input to the June 2003 Consultative Committee Meeting, Revelstoke

Dear Patricia,

Thank you for the invitation to attend the CC meeting this week. With regrets I must decline, as I am currently involved with a number of initiatives regarding the Proclamation of the Species at Risk Act on June 5. I have received the schedule of further meetings from Sue and will be in contact to discuss plans over the rest of the process.

In response to the meetings, phone calls, and briefing notes on the WUP that have taken place recently, I am sending this summary as input to the discussion. If it were possible or desirable to have me participate today by teleconference at some point that would be fine.

Background
Since August of 2001 I have been in contact with the former WUP Coordinator, Wayne Duval, regarding the development of this plan and its potential impact to migratory birds, their nests, and the habitat supporting them. This has included a series of verbal discussions, written submissions, and one meeting with Wayne Duval, Ed Hill, and Basil Stumborg of BCH, and Ian Robertson. I have also had discussions with Susan Hall of Parks Canada regarding her concerns for the Revelstoke Wetlands and visited the site with her in October of 2002. Since May 2003 I have also been in contact with yourself, Kevin Conlin and Sue Foster of BCH to discuss ways to have migratory bird interests represented in the WUP process.

The Canadian Wildlife Service is the federal agency responsible for migratory birds and their habitat. CWS works with BCH through various means to ensure that the diverse hydro operations to not negatively effect birds. The Migratory Bird Convention Act requires that birds, their eggs, and nests be protected during the operation of hydro facilities. Water Use Planning is one way in which we are trying to meet that requirement.

Issues
There are two components of the plan which I feel relate directly to migratory bird conservation.

1. Vegetation in the reservoirs.
It is well understood that riparian vegetation in the upper and lower Columbia system (where influenced by hydro operations) is limited. The Revelstoke wetlands are a regionally important habitat feature and support diverse species, including but not limited to migratory birds. This habitat is the result of a BCH seeding program in the early 1990's to control dust from the draw down zone. It is important that water management is done in such a way that allows the present vegetation community to persist, while also allowing continuation of the natural succession that is being witnessed.

2. Migratory bird use of the vegetated areas.
Survey work has shown that the vegetated flats in the Revelstoke area are used by migratory bird species for spring and fall staging and for breeding. Of course, the habitat is useful for non-migratory bird species, fish and other wildlife as well. Water management has the potential to impact bird nesting in two major ways 1) by disallowing use of the area by covering it with water prior to the spring season, and 2) causing direct mortality of nests and nestlings by raising the water over the nests prior to fledging.

Discussion
1. Vegetation
As stated in the BN for the June CC meeting (page 7), there is concern that the PM's 11 have the possibility of inundating the vegetation community at too high an elevation, for too long a period, for too many consecutive years. There is a lot of further work (on the biology of the vegetation) required to be able to agree what the allowable inundation should be for this community. The vegetation protection clause seems like a reasonable application, though refinement is obviously necessary.

It seems that this community is important for many reasons, migratory bird conservation among them. Having this community persist and not be degraded or destroyed by water management un-conducive to the community is obviously of great importance.

2. Migratory bird use of the vegetated areas.
The most pressing issues that need to be resolved stem from the fact that:
– The birds are nesting at elevations lower than the maximum for Alternatives 11 b and d
– A high proportion of nests are being drowned under current water regimes, and thus whatever is being done to manage water over the last few years is not appropriate for migratory bird conservation.
– The current alternatives propose maximum water levels that would cover the nesting habitat at a time the birds would need to access it.
– Habitat that is available in the spring would be covered before birds were able to fledge, meaning the drowning of nests and mortality of nestlings.

This matter was discussed at the FWTC meeting, though it is far from being resolved. While I think there is better appreciation on how to quantify breeding bird habitat, due in part by good inquiry by Ian Robertson and discussion with Josh Korman, there is still no explanation of how BCH will address the issue.

Nesting islands are mentioned in the BN as having the potential to deliver safe nesting habitat at reduced cost, though there is more complexity to the problem than what can be addressed through that measure alone. Ed Hill of BCH has prepared terms of reference for the nesting islands study idea, which is endorsed strongly by the Canadian Wildlife Service. The CC should be aware that the nesting islands option is an idea in its infancy, and decisions on the water regime should be reserved until such time as it is actually shown that the islands will provide the desired result in a short enough time frame.

It seems as though there has been an alteration of the “hectare-weeks” calculated as bird habitat in the model by Josh Korman, to disclude weeks that the vegetation is un-wetted after July 1. It should be stated that July 1 is not an established fledging date for any or all bird species. It is simply a very rough guess at when the majority of the fledging would have taken place. This is a question that must be answered empirically, as it will vary greatly geographically and temporally (depending on the conditions in any particularly year). Also, it will be different for all species. To make an informed decision as to when the water level should be allowed to rise, inquiry should be done by competent ornithologists on the data set that exists for the area to determine in detail which species are present where and at what time, when they breed, and when fledging is likely to conclude. Otherwise it is just conjecture.

Conclusion
I realize that there are many interests present in the WUP process. I appreciate the approach taken to try and accommodate the diverse recommendations and hope that this summary will be helpful. While the migratory bird habitat is important and needs to be protected and managed properly, I hope the CC will remember the Revelstoke wetlands are important for other reasons as well, wildlife viewing recreation among them. I look forward to seeing how the above knowledge gaps are going to be addressed and commit to helping with it as much as I can.

If there are any questions, members of BCH or the two committees can contact me at any time.

Sincerely,

Stephen Hureau
Conservation Biologist
Canadian Wildlife Service

ATTACHMENT #12

From: Brock,Ken [PYR] [Ken.Brock@ec.gc.ca]
Sent: Wednesday, November 26, 2003 1:35 PM
To: Pat Vonk (pat.vonk@bchydro.com)
Cc: McKelvey,Rick [PYR]
Subject: CWS comments to WUP

I spoke with Stephen and he has not been available today to put together technical comments on the WUP. We will continue to put together the position letter we discussed yesterday and that will be sent to you shortly.

It is still my hope that we can continue to work together either as part of the WUP process, though our capacity to engage at the level that Hydro would see as necessary will be no greater, or as part of another process that addresses migratory bird concerns more directly.

Best regards,

Ken Brock
Head, Habitat Conservation
Canadian Wildlife Service
Pacific and Yukon Region
5421 Robertson Road, RR 1
Delta, BC
V4K 3N2
ph: (604) 940-4690
fax: (604) 946-7022
e-mail: ken.brock@ec.gc.ca

ATTACHMENT #13

Environment Canada Environnement Canada

Stephen Hureau
Canadian Wildlife Service
RR1 5421 Robertson Rd
Delta, BC V4K 3N2

November 27, 2003

Patricia Vonk
Environmental Coordinator
Columbia Water Use Plan
6911 Southpoint Drive, Burnaby BC

Re: Input to the November 2003 Consultative Committee Meeting, Revelstoke

Dear Ms. Vonk,

I have received your invitations to attend the Columbia River WUP Consultative Committee meetings in Revelstoke November 26 to 28th. As I relayed to you on the phone I will not be attending this meeting. Suggestions regarding the procedures by which the Canadian Wildlife Service (CWS) and BC Hydro might discuss issues relating to migratory bird mortality resulting from hydro operations in the Columbia system will be sent in a separate submission. Instead of travelling to Revelstoke and requesting to be able to participate in your meeting, I have chosen instead to provide some feedback on the many documents you have provided as the pre-reading packages. The following should not be interpreted as a position paper that supports any of the proposed alternatives over each other.

Background

I find in necessary to re-iterate the history I have with this process. Since August of 2001 I have been in contact with the former WUP Coordinator, Wayne Duval, regarding the development of this plan and its potential impact to migratory birds, their nests, and the habitat supporting them. This has included a series of verbal discussions, written submissions, various meetings with Wayne Duval, yourself, Ed Hill, Basil Stumborg, and Kevin Conlin of BCH, Ian Robertson, and attendance at fish and wildlife technical committee meetings. I have also had discussions with Susan Hall of Parks Canada regarding her concerns for the Revelstoke Wetlands and visited the site with her in October 2002, and again with members of the WTC September 2003.

The goal of my efforts has been to inform participants in the process about the natural history of migratory birds and other wildlife, demonstrate existing impacts of hydro operations on birds and their habitat, and provide advice as to how those impacts could be properly assessed and subsequently managed and mitigated. I have found this to be an extraordinarily difficult task. This seems due to the lack of standard efforts to describe the species and the baseline environment, a very late attempt at collecting and summarizing vital bird use information, and inability to have modelling done on alternatives that would be the obvious approach taken if operations were being managed to conserve birds or their habitat.

Discussion

I find the material presented in the briefing notes (#7 for example) to be of little value in informing the trade-off exercise that you have asked me to participate in. The modelling done seems to have made some linkages between summer and fall use of habitat that are not supported by ecology. 11B is the only alternative that attempts to hold the water at a steady level during the nesting period. Note, this is held at a level that has not yet been demonstrated to be low enough to allow sufficient access to nesting (or migratory) habitat. It also has the water rise before nesting is completed, and makes no attempt to accommodate the majority of the nesting (including fledging) of the individuals or species shown to be present in the summary by John Cooper. Since this alternative was developed (to my knowledge) by WTC members as the “best of the worst” approaches to dealing with migratory birds I find it difficult to comment too much on it.

It is suggested that this will somehow conflict with 11D, since the modelling shows gains for D over B in terms of fall migration habitat. That doesn’t seem to be based on reality. It was said at the committee meetings that fall migration would be aided by having the water recede past 436-438 in late August and September. The differences between alternatives in this regard seem minimal.

This is one example of the incredible difficulty in working with this process. I cannot and will not trade away the value of these species or their habitat based on models that are so poorly informed. The best that I can say to the consultative committee is that to protect these animals and their habitat the water needs to allow their usage of the drawdown zone during the spring migration and nesting period. It must remain at a stable level during the entire nesting period to allow fledging. It must recede in the late summer to allow fall migratory use. Other technical criticisms were provided to me by Susan Hall of Parks Canada, which I endorse with their regard to migratory and other birds.

One suggestion in the BN is the cost of monitoring. Recall that plan was very quickly drawn together and was asked to be reviewed and commented on in short order and often over email. To properly understand the impact of reservoir operations there are a number of research and monitoring options that could be considered. CWS still commits to advising BC Hydro on those respecting migratory birds, but this advice must be acquired by BCH dealing with CWS scientists and other ornithological experts directly and with appropriate amount of time given to the process. It is impossible to estimate accurately what the cost would be without defining the objective, scope, and length of the study program. Ed Hill has done a very good job on beginning this, but it is not yet at a stage the “trade-offs” can be made using its apparent cost.

Lastly, there seems to be some questioning as to “how important are these birds” in your material. I would refer you and your colleagues to the *Migratory Birds Convention Act and the Canadian Biodiversity Strategy* to provide context to the Government of Canada’s position on that question. The Columbia Valley is a very important flyway for birds. The remaining habitat in the valley itself has been shown to be very important for nesting and migration. These are all statements that have been well established, and should not need to be re-iterated constantly in the WUP process.

I may have some comments to send on the monitoring plan before the end of the consultative committee meeting. If I am unable to do so I will endeavour to provide same in the near future. If you have any questions please contact me.

Regards,

Stephen Hureau
Conservation Biologist
Canadian Wildlife Service

ATTACHMENT #14

BC hydro THE POWER IS YOURS

Patricia Vonk
Columbia River WUP– Environmental Coordinator
Water Use Plans
Phone: 604.528.7873
Fax: 604.528.2905
E-mail: pat.vonk@bchydro.com

05 December 2003

Stephen Hureau
Canadian Wildlife Service
5421 Robertson Road
Delta, BC
V4K 3N2

Dear Mr. Hureau,

Thank you for your letter dated November 27, 2003 regarding the MCA WUP briefing notes prepared for the Nov 26–28 Consultative Committee meeting. As I noted during our telephone conversation on that day, I was unable to distribute your letter to the CC members due to difficulties in retrieving my email. However, many of your comments were brought to the table by Susan Hall (Parks Canada), based on earlier conversations that you had with her.

I would like to take this opportunity to provide some comments and clarification on a number of issues that you raised in your letter. These are provided below and referenced directly to statements made throughout the letter.

p. 1, 2nd paragraph under Background

In response to your comments regarding "...lack of standard efforts to describe the species and baseline environment, a late attempt at collecting and summarizing vital bird use information..." and its implications to properly assessing, managing and mitigating impacts on birds and their habitat.

As you are aware, a number of bird-related studies have been undertaken in the Revelstoke Wetlands through BC Hydro's Strategic Environmental Initiatives Program (SEIP). These include an examination of songbird use of four floodplain vegetation types, preparation of an Access database to document 10 years of waterbird survey data, and funding of the Columbia River–Revelstoke Banding Station. The methodologies used in these studies and projects were developed collaboratively by staff from CWS, Parks Canada and BC Hydro as well as local contractors. BC Hydro has also funded two preliminary nest mortality studies in the Revelstoke Wetlands drawdown zone to provide additional information on the source-sink issue. These investigations have utilized standard methodologies with input from various experts. To further support the efforts of the WUP, a study was also undertaken as part of Step 5 of the process to assess the potential effects of the proposed alternatives on breeding and fall migration habitat (Axys and Manning, Cooper & Assoc 2002). This was a study that you provided input on regarding study design and expressed support of its report and overall conclusions.

Concerted efforts were made early in the process to collect and summarize available wildlife information for the Columbia River Basin, along with local knowledge brought to the table by some WTC members and BC Hydro biologists. Based on this, operating alternatives and performance measures were developed to the best of our abilities to address issues around nesting and migrating bird habitat, and refinements continued to be made based on information that you and others on the WTC have brought to discussions in recent months. As is the case for other interests, best efforts are being made to accomplish what we can based on sometimes limited information, while fully recognizing the importance of post-WUP monitoring studies to address remaining uncertainties for future decision making.

In June 2003, you had expressed a need for a summarization and analysis of wildlife information (specifically migratory birds in Revelstoke Wetlands) to allow you to participate more actively and more effectively in the Columbia WUP. In response to this, BC Hydro funded such a study in September 2003 (Cooper 2003) with the understanding that this would allow you to better understand the impacts of the proposed Arrow operating alternatives and associated tradeoffs, and allow you to provide more input into the development of physical works proposals. Much of this information was available and discussed during previous WTC meetings, and was used in developing the alternatives and performance measures.

p. 2, Background
In response to your comment regarding "… inability to have modeling done on alternatives that would be the obvious approach taken if operations were being made to conserve birds or their habitat."

As we have discussed, the Columbia WUP can consider operating alternatives that include incremental changes to existing operations that BC Hydro can unilaterally implement, including constraints on reservoir maximum/minimum levels that can be accomodated within the Columbia River Treaty operations. One of the priorities of the CRT is refill of Arrow Reservoir by 15 July to maximize firm energy capability for the following year. Working within these constraints, the Project Team was tasked with developing operating alternatives to benefit breeding and migratory bird habitat and use, as well as other interests in the Columbia River.

While it is recognized that the operating alternatives presently being considered are not optimal in fully mitigating nest failure due to rising reservoir levels in the spring/summer (particularly the late nesters and species that have later fledging periods), many of these alternatives would perform better than what has occurred historically (1984–1999). An alternative that would see maximum water levels maintained at 434–435 m until 15 July (the preferred hydrograph for nesters) would not be practical given the CRT and the substantial costs associated with this constraint. It was estimated that this alternative would cost about $37–42 million/year on average in lost storage. The CC had agreed early on that the original Alt 11 came at a cost ($23 million/year) that was beyond the level of benefits it could provide. The CC recommended that, while the inundation of some habitat was inevitable, physical works such as bird islands should be investigated as a way of reducing these impacts.

<u>p. 2, 1st paragraph under Discussion</u>

In response to your comment "The modeling done seems to have made some linkages between summer and fall use of habitat that are not supported by ecology."

During the Sep 30/Oct 1 WTC meeting in Revelstoke, it was noted that the shorebird performance measure did not adequately consider fall migratory birds and that there was a need to develop separate PMs that specifically address migration and breeding. New performance measures were developed during this meeting by Josh Korman based on input provided by you, Janice Jarvis and Susan Hall regarding timing of nest development, timing of fledging, timing of arrival/departure dates, preferred habitat and proportion of nests put down at each elevation. During a subsequent WTC meeting (Oct 28, 2003), further definition of the preferred hydrograph for fall migrants was provided. Specifically, it was noted that bringing the reservoir down lower and sooner after July would be beneficial for fall migration, and there was agreement that the current PM captures this effect. Results of the modeling are consistent with this, showing that alternatives that keep the reservoir lower longer during the summer are more beneficial to nesters, while alternatives that cause the reservoir to drop quickly after July are more beneficial to fall migrants. Clearly, monitoring the performance of the selected alternative with respect to use of breeding and fall migrant habitat of the Revelstoke Wetlands and getting a better perspective on how significant losses of habitat are to these bird populations will be critical to addressing underlying assumptions of the modeling and the soundness of its results.

<u>p. 2, 1st paragraph under Discussion</u>

In response to your comment regarding "this alternative was developed… as the best of the worst approaches to dealing with migratory birds…"

None of the operating alternatives fully mitigate nesting failure due treaty operations. However, it has been expressed by the CC that improvements in survivorship expected under alternatives 11B and 11D are a step in the right direction.

I would also point out that the modeling of the nesting bird PMs makes a number of assumptions about the availability and use of nesting habitat in the Revelstoke Wetlands that have not been substantiated and may make the PMs overly conservative. Specifically, it assumes that nesting habitat is at carrying capacity so that a rising reservoir that either inundates previously built nests or denies nesting due to flooding of habitat represents a loss of successful breeding for that pair for that given year. There will be no opportunity for the breeding pair to use alternate habitat in the area for nesting or rebuilding of nests. It also assumes a static distribution across elevations.

By the end of the consultative process, the CC will have made decisions around the operating alternatives based on expected benefits, expected learnings and a willingness to pay (i.e. are the benefits/gains expected from the operational change worth the $ required to implement it). Development of cost-effective feasible approaches to physical works required to compensate for nest losses (i.e. bridging the gap between the selected alternative and "best" alternative) will no doubt factor into this decision making. As proposed by Janice Jarvis, there are likely some smaller scale physical works that could be undertaken over the short term to address obvious impacts to species such as the short-eared owl. As Janice has pointed out, there is no need to monitor for 10 years to know that the impact on the two known breeding pairs in Revelstoke Reach is significant at the local population level and probably the regional level. However, there is a need to undertake further monitoring as part of the Columbia WUP to define the scope of the migratory bird issue and define what is required to compensate for the losses (nature, scope, magnitude and target species of physical works required) over the longer term.

p. 2, 2nd paragraph under Discussion

In response to your comment regarding "… differences between alternatives in this regard seem minimal."

Yes, the modeling results do show some limited gains for fall and shorebird migration under Alternative 11D over Alt 11 B because it forces the reservoir down faster in the fall. However, the significance of these gains is uncertain. The more important tradeoff that was considered by the CC was the gains in % nest survival under alternatives without rainbow trout flows vs. the gains in fall migration habitat under alternatives with rainbow trout flows.

p. 2, 4th paragraph under Discussion

In response to your comments regarding the short turn around on comments and input into the wildlife monitoring programs.

Development of the wildlife monitoring studies began in earnest in September 2003. Through correspondence/discussions with Ed Hill (BC Hydro) and attendance of the WTC/FWTC meetings (Sep 30/Oct1; Oct 28; Nov 4), WTC members had several opportunities to provide input into the development of these studies over the past three months. Ed also contacted you, Wendy Easton and Rob Butler (CWS) for advice regarding the design, duration and cost estimates for the bird-related studies, and will continue to seek advice of CWS and other ornithology experts in further defining these studies as part of WUP implementation.

The Project Team looks forward to continued participation of CWS in the Columbia WUP process both through your participation in subcommittee meetings and input on monitoring and physical works proposals. Next steps over the coming months will be to develop some of the smaller scale physical work concepts as suggested by Janice, (design, scope, estimated costs) to present to both the WTC and CC levels.

Thank you for your continued interest in the Columbia WUP process.

Sincerely,

Patricia Vonk
MCA WUP Environmental Coordinator

APPENDIX F: CORRESPONDENCE FROM THE CANADIAN WILDLIFE SERVICE

Environment Canada Environnement Canada

Sue Foster
Project Manager
Water Use Plans
BC Hydro

Dear Ms. Foster:

Re: Columbia Water Use Plan

I am writing to provide clarification of the position of the Canadian Wildlife Service (CWS) with respect to the Columbia Water Use Plan (WUP). I understand that there has been concern expressed by some of the WUP stakeholders regarding the lack of participation by CWS in WUP deliberations and this has led to much uncertainty regarding how we as an agency will respond to alternatives currently before the Consultative Committee (CC).

I appreciate the value of the Water Use Plan process and the principles of best use of water resources across the range of interests. Unfortunately, CWS staff are fully subscribed to other priorities, most notably *Species at Risk Act* implementation, and we are unable to become any more engage in this process, at this time.

I understand that the CC has narrowed the range of operating alternatives for Arrow Reservoir down to three options (and possibly some hybrid alternatives of these), one of which is designed primarily to reduce losses of nests of migratory birds due to flooding. I also understand that both Alternative 11B and 11D are predicted to perform better for percent nest survival and fall migrating habitat than historic operations based on the last 16 years of records of water levels and BC Hydro's current understanding of migratory bird habitat and its use. In other words regardless of which alternative or hybrid is ultimately chosen, there will be an expected incremental improvement in nesting success and fall migration habitat.

It would appear that performance measures for nesting and fall migratory birds could be met in a more cost effective fashion if, rather than pursuing option 11B, BC Hydro undertook some of the mitigative measures identified in the Cooper report. For example, securement and enhancements of wetland and grassland habitats within the affected zone would likely be more advantageous in the long run than would major changes in the operation of the reservoir and habitat conditions at full pool. With the information at hand now, it would appear difficult to justify the costs associated with changes in reservoir operation as envisioned by option 11B. Given uncertainties around the probable significance of nest mortalities under the current operating regime, small scale, site-specific habitat enhancement projects would likely be adequate in the short to medium term, while more detailed information is collected.

In earlier correspondence with BC Hydro, CWS proposed an approach that we believe would mitigate potential liabilities under the *Migratory Bird Convention Act* for incidental losses of nests, due in this case to reservoir operation. That approach would consist of management planning that would address mitigation of these loses at a regional level, as well as providing a well developed monitoring and assessment program to enable an adaptive approach to reservoir management. I would like to propose that the WUP consider these elements, and in particular commit to undertaking mitigation, and development and implementation of a monitoring plan. CWS is prepared to provide further comments and assistance, as we are able to, in recommending mitigation, and in designing the suggested monitoring scheme. In particular, studies which accurately determine the value of this area as a migratory flyway as well as detailed surveys concerning preferred nesting and feeding use would be of the greatest benefit for future decision making.

Having stated this I am very appreciative of the CC members who have been working so diligently to protect these values, particularly in our absence. I am also pleased that other interests, specifically Fisheries and Oceans Canada, are prepared to look at ways to modify the alternatives to improve wildlife values in order to reach a consensus based decision for Arrow Reservoir operations. I understand you have scheduled a wildlife technical committee meeting and a joint fisheries/wildlife technical meeting soon. I intend to have CWS participate in one or both of those meetings and I hope that we will be able to expand on and clarify the above. If you have any questions please call me at (604) 940-4646.

Yours truly

Rick McKelvey,
Manger
Canadian Wildlife Service.

Canada

www.ec.g.c.ca

APPENDIX G: CORRESPONDENCE RELATED TO THE COLUMBIA POWER CORPORATION AND THE 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

November 26, 2003

Sue Foster
Columbia Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C. V3N 4X8

Dear Ms. Foster:

Subject: BC Hydro's Mica/Revelstoke/Keenleyside Water Use Plan ("Columbia WUP")

Further to our letter dated September 20, 2002, I am writing to clarify Columbia Power Corporation's ("CPC") interest and role in BC Hydro's Columbia WUP process.

CPC and the Columbia Basin Trust ("CBT") are joint venture owners of hydro-electric power facilities located on the Columbia and Kootenay Rivers. CPC is the manager of the joint ventures. The joint ventures include the following:

- Arrow Lakes Power Corporation, for the Arrow Lakes Generating Station (formerly the Keenleyside Powerplant) on the Columbia River;
- Columbia Basin Power Company, for the Brilliant Dam and Powerplant on the Kootenay River; and,
- Brilliant Expansion Power Corporation, for the Brilliant Expansion Project on the Kootenay River.

Power from the Arrow Lakes Generating Station is sold under a long-term contract to BC Hydro. Under the terms of a related 1998 agreement, BC Hydro has an obligation to consult with CPC in the preparation of a water use plan and to take impacts on the Arrow Lakes Generating Station into account.

BC Hydro is undertaking WUP in accordance with Treasury Board decisions regarding the System Operating Fund and the provincial government's November 1998 Letter of Direction to BC Hydro to complete WUPs. In keeping with that Direction and the WUP Guidelines, the decisions resulting from the Coumbia WUP must recognize and consider any adverse impact on the important social, environmental and economic interests represented by the CPC/CBT facilities. 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 and given prominence in decision-making under section 12(2) of the *Water Act.*

CPC is participating in the Columbia WUP primarily to assist BC Hydro in understanding and measuring potential impacts on CPC/CBT facilities that may result from the alternatives being considered in the Columbia WUP. Understanding how the outcome from this Columbia WUP may affect the operation of the CPC/CBT facilities is important so the public interests those facilities serve are not adversely affected.

At this point in the discussions, CPC is still reviewing the preliminary information that is available to measure the potential impact on the CPC/CBT facilities. CPC will work diligently with BC Hydro to complete its review of the information, but until that review is complete CPC is not in a position to support any of the alternatives under consideration. CPC will reserve its decision until it has completed its review.

I would be pleased to elaborate further on any of these points to assist your understanding of our interests and role in these discussions.

Yours truly,

Bruce Duncan

Bruce Duncan
Vice President, Strategic Planning

cc: Lorne Sivertson, Columbia Power Corporation
Ken Epp, CBT Energy Inc.
Josh Smienk, Columbia Basin Trust
Gary Rodford, BC Hydro
Columbia WUP Consultative Committee

BRITISH COLUMBIA

MAY 0 6 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
Mailing Address:
PO Box 9048 Stn Prov Govt
Victoria BC V8W 9E2
Telephone: 250 387-3751
Location:
Parliament Buildings
Victoria

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

June 18, 2004

Sue Foster
Columbia Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C.
V3N 4X8

Subject: Columbia Water Use Plan – Notice of Objection

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 Dam WUP, which led to our letter of April 19, 2004.

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 and CBT have a direct interest in the outcome of BC Hydro's Columbia WUP. 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.

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CPC's interest in the Columbia 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 Columbia WUP.

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.

The information presented in the Columbia WUP process indicates that the rights of the CPC/CBT joint ventures could be impaired significantly, without any compensation for the loss. This risk is particularly acute once the volatility/variability of annual costs and the uncertainty related to the expiration of the Non-Treaty Storage Agreement are taken into account. 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 Columbia 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: Columbia WUP Consultative Committee

Gary Rodford
BC Hydro

Lorne Sivertson
Columbia Power Corporation

Ken Epp
CBT Energy Inc.

Josh Smienk
Columbia Basin Trust

BRITISH COLUMBIA

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COLUMBIA POWER CORPORATION

JUN 2 4 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 | Mailing Address: PO Box 9060 Stn Prov Govt Victoria BC V8W 9E2 Telephone: 250 387-5896 Facsimile: 250 356-2965 | Location: Parliament Buildings Victoria 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

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- 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.

BChydro

Bob G. Elton
President & Chief Executive Officer

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OCT 2 8 2004
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;

British Columbia Hydro and Power Authority, 18th Floor, 333 Dunsmuir Street, Vancouver BC V6B 5R3
www.bchydro.com

- 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

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

COLUMBIA BASIN TRUST

445 13 Avenue
Suite 300
Castlegar, BC
V1N 1G1

Toll Free: 1-800-505-8998
Tel: (250) 365-6633
Fax: (250) 265-2246
Email: cbt@cbt.org
www.cbt.org

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.

a legacy for the people

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

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

March 18, 2005

Ms. Sue Foster
Columbia Water Use Planning
BC Hydro
4th Floor
6911 Southpoint Drive
Burnaby, B.C.
V3N 4X8

Dear Ms. Foster:

Subject: Columbia River Water Use Plan

I am writing to you to clarify Columbia Power Corporation's ("CPC") position regarding the recommendations of the Columbia River Water Use Plan Consultative Committee ("CC") as recorded in the Final June 2004 CC Meeting Minutes provided to us on February 25, 2005.

On June 18, 2004, prior to the June Consultative Committee ("CC") meeting, I wrote setting out CPC's interest in BC Hydro's Mica/Revelstoke/Keenleyside Water Use Plan ("Columbia River WUP") deliberations. This interest stems from CPC's position as joint venture owner, 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 Columbia River 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 Columbia River WUP.

Ms. Sue Foster
March 18, 2005
Page 2

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, without appropriate compensation. As recorded on page 58 (and referenced on pages 60, 70 and 86 of the Final June 2004 Columbia River WUP CC Meeting Minutes distributed February 25, 2005):

> *CPC on behalf of CPC and CPC/CBT power project companies Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation (collectively "CPC/CBT") cannot support or accept any alternative other than the status quo 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 implementation of this WUP taking into account the year to year variability of the impacts. CPC registered a similar position to the Duncan Dam WUP CC. As with the Duncan WUP, CPC is prepared to conditionally accept the consensus recommendations of the CC with the strict proviso that CPC/CBT are saved harmless or appropriately compensated. CPC will continue to work diligently with the Province and BC Hydro to resolve this issue and will update the CC as appropriate.*

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.

Ms. Sue Foster
March 18, 2005
Page 3

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, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation, can now accept the implementation of the recommended Columbia River WUP "Total Package", as recorded on page 86 of the Final June 2004 Columbia River WUP CC Meeting Minutes.

As holders of water licences and water rights who might be affected by the changes stemming from a decision on the Draft Columbia River WUP by the Comptroller of Water Rights under the provisions of the *Water Act*, Arrow Lakes Power Corporation, Brilliant Power Corporation, Brilliant Expansion Power Corporation and Waneta Expansion Power Corporation reserve their right to provide comments directly to the Comptroller of Water Rights regarding the Draft Columbia River WUP as part of the review and approval process (described in Step 10 of the provincial government's Water Use Plan Guidelines).

Yours truly,

Bruce Duncan

Bruce Duncan
Vice President Strategic Planning
Columbia Power Corporation

Attachments

cc: Columbia WUP Consultative Committee

Gary Rodford, BC Hydro

Lorne Sivertson, Columbia Power Corporation

Ken Epp, CBT Energy Inc.

Josh Smienk, Columbia Basin Trust

Glen Davidson, Water Management Branch
Land and Water BC Inc.

Pieter Bekker, Water Use Planning and Utilities Branch
Land and Water BC Inc.

APPENDIX H: CORRESPONDENCE FROM THE REGIONAL DISTRICT OF CENTRAL KOOTENAY

Regional District of Central Kootenay

Box 590, 202 Lakeside Drive
Nelson, BC V1L 5R4
web: www.rdck.bc.ca

Telephone (250) 352-6665 Fax (250) 352-9300
BC Toll Free 1-800-268-7325
e-mail: rdck@rdck.bc.ca

October 3, 2003

SUE HEATON,
BC HYDRO
601 – 18th St.,
CASTLEGAR BC V1N 2N1

Dear Ms. Heaton:

RE: WATER USE PLANNING PROCESS

The Board of the Regional District of Central Kootenay, at its meeting held on September 30, 2003, adopted the following resolution:

RESOLUTION NO. 1056/03

"The following motion submitted by Director Greenlaw be ***referred*** to the Land Use, Inspection and Resources Committee for consideration:

WHEREAS, in the opinion of Regional Directors appointed by the Regional District Board to BC Hydro's Columbia and Duncan Water Use Planning Groups, there is:

1. a lack of meaningful public consultation; and

2. a lack of adequate attention being given to the human and social impacts with an over-attention given to biological issues;

THEREFORE BE IT RESOLVED THAT the Regional District of Central Kootenay withdraw from the Columbia and Duncan Water Use Planning process; AND FURTHER, the following entities be so advised:

- BC Hydro
- Minister of Water, Land and Air Protection
- Minister of Energy
- Kootenay Boundary, East Kootenay, and Columbia-Shuswap Regional Districts
- Ktunaxa-Kinbasket Tribal Council."

Continued…../2

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

Page 2
BC Hydro – Water Use Planning Process
October 3, 2003

AND FURTHER, representatives of B.C. Hydro be invited to meet with the Committee to discuss the Regional District's concerns and continued involvement in the Water Use Planning process; with invitation also extended to Directors of the Administration & Finance Committee to attend and participate in discussions."

You are invited to the Land Use, Inspection And Resources Committee meeting scheduled as follows:

Time:	**5:30 p.m.**
Date:	**Wednesday, November 5, 2003**
Place:	**RDCK Boardroom** *(entrance at front of building)*
	202 Lakeside Drive, Nelson, B.C.

Sincerely,

Don Harasym

DON HARASYM, M.C.I.P.
Planning Manager

DH:amkw:\departments\plandept\luirc\03-heaton.doc

BC hydro   THE POWER IS YOURS

Sue Heaton
Public Affairs Officer
Community Relations, Kootenay/Lower Columbia
Phone: 250-365-4562
Fax: 250-365-4559
E-mail: sue.heaton@bchydro.com

21 October 2003

Mr. Don Harasym
Planning Manager
Regional District of Central Kootenay
Box 590, 202 Lakeside Drive
Nelson, BC
V1L 5R4

Dear Mr. Harasym:

Thank you for your letter dated October 3, 2003 with regard to Resolution No. 1056/03 that outlines the Regional District's concerns with BC Hydro's Columbia and Duncan Water Use Planning process.

This letter confirms that representatives from BC Hydro will be pleased to attend the November 5th, Land Use, Inspection and Resources Committee meeting to discuss the Regional District's concerns and continued involvement in the Water Use Planning process.

By way of background information, the Duncan Dam water use planning process was initiated in August of 2001. Throughout August and September 2001, over 50 individuals were contacted by BC Hydro to introduce them to the process and invite them to articipate in the process. On September 19, 2001 BC Hydro held an Open House and Information Session at Meadow Creek. At present, the Consultative Committee members from the Duncan Dam area include Director Larry Greenlaw, Gail Spitler, and Stephan O'Shea. In addition, Bob Douglas, Mayor of Kaslo and RDCK Director has participated in the process as Mr. Greenlaw's alternate. Mary Hallam, Brenda Herbison, Brenda Drury, Jane Lynch, and Rowena Eloise participate as Observers.

In response to a letter from the RDCK dated March 5, 2002, on April 5, 2002, BC Hydro sent additional letters to companies in the Kaslo area inviting them to participate. This resulted in one of those companies agreeing to be an observer to the process.

At the April 9 and 10, 2003 Duncan Dam Water Use Plan Consultative Committee meeting, participants discussed the continued concerns with the composite of the Committee raised by the Regional District of Central Kootenay Board. There was also clarification from Larry Greenlaw that the Regional District believes that the structure of the Water Use Plan Program is flawed and that local stakeholders should make the decisions rather than a group of regulators, external agencies and organizations and local community representatives. It has also come to the Committee's attention that some misinformation has circulated in the local community regarding the water use planning process and its objectives concerning the Duncan Dam facility. As a result, on April 22, 2003 the Consultative Committee formally requested the Regional District to host an information session with the local community on the Duncan Dam Water Use Plan. Subsequently, the Regional District on June 21, 2003 referred the information session back to BC Hydro.

On October 8, 2003 BC Hydro hosted a Duncan Dam Water Use Plan Information Session in Meadow Creek. The objectives of the meeting were to provide area residents with an overview of the Duncan Dam water use planning process, the progress to date, gain an understanding of the operating alternatives being explored, and how operations could be altered at Duncan Dam to better balance water use interests. Those in attendance acknowlegded that the region's main concerns, namely, mosquitoes, recreation and flooding are being discussed and considered by the Consultative Committee as depicted by the operating alternatives. Further, during Step 5 of the Duncan Dam water use planning process a number of studies were conducted to determine the impact of operations on mosquito production, recreation and flooding.

The Duncan Dam water use planning process is currently in step 6 – creating operating alternatives and step 7 – assessing trade-offs between operating alternatives. Effects related to the operation of the facility and part of water use plans include adverse impacts that can be achieved by changing water flows or reservoir levels as well as beneficial effects that can be altered, such as the quality of fishing spawning or rearing areas, flood protection, or recreational activities such as swimming. The Consultative Committee is currently evaluating and comparing the various operating alternatives and has yet to make a recommendation on a final operating regime. At this time, it is expected that the Duncan Dam Water Use Plan consultative process will be completed in early 2004.

Initiated in August 2000, the aim of the 39-member Columbia River Water Use Plan Consultative Committee is to develop an operating regime for the Columbia River system that balances the needs of all water use interests in and along the Columbia River system from the Canada/US border to Valemount.

Over the past two and a half years the Columbia River Consultative Committee has moved ahead by conducting studies to fill data gaps, and developing ways to measure the positive or negative aspects of potential operating alternatives. To date, the Consultative Committee has identified a number of potential operating alternatives. These alternatives have been modeled and the Consultative Committee will now consider the overall impacts of each alternative, including how they affect other interests at the table. Interests being considered during this trade-off phase of the consultative process include: fish, recreation (access), cultural and traditional use, navigation, power generation, flood management and wildlife.

The Columbia River Water Use Plan Consultative Committee includes First Nations, provincial agencies, Fisheries and Oceans Canada, local government, community groups, industry, BC Hydro and other interested parties. The Consultative Committee has met five times since the water use planning process began. Numerous meetings of the Consultative Committee technical sub-groups (fish, wildlife, heritage and recreation) have taken place to address specific issues. The next meeting for the Columbia River Consultative Committee is schedule for November in Revelstoke. At this time, it is expected that the Columbia River Water Use Plan consultative process will be completed in early 2004.

BC Hydro has been diligent in recruiting individuals and organizations to participate in both the Duncan Dam and Columbia River water use planning processes as either Consultative Committee members or Observers.

As per the provincial *Water Use Plan Guidelines*, the scope of Water Use Plans is intended to help define future operating parameters for each BC Hydro facility in the province. Water use planning is a collaborative process designed to consider economic, social and environmental values. The goal of the water use planning process is to achieve consensus on a set of operating parameters for each facility that satisfies the full range of water use interests at stake, while respecting legislative and other boundaries.

In closing, I encourage the Regional District of Central Kootenay to discuss their concerns at both the Duncan Dam and Columbia River Consultative Committee table which provides a forum to share information and promote understanding of interests, perspectives and values, and explores alternative ways to operate the facility. By doing so, you will support the objectives of the water use planning process.

BC Hydro will continue to work cooperatively with interested parties to develop a Water Use Plan for both the Duncan Dam and Columbia River in an open and transparent manner.

Thank you for your interest in the water use planning process. I look forward to meeting with you on November 5th.

Sincerely,

Sue Heaton

CC. Columbia and Duncan Consultative Committee members
Comptroller of Water Rights
BC Hydro Columbia and Duncan Water Use Plan Project Team

Regional District of Central Kootenay

Box 590, 202 Lakeside Drive
Nelson, BC V1L 5R4
web: www.rdck.bc.ca

Telephone (250) 352-6665 Fax (250) 352-9300
BC Toll Free 1-800-268-7325
e-mail: rdck@rdck.bc.ca

Pin 6-2

February 6, 2004

BC Hydro & Power Authority
601 – 18th Street
Castlegar, BC V1N2N1

Attention: Sue Heaton, Public Affairs Officer
Community Relations, Kootenay/Lower Columbia

Dear Ms. Heaton:

Please be advised that the Board, in reconsidering its involvement in the Columbia and Duncan Water Use Planning process, adopted the following resolution at its meeting of January 24, 2004:

76/04 Regional District of Central Kootenay participation in the Columbia and Duncan Water Use Planning process be continued.

Yours truly,

C. McGowan

Carol McGowan
Deputy Chief Administrative Officer

CM:mem
Cc: Director L. Greenlaw, Area D
Director P. Peterson, Area K

W:\Departments\ADFINSC1\WINWORD\Gen 2004\JAN24CORRESP.doc

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

APPENDIX I: CONSULTATIVE COMMITTEE TERMS OF REFERENCE AND CODE OF CONDUCT

The following Terms of Reference are based on those developed by previous Water Use Plan Consultative Committees and the provincial government's *Water Use Plan Guidelines*. These Terms of Reference and Code of Conduct were reviewed at the Columbia River Water Use Plan Consultative Committee meeting held in March 2001.

1.0 INTRODUCTION

The purpose of the Terms of Reference is to ensure that participants of the Columbia River 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 to enhance the smooth functioning of the Consultative Committee work.

2.0 COMMITTEE PURPOSE

The purpose of the Consultative Committee is to integrate public values into water flow management decisions related to BC Hydro operations. Specifically the Committee is to provide clearly documented value-based recommendations for consideration by BC Hydro when preparing their Water Use Plan for the Columbia River hydroelectric facilities. The Committee will 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, industry, power generation, traditional use, aquatic ecosystem "health," and recreation);
- Criteria for a monitoring and assessment program; and/or
- Timing for periodic review of the Columbia River 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 which 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 will indicate differences of opinion and reasons for disagreement.

3.0 CODE OF CONDUCT

All participants of the Columbia River water use planning process will endeavour to:

- Treat others with courtesy and respect.
- Listen attentively with an aim to understand other water use interests.
- Speak in terms of interests instead of positions.
- Be concise in making your point.
- Challenge ideas not people.
- Let opposing views co-exist.
- Use the "parking lot" for issues that fall outside the day's agenda.
- Act in "good faith" in all aspects of the process.
- Avoid disruption of meetings (e.g., use of cell phones, caucusing at the table, etc.).
- Aim to achieve consensus on issues being addressed.

The Facilitator will ensure that the code of conduct is followed by Consultative 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:

STEP 4 Confirm issues and interests in terms of specific water use objectives along with quantitative and/or descriptive measures for assessing their achievement.

STEP 5 Identify existing information and information gaps related to the impacts of water flows, and their timing, on each objective.

STEP 6 Create alternative operating regimes to compare impacts on water use objectives.

STEP 7 Assess the trade-offs between alternative operating regimes in terms of the objectives.

STEP 8 Determine and document areas of agreement and disagreement, including consensus on a preferred operating regime or non-consensus.

5.0 DELIVERABLE

The deliverable of the Consultative Committee is a Columbia River Water Use Plan Consultative Committee Report, signed off by the Members, that documents the overall process; water use interests, objectives and performance measures; existing information and data gaps; operating alternatives reviewed, trade-off assessment, and areas of final agreement and disagreement (including a preferred operating alternative if the Committee reaches a consensus).

The target date for the delivery of this report is the fall of 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 Columbia River Water Use Plan. A copy of the Draft Water Use Plan, prepared by BC Hydro, will be distributed to the Committee for review.

The Draft Columbia River Water Use Plan and the Consultative Committee Report will be submitted to the BC Comptroller of Water Rights, in accordance with Step 9 of the provincial government's *Water Use Plan Guidelines*. The Comptroller will coordinate a final regulatory review and approval as outlined in Steps 10 and 11 of the *Water Use Plan Guidelines*.

7.0 MEMBERSHIP

7.1 Committee Membership

The Columbia River Water Use Plan Consultative Committee has been established in accordance with Steps 2 and 3 of the provincial government's *Water Use Plan Guidelines*. Members represent a broad range of interests affected by BC Hydro's operations in the area.

7.2 Alternates

Consultative Committee Members should 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.

Members should ensure that their Alternate is familiar with these Terms of Reference and with the provincial government's *Water Use Plan Guidelines* and is up-to-date on issues being discussed.

7.3 New Members

Individuals or organizations may apply to become Consultative Committee Members under the following process:

- Submitting a request for Committee membership to the Facilitator, or a member of the BC Hydro Project Team. The membership request will then be scheduled as an agenda topic for the next Committee meeting.
- Applicants must be present at the meeting in which their 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 water use planning process.
- Current Committee Members will consider new applications based on the principles of 1) a fair, inclusive and representative process; and 2) efficient and effective functioning of the Committee.

New Consultative 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

Consultative Observers will be given opportunity to provide input into the discussions of the Committee at specified points in the meeting as designated by the Facilitator.

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 Columbia River Water Use Plan.

Observers and guests will not participate in making Consultative Committee decisions.

8.0 ROLES AND RESPONSIBILITIES

8.1 Committee Members

In addition to following the code of conduct, the Columbia River Water Use Plan Consultative Committee Members have the authority and responsibility for:

- Attending and participating in Columbia River Water Use Plan Consultative Committee meetings.

- Articulating their interests with respect to water use.
- Reviewing relevant information and coming to meetings prepared.
- Establishing Subcommittees, Working Tables and Technical Work Groups as needed that will report to them on specific issues.
- Ensuring continuity in representation.
- Receiving comments and feedback from the broader public and ensuring the public and other interested parties are informed of the issues under discussion and decisions taken.
- Seeking areas of agreement.
- Signing off on the final Consultative Committee Report (which should be an accurate report of the consultation process, regardless of whether consensus is reached or not).

8.2 Subcommittees and Working Groups

To expedite the completion of tasks identified by the Consultative Committee, subcommittees or technical working groups may be established to undertake work at the direction and request of the Committee. Subcommittees will not make decisions on behalf of the Committee.

Subcommittees may include non-Consultative Committee Members as appropriate (especially for technical expertise). Meetings will normally be facilitated, unless the Committee agrees facilitation is unnecessary. For efficient functioning, subcommittee size may in some cases be limited.

8.3 Role of the Facilitator/Trade-off Analyst

In addition to enforcing the code of conduct, the Facilitator/Trade-off Analyst of the Columbia River water use planning process is responsible for:

- Ensuring that the information and methods used for consultation and analysis support decision quality and maintain the integrity of the decision process as outlined in the provincial government's *Water Use Plan Guidelines*.
- Assisting 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.

Regardless of contractual arrangements covering payments for the facilitation services, the Facilitator serves the Columbia River Water Use Plan Consultative Committee. His/her mandate is to ensure that the consultation process delivers information that is useful for informing regulatory decisions about the approval of a Water Use Plan.

8.4 BC Hydro Project Team

A BC Hydro Columbia River Water Use Plan 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 with technical activities which include:

- Managing the process to maintain an acceptable time schedule, scope and budget.
- Compiling and providing existing data and information as it pertains to the development of the Water Use Plan.
- In conjunction with the Columbia River Water Use Plan Consultative Committee 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.
- Taking notes at Consultative Committee meetings or any subcommittee, working table or technical work group meetings.
- 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 publication of the Consultative Committee Report.
- Presenting the Draft Water Use Plan to the Consultative Committee.

9.0 PUBLIC COMMUNICATION

The following procedure will be followed with respect to public communication:

- 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 with approval from the Consultative Committee.
- 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 to represent the Committee.

10.0 PROCEDURES 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.

If Consultative Committee Members are unable to reach agreement on an issue, a break-out group of interested Committee Members may be formed to discuss the issue in more detail. The break-out group will attempt to resolve the issue and report its recommendations back to the main Committee. Alternatively, when appropriate, external resources may be engaged to provide an independent opinion.

In the event of failure to agree, the Facilitator will make a decision that reflects his/her unbiased professional judgment about the course of action that will best serve the goal of ensuring a quality decision process.

Decisions may be reopened at the discretion of the Facilitator if new information becomes available that affects a previous decision.

11.0 CHANGES TO THE TERMS OF REFERENCE

The terms of reference may be amended at any time based on a consensus decision of the Consultative Committee.

APPENDIX J: BC HYDRO PROJECT TEAM, AND FACILITATION AND DECISION ANALYSIS TEAM

A BC Hydro Project Team was responsible for overseeing the Columbia River Water Use Plan consultation process and working with a team of independent facilitators and consultants to assist the Consultative Committee. The members of the BC Hydro Project Team and their specific responsibilities are outline in Table J-1.

Table J-1: BC Hydro Project Team

Position	Primary Role/Responsibility	Name (period of service)
Project Manager	Management and co-ordination of the activities of the Project Team. Preparation of the Columbia River Water Use Plan.	Al Geissler (May 2000–spring 2002) Sue Foster (spring 2002–June 2004)
Resource Valuation Task Manager	Management and co-ordination of facilitation, decision analysis and overall Columbia River Water Use Plan Committee process, and facilitation of Technical Subcommittee meetings.	Basil Stumborg
Environmental Task Manager	Co-ordination of environmental studies, and assistance of the Consultative Committee and Fish and Wildlife Technical Subcommittees in development of environmental objectives and performance measures, operating alternatives, and monitoring programs.	Wayne Duval (May 2000–September 2003) Patricia Vonk (April 2003–June 2004)
Recreation Task Manager	Co-ordination of recreational studies, and assistance of the Consultative Committee and Recreation Technical Subcommittee in development of recreation objectives and performance measures, operating alternatives and monitoring programs.	Wayne Duval (May 2000–September 2003) Basil Stumborg (September 2003–June 2004)
Communication Task Manager	Key contact person for all inquiries related to the Columbia River water use planning process.	Sue Heaton
First Nations Task Manager	Assistance to First Nations in effective participation in the Columbia River water use planning process.	Trevor Jones (May 2000–June 2001) Lorrie MacGregor (June 2001–November 2001) John Emery (June 2001–June 2004)
Power Studies Task Manager	Co-ordination of BC Hydro's operations modellers. Provide input and information support on issues related to power facilities operations.	Alan Woo
Power Studies Modellers	Modelling of operating alternatives proposed by the Columbia River Water Use Plan Consultative Committee and Technical Subcommittees.	Tom Siu Herbert Louie

Table J-2 identifies the members of the facilitation and consulting team for the Columbia River Water Use planning process.

Table J-2: Facilitation and Decision Analysis Team

Position	Primary Role/Responsibility	Name (period of service)
Facilitator	Facilitation of the Columbia River Water Use Plan Consultative Committee Meetings.	Lee Failing, Compass Resource Management (January 2001–July 2003). Replaced by Stuart Gayle (June 2004)
	Facilitation of the Columbia River Water Use Plan Fish and Wildlife Technical Subcommittee Meetings.	Lee Failing, Compass Resource Management (January 2001–July 2003). Replaced by Basil Stumborg (July 2003-June 2004).
	Facilitation of Recreation Technical Subcommittee Meetings.	Graham Long, Compass Resource Management (January 2001–September 2002). Replaced by Basil Stumborg (September 2002–June 2004).
Decision Analyst	Assistance to the Committee and Subcommittees in following a structured decision-making approach.	Lee Failing, Compass Resource Management (January 2001–July 2003). Replaced by Basil Stumborg (July 2003-June 2004).
Ecological Specialist	Integrated modelling of the Columbia Water Use Plan performance measures.	Josh Korman, Ecometrics Research
Vegetation Specialist	Development of revegetation programs and riparian vegetation performance measures.	Anne Moody, AIM Ecological Consultants
Archaeology Specialist	Cultural resource advice to the First Nations.	Wayne Choquette
Wildlife Specialist	Scoping of wildlife issues in the Columbia River system	Ian Robertson, Robertson Environmental Services

APPENDIX K: CORRESPONDENCE FROM COMPASS RESOURCE MANAGEMENT LTD.

Compass Resource Management

Compass Resource Management Ltd.
2nd Floor – 1260 Hamilton St.
Vancouver, B.C. Canada V6B 2S8
Tel: 604-641-2875 Fax: 604-641-2878
www.compassrm.com

Memorandum

To: MCA WUP Consultative Committee

From: Lee Failing

Date: June 8, 2003

Re: MCA WUP CC Meeting

This letter is to advise you that the June 11-13 meeting will be my last meeting as the MCA WUP facilitator. The extension of MCA WUP into April of 2004 unfortunately conflicts with personal plans that I had made to take an extended period of time away from consulting during the fall and winter of 2003. After much consideration, I have decided that these plans cannot be put on hold for such a long period of time.

There are three basic options for providing resource valuation and facilitation services for WUPs:

- services provided solely by independent consultants
- services provided solely by BC Hydro's resource valuation staff
- services provided by a combination of BC Hydro staff and consultants.

All of these have options have been used at various WUPs, and there have been several examples where the division of roles between consultants and BC Hydro staff have changed over the course of the WUP.

For MCA WUP, the hiring of a new consultant would have benefits in terms of neutrality of the facilitator, but significant inefficiencies for the process in terms of transition. Under the second option, services would be provided by Basil Stumborg, BC Hydro's resource valuation manager, with whom I've worked closely over the past two years. Basil has already been leading the recreation and heritage subgroups, and conducting some analysis for the fisheries subgroup. He has been involved with many WUPs, in some cases, leading the facilitation and resource valuation analysis. Under the third option, Basil would continue to lead the project from an analytical and process perspective, but bring in an independent facilitator for CC meetings.

We will discuss pros and cons of these (and other) options near the end of this week's meeting. The BC Hydro project team will take your comments into consideration in choosing the way forward to the end of this WUP process.

I look forward to your feedback and suggestions at the meeting.

APPENDIX L: CORRESPONDENCE FROM MINISTRY OF WATER, LAND AND AIR PROTECTION AND FISHERIES AND OCEANS CANADA

BRITISH COLUMBIA

November 1, 2002

Sue Foster
Project Manager MCA WUP
BC Hydro
6911 Southpoint Drive
Burnaby, B.C.
V3V 4X8

Ms. Foster,

I'm writing to more formally express a number of concerns that have arisen within the Columbia River water use planning process(MCA WUP). These concerns have previously been discussed within the FTC, but have not yet led to sufficient resolution. My office sees WUPs as a very positive process, and it is our hope that the MCA WUP can continue in this manner. However, as the MCA WUP process moves towards its proposed end the failure to address issues discussed herein leads to an increasing concern regarding its satisfactory completion.

All participants in the MCA WUP are fully aware that this process has been challenged due to the limited budget and time that BCH has allocated to this WUP. It is also acknowledged by participants that the scale and scope of changes foreseen for the Columbia River may not match the kinds of changes agreed to for some of the coastal facilities. In spite of that, the WUP process still needs to make recommendations about the operations of these particular facilities. Decisions made within the MCA WUP will have significant environmental and economic implications, and it is therefore important that we are able to make the best decisions possible. Unfortunately this ability may be threatened for the MCA WUP. A number of concerns are mentioned more specifically below.

One particular problem has been the limited interaction and communication. The limited number of meetings has led to a discontinuous process. Information and communication between meetings is certainly not what it could be, and is unlike most other WUPs. An undesirable outcome of this approach is that it may diminish consensus that needs to be built through the course of the process. A lack of confidence in the methods being used leads to a significant risk that methods and the decisions they lead to may be rejected by participants. This may be particularly true for some fisheries issues where there are some significant uncertainties. One outcome of this may be the process "stalling" as it nears completion. Another may be that poor decisions are made if participants reject information

Ministry of Water, Land and Air Protection
Biodiversity Branch

Mailing Address:
PO Box 9338 STN PROV GOVT
Victoria BC V8W 9M1
Phone: (250) 387-9500

Location:
4th Fl., 2975 Jutland Rd
Victoria

and analysis generated for this WUP. This risk has always been present, but after our October 24/25 FTC it may have increased to the point where it must be mentioned.

One of the particular challenges this WUP has faced is the availability of information. New information gathered as part of the WUP process has been limited when compared to the information needs. This applies to both biological studies and power studies being conducted by BC Hydro. Related to this is the repeated pattern within the FTC of being requested to discuss reports and make decisions without sufficient review time. This has led to some of our restricted meetings being less efficient than they could be. Our previous agreement that information would be made available at least one week prior to meetings (or meetings would be cancelled) was not adhered to as recently as our October 24/25 FTC meeting. In that case, one significant study was provided the day before the meeting, and other significant analyses were introduced only at the meeting itself. Such a practice did not allow for the most fruitful discussion and did not allow sufficient time for review. These are but two of many examples that have occurred over the course of this WUP.

Power studies and modeling efforts by BC Hydro have also presented significant challenges throughout this process, and have certainly led to delays. The Columbia River Treaty is a particularly large constraint upon the MCA WUP, and therefore it is important to understand what sorts of operational changes would be feasible. However, a clear understanding on this issue has not been forthcoming. For example, review of one operating alternative (alternative 7) led to the conclusion that it would violate the Treaty, without specific guidance as to how it would violate the Treaty. The delay in receiving such responses are often compounded, with the result that we are still crafting alternatives at this late point in the process. Recent input from Allan Woo suggested that any single operation suggested for Keenleyside Dam would violate the Columbia River Treaty was very informative. The fact that it came at this stage in the process was troublesome. If true, his comments indicate a very different type of WUP decision structure will be required for this stretch of the river. Again, it is very late in the process to be doing such a reorientation. The apparent idea that our October 24/25 FTC meeting is the last meeting is clearly unacceptable given the large volume of work that remains to be done for this WUP.

A further challenge for the MCA WUP is the extensive monitoring that we anticipate will be part of this WUP. To date I am not aware of any significant attention being directed toward our monitoring needs. I mention this point specifically to ensure that you are aware of the anticipated need to put resources toward this matter within this WUP process.

The challenge on the Columbia WUP is perhaps greater than elsewhere given the complexities of this system and the approach being taken within this WUP. Operational changes may have significant economic consequences, and a strong rationale will need to be

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Mailing Address:
PO Box 9338 STN PROV GOVT
Victoria BC V8W 9M1
Phone: (250) 387-9500

Location:
4th Fl., 2975 Jutland Rd
Victoria

presented for any such changes. As detailed above the informational and procedural limitations within the MCA WUP pose a threat to us making a good, well informed, and timely decision. Such a consequence would clearly be undesirable, and so it is my hope that you, as project manager for the MCA WUP, can work to ensure that these concerns can be addressed within this WUP process. With the hope of bringing a positive resolution to these issues I think it would be useful to meet and discuss them. I would very much like to be a part of that discussion, but unfortunately I will be away until December 10. In my absence this matter could be discussed with my manager Jamie Alley.

Thanks for your attention,

Steve McAdam
Senior Hydroelectric Impacts Biologist

cc. Graeme Matthews
Kevin Conlin
Jamie Alley

Ministry of Water, Land and Air Protection
Biodiversity Branch

Mailing Address:
PO Box 9338 STN PROV GOVT
Victoria BC V8W 9M1
Phone: (250) 387-9500

Location:
4th Fl., 2975 Jutland Rd
Victoria

Fisheries and Oceans Canada
112 Mcdonald Dr.
Nelson, B.C.
V1L 6B9
Tel (250) 352-0891 Fax (250) 352-0916

November 6, 2002

Sue Foster
Project Manager MCA WUP
BC Hydro
6911 Southpoint Dr.
Burnaby, B.C.
V3V 4X8

RE: Columbia Water Use Planning Process
Support for Steve McAdam's Letter dated November 1, 2002

Ms. Foster,

I am writing to express Fisheries and Oceans Canada's support and agreement with Steve McAdam's letter to you, dated November 1, 2002, expressing concerns and issues relating to the Columbia Water Use Planning process. I hope that you will take our concerns under serious consideration and that they can be addressed prior to the next Consultative Committee meeting in February 2003.

I have attached Steve's letter for reference.

If you have any questions or concerns, please don't hesitate to contact me.

Sincerely,

Tola Coopper

Tola Coopper
Habitat Biologist
Fisheries & Oceans Canada
112 McDonald Dr.
Nelson, B.C.
V1L 6B9

(250)352-0895

APPENDIX M: MINUTES OF THE APRIL 2003 BC HYDRO/AGENCY MEETING

MCA WATER USE PLAN PROJECT
April 14, 2003
9:00 am to 11:20 am, D-11
AGENDA

Attendees:

Basil Stumborg	BC Hydro
Bill Green	CCRIFIC
Bob Westcott	BC Hydro
Graeme Matthews	BC Hydro
Kevin Conlin	BC Hydro
Pat Vonk	BC Hydro
Steve McAdam	MWALP
Steve Mcfarlane	Fisheries and Oceans Canada
Terry Anderson	MWLAP
Sue Foster	BC Hydro
Tola Cooper	Fisheries and Oceans Canada

AGENDA
1. Draft MCA WUP Workplan
2. Water Use Plan and the Columbia River Treaty
3. Performance measures for recreation
4. Responsibility for biological analysis
5. Length of CC meetings
6. Modelling of new alternatives proposed at the WFTC
7. Bringing studies from outside WUP into the consultative process
8. Specific operational issues from agencies and BC Hydro
9. Lee's Involvement

1. Draft MCA WUP Workplan

- Summary of the draft MCA WUP workplan. Three additional CC meetings to be held in June 2003 November 2003 and April 2004. It is expected that there will be two FWTC meetings in advance of each CC meeting.
- A vegetation workshop is planned for May 2003. A technical vegetation planning meeting to be held today April 14, 2003 to develop a number of options.
- Comment by Steve McAdam that the past approach versus the actual schedule of meetings was the key area of concern. Lack of involvement and communications in plans, studies, etc…. Request that future development of plans occur early in the process with communication and consultation with the agencies.
- Concern with ensuring appropriate resources (i.e., operations experts, and specialists as required) at future meetings.
- Recognition by Steve McAdam that within the past couple of months that the approach has improved and that there is better communications and involvement with the agencies.

ACTION: THE MCA WUP WORKPLAN WILL BE DISCUSSED AT THE JUNE 11, 12, 13 CC MEETING – BASIL STUMBORG

2. Water Use Plan and the Columbia River Treaty

- Discussion of the WUP and the Columbia River Treaty (CRT).
- Comment that BC Hydro has regulatory obligations within the CRT, which is challenging to deal with in the WUP.
- Not a good understanding by the agencies as to what can and can not be done within the CRT and what needs to be negotiated with the US. There was a comment that perhaps all flow changes may have some effect on the Columbia River Treaty.
- Comment by Tola that WUP needs to meet Fisheries and Oceans minimum needs first. If these cannot be met in the water use planning process, then DFO will not be able to agree with the WUP and the *Fisheries Act* can be applied.
- Need to review how key fisheries issues can be addressed under the WUP. Bob to solicit list of issues from agency/CCRIFC staff.
- Comment by Kevin that that water use planning process is intended to look at the best balance of interests including fisheries for the available water. The consultative process is structured to identify and explore a range of alternatives, and to seek compromises across interests while remaining within regulatory and other boundaries.
- Confirmed that Kelvin Ketchum will attend the next FWTC meeting to:
  - provide an overview of the Columbia River Treaty
  - review operations over last two years and impacts on Whitefish
  - discuss areas of flexibility
  - Review operations over last two years and provide examples of issues that required negotiations with the US and their respective costs (e.g., Whitefish flows)
  - Agencies require summary of Libby-Arrow Swap, VARQ and Duncan-Arrow swap influence on MCA WUP alternatives
- It was suggested that First Nations and fisheries agencies should be able to have greater participation in the negotiations of the annual operating plan. Bill Green pointed out that the US side had a structure in place to do that. Graeme Matthews felt that this is a policy issue for BC Hydro and the provincial government that could not be solved by the WUP process.
- Suggestion Steve Macfarlane that technical committees need to start thinking about flow experiments and monitoring programs. Comment by Graeme Matthews that these should be part the recommended operating alternative in the WUP. CC is currently in Step 6 – creating alternatives and Step 7 – tradeoff analysis. After June CC meeting, technical subcommittee meetings should start developing monitoring proposals to be discussed at the fall 2003 CC meeting.

ACTION ITEM: DISCUSS APRIL 30 FWTC PRESENTATION/INFORMATION REQUIREMENTS WITH KELVIN KETCHUM – BASIL STUMBORG AND PAT VONK

3. Performance measures for Recreation

- Suggestion by Bill Green that BC Hydro project team needs to clarify recreation interests and get a strong consensus among the recreation interests (shore vs other). Strengthen analysis of recreation interests and ensure participation at the CC.

- Need to ensure that boat based recreation, impacts on beaches (re-vegetation with lower water) and impacts to private recreation improvements (docks) are adequately discussed in WUP.

ACTION ITEM: RECREATION SUB COMMITTEE MEETING TO BE HELD ON xxx, 2003 TO REVIEW ALTERNATIVES AND PERFORMANCE MEASURES – BASIL STUMBORG

4. Responsibility for biological analysis

- Suggestion by Bill Green that technical subcommittee needs to understand the biological impacts of operating alternatives at technical meetings. Need to develop links between PMs and end points.
- Acknowledgment that this was a responsibility of the BC Hydro project team with input from technical experts on the subcommittees and CC members within the limits of the program. What cannot be done that needs to be done must be built into the WUP monitoring.

ACTION ITEM: SUMMARIZE/ELABORATE ON IMPACT HYPOTHESIS FROM FWTC MEMBERS – MCA WUP ENV TEAM

5. Length of CC meetings

- Comment by Bill Green that at times the CC has been rushed at the two-day meetings and there should be additional time set aside if needed. Perhaps the CC meetings should be three days.
- There will be a four-hour information/review session on June 11, 2003 in advance of the June 12 and 13 CC meeting. The BC Hydro project team will encourage new CC members and existing CC members not on the technical subcommittees to attend.

ACTION ITEM: LOOK INTO POTENTIAL FOR THREE DAYS FOR JUNE AND SUBSEQUENT CC MEETINGS – SUE FOSTER

6. Modelling of new alternatives proposed at the FWTC

- Two new operating alternatives were specified at the April 10 and 11, 2003 WFTC meeting in Castlegar.
- Request by technical subcommittee to have the operating alternatives modelled and performance measures calculated for the April 28, 29 and 30, 2003 FWTC meeting. At the April 10 and 11, 2003 WFTC meeting, Allan Woo could not commit to delivery of the results within this timeline.
- Graeme Matthews outlined competing demands on modeller's time between Energy Policy issues and WUP.

ACTION ITEM: REVIEW OPERATING ALTERNATIVES AND DELIVERY DATE WITH ALLAN WOO AND – BASIL STUMBORG AND SUE FOSTER

7. Bringing studies from outside WUP into the consultative process

- Request to have studies from outside WUP brought into the consultative process. Examples of studies included stranding and ramping issues on Lower Columbia River.

- Comment by Graeme Matthews that it is both BC Hydro and agencies responsibility to bring forth studies outside of the WUP into the process if appropriate.
- Bob Westcott confirmed that a TOR for interstitial protocol stranding monitoring study is being prepared by Gary Birch.
- Recognition that modelling can not provide the level of detail required. There is likely enough information available to come up with ramping rates below Keenleyside.

ACTION ITEM: CONTACT LLEWELLYN MATTHEWS AND OTHERS REGARDING ANY RELEVANT CPCSTUDIES – BOB WESTCOTT

ACTION ITEM: BRING FORTH STUDIES OUTSIDE OF THE WUP PROCESS INTO THE WUP IF APPROPRIATE – BC HYDRO AND AGENCIES

8. Specific operational issues/questions from agencies and BC Hydro

- What are the local flood control constraints? Potentially could consider physical works in lieu of flows.

ACTION ITEM: PROVIDE LOCAL FLOOD CONTROL CONSTRAINTS TO CC – BOB WESTCOTT

- What is the Lower Columbia River flow habitat relationships? Discussion that this potentially could be dealt with in the monitoring program if it meets the WUP program monitoring criteria. Need to be able to measure significance in relation to base flows.
- Comment that Aquila plants are being auctioned off. No information on whom is bidding.
- Clarification on how Kootenay flows are included in the modelling was requested.
- Developing al flow option priority list, as described at past FWTC for annual review and implementation as water management opportunities arise does not provide the certainty some agency reps would like. Ensure that operational suitability commentary on each issue is provided with respect to gaining long-term operating certainty with key issues (Priority approach vs. hard constraints).
- With respect to issue above, provide options for WUP structure to deal with key agency issues within context of treaty (current and future protocols and annual agreements, items that require negotiation with US (annual and long-term)).
- Provincial Fish Management Plan would assist DFO in prioritizing fish issues.
    - In absence of a fish management plan, DFO/BCH could work with MWLAP on helping to develop.
- As discussed at previous FWTC meetings, there is support by agency and CCRIFC for a longer-term approach to data collection for those issues without sufficient information to assist in future re-negotiation of the Treaty - monitoring.
- Analytical Implications of Flow Alternatives: Agencies and CRIFC require concise, descriptive assessments of issues and implications to both water management and species of interest. There is confusion with respect to how different flow options affect species of interest and how the flow options influence water management in the system. Review of material for implications of flow options on species of interest by Larry Hildebrand was suggested

ACTION ITEM: CLARIFY IF AND HOW KOOTENAY FLOWS ARE INCLUDED IN THE MODELLING – BASIL STUMBORG

ACTION ITEM: DEVELOP ANALYTICAL IMPLICATIONS MATRIX OF FLOW ALTERNATIVES – MCA WUP ENV TEAM

ACTION ITEM: FORWARD ADDITIONAL OPEATIONAL ISSUES AND QUESTIONS TO BASIL STUMBORG

9. Lee's Involvement

- After the end of June 2003, Lee Failing's involvement in the water use planning process will be ramping down. Lee will facilitate the June CC meeting.
- After the end of June 2003, Basil Stumborg will be assuming the role of facilitator and resource valuation task manager if acceptable to the CC.
- Comment by Bill Green that he is very comfortable with Basil taking on this role.

10. Policy Issue: WUP Implementation

- CCRIFC suggested possible US Implementation Team model to allow CCRIFC and Agency input into annual and longer-term decisions.
- This is a policy issue and cannot be addressed in the WUP, but can certainly be discussed

APPENDIX N: COLUMBIA OVERVIEW DOCUMENT

31 May 2001

Prepared by: Al Geissler, P. Eng.
Project Manager, Columbia Water Use Planning

The Columbia Overview document summarizes how the Columbia and Kootenay Rivers are operated within British Columbia and is specifically written for those who are participating in BC Hydro's Water Use Planning Program.

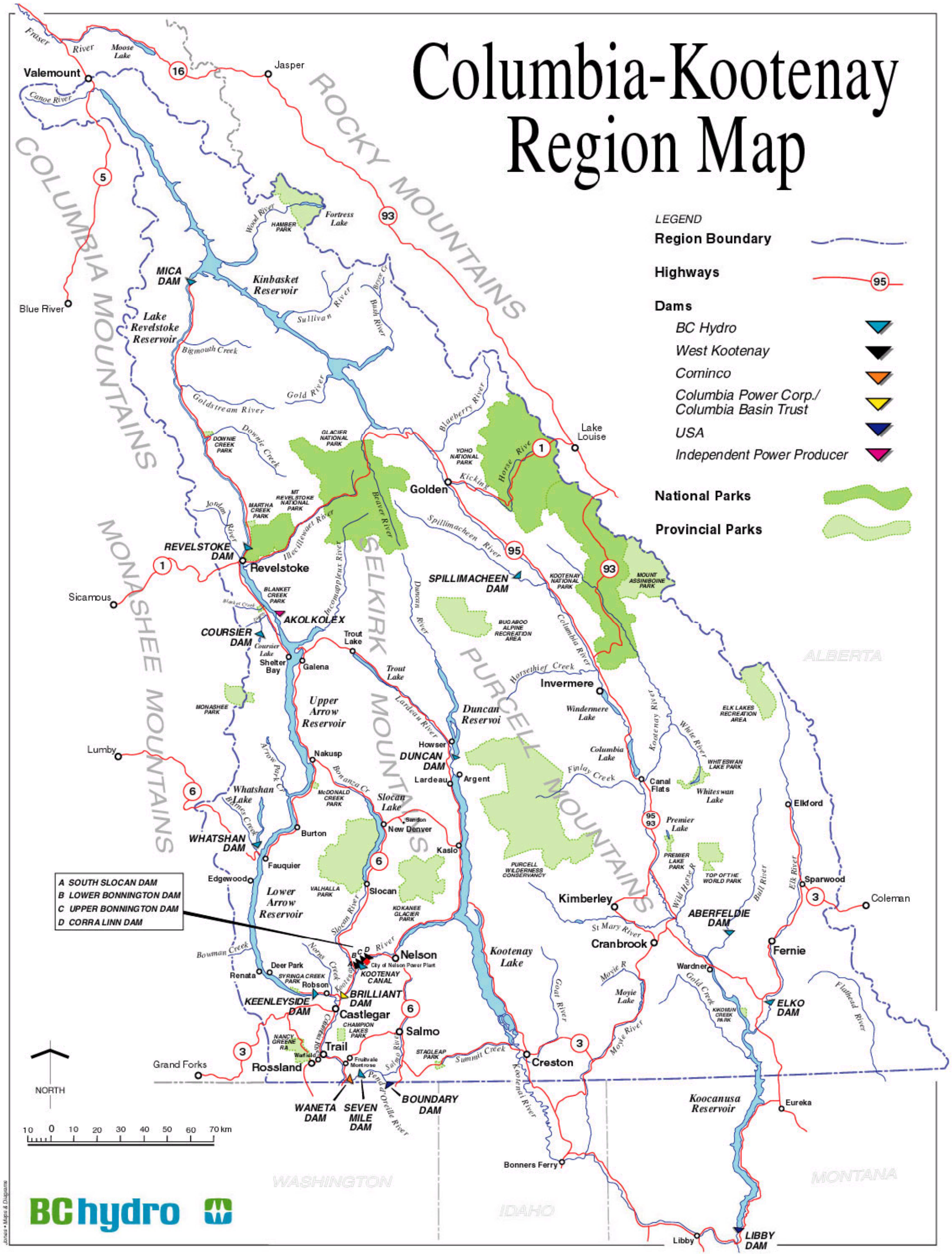
Planning and operations described throughout this document refers to the Columbia River System, co-ordinated through the Columbia River Treaty, with emphasis on the Canadian portion of the basin.

A brief history of hydroelectric development within the region is included in this paper. Summaries of the various co-ordination agreements are also presented including the Columbia River Treaty, Non-Treaty Storage Agreement, Kootenay Canal Agreement and the 1938 International Joint Commission Order on Kootenay Lake.

Flood management and electrical energy production are the two primary reasons all the Canadian Columbia projects were built. Included within this operation are the ancillary services, which allows the electrical system to provide the flexibility needed to match our customers' variable electrical demand.

Adapting flexibility in system operation to these and other interests is what Water Use Planning is all about. Water Use Planning recognizes the initial objectives of each project, determines objectives and measures of other key interests and then recommends to the Water Comptroller incremental changes to the way the system is operated to address these interests.

A great deal of thanks go to many people who assisted in the preparation of this document including Charanjit Singh, Ralph Legge, Allan Woo, Jim Gasphard, Tim Newton, Ian MacLean, Kelvin Ketchum and Ken Spafford.


Columbia-Kootenay
Region Map
LEGEND
Region Boundary
Highways
Dams
BC Hydro
West Kootenay
Cominco
Columbia Power Corp./
Columbia Basin Trust
USA
Independent Power Producer
National Parks
Provincial Parks
ROCKY MOUNTAINS
COLUMBIA MOUNTAINS
MONASHEE MOUNTAINS
SELKIRK MOUNTAINS
PURCELL MOUNTAINS
Valemount
Jasper
Blue River
MICA DAM
Kinbasket Reservoir
Lake Revelstoke Reservoir
REVELSTOKE DAM
Revelstoke
Sicamous
Golden
Lake Louise
SPILLIMACHEEN DAM
AKOLKOLEX
COURSIER DAM
Galena
Upper Arrow Reservoir
Nakusp
Duncan Reservoir
DUNCAN DAM
Invermere
Lumby
WHATSHAN DAM
Lower Arrow Reservoir
Slocan
Kaslo
Kimberley
Cranbrook
ABERFELDIE DAM
Nelson
Kootenay Lake
KEENLEYSIDE DAM
BRILLIANT DAM
Castlegar
Salmo
Trail
Rossland
Grand Forks
Creston
WANETA DAM
SEVEN MILE DAM
BOUNDARY DAM
Fernie
ELKO DAM
Sparwood
Elkford
Coleman
Koocanusa Reservoir
Eureka
Bonners Ferry
Libby
LIBBY DAM
ALBERTA
WASHINGTON
IDAHO
MONTANA
A SOUTH SLOCAN DAM
B LOWER BONNINGTON DAM
C UPPER BONNINGTON DAM
D CORRA LINN DAM
NORTH
BC hydro

Canadian Columbia-Kootenay Region Hydroelectric and Flood Control Storage Projects

Project Name	Owner
Mica	BC Hydro
Revelstoke	BC Hydro
Keenleyside Dam	BC Hydro
Keenleyside Power House	Columbia Power Corporation (CPC) and the Columbia Basin Trust (CBT)
Walter Hardman (Coursier Dam)	BC Hydro
Whatshan	BC Hydro
Spillimacheen	BC Hydro
Aberfeldie	BC Hydro
Elko	BC Hydro
Koocanusa Reservoir (Within Canada)	BC Provincial Government
Duncan	BC Hydro
Corra Linn	West Kootenay Power
Kootenay Lake (IJC order)	West Kootenay Power
Upper Bonnington	West Kootenay Power
Nelson City Power House	City of Nelson
Lower Bonnington	West Kootenay Power
South Slocan	West Kootenay Power
Kootenay Canal	BC Hydro
Brilliant	CPC and CBT
Seven Mile	BC Hydro
Waneta	Cominco

Brief History of the Columbia-Kootenay Region and Its Hydroelectric Development

The Columbia River is the fourth largest river basin in North America with respect to length and average volume of runoff, exceeded only by the Mississippi, Mackenzie, and St. Lawrence Rivers. The Columbia River is the dominant water system in the Pacific Northwest. Within Canada it has a drainage area of 155 000 square kilometers all contained within British Columbia, while in the United States it drains 560 640 square kilometers in seven states: Washington, Oregon, Idaho, Montana, Wyoming, Nevada, and Utah.

Flood control storage, hydroelectric development and irrigation are the main purposes behind most of the river control structures built within the Columbia. To illustrate the significance of flood control, reference is made to the Columbia River Treaty and Protocol, which states, "the largest known flood of general occurrence in the Columbia River basin was that of June 1894. The flood resulted from rapid melting of an above-normal snow pack that had accumulated during the preceding winter. Maximum discharge of the Columbia River was estimated at 680 000 cubic feet per second

(19 255 cubic meters per second) at the international boundary…" (page 14). It goes on to say that, "The nature of the river basin results in wide fluctuations in streamflow. Extremes of 680 000 cfs and 12 900 cfs (19 255 and 365 cms) have been estimated for one point on the international boundary. At Revelstoke, farther upstream in the basin, the highest recorded flow was 99 times as great as the lowest. …. It is not surprising that in the 1948 flood the Columbia killed fifty people, made 38 000 homeless and destroyed a community in the United States numbering 18 000."

With respect to energy development within British Columbia (BC), the Lower Bonnington Dam was built on the Kootenay River in 1898. In subsequent years several others facilities were built including in the years following West Kootenay Power's construction of the Corra Linn Dam in 1938, in combination with the dredging of Grohman Narrows that regulated the natural flows from Kootenay Lake. Corra Linn provided the first flood control within the Columbia River Basin in British Columbia.

In the early 1960's, Premier W.A.C. Bennett established what was commonly called the "two river policy". He envisioned opening up the Province of BC through economic development fueled with the investment and employment created by the construction of hydroelectric dams. His long-term vision for economic prosperity required electrical generation far greater than what existed or was needed in the Province at that time.

The Canadian federal government signed a Columbia River Treaty with the United States in 1961 which was ratified by the Canadian Federal Government in 1964. Subsequently, the ratified Columbia River Treaty, the Canada/BC agreement, and a protocol agreement were all signed at a Peace Arch Ceremony in 1964. The Canada/BC agreement transferred all federal responsibilities and rights associated with the Columbia River Treaty to the BC government. The protocol agreement allowed the province to negotiate a 30-year sale of downstream benefit energy to the United States.

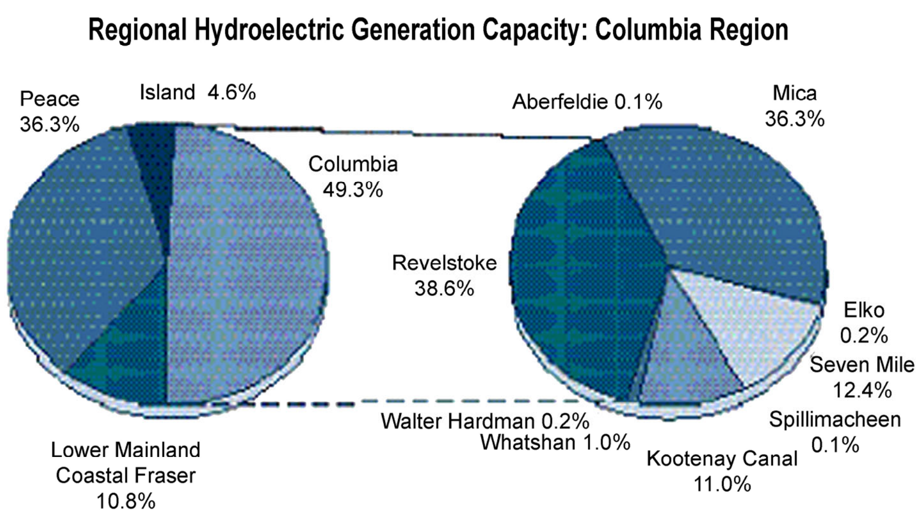
With this Downstream Benefit sale, Premier Bennett had sufficient funds to build Keenleyside and Duncan, and the Treaty portion of Mica. At the same time this enabled the province to borrow funds to increase the size of Mica for Non Treaty storage, build a major electrical generation powerhouse at Mica, and develop the Peace River system. BC Hydro was assigned the task of building the Peace and Columbia Rivers system projects and was assigned by the provincial government to be the Canadian entity of the Columbia River Treaty.

To put the significance of this development into perspective, prior to 1968, the total installed hydroelectric capacity was approximately 780 Mega Watts (MW) owned predominantly by West Kootenay Power, East Kootenay Power, the City of Revelstoke, City of Nelson, and the BC Power Commission (BC Hydro's predecessor). By 1984 with the development of the Peace and Columbia Rivers, BC Hydro had added 8369 MW to its electric system. In addition, BC Hydro began to co-ordinate reservoir management between the two river systems, Peace and Columbia, for flood control and electricity generation. This enabled BC Hydro to guarantee electricity supply to all of British Columbia by taking advantage of differences between provincial regional variations in snowpack and moisture content conditions, transmission line availability, and generation unit availability.

Nearly 80% of all electrical generation originates in the northern and southeastern parts of British Columbia, while 70% of the customer and population base resides on Vancouver Island and in the Lower Mainland (the "load center"). To generate this electricity and transport it to its consumers requires BC Hydro to co-ordinate its system operations and transmission infrastructure with other facility owners (mostly regulated utilities, but also independent power producers and self-generators). All this is done while honouring international treaties, co-ordination agreements, and commercial agreements.

Mica and Revelstoke generating stations, the two largest BC Hydro installations in the Columbia River Basin, contribute about 38% of the total amount, while Kootenay Canal and Seven Mile generating stations supply about 12%.

BC Hydro's Integrated System Generation



BC Hydro's Role in the Region

In 1964, following ratification of the Columbia River Treaty (CRT) between Canada and the United States, the Province of British Columbia assigned specific tasks to various government agencies to implement the requirements listed in treaty documents and associated licences. The terms and conditions provided in the CRT specified which projects to build and that operation of these facilities would be managed to maximize mutual benefits for both countries with respect to flood control and electric energy production.

BC Hydro was given the task of building the dams and associated reservoirs, at the locations designated in the CRT now known as Duncan, Keenleyside and Mica (hereafter "the treaty dams"). BC Hydro was also assigned the position of Canadian Entity of the Columbia River Treaty.

Following completion of the treaty dams, BC Hydro constructed Kootenay Canal. This project was now economically viable as a result of upstream storage at Duncan and Libby Dams. Similarly, Revelstoke was built and is operated at near full reservoir elevation by taking advantage of the upstream storage at Mica to regulate flows into its reservoir. Seven Mile Dam was built on the Pend d'Oreille River and accommodates the Skagit Valley agreement.[1]

Today additional work is ongoing to install a fourth generation unit at Seven Mile and studies are ongoing to examine the economic viability of a fifth unit at Revelstoke or Mica. Work is also underway on the installation of generation capability at Keenleyside through a joint effort between the Columbia Power Corporation and the Columbia Basin Trust, known as the Arrow Lakes Power Development Corporation.

Notwithstanding development of the many projects in the Columbia region with a primary focus on flood control and electricity production, other resource interests and users have been considered in the licensing decisions for these facilities. For example, water licences, issued to BC Hydro by the Province, include conditions that limit the use of water for generation, and provide for management of impacts on fish and wildlife. Detailed operations procedures based on the licences are incorporated into BC Hydro operating orders, which guide operations personnel and set the routine for system operations. Flood control, electrical energy production and irrigation were the predominant interests in the 1950s and 1960s. Today, additional values, interest and knowledge of dam and reservoir operations are significant. Water Use Planning (WUP) recognizes these changes, seeks opportunities for maintaining the integrity of the investments in BC Hydro's facilities, and recommends incremental changes in the way the system is operated to address flood control, electrical energy production, environmental, industrial, recreation and other interests.

The Columbia River System

(i) The Basin

The Columbia River originates at Columbia Lake on the west slope of British Columbia's Rocky Mountain Range. From Columbia Lake the river flows north through the Columbia Marsh Lands in the Rocky Mountain Trench to Donald Station where the river flows into Kinbasket Reservoir, formed by Mica Dam near the confluence of the Canoe River.

At Mica the river begins its southern journey with the tail race of Mica entering Revelstoke Reservoir, a run-of-the-river reservoir formed by Revelstoke Dam located 136 km (85 miles) further south.

From Revelstoke the river continues its journey into another Columbia River Treaty reservoir, Arrow, raised from earlier lakes by the Keenleyside Dam located

[1] The Skagit Valley Agreement is summarized in Appendix B.

232 km(145 miles) further south near the City of Castlegar where the Kootenay River joins the Columbia.

From Castlegar the combined flows from the Columbia and Kootenay Rivers continue their journey south where 100 m (330 ft) north of the Canada/USA border the Pend D'Oreille River joins the Columbia. From this confluence, the Columbia River flows across the border into the United States, continues through 11 more reservoirs and dams, and completes its 1942 km (1207 mile) long journey at the Pacific Ocean near the city of Astoria.

The Kootenay River originates in the Rocky Mountains near the source of the Columbia River and flows south to Koocanusa Reservoir formed behind Libby Dam in Montana with half its reservoir extending into British Columbia. From Libby, the river turns north and re-enters British Columbia near the community of Creston flowing into the southern end of Kootenay Lake. Duncan Dam is located on the Duncan River, north of Kootenay Lake.

BC Hydro Projects within the Columbia Basin

Flood Control in the Columbia Basin

The basin is located in the southeast interior climatic region, and is affected by both continental and modified maritime conditions. The basin generally experiences high snowpack accumulations during winter, warming conditions and snow melt from April to July, and frequent short-duration heavy rainfall from May through August.

Rainfall is a minor contributor to annual runoff volume compared to snowfall, but rainfall can cause high peak flows when coincident with high snowmelt conditions. Runoff in the upper Columbia Basin usually peaks in June or July, while runoff in the Kootenay and Pend D'Oreille basins peaks about one month earlier. About 60 per cent of the natural runoff in the basin occurs during May, June, and July. In the Columbia River Basin, flood flows are historically limited to two periods: rain-induced floods in the winter, and snowmelt floods in the spring and early summer. In general, the northernmost part of the basin (Mica and Revelstoke) is a high runoff area and runoff in the southern portion is lower and more variable.

The most serious snowmelt floods develop when extended periods of warmer weather combine with a large accumulation of winter snow. Fortunately however, the magnitude of the greatest source of flooding, snowmelt, can be forecasted several months in advance with fairly high accuracy using snowpack accumulation and its associated moisture content data.

As a result, the amount of flood control storage space kept in the Columbia River reservoirs is only the amount expected to be necessary during those months when flood risk exists. This makes it possible to use reservoir space for storing water for hydropower, irrigation, recreation, and other purposes during periods when there is no flood risk and to use the space jointly for flood control and the other purposes during the flood season.

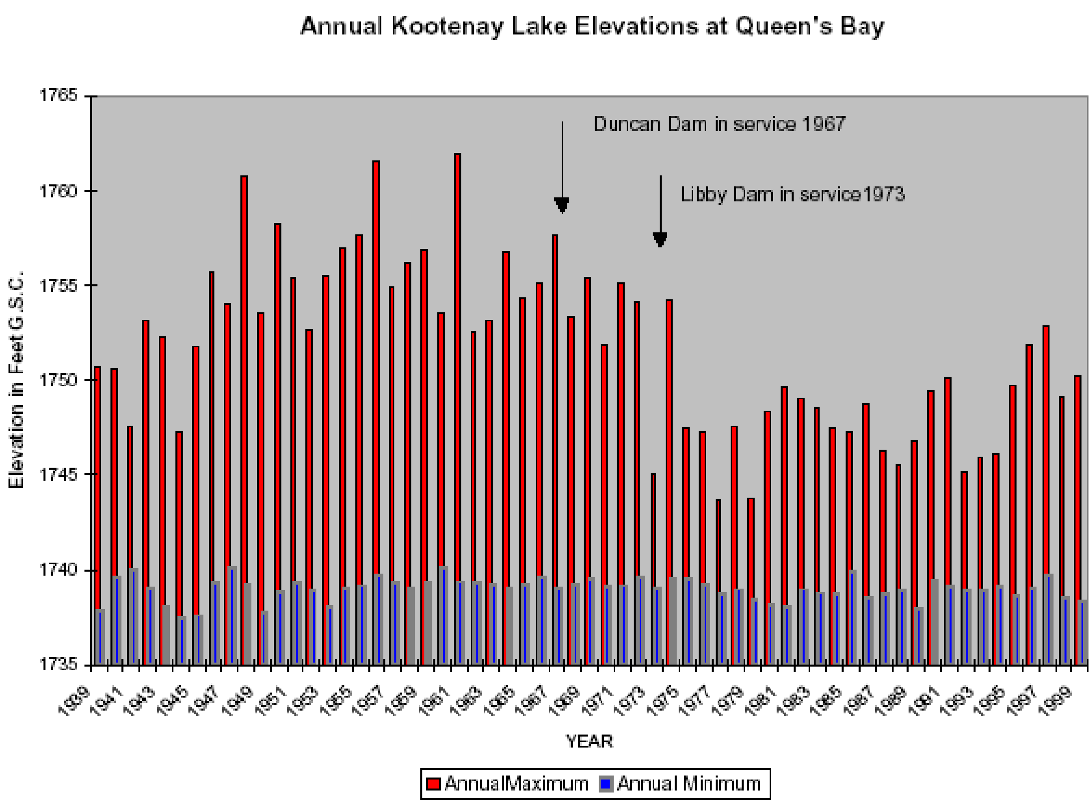
Water is stored in the reservoirs during the spring freshet when water supply is greater than electrical generation needs. In the Fall and Winter when flows are naturally lower and customer electrical demand is higher, evacuation of reservoirs takes place. This generally takes place from September through December when electricity demand is high, and also ensures storage space will be available for flood control in the spring. As runoff forecasts are not available during this early snowfall period, the levels of evacuation are based on a statistical analysis of historical events.

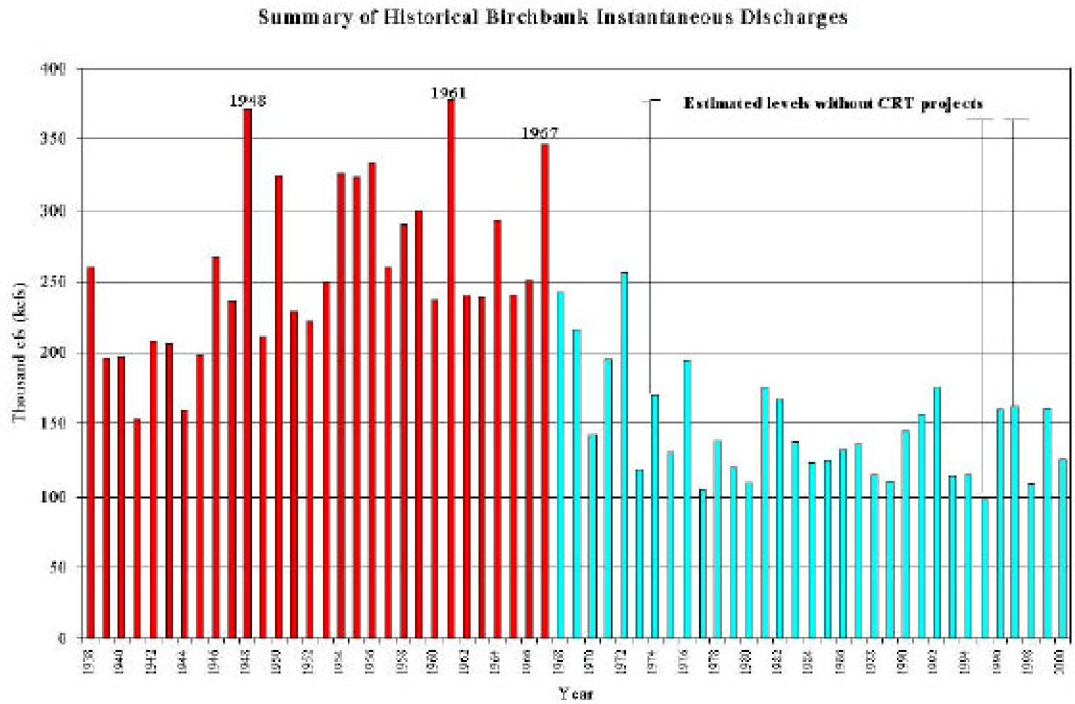
Operations from January through April are generally better defined because snowmelt runoff is more predictable than just using the historical record. The runoff expected to occur determines the amount of reservoir storage space needed to control floods for the balance of the operating year. The storage space necessary is determined and updated monthly as revised forecasts become available.

From April through July, reservoirs are generally allowed to gradually refill, at a rate that maintains downstream flows to reduce flooding in Canada and in the United States and meet electrical energy needs and reservoir refill requirements. To guide this operation, BC Hydro uses computer models that take various weather information and measurement data to forecast runoff and simulate reservoir operation. In moderate to high runoff years, careful monitoring is required to ensure that damaging flows do not occur.

The graphs shown on the next two pages highlight the success of flood control operation in the Columbia Region. For example, the first graph shows Kootenay Lake levels prior to and after construction of Duncan and Libby Dams together with Corra Linn and the 1938 dredging of Groman Narrows. This operation has resulted in its natural elevation range of up to 8.8 meters (29 ft) change to the 4 meter range (13 ft). It is estimated that in 1974, without CRT storage projects, the elevation of Kootenay Lake would have exceeded the 1961 record. For 1997, it is estimated that Kootenay Lake elevations would have been 3 meters (10 ft) higher than the elevation reached in that year.

Similarly, Birchbank gauge data, obtained from its location on the Columbia River half-way between Castlegar and Trail, shows the lower flows reached after completion of the CRT projects and gives comparisons to the 1948 flow levels. For example, it is estimated that 1997 flows at Birchbank gauge would have reached the 1948 level were it not for the flood control operation that year.





Baseline Operations

Storage reservoirs and Generation stations designed with flexible ancillary services are the key to matching the region's plentiful water resources with British Columbia's electricity use pattern. As noted earlier, the main purpose of storage reservoirs is to capture the spring snow melt in order to manage floods and later to release the water when it is needed to produce electricity and address other uses. This results in a modified flow pattern in the river that closely matches electrical energy demands of electrical energy consumers. Another way to look at this is to say that, energy in the form of water is stored in reservoirs when natural streamflows exceed electrical generation requirements, with increased releases when energy demand is higher than natural streamflows.

Run-of-river projects, on the other hand, have very limited storage and have historically been developed in British Columbia primarily for electrical generation. Run-of-river projects pass water at the same rate as it flows into the forebay. There is a variance of only one to two meters in pondage levels under normal operating conditions in run-of-river reservoirs.

Of the six major facilities in the Columbia, Mica and Revelstoke are operated in a manner referred to as hydraulic balance. That is, Revelstoke is operated as a run-of-river plant varying in elevation within the top two meters by using the storage capability of Kinbasket Reservoir behind Mica Dam. About 70% of the river flow at Revelstoke is discharged from Mica; the remaining 30% comes from local inflow.

Keenleyside Dam, which has no generating capacity at this time, but impounds 8758 million cubic meters of active storage (7.1 Maft) in Arrow Reservoir, is operated as a storage reservoir. However, water stored by Mica Dam, under certain CRT and economic conditions, can be released to increase the level of Arrow Reservoir. This action results in immediate use of the water for generation at Mica and Revelstoke, rather than storage for future use. Due to this hydraulic link to the Mica/Revelstoke system the three systems must be operationally co-ordinated when developing final Water Use Plans.

Of all the BC Hydro reservoirs in the basin, Arrow Reservoir has the largest population base and the highest recreation interest. Although generation is currently being constructed at Keenleyside the storage capability of the reservoir is valuable from both a flood control perspective and in the generation of downstream benefits.

River flows downstream of Keenleyside to the Canada/USA border are of high interest to local communities. These interests include recreation, major industries who use the river extensively for log transportation and industrial water supply, and by BC Hydro, federal and provincial fisheries staff with respect to fisheries interests.

Kootenay Canal, which has 528 MW of installed generating capacity, operates under the Kootenay Canal Agreement. Kootenay Canal uses water released from storage in Duncan Reservoir, Libby Reservoir and Kootenay Lake in order to be economically viable. Since both Libby and Duncan Dams discharge water into Kootenay Lake there is an opportunity under certain conditions to trade flows from one reservoir to the other to maintain Kootenay River flows. However, for flood control, these two projects only control about 50% of the inflow into Kootenay Lake. These two reservoirs, together with the operation of Corra Linn Dam, control levels as outlined by the International Joint Commission Order on Kootenay Lake. Since there are four other private owners of hydroelectric generation plants, electric generation on the Kootenay system is co-ordinated under the Kootenay Canal Plant Agreement in order to maximize energy production among all facilities.

Seven Mile, is a three unit, 594 MW generating station and has daily storage capability only. Seven Mile is located between Seattle City Light’s Boundary Dam located in Washington State and Cominco’s Waneta Dam located just upstream from the confluence with the Columbia in Canada.

West Kootenay Power has four generating stations on the Kootenay River: the Corra Linn, Upper Bonnington, Lower Bonnington, and South Slocan and each operates as a run-of-river generating station. Under the Kootenay Canal Agreement,[1] additional hydroelectric potential in this part of the river was captured by the construction of the Kootenay Canal generating station.

Downstream from Kootenay Canal is the Brilliant Dam and generating station owned by the Columbia Power Corporation and the Columbia Basin Trust. The dam is located on

[1] The Kootenay Canal Agreement is summarized in Appendix B.

the Kootenay River just upstream from the confluence of the Kootenay and Columbia Rivers. Downstream benefits generated at Brilliant Dam, which are associated with Duncan and Libby, revert to BC Hydro.

Due to the close link between operations of the Kootenay River combined with flow releases from Keenleyside Dam on the Columbia, flows downstream of their confluence can under certain conditions be controlled for flood purposes. As a result, any development of a WUP for the Columbia must consider the Kootenay River operation. Keenleyside is described at times as the fine tuning valve for flood control in British Columbia's portion of the Columbia as measured at the Birchbank gauge.

There are five small hydroelectric generating stations in the Columbia Region. 1.) A 5 MW Aberfeldie generating station on the Bull River is a run-of-river facility with water flowing over the spillway much of the year. 2.) A 12 MW Elko generating station is located on the Elk River, approximately 26 kilometers from its confluence with Koocanusa and like Aberfeldie, water flows over the spillway much of the year. 3.) A 4 MW Spillimacheen generating station located on a tributary of the Columbia River upstream from Kinbasket reservoir. 4.) An 8 MW Walter Hardman generating station located on the shore of Arrow Reservoir and 5.) A 50 MW Whatshan Generating station also located on the shore of Arrow Reservoir.

Planning for System Operations

(ii) View of BC Hydro Planning Process

The operation of a large and complex electric system requires careful study and continuous planning. BC Hydro must plan ahead to account for the many variable factors that can affect the day-by-day and long-term supply of electricity.

Many factors influence how much and when each project is called on to generate electricity. These factors include:

- Current and forecast B.C. electricity demands.
- Current and forecast stream flow conditions.
- Current and target reservoir levels.
- Turbine and generator restrictions.
- Equipment and facilities maintenance requirements.
- Transmission network constraints.
- Fishery and other environmental and social requirements and objectives.
- Flood control requirements and Columbia River Treaty obligations.
- Regulatory and legal obligations.
- Ensuring reliability and security of supply issues.
- Efficiency of operations considerations.

- Market pricing, energy values and fuel cost considerations.
- Other considerations.

Operations are generally developed to satisfy multiple objectives according to the following order of importance:

1. Ensure safety of lives and property.
2. Satisfy regulatory and legal obligations.
3. Ensure electrical system energy reliability to meet present and future electricity demand.
4. Achieve appropriate balance between economic and environmental objectives.

Computerized models are employed to simulate and help develop optimal operation of the hydroelectric system to maximize the financial value of system generation to British Columbia while meeting electrical system and generating plant constraints. These modelling studies are designed to indicate how the electric system is best operated to accommodate a wide range of outcomes of the uncertain variables described above.

BC Hydro divides its complex operations planning process into four time horizons:

1. Long Term System Planning – Five to 30 Years

   The primary purpose of these longer-term studies is to identify the necessary resource acquisitions that are required to maintain a reliable electric system and to ensure the resource acquisitions reflect an appropriate trade-off between project cost, environmental impact and other factors.

   In planning and operating the generation system, new resources are scheduled so those specific reliability criteria are satisfied. For example, BC Hydro is obligated to have adequate firm resources to meet electrical operating reserve requirements set by the Western Systems Coordination Council. For the BC Hydro system this requires capacity reserves equal to about 7% of system electrical demand. In addition, to allow for generating units outages, and maintenance requirements, guidelines recommended by the WSCC require total planning reserves equal to about 12% of anticipated demand. However, these requirements can often be reduced through ad hoc energy purchases and the net result for BC Hydro's system is a capacity planning reserve equal to about 8% of anticipated demands.

2. Medium Term Operations Planning – One to Four Years

   In addition to the Treaty Assured Operating Plan studies and Detailed Operating Plan studies, BC Hydro system planning studies are primarily to provide guidance for the system wide operation of the Columbia and Peace Rivers.

Additional studies are performed monthly to evaluate the capability of the existing system to meet operations requirements, given the uncertainties of inflow and electricity demand, and various operating factors. These studies provide information that is used to assist in making decisions about when to operate thermal plants and whether to purchase or sell energy. Marketing, import and export decisions use the information developed in this area.

3. Short Term Operations Planning – Next Day to 12 Months

   These planning studies are used to define operating plans for each reservoir, generating station, and individual generating units in order to meet domestic and contracted power requirements. Short Term Operations studies use two types of inflow forecasts: five day short term inflow forecasts, and seasonal water supply forecasts to estimate inflows into the reservoirs. These studies focus on the more predictable aspects of operational problems, and are used for system analysis and the determination of reservoir, generating station, generating unit and interchange schedules. Studies are typically performed over a time horizon of one day to two weeks and are updated on a daily basis as needed.

4. Real Time Operations – Same Day

   System Control dispatchers perform Real Time Operations studies over a time horizon of one to 72 hours and focus on the day-by-day and minute-by-minute operations issues such as reliability, automatic generation control, static plant unit commitment, and hydro generation dispatch. These studies are carried out when conditions change from those contained and considered in the short-term operational schedules

Overview of Columbia System Planning

Power developments on the Columbia River and its tributaries are directly affected by the Columbia River Treaty signed by Canada and the United States in 1964 (the treaty is described further in the Appendix B).

The Treaty requires the United States and Canada to prepare an Assured Operating Plan (AOP) for Canadian Treaty Storage (i.e., Mica, Arrow and Duncan) six years in advance of actual operation. The plans must conform to the original objectives and criteria of the Treaty, i.e., maximization of power benefits within the context of satisfying flood control objectives. The treaty also permits the entities to prepare additional Detailed Operating Plans (DOP) that produce operations more advantageous to the parties. In practice, a Detailed Operating Plan is prepared each year immediately prior to commencement of the operating year, but may be augmented with other agreements developed by the entities throughout the operating year. The DOP is often based on the AOP, but can include mutually agreeable operations for both power and non-power objectives. The DOP also specifies water and power scheduling procedures in greater detail than the AOP. Actual operation is guided by the DOP.

During the operating year, Treaty Storage Regulation (TSR) studies are performed twice monthly as part of the short term planning process. These studies utilize current and forecast stream flow information, current reservoir levels and projected non-power requirements to simulate Columbia River operations in accordance with the DOP. Each week, the US and Canadian entities develop a Weekly Flow Request for Canadian Treaty Storage utilizing the operating rules specified in the DOP and the TSR studies as a guide.

Once the Weekly Flow Request is determined, BC Hydro and Bonneville Power may make further adjustments to releases from Arrow as permitted by the Non-Treaty Storage Agreement. In addition BC Hydro may adjust releases between its own reservoirs in a manner that does not impact flows across the border to meet its own power and non-power objectives identified in the BC Hydro planning process.

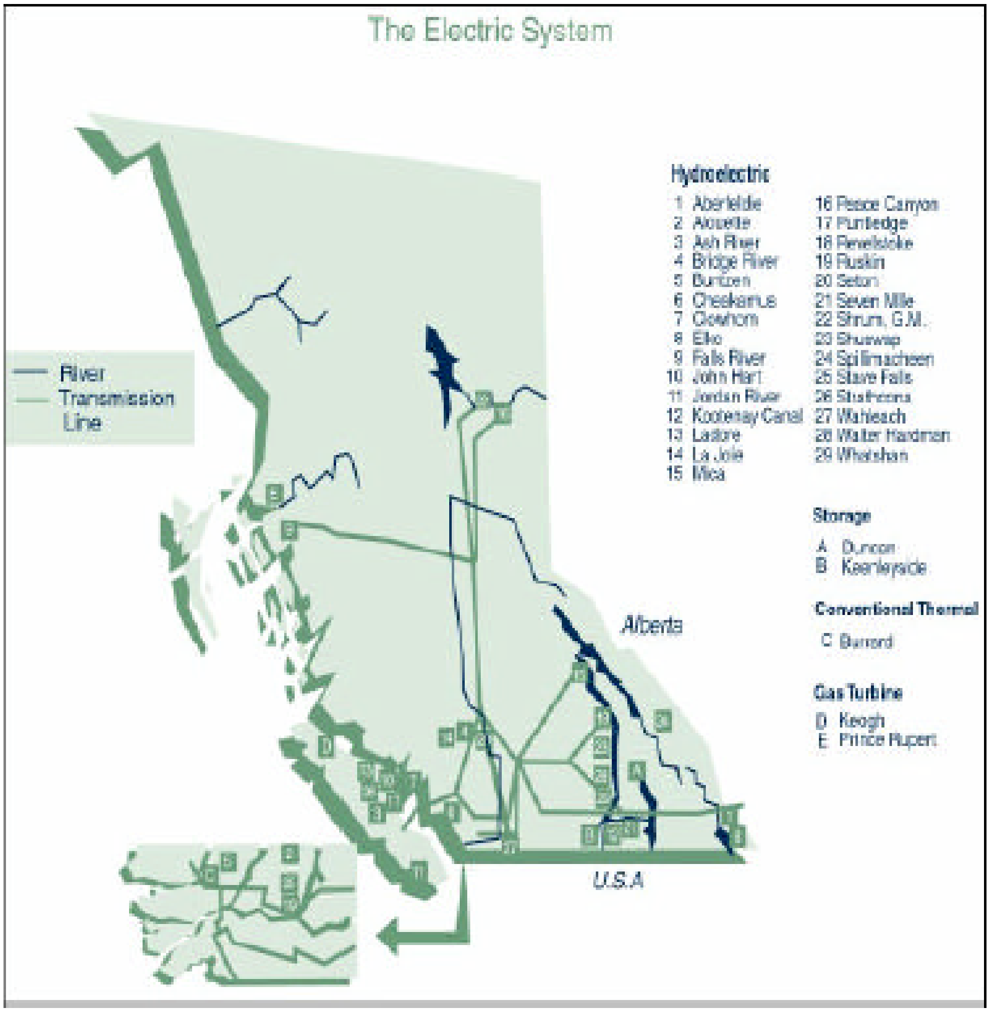
BC Hydro Integrated System Load Graph

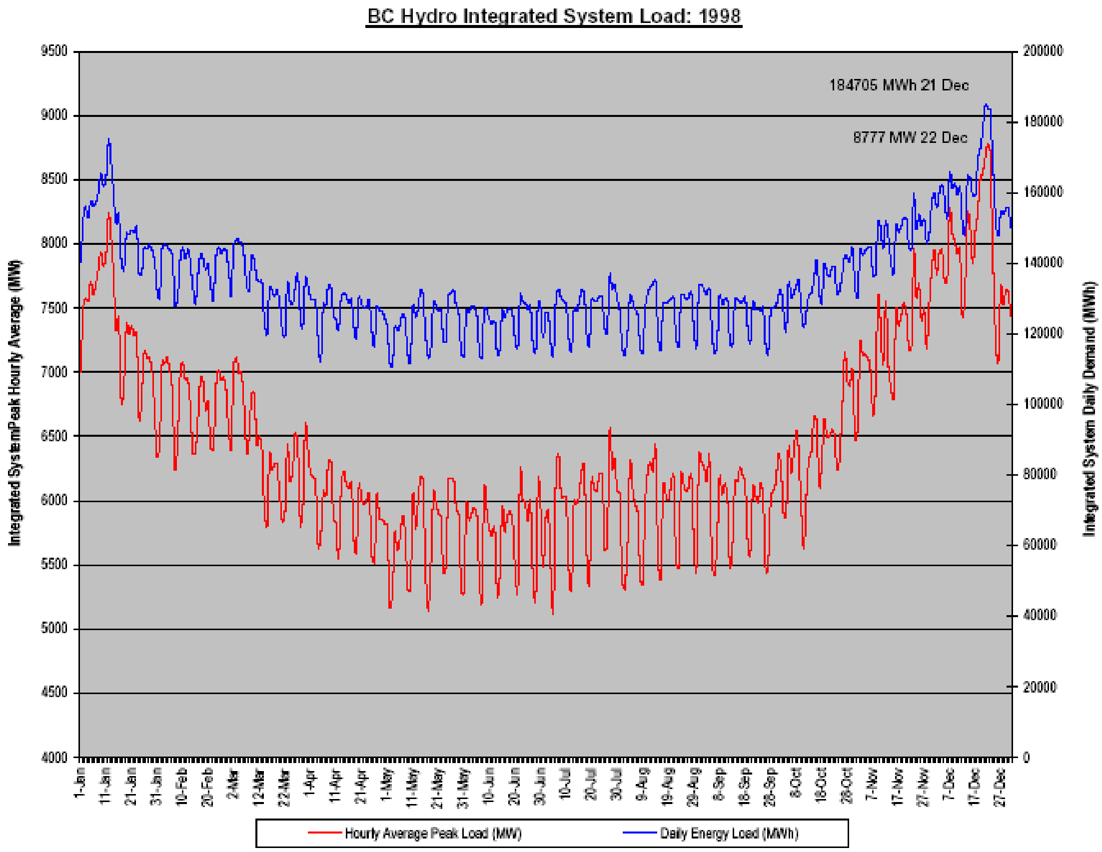
The following graph illustrates the real time variable nature of electricity needs in British Columbia and is presented here to illustrate the large daily swing in river flow at Revelstoke. Electricity needs are generally higher in the winter due to both colder weather and shorter daylight hours. Similarly, the graph shows reduced needs in the summer due to warm weather and longer daylight hours.

Within that annual cycle, which is managed throughout the BC Hydro system, daily power needs fluctuate significantly. The graph indicates that while Monday-to-Friday electricity use remains relatively constant, there are large reductions in demand for electricity on weekends when many commercial and industrial customers are not in full operation. Not shown on the graph is hourly electricity usage which would show use increases and decreases during and after the breakfast, lunch and the late afternoon early evening dinner hours.

During all of these fluctuations in demand for electricity, the electricity supply system must operate to produce just enough electricity to exactly match demand. If too much or too little is generated, electrical network outages can automatically take place, beginning with large industrial users. As hydroelectric system generators are run to match the electrical usage curve, reservoir water is released through the electrical generator turbines to match the electrical consumers demand for electricity with the result that river flow will ramp up and down and reservoir elevations increase and decrease accordingly. Revelstoke generating station, due to its modern technology, large generation capacity and upstream storage at Mica has the ability to match electrical consumers’ demand for electricity and it is used for this purpose.

BC Hydro's Electric System





Operating and Commercial Agreements

The operation of a major water resource such as the Columbia River must take into account diverse interests from a broad spectrum of government agencies and river users. In addition, by virtue of the Columbia River Treaty, the operation of the treaty projects must also be co-ordinated between Canada and the United States. Experience gained over years of actual operation has shown that additional energy and non-energy benefits, such as recreation and fish flow enhancement, can be realized through increased co-ordination above those specifically required under the treaty.[1] The desire to optimize generation, while taking into account evolving environmental and social values has led to additional long-term and multi-year co-ordination agreements and other short-term co-ordination agreements which are renegotiated each year. These and other initiatives have resulted in a complex and interrelated set of regulations, treaty requirements, operating agreements and guidelines that are used to guide the actual operation of the Columbia River System.

The daily operation of the Canadian Treaty reservoirs can be viewed as a summation of three separate but interrelated types of operations; treaty, flex, and non-treaty operation.

[1] Reference in draft document, *The Flow principles and fish habitat enhancement plan for the Lower Columbia River Basin, British Columbia.* January 1999. This document was prepared for DFO, MELP, CCRIFC by BC Hydro.

While flood control and energy generation have always been important drivers behind each of these operations, in recent years, environmental and social objectives have also played a significant role.

The following agreements are key to the way in which Columbia Basin hydroelectric projects are operated.[1]

- **Columbia River Treaty**

  The Columbia River Treaty provides that the operating arrangements necessary to implement the treaty will be formulated and carried out by the entities designated by Canada and the United States. BC Hydro is designated as the Canadian Entity. The US Entity is composed of the administrator of Bonneville Power and the division engineer of the North Pacific Division, Corps of Engineers. Treaty operation is co-ordinated between the entities through a number of hydroelectric operating plans developed by the Treaty Operating Committee. These operating plans span a range of planning horizons ranging from one week ahead to six years ahead. During periods of active flood control operation, operating plans may be updated on a daily basis.

  At 11:00 am each Thursday, a conference call is convened between BC Hydro, West Kootenay Power, Bonneville Power and the Corps of Engineers to review hydrology and expected treaty operation for the following week (starting and ending on Saturday 08:00 am). The Treaty operation for the week is confirmed by noon on Friday through a formal request issued by the US entity for specified releases from Canadian Treaty projects. Unless forecast inflows change significantly, treaty flows would normally remain constant during the week.

  Flex Operation

  The specification for storage releases under the Treaty is made effective at the Canada–United States border. BC Hydro has the right to vary releases between Treaty projects as long as the sum of discharges from Duncan Dam and Keenleyside Dam is not changed consistent with Treaty requirements. This flexibility and the strategic location of the Keenleyside Dam, which acts as a re-regulation project for the upstream power plants, enables BC Hydro to preserve independence in its power operation and at the same time meet Treaty flow requirements.

  The flex operation allows Mica and Revelstoke, whose total generation comprises about 38% of the BC Hydro system capacity, to be operated to meet BC Hydro system load. To account for Mica's actual discharges not matching Treaty discharges, "Flex Accounts" are set up to monitor the cumulative deviations. An "over run" occurs when Mica actual discharge exceeds the Treaty discharge and an "under run" occurs when Mica actual discharge is less than the Treaty discharge.

[1] Brief summaries of the key agreements are provided in Appendix B.

Since the flex operation has no effect on the Keenleyside discharge, the net effect is that total storage behind Canadian Treaty Projects as a whole remains unaltered. While there is no predefined limits on flex operation, the flex account must be managed carefully so as not to impact Treaty operation. A large under run causes the Keenleyside Reservoir to be lower than otherwise. This reduction in head may reduce the discharge capability of the dam to a point where it can not physically discharge Treaty flow requirements. A large over run causes the Keenleyside Reservoir to be higher than otherwise. This may cause the Keenleyside Reservoir to encroach on the flood control curve and its ability to meet flood control requirements.

- **Kootenay Canal Agreement, Kootenay Lake International Joint Commission Order, Libby Coordination Agreement**

  The Kootenay River enters the Columbia River about 7 km downstream of Keenleyside Dam. The Kootenay system includes projects owned by BC Hydro, Duncan Dam and Kootenay Canal, West Kootenay Power's Corra Linn, Upper Bonnington, Lower Bonnington, and South Slocan, Columbia Power Corporation's Brilliant Dam, the City of Nelson (Nelson Hydro) powerhouse at Upper Bonnington, and the US Army Corps of Engineers project at Libby, Montana.

  Duncan and Libby are two of the four projects constructed under the Columbia River Treaty and are operated in accordance with Treaty requirements. However, in 1994, the US unilaterally altered the operation of Libby to meet other United States non-power objectives. This alteration of flow deprived Canada of actual downstream benefits arising from co-ordinated operation of Libby with the projects in Canada. An agreement aimed at resolving this issue was finalized in February 2000 and is called the Libby Coordination Agreement. This agreement includes a Libby operating plan and procedure for co-ordination of Libby with Canadian projects.

  Kootenay Canal was constructed to take advantage of the stream flow regulation provided by Duncan and Libby and is located in parallel with the four West Kootenay projects. The Kootenay Canal Agreement was developed to obtain the most efficient operation from co-ordinated operation of those Kootenay River projects. Through this Agreement, BC Hydro has the ability to co-ordinate the operations of all Canadian projects (except the City of Nelson plant) on the Kootenay and Pend d'Oreille Rivers and is the beneficiary of all generation produced. In return, the other project owners are provided with a specified amount of energy and capacity referred to as the Basic Supply. However, West Kootenay Power remains the holder of the International Joint Commission (IJC) Order for the regulation of Kootenay Lake and retains the responsibility to monitor the operation of Kootenay Lake to ensure adherence to the IJC Order.

- **Seven Mile Operation and the Skagit Valley Agreement**[1]

  The Pend d'Oreille River enters Canada from the United States and flows about 25 km in Canada before joining the Columbia River just north of the International Boundary. Hydroelectric developments in Canada include Seven Mile Dam owned by BC Hydro and Waneta Dam owned by Cominco. There are ten hydroelectric developments upstream of Seven Mile, which provide substantial flow regulation beginning at the headwaters with Hungry Horse Dam in Montana.

  Seven Mile and Waneta are run-of-river plants with only sufficient storage for daily pondage. These plants benefit from the regulation provided by the upstream projects in the US and Seven Mile is co-ordinated with the operation at Cominco's Waneta project under the terms of the Kootenay Canal Agreement.

- **Keenleyside Release Coordination Agreement (future operations)**

  The Keenleyside Release Coordination Agreement is the primary mechanism for co-ordinating the operation of the generating facilities being developed by Arrow Lakes Power Development Corporation (ALPDC) (a joint venture of the Columbia Power Corporation and the Columbia Basin Trust) with the operation of the Arrow reservoir.

  Columbia River Treaty flows will continue through Keenleyside with up to 35 000 cfs going through the new powerhouse and the remaining treaty flow going through Keenleyside Dam's low-level ports or spillway. Operations of the Arrow Reservoir will not change as a result of the power house addition to the dam as Columbia River Treaty flows must be maintained.

- **Non-Treaty Storage Agreement**

  Non-treaty operation is co-ordinated with Bonneville Power (BPA) in accordance with the Non-Treaty Storage Agreement. This agreement allows BC Hydro and BPA the ability to either add or subtract from the weekly treaty operation. Non-treaty operation could result in daily changes to flows at Keenleyside Dam as well as daily energy interchanges between BC Hydro and BPA.

[1] The Province of BC through BC Hydro committed to supply equivalent electrical power to Seattle City Light in lieu of actually raising Ross Dam and was given the rights to raise the Seven Mile Dam to elevation 1730 feet which involved flooding into Washington State. Details are in Appendix B.

APPENDIX B

Brief Description of Key Hydroelectric and Coordination Agreements within the Columbia Region

Columbia River Treaty

The Columbia River Treaty is an international agreement between Canada and the United States on the development and operation of the Columbia River basin. The treaty was initially signed in 1961, however further negotiations resulted in a protocol being developed in 1964 that further clarified Canada's rights. With these adjustments, both parties ratified the Treaty in 1964. While the treaty is between Canada and the United States, an agreement was also signed between the Government of Canada and the Province of British Columbia, that essentially passes all the rights and obligations under the treaty on to B.C.

The key features of the treaty and related documents are:

1. Canada was to provide 19 100 million cubic meters (15.5 million acre-feet (Maf)) of usable storage. This has been accomplished with 8600 million cubic meters (7.0 Maf) provided by Mica, 8800 million cubic meters (7.1 Maf) provided by Arrow and 1700 million cubic meters (1.4 Maf) provided by Duncan.

2. For the purpose of computing downstream power benefits the US base system hydroelectric facilities were to be operated in a manner that makes the most effective use of the improved streamflows resulting from operation of the Canadian storage, with Canadian storage treated as first-added.

3. Canada and the United States were to equally share the downstream power benefits generated in the US resulting from operation of the Canadian storage. All benefits realized in Canada from Treaty storage, both flood control and power generation, are retained by Canada.

4. The US paid Canada a lump sum of the $64.4 million (1964 $US) for one half of the present worth of expected future flood control benefits in the US resulting from operation of the Canadian storage.

5. The US retained the option of requesting the evacuation of additional flood control space above that specified in the treaty, for a payment of $1.875 million (US) for each of the first four requests for this "on-call" storage.

6. The US had the option (which it exercised) to construct Libby Dam with a reservoir that extends 42 miles into Canada and for which Canada agreed to make the land available. Canada retains all downstream power benefits, generated in Canada due to Libby regulation.

7. Both Canada and the United States retained the right to make diversions of water for consumptive uses. In addition, since September 1984 Canada has had the

option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

8. Differences arising under the treaty which cannot be resolved by the two countries may be referred to either the International Joint Commission (IJC) or to arbitration by an appropriate tribunal.

9. The Treaty was to remain in force for at least 60 years from its date of ratification, 16 September 1964. The earliest termination date for the treaty is therefore 16 September 2024.

10. In the Canadian Entitlement Purchase Agreement of 13 August 1964, Canada sold its entitlement to half of the downstream power benefits to the United States for 30 years beginning at Duncan on 1 April 1968, at Arrow on 1 April 1969, and at Mica on 1 April 1973. The sale expired for Duncan benefits in April 1998 and for Arrow benefits in April 1999. The sale of Mica benefits expire in April 2003, after which the electricity returned to B.C. each year is expected to exceed 4400 GWh.

11. Canada and the US are each to appoint entities to implement treaty provisions and are to jointly appoint a Permanent Engineering Board (PEB) to review and report on operations under the treaty. The Canadian entity is the British Columbia Hydro and Power Authority (BC Hydro). The United States entity is the Administrator of the Bonneville Power Administration (BPA) and the Division Engineer of the Northwestern Division, US Army Corps of Engineers (ACE).

One of the main duties of the entities is to prepare operating plans. In accord with the principles of the treaty, a revised Flood Control Operating Plan was developed in 1972, further revised in 1999, to govern the operation of treaty projects for flood control purposes in Canada and the US. The plan ensures that sufficient storage space is emptied of water ahead of when a flood is expected (typically during the freshet period from April through June), and then sees that the best use of this space is made to reduce flood damage. The amount of water released from the projects is calculated each day during the peak runoff period.

Operating plans for power are made each year. The Assured Operating Plan (AOP) is so named, because it provides an assurance to both parties that a particular base operation can be implemented. The AOP is prepared six years in advance of its implementation date, because at the time the CRT was negotiated, that was assumed to be long enough to build generation projects to address potential supply deficits. The 1999/2000 AOP was developed in 1994.

An important component of the AOP is a set of four “critical rule curves” prepared for each reservoir. Each curve corresponds to one of the four years of the critical runoff sequence for the combined system (October 1928 to February 1932). The curves represent “generation-optimal” reservoir storage trajectories from full pool at the start of the critical period, to empty at the end of the period. All storage reservoirs in the US–

Canadian system are to be drafted "proportionately" between rule curves to meet firm load in the US. For example, if one reservoir is drafted to a point halfway between its second and third critical curves, then all reservoirs in the system are to be drafted to that point. Individual project constraints such as minimum flows sometimes prevent the full equalization of proportional draft points (PDPs) throughout all reservoirs in the joint US/BC system.

The AOP also outlines special "Mica Project Operating Criteria," designed to keep treaty storage contents at Mica and Arrow in appropriate balance. For each month (or half-month during April and August), a target Mica discharge or end-of-period Mica treaty storage content is specified. The Mica targets are determined by the end-of-period Arrow treaty storage contents in the prior period.

The CRT provides for an update of the AOP, when the actual year approaches and additional information is available. Detailed Operating Plans (DOP) are prepared annually for operation of treaty storage in the following year. At that time, critical rule curves and operating rules developed in the AOP may be updated and/or altered by mutual agreement between the operating entities. If no agreement is reached, the rules developed in the AOP are repeated in the DOP. Once completed, the DOP is the guiding document for treaty storage operation each year. The DOP contains detailed information on project-specific constraints and special operating rules.

Under the provisions of the CRT and the Pacific Northwest Coordination Agreement (PNCA), the DOP operating rules are included in the Treaty Storage Regulation Study, which is completed at least twice per month by the Northwest Power Pool (NWPP). Actual and forecast runoffs for each facility are updated for each Treaty Storage Regulation Study, which determine the weekly treaty storage operation request.

The CRT specifies that Canada may alter releases at Mica, Arrow and/or Duncan, provided that the total flow at the US border is unchanged from the official treaty request, and the flood control operation is not adversely impacted. This provision allows Mica to over-run or under-run the releases specified in the weekly treaty storage operation request. Similarly, this allows storage (and release) transfers from Duncan.

Kootenay Canal Agreement

Under the original Kootenay Canal Agreement (1972), BC Hydro co-ordinated the operation of projects on the Kootenay and Pend d'Oreille rivers. The three parties to the original agreement; namely BC Hydro, West Kootenay Power (WKP), and Cominco, were the owners of the various projects. However, recently, the Columbia Power Corporation (CPC) has acquired one of the Cominco projects at Brilliant. The Canal Plant Agreement is currently under revision to include the new owner as well as accommodate present and potential project upgrades and new methodologies dealing with sharing of benefits between various stakeholders. BC Hydro will continue to co-ordinate the operation of all projects with the purpose of obtaining optimum generation from all projects in the new agreement.

For the purpose of providing firm energy and capacity the Canal Plant Agreement defines the Base System as composed of the six WKP/Cominco projects, storage and diversion licences, including prior rights and agreements. The Total System is composed of the Base System plus the canal plant and the Duncan and Libby Reservoirs. The Basic Supply is the output of the Base System excluding the effects of the Duncan and Libby storage. The Base System operations based on thirty years of streamflow records and the requirements of the IJC order were used to determine the energy and capacity entitlements to the parties in the agreement. Parties to the agreement are assured certain basic entitlements with some seasonal and monthly variations. BC Hydro is entitled to the Total System generation in excess of the Basic Supply and is liable to make up the difference if total generation is less than the guaranteed entitlements. The output of the Base System may or may not supply the Basic Supply and the difference is added or subtracted from the Total System.

Although BC Hydro dispatches power from the WKP/Cominco installations and, in effect, regulates Kootenay Lake, WKP is responsible for complying with the International Joint Commission (IJC) Order requirements. In practice, both BC Hydro and WKP continually consult with each other in ensuring that the IJC order is complied with while deriving optimum generation from the Base System. Under the Columbia River Treaty operating plans, discharges from Libby Dam in the United States and Duncan Dam in Canada are co-ordinated with the operation of projects on the Kootenay River.[1]

Skagit Valley Agreement

During the 1940s, the City of Seattle (Seattle City Light – SCL) obtained appropriate approvals and intended to raise the elevation of Ross Dam from a normal full-pool elevation of 1602.5 feet to 1725 feet (High Ross Dam). The raising of the Ross Dam would have flooded into Skagit Valley in the Province of British Columbia. The Skagit Agreement was negotiated between the Province of British Columbia and the City of Seattle in order to:

- preserve the natural environment of the Skagit Valley, and
- provide for economic growth and development of the City of Seattle with the electric power that would have been produced by the raising of the Ross Dam.

The Province of British Columbia through BC Hydro committed to supply equivalent electrical power to City of Seattle in lieu of actually raising the Ross Dam and was given the rights to raise the Seven Mile Dam to elevation 1730 feet which involved flooding into Washington State.

The Skagit Agreement between the Province of British Columbia and the City of Seattle came into effect on 1 January 1986 and has a term of 80 years, until 1 January 2066, with a cancellation clause requiring five years advance notice. Because the Skagit

[1] Between 1994 and 2000 this operation deviated from the intended operating plans. This was resolved through development of the Libby Coordination Agreement.

Agreement involves international waters, a treaty between the US and Canadian governments was also signed. A subsequent agreement between the Government of Canada and the Province of B.C., and another separate agreement between the Province of B.C. and BC Hydro, assigns most elements of the Skagit Agreement to BC Hydro for implementation.

The electric power deliveries under the Skagit agreement are considered part of the BC Hydro's firm load and the delivery schedules are arranged each week under a recently renewed wheeling agreement which became effective 1 February, 1999.

Keenleyside Release Coordination Agreement

The Keenleyside Release Coordination Agreement is the primary mechanism for co-ordinating the operation of the generating facilities being developed by Arrow Lakes Power Development Corporation (ALPDC) (a joint venture of the Columbia Power Corporation and the Columbia Basin Trust) with the operation of the Arrow reservoir. Under this agreement, the parties agreed that:

BC Hydro is responsible for determining the total releases from combined facilities (powerhouse and dam discharges) and the resulting operation of Arrow reservoir following CRT operations.

ALPDC will determine the capability of its facilities to discharge water in accordance with its legal obligations and provide such information to BC Hydro in a timely manner. Subject to the physical characteristics of the facilities and their respective legal obligations, the parties will maximize the discharge from the powerhouse.

The agreement allows maximization of the generation at the new Keenleyside power plant while clarifying the legal obligations of each party in determining and implementing the operations of their respective facilities.

Non-Treaty Storage Agreement

Under the terms of the Non-treaty Storage Agreement (NTSA) between BC Hydro and Bonneville Power Administration (1984; expanded 1990), operation of storage additional to CRT storage at Mica (5550 million cubic meters; 4.5 MAF) and Arrow 320.7 million cubic meters; 0.26 MAF) is co-ordinated to benefit both power systems. NTSA activity is determined by agreement on a daily basis, and may result in daily changes to Arrow releases and energy interchanges between the two utilities.

Although five million-acre feet of storage at Mica is called non-treaty storage, only 4.5 Maf is included in the Non-treaty storage agreement. Of the 4.5 Maf, 2.25 Maf is deemed to be USA's and 2.25 Maf is deemed to be Canada's with the additional 0.5 Maf used as a buffer for BC Hydro operations.

When Canada releases part of its 2.25 Maft, all the energy it generates at Mica, Revelstoke and the USA plants downstream is returned to Canada. Similarly, when the

USA releases part of its 2.25 Maf, all the energy it generates at Mica and Revelstoke is sent to the USA.

This operation enables a fully co-ordinated use of the water resource for energy production rather than the ad-hoc process that was in place prior to the agreement being drafted.

Prior to this, both Canada and the USA shared 1.25 Maf each and the remaining was used by Canada on an as required and market basis.

Kootenay Lake International Joint Commission Order

The International Joint Commission (IJC) Order for Kootenay Lake (1938) allowed West Kootenay Power to excavate Grohman Narrows near the outlet of Kootenay Lake and build Corra Linn Dam to regulate Lake level. In return, West Kootenay Power regulates Kootenay Lake in order to manage and mitigate flooding and drainage problems in the area.

The order specifies fixed lake levels from September through March. From 1 April to 31 August, the order requires a daily-calculated allowable lake level based on the "lowering" of the lake from its natural level.

APPENDIX O: LIST OF INITIAL ISSUES IDENTIFIED FOR THE COLUMBIA RIVER WATER USE PLAN

This appendix summarizes water use issues and interests identified through discussion with regulatory agencies, First Nations, local governments and other interested parties in the Columbia River basin. These issues and interests were identified by participants attending a number of information meetings and open houses as part of the Columbia River Water Use Plan initiation between May and September 2000. This initial list of issues became a starting point for members of the Columbia River Water Use Plan Consultative Committee, once it formed early in 2001, in identifying its full range of issues and interests related to operation of BC Hydro's hydroelectric facilities on the Columbia River.

Generally, Water Use Plans are intended to address issues related to the operation of BC Hydro's hydroelectric facilities as they currently exist and incremental changes to operations to accommodate other water uses. Some of the issues summarized below were not considered within the scope of water use planning, and, where possible, the Consultative Committee explored opportunities to address these through broader stewardship and planning initiatives within the watershed.

The following tables summarize the interests and issues that were identified with respect to Columbia River hydroelectric operations during the initiation phase of the Columbia River water use planning process.

Table O-1: Aesthetics/Recreation/Tourism Issues

Interest	List/Description of Dust and Erosion Issues
General	In season: Canoeing, kayaking, fishing, ice fishing, boating, camping, sightseeing, hiking, picnicking, water-skiing, cottages, hunting, ATV/snowmobiling, mountain biking, photography, nature appreciation, artistic inspiration, cross-country skiing, log debris and float plane take off and landing.
Kinbasket Reservoir	Appearance of Valemount end of Kinbasket Reservoir (Canoe Reach), exposed shoreline and mudflats at low water.
	Weir or mini-dam at Valemount end of Kinbasket reservoir would keep water levels up and reduce dust.
	Spring siltation clouds the water and is unsightly.
	Unsightly and dangerous debris piles on shoreline.
	Reservoir can't be used during certain periods of the year for boating due to water levels.
	Debris on Kinbasket packs around boats at marinas/moorage sites, also makes navigation of reservoir very difficult.
	The season on Kinbasket is too short for entrepreneurs due to water levels.
	Clean up Kinbasket for recreational and tourism-related commercial use.
	Ensure water levels for the boating season, that is water at each end of the reservoir from at least 15 June to 15 October.

Interest	List/Description of Dust and Erosion Issues
	Ensure safe harbours, not just at each end of the lake, but also a couple strategically located towards the middle. Make sure forestry companies take their share of the responsibility for debris on the reservoir. Access for recreational fishing. General access to the reservoir. Low water levels reduce swimming opportunities. Seasonal reservoir fluctuations. Debris/driftwood on shoreline. Promotion of responsible use of the land. Development of Hot Springs in Valemount. Tourism and recreational shore development impossible. Ministry of Transportation and Highways, McBride office: Our only interest in the process would be in respect to plans for the Kinbasket Reservoir. Even though there are no Ministry roads at or on the lake at this time, the long term planning around access is of interest.
Revelstoke Reservoir	Boating. Seasonal reservoir fluctuations. Recreational values attached to water flows. Guests at resorts enjoy viewing wildlife.
Mid Columbia River	Dust. Erosion. Boating.
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	Fluctuation of Arrow Lakes Reservoir are unreliable and inhibit the growth of tourism. Water fluctuations downstream from the dam affects log handling operations at both the Pope and Talbot sawmill and Celgar, City of Castlegar, Trail and Cominco upstream reservoir levels affect log storage, transportation marina moorage and tourist potential. Fluctuation of Columbia River and Arrow Lakes Reservoir dangerous to anglers and recreational users. Fisheries in the Columbia River are a great concern through a recreational point of view. Levels that fluctuate can cause problems for trails and parks next to the water. Access to shoreline (beaches). Maximum change of flow per day 15 000 cfs ➧ City of Trail's retaining wall. Less than 10 000 cfs ➧ problems for Pope and Talbot getting logs to their log deck. Operation of marinas (Scotties and Syringa) are affected at low levels. Debris is set adrift at 1446 ft.

Interest	List/Description of Dust and Erosion Issues
	Promised recreation facilities due to Columbia River Treaty. Hazardous conditions for swimmers/divers. Access to boat launches necessary as recreation and tourism increases. Too much fluctuation from June to September a real problem for recreational development. Want long-term predictions and access to this information via the web. Try to maintain reservoir between 1433 and 1443 ft (the maximum). Want to know the Columbia River's elevations in a given day. Exposed shoreline is unsightly and restricts tourism potential. Floating vegetation and debris is unsightly. Negative perceptions of Arrow Lakes Reservoir at low levels. Waterfront properties would be more appealing if the reservoir was stable. Lake shore erosion, predominately unstable clay soils over large areas are prone to erosion (dissolving), fluctuating high water mark undercuts toes of slopes creating undermining and subsequent settling of large chunks of ground. Less fluctuation of water level combined with physical shoring up and re-vegetation of lakeside areas may be eventually required.

Table O-2: First Nations, Heritage and Traditional Use Issues

Interest	List/Description of Heritage and Traditional Use Issues
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	Water fluctuations erode the First Nation rock carving south of Deer Park. Preserving historic trails (i.e., Waldie Island).

Table O-3: Fish Issues

Interest	List/Description of Fish Issues
General	Habitat. Tributaries streams for each reservoir; can they be managed/developed to make fisheries in reservoirs self-sufficient. Water levels in summer. Access to fisheries.
Kinbasket Reservoir	Access to spawning areas seasonally disrupted (ESOR-Mica). Kinbasket fishery. Small fish size. Can improvements be made to the survival of fish species by altering the way water levels change in the reservoir.
Revelstoke Reservoir	Reduced reservoir productivity.

Interest	List/Description of Fish Issues
Mid Columbia River	Dewatering of spawning areas. Entrainment of fish due to high flows. Flows disrupt downstream biological cues. Increased Total Gas Pressure levels during spilling. Loss of littoral habitat. Impact on angling from flow fluctuations.
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	Stranding of fish and fish eggs. Low water may prevent access to spawning channels. Reduced planktonic productivity, from drawdown, resulting in decreased fish populations. Sturgeon population above and below Hugh Keenleyside Dam. High Total Gas Pressure below the dam. Genetic studies that can be planned now to deal with the native vs. non-native rainbow spawning issue. Lost of spawning channels – up to 300 m on some creeks, below high water mark eliminating as much as ½ to ¾ of historic spawning beds.

Table O-4: Issues Related to Water Supply and Quality

Interest	List/Description of Industry Issues
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	Wastewater treatment plant in Trail – high water levels can effect infiltration/inflow into sewage systems. Drinking water in Trail – flow fluctuations can affect turbidity at water treatment intake facilities.

Table O-5: Issues Related to Power Generation

Interest	List/Description of Issues
General	Columbia River Treaty.

Table O-6: Flood Control and Water Management Issues

Interest	List/Description of Flood and Ice Management Issues
General	Water levels.
	Riverbank erosion.
	Notification re: water levels.
	Reservoir operations.
	Property impacts.
	Water quality.
Kinbasket Reservoir	Water discharges.
	Dust.
	Flooding.
	Safe line on property/set backs.
	Recreational development of shoreline property.
	Visual appearance of Kinbasket reservoir is best when at full pond.
	Access to property (Island Causeway) and others.
	Commercial development.
	Private land could be reclaimed if reservoir was stabilized at lower level (ESOR-Mica).
	Considerable silting near the Big Lake Resort (ESOR-Mica).
	Drawdowns create dry conditions in Blaeberry, near Golden.
Revelstoke Reservoir	Water levels.
	Water discharges.
	Recreational development of shoreline.
	Commercial development.
Mid Columbia River	Bank stability/erosion concerns with spilling.
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	Riverbank erosion when water levels are high.
	Flooding is minimal downstream.

Table O-7: Forestry Issues

Interest	List/Description of Recreation and Tourism Issues
Kinbasket Reservoir	Water levels need to be within a certain range to operate tugs, barges (low water concern).
	Water levels determine when certain forestry roads are accessible and when some stands of timber can be harvested.
	Drawdowns increase cost of operations when timber has to be trucked around lake rather than barged.
	Would prefer constant level on Kinbasket reservoir from July to September.
	Slocan Forest Products has planning/harvesting interests in the Kinbasket from Canoe River south to a point just south of Howard Creek.
	Debris can hinder log transportation at full pool.
	Low water levels can hinder log boom transportation.
	Timber lost due to flooding and nothing replaced this income source.

Table O-8: Wildlife Issues

Interest	List/Description of Transportation Issues
Kinbasket Reservoir	Water levels can affect wildlife habitat, e.g., beavers, ungulates.
	Access to Kinbasket reservoir at Golden end (Columbia Reach).
	Road closures.
	Ducks won't use reservoir when at full pool.
	High water levels flood wetland nesting sites in spring.
	Disappearance of fur trap lines.
	Wildlife fall through ice near the dam.
Revelstoke Reservoir	Wildlife values.
	Water fowl habitat.
Mid Columbia River	Biodiversity of wetlands due to fluctuating water levels.
	Conservation designation from Illecillewaet to Cartier Bay (below REV).
	Water fowl habitat.
	Grasslands are prime wildlife habitat, but water fluctuations impede access and use.
Arrow Lakes Reservoir and Columbia River below Hugh Keenleyside Dam	High water in river in winter causes food availability problems for Blue Herons.
	High water during shore bird migration reduces feeding sites.

Table O-9: Public Safety Issues

Interest	List/Description of Water Quality Issues
Mid Columbia River	Low levels expose mudflats and sinkholes, particularly near West Arrow Park, Nakusp, McDonald Park and Burton, creating a hazard for anglers, recreational users and tourists.

APPENDIX P: INTEGRATED RESPONSE MODEL

Simulating the Response of Aquatic and Riparian Productivity to Reservoir Operations: Description of the Vegetation and Littoral Components of BC Hydro's Integrated Response Model (IRM)

Prepared for:

Generation Environment
B.C. Hydro and Power Authority
6911 Southpoint Drive
Burnaby B.C.
V3N 4X8

By:

Josh Korman
Ecometric Research Inc.
3560 W 22nd Ave.
Vancouver, B.C.
V6S 1J3

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EXECUTIVE SUMMARY

A simulation model, predicting the response of riparian vegetation and benthos produced in the littoral zone to water surface elevation schedules and fall rye planting in storage reservoirs was developed. The intent of the modeling effort was to provide a predictive tool for water management, but more importantly, to highlight key gaps in data and understanding to strengthen future monitoring and research efforts. Model development was a collaborative effort that integrated data and hypotheses from vegetation ecologists and limnologists who were actively working in the Revelstoke Reach of the Arrow Reservoir, British Columbia.

The vegetation component of the simulation model makes predictions about changes in biomass of various plant groups on a weekly timestep over the growing season. A multi-year sequence of average weekly reservoir water surface elevations is provided as input to the model. In conjunction with a digital elevation model, this time series is used to compute statistics on wet and dry stresses that are accumulated at each 1-meter elevation band in the reservoir. These stress statistics in turn are used to determine seedling establishment rates, and the survival and growth rates of mature plants. The groups of plants that are simulated are: fall rye, horsetail, reed canary grass, sedge, willow, and cottonwood. These plant groups were defined based on differences in growth rates, their responses to wet and dry stress, and their importance to wildlife habitat. A summary of the data used to parameterize the model and model dynamics is provided.

Two major weaknesses in our understanding of the response of vegetation to reservoir operations and fall rye planting were identified in the modeling process. There is almost a complete absence of multi-year data collected in a consistent manner from an informative monitoring design. The lack of this type of information makes it difficult to separate the effects of wet and dry stress on growth, survival, and seedling establishment. The other major uncertainty identified in the model development process was the lack of quantitative understanding of the effects of fall rye planting on native vegetation establishment.

The littoral-benthic component of the simulation model predicts the production of benthos on an annual timestep for 1-meter elevation bands in the reservoir. The two key processes that are simulated are the effects of inundation and flooding of vegetation. The contribution of fall rye, and to a lesser extent reed canary grass and sedge, to the total littoral biomass in the Revelstoke Reach of Arrow Reservoir is potentially very large. Fall rye generates about 12 mg dry wt/g plant after 10 wks of inundation, a value that is almost an order of magnitude higher than the estimates for sedge and reed canary grass). Fall rye is 5-fold more productive that native vegetation. Taken together, these data imply that flooded fall rye generates about 50 times more benthic invertebrates per m^2 relative to that from sedge or reed canary grass in situations when these vegetation groups are at maximum biomass levels. There is large uncertainty about whether this contribution to benthic production is translated into any benefits for fish populations.

Recommendations for the design of future monitoring programs and model improvements are provided. A user's guide describing the installation and operating procedures for the simulation model is provided.

ACKNOWLEDGEMENTS

This project was funded by a contract to Ecometric Research Inc. from BC Hydro through the Strategic Environmental Initiatives Program. Thanks to Ed Hill and Wayne Duval for administering the contract. Thanks to Anne Moody, Chris Perrin, Will Carr, Brian Gadbois, and Wendy Beauchamp for providing data used to parameterize the models. Thanks to Anne Moody, Will Carr, and Chris Perrin for reviewing a previous draft of this document.

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1.0 INTRODUCTION

Reductions in water surface elevation during the winter and early spring is a common dynamic in the operation of many storage reservoirs used for hydroelectric generation. The magnitude of this annual cycle, or reservoir drawdown regime, can be extensive in British Columbia because of steep valley morphology and reduced inflows during winter months. As a result of water level changes, much of the shoreline in the drawdown zone is denuded of vegetation. These denuded areas are unattractive, have little wildlife value, and can generate dust storms that degrade air quality. As a result of the latter issue, a dust control program, consisting of seeding fall rye, was initiated in the Revelstoke Reach of the Arrow Reservoir in the late 1980's. The program successfully reduced dust levels by stabilizing fine sediments that were exposed during the drawdown period (Carr et al. 1993). Over time, additional benefits of the program became apparent. Native vegetation began colonizing areas that had been planted with fall rye (AIM 2002a). Planting rye improved the carbon content of the soil and provided a roughness that, coupled with the drill seeding process and fertilization to improve seedling growth, enhanced the establishment of native seedlings (W. Carr, Carr Environmental, Cloverdale, BC, pers. comm.). Newly vegetated areas have apparently been heavily used by geese, songbirds, and other wildlife (B. Gadbois, BC Hydro, Revelstoke BC, pers. comm., J. Jarvis and J. Woods, Parks Canada, unpublished data). Flooding riparian vegetation during the reservoir cycle has the potential to increase aquatic productivity by providing a nutrient source and colonization substrate for bacteria, periphyton, and benthic invertebrates. Increases in aquatic productivity associated with the inundation of fall rye and other plants in the Revelstoke Reach is well documented (Perrin and Stockner 2002). In addition, fish have been observed to follow rising water in the drawdown zone each year, and an active rainbow trout fly fishery developed after annual seeding started where no fishery was present before (Perrin and Stockner 2002). It has been hypothesized that the fishery is a result of the additional food production associated with the flooded riparian vegetation. As a result of all these observations, the perception of fall rye planting has evolved from a means of controlling dust to an enhancement technique that can be used to improve riparian and aquatic productivity of reservoirs.

Vegetation communities that establish in the drawdown zone of reservoirs are determined by a combination of factors including topography, aspect, substrate, and the inundation frequency and duration. The planting of crops such as fall rye also assists in the establishment of vegetation cover. The potential enhancement of aquatic productivity will depend on the biomass and composition of the vegetation that is flooded, as well as the depth and duration of inundation. Given the multitude of potential interactions between reservoir operations and riparian and aquatic responses, it became apparent that a computer model, which predicts the growth, survival, and colonization of vegetation and aquatic productivity responses to alternate planting and water management strategies, would be a useful planning tool. It was also recognized that the conceptual model and data required to build the computer model would improve future monitoring and research activities. The development of this model began in 1999 through funding from the BC Hydro Strategic Environmental Initiatives Program as part of the Ancillary Benefits of Reservoir Revegetation Project.

Model development integrated data and hypotheses from vegetation ecologists and limnologists who were actively working on the Arrow Reservoir. This report describes the computer model that was developed through this effort. The main component of the model consists of a vegetation module that predicts the response of different vegetation groups to reservoir water surface elevation schedules. The model simulates the dynamics of plant growth, survival and seedling establishment. An aquatic productivity module simulates the response of benthic invertebrates utilizing the littoral zone of the reservoir to water elevations and inundation of riparian vegetation. The model has been applied to the Revelstoke Reach of the Arrow Reservoir and Carpenter Reservoir, and has been used to evaluate alternate reservoir operating strategies in the Columbia and Bridge River systems as part of the Water Use Planning (WUP) process.

This report consists of four sections. The structure and assumptions of the vegetation model, data used to parameterize it, and model dynamics are summarized in Section 2. Section 3 describes the aquatic production model, and its parameters and dynamics. Section 4 provides recommendations for the design of future monitoring programs and model improvements. Section 5 is a user's guide that describes how to install and operate the modeling software.

2.0 VEGETATION MODEL STRUCTURE

The vegetation model simulates changes in biomass of various plant groups on a weekly timestep over the growing season. A multi-year sequence of average weekly reservoir water surface elevations is provided as input to the model. In conjunction with a Digital Elevation Model (DEM, Fig. 1), this time series is used to compute statistics on wet and dry stresses that are accumulated at each 1-meter elevation band in the reservoir. These stress statistics in turn are used to determine seedling establishment rates, and the survival and growth rates of mature plants. The groups of plants that are simulated are: fall rye, horsetail, reed canary grass, sedge, willow, and cottonwood. These plant groups were defined based on differences in growth rates, their responses to wet and dry stress, and their importance to wildlife habitat.

2.1 PLANT GROWTH

A logistic model is used to simulate the change in above-ground plant biomass over time,

$$B_{iv,ib,t+1} = B_{iv,ib,t} + g_{iv,ib,t} * B_{iv,ib,t} * (1 - \frac{B_{iv,ib,t}}{K_{iv}}) + Seed_{iv,ib,t}, \tag{1}$$

where B_t is the biomass (grams in dry weight/m^2) on timestep t for vegetation group iv at elevation band ib, $g_{iv,ib,t}$ is the weekly growth rate, K_{iv} is the carrying capacity which is the maximum biomass that can be achieved under ideal growing conditions, and $Seed_{iv,ib,t}$ is the biomass contribution from seedlings which have survived the seedling establishment window (see Section 2.2) through natural reproduction or from planting.

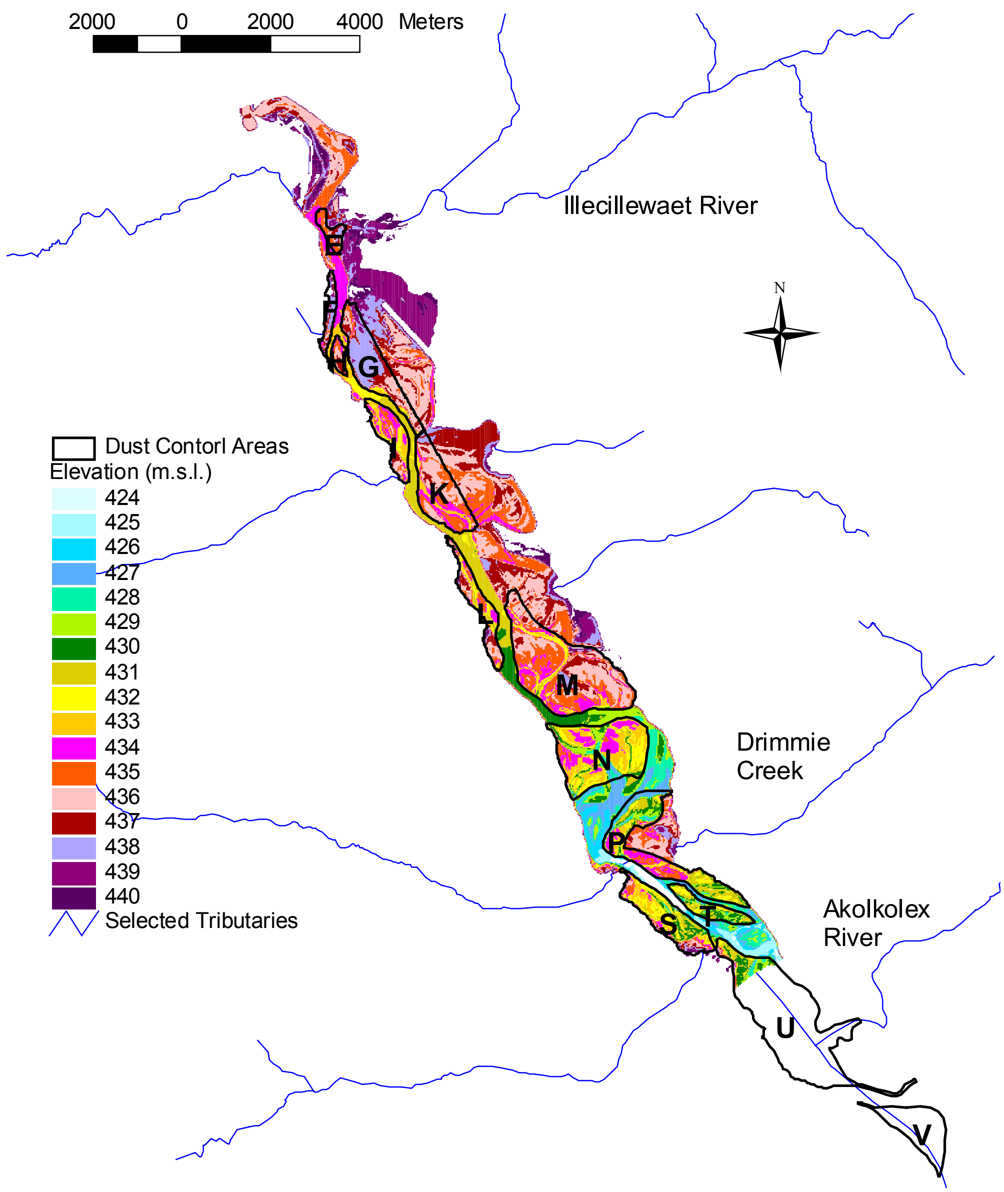


Figure 1: Elevation contours for the Revelstoke Reach of Arrow Reservoir based on the Digital Elevation Model (DEM) derived from the May 2000 air photographs. The elevation data show the total extent of the area that can be modeled. Also shown are the locations of the dust control polygons. The extent of the DEM used in the Arrow Reservoir vegetation model extends beyond the colored area shown here to below the confluence of Akokolex River (to just below dust control area 'V').

Biomass values for each vegetation group at each elevation band must be initialized for the first week of the growing season in the first year of the simulation (t=1). This is accomplished by specifying the % cover for each plant group for each elevation band ($IniCover_{iv,ib}$) and converting this value to its biomass equivalent using the equation,

$$B_{iv,ib,1} = IniCover_{iv,ib} * \frac{1}{CB_{iv}}, \qquad (2)$$

where CB_{iv} is the cover-to-biomass ratio for each vegetation group. The model can be initialized using data from current surveys for forecasting purposes, or using cover estimates from older surveys when running the model in hindcasting mode to recreate historical trends in vegetation development.

The growth and survival of each plant group is determined by their responses to flooding and desiccation as indexed by stress statistics calculated by the model. Stress statistics for each 1-meter elevation band in the reservoir are computed using a 'degree-day' approach. The wet stress for each band at any point during the growing season ($WetStress_{ib,t}$, in units of meter-weeks), is simply the sum of the depth of water over each band up to any week in the growing season,

$$WetStress_{ib,t} = \sum_{t=1}^{GrowWks} WS_t - Elev_{ib}, \quad \text{if } \mathrm{WS_t > Elev_{ib}} \qquad (3)$$

where, depth is computed as the difference between the water surface elevation on week t (WS_t) and the elevation of the band ($\mathrm{Elev_{ib}}$). Note that wet stress will increase with both the duration and depth of inundation and is 0 until the elevation band is flooded.

A dry stress statistic is used to quantify the stress that a vegetation group will accumulate by being in conditions that are too dry. A large component of this stress is determined by the plants position relative to the water table. This can be indexed by the difference between the elevation of each band and the reservoir water surface. Vegetation groups in elevation bands near the water table should undergo less dry stress than plants that are in elevation bands well above the water table. Dry stress ($DryStress_{ib,t}$, in units of meter-weeks) for each elevation band is simply the sum of the differences between the elevation of each band and the reservoir water surface,

$$DryStress_{ib,t} = \sum_{t=1}^{GrowWks} Elev_{ib} - WS_t, \quad \text{if } \mathrm{Elev_{ib} > WS_t} \qquad (4)$$

Note that dry stress will increase with the duration of exposure and the height difference between the elevation band and the reservoir water surface.

The growth rate of each vegetation group at each elevation band on each week ($g_{iv,ib,t}$ from eqn. 1) is determined based on a maximum growth rate under ideal conditions ($gBase_{iv}$) and multipliers that depend on the amount of wet ($gMultWet_{iv,ib,t}$) and dry stress ($gMultDry_{iv,ib,t}$) that is accumulated,

$$g_{iv,ib,t} = gBase_{iv} * gMultWet_{iv,ib,t} * gMultDry_{iv,ib,t} \tag{5}$$

where, $gMultWet_{iv,ib,t}$ and $gMultDry_{iv,ib,t}$ must range from 0-1. These growth rate adjustments are predicted from a declining Type III functional response of the form,

$$gMultX_{iv,ib,t} = 1 - \frac{XPStressi_{iv,ib,t}{}^{XSl_{iv}}}{XHf_{iv}{}^{XSl_{iv}} + XPStress_{iv,ib,t}{}^{XSl_{iv}}} \tag{6}$$

where, all references to 'X' should be replaced with the words 'Wet' or 'Dry', $XPStress_{iv,ib,t}$ is the proportion of accrued wet or dry stress relative to the maximum tolerable values (i.e., $WetPStress_{iv,ib,t} = WetStress_{ib,t}/MaxWetStress_{iv}$), XHf_{iv} (i.e., $WetHf_{iv}$ or $DryHf_{iv}$) is a parameter that determines the stress level where growth is reduced to ½ of its maximum value (i.e., 0.5*$gBase_{iv}$), and XSl_{iv} (e.g., $WetSl_{iv}$ or $DrySl_{iv}$) is the slope coefficient determining the steepness of the relationship.

2.2 PLANT SURVIVAL AND SEEDLING ESTABLISHMENT

Survival of mature plants is determined by specifying maximum-tolerable wet and dry stress levels for each vegetation group ($MaxWetStress_{iv}$, and $MaxDryStress_{iv}$, respectively) and comparing these values with the accumulated stress levels at each elevation band over time. Biomass ($B_{iv,ib,t}$ in eqn. 1) is set to zero whenever the stress levels equal or exceed the maximum tolerance values, that is,

$$\begin{aligned} WetStress_{ib,t} &\geq MaxWetStress_{iv} \\ DryStress_{ib,t} &\geq MaxDryStress_{iv} \end{aligned} \tag{7}$$

Note that equivalent wet stresses can be achieved by flooding an elevation band to 10 meters depth for one week or flooding the band for 10 weeks to a depth of one meter. The model therefore assumes that survival is equivalent under these two scenarios. The identical issue applies to computation of survival from dry stress. The model also assumes that the survival response to wet and dry stress is similar across all ages of plants beyond the seedling stage. It may be that younger or smaller plants have a lesser ability to withstand wet and dry stress relative to older and larger plants, but there was not sufficient data to model this dynamic. Note that the model does not account for stress accumulated in previous years when computing survival from Eqn. 7. It may be that plants that approached the maximum stress level in year t-1 have a lower stress threshold in following years, i.e., that stress is accumulated across years. Again, the data that is available is not sufficient to model processes at this level of detail.

Seedling establishment in the model has little effect on biomass trajectories, except in situations where a vegetation group is absent from an elevation band, either due to mortality from flooding or desiccation, or because the elevation band was never initialized with a cover value for the first week of the simulation. Seedling establishment is controlled by six parameters. A seedling establishment window defines the period of the growing season when seeds are available and can potentially grow into seedlings ($SeedWkMin_{iv}$, $SeedWkMax_{iv}$). During this time period, wet and dry stress statistics are computed and seedling establishment for a weekly-cohort fails whenever these statistics exceed maximum tolerances ($SeedFloodMax_{iv}$ $SeedMaxDrySress_{iv}$). If these tolerances are not exceeded for the minimum number of weeks required for seedling establishment ($SeedWks_{iv}$), a seedling establishment event is simulated,

$$SeedWks_{iv} \le \sum_{t=SeedWkMin_{iv}}^{SeedWkMax_{iv}} wk = wk + 1 \left| \begin{array}{l} WS_t - Elev_{ib} < 0 \\ DryStress_{ib,t} < SeedMaxDryStress_{iv} \end{array} \right. \tag{8}$$

The contribution of biomass from newly established seedlings ($Seed_{iv,ib,t}$ in eqn. 1) to the total above-ground biomass on any timestep depends on a parameter that specifies the additional cover associated with a seedling establishment event ($SeedIniCover_{iv}$),

$$Seed_{iv,ib,t} = SeedIniCover_{iv} * \frac{1}{CB_{iv}}. \tag{9}$$

2.4 PARAMETERIZATION OF VEGETATION MODEL

A large number of parameters are required to model the growth, survival, and seedling establishment of six different vegetation groups (Table 1). The reliability of the parameter values used in the model varies considerably. In some cases, the values could be directly estimated from data collected in the Revelstoke Reach of the Arrow Reservoir. For many parameters, professional judgment (L. Stevens, Flagstaff AZ., W. Carr, Cloverdale B.C.) was used to provide initial guesses that were further refined by tuning the estimates so that model predictions of biomass or relative abundance-by-elevation fit the observed patterns in the Revelstoke Reach of Arrow Reservoir based on a recent mapping exercise (Moody 2002a). What follows is a brief summary of how the various parameters values of the vegetation model were derived.

2.4.1 Maximum Wet and Dry Stress Parameters

Initial estimates of maximum tolerable wet ($MaxWetStress_{iv}$) and dry stress ($MaxDryStress_{iv}$) values were obtained from data on the spatial distribution of vegetation groups derived from an air photograph mapping analysis.

1: 5000 scale color air photographs taken on May 24, 2000 were used to classify polygons within dust control areas F-T according to dominant vegetation type and relative biomass classes (Moody 2002a). Note that these polygons are not homogenous stands comprised of a single vegetation type but represent a complex made-up of multiple species, but classified according to the most dominant type. The polygons were then overlaid on 1-meter elevation contours (W. Beauchamp, B.C. Hydro, unpublished data), to compute the area of each dominant vegetation group-biomass class for each 1-meter elevation band (Fig. 2). Reed canary grass is the dominant vegetation group in the drawdown zone of the Revelstoke Reach covering about 350 Ha of the sampled area. Sedge is the next most abundant group covering 92 Ha. Horsetail and willow vegetation groups were relatively rare, covering only 30 Ha and 4 Ha of the sampled areas, respectively.

Table 1: Summary of parameters used in vegetation model.

PARAMETER DESCRIPTION	Units	Parameter Name in Equations	Fall Rye	Horsetail	Reed Canary Grass	Sedge	Willow	Cotton-wood
Maximum Growth Rate	$gC/m^2/wk$	gBase	0.53	0.015	0.03	0.015	0.03	0.03
Carrying Capacity (maximum potential biomass)	gC/m^2	K	3000	200	650	650	1000	1000
Crown Cover-to-Biomass Ratio	no units	CB		0.23	0.13	0.14	0.1	0.1
Root-to-Shoot Biomass Ratio	no units	RS	0.65		2.5	3.2		
Maximum tolerable wet stress	meter-weeks	MaxWetStress	0	85	85	125	20	30
Maximum tolerable dry stress	meter-weeks	MaxDryStress	1000	300	150	150	175	1000
Wet stress at which growth rate is reduced by 50%	meter-weeks	WetHf	0.5	0	0.2	0.05	0.05	0.05
Slope of wet stress - growth relationship	no units	WetSl	5	10	10	10	10	5
Dry stress at which growth rate is reduced by 50%	meter-weeks	DryHf	0.5	0.4	0.01	0.6	0.05	0.5
Slope of dry stress - growth relationship	no units	DrySl	5	10	10	10	10	10
Maximum number of flooded weeks that seedlings can tolerate	weeks	SeedMaxWetStress	0	0	5	5	1	5
Maximum tolerable dry stress for seedlings	meter-weeks	SeedMaxDryStress	600	0	600	600	1000	10
Number of consecutive wks. required for seedling establishment	weeks	SeedWks	5	5	5	5	10	10
First week of seedling establishment period	julian week	SeedWkMin	28	28	28	28	19	28
Last week of seedling establishment period	julian week	SeedWkMax	42	42	42	42	42	41
Crown cover following seedling establishment	%	SeedIniCover	5	5	5	5	5	5
Constant of invertebrate biomass - plant biomass relationship	mg dry wt / g of plant	BenVegConst	0	0	1.27	0	0	0
Slope of invertebrate biomass - plant biomass relationship	mg dry wt / g of plant	BenVegSlope	1.181	0	0	0.15	0	0

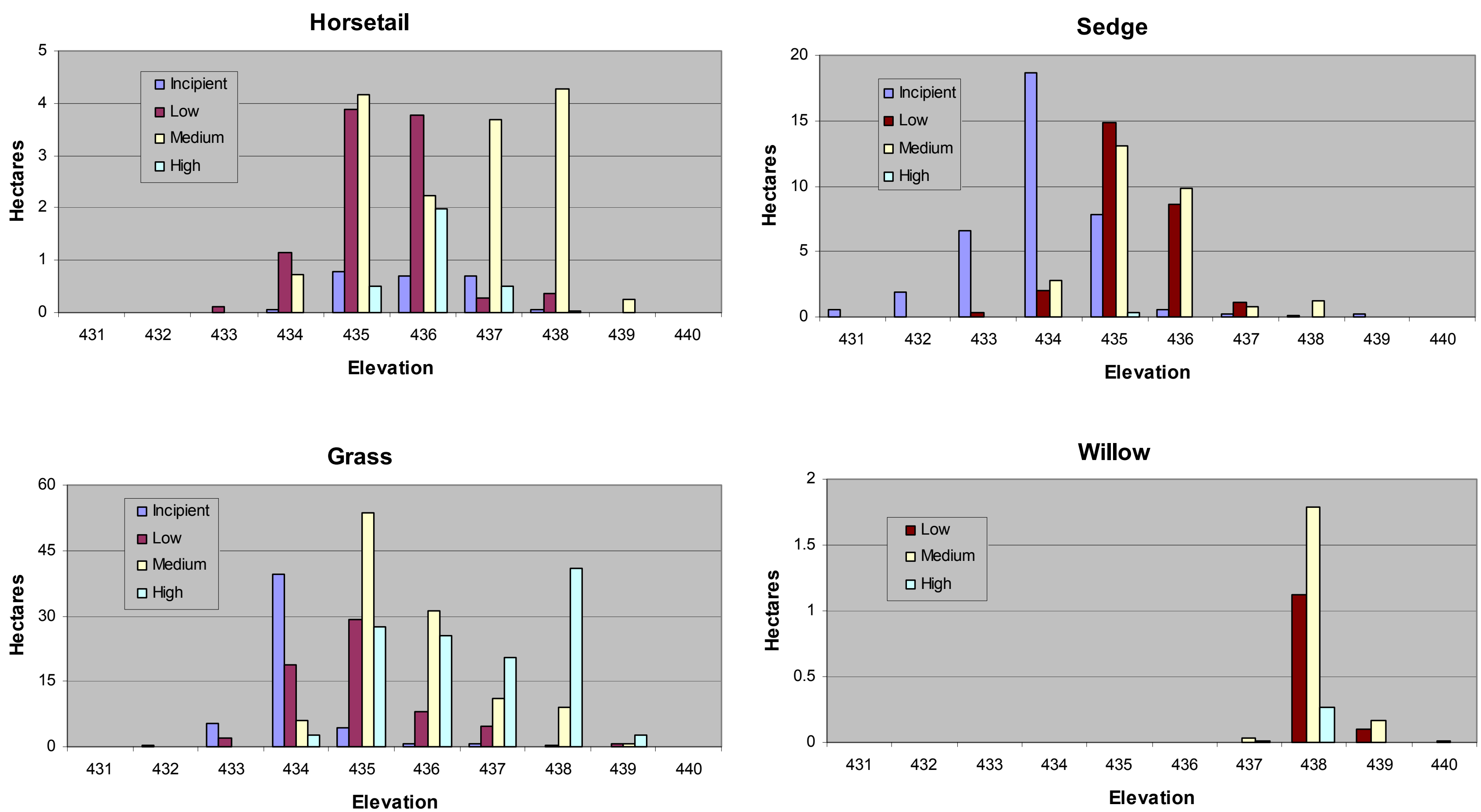


Figure 2: Total area of vegetation groups by different biomass classes and 1 meter elevation bands (data modified from Moody 2002a).

Data on the distribution of vegetation groups by elevation can be used to parameterize model relationships predicting growth and survival to wet and dry stress. The mapping data provides the raw information to do this but it must be corrected because, the areas of 1-meter elevation bands that can potentially be mapped, are not equivalent. The surface of dust control areas F-T, where vegetation mapping data was produced, is dominated by elevations 431-434 m.s.l. (Fig. 3). Thus, the presence of vegetation at elevations above this range will be under-represented in the mapping results because these elevations represent a smaller proportion relative to what exists in the Revelstoke Reach covered by the DEM (i.e, the modeled area). To adjust for this bias, a correction factor was developed which standardized the vegetation area to 432-m.s.l.-equivalnts (the elevation band with the greatest total area). Correction factors were computed for each 1-meter elevation band as the ratio of the total area across dust control areas F-T for elevation 432 m.s.l. to the total area for that band (i.e., $CF_{ib} = \mathrm{Area}_{432}/\mathrm{Area}_{\mathrm{ib}}$). The total vegetated area for any vegetation group at an elevation band is the product of the mapped area and the correction factor. Note that these correction factors can be substantial (15 or greater) for elevations above 437 m.s.l. Average wet and dry stress statistics for each 1-meter elevation band (eqn.'s 3 and 4) were then computed using the 1990-1999 Arrow Reservoir elevation data. The statistics were overlaid on the area-corrected vegetation group-biomass results to determine the maximum tolerable wet and dry stress limits (Fig. 4, Table 1). The following general conclusions about vegetation distribution as a function of elevation and stress levels can be made:

- Horsetail cannot survive at elevations below 434 m.s.l. corresponding to a maximum wet stress level of about 80 meter-weeks.

- Reed canary grass has a wide tolerance for both wet and dry conditions. It extends down to an elevation of 434 m (wet stress <=75 meter-weeks) and attains very high abundance levels up to 439 m (maximum dry stress <= 180 meter-weeks).

- Sedge is the most flood-tolerant vegetation group with coverage down to (431 m.s.l.). Sedge appears to be quite sensitive to dry stress, and was rarely observed at elevations greater than 438 m (dry stress < 140 meter-weeks).

- Willow is sensitive to flooding and was not found at elevations below 438 m.s.l., which corresponds to a maximum wet stress level of <=15 meter-weeks.

Initial estimates of maximum wet and dry stress were used in model simulations driven by historical reservoir elevations from 1990 – 2000. Predictions of the distribution of vegetation groups by elevation were compared to the standardized observations (Fig. 4). Adjustments to the maximum wet and dry stress parameters were made to improve the fit between observed and predicted elevation distributions.

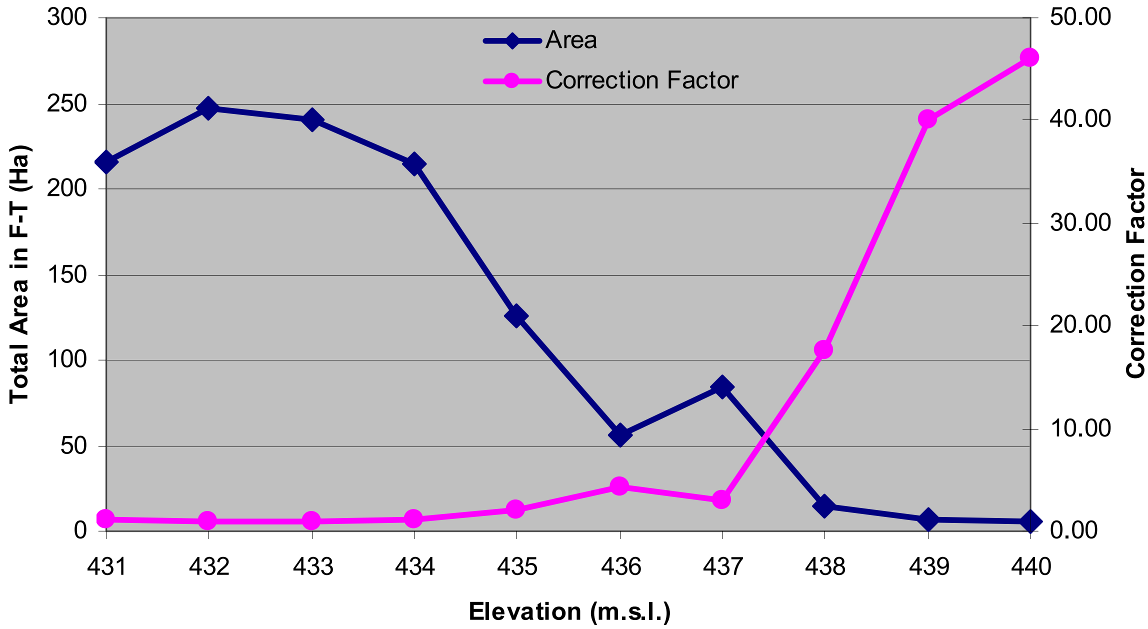


Figure 3: Total area for 1-meter elevation bands in dust control areas F-T in the Arrow Reservoir, and the correction factors used to standardize vegetation mapping results from Moody (2002a). The correction factor is computed as the ratio the area at 432 m.s.l. (the elevation that has the most area across dust control areas F-T) to the area from each elevation band. Multiplying the area of mapped vegetation polygons at any elevation slice by its corresponding factor corrects for differences in the availability of total area across elevation bands.

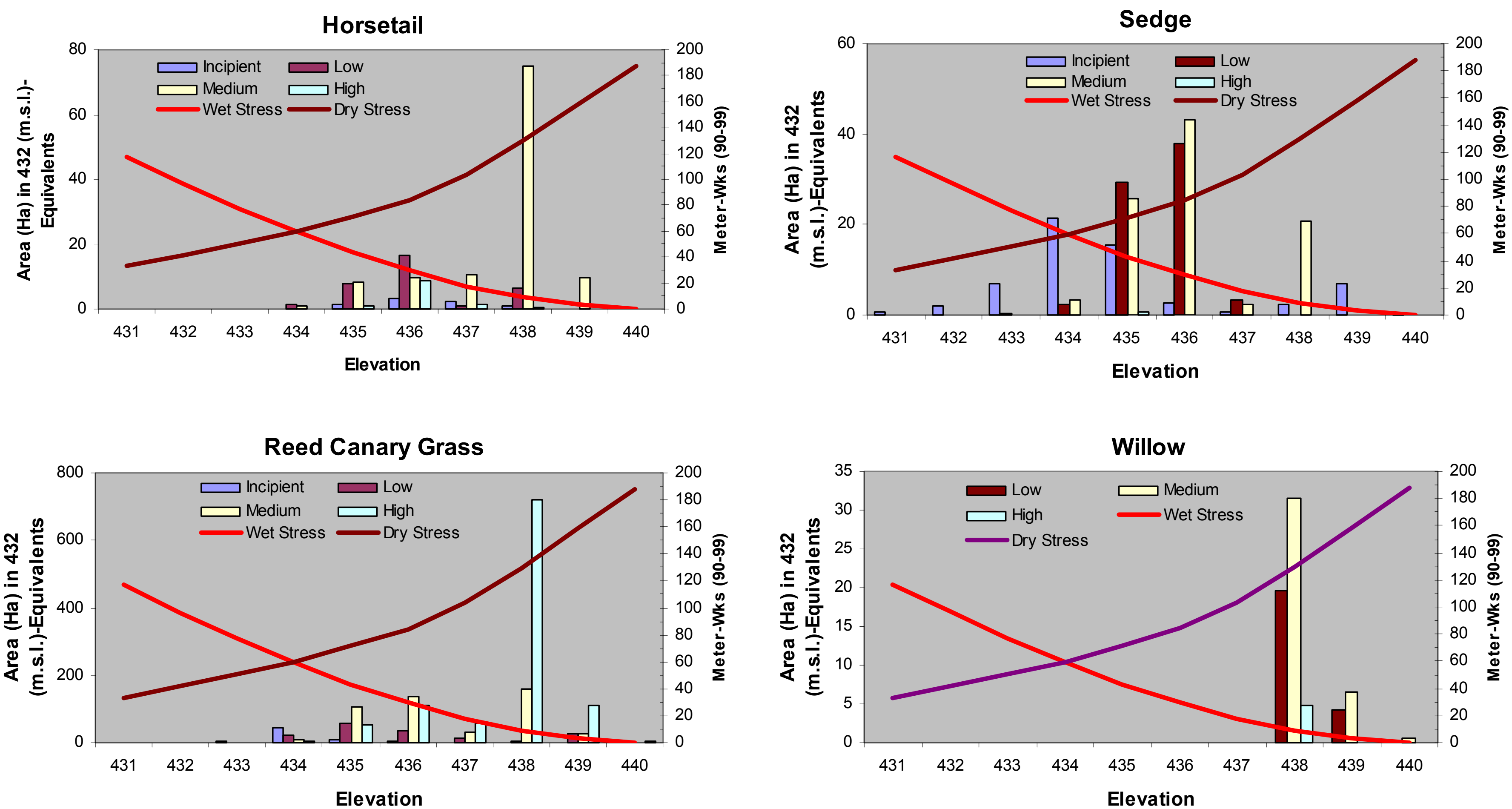


Figure 4: Area (in 432 m.s.l.-equivalent Hectares) of vegetation groups by different density classes and 1-meter elevation bands. The 432-equivlant area for any elevation-density class combination is computed as the total area for this class (Fig. 2) times a correction factor (Fig. 3). See caption for Fig. 3 and text for details.

2.4.2 Growth Parameters

Carrying Capacity

Carrying capacity refers to the maximum potential biomass that vegetation groups can attain under ideal natural growing conditions in the absence of flooding. Note that the actual biomass achieved for any vegetation group on any week of the simulation ($B_{iv,ib,t+1}$) depends not only on carrying capacity, but also on the antecedent conditions ($B_{iv,ib,t}$), the mature plant growth rate ($g_{iv,ib,t}$) and potential seedling recruitment ($Seed_{iv,ib,t}$). Estimates of carrying capacity (*K* in Table 1 and eqn. 1) were based on a combination of professional judgment and field data. Field data from the Arrow Reservoir vegetation studies were used to estimate carrying capacity estimates (maximum potential biomass value) for fall rye (Carr et al. 1993), horsetail, reed canary grass, and sedge (Moody 2002b) based on maximum observed biomass values (Fig. 5). Maximum biomass estimates for willow and cottonwood were not measured and are based on professional judgment.

Maximum Growth Rate

There is a paucity of data to estimate maximum growth rates (*gBase* in Table 1 and eqn. 1) for most of the vegetation types that were modeled except for fall rye and sedge. The model operates on a weekly timestep and growth rates must be estimated at this same resolution. Estimating growth rates for fall rye was relatively easy as the plant is an annual and studies evaluating the effectiveness of fall rye planting (Carr et al. 1993) quantified the biomass change of fall rye over the course of the growing season in 1991 and 1992. The maximum growth rate for fall rye was fit using a non-linear iterative search procedure to find a *gBase* value that minimized the sums of squared differences between observed and model predictions of biomass over the growing season (Fig. 6). During the fitting procedure the *K* parameter of the logistic model (eqn. 1) was held constant at the maximum biomass value of 3000 gC/m^2 observed by Carr et al. (1993). As fall rye dies when inundated to any degree, there was no need to account for the effects of flooding when trying to estimate maximum growth rate. The fall rye growth rate estimate was 0.53 $gC/m^2/wk$, which is about 35-fold greater than the sedge growth rate estimated below (Table 1).

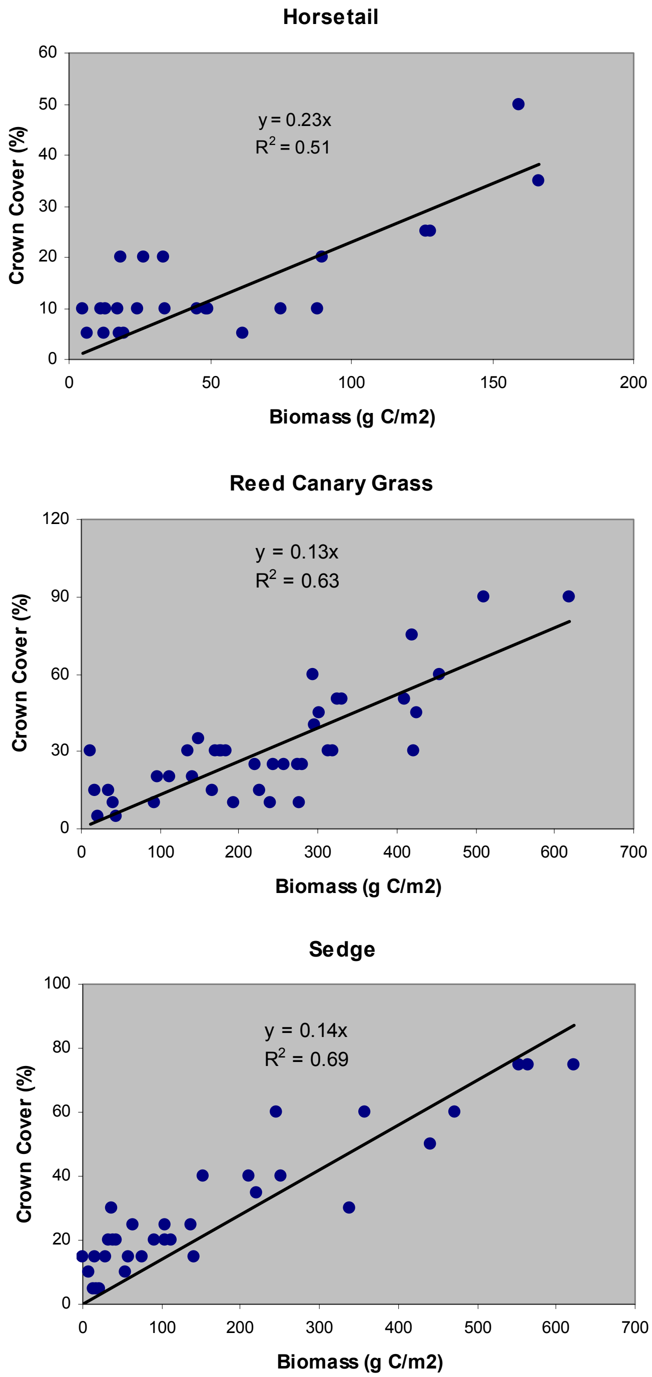


Figure 5: Relationships between crown cover and biomass for horsetail, reed canary grass and sedge based on data collected in 1999 and 2000 in the Arrow Reservoir (data provided by Anne Moody).

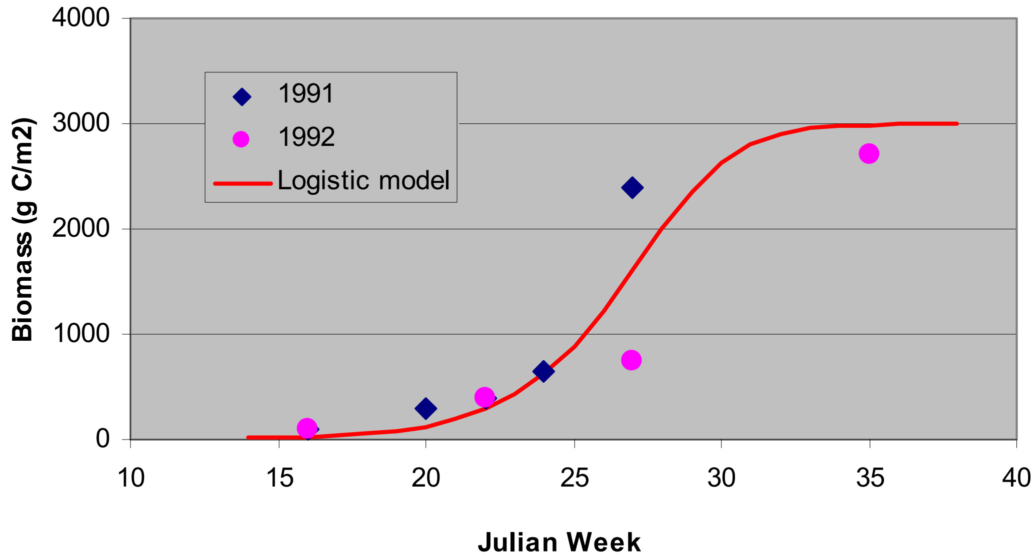


Figure 6: Logistic growth model fit to fall rye biomass data collected in the Arrow Reservoir in 1991 and 1992 (data from Carr et al. 1993).

Estimation of growth rate for sedges is more complex relative to fall rye due to the nature of the long-term plot data, the perennial life history of the plant, and the effects of flooding on growth. Data that can be used to compute sedge growth was only collected on one date within each growing season, so weekly estimates of growth rate must be computed by fitting to a series of annual estimates. In addition, sedges can survive when inundated and the elevations of the long-term plot data used in this analysis (435-437 m.s.l.) were inundated in most years. Thus any estimate of the maximum growth rate based on these data includes the effects of flooding. As the long-term plot data did not span a large range of elevations with very different inundation frequencies (because vegetation has extended in elevation from approximately 436 m.s.l in 1990 to 434 m.s.l. in 2000), it is not possible to directly estimate both the maximum growth rate (*gBase* in eqn. 5) and the parameters that determine the reduction in growth due to inundation (eqn. 6).

Data on sedge basal diameter (B.D.) and number of sedges per unit area is available from 1993 to 2001 at long term monitoring sites in dust control areas P, G, and K (Moody 2002b). These data were converted to biomass estimates by developing a linear relationship between plant weight and basal diameter for plots at elevations above 436 m.s.l. (Dry Weight = 6.26 * BD – 37.54, $r^2 = 0.88$, n= 15 plants) where effects of inundation on plant diameter-weight relationships were relatively consistent. The converted long-term plot data shows an initial sedge biomass in 1992 of approximately 20 gC/m^2 for areas P and G, increasing to values of about 200 gC/m^2 by 2000-2001 (Fig. 7). Data from dust control area

K were excluded from the analysis because plant biomass was considerably reduced due to foraging by Canada Geese (A. Moody, pers. comm.). The growth rate parameter of a logistic model (*gBase* of eqn. 1) was then fit to data from areas P and G while holding the carrying capacity value constant (K in eqn. 1) at the maximum observed biomass level of approximately 650 gC/m^2) (Fig. 5, Table 1). The growth rate was estimated by fitting the dynamic model predictions from the long-term plot elevation (435-436 m.s.l.) to the trajectory of observed biomass levels at these plots (Fig. 7). Under ideal conditions (no reductions in growth rate due to wet or dry stress), this estimate of the maximum growth rate predicts that a barren plot can achieve maximum biomass levels in about 10-12 yrs.

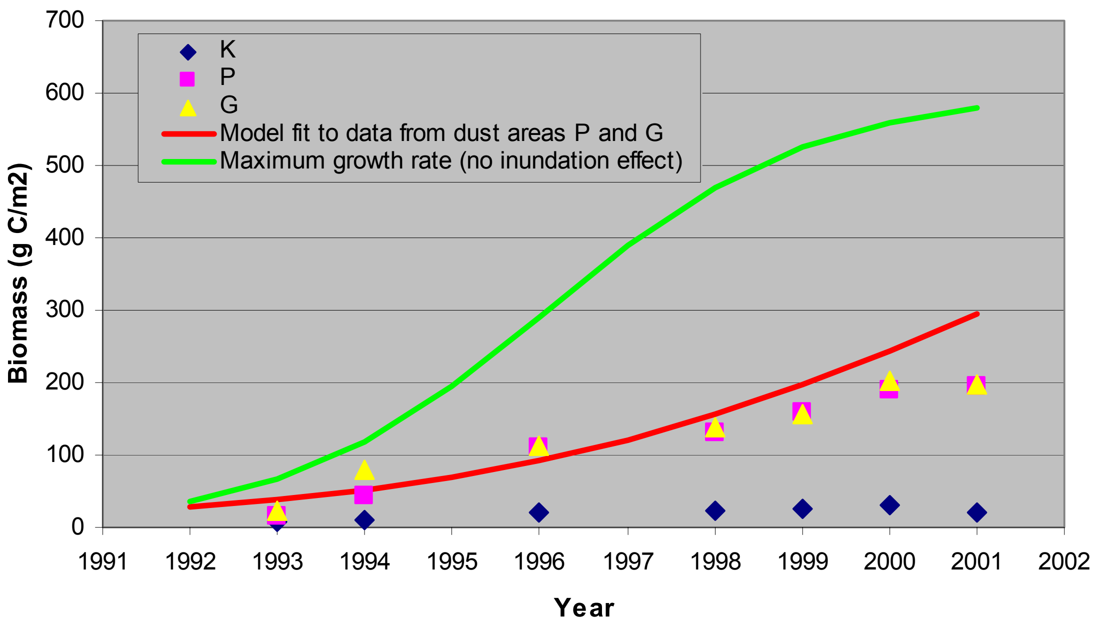


Figure 7: Biomass of sedges from long-term monitoring plots in dust control areas K, P, and G (A. Moody, unpublished data) in the Arrow Reservoir. A logistic growth model (red line) was fit to data from areas P and G. The increase in biomass assuming no inundation effects (green line) is shown for reference.

Data to estimate growth rates for other vegetation groups were not available in the Arrow system. There is no long-term or within-season plot data for horsetail, reed canary grass, willows, or cottonwood. Growth rates for these vegetation groups were derived by setting their values relative to the growth of sedge using the following assumptions: 1) horsetail grows at the same rate as sedge (0.015 gC/m^2/wk); 2) reed canary grass, willow and cottonwood grow two times faster than sedge (0.03 gC/m^2/wk). These assumed relative differences in growth rates are highly uncertain.

Wet and Dry Stress Growth Adjustments

Parameters controlling the computation of growth reduction multipliers resulting from wet and dry stress (*WetHf, WetSl, DryHf, DrySl* from eqn. 6) could not be computed directly from field data. To do this, one would need a multi-year dataset that measured above-ground biomass at a range of elevations with different wet and dry stress levels. Sedge was the only vegetation group monitored in Arrow Reservoir over successive years and unfortunately, only within a narrow elevation band (435-437 m.s.l.) relative to the current distribution of this group (Fig. 4). Growth reduction parameters were therefore tuned by running the model with the historical reservoir elevation schedule from 1990-2000 and comparing the predicted biomasses at each elevation in 2000 with rough estimates of the observed values in the same year measured from the mapping analysis (Fig. 4, Moody 2002a).

Cover-to-Biomass Conversion Rates

The ratio of % crown cover to biomass (CB_{iv}) was estimated from field data collected in Arrow Reservoir in 1999 and 2000. Ratios for horsetail (0.23, r^2= 0.51), reed canary grass (0.13, r^2=0.63), and sedge (0.69, r^2 =0.69) were estimated (Fig. 5). Data for other vegetation groups were not available so the following estimates were assumed: fall rye=0.03; willow and cottonwood=0.1 These estimates are highly uncertain.

2.4.3 Seedling Establishment Parameters

There was no field data available to fit parameters of the seedling establishment component of the vegetation model, and there was little useful information available from the literature. The following assumptions were made (Table 1):

1. Cover following seedling establishment was set to 5% for all vegetation groups except for fall rye, which was set to 0. This ensured that fall rye did not naturally reproduce and would only grow if planted.

2. The seedling establishment period spanned from mid-July to mid-October for all vegetation groups except for Willow, where the period was greater and ran from mid-May to mid-October.

3. 5 consecutive weeks were required to establish seedlings for reed canary grass and sedge, while 10 wks were required for willow and cottonwood.

4. Seedlings from all vegetation groups could withstand up to 5 weeks of inundation except for Willow, which could only withstand 1 week of inundation.

5. Seedlings from all vegetation groups were not sensitive to dry stress with the exception of horsetail and cottonwood.

While many of these assumptions are not supported by data, they have little effect on the model in most cases. Model predictions are driven by initial cover estimates at each elevation and growth/survival parameters for mature plants. The only time seedling establishment parameters come into play is when a vegetation group is eliminated from an elevation band due to wet- or dry stress-related mortality. In these situations, the seedling establishment component determines whether the vegetation group can re-establish in a particular year. This establishment process is suspected to be dominated by effects from the fall rye planting program.

2.5 DYNAMICS OF VEGETATION MODEL

An example of the effects of reservoir elevation on stress statistics and plant growth rates at 3 elevation bands (430, 435, and 440 m.s.l.), using the Arrow Reservoir water surface elevations for 2000, is provided in Figure 8. As water surface elevation increases from the start of the growing season (Julian week 14, or April 15), wet stress (eqn. 3) begins to accumulate when the water surface exceeds the elevation of the band (Fig. 8a). Wet stress attains higher values at lower elevations that are submerged to greater depth for longer periods. Dry stress (eqn. 4) accumulates quickly at higher elevations at the beginning of the growing season when the difference between these elevations and the water surface is greatest (Fig. 8b). The functional relationships (eqn. 6) predicting the responses of the maximum growth rate to stress levels are shown in Figure 8c. Based on the parameter values and stress statistics (Fig. 8a and b) used in this example, growth rates (Fig. 8d) attain near maximum values at the intermediate elevation (435 m.s.l.), are severely impaired at the lowest elevation (430 m.s.l.) when the wet stress level exceeds about 80 meter-weeks, and moderately impaired at the highest elevation (440 m.s.l.) due to the dry stress (ca. 140 meter-weeks) accumulated during the initial two months of the growing season.

Time series of model projections of vegetation biomass at 432, 436, and 440 m.s.l. using the historical Arrow Reservoir water surface elevations from 1990-2000 are presented in Figure 9. Model predictions match observed elevation gradients in biomass (Fig. 4) relatively well. The distribution of horsetail-dominated communities is limited at the upper elevation by dry stress and cannot grow at the lowest plotted elevation due to wet stress. Relative to reed canarygrass- and sedge-dominated communities, biomass of horsetail-dominated communities is relatively low due to the lower carrying capacity estimate used in the model (Table 1). In contrast, reed canarygrass-dominated communities attain much higher biomass levels due to their higher carrying capacity and growth rate estimates. Sedge-dominated communities achieve higher biomass levels at lower elevations relative to reed canarygrass ones, and although sedge-dominated communities have the same carrying capacity as reed canarygrass ones, biomass levels of the former vegetation group are lower due their lower maximum growth rate. In contrast to the other vegetation groups shown, sedge-dominated communities can colonize lower elevation bands because of their higher tolerance to wet stress (Fig. 10).

On a reach-wide basis, predictions of the distribution of vegetation across elevations match the observed data relatively well (Fig. 9 vs. Fig. 4), however, on a site-specific basis there can be significant discrepancies. For example, in dust control area 'N' (Fig. 1), the model predicts a low-biomass sedge-dominated community (Fig. 10) while the mapping data shows that the area is mostly unvegetated except for small areas at higher elevations (Moody 2002a). Note that model predictions of vegetation biomass at an elevation band are not site-specific because the model does not include site-specific factors (e.g., aspect, substrate, fall rye planting history). Site-specific factors were not included in the model because the existing data and understanding was not sufficient to quantify relationships between planting history, substrate, aspect, etc. with key processes like plant survival and seedling establishment. In other cases, discrepancies at a site-specific level reflect the quality of the DEM. For example, the model predicts vegetation presence in the river channel (e.g., river channel in area K, see Fig's 1 and 10) because the elevations in these areas as specified by the DEM are incorrect. The current DEM used in the model was developed from an air photograph, so elevations for the topography in the river channel is incorrectly measured as the water surface elevations, not the elevations of the land.

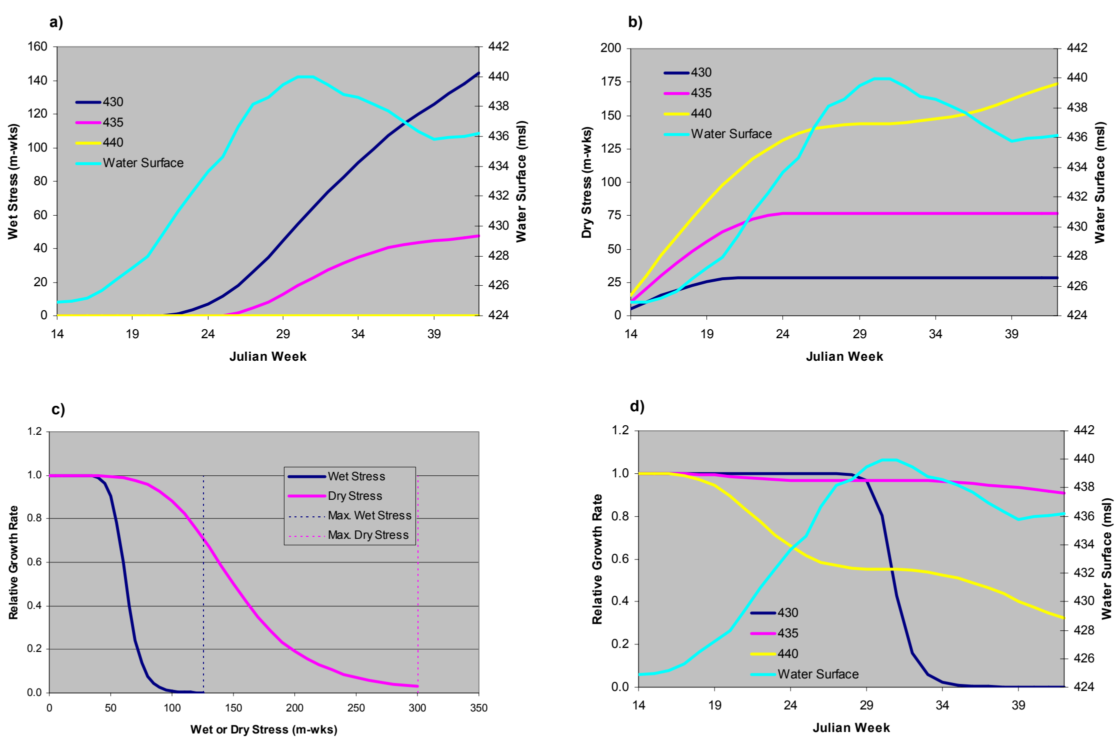


Figure 8: The simulated effects of wet and dry stress on the growth rate of plants in the vegetation model. In this example, water surface elevation in Arrow Reservoir from 2000 drives model predictions at 3 elevation bands (430, 435, and 440 m.s.l.). Wet (a) and dry (b) stress statistics accumulate as a function of the depth and duration of inundation and exposure over the course of the growing season. Functional relationships (eqn. 6) determine the relative change in the maximum growth rate that will occur as wet and dry stress levels increase (c). The actual reduction in the maximum growth rate (d) results from the combined effect of wet and dry stress levels (a, b) and the functional relationship determining the growth response to these stresses.

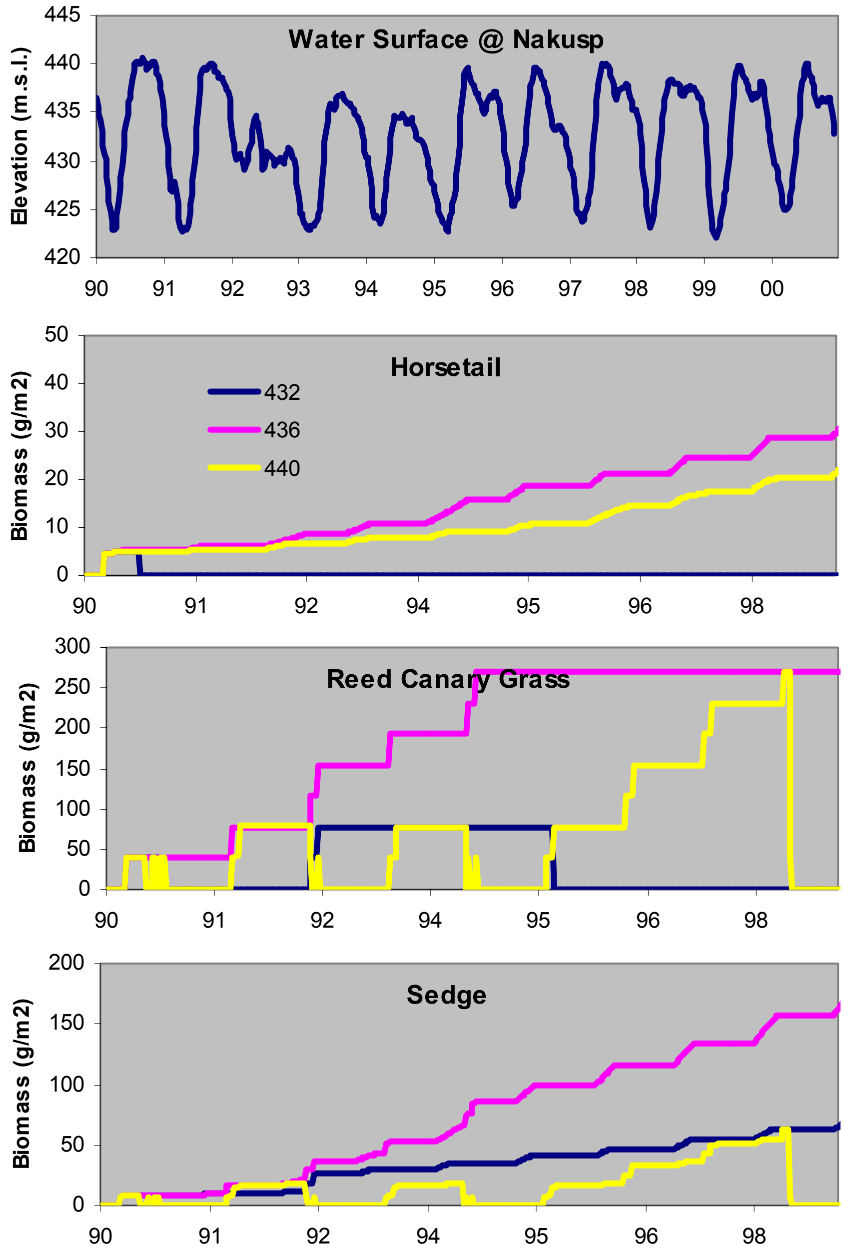


Figure 9: Arrow Reservoir water surface elevations at Nakusp (1990-2000) and the predicted biomass trajectories for horsetail, reed canary grass, and sedge at 3 elevations.

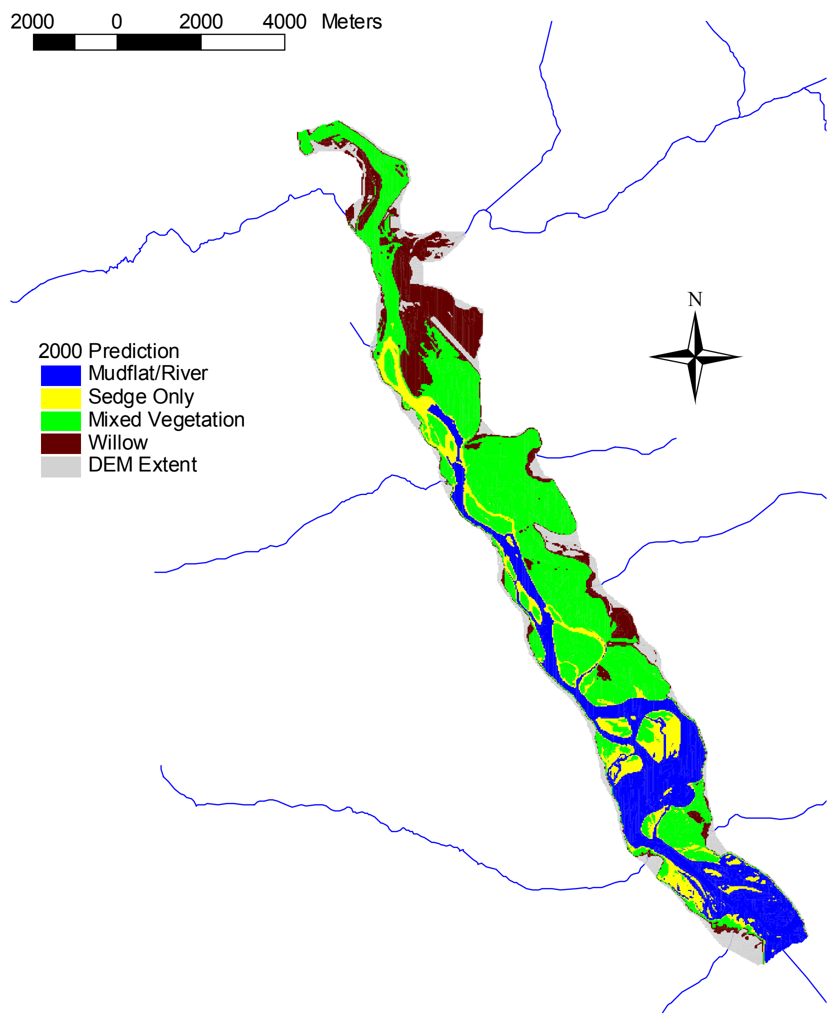


Figure 10: Map of the Revelstoke Reach of Arrow Reservoir showing the predicted distribution of willow (437-440), mixed vegetation (mostly reed canary grass with some sedge and small amounts of horsetail at elevations 433-437), sedge only (431-433), and barren substrate (< 431). The map shows results from 2000 from an 11 yr. simulation beginning in 1990 using the historical reservoir elevation schedule.

The vegetation model has been used to compare alternate reservoir operating strategies in both the Bridge and Columbia River WUP processes. An example of such a comparison is given in Figure 11 where elevation schedules for Arrow Reservoir were provided by BC Hydro operations modelers based on below average inflows to simulate a range of alternatives in a typical dry year. It is clear that '1-Dry' scenario provides the best conditions for both sedge and willow. The lower elevations during the latter half of the growing season allows sedge to extend down to 431 m.s.l. and willow to 436 m.s.l. Scenarios '0-Dry' and '2-Dry' maintain full pool elevations for about ½ of the growing season. As a result, willow distribution is limited to 439-440 m.s.l. The patterns of sedge distribution under '0-Dry' and '1-Dry' scenarios are similar and are mostly controlled by wet stress. The greatest biomass levels are achieved at the highest elevations that are also the driest.

2.6 KEY UNCERTAINTIES IN MODELLING RIPARIAN VEGETATION

Development of a computer simulation requires the articulation of key hypotheses that drive the predicted responses of modeled variables (e.g., vegetation biomass) to management actions. To fit the parameters of the models that embody these hypotheses, existing data must be compiled and analyzed. Difficulties in parameterizing these models highlight deficiencies in the data, and can therefore identify improvements for future research and monitoring programs. The primary focus of the Upper Arrow revegetation program has been dust control since it was implemented in the 1980's. However, as ancillary ecological benefits became apparent, a small monitoring program developed. , The combination of limited funding for monitoring, and limited knowledge about potential vegetation responses to planting and reservoir operations early in the program, has resulted in a dataset which provides only a limited quantitative understanding of the response of native plants to alternate planting regimes and reservoir operation scenarios.

Two major weaknesses in our understanding of the response of vegetation to reservoir operations and fall rye planting were identified in the development of the vegetation model for the Revelstoke Reach of Arrow Reservoir. Separation of the effects of wet and dry stress on growth, survival, and seedling establishment was problematic due to an almost complete absence of informative data on changes in vegetation over time. Although data from vegetation sampling began in 1991, changes in methodology and relatively uninformative sampling designs limited the utility of this information for making representative and quantitative statements about changes in vegetation. Fall rye is the only vegetation group where we have good information to estimate growth rates because only within-season data is required. For other vegetation groups, a multi-year dataset is required, which only exists for sedge (Moody, 2002b). Unfortunately, there was little variation in elevation among the long-term sedge monitoring sites. Consequently all these sites experienced similar wet and dry stresses over the duration of monitoring, making it impossible to tease-out the effects of these stresses on growth and survival. There is no long-term monitoring data available for other important vegetation groups like reed canary grass, willow, and cottonwood. This is a significant data gap as reed canary grass is the dominant vegetation group in the Revelstoke Reach at the lower elevations influenced by hydro operations (Fig. 4), and the latter two groups provide valuable wildlife habitat as documented in a recent study (J. Jarvis and J. Woods, Parks Canada, Revelstoke, B.C., unpublished data).

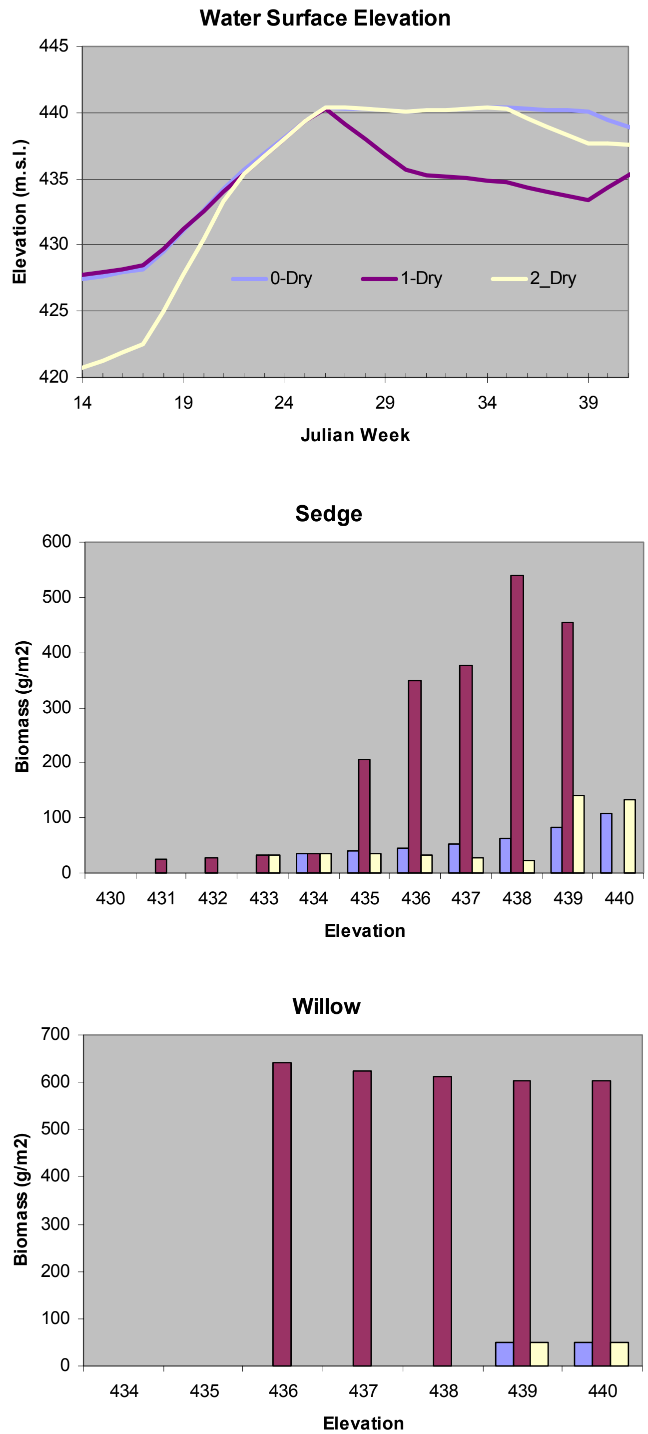


Figure 11: Model predictions of sedge and willow biomass in the Revelstoke Reach of Arrow Reservoir (bottom graphs) based on alternate water surface elevation schedules (top graph) being considered in the Columbia River Water Use Planning process. Reservoir elevations were provided by BC Hydro operations modellers' based on input hydrology from a typical dry year where inflows are lower than normal.

A recent mapping exercise (Moody, 2002a) attempted to quantify the changes in vegetation distribution over time. Such data would have been very helpful to estimate survival, growth, and seedling establishment parameters for all vegetation groups. However, technical problems and the restricted scope of the study limited its utility for modeling. The classification of vegetation varied considerably among the 4 years when air photographs were available due to differences in the scale and color of the photographs. Thus, the historical air photograph analysis could not quantify changes in the distribution of vegetation groups over time except in the grossest sense (e.g., area of vegetated vs. barren terrain). Only the 2000 air photographs, which had sufficient detail to classify polygons by vegetation group and relative density, provided useable data for the model. However, with only one year of data, the effects of wet and dry stress on growth, survival, and seedling establishment are heavily confounded. That is, we can fit the predicted distribution of vegetation groups and biomass classes across elevations to the 2000 data through many different combinations of survival, growth, and seedling establishment parameters. Confounding among parameters increases uncertainty in model predictions. The spatial extent of the mapping exercise was also limited to the northern dust control areas (F-T), so inferences about changes in vegetation at higher elevations (>436 m.s.l., see Fig. 3), in the southern portion of the Revelstoke Reach (Fig. 1), and for the most important vegetation for wildlife (willow and cottonwood) are either very limited or impossible to make from the available data.

The other major uncertainty identified in the model development process was the lack of quantitative understanding of the effects of fall rye planting on native vegetation establishment. A number of hypotheses for why natural vegetation has established in areas previously planted with fall rye were identified by participants during the model building process:

- Fall rye planting and fertilization increases the carbon and nutrient content of the substrate leading to higher seedling establishment rates;

- Fall rye protects fragile seedlings from high winds and hot temperatures that could jeopardize their survival;

- The presence of fall rye 'stubble' helps retain seedlings that would otherwise be washed or blown away; and

- The mechanical action of the drill seeding process pushes native seeds into the substrate and potentially enhances their survival.

Unfortunately, there is little data to quantify these hypotheses. The elevations and areas where fall rye has been planted have not been recorded in sufficient detail. Even if this information were available, there is no systematic long term monitoring of natural vegetation in areas that were exposed to different treatments (different planting intensities, durations, fertilization rates, etc.). Consequently, the hypotheses outlined above cannot be tested from the available data or developed into quantitative models that can be incorporated into the simulation framework.

One of the key reasons for predicting vegetation responses to reservoir operations and fall rye planting is to make inferences about potential benefits to wildlife habitat. Recent studies by Jarvis and Woods (Parks Canada, Revelstoke, B.C., unpublished data) document how songbird species diversity and abundance varies by vegetation group in the Revelstoke Reach of Arrow Reservoir. These data were collected from a statistically sound design and are representative and informative. An obvious next step in the analysis of this information is to link the point count data with the vegetation biomass mapping data from Moody (2002a) to develop statistical models predicting diversity and abundance as a function of vegetation group, vegetation biomass, and other factors. Once these statistical models are developed they could easily be integrated into the simulation framework to make predictions about changes in songbird habitat under different operational strategies. Preferences of ducks and geese to vegetation and flooding conditions are generally known but not well quantified, but will need to be if they are to be included in a wildlife habitat simulation model.

3.0 LITTORAL PRODUCTION OF BENTHIC INVERTEBRATES

3.1 LITTORAL MODEL STRUCTURE

Benthic invertebrate production and community structure in reservoirs can be severely affected by fluctuations in water surface elevations. Larger forms (Ephemoeroptera, Gammarus) are typically replaced by smaller forms (Oligochaeta, Chironomidae) and total biomass is reduced. Hellsten et al. (1996) developed a model predicting the dry weight of macrozoobenthos in the 0-3 m depth zone (B, in mg dry wt/m^2) based on data from twelve Finnish lakes and reservoirs,

$$B = 10^{4.25 - 1.33 \log(\frac{W_y}{D_s} 100)} \tag{10}$$

where, W_y is the annual water level fluctuation (m) and D_s is the secchi depth (m). Perrin et al. (2002) measured a mean total benthic biomass in the Revelstoke Reach of the Arrow Reservoir in barren soils of about 50 mg dry wt/m^2 and a macrobenthic (> 1mm) biomass of 7 mg dry wt/m^2. Based on the average secchi depth during the sampling period (3 m) and the 15 m yearly water level fluctuation in 2000, Hellsten et al.'s (1996) model predicts a macrobenthic biomass of 5 mg dry wt/m^2, quite close to the value measured by Perrin et al. (2002). Hellsten et al.'s model predicts a macrobenthic biomass in a more natural environment with fluctuations of 1 meter per year of 170 mg dry wt/m^2. The modeling results, coupled with Perrin et al.'s data, indicate the benthic production in the littoral zone of Arrow Reservoir is severely impaired, and that the effects of water level fluctuations must be accounted for in any model that tries to predict the response of benthos to different operations.

Flooding of terrestrial vegetation is known to stimulate benthic invertebrate productivity by providing additional substrate for colonization and by releasing nutrients required for autotrophic and heterotrophic production. Perhaps the best-known documentation of this dynamic is the “Flood Pulse Concept” of Junk et al. (1989). The drawdown zone of a reservoir is identical to the “aquatic / terrestrial transition zone” or “moving littoral zone” described by Junk et al. Recent studies in Arrow Reservoir (Perrin et al. 2002) have quantified the additional contribution of submersed terrestrial plants to benthic invertebrate biomass. The extent of the enhancement in the Arrow Reservoir was shown to be a function of the vegetation type and the period of inundation.

A simple benthic littoral production model was developed to simulate these processes on an annual timestep for 1-meter elevation bands in the reservoir. Mean benthic invertebrate biomass in barren substrates at all elevations that are wetted is assumed to remain at a constant value ($BenBio_{barren}$). This assumption is supported by data from Perrin et al. (2002), who showed that biomass measured at 10 and 80 days after inundation in barren substrates was fairly similar. The vegetation model tracks the biomass of vegetation groups and duration of inundation at 1-meter elevation bands over the course of the growing season (Section 2). The maximum biomass of each vegetation group ($MaxTotBio_{iv,ib}$) and maximum inundation period for each elevation band ($FloodWks_{ib}$) over the growing season is used as input to the benthic biomass – plant weight relationships developed by Perrin et al. (2002) to predict the additional biomass produced from flooded vegetation ($BenBio_{veg,iv,ib}$),

$$BenBio_{veg,ib} = \sum_{iv=1}^{6} MaxTotBio_{iv,ib} * (BenVegConst_{iv} + BenVegSlope_{iv} * FloodWks_{ib}) \quad (11)$$

where, $BenVegConst_{iv}$ and $BenVegSlope_{iv}$ are the slopes and constants of vegetation group-specific linear regressions. The maximum total plant biomass for each vegetation group-elevation band combination is computed as the sum of above and below-ground biomass, where the above-ground biomass is computed from eqn. 1, and below-ground biomass is computed by multiplying above-ground biomass by the root-to-shoot ratio (RS_{iv}), which is specific to each vegetation group. The total biomass of benthic invertebrates at each elevation band is the sum of the barren-ground estimate plus the sum of the additional contribution provided by all vegetation groups.

The total production of benthic invertebrates in the reservoir over the growing season (*PBen*) is computed as the product of the sum of benthic biomass across all elevations and the turnover rate, also termed the production-to-biomass ratio (*PtoB*),

$$PBen = \sum_{ib=MinElev}^{MaxElev} (BenBio_{barren} + BenBio_{veg,ib}) * PtoB * \frac{FloodWks_{ib}}{GrowWks}, \qquad (12)$$

where $FloodWks_{ib}$ is the number of weeks each 1-meter elevation band is inundated over the growing season, and *GrowWks* is the total number of weeks in the growing season. The latter ratio is an adjustment that accounts for the effect of the period of inundation on the opportunity for benthos to turnover.

3.2 PARAMETERIZATION OF LITTORAL MODEL

A barren-ground benthic invertebrate biomass ($BenBio_{barren}$ from eqn. 12) of 50 mg dry wt/m^2 was used in the model based on the average value measured by Perrin et al. (2002) in the Revelstoke Reach of Arrow Reservoir in 1999. A production-to-Biomass ratio (*PtoB* from eqn. 12) of 10 was used, based on the average value of estimates provided from the literature documenting studies of chironomid production in temperate oligotrophic lakes (Waters 1969, Benke 1984), one of the common taxa found in the Revelstoke Reach benthic samples.

Root to shoot (RS_{iv}) ratios were used to convert above-ground biomass of each vegetation group estimated by the model (eqn. 1) to total plant biomass values required by the plant-benthic invertebrate relationships (eqn. 11). Ratios for sedge (RS_{iv} = 3.2, see Table 1), reed canarygrass (2.5), and fall rye (0.65) were computed from field data collected in Arrow Reservoir in 1999 and 2000 (AIM and CARR 2002). Root to shoot ratios for other vegetation groups (horsetail, willow, and cottonwood) do not influence the benthic invertebrate biomass computations as it was assumed that these vegetation groups do not make any contribution to the biomass of invertebrates when flooded. This is a reasonable assumption as the vegetation biomass from these groups is either very limited (horsetail), or distributed over high elevations (willow and cottonwood) that are rarely inundated.

The linear relationships used in the model for predicting the contribution of benthic invertebrate biomass from flooded vegetation as a function of the inundation period and total plant biomass (eqn. 11, Perrin et al. 2002) are shown in Figure 12. Estimates are only available for fall rye, sedge, and reed canary grass. Invertebrate biomass tended to increase for fall rye and sedge with the period of inundation, so in these cases, a regression model fit to the data without a constant ($BenVegConst_{iv}$=0, i.e., no inundation = no invertebrate contribution) was used to estimate the slope ($BenVegSlope_{iv}$). For reed canary grass, there was no evidence that inundation period affects the plant-specific biomass of invertebrates. In this case the slope of the regression was set to zero and the average plant-specific biomass of 1.3 mg dry wt/g plant was used as the constant.

It was assumed that additional benthic invertebrate production from flooded horsetail, willow, and cottonwood is minimal for reasons described above, hence constant and slope parameters for these vegetation groups were set to zero.

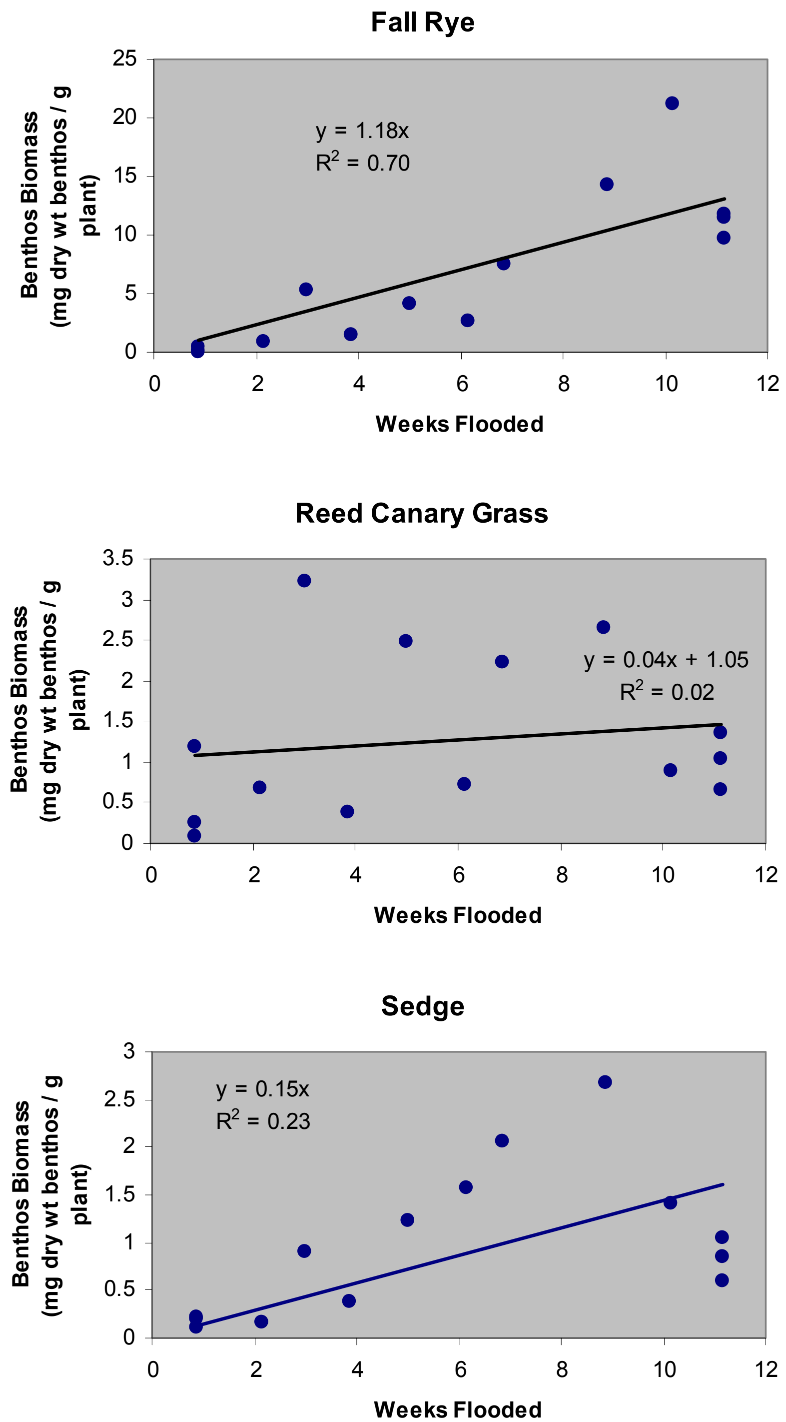


Figure 12: Relationships between plant-specific benthic invertebrate biomass (mg dry wt invertebrates / g plant, dry weight) and inundation period for fall rye, reed canary grass, and sedge (data from Perrin et al. 2002).

3.3 DYNAMICS OF LITTORAL MODEL

The contribution of fall rye, and to a lesser extent reed canary grass and sedge, to the total littoral biomass in the Revelstoke Reach of Arrow Reservoir is potentially very large (Table 2). Fall rye generates about 12 mg dry wt/g plant after 10 wks of inundation, a value that is almost an order of magnitude higher than the estimates for sedge and reed canary grass. Fall rye can achieve maximum biomass levels that are about 5-fold higher than those for sedge and reed canary grass (Table 1). Taken together, these data imply that flooded fall rye generates about 50 times more benthic invertebrates per m^2 relative to that from sedge or reed canary grass in situations when these vegetation groups are at maximum biomass levels. However, inundated fall rye rarely occurs at its carrying capacity as growth stops following inundation, so the typical production from fall rye will be less then the theoretical value presented above. Based on the 1999 submergence study (Fig. 5 from Perrin and Stockner 2002), benthos biomass from fall rye (at the intermediate elevation of 431.2 m.s.l.) was typically 2-fold higher compared to the biomass values associated with sedge or reed canary grass.

When plant specific benthic invertebrate estimates from Perrin and Stockner (2002) are applied to the portion of the Revelstoke Reach contained by the DEM that is likely to support vegetation of any kind (431-440 m.s.l., Fig.'s 1 and 2) it is clear that flooded vegetation can provide an enormous benefit to benthic invertebrate biomass (column 3 of Table 2). Under current conditions in areas where we have sufficient data (mapped polygons of vegetation in dust control areas F-T by Moody 2002a), sedge and reed canary grass biomass levels are generally well below maximum values. The additional contribution to benthic biomass from sedges in the dust control areas is about equivalent to the biomass produced by barren substrate in unvegetated areas (1090 Ha). Reed canary grass development is more extensive, and produces about a 4-fold higher contribution to benthic biomass relative to either sedge or barren substrate. In contrast, if the entire 500 Hectares of the vegetated area was composed of fall rye that grew to 50% of its maximum biomass levels (plants about 50 cm high), the contribution would be about 35-fold higher relative to that provided by the combined contribution from sedge and reed canary grass.

Table 2: Estimates of benthic biomass contributions from barren substrate and flooded vegetation in the Revelstoke Reach of Arrow Reservoir. Plant specific-benthic biomass estimates are from Perrin et al. (2002). Maximum biomass estimates are from A. Moody (AIM Ecological Consultants, unpublished data). The 4th column computes the benthic biomass over the entire area of the DEM at elevations between 431 and 440 m.s.l. (ca. 3500 Ha) assuming that the entire surface area is covered at maximum biomass levels for each vegetation group (or covered with barren substrate). The last column computes benthic biomass for vegetated polygons in the dust control areas mapped by Moody (2002a, 500 vegetated Ha out of a 1590 Ha total in dust control areas F-T) and represents the approximate inputs under current conditions.

Substrate Type	Plant Specific Benthos Biomass (mg dry wt / g Plant) after 10 weeks of inundation	Maximum Plant Biomass (g/m^2)	Benthic Biomass (tons) @ Maximum Plant Biomass over DEM from 431-440 m.s.l. (3500 Ha)	Benthic Biomass (tons) @ Current Conditions in Dust Control Areas F-T (500 Ha mapped out of 1590 Ha total)
Barren	50[1]		2	0.5[2]
Fall Rye	11.8	3000	1,246	88.6[3]
Reed canary grass	1.3	650	30	2.0[4]
Sedge	1.5	650	33	0.4[4]

[1] Barren substrate value has units of mg dry wt/m^2

[2] Based on barren area estimate for dust areas F-T of 1090 Ha (=1590 total – 500 vegetated)

[3] Assumes that entire vegetated area of dust control areas F-T (500 Ha) is covered with fall rye growing to 50% of it's maximum biomass level.

[4] Biomass of reed canary grass and sedge used in these computations based on translating the areas of Moody's (2002a) density classes into the following biomass equivalents (Incipient = 111 g C/m^2, Low = 278 g C/m^2, Medium=444 g C/m^2, High = 650 g C/m^2).

Variation in benthic littoral production predicted by the model based on the 1990-2000 Arrow Reservoir water surface elevations (Fig. 13) demonstrates the effects of both water surface elevation and riparian vegetation biomass. In this example, an index of naturally growing vegetation biomass that potentially contributes to littoral production is computed as the sum of reed canary grass and sedge biomass at 435 m.s.l. The simulations do not include the contribution from fall rye. Biomass increases over the course of the simulation as the vegetation expands from the low cover estimates used to initialize the simulations. The total benthic production (yellow line), which includes contributions from both barren sediment and flooded vegetation, is driven mostly by the increase in vegetation. In years when the reservoir does not fill to near-full pool levels (e.g., 1992 to 1994), very little riparian vegetation is flooded, hence littoral benthic production is produced. The benthos biomass contributed by barren substrate (magenta line) is not dependent on vegetation biomass and only responds to direct effects from changes in water surface elevations across years. In years when the reservoir fills, the wetted surface area over which production can occur, and the proportion of the growing season available for benthic production (eqn. 12), are both higher, leading to higher production values.

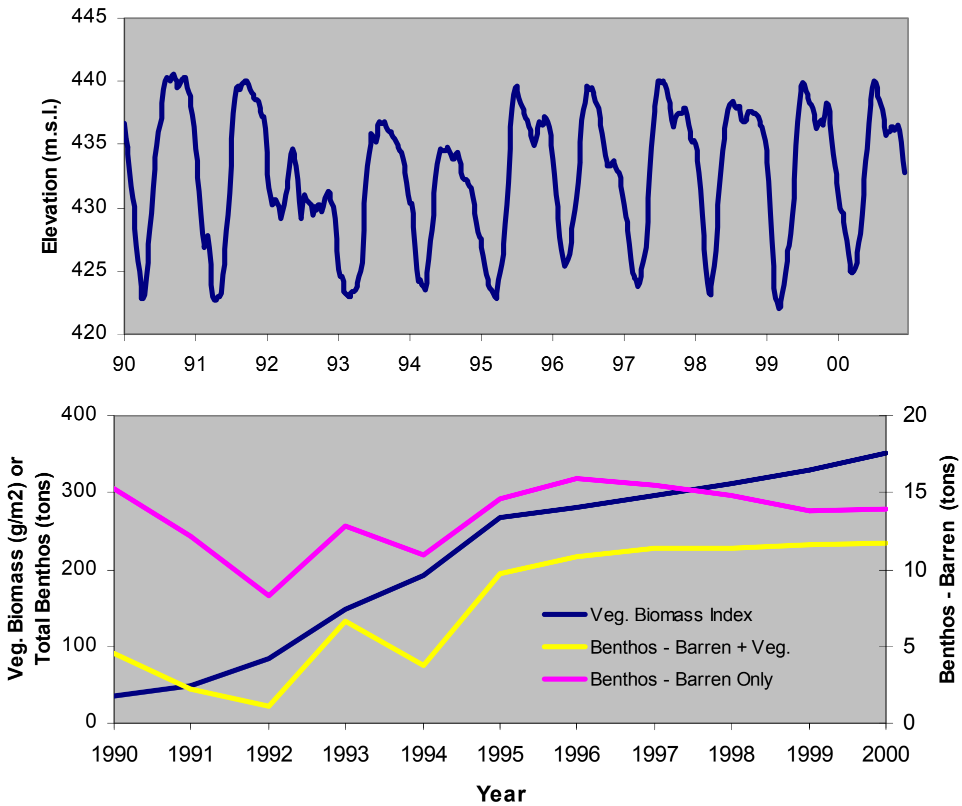


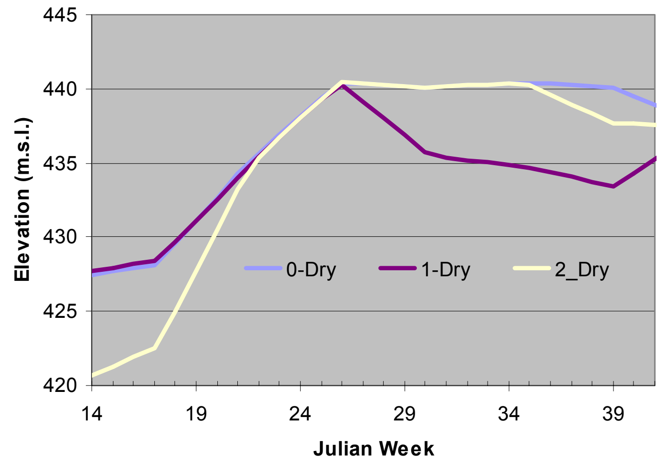
Figure 13: Time series of historical Arrow Reservoir water surface elevations at Nakusp and responses of riparian vegetation and benthic invertebrate production predicted by model. The sum of reed canary grass and sedge biomass at elevation 435 m.s.l. is plotted (blue line) as index of vegetation biomass that contributes to total benthic production over the growing season (yellow line). The benthic production that would be produced in the absence of any enhancement from flooded vegetation is also shown (magenta line on secondary axis).

An examination of the effects of some operating strategies for Arrow Reservoir being considered as part of the Columbia River WUP process on benthic production in the littoral zone is shown in Figure 14. In the absence of any vegetation effect on benthic production (blue bars), scenarios ‘0-Dry’ and ‘2-Dry’ produce the greatest benefits because the reservoir fills and is maintained at full pool for a much longer period of time relative to the ‘1-Dry’ scenario. This increases both the total area of substrate that is flooded and the duration of flooding. When the effect of flooded vegetation on benthos production is considered (red bars), the ‘1-Dry’ scenario outperforms the others because it provides the greatest benefits for riparian vegetation due to the lower water surface elevations (Fig. 11), yet still floods these elevations for sufficient time to generate a significant contribution to the benthos. Operating regimes that attain full pool levels for long enough to stimulate benthic production, but short enough to allow extensive riparian development, are probably optimal for enhancing reservoir productivity in the littoral zone.

3.4 KEY UNCERTAINTIES IN MODELLING AQUATIC PRODUCTIVITY

Model predictions about the response of benthic invertebrates in the littoral zone to flooded vegetation are relatively certain due to the informative data collected by Perrin et al. (2002). Ideally, it would have been useful to quantify the biomass of terrestrial insects made available as fish food when plants are flooded. Other components of related studies that focused on bacterial-algal-microflagellate community structure, or the nutrient content of the flooded plants, did not provide any useful information for the model.

The ultimate objective of the aquatic productivity component of the model is to evaluate the impacts of operations and fall rye planting on fish communities. The littoral-benthic module makes predictions about the amount of food potentially available to fish, but this is only part of the story. There is large uncertainty about whether this additional food is translated into any benefits to fish populations such as increased growth or survival. Documenting the relative abundance of fish in vegetated and unvegetated areas as done by Perrin et al. (2002) may indicate fish preference, but it says little about whether the fish found at vegetated sites are gaining any energetic or survival benefits. Stable isotope analysis (SIA) could be used to determine the extent to which production of benthos in vegetated littoral zones contributes to the biomass of different fish species. Only a properly designed Adaptive Management experiment, where fish populations are monitored for many years before and after the initiation of a substantial fall rye planting program, will provide useful information for assessing population level effects. It is too late to conduct such an experiment in the Revelstoke Reach of Arrow Reservoir, but this approach should be considered for other systems prior to implementing large-scale fall rye planting programs.



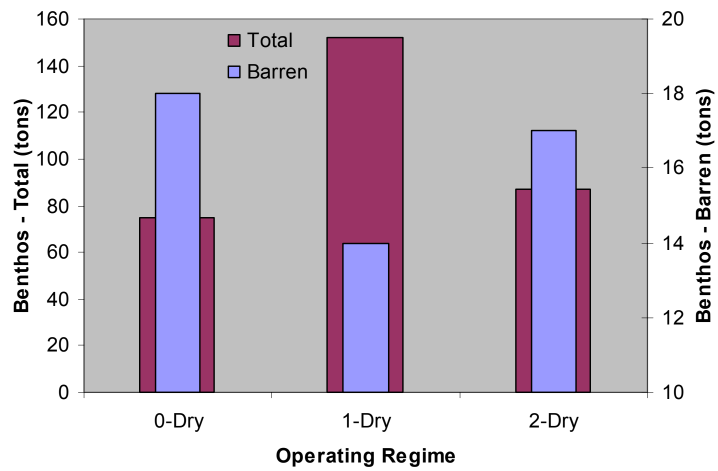


Figure 14: Model predictions of benthic production from the littoral zone (tons carbon over growing season) in the Revelstoke Reach of Arrow Reservoir (bottom graph) based on alternate water surface elevation schedules (top graph) being considered in the Columbia River Water Use Planning process. Reservoir elevations were provided from BC Hydro operations modellers based on input hydrology from a typical dry year where inflows are lower than normal. The lower graph shows the average total littoral benthic production (red bar, left-hand axis) and the production without including the enhancement from flooded vegetation (blue bars, right-hand axis).

4.0 RECOMMENDATIONS FOR THE DESIGN OF FUTURE MONITORING PROGRAMS AND MODEL IMPROVEMENTS

A key objective for any modeling exercise should be to expose data gaps and uncertainties in the processes that are being modeled. For many ecological models where data is limited and uncertainties are high, the benefits of meeting this objective often outweigh the utility of being able to make quantitative predictions about various policy alternatives such as water level management and planting. The development of the vegetation model for the Revelstoke Reach of the Upper Arrow Reservoir was very helpful in differentiating what we know about this system from quantitative and qualitative perspectives. While monitoring on this system has been conducted since the early 1990's and many numbers have been collected, our quantitative understanding on how vegetation has changed over time, and the response of this vegetation to inundation and fall rye planting, is quite weak. Section 4.1 provides a set of recommendations for improving future monitoring efforts based on the problems identified in the development of the vegetation model.

Development of a computer model is a continual process. As our understanding improves and more data becomes available over time, model structure and parameters can be refined to make better predictions. The review process of this document has identified improvements to model parameters that should be implemented in the next application of the model. Section 4.2 summarizes these improvements.

4.1 MONITORING RECOMMENDATIONS

A vegetation monitoring program should track changes in vegetation and seedling establishment over time, and help establish key relationships between survival, growth and various management practices such as planting and water elevation schedules. Quantifying of changes in vegetation is most important component of the monitoring program and should be accomplished by repeat sampling of plots and interpretation of aerial photographs. The selection of sampling plots should be based on a random-stratified design with the strata being defined by key variables that control the establishment, growth, and survival of vegetation (elevation, fall planting intensity, substrate, aspect). It is very important that these plots cover the potential range of elevations that could be colonized by terrestrial plants (and submerged marcophytes if appropriate). It is also important that sampling plots be established in areas that receive a range of fall rye planting intensities. Sampling should be conducted on a monthly basis from the start of the growing season, and all elevations that are not inundated should be sampled on each monthly period. Parameters to be measured at each sample plot should include cover, biomass (of roots and shoots), mortality of mature plants, and some index of seedling establishment. Measures of cover should be consistent across vegetation groups. Using different methods to estimate cover for different vegetation groups introduces unnecessary complications and error into any subsequent analysis. Plot boundaries should be spatially referenced to a reasonable degree of horizontal accuracy (+/- 2-5 meters) to assist in the interpretation of aerial photographs.

The interpretation of aerial photographs will provide a system-wide estimate of vegetation change over time. A DEM for the monitoring area should be developed and color photographs taken at a pre-determined intervals (e.g. every 3 yrs). The photographs for the DEM should be flown when the water surface elevation is at its lowest, usually in the early spring. For vegetation monitoring, the photographs should be taken early enough in the year to document before vegetation at lower elevations is flooded, but not too early so that vegetation has not had sufficient time to green-up. Ideally, field sampling of plots should be conducted close to the time air photographs are taken to assist in the interpretation. Analysis of the photographs should be based on modern image-processing techniques. The photographs should be rectified so they can be overlaid on the DEM. Algorithms should be developed to predict vegetation community structure and cover based on the color and intensity of each pixel. Such an approach would avoid problems encountered by AIM (2002a) where polygons classified as 'incipient vegetation' contained large areas of barrens substrate, resulting in substantial overestimates in the amount of vegetation cover. Plot data should be spatially linked to the photographs to develop the interpretation algorithms.

The development of the aerial photograph interpretation methods is a substantial task and should not be underestimated. The level of resolution at which these algorithms can predict community structure and cover is uncertain. It may be that manual interpretation is the only way to estimate community structure with any reasonable degree of resolution (e.g., AIM 2002a). In this case, a stratified random subsample of the total area covered by the aerial photographs will likely be required. The stratification should follow the same delineation developed for monitoring the plots. A combination of manual and automated interpretation should be explored. For example, community structure for plots could be estimated manually, with cover estimated by a computer algorithm.

The monitoring program should contain an experimental component that allows estimation of certain model parameters that could not be achieved by the monitoring activities described above. Quantifying the effects of inundation on survival and growth of seedlings and mature plants could be accomplished by experimental planting at a range of elevations. These areas would be sampled over the growing season to determine the proportion of seedlings and mature plants that died under different inundation conditions (duration and depth) and how their growth was affected. Similar experiments could be conducted to estimate the effects of dry stress. The feasibility of performing these experiments in the field should be compared to the feasibility and utility of performing them under more controlled conditions that could be attained in a greenhouse.

The bounds of the monitoring program should be carefully defined. The lateral and elevational extent of the monitoring area should include not only areas that are currently vegetated, but also include barren areas that have the potential to recover under conceivable planting and water management schedules. The types of vegetation to be monitored should be based on not only their dominance in the current community, but also on their importance to wildlife. There was virtually no monitoring of cottonwoods or woody shrubs (e.g., willow) in the Revelstoke Reach monitoring program, yet these vegetation groups are influenced by dam operations and very important to wildlife. A similar argument can be made for wetland species. The design of a vegetation monitoring should consider the needs of other programs. For example, if mammals and birds are monitored, ensure that the types of variables collected by the vegetation program are useful in the interpretation of the mammal and bird data. This argument is also relevant for linkages with aquatic productivity or fish population monitoring programs.

4.2 MODELLING IMPROVEMENTS

Refinements to vegetation model parameters effecting seedling establishment (Table 1) were suggested by W. Carr and A. Moody. A summary of these changes is presented in Table 3. A structural change to the seedling establishment component of the vegetation model was also suggested. The maximum number of flooded weeks that seedlings can tolerate will change according to the age of the seedlings (A. Moody, pers. comm.). The original values used in this modeling exercise (5 wks for most groups) are potentially too high for very young seedlings and too low for older seedlings. In general, seedlings less than one month old cannot tolerate any inundation and those greater than 3 months can tolerate inundations of up to 8 weeks. This dynamic could be simulated in the model by developing a functional relationship between the age of the seedling and the maximum wet stress that it can tolerate. While this improvement could be easily made, it should be noted that we have no data to tune or test the seedling establishment component of the vegetation model. Predictions of seedling establishment are highly uncertain, and increasing model complexity will not reduce this uncertainty.

Table 3: Refinements to vegetation model parameters that should be implemented for future applications of the vegetation model.

Parameter Description	Parameter Name	Vegetation Group	Original Value	Refined Value
First week of seedling establishment period	SeedWkMin	Fall Rye	28	16
Last week of seedling establishment period	SeedWkMax	Fall Rye	42	36
Number of consecutive weeks required for seedling establishment	SeedWks	All groups	5-10	8
Crown cover following seedling establishment	SeedIniCover	All groups	5	1
Maximum tolerable dry stress for seedlings	SeedMaxDryStress	All groups	600-1000	Higher values

A significant improvement to the littoral production model was suggested by C. Perrin (Limnotek Research and Development Ltd., Vancouver, B.C.). Benthos biomass at any one-meter elevation slice is the sum of barren substrate biomass and biomass on the roots and leaves of vegetation (eqn. 11). Benthic biomass in barren substrate is assumed to be independent of the inundation period. Perrin pointed out that this assumption in valid in barren substrate at lower elevations that are not surrounded by plants. At higher elevations, very little barren substrate was observed, and benthic biomass increased with inundation time, presumably in response to increased benthic biomass on plants adjacent to the barren substrate. To simulate this dynamic the following changes to the littoral model should be made. First, the amount of barren substrate for each one-meter elevation slice ($Area_{barren}$) should be computed as,

$$Area_{barren} = TotalArea * (1 - \sum_{i=1}^{MaxVegTypes} prop\_co) \tag{13}$$

where, *TotalArea* is the total area of the elevation slice and *prop_co* is the proportion of cover for each vegetation group at that model timestep. In cases where the total cover across all vegetation groups exceeds 1, no barren area will be present. The benthic biomass for this remaining area ($BenBio_{barren}$) would then be predicted based on the number of days since inundation (t) by the equation,

$$BenBio_{barren} = 4.33 * 10^{0.016*t} \tag{14}$$

The total benthic biomass for barren areas for any elevation slice is simply the product of the barren area (eqn. 13) and the unit area-biomass of this area (eqn. 14).

5.0 MODEL USER'S GUIDE

The vegetation and littoral-benthic models are incorporated into the Integrated Response Modelling (IRM) framework. IRM is a Visual Basic application that will run on PC-compatible computers under any of the Mircosoft Windows-based operating systems. This section describes how to install and use IRM.

IRM can incorporate multiple models that can be run in multiple areas within a watershed. The Bridge River configuration for IRM is extensive, incorporating over 13 different models that can be applied to as many as six modeling areas. The Arrow configuration is much simpler, consisting of only two models (Riparian Vegetation and Littoral-Benthic) in a single area, the Revelstoke Reach of the Arrow Reservoir. Note that this guide does not describe how to manipulate the input data files to incorporate additional models or areas into the IRM framework. This task requires an advanced knowledge of the modeling environment and is best left to the model developers.

5.1 SETUP

To install IRM on your computer, insert the IRM CD into your CD-Drive and click on the file 'setup.exe' to initiate the installation program. This program will copy IRM and supporting files onto your hard disk, and register the required '*.dll' and '*.ocx' files. You will be prompted to specify the directory where you want IRM to be installed. Two subdirectories will automatically be created below this directory (/Arrow and /Bridge). These subdirectories contain all the required data and parameter files to run IRM in the Bridge River and Columbia River watersheds.

5.2 RUNNING THE MODEL AND UNDERSTANDING THE OUTPUT

To start the model click on the file 'irm.exe' located in the directory where you installed the model. The main form of the IRM interface consists of three elements (Fig. 15). A menu system allows you to access a variety of dialogue boxes to control model output, parameter values, and hydrologic and planting scenarios. Below the main menu, output graphics are displayed as time series graphs and maps. At the bottom of the main form are a series of controls that let you define how the model will be run.

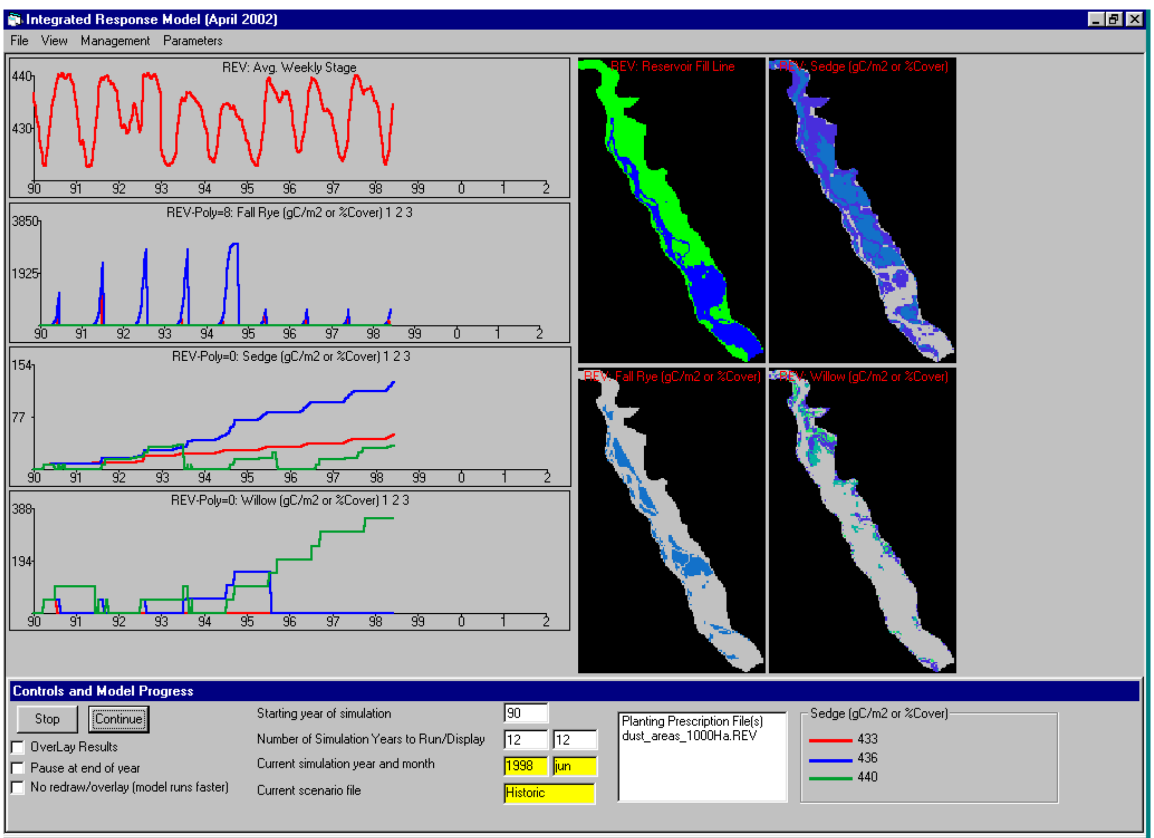


Figure 15: The main form of the Integrated Response Modelling (IRM) framework.

Click on the 'Start' button to begin a simulation. To temporarily suspend model execution click on the 'Pause' button. While the model is paused you can change parameter values or management actions or graphics. To resume execution, click on the 'Continue' button. To stop a simulation completely in order to restart from the start year, click on the 'Stop' button. The 'Pause at end of year' option forces the model to automatically pause after each simulation year is complete. You can define the starting year of the simulation, the duration of the simulation, and the number of years that will be displayed on the time series graphs. The 'Overlay results' option allows you to compare the previous simulation's results with values from a new run. To use this option, complete the first simulation, click on the 'Overlay results' check box, modify any parameters or management actions, and click on the 'Start' button to begin the second simulation. The results from the original simulation will be displayed as lines, while the more recent simulation results will be displayed as filled circular symbols. Clicking on a time series graphic will update the legend for the graph (defining what the lines represent) that is displayed in the lower-right corner of the main IRM form.

5.3 CONTROLLING OUTPUT GRAPHICS

To adjust the graphics that are displayed on the main IRM form, access the 'Set Graphics' dialogue box from the 'View-Select Graphics' menu item (Fig. 16). The hierarchical list on the left side of the dialogue box displays the models, the areas where each model can be applied, and the indicators that are specific to each model. You can 'drill-down' through this list to select indicators to plot. Clicking on an indicator will bring up a pop-up menu where you determine whether the indicator is displayed as a time series graph or map. When one of these items is selected, the indicator will appear in the list box on the right side of the dialogue box. For indicators that are specific to polygons and elevation slices (e.g., the vegetation biomass indicators), you must specify the polygon and elevation slices that will be plotted via the dropdown list boxes located below the list. These selections can automatically be applied to other indicators in the list by clicking on the 'Sync Elevations…' button. For time series graphs, the y-axis minimum and maximum can be specified. The order of an indicator on the output graphic component of the main IRM form can be adjusted by selecting an indicator and moving it up or down the list by clicking on buttons of the same name located below the list.

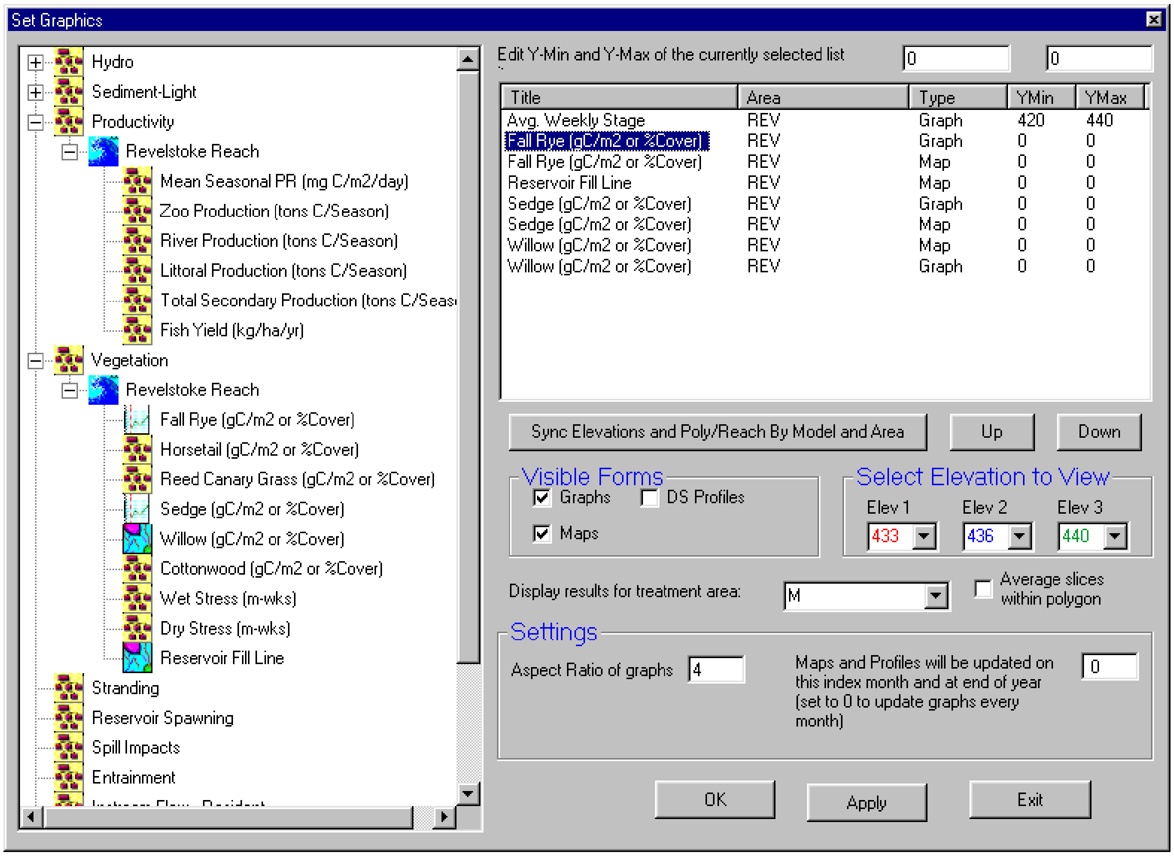


Figure 16: The 'Setup Graphics' dialogue box in IRM allows you to select indicators to plot as time series graphs and maps.

Once output configuration has been specified, click on the 'OK' button to dismiss the 'Set Graphics' dialogue box and implement the graphic changes. To implement the graphic changes without closing the dialogue box, click on the 'Apply' button. To exit the dialogue box and loose the changes you have made, click on the 'Exit' button. To save the graphic configuration to a project file ('*.prj), select the 'File-Save Project Settings File' menu item from the menu of IRM's main form. To restore a previously saved graphic configuration, select the 'File-Load Project Settings File' menu item.

The legends controlling the colors and breakpoints of the map displays can be adjusted by accessing the 'Legend Editor' dialogue box (Fig. 17) accessed by clicking on the 'View – Map Legends' main menu item or by selecting the 'Legend' item from the pop-up menu that appears when right-clicking on any of the maps. For each model indicator, which you specify by selecting the appropriate item form the 'Available Legends' dropdown list box, you can specify whether you want a continuous or categorical color range. With a continuous range, 50 colors will be used to represent the range of values between a minimum and maximum that you specify. For a categorical display, you specify the number of categories to use, and set the upper and lower limits for the range. When you press on the return key after clicking on the "Number of Categories" text box, the break points for each range and color selection will be automatically populated. If you wish to change the colors for a particular range, click on the new color in the color palette and then click on the color box beside the category in the 'Palette' frame. You can manually edit the breakpoints as well. When you exit the dialogue box via the "OK" or "Apply/Save" buttons, any changes you make to the map legend are automatically saved to the file that stores this information ('default.leg') and will be available for subsequent modelling sessions. Note you can create and load alternate legend files from the 'File' menu item within the 'Legend Editor' dialogue box.

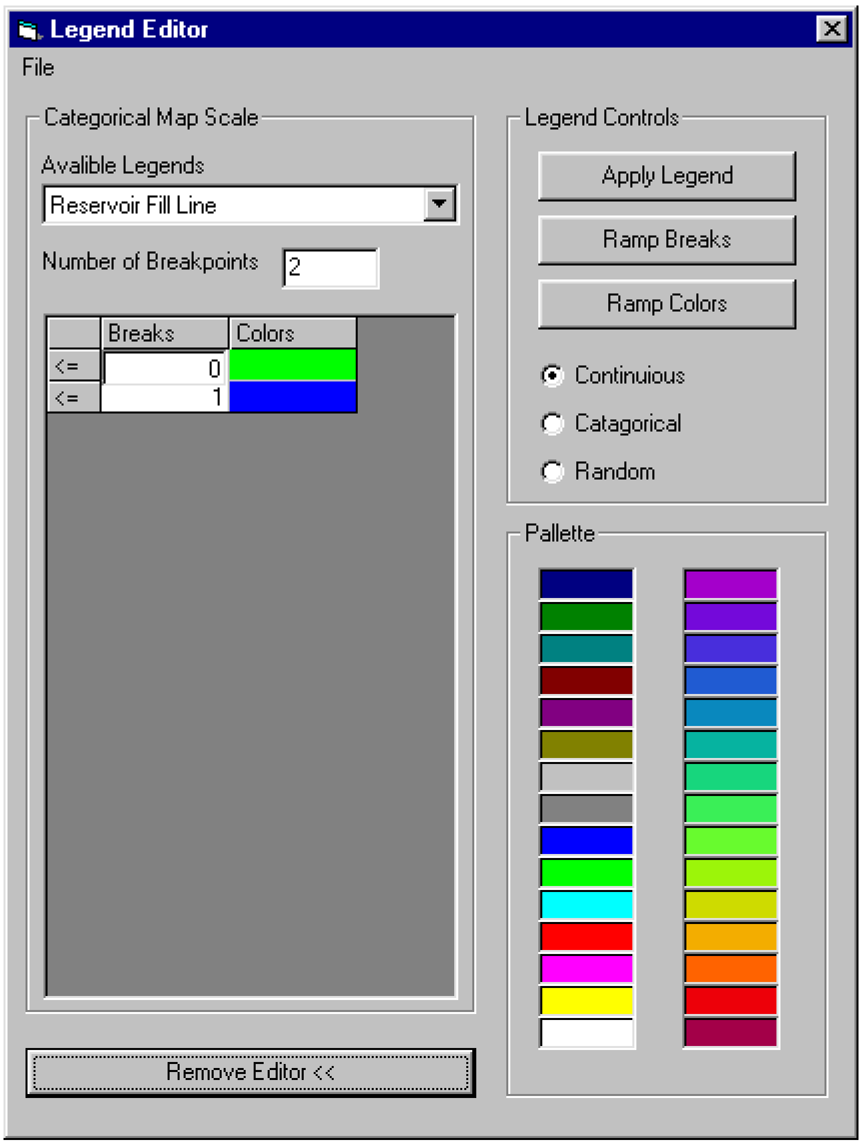


Figure 17: The 'Legend Editor' dialogue box in IRM allows you to manipulate the legends used to display maps.

5.4 LOADING AND CREATING RESERVOIR OPERATING STRATEGIES

The main forcing data driving model predictions is a multi-year set of weekly reservoir elevations and discharges for each modeled area. These data are stored in the file 'scenarios.xls' for each project watershed. By default, the model loads the historical scenario (the actual historical values), however you can load any other scenarios that exist in 'scenarios.xls' via the 'Hydrologic Scenarios' dialogue box (Fig. 18) accessed by clicking on the 'Management- Load Hydrologic Scenario from Spreadsheet' menu item.

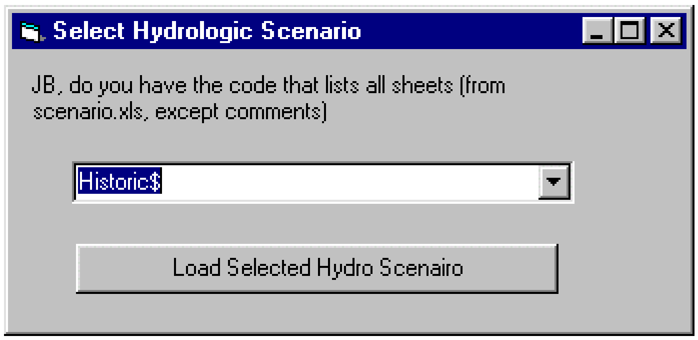


Figure 18: The 'Hydrologic Scenarios' dialogue box in IRM allows you to select alternate hydrologic scenarios to drive model predictions.

To develop your own hydrologic scenarios, create a new sheet in 'scenarios.xls' by creating a copy of the 'historic' sheet. Then open the 'Scenario Builder' dialogue box (Fig. 19) by selecting the 'Management – Build New Hydrologic Scenario' menu item. Select the sheet name you just created from the 'Scenario' dropdown list box. Select the area and variable of interest in the dropdown list boxes below this. If you also select a year and click on the 'Display Profile' button, the 52 values for that year will be displayed in the graphic.

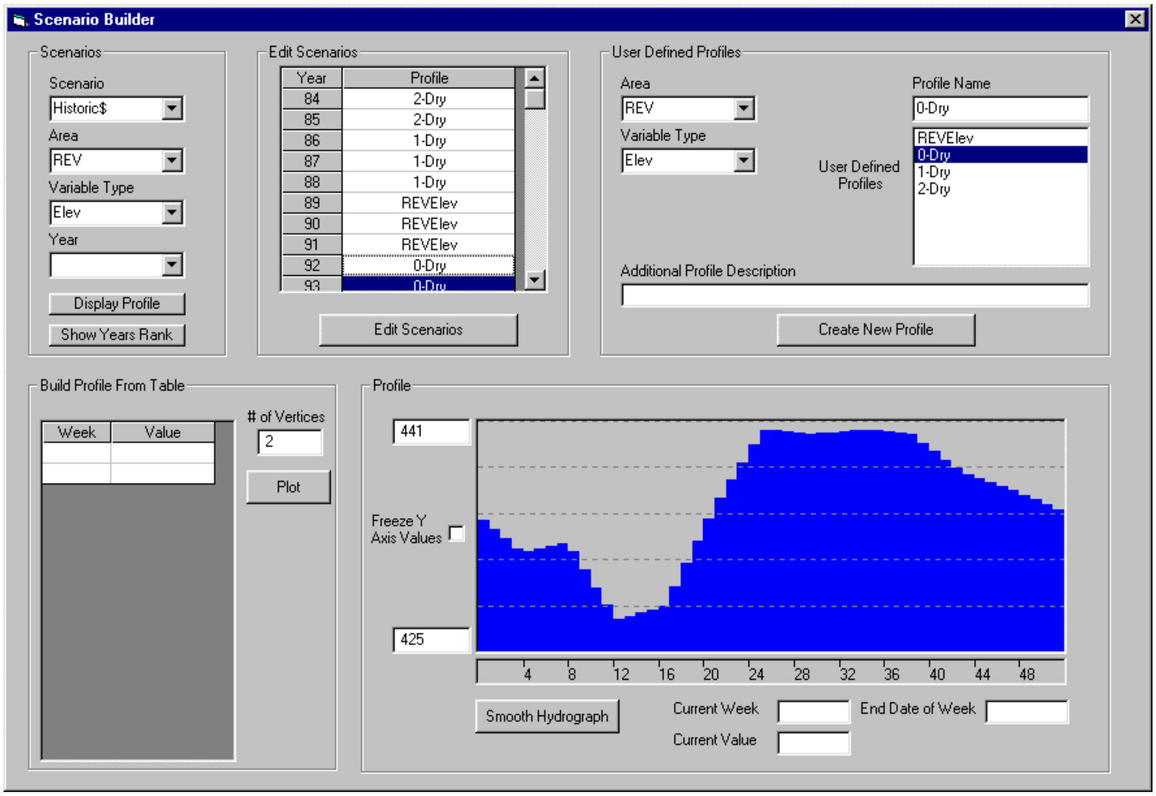


Figure 19: The 'Scenario Builder' dialogue box in IRM allows you to review, edit, and create alternate hydrologic scenarios.

You can edit this weekly time series by holding down the left mouse button while dragging the pointer over the graphic to sketch in a new profile. You can smooth the profile, or create a new one by defining a set of vertices (week and value for 'n' vertices) in the grid within the 'Build Profile from Table' grid. If you want to save this weekly profile to scenarios.xls, select the modeling area and variable type in the dropdown list boxes in the 'User Defined Profiles' frame, type in the name of the new profile in the 'Profile Name' text box, and click on the 'Create New Profile' button'. To use this profile in a simulation, you must assign it to specific years for the currently loaded scenario-area-variable type specified in the 'Scenarios' frame. To do this, click on the profile name is the 'User Defined Profiles' list, and then click on a cell for a specific year in the grid within the 'Edit Scenarios' frame. If you want to assign the profile to multiple years, hold the mouse down while you drag it over the appropriate cells in the grid. Click on the 'Edit Scenarios' button when you are done to save the edits to 'scenarios.xls'.

5.5 VEGETATION MODEL PARAMETERS AND PLANTING SCENARIOS

Parameters controlling the vegetation model can be viewed and edited by accessing the ‘Vegetation Parameters’ dialogue box (Fig. 20) by clicking on the ‘Parameters-Vegetation Model Parameters’ menu item from IRM’s main form. Alternate parameter values can be saved and restored from different files by selecting the ‘Load…’ and ‘Save Vegetation Parameter File’ menu items.

Planting scenarios, defining the years, quantity, and areas in which fall rye and other vegetation types can be planted are set by accessing the ‘Planting’ dialogue box (Fig. 21) from the ‘Management – Define Planting Regime’ menu item. Select the desired modeling area from the dropdown list box at the top of the dialogue box (e.g., the ‘Revelstoke Reach’ for the /Arrow configuration of IRM) and click on the ‘Map Horizontal’ or ‘Map Vertical’ option to optimize the display of the map in the dialogue box (e.g. Vertical for Revelstoke Reach because it runs North-South).

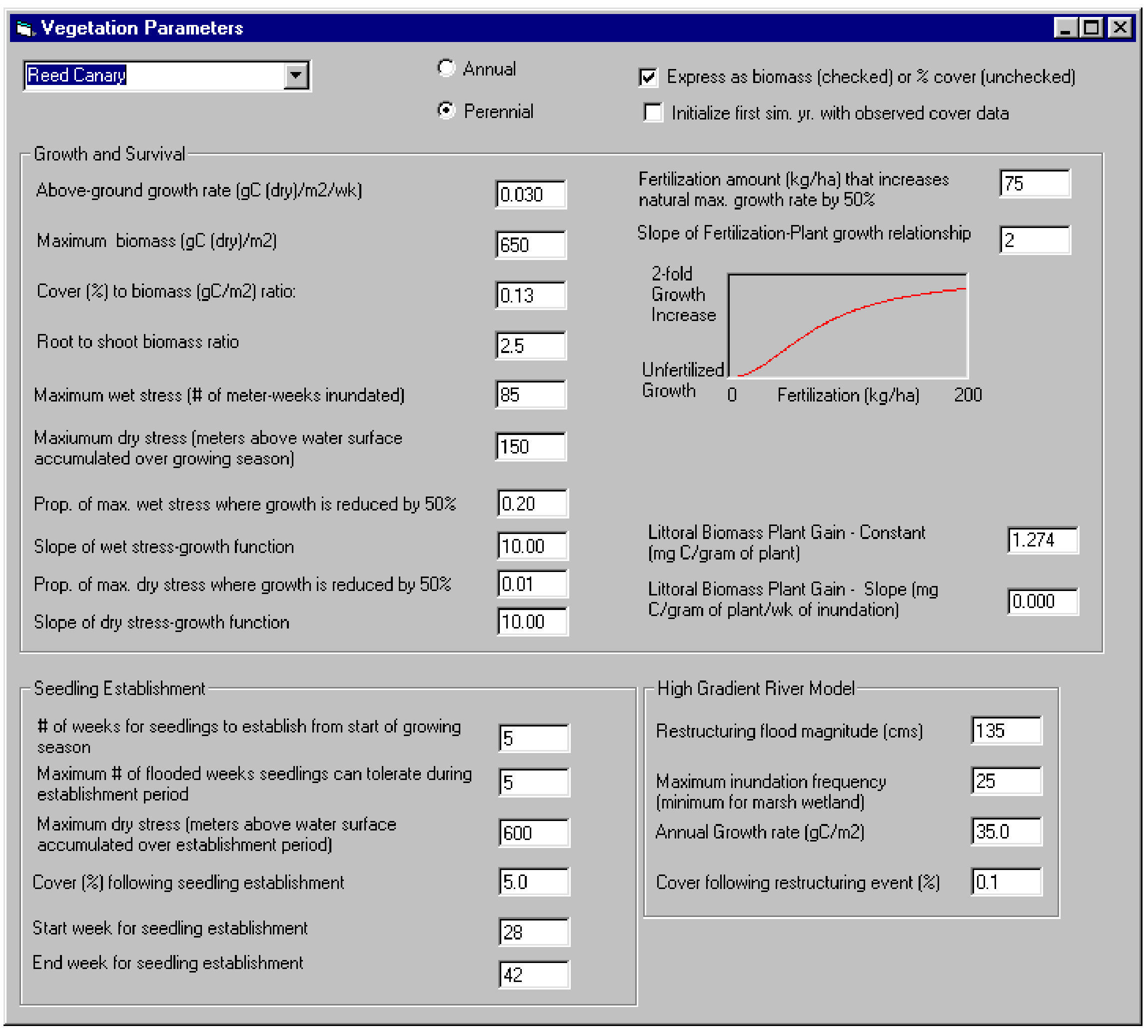


Figure 20: The ‘Vegetation Parameters’ dialogue box in IRM lets you review and edit parameters that control the vegetation component of the model.

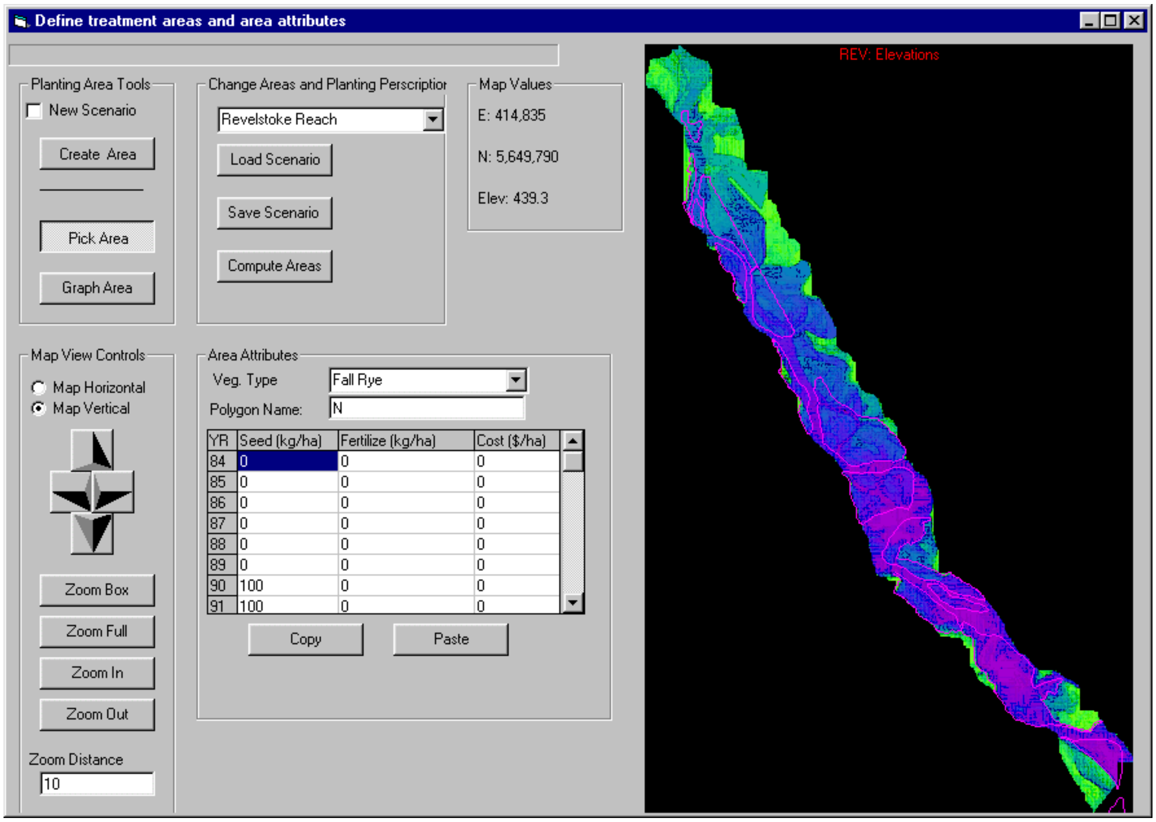


Figure 21: The ‘Define Planting Regime’ dialogue box lets you view existing planting polygons and their associated planting histories, create new planting polygons and histories, and review other characteristics of the digital elevation model.

The map that is displayed in the ‘Planting’ dialogue box is the digital elevation model used for many of the model calculations. As you move your mouse over the map, the Easting, Northing, and elevation of each pixel (representing a 25 * 25 m grid) is updated in the ‘Map Values’ frame. Use the controls in the ‘Map View Controls’ frame to zoom in/out or pan over the map. Planting scenario files contain the coordinates of any planting polygons (e.g., dust control areas in the Revelstoke Reach) as well as the planting history for these areas. If you click on a polygon, the planting history will be displayed in the grid adjacent to the map. If you click on the ‘Graph Area’ button and then click on a polygon, the hypsometry for the polygon (the amount of area at each elevation band) will be displayed in a graph adjacent to the map. To create a new polygon in an existing scenario file, click on the ‘Create Area’ button and then digitize the polygon onto the map by pointing and clicking on the vertices. Double-click on the last vertex to close the polygon. Once this is complete, name the polygon and defined the seeding rate for specific years for any or all of the vegetation groups. Save the planting scenario file to keep these changes. To create a new planting scenario file from scratch, select the ‘New Scenario’ option.

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APPENDIX Q: FISH HABITAT PERFORMANCE MEASURES TO EVALUATE MINIMUM DISCHARGE REQUIREMENTS FOR REVELSTOKE CANYON DAM

Prepared for Columbia WUP Fisheries Technical Committee

By:

Josh Korman
Yao Lan
Larry Hildebrand
Lee Failing

Ecometric Research Inc.
3560 W 22nd Ave.
Vancouver, B.C.
V6S 1J3

November 8, 2002

1.0 Introduction

Discharge from the Revelstoke Dam undergoes extreme fluctuations over short time periods. It is not uncommon for discharge to drop to zero during the middle of the night when power demand is low. During the day, discharge can exceed 1600 m^3/sec. These short-term or diel variations in flow are potentially harmful to white sturgeon, bull trout, rainbow trout, sculpin, and dace that use the Columbia River downstream of Revelstoke Dam (hereafter referred to as the Middle Columbia River or MCR). The Columbia WUP consultative committee (CC) and fisheries technical committee (FTC) have agreed to review a series of flow alternatives for Revelstoke Dam that would limit the extent of diel variation in flow. Predicting the effects of these alternatives on fish populations downstream of the dam is highly uncertain, although there are a number of cases where reductions in diel variation in flow have led to large increases in fish populations in other systems (e.g., McKinney et al. 2001). The CC has agreed in principle to identify flow regimes that might be worth evaluating through a long-term adaptive management program. Here, we develop a series of performance measures that will quantify the physical response of the MCR to these alternatives. This information should be useful in defining a flow regime to test via adaptive management.

Predicting the effects of changes in depth, velocity, and habitat area on fish populations is highly uncertain and controversial. We developed a simple conceptual model of how these physical factors could influence the somatic growth and survival rates of fish populations in the MCR (Fig. 1). Diel variation in flow influences the inundation frequency of substrates at different elevations and very likely affects the productivity of lower trophic levels that provide food for fish. Previous efforts to find benthic invertebrates in the MCR for stable isotope analysis had limited success (D. Hunter, BC Hydro, Burnaby BC, pers. comm.); there is little doubt that the fluctuating flows in the MCR severely limit benthic invertebrate abundance, although the highly armored riverbed could become a limiting factor if flow fluctuations were reduced. Higher discharges will increase the amount of wetted area by increasing river width, but this area may not be useable or of lesser value if velocities are very high, or if velocities and depths fluctuate over short time periods. These fluctuations increase energy expenditure because fish must constantly be moving to find suitable depth and velocity conditions. This movement also increases predation risk, especially for juvenile and small fish.

We developed three performance metrics that account for the dynamics of these hypotheses. We compute the average maximum daily velocity difference over the month as a measure of potential energy expenditure and predation risk. We compute the amount of productive habitat, defined as the area of substrate that is continuously submerged for more than 21 days, as an index of the response of lower trophic levels (algae and benthic invertebrates) to reduced flow fluctuations. We also compute the total amount of wetted area as an index of habitat availability, recognizing that increasing wetted width may have some benefits to fish even if the increased width occurs over areas that are not colonized by a benthic community.

This document summarizes the methods used to compute the MCR fish habitat performance measures, and how they respond to alternate flow scenarios. The intent of the document is to provide sufficient background to the FTC so that they can thoroughly review the behaviour of the performance measures and the associated assumptions.

2.0 Methods

The computation of MCR fish habitat performance measures is based on results from the HEC-RAS 1-dimensional (1D) backwater hydraulic model. HEC-RAS is the official software released by the U.S. Army Corps of Engineers to perform both steady- and unsteady-state flow analyses in a river system. Such 1D hydraulic models are commonly used to predict the effects of discharge on wetted width, depth, and average velocity at individual cross sections. The relationships between discharge and width, depth, and velocity at particular cross-sections are referred to as hydraulic geometry. The effects of backwatering are considered in the HEC-RAS model, which is important as Arrow Reservoir water surface elevations have a large influence on width, depth, and velocity in the MCR.

We ran the HEC-RAS 1D model under a large range of discharges and downstream boundary conditions (Arrow Reservoir elevations) to generate a series of lookup-tables for water elevation, wetted width, and average cross-sectional velocity. Flow scenarios consist of a series of hourly predictions of discharge from the BC Hydro GOM model and corresponding local inflows and reservoir elevations for each day. The flow and elevation data from these scenarios are used to find the appropriate water surface, width, and velocity estimates in the lookup tables for all cross-sections for each time step. These values are then used to compute the maximum daily velocity difference and the amount of productive and total wetted area.

Predictions of discharge at each cross-section for each time period form the basis of the computations. In the steady flow analysis, the discharges at each cross-section are assumed to be the same for a given 2-hour time step, except for the local inflows that are added at particular locations downstream of the dam. That is, the flow throughout the MCR varies spatially due to local inflows, but not temporally. In reality, even in the absence of local inflows, the discharge at an upstream cross-section at a particular time will be different than the discharge at a downstream location at that same time if releases from the dam are not constant. This temporal variation in discharge among cross-sections is controlled by the travel time of the discharge wave and the extent to which the wave gets attenuated. Wave attenuation occurs because the leading edge of the discharge wave (the peak flow) travels faster than the trough of the wave (the minimum flow). At some point downstream, the peak of the wave catches up to the trough, resulting in a decrease in the maximum flow and an increase in the minimum flow. Thus flow routing, which incorporates the effects of unsteady discharge releases, becomes important for consideration. In the unsteady flow analysis, we use the unsteady module of HEC-RAS to compute the discharge at each cross-section to account for the effects of wave attenuation and travel time.

2.1 Development of Hydraulic Geometry

We used a series of 245 cross-sections (e.g., Fig. 2) to characterize channel bathymetry for the MCR from Revelstoke Dam to below the confluence with the Akolkolex River, approximately 37 km downstream of the dam (Fig. 3). A Digital Elevation Model (DEM) was used to develop cross-sections downstream of Revelstoke. The DEM was generated by combining elevation points obtained from the 2000 aerial photographs (Jack Matches, BC Hydro Surveys and Photogrammetry) and coarser elevation data provided by the Canadian Hydrographic Surface for elevations below the water surface at the time the aerial-photographs were taken. A new DEM was generated from the combined data set from which 169 cross-sections were taken. For the area upstream of Revelstoke, we used 76 cross-sections developed by RL&L as part of the Revelstoke tailrace elevation study in the early 1990s (RL&L 1994). On average, there is a cross-section every 150 meters along the course of the river channel.

A HEC-RAS model was developed from these cross-sections based on the following assumptions:

1. A Manning's roughness value of 0.035 was used for cross sections 1-176 (d/s of Akolkolex River to the Highway 1 Bridge) based on the assumption that the predominant riverbed and flood plain material is sand, This value is on the higher end of the Manning's roughness value for sand-sized material to account for the presence of vegetation in the floodplain. No observed water surface level data were available to calibrate the average bed roughness for this section of the MCR.
2. A Manning's roughness of 0.04 was used for cross sections 177-245 (Highway 1 Bridge – Revelstoke Canyon Dam), where the predominant riverbed is cobble. Similarly, no water surface level data were provided to calibrate the average channel roughness for this section of the MCR.
3. Normal depth for each specific flow was used as the downstream water-level boundary condition at the most downstream cross section (1) unless the normal depth was submerged by the water level in the Arrow Reservoir. In this case, the downstream boundary condition for the most downstream cross section was set to the water surface elevation of the reservoir.

4. A frictional slope of 0.00042 was used to determine the normal depth for each specific flow. A frictional slope of 0.00042 was the average water surface slope between cross section 75–135 for flows ranging from 71 m^3/sec (2500 ft^3/sec) to 2832 m^3/sec (100 000 ft^3/sec).
5. By default, HEC-RAS assumes energy loss coefficients of 0.1 and 0.3 for energy losses incurred in flow cross sectional area contraction and expansion, respectively.

The HEC-RAS model was run under all combinations of 20 reservoir elevations ranging from 422–441 m.s.l. and 29 discharges ranging from 1–2832 m^3/sec. For each of these 580 runs, we saved the predicted water surface elevation, wetted width, and average velocity for each of the 245 cross-sections. Lookup tables for each of these parameters consisted of 245 columns for the cross-sections and 580 rows for all the combinations of discharge and reservoir elevation.

2.2 Prediction of Discharge

In the steady-flow analysis, we do not consider the effects of wave attenuation on discharge at cross-sections downstream from Revelstoke Dam. Discharge at a cross-section is computed by,

$$Q_{cx} = Q_{\mathrm{Rev}} + Q_{Leak} + Q_{local} * Drain_{cx} \qquad [1]$$

where, Q_{cx} is the discharge at cross-section ‘CX’, Q_{Rev} is the total discharge released from Revelstoke Dam, Q_{Leak} is the assumed leakage from all components of the dam (assumed to be constant 300 ft^3/sec or 8 m^3/sec, L. Hildebrand, Golder and Associates, Castlegar, BC, pers. comm.), Q_{local} is the total local inflow to Arrow Reservoir, and Drain_{cx} is the cumulative proportion of the local Arrow Reservoir watershed draining into cross-section ‘CX’. Historical inflows show strong seasonality driven by snowmelt (Fig. 4). Local inflows used in the scenario analysis were provided by BC Hydro and correspond to inflows estimated for the 1964–65 to 1973–74 water years.

The cumulative local drainage proportion for each cross-section (Drain_{cx}) was computed from a GIS analysis using the 1–50 000 BC Watershed Atlas map base (e.g., blue lines on Fig. 3). The general relationship between watershed area and mean annual discharge (MAD) is well established (Maidment 2000). Thus, reservoir-wide estimates of local inflows can be apportioned among cross-sections if the local drainage areas between cross-sections are known. While drainage areas for each cross-section are not available, the total length of streams draining between cross-sections is computable from the Watershed Atlas. From past experience with the Watershed Atlas we know that the sum of stream lengths in a drainage is a good predictor of its watershed area. The relationship appears to hold reasonable well in the Arrow system (Table 1). Stream lengths of gauged watershed scale with the drainage areas estimated by Water Survey of Canada. The predicted and observed mean annual discharges (MADs) are in reasonable agreement, and discrepancies are more likely caused by differences in the periods of record used in the MAD computation rather than by differences in the MAD-drainage area relations. $Drain_{cx}$ is therefore computed as the ratio of stream length draining into the reservoir upstream of cross-section 'CX" to the total stream length draining into Arrow Reservoir (e.g., Table 1).

The fluctuating discharge from Revelstoke Dam on an hourly basis results in unsteady discharge over space as well as time. The extent of the resulting attenuation depends on channel bathymetry, roughness, and the characteristics of the Revelstoke Dam hydrograph. Unsteady 1D hydraulic models can be used to compute the change in discharge at individual cross-sections over time resulting from these dynamics. Unsteady models are computationally intensive because the model time step must be in the order of seconds to obtain a stable solution to the mass conservation and momentum equations (Saint Venant equations) that govern the dynamic flow routing processes. We applied the unsteady module of HEC-RAS to some example hydrographs from Revelstoke Dam to assess the impact of unsteady wave dynamics on discharge predictions at various points along MCR. To apply the module, we had to linearly interpolate between 2-hour discharge predictions to provide input files with time steps as fine as 10 seconds.

2.3 Computation of Performance Measures

The computations for the three fish habitat performance measures for the Middle Columbia are described below.

Average Monthly Maximum Daily Velocity Difference

- Discharge for each cross-section every 2 hours for each day is computed from Eqn. 1 for the steady flow analysis. For unsteady flow analysis, Eqn. 1 is used in conjunction with unsteady module of HEC RAS to estimate the discharge at each cross-section for each time step.
- Based on the 2-hour discharge estimates and hydraulic geometry generated from the HEC-RAS model, the maximum and minimum average cross-sectional velocities are computed for each day and cross-section;
- The difference between maximum and minimum velocities at each cross-section are computed for each day and averaged over the month;
- A weighted average across all cross-sections that make up the riverine portion of the modelled area is used to compute the river-wide average maximum velocity difference for each month. The weighting is based on the length of river each cross-section represents;
- To determine if a cross-section is riverine in nature, the average daily discharge is used to compute an average velocity. If this velocity exceeds the minimum velocity criteria of 0.2 m/sec, the cross-section is considered riverine in nature for that day;

- If multiple years of hydrology are used in the analysis, monthly values are averaged across years. The standard deviation of the performance measure for any month is computed from the variability across years.

Productive Habitat Area

- The amount of area at 0.25 m elevation increments for each cross-section is computed;
- The minimum daily discharge for each day over the month is used to determine which of the 0.25 m elevation 'slices' for each cross-section are wet;
- An elevation slice is considered productive when it has been continuously wetted for 21 days or more. The number of productive days for each slice-cross-section combination over each month is computed. An estimate of 21 days was used as the minimum time required for a significant benthic community to develop following inundation;
- The monthly productive area for each slice-cross section combination is the product of the number of productive days times the area that the slice represents. The sum of these products across all cross-sections that are riverine in nature (average daily velocity >=0.2 m/sec) is used to compute the productive area statistic, which is in units of Hectare-Days.

Total Wetted Area

- The minimum daily discharge at each cross-section in conjunction with its hydraulic geometry is used to compute the daily minimum wetted width. The wetted width is multiplied by the length of river the cross-section represents to determine the minimum wetted area;
- The minimum wetted areas for each cross-section are summed across all days in the month to compute the wetted area statistic, which is in units of Hectare-Days. The sum is only conducted for cross-sections that are riverine in nature (average velocity >= 0.2 m/sec);

The performance measure statistics reported in this document are always based on a steady flow analysis. The unsteady flow analysis shown here demonstrates the effects of flow routing on discharge at particular cross-sections over time periods of a few-days. The unsteady flow analysis will be carried through to the computation of performance measure statistics for the final WUP analysis to be conducted in 2003.

3.0 Results

Results are divided into five sections. Hydraulic geometry predicted by the HEC-RAS model is summarized in section 3.1. The effects of wave attenuation on downstream patterns of discharge are summarized in section 3.2. An analysis of Columbia WUP alternatives related to the Revelstoke Dam minimum flow analysis is presented in section 3.3. A sensitivity analysis on the effects of minimum river velocity and the minimum number of productive days on performance measures is presented in section 3.4. Finally, in section 3.5, we evaluate a series of theoretical hourly hydrographs from Revelstoke Dam to evaluate how the fish performance measures respond to flow regimes that provide increasingly higher minimum flows and reduced daily fluctuations.

3.1 HEC-RAS Hydraulic Geometry

Predictions of wetted width and average cross-sectional velocity as a function of discharge are presented in Figure 5. Results are segregated among three reaches that represent different morphologies. The ‘Dam-Jordan’ reach is relatively narrow and confined (Fig. 3) so increases in discharge have little effect on wetted width but result in large differences in velocity. The ‘Jordan – Illecilleweat’ reach is wider which leads to a greater sensitivity of wetted width to discharge but reduced sensitivity of velocity. The ‘Illecilleweat – Akolkolex’ reach is the widest and least confined. Here, increases in discharge result in smaller differences in velocity but cause large increases in wetted width.

The shapes of the hydraulic geometry relationships (Fig. 5) provide insights into the potential physical effects of minimum flow restrictions on discharge from Revelstoke Canyon Dam. The greatest changes in average velocity at a cross-section occurs from 0–250 m^3/sec. At discharges beyond 250 m^3/sec the increase in velocity is smaller per unit discharge. Thus we would expect minimum flows of around 250 m^3/sec to possibly be the most efficient limit in terms of minimizing daily variation in velocity. However, this observation does not hold across all reaches. The velocity-discharge relationships for cross sections between the Revelstoke Dam and the Jordan River are relatively steep through a much higher range of discharges. Controlling daily variation in velocity in this reach will be difficult, but large gains can be made for reaches downstream of the Jordan River. Changes in wetted width as a function of discharge are very minor in the ‘Dam-Jordan’ reach, suggesting that the effects of minimum flow restrictions on productive habitat area in this section of river will be relatively minor compared to downstream reaches where width is more sensitive to changes in discharge.

Predictions of wetted width and velocity are driven by estimates of water surface elevation from the HEC-RAS model, which in turn, are dependent on both discharge and the elevation of the Arrow Reservoir (Fig. 6). Water surface elevations are lowest when discharge is lowest and when the reservoir elevation is low (422 m.s.l.). As discharge is increased, the water surface elevations rise in the upper sections of the river. The surface elevations for lower sections are not very responsive to discharge when the reservoir is high (e.g., 436 m.s.l.) due to its backwatering effect. The backwatering effect is also very noticeable in the longitudinal plots of velocity and wetted width (Fig. 6b and c). Backwatering results in reduced velocities and larger widths. Backwatering effects are present in the upper sections of the river right up to the Revelstoke Dam when discharge is low and the reservoir is moderately high (436 m.s.l.– 212 m^3/sec).

3.2 Wave Attenuation

The attenuation of the discharge wave in the Middle Columbia River has the potential to increase minimum discharge and reduce maximum discharge as distance from the Revelstoke Canyon Dam increases. The extent of this attenuation depends on the shape of the discharge release from Revelstoke Dam (Fig. 7). Attenuation of the minimum flow was greatest when the duration of the minimum flow was short (Fig. 7a). In such circumstances, minimum flows increased from near 0 m^3/sec at the dam to over 400 m^3/sec within 10 km downstream. By the time the discharge wave reached the Akolkolex River 37 km downstream from the dam, the minimum flow had increased to over 800 m^3/sec. Note that this analysis does not include any local inflows to illustrate the extent of the mitigating effects of wave attenuation.

The effect of wave attenuation on minimum flows is greatly reduced when the duration of the minimum flow period is increased (Fig. 7b). In our June example, discharge was near 0 m^3/sec from 2:00 – 6:00. The long minimum period gave the trough of the discharge wave a good ‘head-start’ on the high flows that were released from the dam at 10:00. Consequently, the leading edge of the discharge wave did not catch the trough until about 26 km downstream. Upstream of this distance, the minimum flows at downstream locations were very close to the minimum flow at the dam, although peak flows were slightly reduced.

3.3 Analysis of Initial WUP Minimum Flow Scenario

All three MCR fish habitat performance measures depend on the prediction of whether a cross-section is riverine in nature, that is, has a predicted velocity from the average daily flow greater or equal to 0.2 m/sec. The sum of the lengths of riverine cross-sections provides an estimate of the length of river on any day. An example of the change in predicted river length over a single year is shown in Figure 8. River length increases with reductions in Arrow Reservoir water surface elevations and increased discharge from Revelstoke Dam. The entire modeling area is considered riverine (> 37 km) in the month of February when discharge is quite high (ca. 900 m^3/sec) during a period when the reservoir is low (ca. 430 m.s.l.). Differences in patterns in river length by month between the Base Case and Min5000 scenarios were undistinguishable because the average daily discharges were almost identical.

The discharge predictions for the Base Case and Min5000 scenarios were very similar (Fig. 9). The Min5000 scenario simulates the effect of a 5000 ft^3/sec (or 143 m^3/sec) minimum flow from Revelstoke Dam during the months of June, July, and August. The minimum flow did limit the minimum discharge in the summer months, but the maximum values were not noticeably lower than the Base Case (Fig. 9a). The minimum flow requirement changed the maximum daily difference in discharge from values ranging around 1400 m^3/sec to 1250 m^3/sec (Fig. 9b). It is worth noting that the duration of the minimum flow periods from the GOM model can be quite short. There are many days in the months of July and August where the minimum flow period only lasts for one or two time steps (2-4 hrs.). Attenuation of the minimum and maximum flows can be substantial under these circumstances (Fig. 7a).

There was considerable seasonal variation in all three fish habitat performance measures (Fig. 10). The seasonal patterns in the maximum daily velocity difference and productive and wetted area metrics are the result of the combined effect of differences in power load following (driving daily variation in discharge) and differences in reservoir elevations and average discharge from Revelstoke Dam effecting the predicted river length. The maximum daily difference in velocities is lowest in Oct and Nov. when load following is relatively small compared to other months. The amount of productive and wetted area is lowest in the spring (April – June) when daily variation in flow and minimum flows are not mitigated by high reservoir elevations. The total amount of wetted area is highest in June when reservoir elevations are not at full pool and discharge is high.

There was generally not much difference in the values of fish habitat metrics between the Base Case and Min5000 scenarios. The 5000 ft^3/sec minimum flow reduced the maximum daily velocity difference from 1.1 m/sec to almost 0.8 m/sec in June, but the effect was not as large in July and August. The minimum flow had very little effect on productive and wetted area. During the summer months the reservoir elevation was usually quite high which limited the river to the most upstream areas (e.g., Fig. 8) where changes in width as a function of discharge are quite small (Fig. 5 and 6). We would expect minimal flow requirements to have more of an effect in winter months when reduced local inflows and lower reservoir elevations increase the sensitivity of width to changes in the minimum discharge.

3.4 Sensitivity Analysis on Effects of Minimum River Velocity and Productive Day Criteria

The minimum river velocity criteria determines the downstream extent of the river for any given discharge and Arrow Reservoir water surface elevation (Fig. 6b). The criteria of 0.2 m/sec was derived by estimating the downstream extent of the river through examination of the longitudinal profiles of velocity and water surface elevation (Fig. 6b and 6a, respectively). As there is some uncertainty in this derivation and the actual average cross-sectional velocity that constitutes a river from the perspective of fish and benthic habitat, we performed a sensitivity analysis on this parameter.

The minimum river velocity criteria influenced the predicted river length (Fig. 11) with increasing values reducing river length. However, the predicted river length for any month-velocity criteria combination was virtually identical for both the Base Case and Min5000 scenarios. This was not surprising as the determination of whether a cross-section is riverine in nature is dependent on the average daily velocity that was virtually identical across the Base Case and Min5000 scenarios. The velocity criteria had almost no effect on the maximum daily velocity difference.. The productive area metric was quite sensitive to the criteria in the months of June and July. The criteria changes the downstream limit of the river (Fig. 8) and thereby changes the hydraulic geometry that is used in the computations (Fig. 5) which in turn effects the productive habitat area statistic. In the most extreme case (June), a criteria of 0.3 m/sec predicts that productive area will increase by 20% under Min5000 relative to the Base Case, compared to less than a 10% increase for a criteria of 0.1 m/sec. Differences in the sensitivity to the velocity criteria between months were mostly driven by changes in reservoir elevation (Fig. 8, June=435 m.s.l. vs. July=439.5 m.s.l.). The wetted area statistics showed a very similar sensitivity to the minimum velocity criteria, but only in the month of June. We consider these differences relatively minor given the major uncertainties in translating changes in fish habitat to population-level responses.

The minimum productive day criteria is used in the computation of the productive area statistic. Not surprisingly, productive area values increased as the minimum day criteria was reduced (Fig. 12a). The minimum day criteria effected the estimated effect size of a 5000 ft^3/sec minimum flow in some months, but only to a significant extent when the minimum criteria was extended to 35 days (5 weeks). The extended minimum day criteria substantially reduced the amount of productive area under the Base Case scenario in July (Fig. 12a) thereby emphasizing the benefits of minimum flows. In June, increasing the minimum productive day criteria to 35 days had the opposite effect of minimizing the difference between the Base Case and Min5000. The extent of the effect of the minimum day criteria will depend on the multi-day pattern in minimum flows.

3.5 Analysis of Theoretical Hourly Hydrographs

The hourly discharge scenarios from Revelstoke Dam that have been examined to date in the Columbia WUP process have been relatively constrained. The only scenario other than the Base Case that was available to perform this analysis was the implementation of a 5000 ft^3/sec minimum flow in the months of June, July, and August. The magnitude of this minimum flow is quite small considering the maximum power plant discharge is 60 000 ft^3/sec. In addition, the minimum flow was only implemented in summer months when reservoir elevations and local inflows were high, thereby minimizing the potential benefits of a minimum flow requirement on fish habitat.

The limited implementation of a minimum flow requirement makes it difficult to evaluate the performance of our fish habitat metrics. We therefore created a series of more restrictive minimum flow scenarios. To create them, we specified an hourly weighting factor that represented both the hourly price differential in power and the total BC load requirement that would be supplied by the Revelstoke Dam. We then used a non-linear search procedure to compute the hourly discharge values that would maximize the sum of the product of the hourly weighting factor and discharge (i.e., we assumed a linear relationship between discharge and generation). The search procedure was constrained so that the average discharge from the dam over the day was 800 m^3/sec, and constrained so the hourly discharge values exceeded the specified minimum flow requirement but did not exceed power plant capacity (1700 m^3/sec). We then implemented a series of minimum flow restrictions of 0, 143, 286, 425, and 566 m^3/sec (0, 5000, 10 000, 15 000, and 20 000 ft^3/sec, respectively).

To achieve water balance over the day (an average discharge of 800 m^3/sec), the maximum flow that is attained is reduced as the minimum flow requirement is increased (Fig. 13a). Increasing the minimum flow therefore also reduced the daily variation in discharge. At minimum flows of 0, 143, 286, 425, and 566 m^3/sec the maximum daily difference in flow was 1700, 1558, 1241, 898, and 568 m^3/sec, respectively. We computed performance measure statistics for the five minimum flow scenarios by simulating a single year using the 1963–1974 monthly average inflow and elevations for Arrow Reservoir provided from the GOM Base Case scenario (Fig. 13b).

Increasing the minimum flow requirement led to progressively larger reductions in the maximum daily velocity difference (Fig. 14a). The improvements were greater in February than in August due to reduced local inflows and reservoir elevations in February (Fig. 13b). Increasing minimum flows led to substantial gains (>25%) in the productive area and total wetted area statistics (Fig. 14b), but only in the winter months, again, because of reduced local inflows and lower reservoir elevations. In summer months, higher reservoir elevations and local inflows dominated the productive area and wetted area computations. The total wetted area and productive habitat area statistics were strongly correlated because there was no across-day variation in flows (the same hydrographs from Revelstoke Canyon Dam were repeated on each day).

4.0 Conclusions

The HEC-RAS 1D hydraulic backwater model for the Middle Columbia River provides a useful tool for evaluating the effects of discharge from Revelstoke Dam, Arrow Reservoir elevations, local inflow, and wave attenuation on discharge, velocity, and wetted width along the river corridor. The hydraulic geometry (Fig. 5) identifies flow ranges where wetted width and velocity change at the highest rates per unit change in discharge. For cross sections downstream of the Jordan River, there won't be much variation in velocity at discharges greater than 250 m^3/sec. Upstream of the Jordan River, velocity is very sensitive to discharge across a wider range of values, so reductions in daily variation in velocity to some minimum limit may be harder to achieve. Increases in wetted width as a function of increasing discharge are relatively small at cross sections upstream of the Illecilleweat River, so we would expect the biggest gains in productive area resulting from minimum flow restriction to occur downstream of the Illecilleweat. The greatest physical changes in width and velocity resulting from minimum flow restrictions will occur in winter months when this portion of the river is exposed because the reservoir is drawn-down (Fig. 4). Reduced inflows during the winter months will also highlight the benefits of minimum flow requirements.

Our unsteady flow analysis (Fig. 7) demonstrates that wave attenuation can have a significant effect on minimum and maximum discharges downstream of Revelstoke Canyon Dam. This presents a potentially serious computational problem for the Columbia WUP minimum flow analysis. Unsteady flow calculations are computationally very intensive. A very small time step, in the order of seconds, is required to solve the mass conservation and momentum equations that govern the physics of wave travel. Simulating a months worth of hourly discharges from Revelstoke Canyon Dam requires over a day of computational time. The performance measure analysis presented in this document is based on 12 discharge values per day over 10 years. An unsteady flow analysis of these data would have taken over 120 days of computational time per scenario! However, an unsteady analysis of flow can be accomplished if we select a very limited set of representative years (low, median, and high inflows) and months (February and August). Such an analysis would require about six days of computational time per scenario. At the Oct. 24-25, 2002 FTC meeting, it was agreed that 10 scenarios would be examined based on the combination of two monthly alternatives that control Arrow Reservoir elevation and mean monthly discharge from Revelstoke Canyon Dam (Alt0 and Al11), and five hourly alternatives where the minimum daily flow varies from 0, 5000, 10 000, 15 000, and 20 000 ft^3/sec. A feasible strategy is to simulate all three types of water years for the most promising scenarios (based on cost estimates and the steady flow analysis) and only simulate the median flow year for the less likely ones. This strategy would limit computational time to about one month.

The results of the sensitivity analysis on the effects of the minimum velocity criteria determining river length and the minimum number of continuously wetted days effecting the productive habitat area statistic were quite variable. The maximum daily velocity difference was insensitive to the velocity criteria, but the productive and habitat area statistics showed differences of 10–20% in some months. The effect of the minimum number of continuously wetted days on the productive area statistic varied by month. We consider the sensitivity to these parameters relatively minor compared to other uncertainties in the decision-making process. In the Base Case and Min5000 comparison, the range of parameter values we used did not change the rank order of the alternatives. We may want to repeat the sensitivity analysis for the final WUP alternatives to ensure that different parameter values do not change the rankings.

Our analysis of the preliminary WUP hourly alternatives (Base Case and Min5000) was not very informative. The two alternatives were very similar (Fig. 9) so it is not surprising that there was little difference in the performance measure statistics (Fig. 10). In a sense, the performance measure statistics quantify what is intuitively obvious from looking at the discharges; making minor alterations to highly fluctuation hydrographs will have minor to no effects on fish habitat. We anticipate seeing greater variation in performance statistics during winter months at a 5000 ft^3/sec minimum flow, and at higher minimum flows throughout the year.

In the absence of more informative minimum flow scenarios, we developed our own for the purposes of this analysis. Our hourly scenarios (Fig. 13a) reflect very simple assumptions about the hourly price differential in power value and system load requirements. By assuming a constant price and load during the day, implementing a minimum flow requirement had the effect of reducing maximum flows to maintain a daily water balance. If we had assumed a sharper peak(s) in the price and load-weighting factors, minimum flow requirements would not affect the maximum flow to the extent that our simulations showed. Thus, our scenarios may overestimate the reduction in daily flow variation caused by minimum flow requirements, which in turn would overestimate the improvement in the average monthly maximum daily velocity difference. In spite of this criticism, our hourly scenarios were useful to demonstrate the additional benefits to the velocity difference and productive habitat area measures that can occur when minimum flow requirements are implemented in the winter when reservoir elevations and inflows are low (Fig. 14). The analysis also provided our first look at the relationship between minimum flow requirements and our performance measures that will be useful for interpreting the final relationships that will be developed based on the BC Hydro GOM model output.

5.0 References

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Table 1: Comparison of predicted and observed mean annual discharge for three tributaries of the Middle Columbia River. Observed discharge is from Water Survey of Canada records while predicted discharge is based on the product of 1985–2000 average local inflows provided by BC Hydro and the estimated proportion of the local drainage for each river from the 1–50 000 map-base GIS analysis.

River Name	Period of Record for Discharge Data	Drainage Area (km^2)	Mean Annual Discharge (m^3/sec)	1-50,000 Stream Length (km)	Estimated Proportion of Local Drainage	Predicted Mean Annual Discharge (m^3/sec)
Jordan	1946-1957	350	10.8	679	0.04	17
Illecilleweat	1911-1916	1,230	61.3	1,727	0.11	43
Akolkolex	1913-1954	394	21.1	571	0.04	14
	Total Arrow Reservoir stream length			15,124		
	1985-2000 Mean Annual Local Discharge to Arrow Reservoir					375

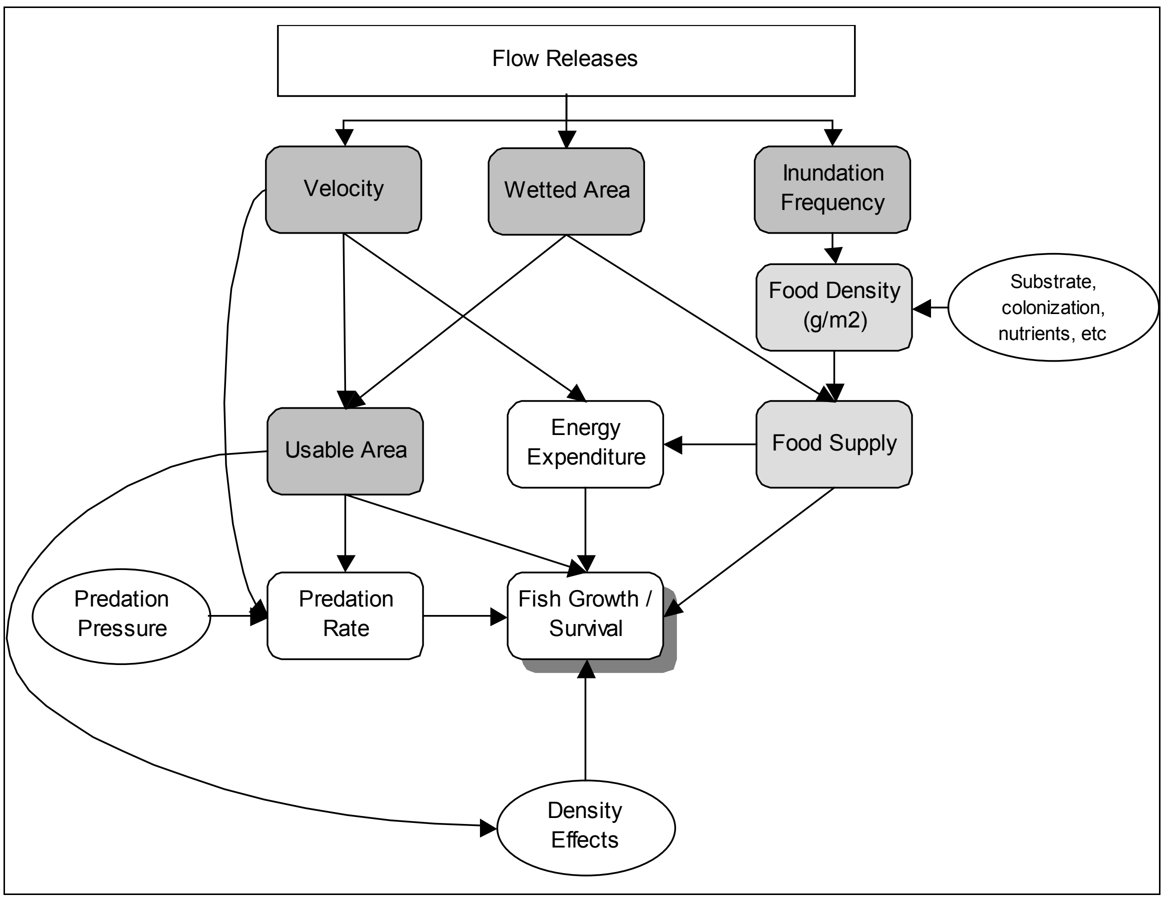


Figure 1: Conceptual model of the potential relationships between physical factors effected by discharge from the Revelstoke Canyon Dam and important processes effecting fish populations in the Middle Columbia River.

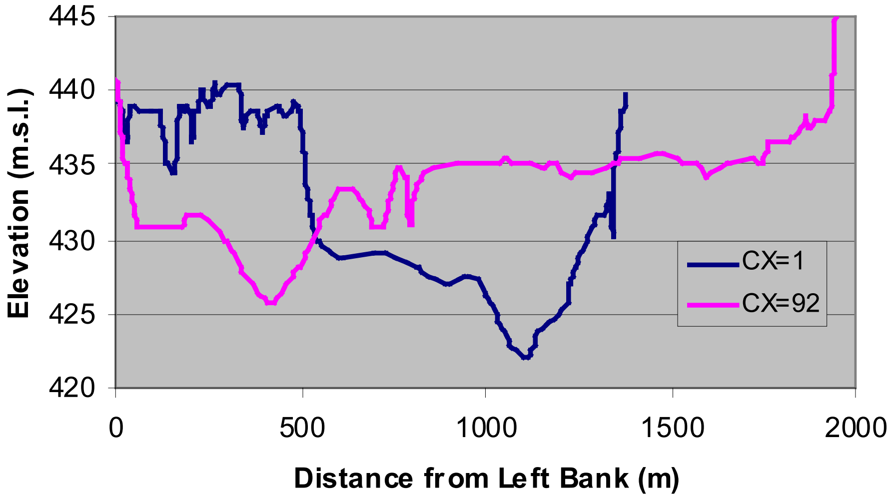


Figure 2: Examples of cross-sections used to characterize channel bathymetry in the HEC-RAS model.

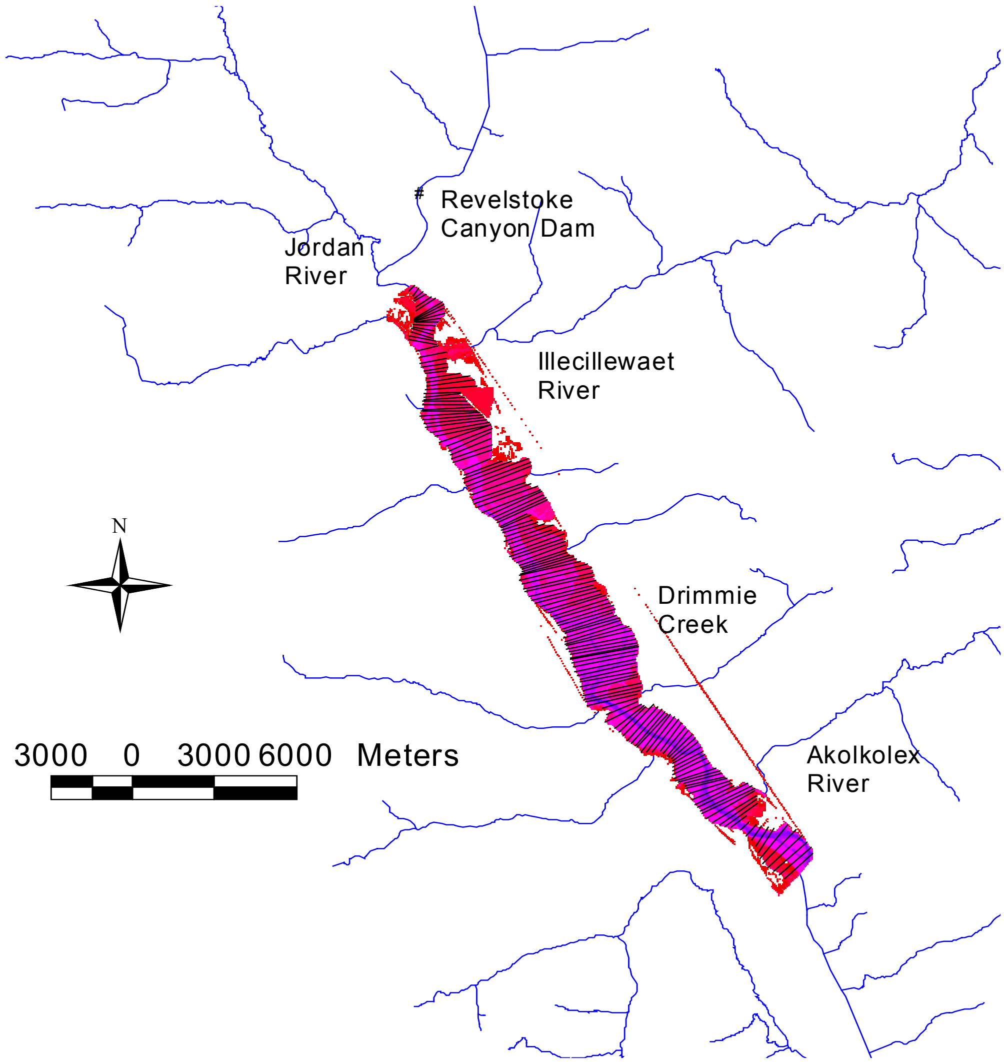


Figure 3: Map showing the extent of the modeling area that runs from the Revelstoke Dam (black circle) to the downstream end of the DEM (colored surface). Cross-sections taken from the DEM are shown as black straight lines. Note there are 76 cross-sections between the dam and the DEM that are not shown but are part of the HEC-RAS model. Blue lines are 2nd order and higher streams found on the B.C. digital Watershed Atlas 1-50 000 map base.

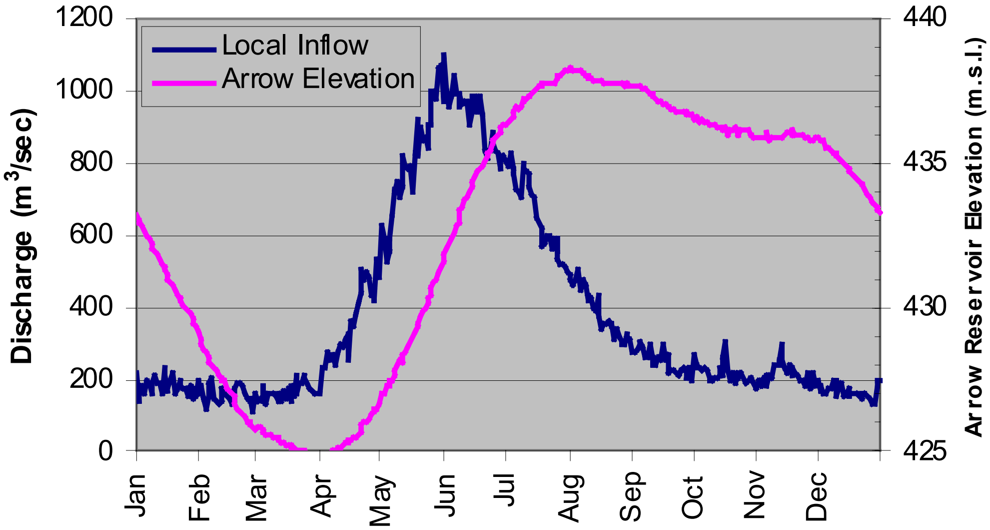


Figure 4: Average daily local inflows and reservoir elevations for Arrow Reservoir based on 1985–2000 hydrology data.

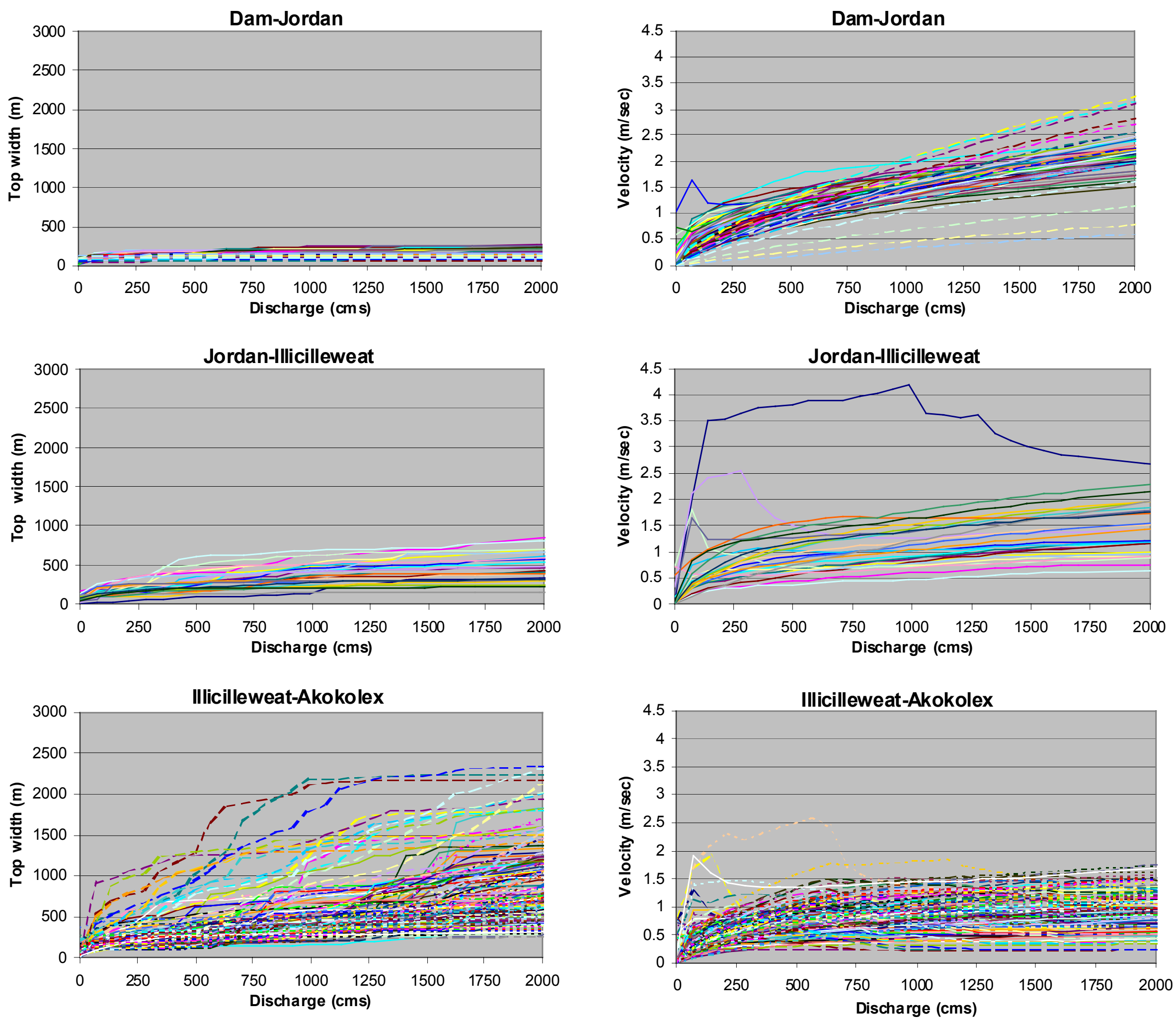


Figure 5: Hydraulic geometry showing wetted width (top width) and average cross-sectional velocity for 3 reaches in the Middle Columbia River. The geometry was generated from the HEC-RAS 1D hydraulic model assuming a reservoir elevation of 422 m.s.l. Note a minimum flow of 5000 ft^3/sec corresponds to 143 m^3/sec

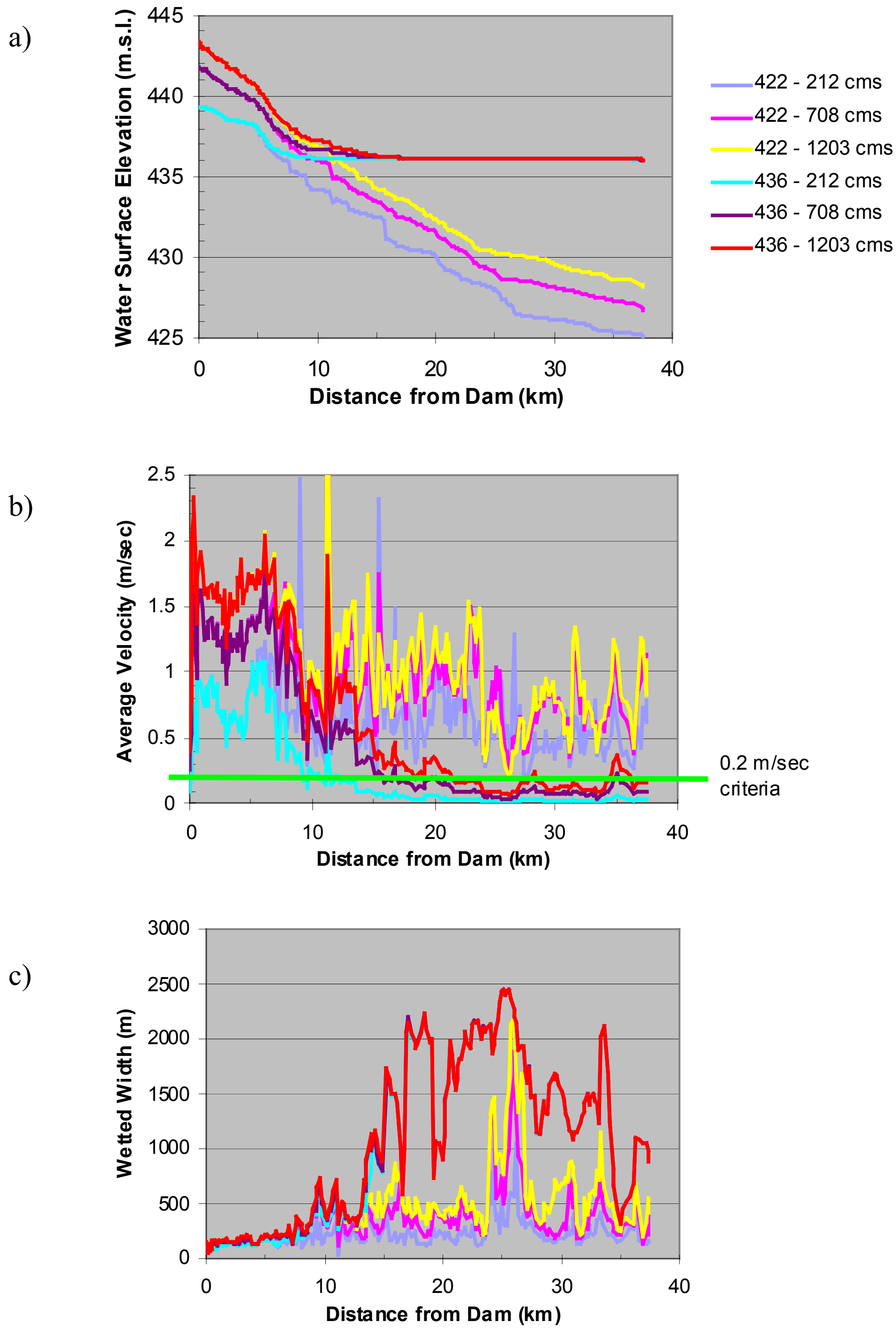
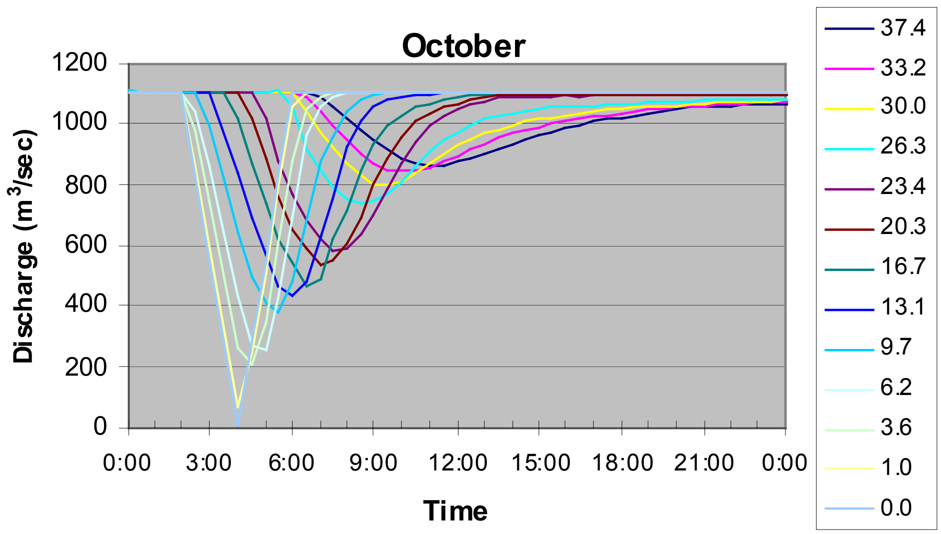


Figure 6: Patterns in water surface elevation, mean water column velocity, and wetted width downstream of Revelstoke Dam based on HEC-RAS predictions under different Arrow Reservoir water surface elevations (422 and 436) and dam discharges (212, 708, 1203 m^3/sec).

a)



b)

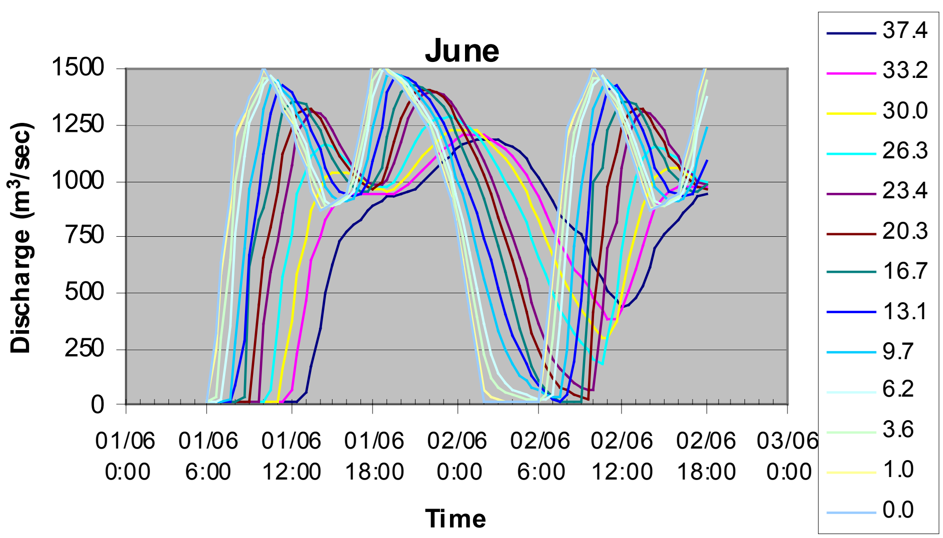
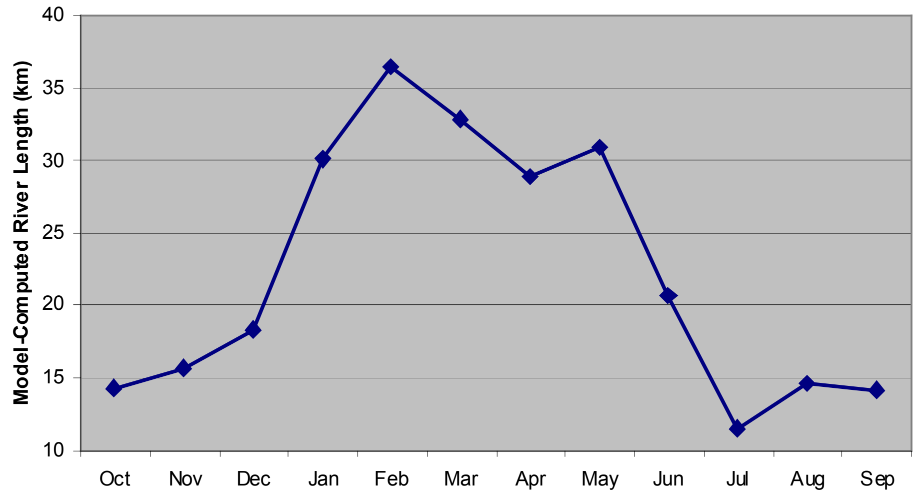


Figure 7: Examples of wave attenuation effects on discharge at various distances downstream from the Revelstoke Dam. Results are based on discharge values from Revelstoke Dam predicted by the GOM model in the months of October (a) and June (b). Note the discharge predictions do not include the effects of local inflows to illustrate the effects of wave attenuation on discharge.

a)



b)

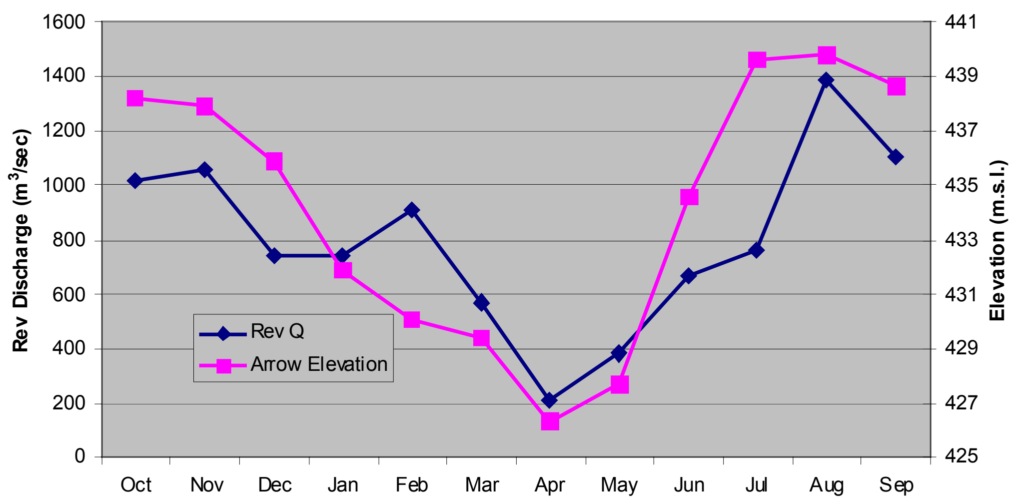


Figure 8: Predictions of river length based on velocity predictions from the 1D hydraulic model (a) and corresponding Arrow Reservoir water surface elevations and Revelstoke Dam discharges (b). All cross-sections with mean daily velocities greater than or equal to 0.2 m/sec were considered riverine and included in the total river length computation. Input hydrology (local inflows and Revelstoke Dam discharge) and Arrow Reservoir elevations were based on the Base Case GOM 1964–65 water year scenario.

a)

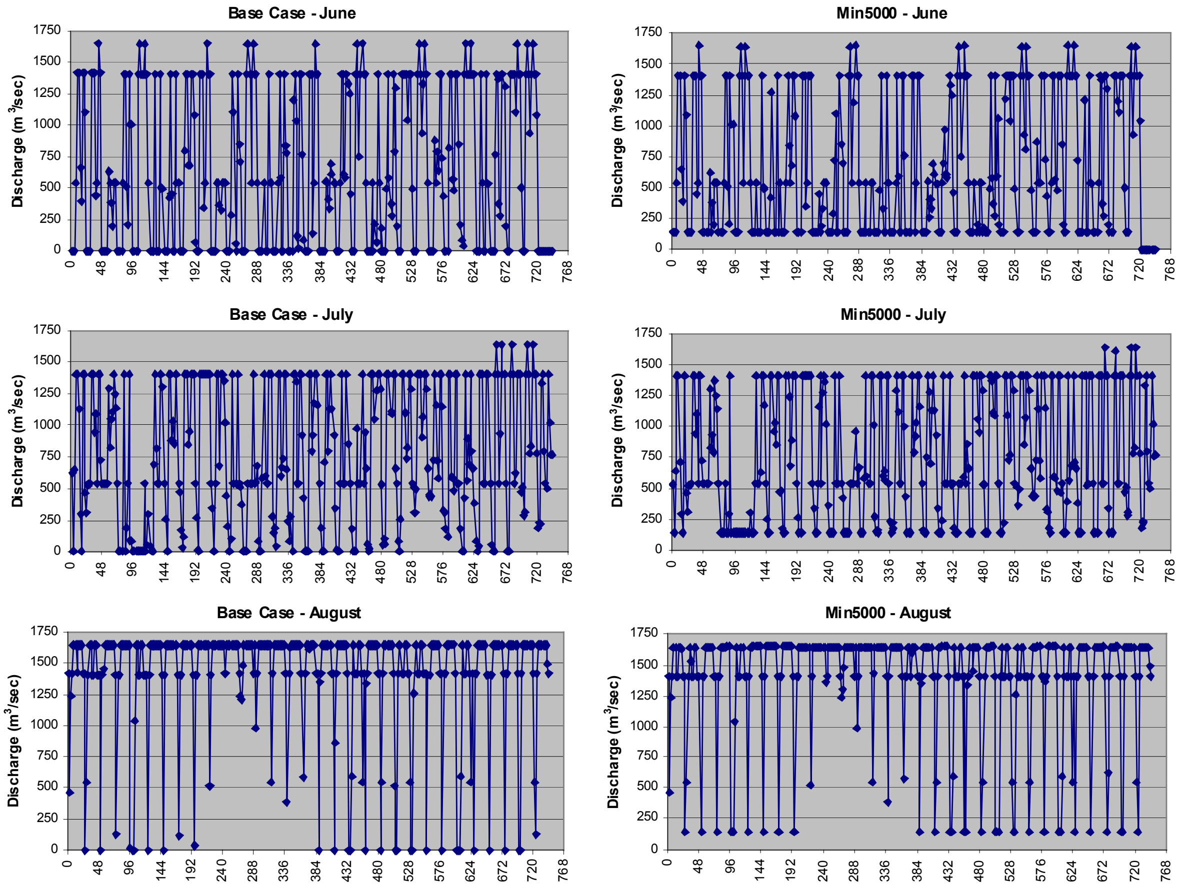


Figure 9: Predictions of discharge from Revelstoke Dam from the BC Hydro GOM model for June, July, and August 1965 under the Base Case and Min5000 scenarios (a) and the maximum daily discharge difference (b). The x-axis shows the cumulative number of hours (a) or days (b) from the beginning of the month.

b)

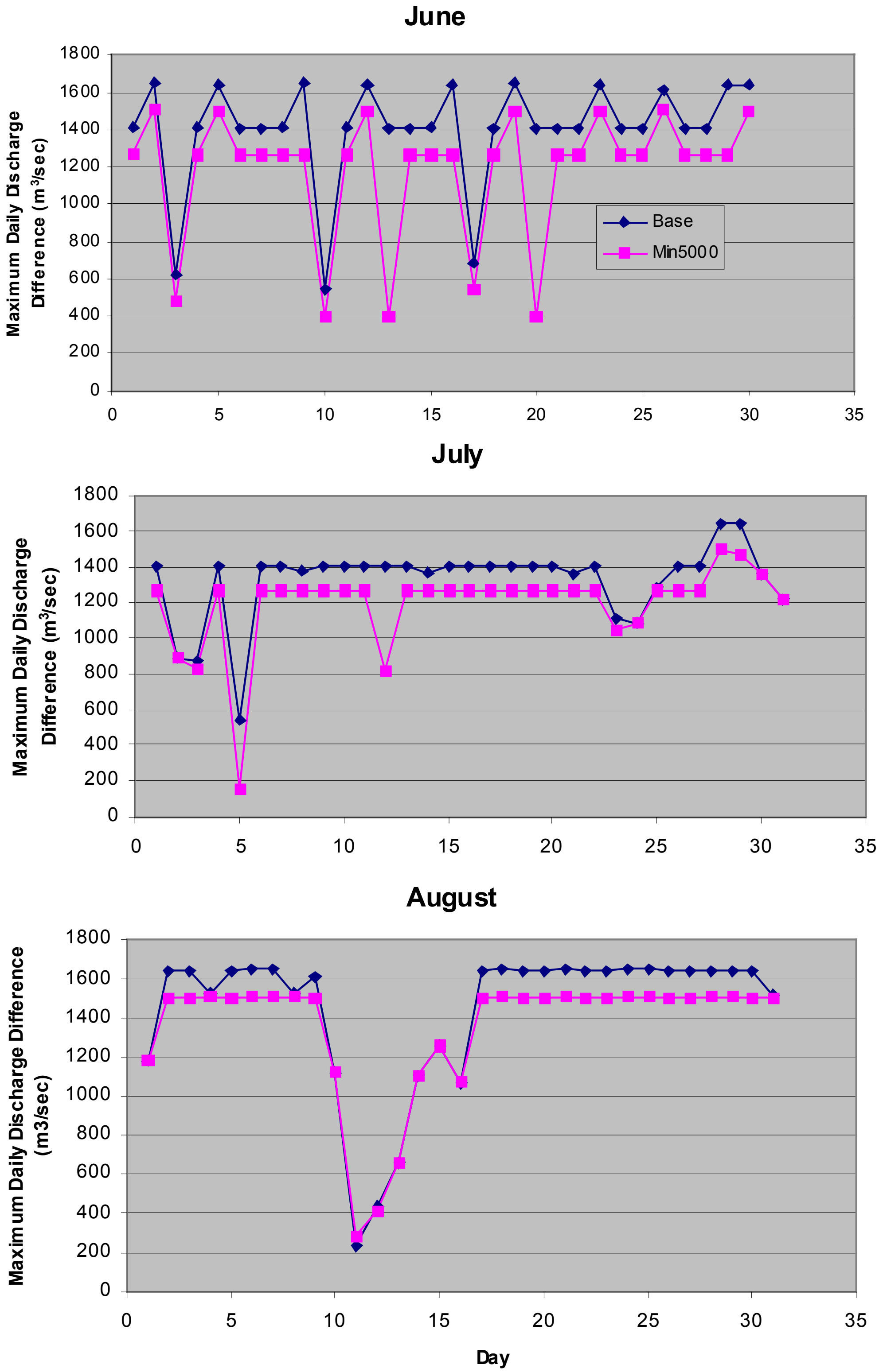
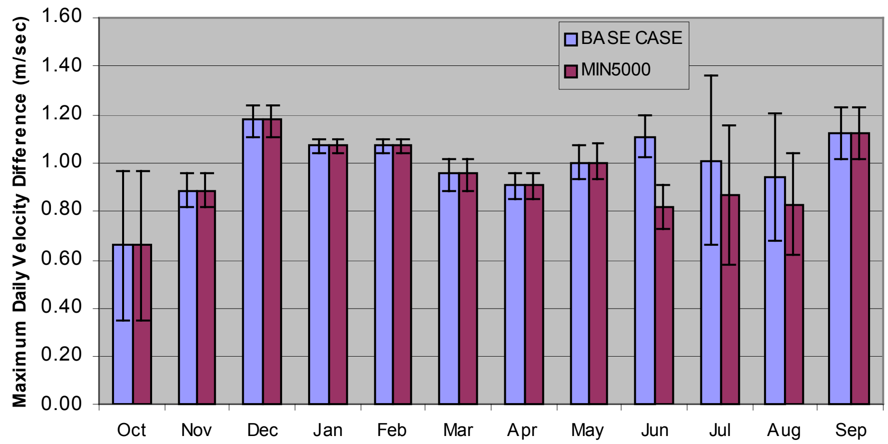


Figure 9: (con't)

a)



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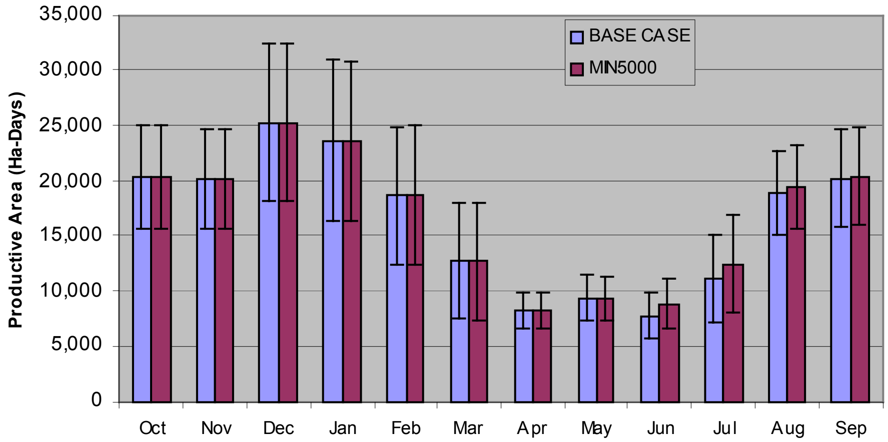


c)

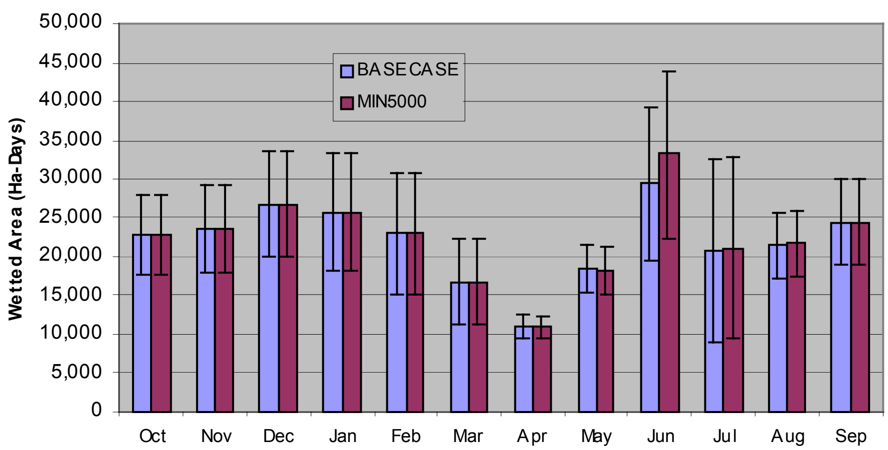


Figure 10: Comparisons of Base Case and Min5000 (minimum flow of 5000 ft^3/sec or 143 m^3/sec in months of June, July, and August only) predictions of average maximum daily velocity difference (a), productive area (b), and wetted area (c). Bars show the mean and standard deviation across 10 water years (1964–65 to 1973–74) for each month.

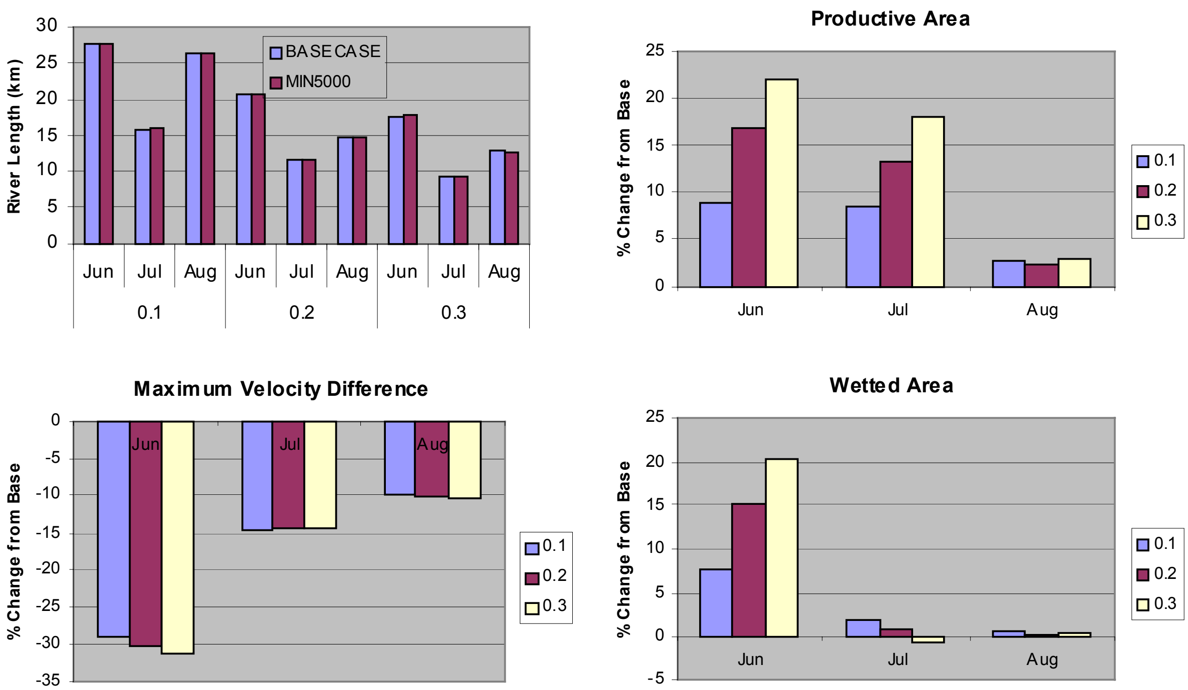
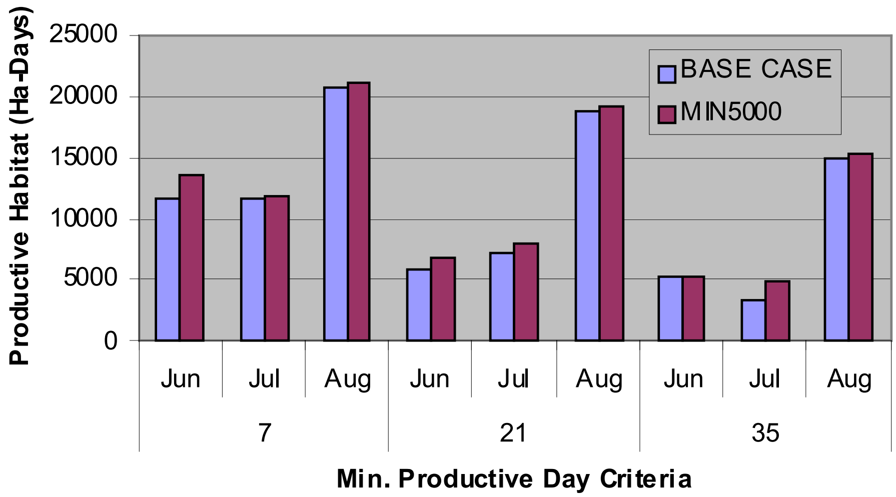


Figure 11: **Sensitivity analysis on the effects of the minimum river velocity criteria (0.1, 0.2 and 0.3 m/sec) on predictions of river length, maximum daily velocity, productive area, and wetted area. % change from base is computed as 100* (Min5000-Base Case)/Base Case. The 1964–65 water year was used for the analysis.**

a)



b)

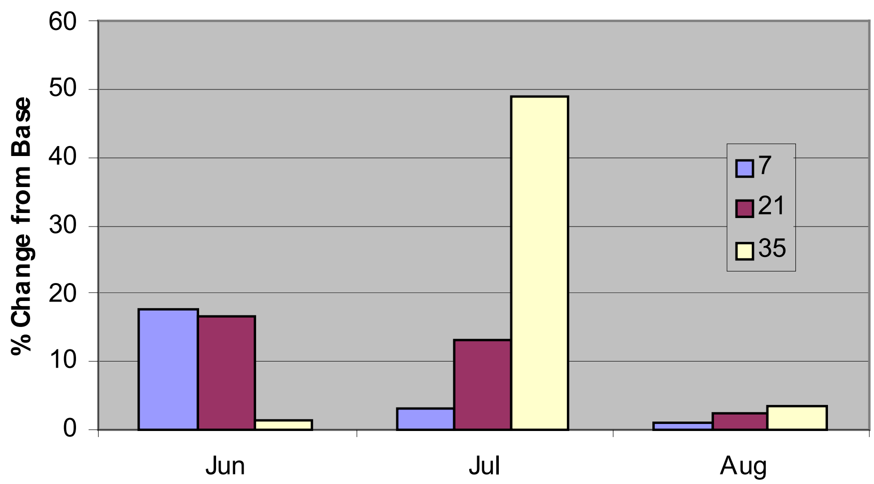
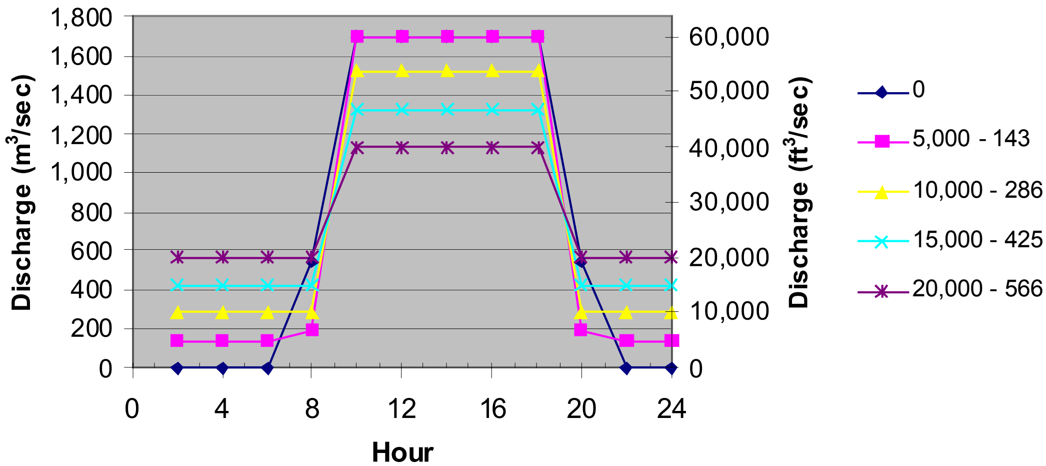


Figure 12: **Sensitivity analysis on the effects of the minimum number of days an elevation slice must be continuously wetted for before it can be considered productive. Changes in productive habitat area as a function of this criteria by month (a), and the relative change of the Min5000 scenario compared to the Base Case (b) are shown. % change from Base Case is computed as 100* (Min5000-Base Case)/Base Case. The 1964–65 water year was used for this analysis.**

a)



b)

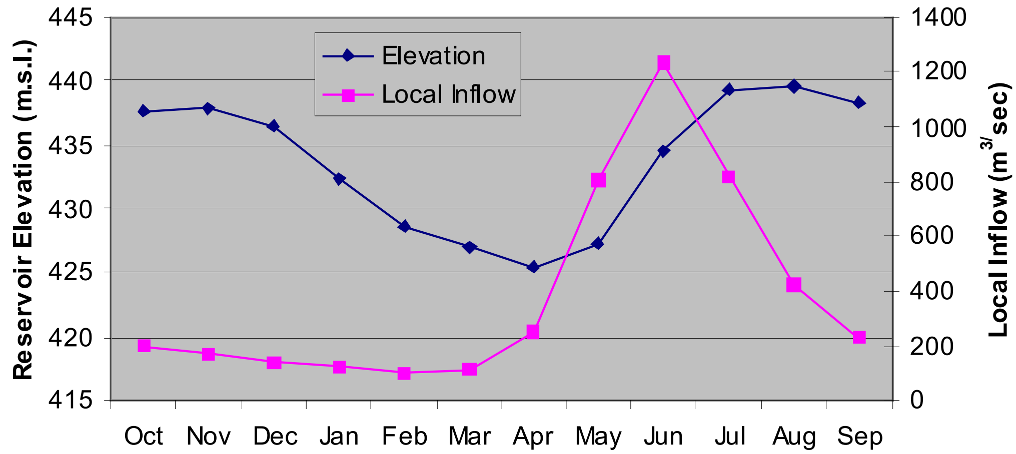


Figure 13: Theoretical discharge hydrographs from Revelstoke Dam (a) under a range of minimum flow scenarios (expressed in m^3/sec and ft^3/sec in legend) and the Base Case 1964–1974 average local inflow and reservoir elevations (b). Scenarios were generated to optimize the value of power generated over the day based on a theoretical hourly power value price differential and load requirement under the constraint of producing an average daily discharge of 800 m^3/sec.

a)

b)

c)

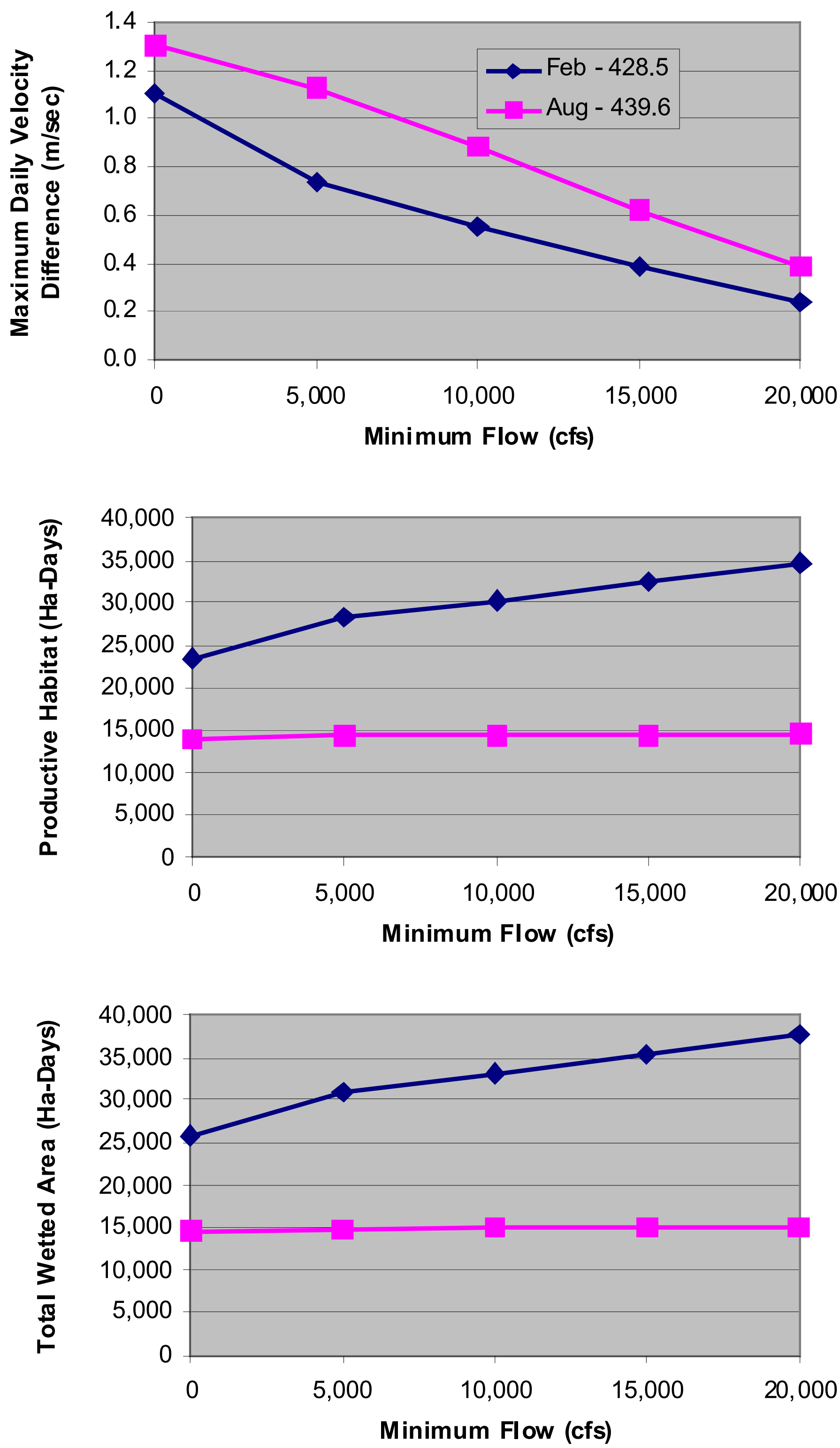


Figure 14: Response of maximum daily velocity difference (a), productive area (b), and total wetted area (c) to a range of minimum flow scenarios for Revelstoke Canyon Dam.

APPENDIX R: Documentation of Preliminary White Sturgeon Spawning Habitat Suitability Model for the Middle Columbia River

DRAFT

Josh Korman and Yao Lin
March 27, 2003

1.0 Introduction

An algorithm was developed to provide an index of spawning habitat suitability for white sturgeon in the Middle Columbia River below Revelstoke Canyon Dam (RCD). This performance measure can be used to assess the potential benefits of minimum flow requirements and changes in arrow lake reservoir elevations being discussed as part of the MCA Water Use Planning process.

2.0 Methods

A one-dimensional step backwater hydraulic model (HEC-RAS) was developed for the Middle Columbia River covering the area from the Revelstoke Canyon Dam to the confluence with the Akokolex River approximately 37.5 km downstream from the dam. The HEC model consists of 245 cross-sections over this area. A small subset of these cross-sections (5) were used to model the hydraulic geometry in the area that is suspected to be used for spawning by white sturgeon (cross-section numbers 176-180). This smaller model area extends 300 meters upstream and downstream of the confluence with the Jordan River. Predictions of depth and velocity for a given discharge were used to compute spawning habitat suitability based on published sturgeon spawning habitat suitability relationships (Parsley et al., 2000, Parsley and Beckman 1994).

Water surface profiles computed by HEC-RAS were used to predict depth and velocity at individual vertical cells (20 per cross section averaging 10–12 m in width) for each modeled cross-section using the following procedure:

1. HEC-RAS was used to compute the normal total conveyance for main channel, left overbank, and right overbank based on the specified water level and discharge.
2. The individual conveyance of each vertical slice in the cross section was computed using eqn. 1.
3. The total conveyance was computed by summing up the individual conveyances of cells and adjusted so that the sum of the conveyance across individual cells was equal to the total conveyance predicted for the entire cross-section.

4. The individual flow rate in each cell was then calculated based on the corrected cells conveyance.
5. The average velocity in each cell was computed by dividing the predicted flow by the cross-sectional area of the cell.

The conveyance (K) of a river channel or a vertical cell in the channel is defined as

$$K=1.49/n * A\, R^{2/3} \tag{1}$$

where 'n' is the Manning's roughness parameter, A is the cross-sectional area, and R is the hydraulic radius. Note that the R=A/P, where P is the wetted perimeter. From this equation we can see that as the ratio of the cross-sectional area to the hydraulic perimeter decreases (e.g., for shallow cells), R will decline and so will the conveyance, discharge and velocity for that cell. Differences in velocity for deep cells in the center of the channel vs. shallow ones or cells adjacent to the bank will be driven by A, P, and the manning roughness parameter.

Cell-by-cell conveyance computations were made assuming that reservoir elevation has a minimal effect on the cross-sections of concern in the month of June when sturgeon spawning likely occurs. This assumption is true for the first half of June, however after this time a backwatering effect reduces velocities and increases depth at cross-sections near the Jordan River confluence. Depending on upcoming FTC discussions on the timing of sturgeon spawning, a more complex conveyance computation, which accounts for reservoir elevation effects, may be warranted. With this current structure, the model likely overpredicts spawning habitat WUA during periods when reservoir elevations are high (>436-7) and underestimates the benefits of reduced reservoir elevation during the sturgeon spawning period (Alt 11).

Predictions of depth and velocity for each cell were translated into suitability values ranging from 0–1 based on the functions shown in Fig. 1. Weighted-useable-area (WUA) for a specific discharge was computed as the sum of the product of the cross-sectional area for each cell (A_i) and its suitability value for velocity only (S_v), or velocity and depth (S_vS_d),

Velocity Only Model: $$WUA_v = \sum_{i=1}^{ncells} A_i S_v \tag{2}$$

Depth and Velocity Model: $$WUA_t = \sum_{i=1}^{ncells} A_i S_v S_d \tag{3}$$

Time-integrated WUA values were computed to derive a single statistic for each model that was used to evaluate alternate minimum flow. Time integration was performed by integrating the predicted WUA values from a cross-sectionally averaged function based on the depth-velocity suitability model. The model used to produce a time-integrated WUA estimate was:

WUA=-4.99 - 1.13e-01 * Q + 8.37e-04 * Q^2 - 4.23e-07 * Q^3 + 6.70e-11 * Q^4,

where Q is discharge in m^3/sec.

To perform the time integration, the bi-hourly discharge from RCD was used as input in the polynomial function to predict WUA for that timestep. These WUA values were summed over the month of June and divided by the total number of timesteps in the month. The procedure was repeated using a discharge input that included both RCD discharge and an estimate of the discharge from the Jordan River (based on the total local Arrow reservoir inflow for the month and the proportion of the Jordan River drainage to the total local drainage). The final PM is the average of the RCD-only and RCD+Jordan WUA estimates under the assumption that the potential spawning areas upstream and downstream of the Jordan confluence are equally important.

3.0 Results

Cross-sections used to compute hydraulic geometry and WUA are shown in Figure 2. Cross-sections 178–180 are located upstream of the Jordan River confluence. Cross-section 177 is located immediately downstream of the confluence wile 176 is the most downstream cross-section for the white sturgeon spawning PM and is located about 400 m upstream of the Big Eddy Pool. The golf course is on the left bank. The cross-sections have a similar shape with the exception of the most downstream transect, which has a more gradual bank on river left.

Example plots of velocity, depth, and suitability for are shown in Fig.'s 3–5. As discharge increases, it is evident that the area of deep and fast water increases, resulting in higher spawning habitat suitability. Including depth in the suitability model (eqn. 3) reduces WUA and limits suitable spawning habitat to portions of the cross-section that are close to the thalweg.

The WUA-discharge relationships for all cross-sections under both suitability models (velocity only or depth and velocity) are shown in Fig. 6. Within a habitat suitability model predictions of WUA are very similar across cross-sections. WUA values are generally higher under the velocity-only suitability model but the general shape of the functions, which determines the relative response among minimum flow options, have similar characteristics (Fig. 7). The biggest difference between functions at discharges which are potentially effected by minimum flow restrictions, is that the velocity-only model predicts a very small amount of suitable habitat at 5000 cfs (9 m^2), while the depth-velocity model requires over 8500 cfs to generate a similar WUA value. Both models suggest that relatively large flows (40 000 cfs) are required to reach reasonably high (>500 m^2) WUA levels.

A comparison of time-integrated WUA values across alternatives is provided in Figure 8. WUA actually declines with increasing minimum flow restrictions because such restrictions also reduce maximum flows where WUA is higher (Fig. 7). Thus the gains in WUA caused by increasing minimum flows are more than offset by the losses incurred by reducing maximum flows.

4.0 Discussion

The utility of our time-integrated approach for providing a single PM value for each minimum flow alternative is questionable. The approach estimates the average WUA over June based on predicted discharges at a 2-hr timestep. We do not know if white sturgeon spawning success is driven by the average conditions as we have assumed, or nighttime, maximum, minimum, or diel variation in WUA values over the month. The time-integrated average WUA is the simplest approach, but is not necessarily the correct one. However, the WUA-discharge relationships that this modeling effort has provided (Fig. 7) provide some guidance on flows that will provide depth and velocities that lead to successful spawning and juvenile survival in other parts of the Columbia. Improvements to the temporal component of the sturgeon PM will hopefully be discussed at the upcoming FTC meeting.

The current hydraulic computations that drive the sturgeon spawning PM estimates assume that the water surface elevation of the reservoir is well below the thalweg of the cross-sections used in the computations and therefore has no effect on depth and velocities at these locations. This assumption is certainly reasonable in early June when reservoir elevations are typically below the deepest sections of cross-sections 176–180. However reservoir elevations do affect depth and velocities at these locations in late June and July in most years. The hydraulic computations in the sturgeon PM therefore need to be refined to account for reservoir elevation effects. The results presented in this document likely overestimate WUA values in general and underestimate the relative benefits of Alt 11 where reservoir elevations are typically 1 meter lower than the base case in June and July.

5.0 References

<to be completed>

Parsley et al. 2000

Parsley and Beckman 1994

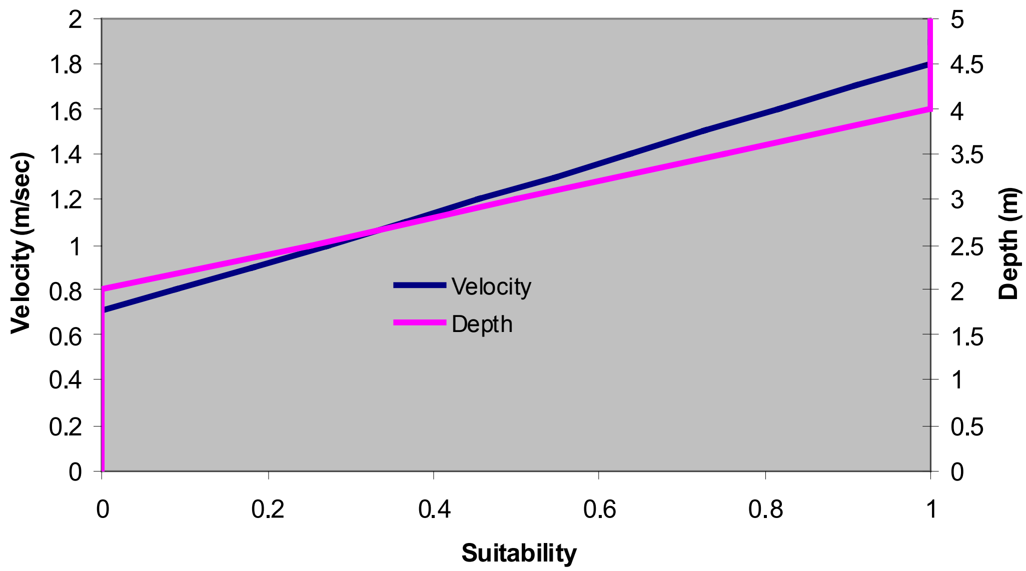


Figure 1: White sturgeon spawning habitat suitability curves developed from data in Parsley et al., 2000 and Parsley and Beckman (1994).

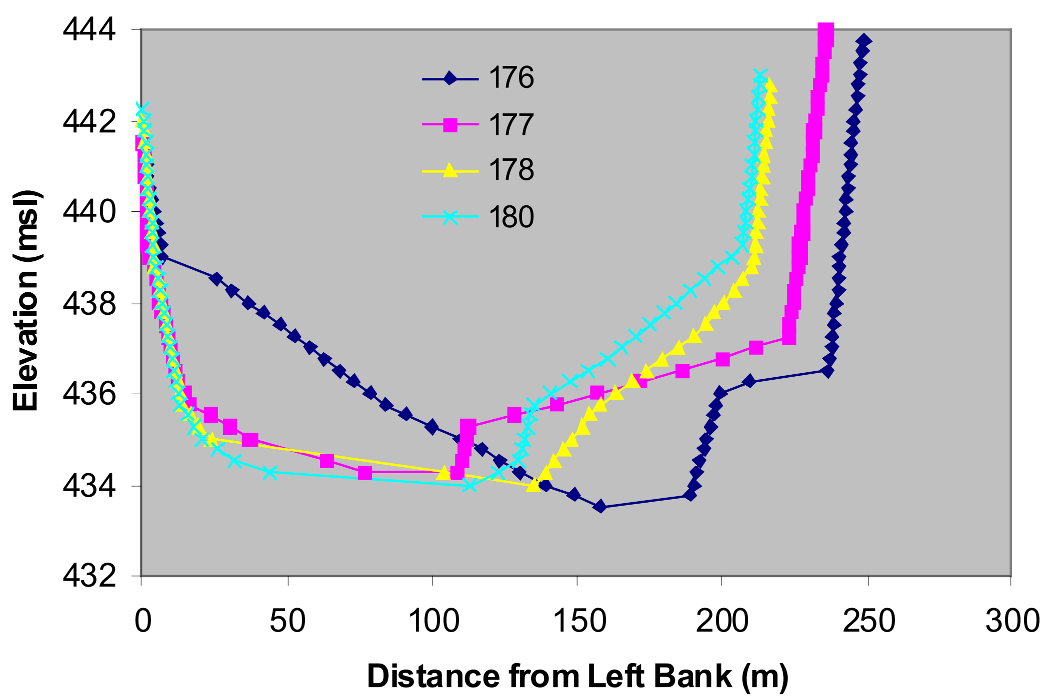
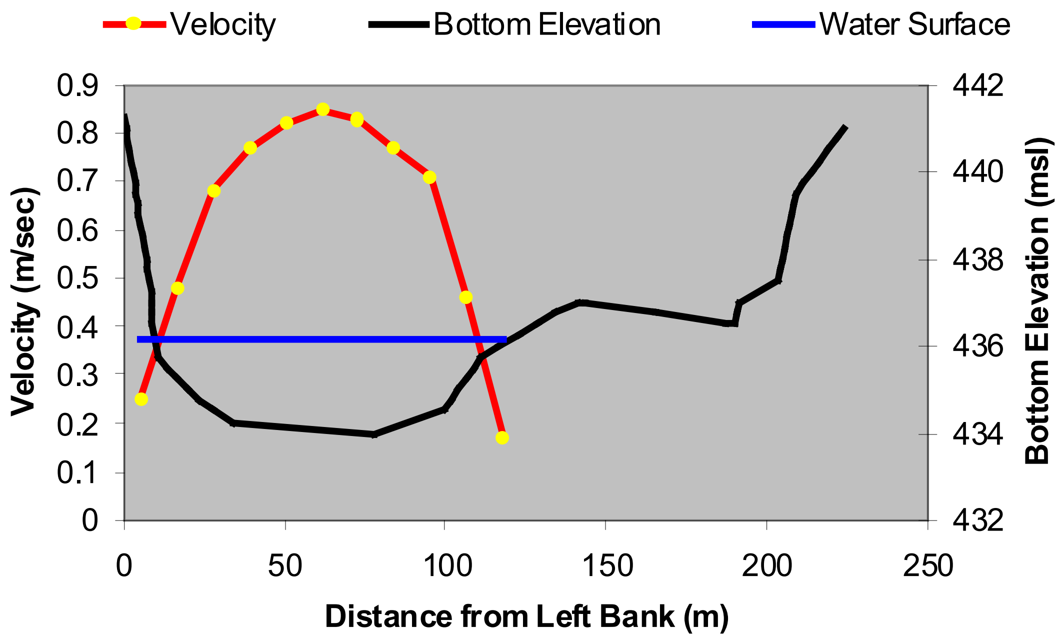


Figure 2: Cross-sections used in the computation of the white sturgeon spawning habitat performance measure. Cross-section 180 is the most upstream transect.



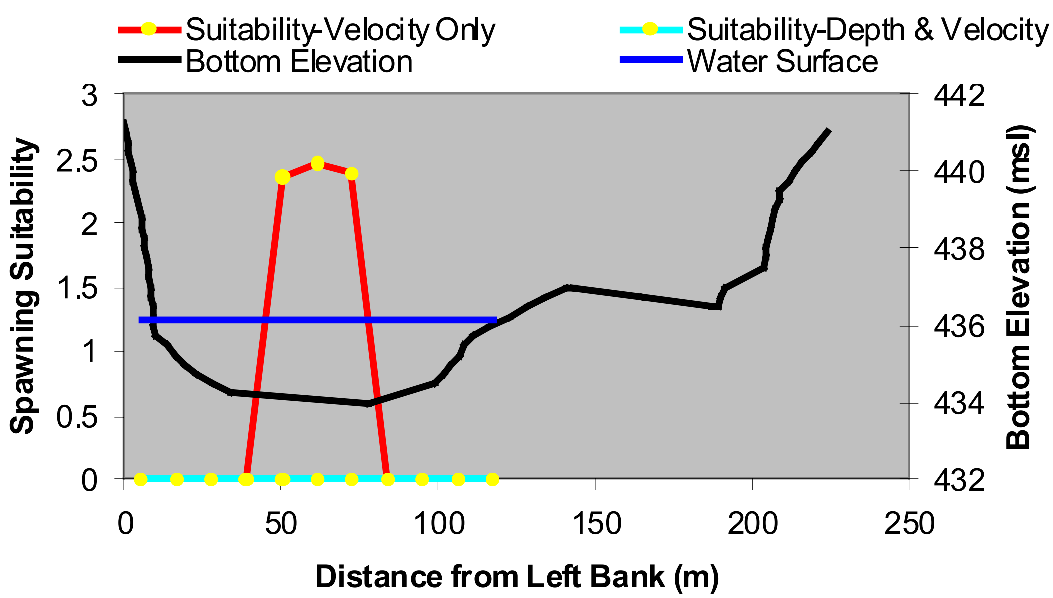


Figure 3: Velocity and depth (top) and WUA (bottom) at cross-section 180 (ca. 300 m upstream of Jordan River confluence) at 5000 cfs. Yellow dots denote the centerpoints of individual vertical cells. Depth is the difference between the royal blue (water surface) and black (bottom elevation) lines.

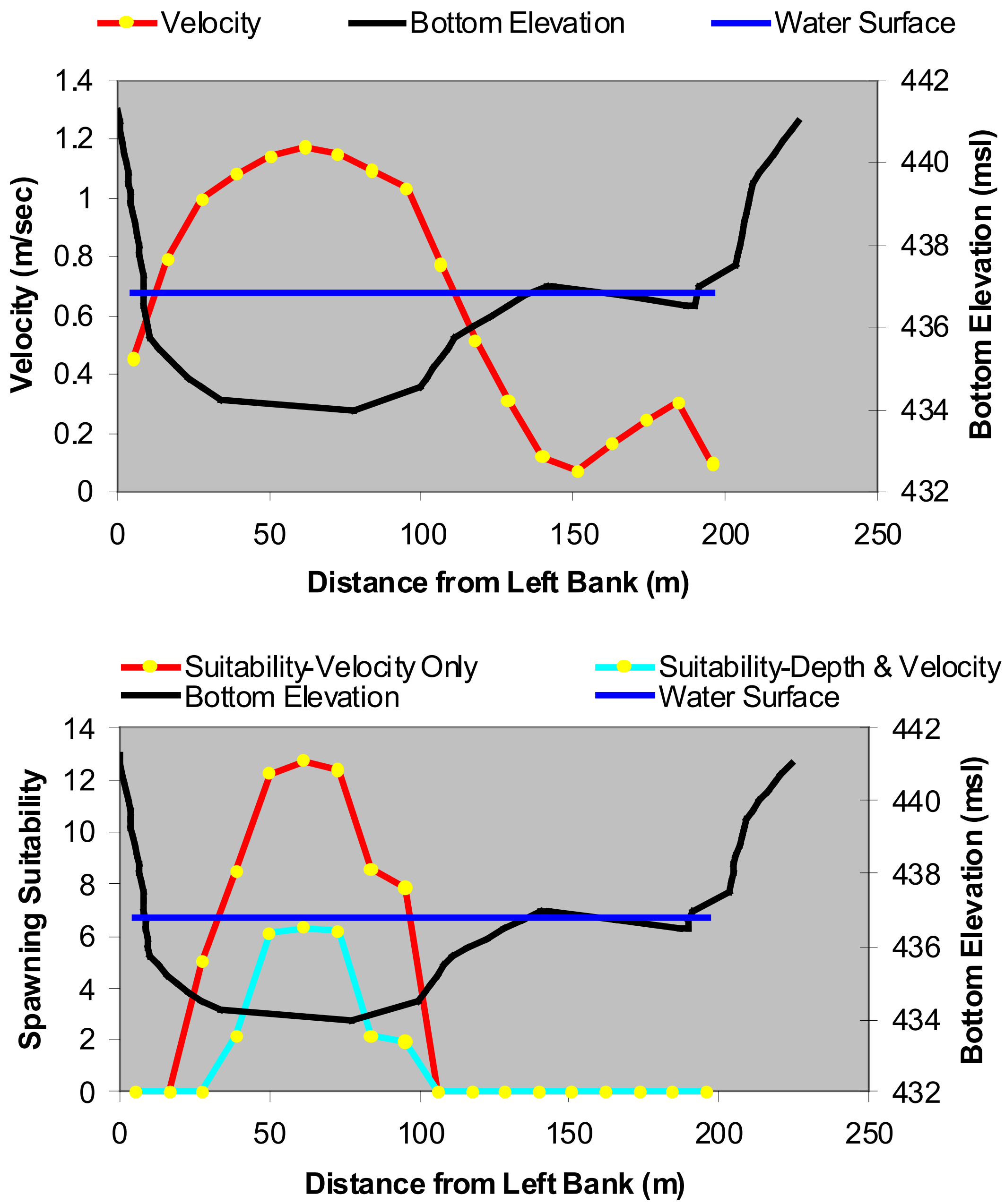


Figure 4: Velocity and depth (top) and WUA (bottom) at cross-section 180 at 10 000 cfs. Yellow dots denote the centerpoints of individual vertical cells. Depth is the difference between the royal blue and black lines.

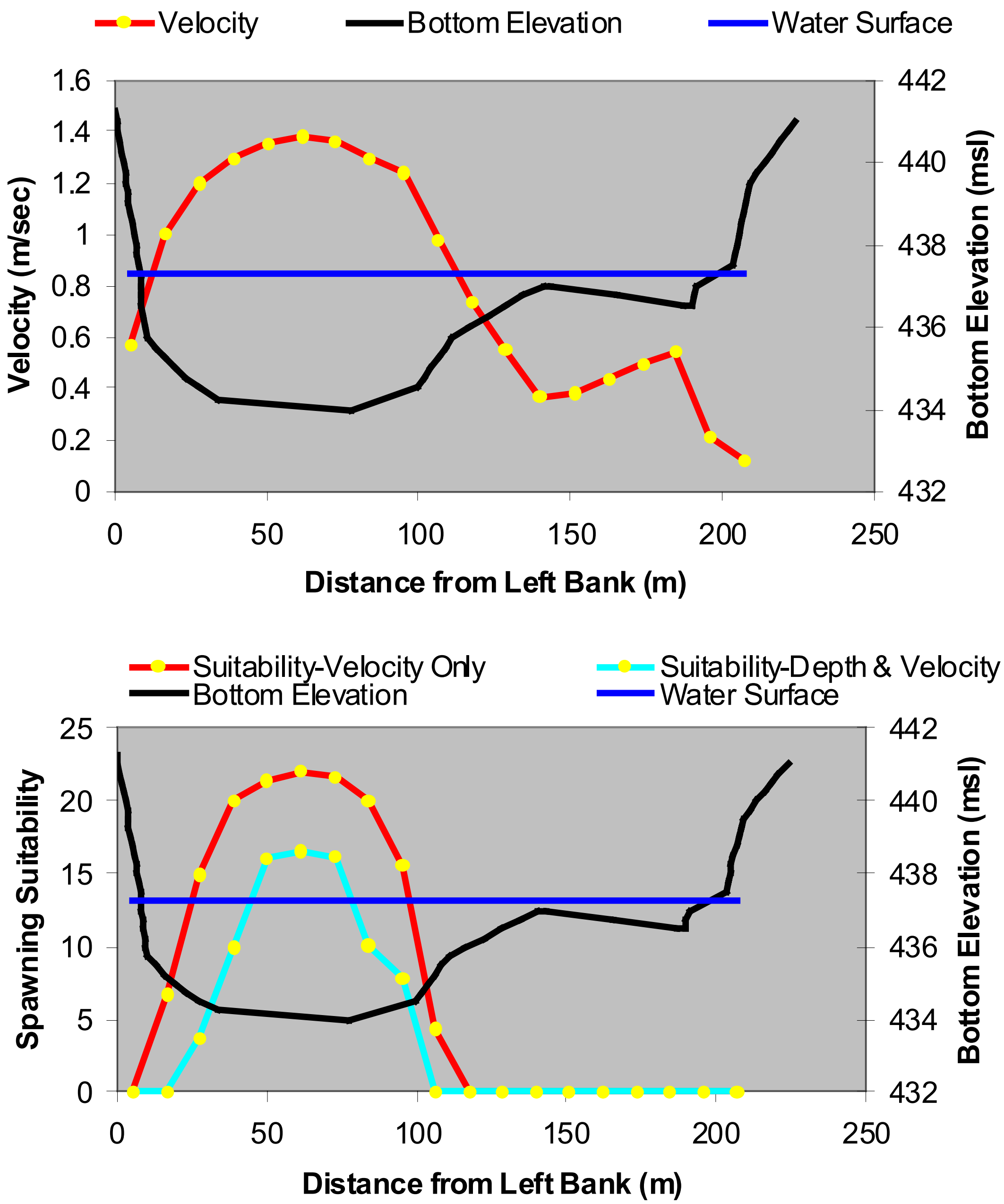


Figure 5: Velocity and depth (top) and WUA (bottom) at cross-section 180 at 15 000 cfs. Yellow dots denote the centerpoints of individual vertical cells. Depth is the difference between the royal blue and black lines.

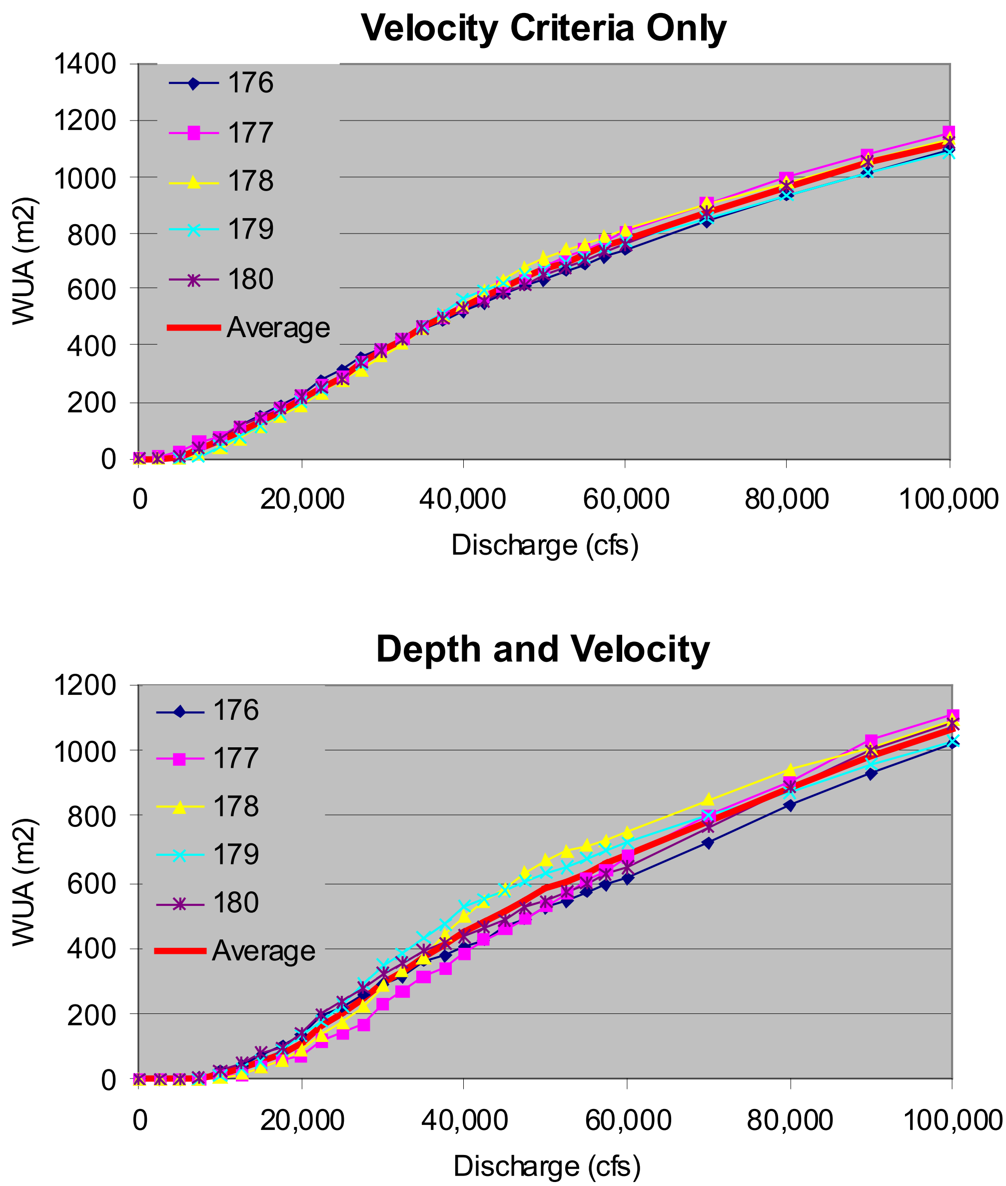


Figure 6: Relationships between weighted-useable-area (WUA) for white sturgeon spawning habitat and discharge based on velocity-only (top) and depth-velocity (bottom) suitability models. The thick red line represents the average response across cross-sections.

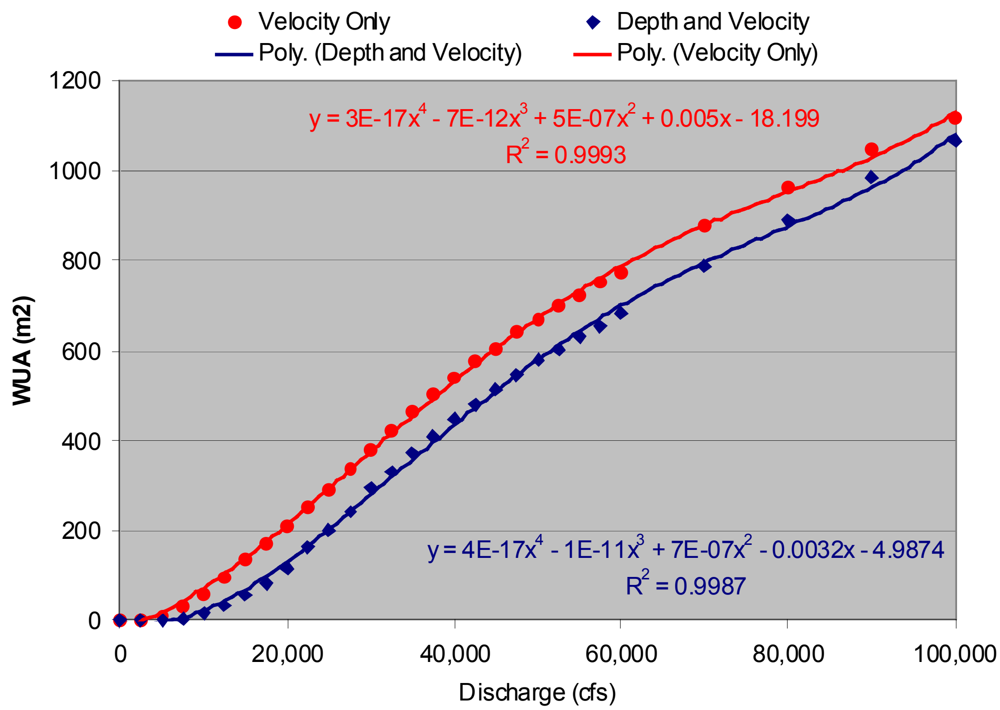


Figure 7: **Cross-sectional average WUA-discharge relationships for velocity-only (red) and depth–velocity (blue) white sturgeon spawning habitat suitability models. Points represent the predicted WUA values at specific discharges and lines represent the best-fit 4th order polynomials to these values.**

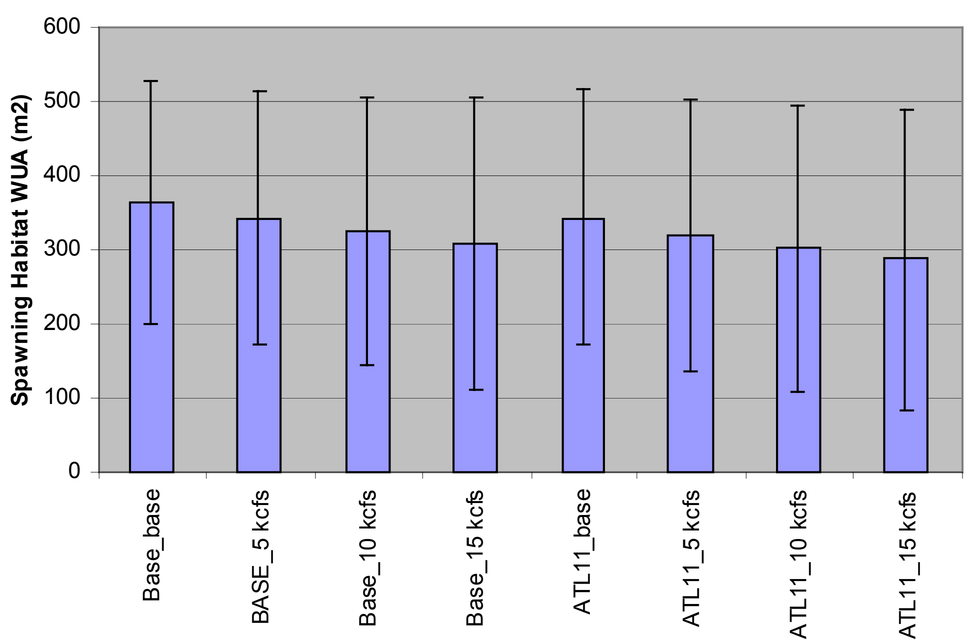


Figure 8: Mean and 90% confidence limits of white sturgeon spawning habitat PM based on 10 years of bi-hourly data in the month of June for 0, 5, 10, and 15 kcfs minimum flow alternatives under normal (Base_) and 1-meter reservoir summer drawdown (Alt11_) scenarios.

APPENDIX S: TOTAL GAS PRESSURE PERFORMANCE MEASURE RESULTS SUMMARY NOTE

1.0 Background

In identifying fish-related issues in the lower Columbia River, the Columbia Water Use Plan Consultative Committee expressed concern that different operating regimes on Arrow Lakes Reservoir, and flow regimes below Hugh Keenleyside Dam might increase the risk of Total Gas Pressure (TGP) production.

Early efforts at tracking the potential impact on TGP production below Hugh Keenleyside Dam focused on tracking the height differential between Arrow Lakes Reservoir elevations and tailwater elevations below the dam. Previous experience had shown that TGP production increased dramatically as this height differential crossed 17 m. However, the group expressed discomfort with these early attempts in that they used monthly elevations as their inputs, whereas TGP production tends to be brief in duration (spiky). Further, the group noted that TGP production was both a function of head differential and flows.

A second attempt to track TGP production was presented to the Fish and Wildlife Technical Subcommittee in Castlegar (October 2002). At that time, a series of daily flows and elevations had been created based on historical fluctuations superimposed on the monthly output from the Columbia Water Use Plan HYSIM model of alternatives. This analysis considered TGP production as both a function of head differential and flows, based on a model developed by Aspen Applied Sciences. However, the group was not satisfied with these results and requested that:

- The influence of the Arrow Lakes Generating Station to be incorporated into the output.
- The most recent decade of modelled flow data be used for all alternatives (Base Case, Alt 7B 1MAF, Alt 7B 2MAF, and Alt 11B).
- More detail be provided around the influence of TGP on fish mortality.
- More time be provided to consider the link between fish mortality and TGP production.

Larry Fiddler of Aspen Applied Sciences subsequently prepared two papers for the Columbia River water use planning process, "TGP Performance Measures for the Mica Water Use Plan: A Derivation Summary," and "TGP Performance Measures for the Columbia Water Use Planning Process: A Review and Evaluation of Relevant Information and Data." These reports were reviewed with interested members of the Fish and Wildlife Technical Subcommittee in January 2003, and results of those discussions formed the basis of modifications to the TGP performance measures.

2.0 Current Performance Measure Calculations (April 2003)

The performance measure calculations for TGP production below Hugh Keenleyside Dam presented at the 10–11 April 2003 Fish and Wildlife Technical Subcommittee meeting were similar to those presented to the subcommittee in October 2002, in that they impose daily deviations, simulated from historical data, onto the monthly outputs of the alternative modelled to data (Base Case, Alt 7b 1MAF, Alt 7b 2MAF, and Alt 11B) (see notes from Fish and Wildlife Technical Subcommittee, October 2002 for more details) for the years 1984/5 to 1999/00. In addition, the performance measures capture the fact that the Arrow Lakes Generating Station (ALGS) can divert up to 1115 m^3/s (~40 000 cfs) of the flows away from the ports at the Hugh Keenleyside Dam where TGP is produced, and pass it through its generators where no TGP is produced. For an overview of these flow calculations, see Attachment 1. For an overview of TGP calculations, see Attachment 2.

3.0 Preliminary Elevations

To check on the initial concerns of the Consultative Committee and the Fish and Wildlife Technical Subcommittee, the average head differential was calculated across the years for the four alternatives considered. These results are presented in Table S-1 and confirm the suspicion that Alternative 7 raises the head differential, and perhaps increases the risk of TGP production.

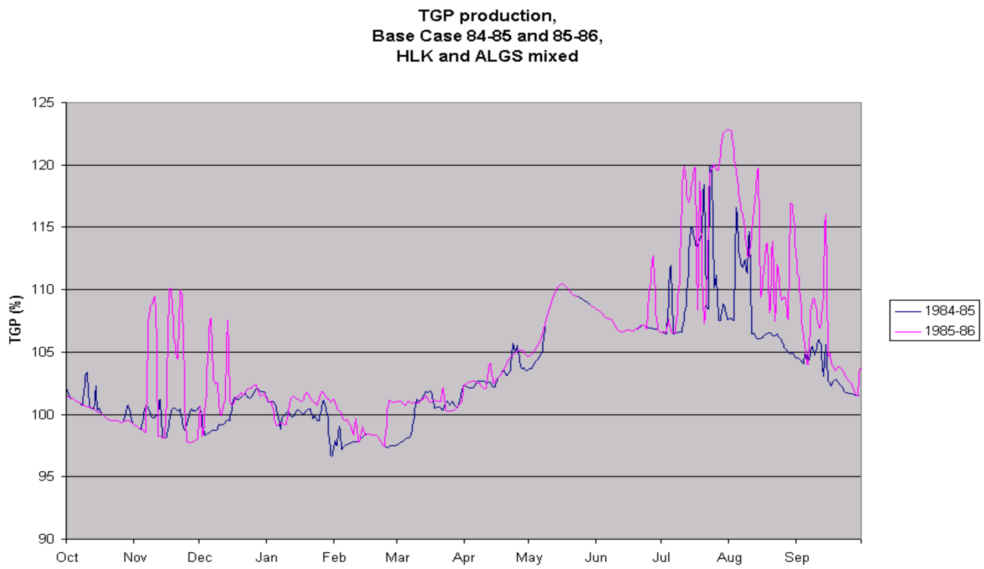
Table S-1: Average Head Differential (m)

	Base Case	Alt 7B 1MAF	Alt 7B 2MAF	Alt 11B
Average Head (m)	12.5	14.4	14.2	12.1

However, since TGP is a function of total head and flows past Hugh Keenleyside Dam and ALGS, Table S-1 may not be a good indicator of TGP production risk.

4.0 TGP Production

A plot of one year TGP production for the base case is reproduced below.



At the request of the group discussing TGP for the Fish and Wildlife Technical Subcommittee, a seasonal analysis was carried out across the alternatives and years. Across all alternatives and all years, TGP production above 115 per cent is limited to the time frame of late June to the end of August. A full graph of all four alternatives, across all years, is shown in Attachment 3.

5.0 TGP Metric

There exists a variety of ways to sum up differences between alternatives. These will be explored below.

The first method is to choose some cutoff value and then count the number of days that TGP production exceeds this across the 15 year period. This is done in Table S-2 for the two threshold values recommended in January, 115 per cent and 120 per cent.

Table S-2: Total Number of Days TGP Exceeds a Threshold from 1984-2000

	Base Case	**Alt 7B 1MAF**	**Alt 7B 2MAF**	**Alt 11B**
# days above 115% in 15 years	170	92	182	39
# days above 120% in 15 years	12	18	22	1

Note that this treats each day above a threshold equally, regardless of its absolute magnitude, and disregards all TGP occurrences below that cutoff. An alternative measure would be to calculate the average daily TGP reported in June, July and August (the months of high TGP production). This is reported in Table S-3 below.

Table S-3: Average Summer (June, July, August) TGP Production (%)

	Base Case	Alt 7B 1MAF	Alt 7B 2MAF	Alt 11B
TGP (%)	107.5	107.8	106.7	106.2

While Table S-2 focuses on peak events, the effect of short duration spikes is lost in the overall average presented in Table S-3.

Some final measurement issues that are not resolvable through the performance measures requested for the Fish and Wildlife Technical Subcommittee are the cumulative effects of TGP production.

6.0 Impact of ALGS Operations on TGP

Since ALGS can divert up to 1115 m^3/s (~40 000 cfs) away from Hugh Keenleyside Dam, it was assumed that the introduction of ALGS would make all alternatives perform better for TGP production than what historically occurred on the lower Columbia River.

To check this assumption, ALGS was removed from the analysis and all water was passed through Hugh Keenleyside Dam. Table S-4 summarizes the total number of days that TGP levels exceed the 115 per cent and 120 per cent thresholds under this scenario.

Table S-4: Total Number of Days TGP Exceeds a Threshold from 1984-2000, No ALGS Operations

	Base Case	Alt 7B 1MAF	Alt 7B 2MAF	Alt 11B
# days above 115% in 15 years	730	1527	849	298
# days above 120% in 15 years	528	1451	534	232

Table S-4 suggests that the introduction of ALGS operations greatly reduces TGP occurrence relative to historical across all of the alternatives. For the upper threshold of 120 per cent, this difference is roughly an order of magnitude.

7.0 Conclusion

The Fish and Wildlife Technical Subcommittee reviewed the above results at its 28 April 2003 meeting in Castlegar. The two main conclusions reached by the group were that a) with the introduction of ALGS, all alternatives would perform much better than recent historic, and b) the calculated performance measures provide no strong basis for choosing among the alternatives.

The group also noted that the impact of having consecutive days of exposure may be missed by the performance measures scores. These results were reviewed by Bonny Antcliffe (Fisheries and Oceans Canada) and Larry Fiddler (Aspen Applied Sciences), who reached the same conclusions as the subcommittee. Consequently, the issue of TGP production in the lower Columbia River was dropped from further consideration.

Attachment 1 Estimating Flows Past Hugh Keenleyside Dam and the Arrow Lakes Generating Station

Simulated daily elevations for the Arrow Lakes Reservoir and simulated daily flows from the Arrow Reservoir and past Brilliant Dam were provided. Tailwater elevations were calculated as a function of flows out of Arrow and flows out of Brilliant using the following approximation:

TW = 1293.72 + 18.606 * ln(Qkeen+0.224*Qkoot+0.0019*Qkoot^2-0.00148*Qkeen*Qkoot+42.82)

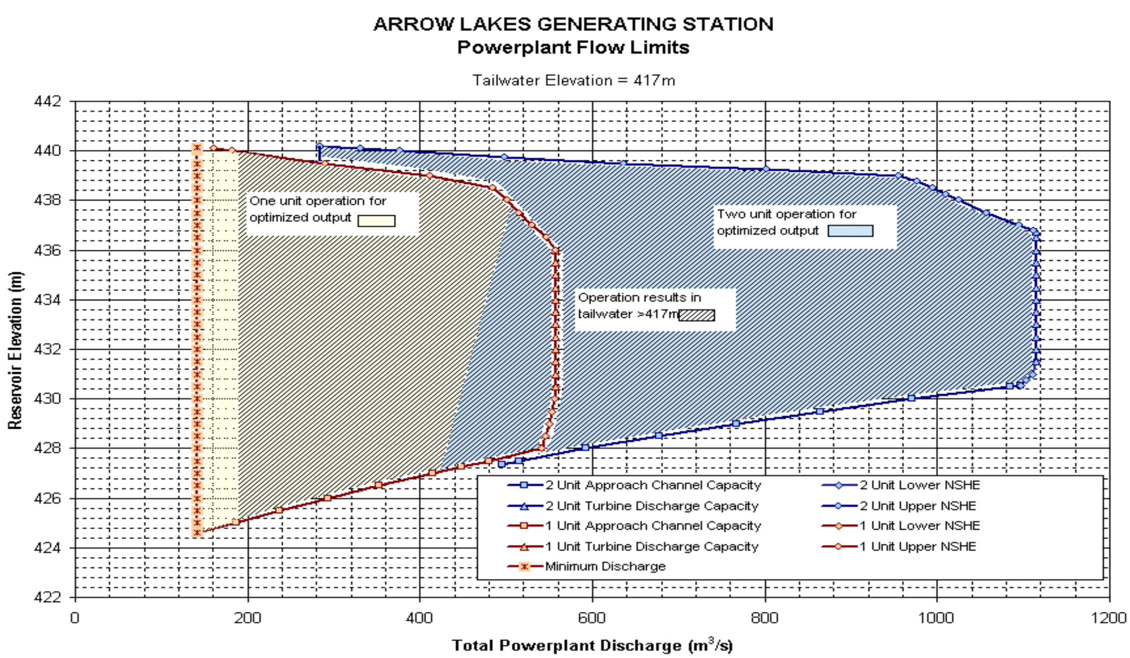
where:

TWL = tailwater elevation estimate at Hugh Keenleyside Dam in feet

Qkeen = keenleyside total discharge in kcfs

Qkeen = Brilliant discharge in kcfs or 31.56 which ever is greater.

The portioning of water between the Hugh Keenleyside Dam and the Arrow Lakes Generating Station (ALGS) follows a complex set of rules. Llewellyn Matthews (Columbia Power Corporation) provided the operating rules for ALGS, where ALGS discharge is a function of tailwater elevation (TW) and elevation of the Arrow Lakes Reservoir. An example of these curves for a tailwater elevation of 417 m is provided below.



A summary of these operating curves for TW elevations 417 m, 418 m, 419 m, 420 m and 423 m was made. Note that this lookup table is an approximation, and simplifies some operational decisions between using one or two units. It is assumed, for these purposes, that ALGS will always maximize output for a given elevation on Arrow Lakes Reservoir.

Table 1: ALGS Flows as a Function of Tailwater Elevation and Arrow Lakes Reservoir Elevation

		TW (m)				
		1	2	3	4	5
Arrow		417	418	419	420	423
Elev. (m)	0	0	0	0	0	0
	424.59	142	142	142	142	
	425	187.04	187	187	194	
	425.5	237.5	237.5	237.5	214.6	
	426	293.2	293	325	315	
	426.5	352.4	375	375	385	
	427	414.47	450	450	475	
	427.5	514.71	514.7	537.5	535	142
	428	592	592.2	592.2	592.2	331.9
	428.5	676.8	6768	676.8	676.8	456.4
	429	767	767.3	767.3	767.3	574
	429.5	864.6	864.6	864.6	864.6	694.2
	430	970	970.5	970.5	963.2	773.6
	430.5	1084.09	1085.6	1076	1046.2	831.1
	431	1115	1101.7	1091.5	1080.7	886
	431.5	1115	1110.8	1100.5	1089.6	941.2
	432	1115	1115	1108.4	1097.3	996.6
	432.5	1115	1115	1115	1104.4	1050.6
	433	1115	1115	1115	1115	1077.3
	433.5	1115	1115	1115	1115	1083.8
	434	1115	1115	1115	1115	1090.4
	434.5	1115	1115	1115	1115	1096.7
	435	1115	1115	1115	1115	1103.1
	435.5	1115	1115	1115	1115	1109.2
	436	1115	1115	1115	1115	1115
	436.5	1115	1115	1115	1115	1115
	437	1095.1	1115	1115	1115	1115
	437.5	1057.9	1112.6	1115	1115	1115
	438	1024.7	1075.6	1115	1115	1115
	438.5	995	1043	1103.5	1115	1115
	439	955	1012.9	1068.2	1115	1115
	439.5	637.1	982.6	1036.5	1098.5	1115
	440	377.4	897.8	1007.4	1070	1115
	440.1	331.3	832.7	1001.8	1057.6	1115
	440.7	284	508	960	1021.7	1115

Despite the approximate nature of this table, several observations can be drawn. It is clear to see that ALGS can take up to 1115 m^3/s (~ 40 000 cfs) of flows away from spilling at Hugh Keenleyside Dam, but that the relationship between elevation, spills, and ALGS output is not clear cut.

For TGP calculations, it was assumed that flows past Hugh Keenleyside Dam were the difference between Arrow outflows and ALGS outflow. In cases where this resulted in a negative number (due to approximation error), this was truncated at zero. Note that this violates the Hugh Keenleyside Dam minimum discharge rule of 5000 cfs. But since these instances in the data set were rare, this is assumed not to have a large consequence.

Attachment 2: Overview of TGP Calculations below Hugh Keenleyside Dam and Arrow Lakes Generating Station

Hugh Keenleyside Dam releases are co-ordinated to minimize the amount of TGP created downstream through the sequential operation of ports and spillways. Modelling by Aspen Applied Sciences has modelled TGP production as a function of Hugh Keenleyside Dam discharge and the head differential between the Arrow Lakes Reservoir and the tailwater (called "head" from here on).

This relationship was provided to the BC Hydro Project Team in the form of a lookup table, of which a portion is reproduced below.

Table 2: TGP Production as a Function of Head Differential (m) and Discharge from Hugh Keenleyside Dam (m^3/s)

Discharge	Head - m >	HLK TGP% as a function of Discharge and Total Head						
V	16.00	16.25	16.50	16.75	17.00	17.25	17.50	17.75
0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9
50	136.9	136.9	136.9	136.9	136.9	136.9	136.9	136.9
75	136.8	136.9	136.9	136.9	136.9	136.9	136.9	136.9
100	101.9	102.0	102.0	102.0	102.0	136.9	136.9	136.9
125	102.2	102.3	102.3	102.4	102.4	136.9	136.9	136.9
150	102.5	102.6	102.7	102.7	102.7	136.9	136.9	136.9
175	102.8	102.9	103.0	103.1	103.1	136.9	136.9	136.9
200	103.1	103.2	103.3	103.4	103.4	136.9	136.9	136.9
225	103.4	103.5	103.5	103.6	103.7	136.9	136.9	136.9
250	103.7	103.7	103.7	103.9	104.0	136.9	136.9	136.9
275	103.9	103.9	103.9	104.1	104.2	136.9	136.9	136.9
300	104.2	104.2	104.1	104.3	104.5	136.9	136.9	136.9
325	104.4	104.4	104.3	104.5	104.7	136.9	136.9	136.9
350	104.6	104.6	104.6	104.8	104.9	136.9	136.9	136.9
375	104.7	104.8	104.8	104.9	105.0	136.9	136.9	136.9
400	104.9	105.0	105.0	105.1	105.2	136.9	136.9	136.9
425	105.1	105.2	105.2	105.3	105.4	136.9	136.9	136.9
450	105.2	105.3	105.3	105.4	105.5	136.9	136.9	136.9
475	105.4	105.5	105.5	105.6	105.7	136.9	136.9	136.9
500	105.5	105.6	105.6	105.7	105.8	136.9	136.9	136.9
525	105.7	105.8	105.8	105.9	106.0	136.9	136.9	136.9
550	105.8	105.9	106.0	106.1	106.1	136.9	136.9	136.9
575	106.0	106.1	106.1	106.2	106.3	136.9	136.9	136.9
600	106.1	106.2	106.3	106.4	106.5	136.9	136.9	136.9
625	106.2	106.3	106.4	106.6	106.7	136.9	136.9	136.9
650	106.3	106.4	106.5	106.6	106.7	136.9	136.9	136.9

Note that the Fish and Wildlife Technical Subcommittee's original guess that the 17 m head differential formed some sort of break point in TGP production below Hugh Keenleyside Dam seems justified. This relationship changes somewhat at higher flow levels, but the idea that there is an increasing risk of TGP production at higher head levels is an accurate one.

Flows through the Arrow Lakes Generating Station (ALGS) were assumed not to produce TGP. Adding ALGS into the analysis reduced TGP production in three ways:

- It reduced the amount of flows through Hugh Keenleyside Dam, which reduced TGP production there (see Table 2).

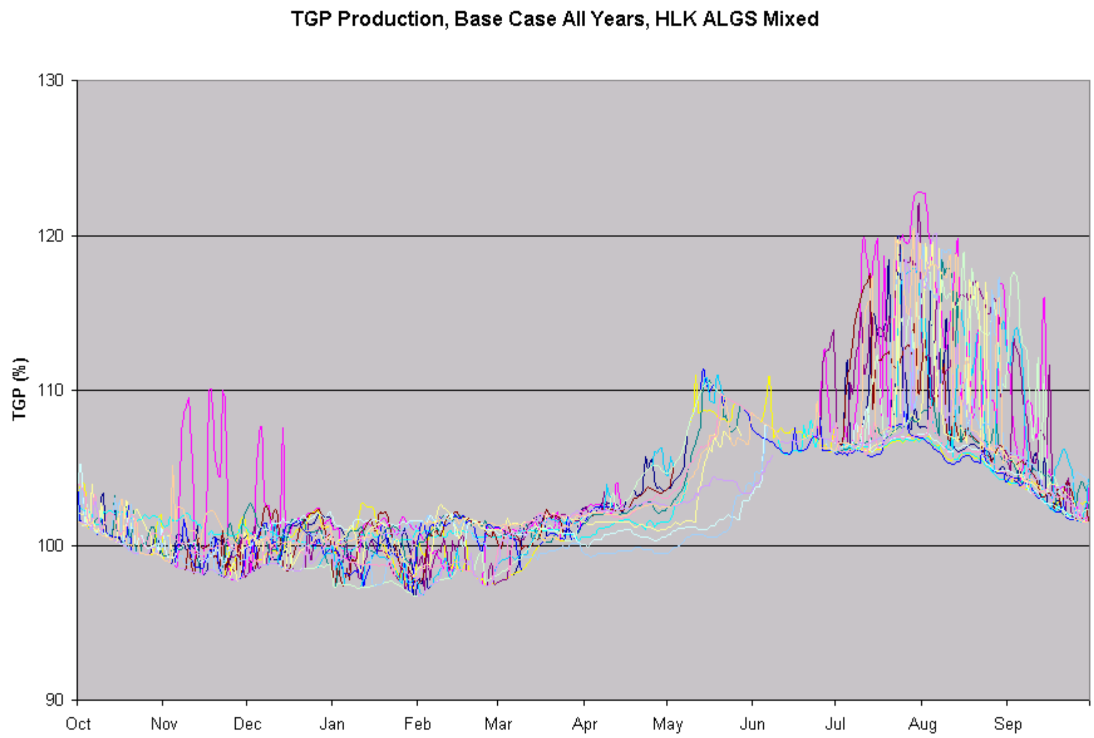
- It eliminated the operation of the worst TGP spill pathways at Hugh Keenleyside Dam, reducing the average TGP production for each unit of water at the dam.
- And by reintroducing water below ALGS with just background TGP from Arrow Lakes Reservoir, it diluted TGP produced by Hugh Keenleyside Dam.

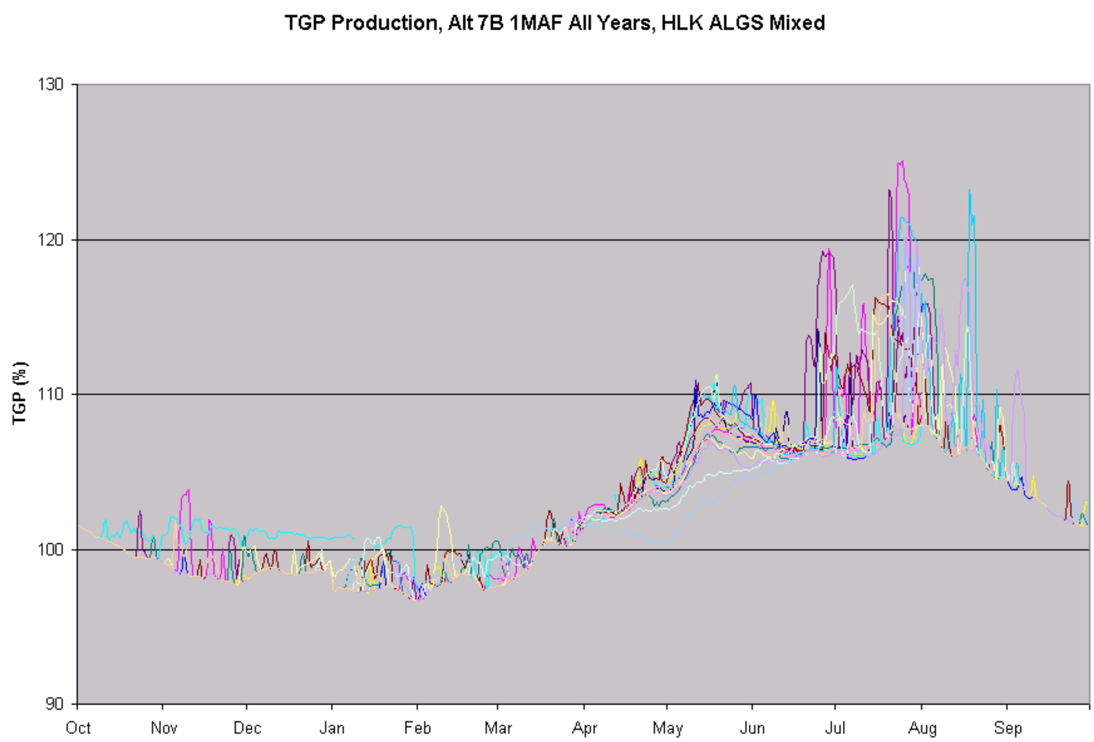
The effects of the first two influences are modest, and can be seen by moving vertically up a column in Table 2 (as flows from Hugh Keenleyside Dam are reduced to go into ALGS). It is the third effect that reduces TGP the most.

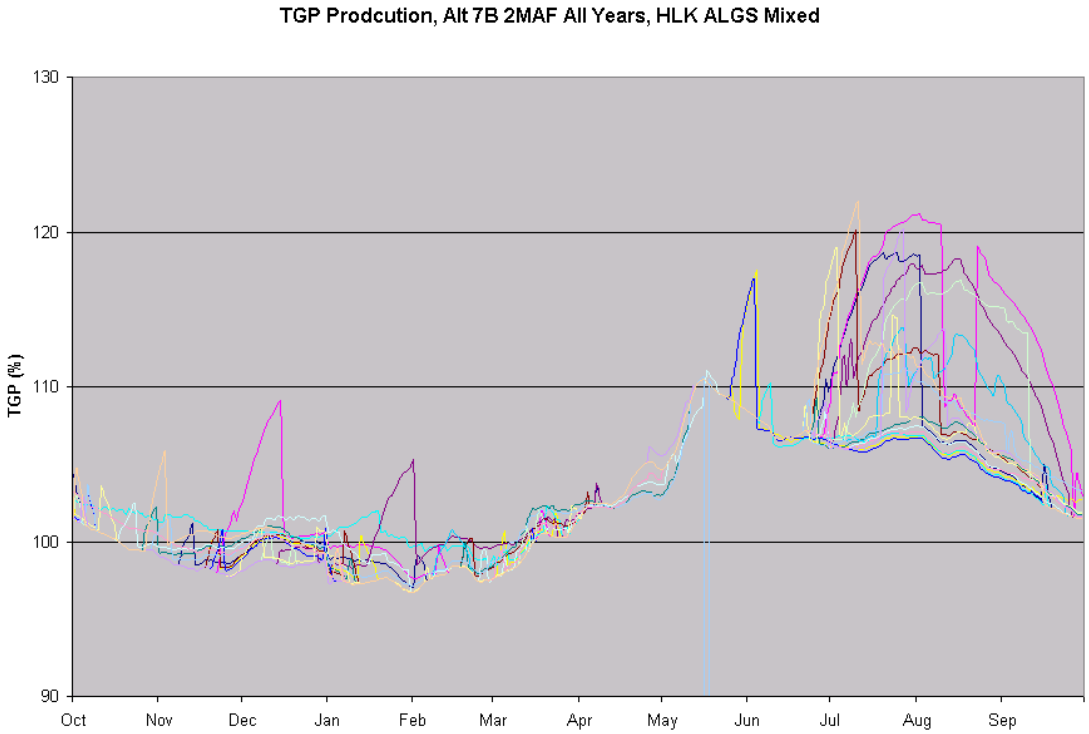
This mixing is assumed to be a mass balance equation of the form:

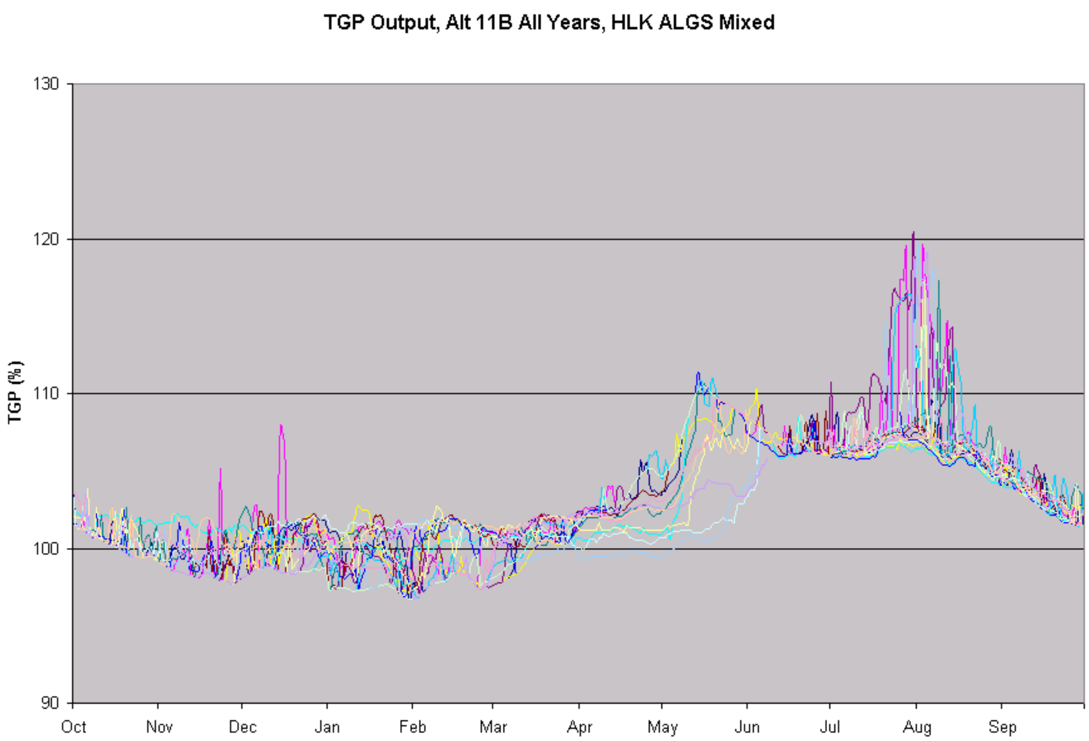
$$TGP_{mixed} = \frac{TGP_{HLK} * HLK_{outlfow} + TGP_{background} * ALGS_{outflow}}{HLK_{outflow} + ALGS_{outflow}}$$

Attachment 3: TGP Production Across All Years, Across All Alternatives






TGP Prodcution, Alt 7B 2MAF All Years, HLK ALGS Mixed
TGP (%)
130
120
110
100
90
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep


TGP Output, Alt 11B All Years, HLK ALGS Mixed
TGP (%)
130
120
110
100
90
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

APPENDIX T: ELIGIBILITY CRITERIA FOR STUDIES CONDUCTED DURING THE COLUMBIA RIVER WATER USE PLANNING PROCESS

1.0 Study Proposals

Studies may include field data collection, analysis and/or model building. The costs and benefits of each study proposed will be described using the "Study Proposal Template." These will be summarized in a summary matrix (Table T-2).

Evaluation Criteria

Figure T-1 shows a flowchart summary of the evaluation criteria for studies to be conducted during the Water Use Planning process. Four criteria are used.

Criterion 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.

Criterion 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.

Criterion 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 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.

Criterion 4

Do the benefits outweigh the costs?

- If Step 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.

2.0 Study Prioritization

After evaluating each study against the above criteria, it will be assigned one of five priorities.

Table T-1 summarizes the five priority levels for Water Use Planning Studies.

Table T-1: Priority Levels for Water Use Planning Studies

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 X	This study may be important, but cannot be completed within the Water Use Plan timeline.

3.0 Study Approval

The Consultative Committee will prioritize studies as above, and will make recommendations to BC Hydro about which studies should be approved. However, BC Hydro retains the final decision making responsibility for study approval, and will make this decision based on the recommendations of the Consultative Committee, the costs and benefits outlined as above (and in the study proposal template), and the availability of resources.

Table T-2 summarizes the studies proposed during the Columbia River water use planning process.

Table T-2: 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.

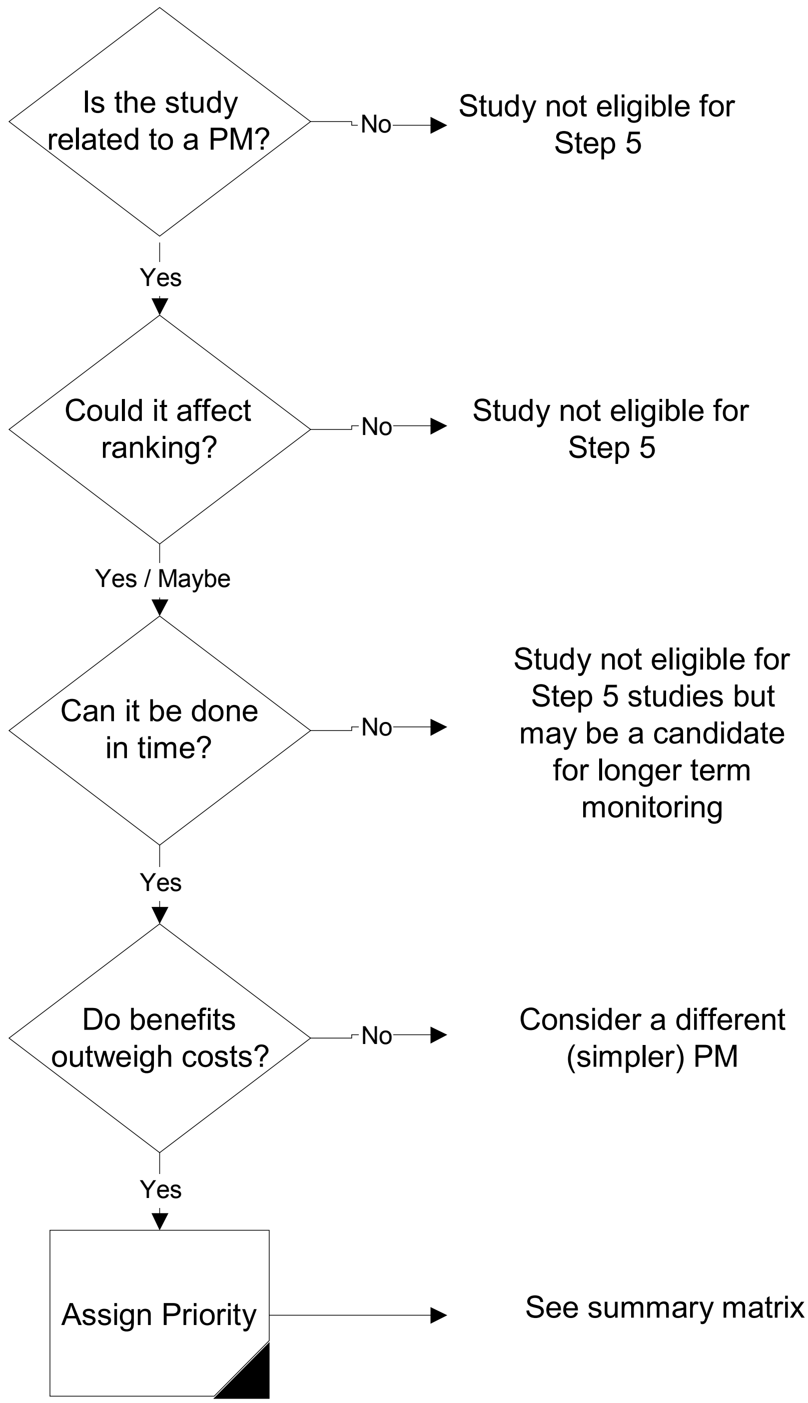


Figure T-1: Guidelines for Prioritizing Step 5 Studies

APPENDIX U: CORRESPONDENCE FROM THE COLUMBIA RIVER WATER USE PLAN PROJECT MANAGER TO THE CONSULTATIVE COMMITTEE

BChydro

THE POWER IS YOURS

Sue Foster
Project Manager
Water Use Planning
Phone: (604) 528-2737
FAX: (604) 528-2905

Mica, Revelstoke, Keenleyside Water Use Plan
Consultative Committee

4 September 2002

Dear Consultative Committee Member:

At the May 8 and 9, 2002 MCA WUP Consultative Committee (CC) meeting there was discussion on the scope of the Water Use Plan (WUP). One of the action items of the meeting was a commitment by the project team to provide the CC with documentation clarifying the scope of the WUP.

Although there are no precedents or guidelines for how the MCA WUP can assess operating alternatives which require negotiations with others to implement, the Provincial *Water Use Plan Guidelines* specifically mentions the Treaty as one of the "international agreements to be taken into account when preparing WUPs". This has been interpreted by the MCA WUP CC as requiring WUPs to honour the Treaty. However, the Treaty does allow for changes to its default operation so long as both parties (U.S. and Canadian Entities) agree to such changes and that the changes would provide additional benefits for both Countries.

The following guidelines can be applied to assist the MCA WUP CC to determine which operating alternative(s) could be considered within the scope of the water use planning process:

Guidelines:

- The MCA WUP may consider operating alternative(s) that include incremental changes to existing operations that BC Hydro can unilaterally implement. A partial list includes some flex operations (swapping water between Arrow and Kinbasket), constraints on reservoir max/min levels which can be accommodated within Treaty operations, ramping rates and incremental use of the BC Hydro portion of non-Treaty storage.

- The MCA WUP may also consider operating alternative(s) that affect Detailed Operating Plans and Supplemental Operating Agreements developed under the Treaty, or that affect operations under the Non-Treaty Storage Agreement. However, BC Hydro's ability to secure such an operating alternative is dependent upon successful negotiations with the US Entity and, possibly, other affected parties following the WUP. The likelihood of achieving such an agreement must be assessed by the CC when considering operating alternatives to be modeled.

- The MCA WUP operating alternative(s) will recognize local and downstream flood control operations, as required by the Columbia River Treaty.

- Violating the Columbia River Treaty is outside the scope of water use planning as it may expose the Province of BC to possible contractual liabilities and potentially very large financial risks associated with downstream benefits.

Domestic power and other social and environmental benefits and costs will be assessed during the water use planning process. US power and other social and or environmental benefits and costs associated with an operating alternative will not be assessed until after the water use planning process. The CC may provide recommendations to BC Hydro on a financial threshold for inclusion of an operating alternative in the MCA WUP.

In order to meet the MCA WUP project targets, an operating alternative will be "screened" by the CC prior to power modeling and the project team will ensure that it meets the above guidelines. For example, an operating alternative could include operations that might require changes to an existing agreement if there is a high probability such changes can be successfully negotiated while incurring costs less than a specified threshold as determined by the CC.

I trust that this has helped to clarify the scope of the MCA WUP. Please contact me should you have any further questions.

Sincerely,

Sue Foster

cc Graeme Matthews, Program Manager
MCA WUP Project Team

APPENDIX V: IMPACT OF FLOW ON RECREATION AND INFRASTRUCTURE ON THE LOWER COLUMBIAA RIVER

1.0 Background

The Water Use Planning process for the Columbia River started by scoping out issues within the Columbia River watershed that could be affected by operations, and has focused its energies on areas where potential opportunities for change seemed likely. During the early phases of this process, participants from the lower Columbia region (the river from Hugh Keenleyside Dam downwards) raised a number of issues and interests. These have been tracked throughout the water use planning process both as a way to look for potential improvements in this region and also to ensure that the pursuit of interests in other regions did not come at a cost to interests along the lower Columbia River. This note will sum up these issues and interests and highlight the ways in which alternatives to date will have an impact.

This note will proceed in several steps. Section 2 will review how we can use historical data as a point of comparison for the water use planning process. Sections 3 and 4, will then look at flow volumes across alternatives, and note how they impact the stated interests along the lower Columbia region. Section 5 will compare the conclusions drawn with the performance measures being used in the Water Use Plan. Section 6 will comment on the issues of volatility and ramping in the river. This note will conclude in Section 7 by considering the expected impacts arising through changes at Brilliant Dam and arising through the Duncan Dam Water Use Plan.

This document was presented in draft to the Recreation Technical Subcommittee for discussion in May 2004, and its conclusions were presented at the final Consultative Committee meeting in June.

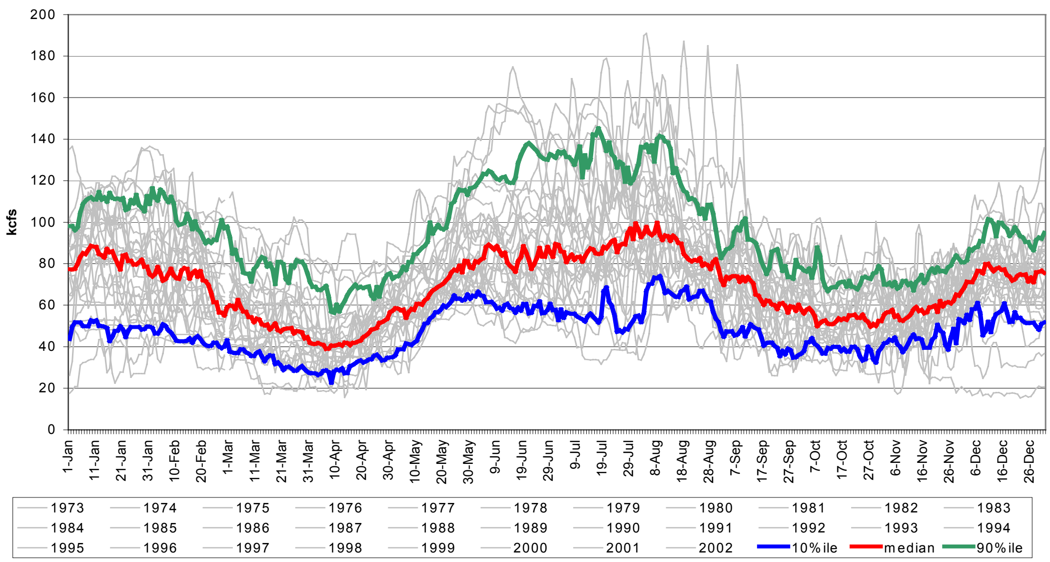


Figure V-1: Historic Readings at Birchbank Gauge (1973 to 2002)

2.0 Using Historical Data for the Lower Columbia River

In this note and in the Columbia River Water Use Plan, impacts to Trail will be measured through flows at the Birchbank gauge. It is important to note that flows there include water coming out of the Arrow Lakes Reservoir as well as the Kootenay River system, and so reflect operations impacts of the Columbia River mainstem dams and the dams on the Kootenay River (notably, Brilliant Dam).

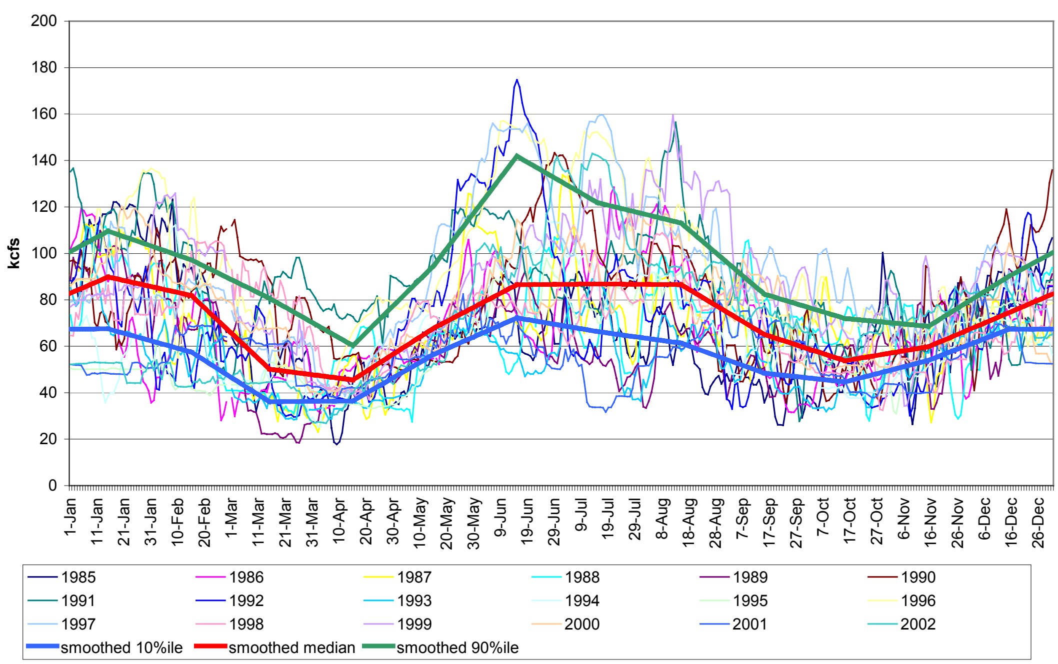


Figure V-2: Historical Data vs. Smoothed Data for Historical Operations (1985 to 2002)

Figure V-1 shows the flows at the Birchbank gauge from 1973 to 2002. Several instances of high flows can be found there, most notably three years (1976, 1981 and 1992) where flows exceeded 160 kcfs.

The comparison of historical data to modelled data is useful only if the system is being run with the same facilities and the same objectives. The Hydro modelling team has pointed out that operations before 1985 were substantially different from current operations, and so should not be used as a point of comparison. Figure V-2 represents the same data as Figure V-1, but using only data from 1985 to 2000 (inclusive).

Modelling in the water use planning process is not done on a daily time step, but rather on a monthly one. As a result, modelled flows at the Birchbank gauge are measured as monthly averages. Any averaging process washes out some variability, and this can be seen in Figure V-2, where the historical daily data is presented in the background, but the historical monthly averages are presented with the thicker lines. The monthly values have then been interpolated (joined) to give daily values, but these daily values lack the data to day volatility of the underlying data.

As an example of this impact, note the highest flow on the graph (1996, flow of 174 kcfs). When averaged out over the month, this extreme still shows up, but as a 90th percentile statistic of 140 kcfs. It is important that this "averaging out" effect is kept in mind by participants as they read through the results below.

3.0 Balancing Out Reservoirs

The Consultative Committee had not yet chosen its preferred alternative for balancing out reservoir interests. However, a guess would have put the final alternative somewhere close to Alternative D. This alternative restricts the Arrow Lakes Reservoir in the early summer and early fall, to keep it lower than it would be under an alternative that sought to maximize revenues from the system.

The impact of this alternative can be compared to the averaged historical flows from Figure V-2 in terms of its impact on flows in the lower Columbia River. This is done in Figure V-3, Figure V-4 and Figure V-5 below.

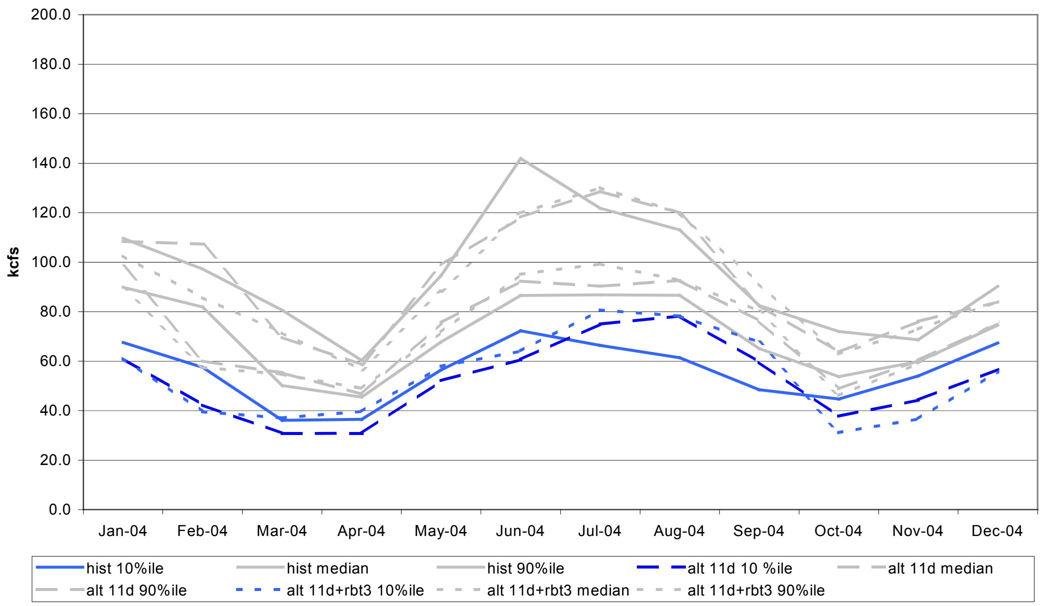


Figure V-3: Comparisons of Modelled vs. Historic Flows at Birchbank Gauge (1985 to 2000) – 10th Percentile

Figure V-3 shows the lower Columbia River in years with low flows (the 10th percentile of flows). It is clear that Alt 11D raises the summer flows from historical experience from about 60 kcfs to about 80 kcfs. And the addition of the rainbow trout and mountain whitefish flows on top of Alt 11D add another increment to this gain. Note that this takes flows from a range that is below acceptable and puts it into the acceptable range for recreation interests (see Section 3 for more details). Note however, that low flow years will have lower than historic flows in the fall and winter months (October to March).

Figure V-4 shows lower Columbia River flows in years of very high flows (90th percentile years). Here, flows in the system are reduced by Alt 11D. And while adding rainbow trout and mountain whitefish flows to Alt 11D raises flows during high water years by a small amount, the final result is still below historical flows, suggesting that these alternatives reduce the risk of flooding impacts in the Trail area and in other sections along the lower Columbia River.

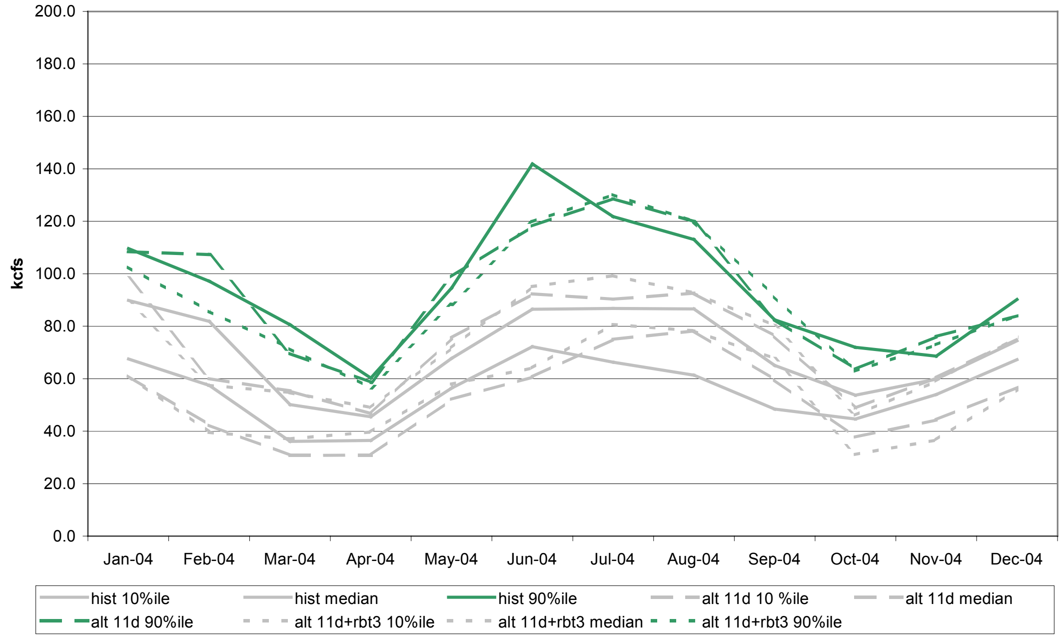


Figure V-4: Comparisons of Modelled vs. Historic Flows at Birchbank Gauge (1985 to 2000) – 90th Percentile

Figure V-5 shows that, in more average years, Alt 11D adds flows in the lower Columbia River during the summer months. And appending the rainbow trout and mountain whitefish flows to these adds incrementally to these. Note that these summer flows in average water years are all within the preferred range identified as acceptable for boat access and shoreline access. However, Alt 11D and Alt 11D+rbt both push closer to the upper end of this preferred range than historical operations do. As a result, this impact is counted as a neutral one to interests along the river.

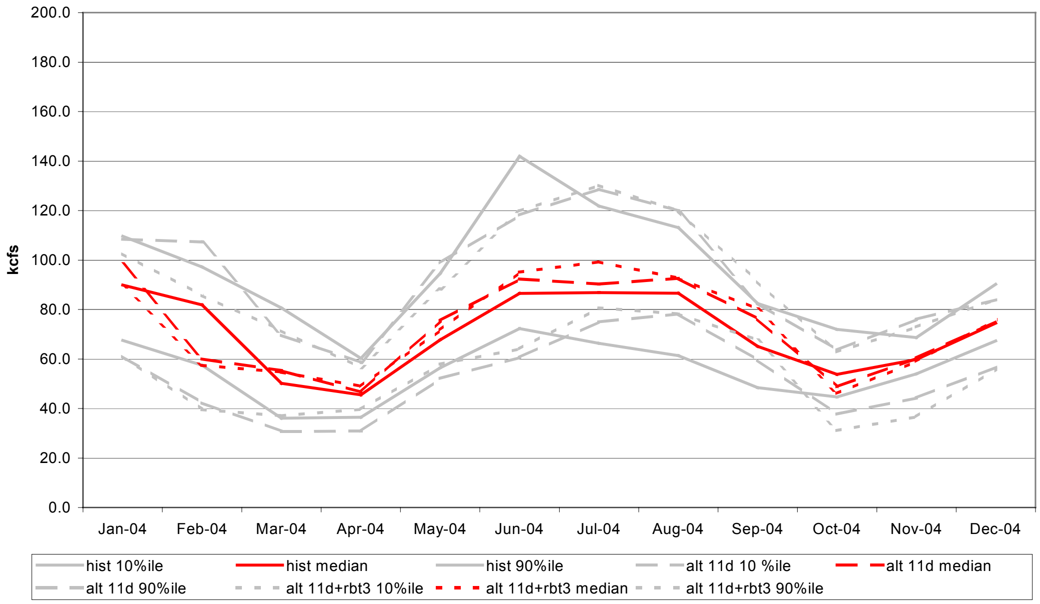


Figure V-5: Comparisons of Modelled vs. Historic Flows at Birchbank Gauge (1985 to 2000) – Median

4.0 Addressing the Needs of White Sturgeon in the Lower Columbia River

The Fish Technical Subcommittee has put a good deal of effort into deriving interventions that might benefit the white sturgeon population in the lower Columbia River. One possibility that has been suggested by the Subcomittee and also considered (without a decision rendered) by the Consultative Committee is having increased spawning flows for 30-day periods during the occasional summer. More specifically, the request was to have flows of 165 kcfs (measured at the Birchbank gauge) for 30 days from mid July to mid August in about three in ten years. No modelling has been done for this, but the impacts of this are shown conceptually in Figure V-6.

While it is clear that these flows exceed flows from recent (1985 to 2000) memory, their impact on the interests along the river will only become clear once a list of issues and flow impacts is compiled. This is addressed in the following section.

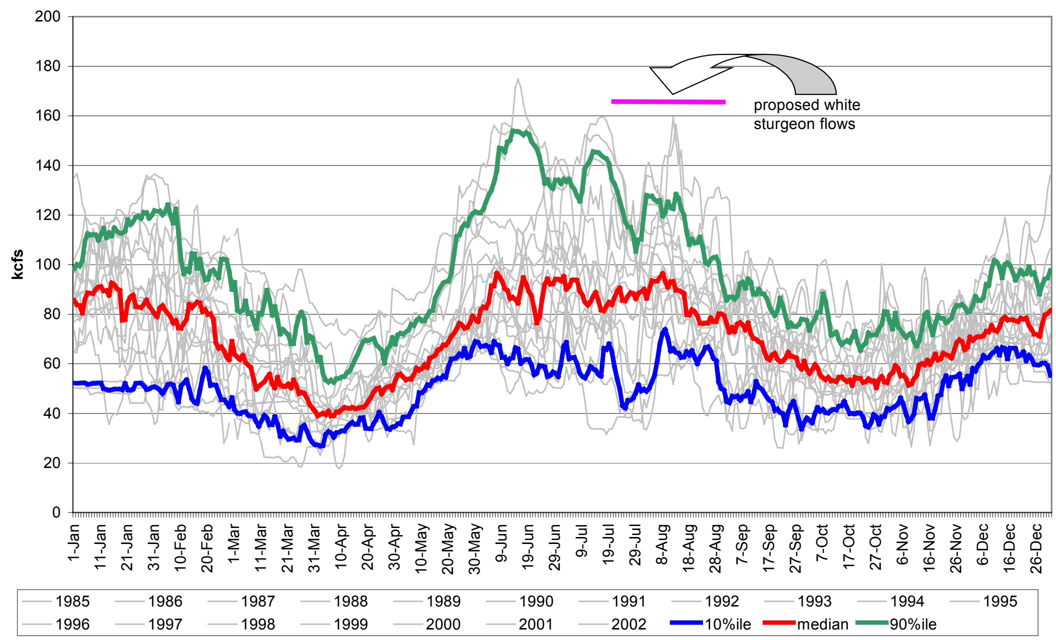


Figure V-6: Historic Readings at Birchbank Gauge (1985 to 2002)

5.0 Identifying Interests and Flow Impacts

The Consultative Committee member and Recreation Technical Subcommittee member Gord de Rosa has sent a list of issues and impacts arising from flows along the lower Columbia River. These are reproduced in Table V-1 below.

Table V-1 also compares historical (1985 to 2000) operations against some candidate alternatives considered by the Consultative Committee in order to give a feeling for the potential impacts on Trail of the proposed alternatives. These comparisons are based on the conclusions reached in the above sections that:

- Alt 11D raises summer flows during low water years and reduces flows in high water years.
- The rainbow trout and mountain whitefish flows, when appended to Alt 11D, also make summer low flows higher and high flow years lower than historical flows.
- The spawning flows for white sturgeon raise flows far above recent historical experience.

Keeping in mind that these results are based on monthly average flows and so speak to trends rather than daily results, several high level conclusions can be reached:

- Issues that are a concern because of low water levels in the summer months will be improved (over historical operations) through the Water Use Plan alternatives. This includes low flows exposing algae covered rocks and low water levels for recreation.

- Issues that are a concern because of extreme high water levels (at or above 140 kcfs) will be improved (over historical operations) through some Water Use Plan alternatives. This includes security of the wharf at Indian Eddy, erosion forces at Indian Eddy, emergency access at Indian Eddy during high flows, loss of Gyro Beach at high flows, influence on storm outflow pipes, infiltration of water into downtown areas during high flow events, restriction of recreation during high flow periods.

However,

- Flows that may be released to assist white sturgeon in the lower Columbia River pose a risk to interests and issues impacted by high flows (recreation, public infrastructure, flooding, etc.).

- Water Use Plan alternatives will have no impact on mitigating Brilliant discharges, and so will do little to reduce the negative aspects of river fluctuations.

- Water Use Plan alternatives will have no impact on issues that occur during extreme high flow events. Under flood control circumstances, public safety and safety of public infrastructure has taken precedence in BC Hydro operations and continues to take precedence over all other water use planning priorities. So facilities will be run to minimize impacts during extreme high water events regardless of what Water Use Plan alternatives are chosen.
  BC Hydro has critical flow levels for the lower Columbia River in its local operating orders and will strive to keep river levels below this when possible.

Table V-1: Interests, Issues and Thresholds – Comparison of Water Use Plan Alternatives to Historic (1985 to 2000) Flows

Interests	Flow Threshold (cfs)	Elevation Threshold (ft)	Alt 11D	"+FFF"	+ white sturgeon flows	Questions/Comments
Security of wharf at Indian Eddy during high flows	170000	1343.7	better (1)	better (1)	worse (3)	
Security of wharf at Indian Eddy during low flows	25000	1317.8	no change	no change	n/a	River fows above flow threshold. WUP alternatives push flows closest to this low level threshold
Erosion forces from high flow at Indian Eddy	170000	1343.7	better (1)	better (1)	worse (3)	
Impact on emergency access to river (Fire Boat) during high flows	170000	1343.7	better (1)	better (1)	worse (3)	
Impact on emergency access to river (Fire Boat) during low flows	25000	1317.8	no change	no change	n/a	River fows above flow threshold. WUP alternatives push flows closest to this low level threshold
Debris from river washed onto shores at Gyro and Indian Eddy from high flows	not given	not given	better (1)	better (1)	worse (3)	
Loss of Gyro beach at high flows	185000	1345.3	better (1)	better (1)	worse (3)	
Outfall pipes from sewage treatment plant exposed at low flows	25000	1317.8	no change	no change	n/a	River fows above flow threshold. WUP alternatives push flows closest to this low level threshold
Storm outfall pipes affected at high flows. Storm sewer surcharges at high flows during heavy rains	170000	1343.7	better (1)	better (1)	worse (3)	
High river flows cause infiltration into downtown areas through ground or storm sewers.	225000	1349.2	better (1)	better (1)	worse (3)	
Low flows cause algae on rocks to smell, expose refuse on river bottom.	25000	1317.8	better (2)	better (2)	better	Low flows in summer months are raised by WUP alternatives.
Lower bound for recreation and fall capacity	65000	1328.5	better (2)	better (2)	worse (3)	
Upper bound for recreation and fall capacity	160000	1342.6	better (1)	better (1)	worse (3)	
Base of river wall	60000	1327	mixed	mixed	n/a	higher flows in summer (June - Sept) and lower flows in winter (Oct - May) give a mixed result here.
Clark Street Lift Station Overflow	120000	1338.1	no change	no change	worse (3)	
Clark Street Lift Station (top)	152250	1341.9	better (1)	better (1)	worse (3)	
Invert of manhole at Spokane and Dewdney	210000	1347.4	not impacted by WUP alternatives	not impacted by WUP alternatives	not impacted by WUP alternatives	
Top of Rip-rap on lower riverside	215000	1348.4	not impacted by WUP alternatives	not impacted by WUP alternatives	not impacted by WUP alternatives	
Downtown basement flooding begins	220000	1349	not impacted by WUP alternatives	not impacted by WUP alternatives	not impacted by WUP alternatives	
"Konkins" basement floor	225000	1349.5	not impacted by WUP alternatives	not impacted by WUP alternatives	not impacted by WUP alternatives	
Other impacts (crown point basement, Bay Avenue St and Portland St (Theatre), Esplande at Eldorado St, Top of River Wall, Top of "Old" Bridge Pier, Deck of "Old" Bridge - all at elevations above 1349.5	225000	1349.5	not impacted by WUP alternatives	not impacted by WUP alternatives	not impacted by WUP alternatives	

(1) based on obseravation that alt 11D reduces high flow events
(2) based on observation that alt 11D increases low flows
(3) based on assumption that 165 kcfs triggers issues affected under high flows

6.0 Flow Volatility and Ramping in the Lower Columbia River

Large and sudden changes in river flow have been noted to have several detrimental effects on the lower Columbia River's recreational interests and infrastructure. If water has infiltrated the downtown area during a high flow period and the river level drops suddenly, there is a fear that the pressure from the land side of the retaining wall may cause it to collapse. As well, sudden changes in river height may cause navigational difficulties for those in boats on the river or beached on the shore.

Flows below the Hugh Keenleyside Dam are a function of both flows out of Arrow Lakes Reservoir (past Hugh Keenleyside Dam) and out of the Kootenay River system (past Brilliant Dam). Since the Columbia River water use planning process only includes Arrow outflows in its scope, the first step in this section will be to sort out the influence of Keenleyside operations on flow fluctuations in the lower Columbia River. Figure V-7, reproduced from the March 2004 Recreation Technical Subcommittee meeting, parcels out these flows for years 2001–2003.

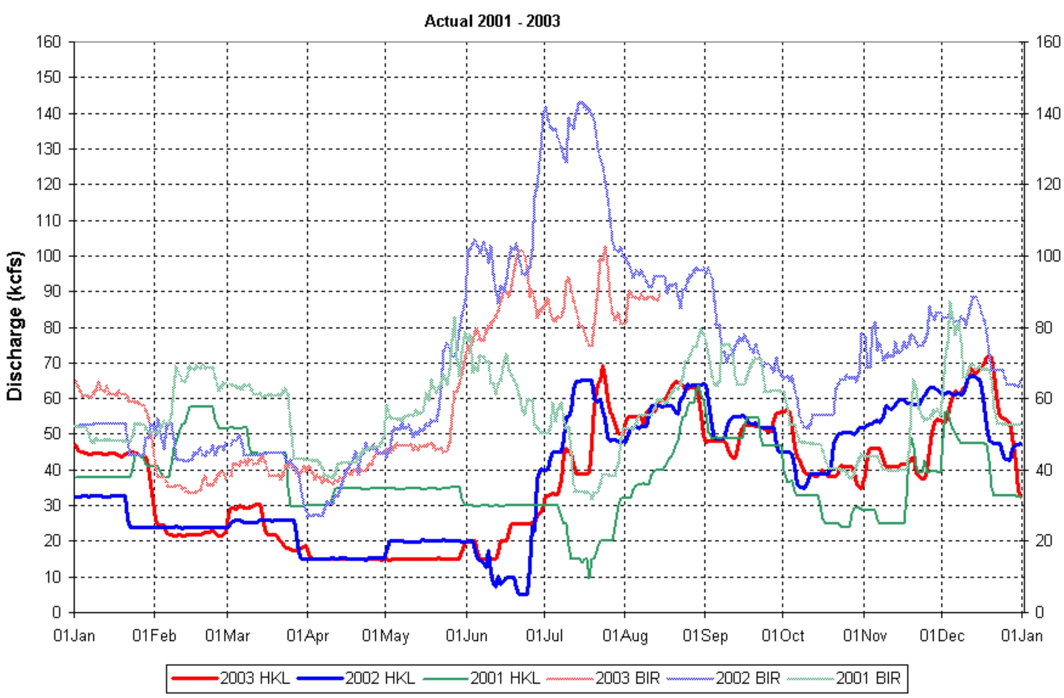


Figure V-7: Arrow and Kootenay Outflows

As Figure V-7 suggests, flows from Hugh Keenleyside Dam (the thicker lines) have relatively stable flows for long periods of time starting in January through to mid summer. These flows are changed through large, infrequent jumps to satisfy treaty flow requirements during weeks or months of time. However, during these periods, Brilliant Dam is load shaping (changing flows across days), creating a much more volatile river profile. With the expansion of the Brilliant Dam, it is expected that these flow changes will be as great, if not greater, than experienced in recent history.

A conclusion to this is that the Columbia River water use planning process does not provide a way to influence flow fluctuations in the lower Columbia River, both due to treaty constraints and due to Brilliant Dam load shaping. One exception to this is the date on which these changes can occur. This topic will be addressed below.

Flow changes from the Arrow Lakes Reservoir are conducted in order to meet Columbia River Treaty requirements at the border. Typically, discussions around weekly or monthly flows needed to achieve treaty flow targets are held mid week (Thursdays). Agreements are then passed out to BC Hydro's operators the next day (Friday), to be implemented the following day (Saturday). However, if the planned change is a flow reduction, this means that the river stage at the start of a weekend (Saturday morning) is higher than what it will be at mid day and at the end of the day. This has resulted in difficulties with boat navigation and stranding. And if planned flows are to rise, then fishermen fishing from exposed parts of the river may get cut off by rising waters.

One suggestion that fits within the scope of Water Use Plan is to have flow changes initiated so that changes happen outside of weekends. This will add to the predictability of river stage height during the high value weekend periods. While this request was tabled at the May 2004 Recreation Subcommittee meeting through this briefing note, it was not brought forward to the Consultative Committee for its final meeting in June 2004.

7.0 Impacts on Interests in the Lower Columbia River arising from Changes in Kootenay River Outflows

The estimation of impacts to interests in the lower Columbia River from the various Columbia River Water Use Plan alternatives have included changes to operations along the mainstem of the Columbia River as well as outflows from the Kootenay River system. This latter set of flows has been considered outside of the scope of this water use planning process, and so has remained unaltered by the alternatives considered on the Columbia River mainstem system. However, several changes have occurred in this system since the start of the Columbia River water use planning process, including:

- Expansion of the Brilliant Dam.
- A 5 kcfs minimum flow constraint on Brilliant Dam flows.
- A new policy on Libby Dam operations (Var Q).
- Duncan Dam water use planning alternatives.

All of these changes have the potential to influence interests along the lower Columbia River. This section will look at these sources of change to see whether they could affect the conclusions reached in the Columbia River water use planning process.

As mentioned in Section 2, the modelling for the Columbia River has been done on a monthly time step, and so flows in the lower Columbia River are measured as monthly average flows. As mentioned above, this averaging affect will mask the day to day volatility, which is expected to increase due to the Brilliant Dam expansion. Keeping this in mind, one would not expect a 5 kcfs minimum flow nor the Brilliant Dam expansion to affect monthly average flows. These may change the flows from day to day, or change the range over which flows vary, but seem unlikely to change the total monthly flow volumes. These high level conclusions will be tested out using Figure V-8, below.

The change in Libby operations, known as Libby Var Q, has been implemented since the start of the Columbia River water use planning process. These flow changes have been captured by modelling within the Duncan Dam water use planning process, but flow files for the Columbia River water use planning process have not included this change.

Finally, the Duncan Dam Water Use Plan has proposed changes that will alter the rates of flow out of the Kootenay River system. These also have the potential to affect interests in the lower Columbia River.

To investigate these sources of change, the flow files used in the Duncan Dam Water Use Plan (which include the Brilliant Dam expansion, the Brilliant minimum flow constraint, Libby Var Q and the Duncan Dam Water Use Plan Alt M90) are compared against the flow files used for Kootenay River flows for all alternatives in the Columbia River water use planning process in Figure V-8 below.

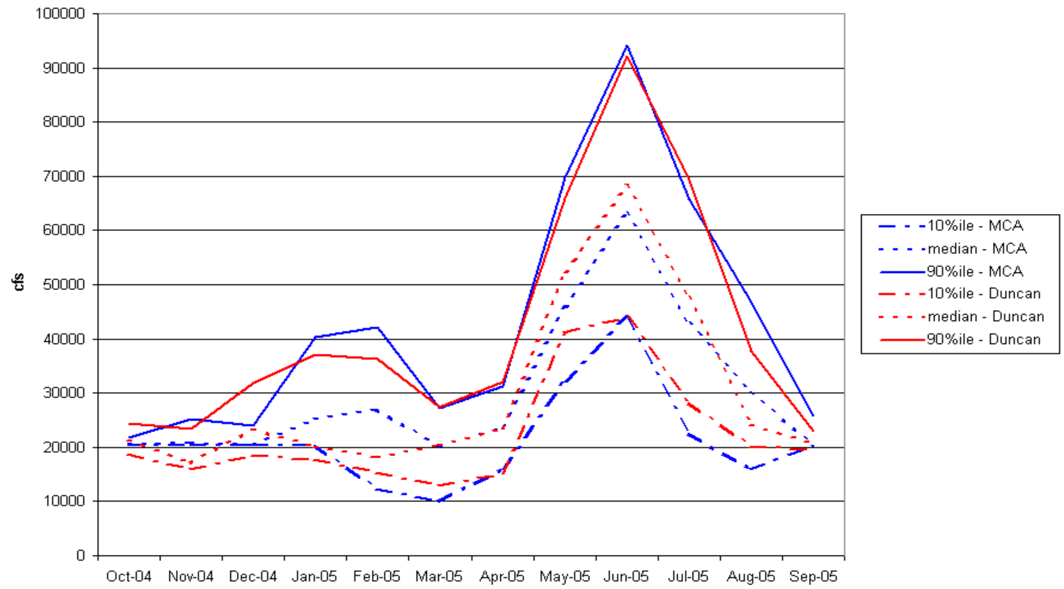


Figure V-8: Comparing Kootenay River Flows for Duncan Dam and Columbia River Water Use Planning Processes

As expected, the updated Duncan Dam flow files for the Kootenay River are a close match to those being used for the Columbia River process. Again, this is because the minimum flow and the expansion at Brilliant Dam will do little to change the monthly flow volumes. If anything, the updated flow files show that the monthly flow averages are moderated somewhat, with the low average flows being higher and the high average flows being somewhat lower. This is likely because of the influence of changing operations at Libby Reservoir.

As a conclusion, there is little reason to believe that changes to the flows coming out of the Kootenay River system since the start of the Columbia River water use planning process warrant a change in the modelling approach or information used to model the Columbia River Water Use Plan alternatives.

8.0 Physical Works to Mitigate Proposed High Flows for White Sturgeon Interests

The Consultative Committee and the White Sturgeon Recovery team (a group working on these issues, which contains Committee members and Fish Technical Subcommittee members) have asked that the periodic release of high flows be considered for the lower Columbia River, as described above.

As Table V-1 shows, these high monthly flows are close to or above the high flow limits for a number of interests. Moreover, these proposed flows would not be transitory, but would be maintained for a period of 30 days.

Conversations with the representative from the lower Columbia, Gord de Rosa, have suggested a partial list of mitigative measures that would be required if such a flow is decided upon by the Consultative Committee. This list is only partial and the costs presented are rough estimates. **If the Committee is interested in pursuing this option, then it is recommended that part of the feasibility studies include an assessment of what negative impacts will occur and what the cost would be, per event, to mitigate these.**

Table V-2: Partial List of Impacts and Mitigative Costs of Lower Columbia River White Sturgeon Flows

Impact	Estimated Cost per Occurrence
Indian Eddy	
• Erosion of ~ 1750 cubic metres rip rap	Not provided
• Accelerated sediment deposit in basin	Not provided
• Risk of damage/loss of boat dock	$150,000
Gyro Park	
• 1000 cubic metres sand	$25,000
Infrastructure	
• Clark Street Pump – manhole extension	$10,000
• Risk of raw sewage pumped into river	Not a cost issue
• Washed out roads	$20,000
• Link to Zuckerberg Island (personal conversation Gary Birch)	Not provided
General Recreation issues	
• Loss of one month of high recreation use areas	Not a cost issue

If this option is pursued at the Consultative Committee table**, then the Committee would have to decide whether these impacts, or mitigative costs, would be worth the expected benefits of the proposed flows.**

APPENDIX W: EVOLUTION OF LOWER COLUMBIA RIVER FISH FLOWS

	Early modelling approach to lower Columbia River flow options – up to and including June 2003	Second approach to modelling lower Columbia River flow options – November 2003	Final approach to modelling lower Columbia River flow options – June 2004
January	Cap January outflows to no greater than 60 kcfs unless higher flow required to meet January flood control level.	Cap January outflows to no greater than 60 kcfs unless higher flow required to meet January flood control level or to limit the January volume reduction to no greater than 400 ksfd.	Same as second round.
February/March	Target smooth discharge over period while storing 1 MAF for flow augmentation subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than 1 MAF flow augmentation.	Target to store 1.0 MAF for US flow augmentation when the 95% confidence inflow volume (January to July) at The Dalles is below 90 MAF (This translated into flow augmentation required in about 60% of the time) while target smooth discharge over period. Flow augmentation storage further subject to Arrow Lakes Reservoir flood control levels. If flood control forces flows to be higher than the target average, no attempt will be made to reduce flows in subsequent month to preserve flow augmentation. Therefore, some years will show less than Target flow augmentation.	Same as second round.
April/May	Target smooth discharge over period subject to reservoir flood control and a discharge floor of 15 kcfs.	Target smooth discharge over period subject to reservoir flood control with a discharge floor of 15 kcfs. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 1438 ft at the end of May. Some Flow augmentation may be released due to this operation but no additional flow augmentation would be stored.	Same as second round.
June	Release up to one-half of stored flow augmentation, subject to reservoir flood control.	Release 20% of remaining (May) flow augmentation, subject to reservoir flood control. Release flow augmentation storage as required to keep Arrow Lakes Reservoir below 1442 ft at the end of June.	Same as second round.
July	Release remaining flow augmentation.	Release remaining flow augmentation.	Same as second round.
August	Draft additional 220 ksfd (equal to 10 ft Swap of Libby water).	No assumed Libby Swap.	Same as second round.
September	Return August draft at rate of 55 ksfd per month.	No assumed Libby Swap.	For years when September energy price > October/November price assume US draft 400 ksfd due to Whitefish Agreement.

	Early modelling approach to lower Columbia River flow options – up to and including June 2003	**Second approach to modelling lower Columbia River flow options – November 2003**	**Final approach to modelling lower Columbia River flow options – June 2004**
October	Return August draft at rate of 55 ksfd per month.	No assumed Libby Swap.	For years when September energy price > October/November price assume US returns 200 ksfd due to Whitefish Agreement.
November	Return August draft at rate of 55 ksfd per month.	No assumed Libby Swap.	For years when September energy price > October/November price assume US returns 200 ksfd due to Whitefish Agreement.
December	Return August draft at rate of 55 ksfd per month.	No assumed Libby Swap.	

APPENDIX X: CORRESPONDENCE FROM J. O'RIORDAN, CHAIR, WATER USE PLAN STEERING COMMITTEE

BRITISH COLUMBIA

FEB 19 2001

File Numbers.: 280-30/ADM
76975-35/PEACERIV
76975-35/COLUMBIA

To: Peace and Columbia Water Use Plan (WUP) Consultative Committees

The Peace and Columbia Water Use Planning projects are being conducted by BC Hydro under the Provincial Water Use Planning Guidelines. On behalf of the Province I want to express my appreciation for your participation in these processes.

Water Use Planning is an innovative initiative that is putting British Columbia at the forefront of making balanced decisions in the allocation of water for fish, wildlife, recreation, industry electricity generation and other interests. The underlying premise of water use planning for BC Hydro's facilities is that adjustments to operations will result in gained social and environmental values to British Columbians that will be equivalent to or greater than any foregone electricity values to the Province. Process participants are encouraged to seek solutions that meet this premise.

To date BC Hydro has completed two plans while nine more, including the Peace and Columbia, are at various stages of completion. In comparison to the other processes, water use planning for the Peace and Columbia systems will have several unique constraints to deal with.

Both the Peace and Columbia are large systems and both play an important role in how BC Hydro manages its integrated system. Together they represent approximately 75% of BC Hydro's hydro-electric generation capacity, with the 26 remaining systems making up the rest. The Province has made a policy decision that the magnitude of change it is willing to accept on the Peace and Columbia is smaller compared to other systems undergoing water use planning. In addition government by policy has set a cap on the funding to support the implementation of water use plans, so it is important to ensure funds are available for a wide range of projects. Government's recognition of the high value of these rivers for power generation was articulated in its 1998 response to the BC Heritage Rivers Board, in which it endorsed the Columbia and Peace remaining as working rivers compatible with natural heritage and recreational values.

.../2

Ministry of Environment, Lands and Parks
Office of the Assistant Deputy Minister Environment & Lands Regions Division
Mailing Address: PO Box 9339 Stn Prov Govt Victoria BC V8W 9M1
Telephone: (250) 387-9877
Facsimile: (250) 387-5669
Location: 5th Floor, 2975 Jutland Road Victoria BC

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As well, both rivers flow across national and/or provincial boundaries. As water use planning is carried out under the auspices of the provincial *Water Act*, the mandate of the WUP terminates at the borders. Those representing out-of-province interests may be invited to observe and monitor the development of water use plans. However, other processes exist to address cross-border water issues. For example, for the Columbia a treaty between Canada and the United States exists to deal with water flows at the border. For the Peace, the Mackenzie river Basin Transboundary Waters Master Agreement specifies bilateral agreements between neighboring jurisdictions will be negotiated. These and other levels of involvement are available to deal with water quantity and quality issues.

Finally, as with all BC Hydro water use plans, the review and approval of the Peace and Columbia plans will occur simultaneously with a number of other water use plans. This recognises that BC Hydro manages its hydro-electric facilities in an integrated system, may create efficiencies in the monitoring and implementation of the various plans and avoids the possibility of any one plan having to bear the brunt of meeting government's limitations on foregone energy values.

We appreciate your interest and contribution to these important Water Use Plans.

Yours sincerely,

J.O'Riordan

Jon O'Riordan
Chair
WUP Steering Committee

APPENDIX Y: 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 Z: PROPOSED REVEGETATION PLAN FOR KINBASKET RESERVOIR

Mica - Revelstoke - Keenleyside Water Use Plan:

Potential Areas for Vegetation Establishment in Kinbasket Reservoir

Prepared for BC Hydro by:

Anne Moody
AIM Ecological Consultants Ltd.
Box 2426
100 Mile House, B.C. V0K 2E0
&

Will Carr
CARR Environmental Consultants
202-5752 176th St.
Surrey, B .C. V3S 4C8

January, 2003

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1.0 INTRODUCTION

This study was initiated in response to a request by BC Hydro and the MCA WUP Consultative Committee to assess the potential for wildlife habitat enhancement in Kinbasket Reservoir through promotion of reservoir vegetation via changes in operating regime and direct intervention (i.e. planting). It is known that vegetation occurs at the north end of the reservoir due to the effects of the current operating regime on the remnant pre-pondage wetlands and some past planting efforts. The WUP Committee is interested in developing planting programs compatible with both the current operating regime and proposed options that will maximize (or encourage) vegetation growth in the drawdown zone around the reservoir. The Canoe Reach south of Valemount and Bush Arm, along with numerous tributary mouths, have been initially identified as having the highest potential for revegetation based on the current operating regime. The number of hectares of willow/sedge-grass-herb vegetation associated with a potential operating regime and planting program will likely be a performance measure relevant to wildlife values.

Kinbasket Reservoir is a 216 km long impoundment of the Columbia River. The reservoir is controlled by Mica Dam, which has been operational since 1973. The major source of inflow is from snowmelt in May and June; refill generally begins in early May and the reservoir reaches full pool by the end of July. The operating range of the reservoir is between 706.9 to 754.4 m.

1.1 OBJECTIVE/APPROACH

The objective of this study is to identify and plot those areas within the drawdown zone of Kinbasket Reservoir which have the highest potential for vegetation establishment and to suggest an operating regime(s) and revegetation program that will facilitate development of this potential.

To achieve this objective, it was proposed that we would use 2002 airphotos (but these airphotos were not available in printed form in time for the initial phases of this project) and pre-pondage topographic maps to identify preliminary areas suitable for vegetation establishment with intervention or planting. Current elevation information was not available. Instead, we were able to access 2001 satellite imagery, and from these images of the entire reservoir, address aspects of the terms of reference not available from other sources.

A brief field visitation was undertaken to assess suitable sites and current vegetation distribution in relation to the historical (1954) distribution of wetlands for vegetation enhancement. Vegetated sites were inspected to determine the dominant plant species that may be candidates for a vegetation enhancement program within the drawdown zone. Recommendations for necessary future steps to solidify the initial assumptions made in this report regarding vegetation establishment parameters have been included with a view to maximize vegetation diversity and wildlife habitat within the drawdown zone.

1.2 WORKING PLAN

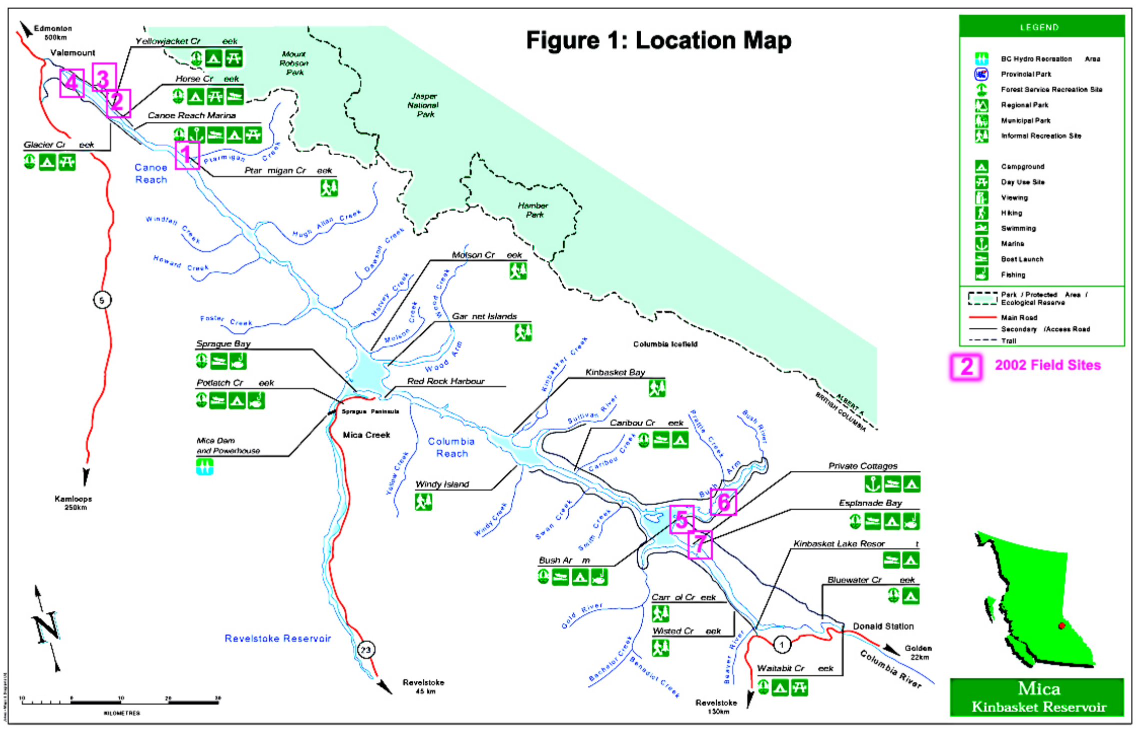
- Information Review - Review of available information, including airphotos, old topographic maps, historical reservoir operating regime and WUP alternatives, and available biogeoclimatic information
- Field Visitation - Visitation of Kinbasket Reservoir; focus on reservoir margin wetlands and riparian vegetation, drawdown zone soil materials, and operational access
- Mapping Inputs and Report - Provide BC Hydro GIS specialist with polygon delineation for map preparation, review maps as developed and make edits as needed. Preparation of project report focused on development and identification of various polygons, including potential impacts of various operating regimes and recommendations, and estimated cost for revegetation options.

2.0 METHODS

2.1 SITE CHARACTERIZATION

Brief field visits were conducted to those areas of the reservoir accessible by vehicle and on foot. Specific sites for investigation were identified from pre-pondage maps. Road travel near the reservoir shore allowed quick overviews of the steep unvegetated shorelines, confirming the lack of opportunity for vegetation enhancement in most areas. Digital video was recorded of the observations for future reference and select images were captured for use in this report. Sites with existing vegetation were inspected to assess the existing vegetation complement. Plant species were noted and collected at several sites (Figure 1).

Figure 1: Location Map



modified from Kinbasket_Lake.pdf – BC Hydro website

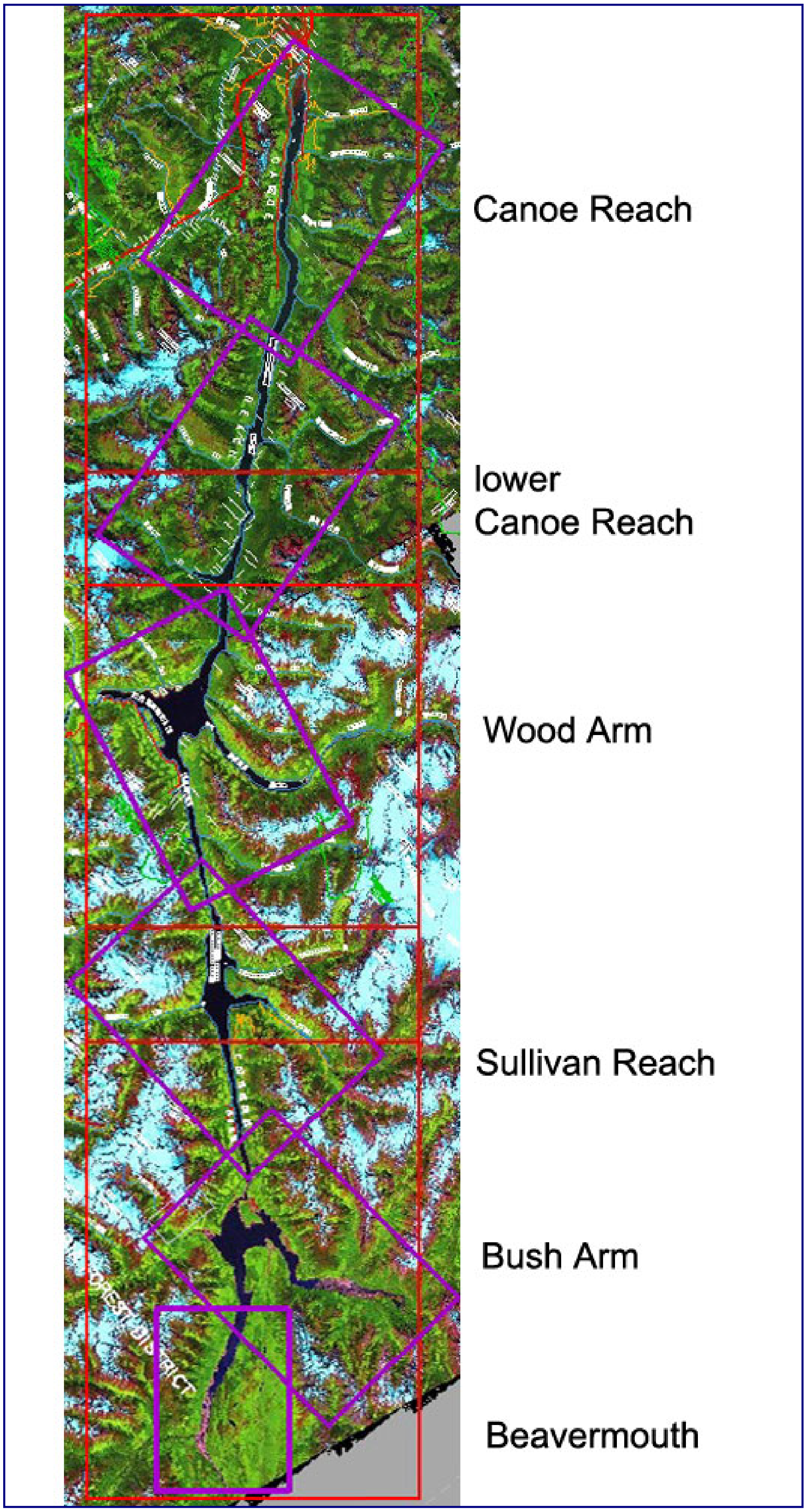
2.2 SATELLITE IMAGERY AND MAPPING

A main limitation of the study was the lack of available current information. Although recent aerial photographs had been taken in 2002, prints of these images were not available during the course of the study. Elevational information was only available from 1951 historical maps, which were based on 1944 aerial photos. Needless to say, substantial differences have occurred in the river basin since that time.

The availability of satellite imagery was explored to provide an alternative for an overview assessment of vegetation resources and potential areas for vegetation establishment within the reservoir. Imagery from 2001 was available for the entire reservoir during relatively low water conditions. For the area south of Hugh Allen Creek, imagery was captured on July 3, 2001 when water levels were at 731 m. The northernmost section of Canoe Reach was captured by imagery on August 11, 2001 with water levels at 741 m. Due to the large area involved, the imagery was segregated into 6 major areas for ease of manipulation (Figure 2). The purple squares identify each of the map sheets with sheet names listed adjacent to each.

Satellite images, imported as TIFF files were examined at maximum resolution to assess presence of vegetation along exposed shorelines and to determine unvegetated sites suitable for planting or enhancement. Initial interpretations were supplemented with the 2002 gray-scale aerial photography (1:10,000) for the Valemount area and with field notes and photographs obtained during the July field visit. Polygons were delineated for areas identified as vegetated and for those having potential for vegetation establishment. The potential for vegetation establishment was based on the spectral reflectance characteristics of the satellite imagery (revealing substrate textures) and cross-checking with the historical maps to evaluate slopes, elevations and probable energy characteristics at each location. Individual areas were numbered, measured and annotated for site characteristics and probable potential for enhancement (Tables 2-7, 8). Reduced versions of the completed maps were prepared for inclusion in this report (Figures 3-8).

Figure 2: Satellite Imagery Sheets



3.0 RESULTS

3.1 PLANT SPECIES IDENTIFIED IN THE KINBASKET RESERVOIR

At the time of the field visit, water levels according to BCH daily records were 2450.1 ft (747 m), approximately 7.4 m below full pool. Gently sloping shoreline areas examined during the field visit exhibited vegetation that extended into the inundated areas. Substrate coarseness appeared to be a major determining factor for vegetation success. Although a thorough inventory of the vegetation complement was not feasible, all plant specimens observed during the field visit were recorded and representative specimens were collected and pressed for future reference (Table 1).

Table 1: Plant species noted during July 2002 field visits to Kinbasket reservoir.

Common Name	***Scientific Name***	**Location**
Red top	*Agrostis alba*	1,2,3,4,5,6
Tickle-grass	*Agrostis scabra*	2,3,4
Water foxtail	*Alopecurusaequalis*	3,4
Meadow foxtail	*Alopecurus pratensis*	4
Bluejoint	*Calamagrostis canadensis*	1,2,3,4,5,6
Slenderbeaked sedge	*Carex anthrostachya*	3
Water sedge	*Carex aquatilis*	3
Bebb's sedge	*Carex bebbii*	1,2,3,4,
Crawford's sedge	*Carex crawfordii*	1,2,3,4,5,6
Yellow sedge	*Carex flava*	3
Lenticulate sedge	*Carex lenticularis*	1,2,3,4, 5,6
Beaked sedge	*Carex rostrata*	3
Sawbeak sedge	*Carex stipata*	1,2,3,4, 5,6
Needle spike-rush	*Eleocharis acicularis*	3
Swamp willow-herb	*Epilobium palustre*	3, 5
Water horsetail	*Equisetum fluviatile*	1,2,3,4, 5,6
Reed mannagrass	*Glyceria grandis*	3
Foxtail barley	*Hordeum jubatum*	1,2,3,4, 5,6
Northern rush	*Juncus alpinus*	1,2,3,6
Dagger-leaf rush	*Juncus ensifolius*	3
Tuberous rush	*Juncus nodosus*	3
Perennial rye grass	*Lolium perenne*	3
White sweet-clover	*Melilotus alba*	1,2,3,4, 5,6
Monkey-flower	*Mimulus sp.*	3
Common forget-me-not	*Myosotis scorpioides*	3
Reed canarygrass	*Phalaris arundinacea*	4,5
Timothy	*Phleum pratense*	4,5
Fowl blue grass	*Poa palustris*	4
Smartweed	*Polygonum persicaria.*	4
Marsh cinquefoil	*Potentilla palustris*	3
Willow spp.	*Salix spp.*	1,2,3,4,5,6
Woolgrass	*Scirpus cyperinus*	3
Floating bur-reed	*Sparganium natans*	3
Red clover	*Trifolium pratense*	3,5
White clover	*Trifolium repens*	3,5

Locations (see Figure 1):
1 – Ptarmigan Creek area
2 – Yellowjacket Creek area
3 – historic wetlands on west side of reservoir (part of L 7399)
4 – seeded area north of area 3 (part of L 7398)
5 – Bush Arm entrance
6 – creek delta on south side of Bush Arm

3.2 REPRESENTATIVE SHORELINES AND ENHANCEMENT OPPORTUNITIES

The following images were obtained by video-capture from the digital video recorded during the field visits. These are presented to provide a visual overview of the existing vegetated sites within the reservoir.

Site 1 – Steep bank in vicinity of Ptarmigan Creek boat launch.
The slope and coarseness of the material at this site are typical of many of the shoreline areas along the reservoir. The present level of vegetation development could potentially be enhanced by planting and fertilization to yield a denser, more productive vegetation community.

Vegetation development is limited by coarse substrates. Shoreline vegetation is characterized by sparse sedges, grasses and annuals. Sawbeak and lenticulate sedge appear above right.

Bluejoint (below left) and water horsetail (below right) in coarse substrates.

Pacific willow (right) occurred along a nearby bank.

Site 2 –Yellowjacket Creek

Substrates were quite variable in this area, from sand to coarse rock. Vegetation was noted predominantly in slight depressions between beach ridges (above). Characteristic species included lenticulate sedge (top right), sawbeak sedge, water horsetail and Crawford's sedge (below left). Enhancement of such sites would be feasible with fertilization to improve growth. Establishment of plants in barren areas by seeding of select species and planting of others could improve the overall coverage by vegetation.

Site 3 - Remnant of Historic Canoe River Wetlands

This natural wetland area is viewed from across the reservoir (left) and from the north-west shore (right). The brown areas (top left) are disrupted peat substrates (remnants from historic wetlands). Historic peat deposits are currently being eroded (top left, below right) and will result in losses of wetland areas. Enhancement of this area may be achieved by some form of erosion control.

This broad band of diverse vegetation (below left), is a remnant of the natural wetlands and water bodies occurring pre-pondage. The diversity of plant species greatly exceeds the normal complement of plant species found within reservoir drawdown zones. A closer view of the far edge of the wetland (below right) reveals that the vegetation continues into the inundated zone for some distance. At the time of the field visit, the water level was 2450.8 ft (747m).

Characteristic species included Crawford's sedge (top left), sawbeak sedge (top right), woolgrass (bottom left), and lenticulate sedge (bottom right). However, these species all occurred as components of a much more diverse mixed community (Table 1).

Historical pond areas have filled in and are now occupied predominantly by species such as the needle spike-rush (below left) with elements of marsh cinquefoil (below right).

Site 4 Seeded area, north of site 3

This area was originally forested and consequently lacks the wetland seed bank and peat deposits of the historic wetland to the south of it. It showed evidence of recent, as well as less recent, seeding activity. Well developed patches of clover and reed canarygrass as well as other agronomic species were scattered throughout the site. Reed canarygrass was not identified in any other location at this end of the reservoir.

Sparse development of fall rye in 2002 seeded area.

Moderate growth of fall rye in 2002 seeded area.

Patches of clover and reed canarygrass in well established seeded areas.

Smartweed growth in seeded and fertilized area.

The success of the seeding program appears to be highly dependent on the substrate characteristics. Site 4 is quite dry and has a fine silt component, similar to the fall rye seeded areas near Revelstoke. Success of the 2002 seeded fall rye appears to be minimal to date due to dry substrate conditions. Of concern at this site is the introduction of reed canarygrass, which could expand rapidly and will probably change the biodiversity of the remnant wetlands in the future.

Site enhancement could be achieved by promoting the perennial species, lenticulate sedge, which is very adapted to such environments in Arrow reservoir. Fertilization would also benefit colonizing species.

Site 4 in foreground with Site 3 (natural wetland) in the background.

Seedling of lenticulate sedge.

Seeded rows of reed canarygrass.

Sparse development of seeded grass species.

Lenticulate sedge and water horsetail scattered among rows of fall rye and clover.

Site 5 Entrance to Bush Arm

Shoreline vegetation at entrance to Bush Arm at water level 2459 ft (748m). Vegetation development is limited in some locations by steepness or by coarse substrates (top right). Enhancement opportunities are similar to those described for Site 1.

Causeway to island (top left) appears to have been seeded at some point with reed canarygrass and sweet clover as well as other agronomic species (below).

Site 6 Gravel fan along south shore of Bush arm

The coarse gravel fan showed a range of vegetation establishment, from the sedges and grasses close to the water line (below left) to the low growing willows in the coarse rock (bottom right). For a relatively inhospitable environment, this site displayed a large vegetation diversity, possibly due to the ongoing moisture input from the creek. Enhancement opportunities are similar to that of Site 1.

Site 7 Boat Launch at Esplanade Bay

Small sheltered bay with a boat launch. Vegetation development is apparent even on the steep shoreline (below left). The main plant species include water horsetail, lenticulate sedge and bluejoint (below right). Based on the vegetation observed during the field visit, no enhancement is required at this site.

3.3 MAPPING RESULTS

The determination of existing vegetation and potential planting areas was based on the site characteristics interpreted from the satellite imagery and an estimation of elevation based on the historical maps. As can be expected, substantial differences were noted between 1944 and 2001 channel and shoreline configurations. These initial assessments must be treated with caution, recognizing the limitations of the available information. However, they do serve as a useful guide for future field verification of potential planting and vegetation enhancement sites. The DEM currently under development will provide valuable additional information for the refinement of this data.

A total of 120 sites were identified from the satellite imagery; 68 vegetated and 52 with a potential for vegetation development (Figures 3-8, Tables 2-7). The vegetated sites, ranging in size from 1 to 559 ha, represented a total area of 2,395 ha around the periphery of Kinbasket Reservoir. The sites identified as having a potential for vegetation development covered a total area of 2,259 ha and ranged in size from 1 to 496 ha. The area supporting the greatest amount of vegetation at present is Bush Arm (1169 ha) followed by Canoe reach 698 ha (Table 1). The Sullivan Arm area supports the least existing or potential for vegetation due to its steep shorelines.

Table 1: Summary of Vegetated and Potential Vegetation Areas According to Location

Sheet	Vegetated Area (ha)	Potential Vegetation (ha)
Canoe Reach	698	232
Lower Canoe Reach	58	336
Wood Arm	292	140
Sullivan Arm	31	30
Bush Arm	1169	891
Beavermouth	146	630
Total	2395	2259

Satellite images with identified existing and potential vegetation sites are presented in Figures 3-8. Descriptions of the sites, presented in tabular form accompany the imagery.

Figure 3: Canoe Reach Map

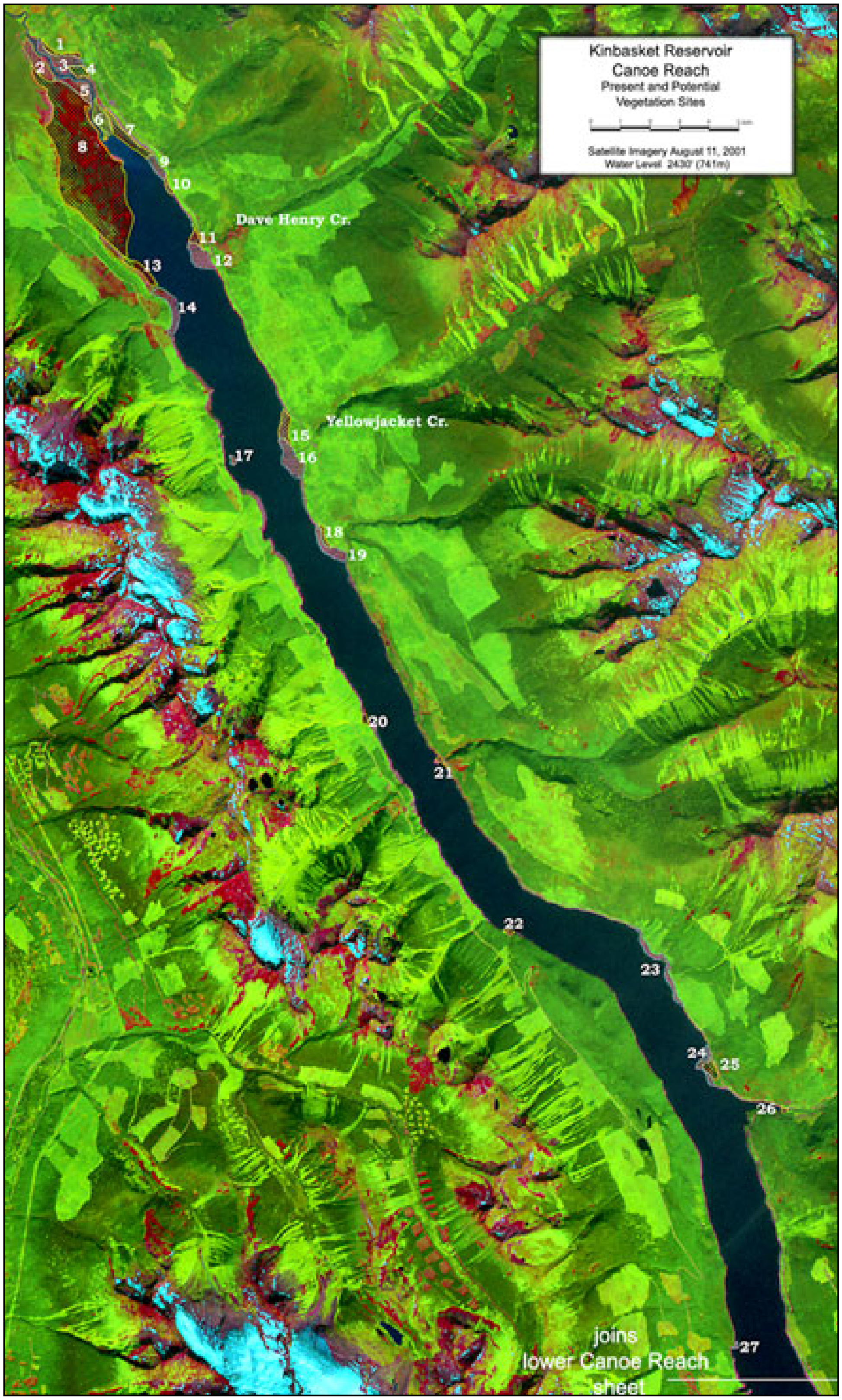


Table 2: Canoe Reach Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
Canoe Reach	**1**	80		wetland band adjacent to shrub/tree-line
Canoe Reach	**2**		26	Field visit site #4-fine substrates, previously drill seeded, reed canary grass has potential to spread
Canoe Reach	**3**		26	across channel from 3, should be similar
Canoe Reach	**4**	79		historic wetland, stable site
Canoe Reach	**5**		21	adjacent to existing wetland, probable high energy site
Canoe Reach	**6**		19	photos show drill seeding
Canoe Reach	**7**	24		relatively sheltered site with steam inflow
Canoe Reach	**8**	454		natural historic wetland, high diversity, existing peat deposits eroding
Canoe Reach	**9**		11	relativelysteep slope but located between vegetated sites
Canoe Reach	**10**	3		small site, relativelysteep slope
Canoe Reach	**11**	7		sparse veg. at creek mouth
Canoe Reach	**12**		22	coarse substrate ? fan
Canoe Reach	**13**	14		tapering end of natural wetland
Canoe Reach	**14**		23	coarse substrate ? fan
Canoe Reach	**15**	14		Yellowjacket Creek (field visit Site 2) variable substrate, patchy vegetation in depressions
Canoe Reach	**16**		29	Yellowjacket Creek lower elevation
Canoe Reach	**17**		2	"island" across from Yellowjacket - high eneergy?
Canoe Reach	**18**	5		upper fan veg.
Canoe Reach	**19**		19	lower elev. fan
Canoe Reach	**20**	3		upper fan veg.
Canoe Reach	**21**	2		upper fan veg.
Canoe Reach	**22**	2		upper fan veg.
Canoe Reach	**23**		23	isolated narrow bench
Canoe Reach	**24**		11	lower elev. fan
Canoe Reach	**25**	10		sparse upper fan veg. near Ptarmigan Cr
Canoe Reach	**26**	2		small delta at mouth of creek
Canoe Reach	**27**		1	small fan

Figure 4: Lower Canoe Reach Map

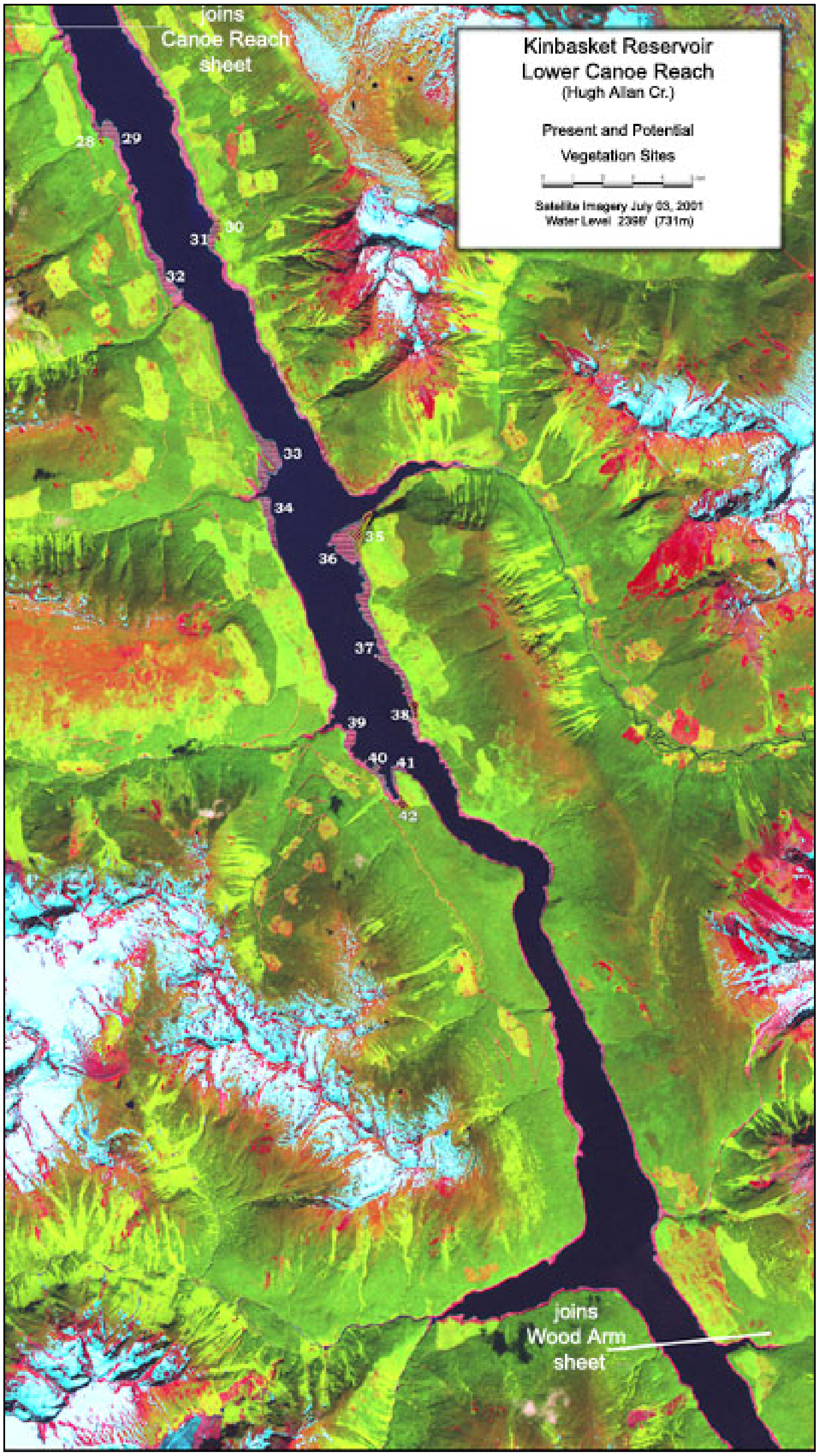


Table 3: Lower Canoe Reach Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
lower Canoe Reach	**28**	1		sheltered bay
lower Canoe Reach	**29**		21	sheltered, relatively gentle point
lower Canoe Reach	**30**	3		small pockets close to high water mark
lower Canoe Reach	**31**		13	sheltered, relatively gentle bay
lower Canoe Reach	**32**		25	Grouse Cr. – relatively gentle shore
lower Canoe Reach	**33**		32	Windfall Cr. bench
lower Canoe Reach	**34**		19	Windfall Cr. bench
lower Canoe Reach	**35**	42		Hugh Allan Cr. bench
lower Canoe Reach	**36**		145	Hugh Allan Cr. low elev. bench
lower Canoe Reach	**37**		61	gentle slope S of Hugh Allan Cr.
lower Canoe Reach	**38**	6		small wetland sheltered by point
lower Canoe Reach	**39**		10	Howard Cr. gentle bench
lower Canoe Reach	**40**		6	Howard Cr. sheltered bay
lower Canoe Reach	**41**		4	Howard Cr. sheltered bay
lower Canoe Reach	**42**	7		small wetland sheltered in bay

Figure 5: Wood Arm Map

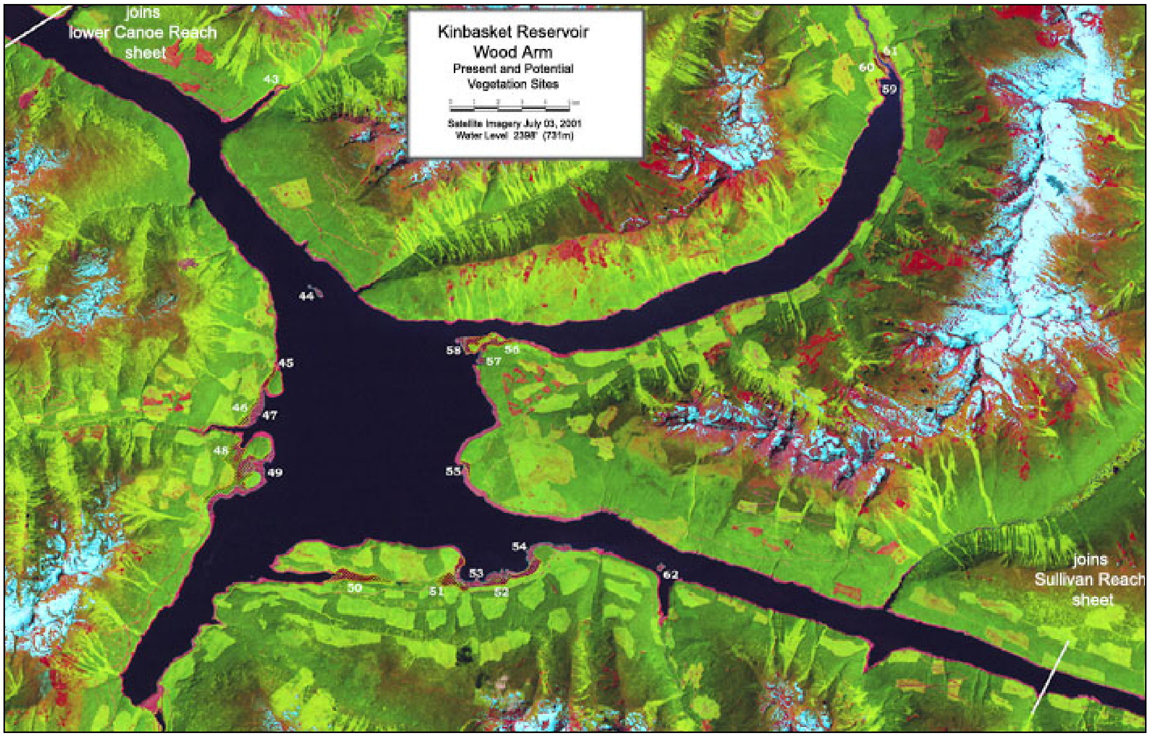


Table 4: Wood Arm Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
Wood Arm	**43**	3		small wetland sheltered in bay
Wood Arm	**44**		4	"island" - probably high energy
Wood Arm	**45**	11		Encampment Cr. sheltered bay
Wood Arm	**46**	15		Encampment Cr. sheltered bay
Wood Arm	**47**		22	Encampment Cr. lower elev. slopes - high energy?
Wood Arm	**48**	95		Encampment Cr. sheltered bay
Wood Arm	**49**		52	Encampment Cr. lower elev. slopes - high energy?
Wood Arm	**50**	39		well developed historic wetland in sheltered bay
Wood Arm	**51**	33		wetland in sheltered bay
Wood Arm	**52**	39		wetland in sheltered bay
Wood Arm	**53**		26	lower elevation slopes adjacent to existing wetlands
Wood Arm	**54**		23	lower elevation slopes adjacent to existing wetlands
Wood Arm	**55**	6		small wetland in sheltered bay
Wood Arm	**56**	35		wetland in sheltered bay and on point
Wood Arm	**57**		6	sheltered embayment, adjacent to existing wetland
Wood Arm	**58**		4	lower elevation slopes adjacent to existing wetlands
Wood Arm	**59**	2		wetland in sheltered bay
Wood Arm	**60**	7		wetland in sheltered bay
Wood Arm	**61**	7		wetland in sheltered bay
Wood Arm	**62**		3	"island" - probably high energy

Figure 6: Sullivan Reach Map

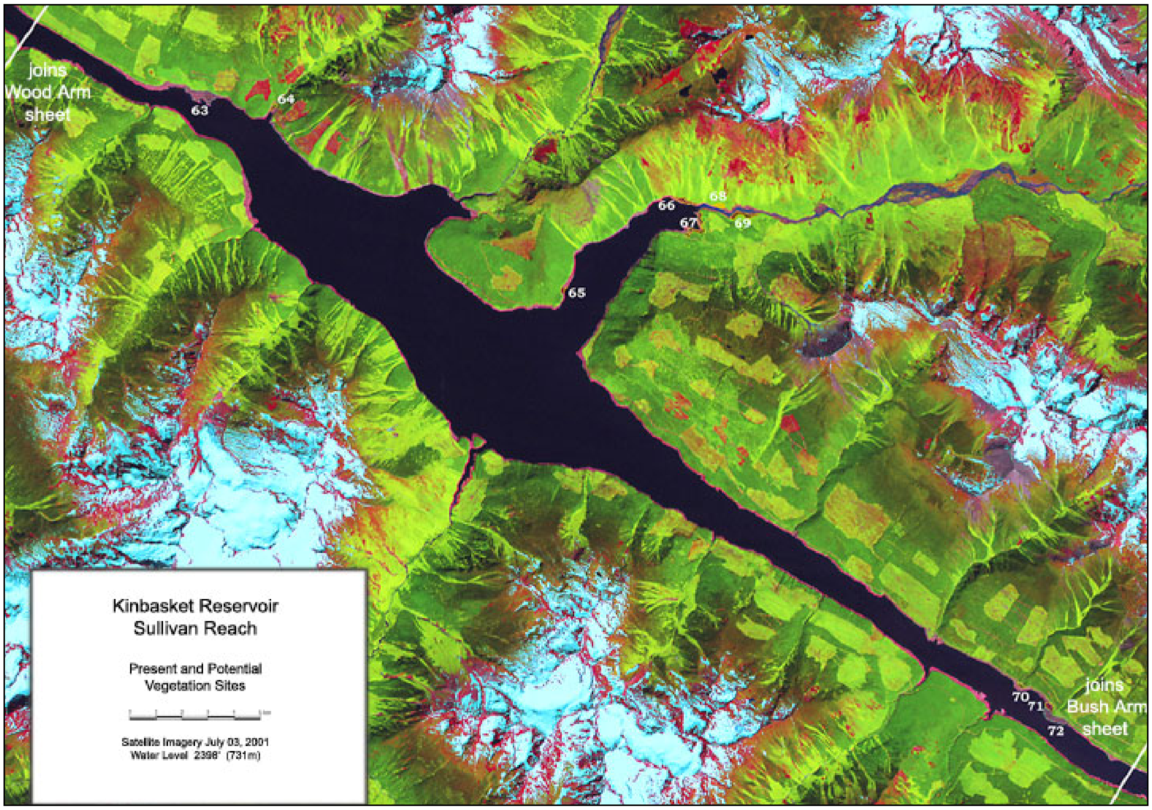


Table 5: Sullivan Reach Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
Sullivan Reach	**63**		18	flat bench, formerly forested
Sullivan Reach	**64**	2		wetland in sheltered bay
Sullivan Reach	**65**	2		small wetland in small embayment along Sullivan Arm
Sullivan Reach	**66**	5		wetland in sheltered bay, mouth of Sullivan River
Sullivan Reach	**67**	8		wetland in sheltered bay, mouth of Sullivan River
Sullivan Reach	**68**	1		wetland in sheltered bay, mouth of Sullivan River
Sullivan Reach	**69**	7		wetland in sheltered bay, mouth of Sullivan River
Sullivan Reach	**70**	2		upper fan veg.
Sullivan Reach	**71**	4		upper fan veg.
Sullivan Reach	**72**		13	lower fan slopes

Figure 7: Bush Arm Map

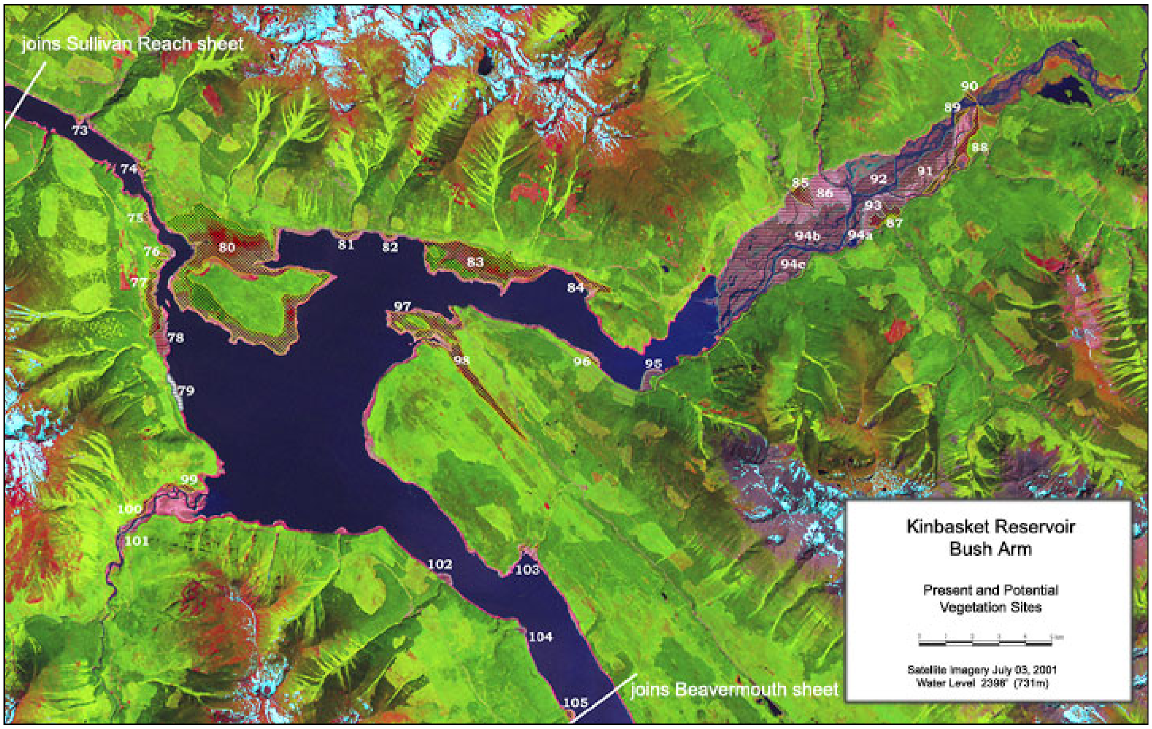


Table 6: Bush Arm Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
Bush Arm	**73**	1		upper fan veg.
Bush Arm	**74**	4		upper fan veg.
Bush Arm	**75**	5		wetland in sheltered bay
Bush Arm	**76**	11		wetland on flat bench on point
Bush Arm	**77**	42		wetland on flat bench
Bush Arm	**78**		24	lower elevation slopes adjacent to existing wetlands
Bush Arm	**79**	14		wetland on flat bench
Bush Arm	**80**	559		large wetland area surrounding island, variable slopes, substrates & exposures. Distant views during field visit showed sparse growth in places
Bush Arm	**81**	10		upper fan veg.
Bush Arm	**82**	3		upper fan veg.
Bush Arm	**83**	210		large gently sloping bench, some historic wetland area
Bush Arm	**84**	18		wetland in sheltered bay
Bush Arm	**85**	26		upper fan veg.
Bush Arm	**86**		114	lower elev. fan
Bush Arm	**87**	26		upper fan veg. field visit site 6
Bush Arm	**88**	45		upper fan veg. near causeway
Bush Arm	**89**	6		historic wetland area
Bush Arm	**90**	3		veg development on river bar, historic wetland area
Bush Arm	**91**		117	developing delta
Bush Arm	**92**		59	developing delta
Bush Arm	**93**		44	lower elev. fan
Bush Arm	**94**		496	developing delta, area includes braided stream channels, not all of which will be suitable for planting
Bush Arm	**95**		14	lower elev. fan
Bush Arm	**96**	3		upper fan veg.
Bush Arm	**97**	73		wetland in sheltered bays and on point
Bush Arm	**98**	89		wetland in sheltered bay
Bush Arm	**99**	8		wetland in sheltered bay
Bush Arm	**100**	8		wetland in sheltered bay
Bush Arm	**101**		14	unvegetated benches along Gold River
Bush Arm	**102**		6	lower elev. fan
Bush Arm	**103**	4		Esplanade Bay, well vegetated field visit site #7
Bush Arm	**104**		4	unvegetated fan
Bush Arm	**105**	3		vegetated fan

Figure 8: Beavermouth Map

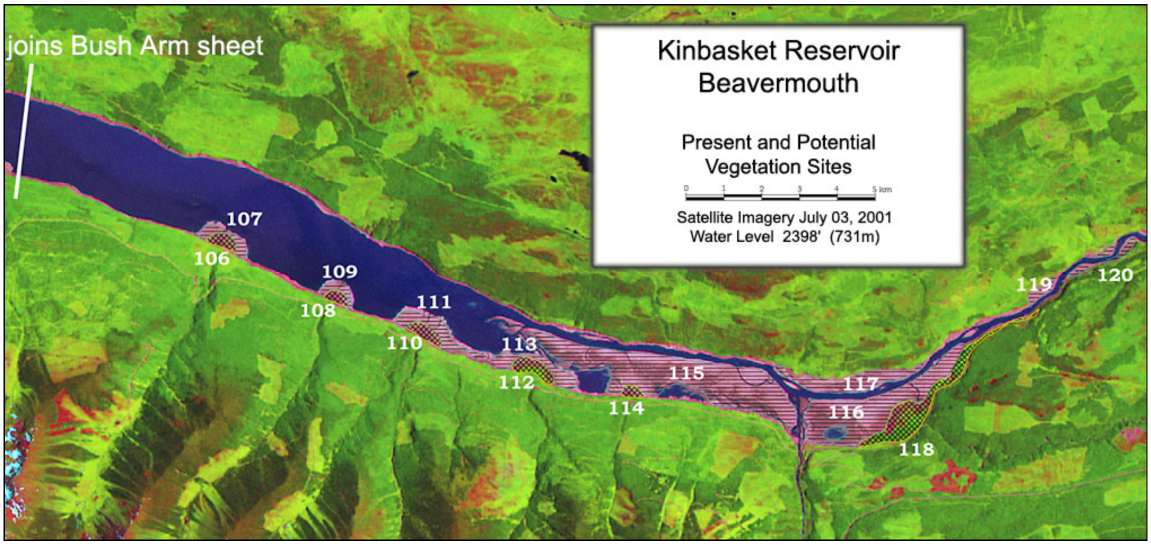


Table 7: Beavermouth Sites

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description
Beavermouth	**106**	13		vegetated fan
Beavermouth	**107**		15	lower elev. fan
Beavermouth	**108**	9		upper fan veg.
Beavermouth	**109**		10	lower elev. fan
Beavermouth	**110**	16		upper fan veg.
Beavermouth	**111**		34	lower elev. fan
Beavermouth	**112**	21		upper fan veg.
Beavermouth	**113**		31	lower elev. fan
Beavermouth	**114**	8		upper fan veg.
Beavermouth	**115**		293	low elev. flats, may be of sufficient elevation to sustain perennial vegetation
Beavermouth	**116**		161	low elev. flats, may be of sufficient elevation to sustain perennial vegetation
Beavermouth	**117**		60	low elev. flats, may be of sufficient elevation to sustain perennial vegetation
Beavermouth	**118**	81		Beavermouth delta area
Beavermouth	**119**		11	gentle slopes appear suitable for vegetation
Beavermouth	**120**		17	gentle slopes appear suitable for vegetation

4.0 ENHANCEMENT OPPORTUNITIES

Enhancement opportunities for reservoir wetlands occur in three major categories:

1. Water Level Modifications

Water level modifications are generally ruled out due to costs or corporate obligations. Vegetation communities that have evolved in the reservoir appear to have responded to long-term water level averages during the growing season. Any changes to the water levels during the growing season (approximately April 1- October 31) will influence the vegetation community. A lowering of the long-term median water level will allow the vegetation community to expand, whereas an increase in elevation will likely cause the vegetation to diminish in area and productivity over time.

Based on the initial information at hand, there appears to be minimal opportunity for vegetation enhancement in Kinbasket reservoir as a result of water level manipulations. However, thorough examination of the Kinbasket reservoir shoreline based on satellite imagery and historical maps has revealed high and moderate potential enhancement opportunities for approximately 3276 ha of shoreline. This is comprised of 1474 ha of currently vegetated habitats, which can be enhanced by fertilization and infill seeding and/or planting, and 1802 ha of presently unvegetated shoreline which offer seeding and planting opportunities. These totals do not include low potential sites for which further consideration is not useful at this time. Thus, these aerial estimates are less than those in Table 1.

2. Vegetation Establishment By Seeding Or Planting

Vegetation seeding and planting allows the establishment of vegetation in those areas where natural establishment is difficult or impossible. This may be the case in certain creek fans or in other substrates where moisture conditions are too severe for seedlings to establish. Planting of vegetation is a labour-intensive, costly process. However, it has the potential for great success in well-chosen locations and when water levels are not drastically changed. Studies at Upper Arrow Lake have indicated the potential to expand vegetation approximately 2m deeper into the reservoir drawdown zone than natural establishment will allow. Site specific assessments are required for determination of site suitability.

3. Enhancement Of Existing Vegetation Growth By Fertilization.

The highest potential is attributed to enhancement of existing vegetated sites by fertilizer applications to increase biomass and vigour of the vegetation. This represents the lowest enhancement cost per area with potentially the greatest habitat gains. Fertilization offers an opportunity to enhance existing or incipient vegetation communities and to boost chances for survival. Fertilization studies at Upper Arrow indicated an average 20% increase in size of plants in one year as a result of fertilizer applied to the substrate. Similar results have been obtained for foliar applications of fertilizer in both Stave and

Williston reservoirs. Kinbasket reservoir appears to offer numerous locations where vegetation is currently established or establishing and where fertilizer applications could benefit the continued development of the vegetation communities.

Proposed enhancement approach for Kinbasket Reservoir

The general approach for Kinbasket Reservoir is a multi-year revegetation program, with the first year in planning and acquisition of plant material (willow and native wetland plants) followed by implementation of various planting programs (treatments) and a subsequent monitoring program. It must be recognized that the development of a 'permanent' riparian/wetland cover in reservoirs is not a single year operation, but one of intervention (planting) over several years that facilitates the long-term vegetation cover.

There are five basic treatments applicable for this area, each with a specific objective, timeframe, and cost. The treatments are as follows:

- T1 – Fall rye seeding to promote surface substrate stabilization, provide organic matter for improvement of soil fertility, and promote native species colonization via 'accidental' incorporation of seed trapped in fall rye stubble. This approach was highly successful in Upper Arrow Reservoir.
- T2 – Direct seeding of lenticulate sedge (*Carex lenticularis*) in conjunction with fall rye drill seeding application. Direct seeding of lenticulate sedge at Upper Arrow and Williston Reservoirs was successful on smaller trials and is viewed as having significant potential for more widespread use.
- T3 – Willow planting using either hardwood cuttings and/or container stock. Willow has been successfully established in Upper Arrow, Upper Campbell and Carpenter Reservoirs in higher elevation areas.
- T4 – Wetland planting using container grown native species from locally collected seed. This technique has been successful in promoting native wetland development in numerous BCH reservoirs.
- T5 – Aerial foliar fertilization of existing vegetation areas to promote a more vigorous plant community in this nutritionally stressed environment. This approach was successful in Williston and Stave Reservoirs.

4.1 TREATMENT OPTIONS AND COSTING ASSUMPTIONS

T1 - Fall Rye Seeding

Fall rye seeding (at 100 kg/ha plus 10 kg/ha of a permanent grass mix) for microsite modification (control of wind erosion and enhancement of soil characteristics) is seen as the initial step in the program, and will be conducted for at least four years. Due to soil characteristics observed in Kinbasket on previous visits, it is assumed that we can only operationally seed 50% of available area. Also, given the dispersed nature of the areas to be seeded, whether by seed drill or ATV and harrowing, barging of equipment will be a major factor in final costs. However, due to issues of scale, this cost is very difficult to estimate.

Given the above factors, an initial estimate of costs is derived as follows:
- Basic seeding –100 kg/ha fall rye seed plus 10 kg/ha of a permanent grass seed mix (inundation tolerant agronomic species), 100 kg/ha fertilizer with seed drill application – estimated average basic cost of $150/ha.
- Though barging or mobilization to sites could increase costs by 100% for smaller areas (<25 ha), we will use a 50% average mobilization factor, thus $75/ha.
- Average estimated seeding cost is $225/ha/yr for four years, or $900/ha for program.
- Remember that it is assumed that this treatment is applicable to only half of the identified treatment site due to operational limitations.

T2 – Lenticulate Sedge Seeding (with Fall Rye as carrier)
Direct lenticulate sedge seeding with fall rye seeding (at 100 kg/ha plus 10 kg/ha of a permanent grass mix) as a carrier for drill seeding application. This is a one-time application to get the sedge seed into the soil substrate where it will stay until suitable conditions occur for germination and growth. This may take several years, but the seed will remain viable for many years. The fall rye application is needed to facilitate the drilling operation.

Given the above, and initial estimate of treatment cost is derived as follows:
- Lenticulate sedge seed cost (custom collection as none is available commercially) is projected at $500/ha (10 kg/ha application rate).
- Fall rye seeding cost as normal for one year, i.e. $150/ha.
- Remember that it is assumed that this treatment is applicable to only half of the identified treatment site due to operational limitations.

T3 - Willow Planting
Willow planting will be applied only in the upper 3 meters (possibly 4 or more if analysis of the water levels deems appropriate). Native willow is to be collected each year for planting the following year. This planting will be a progressive program with:
Year One - cutting collection and propagation
Year Two through Four - planting of previous year's material and more collection (for next year)
Year Five - planting only of material from previous year.

For costing purposes, the following assumptions are used:
- Only 20% of the treatment area will be affected by the willow planting (but high density planting in that portion, with linear bands spaced 3m apart and cuttings spaced 2m apart in the bands)
- With the estimated average cost of this type of planting at $5000/ha plus 25% for fill planting in second year, the cost is $7500/ha for planting.
- A reasonable mobilization cost is included in the $5000, and could be higher if areas are very remote.
- This treatment will be applied to only 20% of the identified treatment site.

T4 - Sedges and Wetland Plants
For sedges and wetland planting, the type of planting and total percentage of affected areas will drive the costing. In small areas, employing high-density plantings on a portion of the total area (the inoculation approach), will result in a smaller cost on a treatment area basis compared to an expansive planting approach.
For costing purposes, the following assumptions are used:

- The basic cost per $15,000/ha using 1m spacing of custom container stock.
- To achieve an inoculation level of establishment that will provide a material base for expansion throughout the treatment area, only 20% of total treatment site will be planted.

T5 - Aerial Fertilization of existing plant communities
On those areas of existing wetlands that we want to promote, aerial fertilization using the AgAir Enhanced Foliar Fertilizer is the best approach. Conducted early in the growing season, this approach has been shown to improve performance of reservoir remnant wetlands significantly (over 40% in height and 25% in biomass). Increases in plant size and biomass improve plant survival under stressful conditions and increase nutrient contributions to the adjacent ecosystems.

As with all field operations, the issue of scale is important. However, for this costing exercise the following assumptions are used:

- The operation is $50/ha per treatment, with a 10 ha minimum per site.
- Fertilizer will be applied for three years to effectively change site production, yielding a treatment cost of $150/ha.

Due to the limited information we have had available upon which to base the area cost estimates, these initial assumptions and area costs will likely change as site specific information becomes available.

4.2 SITE SPECIFIC DESCRIPTIONS

The evaluation of enhancement potential was based primarily on satellite imagery and further analysis is recommended to confirm the substrate, slope and elevations of the sites. Additional elevation data and field inspections may result in reclassification of the enhancement probability for some sites.

Sites identified as having a high probability for enhancement success, reflect a high degree of confidence in the interpretations and in the suitability of the available techniques for enhancement. Seven sites were identified as having a high probability of enhancement success; 5 in Canoe Reach and 2 in Bush Arm (Table 8). These represent 1223 ha of currently vegetated areas and 82 hectares of unvegetated sites. Three of these sites, one in Canoe reach and two in Bush Arm are large existing wetlands that have been recommended for fertilizer application to enhance the vigour of the existing natural flora. In addition, the existing wetlands in Bush Arm have been recommended for supplementary lenticulate sedge seeding to infill bare or impoverished areas. The likelihood of success for enhancement of these areas has been listed as high. The presence of vegetation in these sites confirms the ability of these species to survive. Field visits to some sites and distant views of others indicated that productivity and density of plants could be improved. Field trials at Stave and Williston reservoirs have demonstrated that vegetation biomass can be enhanced dramatically by fertilizer application.

The remaining four High probability sites are delta-type deposits in upper Canoe reach, some of which have already been drill seeded. We have recommended further drill-seeding at these sites, but with the inclusion of a perennial sedge in the seed mix. Lenticulate sedge is a commonly occurring species throughout reservoirs in BC and has proven to be the most inundation tolerant of the species tested at Upper Arrow reservoir. It is capable of maintaining viability in the substrate until appropriate conditions for germination occur. Once established at a site, it produces large quantities of seed which then add to the seed bank and allow further natural vegetation of the site.

An additional 30 sites have been identified as having a moderate probability of enhancement. Overall these represent 251 ha of currently vegetated areas and 1720 hectares of unvegetated sites. Details regarding the High and Moderate probability sites are presented in Table 8. Further consideration of low potential sites is not being pursued at this stage.

Table 8: Wetland Enhancement Opportunities and Estimated Costs (see text for treatment types)

Sheet	Site Number	Vegetated Area (ha)	Potential planting area (ha)	Description	Enhancement Options/Planting Prescriptions	Treatment	Probability of Enhancement	Factors to consider	AreaCost
Canoe Reach	**2**		26	Field visit site #4-fine substrates, previously drill seeded, reed canary grass has potential to spread	drill-seed with lenticulate sedge, fertilize	2, 5	**HIGH**	good access	$12,350
Canoe Reach	**3**		26	across channel from 3, should be similar	drill-seed with lenticulate sedge, fertilize	2, 5	**HIGH**	good access	$12,350
Canoe Reach	**6**		19	photos show drill seeding	drill-seed with lenticulate sedge, fertilize	2, 5	**HIGH**	good access	$9,025
Canoe Reach	**8**	454		natural historic wetland, high diversity, existing peat deposits eroding	vigour of existing wetland could be enhanced with fertilization	5	**HIGH**	good access	$68,100
Canoe Reach	**9**		11	rel. steep slope but located between vegetated sites	shrub/ wetland planting	3, 4	**HIGH**	good access	$49,500
Bush Arm	**80**	559		large wetland area surrounding island, variable slopes, substrates & exposures. Distant views during field visit showed sparse growth in places	vigour of existing wetland could be enhanced with fertilization, possibility of manual seeding in specific sites	2, 5	**HIGH**	large area which can be treated all at one time, reasonable access by boat	$265,525
Bush Arm	**83**	210		large gently sloping bench, some historic wetland area	vigour of existing wetland could be enhanced with fertilization, possibility of manual seeding in specific sites	2, 5	**HIGH**	large area which can be treated all at one time, close to site 81	$99,750
Canoe Reach	**5**		21	adjacent to existing wetland, probable high energy site	drill-seed with lenticulate sedge, fertilize	2, 5	**MODERATE**	good access	$9,975
Canoe Reach	**12**		22	coarse substrate ? fan	shrub/ wetland planting	3, 4	**MODERATE**	good access	$99,000
Canoe Reach	**15**	14		Yellowjacket Creek (field visit Site 2) variable substrate, patchy vegetation in depressions	fertilize existing vegetation, seed/plant to increase cover	2, 4, 5	**MODERATE**	good access	$48,650
Canoe Reach	**16**		29	Yellowjacket Creek lower elevation	seed/plant	2, 4	**MODERATE**	good access	$96,425
Canoe Reach	**25**	10		sparse upper fan veg. near Ptarmigan Cr	fertilize existing vegetation, seed/plant to increase cover	2, 4, 5	**MODERATE**	isolated location	$34,750

Table 8 cont.

lower Canoe Reach	**29**		21	sheltered, rel. gentle point	seed/plant	2, 4	**MODERATE**	isolated location	$69,825
lower Canoe Reach	**31**		13	sheltered, rel. gentle bay	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$43,225
lower Canoe Reach	**32**		25	Grouse Cr. - rel. gentle shore	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$83,125
lower Canoe Reach	**33**		32	Windfall Cr. bench	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$106,400
lower Canoe Reach	**34**		19	Windfall Cr. bench	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$63,175
lower Canoe Reach	**36**		145	Hugh Allan Cr low elev. bench	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$482,125
lower Canoe Reach	**37**		61	rel. gentle slope S of Hugh Allan Cr.	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$202,825
lower Canoe Reach	**39**		10	Howard Cr. gentle bench	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$33,250
Wood Arm	**45**	11		Encampment Cr. sheltered bay	probably not required - confirm with field assessment, fertilizer may be option of planting to occur nearby	0	**MODERATE**	isolated but in group of sites	
Wood Arm	**46**	15		Encampment Cr. sheltered bay	probably not required - confirm with field assessment, fertilizer may be option of planting to occur nearby	0	**MODERATE**	isolated but in group of sites	
Wood Arm	**47**		22	Encampment Cr. lower elev. Slopes - high energy?	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$73,150
Wood Arm	**48**	95		Encampment Cr. sheltered bay	probably not required - confirm with field assessment, fertilizer may be option of planting to occur nearby	0	**MODERATE**	isolated but in group of sites	
Wood Arm	**49**		52	Encampment Cr. lower elev. slopes - high energy?	seed/plant	2, 4	**MODERATE**	isolated but in group of sites	$172,900
Sullivan Reach	**63**		18	flat bench, formerly forested	seed/plant	2, 4	**MODERATE**	isolated	$59,850
Bush Arm	**84**	18		Wetland in sheltered bay	vigour of existing wetland could be enhanced with fertilization, possibility of manual seeding in specific sites	2, 5	**MODERATE**	close to site 80 and 83	$8,550
Bush Arm	**87**	26		upper fan veg. field visit site 6	fertilize existing vegetation, seed/plant to increase cover	2, 4, 5	**MODERATE**	coarse substrates, existing high diversity of spp., north facing slope increases potential for success	$90,350

Table 8 cont.

Bush Arm	**88**	45		Upper fan veg. near causeway	fertilize existing vegetation, seed/plant to increase cover	2, 4, 5	**MODERATE**	coarse substrates, north facing slope increases potential for success	$156,375
Bush Arm	**91**		117	developing delta	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**HIGH**	delta has been forming since historic maps, may be of sufficient elevation to sustain vegetation growth	$90,675
Bush Arm	**92**		59	developing delta	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**HIGH**	delta has been forming since historic maps, may be of sufficient elevation to sustain vegetation growth	$45,725
Bush Arm	**94**		496	developing delta, area includes braided sream channels, not all of which will be suitable for planting	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**LOW**	delta has been forming since historic maps, may be of sufficient elevation to sustain vegetation growth	$384,400
Beavermouth	**115**		293	low elev. flats, may be of sufficient elevation to sustain perennial vegetation	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**MODERATE**	relatively accessible	$227,075
Beavermouth	**116**		161	low elev. flats, may be of sufficient elevation to sustain perennial vegetation	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**LOW**	relatively accessible, historic wetland area	$124,775
Beavermouth	**117**		60	low elev. flats, may be of sufficient elevation to sustain perennial vegetation	fall rye seeding with inclusion of some lenticulate sedge if conditions appear suitable	1, 2	**LOW**	relatively accessible	$46,500
Beavermouth	**119**		11	gentle slopes appear suitable for vegetation	seed/plant	2, 4	**HIGH**	may be high energy along stream	$36,575
Beavermouth	**120**		17	gentle slopes appear suitable for vegetation	seed/plant	2, 4	**HIGH**	may be high energy along stream	$56,525

Treatments
0 - none
1- fall rye seeding
2- lenticulate sedge seeding
3 - willow planting
4 - sedge/grass planting
5 - fertilizer

5.0 DISCUSSION

The main objective of the study will be to identify and plot those areas within the drawdown zone which have the highest potential for vegetation establishment

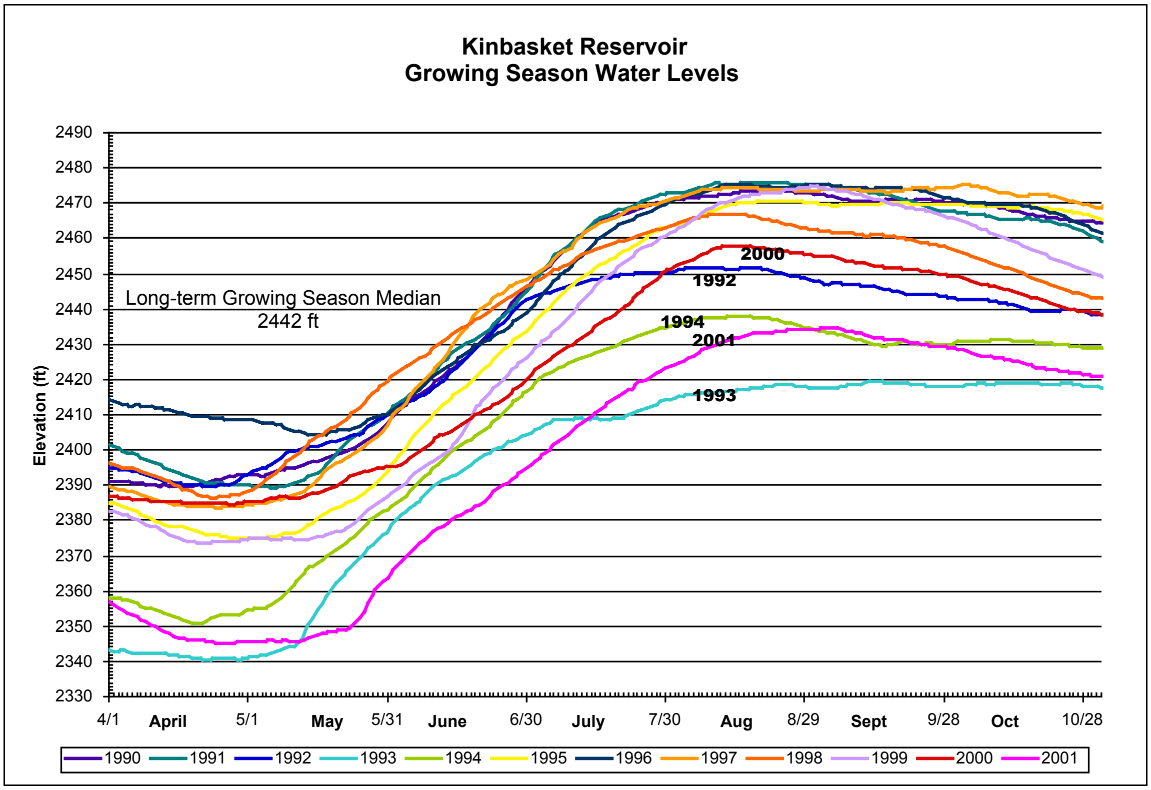
This study will identify cost-effective alternatives to operating changes as a means of improving vegetation around the Kinbasket Reservoir.

Due to the lack of printed aerial photographs and absence of current elevation information, initial efforts to achieve the main objective of this study were impaired. To supplement the field review an examination of the water level records was undertaken. Based on these and comparable analysis of the Upper Arrow reservoir, we were able to make predictions regarding the potential elevations for vegetation distribution. Subsequent analysis of satellite imagery confirmed many of the assumptions made during the initial stages of this study.

The pattern and duration of inundation determine the potential for vegetation to establish and persist in a drawdown zone. Studies at Upper Arrow Lake have suggested a correlation between the long-term median water level and the elevation to which plants can expand in the drawdown zone. This appears to be a reasonable predictor of the lower limit of dense vegetation growth. As an example, at Upper Arrow Lake (Revelstoke Reach) the 1991-2001 growing season median water level was 434.7m. This closely matches the lower limit of dense vegetation growth, although patchy vegetation development may extends as much as another 2 m in depth.

For the same time span, 1991-2001, the Kinbasket long-term growing season median value was 2442 ft (744m). Field work in July, 2002 confirmed that the present distribution of vegetation at Canoe Reach was well below 2452ft (747m). Satellite imagery of the Canoe Reach wetlands (supplemented with the grayscale aerial photographs from 2002), shows that the water level during the time of the imagery (2430 ft or 741m), was at about the lowest limit of vegetation growth in the historic wetlands. Interpretation of the lower edge of vegetation was somewhat limited by the resolution of the satellite imagery (40m pixels) Further work will be needed to confirm the full range of vegetation in the reservoir. The present limitations to vegetation development above 2451 ft are substrate characteristics such as texture and slope. Coarse materials and steep slopes are not conducive to vegetation development. This is the case for most of the Kinbasket reservoir shorelines, where steep slopes have prevented vegetation establishment.

Figure 9: Growing Season Water Levels



6.0 RECOMMENDATIONS FOR FURTHER WORK

Specific needs for additional information have been raised in the report. Preparation of a DEM would provide elevational information essential to the refinement of a vegetation enhancement assessment. It is recommended that a DEM be used in a GIS analysis to further refine the potential vegetation establishment locations discussed in this report.

Vegetation mapping is essential for the determination of the current distribution of vegetation in the reservoir and as a basis for performance measures. Although an overview mapping has been conducted from the satellite imagery, the 40 m pixel resolution is not sufficient to provide detailed vegetation information. The specific sites identified in this report are recommended for further, detailed vegetation mapping. Field verification of mapping results is an essential aspect of such a program. In addition to the field verification, it is also recommended that field assessments be conducted to determine:

- the species composition of existing wetlands
- density of vegetation communities in relation to elevation
- biomass of communities in relation to elevation
- potential for fertilization benefit.

In particular, the remnant (historic) wetlands need to be assessed to evaluate the species that have been successfully surviving long-term inundation within the reservoir. All of these items relate to the measure of success (and performance measures) if and when enhancement is undertaken.

One of the greatest lessons learned from a decade of vegetation work at Upper Arrow Lake was that the lack of baseline data made it impossible to measure the long-term success of the re-vegetation program or to determine which were the most important elements of the program. We know it worked, we think we know why but we can't prove it. This limits the applicability of the data to other reservoirs and for developing operational plans. Based on this experience, prior to undertaking any enhancement activity, we strongly recommend the assessment of baseline environmental data against which subsequent change can be measured. Regular monitoring should be established once enhancement activity has begun, and the planning process should include budgeting for the long-term.

TERMS OF REFERENCE

MICA-REVELSTOKE –KEENLEYSIDE (MCA) WATER USE PLAN POTENTIAL AREAS FOR VEGETATION ESTABLISHMENT IN KINBASKET RESERVOIR

Introduction

Water Use Plans (WUPs) are currently being developed for the operations of BC Hydro's Mica, Revelstoke, and Keenleyside projects. The purpose of these WUPs is to determine how our current operations could be changed to reflect a better balance between various water uses – maintenance of ecological health (fish, wildlife), recreation, power generation, culture/heritage, navigation, and flood control. The process used to develop the plan is a collaborative one involving many interest groups, First Nations, government agencies and other stakeholders collectively referred to as the Consultative Committee.

The MCA WUP Consultative Committee, with the support of a Wildlife Technical Committee (WTC), has approved a limited number of studies designed to fill specific data gaps identified in earlier phases of the process. The constraints associated with these projects are that they must address relevant performance measures, and be completed by fall 2002 so that their results can contribute to the next steps in the process (creation of operating alternatives and assessment of tradeoffs). In the case of this project, the relevant wildlife performance measure is the number of hectares of willow/sedge-grass-herb vegetation within the drawdown zone of Kinbasket Reservoir. One of the approved studies is directed specifically at this performance measure: an assessment of potential areas for vegetation establishment within the Kinbasket Reservoir.

Preliminary modeling of alternatives has demonstrated very little benefit from operational alternatives alone, because the limiting factor is plant establishment. This study will identify cost-effective alternatives to operating changes as a means of improving vegetation around the Kinbasket Reservoir.

The main objective of the study will be to identify and plot those areas within the drawdown zone which have the highest potential for vegetation establishment through planting relative to current and alternative proposed operational regimes at Mica Dam. The areas would be delineated on large-scale maps (e.g. 1:20,000 or 1:10,000 scale).

Study Design

The proposed project work plan should involve the following key components:

- Assemble existing information (e.g., air photos, topographic maps, recent climate records, and reservoir operations data) on Kinbasket Reservoir;
- Evaluate results of 2001 field planting trials conducted by BC Hydro (Upper Columbia Generation – Revelstoke) in terms of project objectives;
- Develop map of reservoir identifying preliminary polygons of potential revegetation;
- Verify with limited scope ground truthing; and
- Document results in report whose audience will be both the general public and technical specialists.

Proposal

The proposal should provide detail on how the successful consultant would address the project work plan components itemized above under Study Design. The methods used to carry out the work will be finalized in consultation with the Wildlife Technical Committee (Contact: Ian Robertson, BC Hydro).

It is expected that the study team will include a plant ecologist and a professional experienced with reservoir operations. Some technical support will be provided from the Photogrammetry Services Department in the form of May 2002 air photos (1:10,000), but development to prints will be the responsibility of the successful consultant. Modeling support will be provided by Ecometrics Research.

Your proposal should be submitted by e-mail to Wayne Duval by June 24, 2002 (noon) (wayne.duval@bchydro.com)

Deliverables

1. A map indicating preliminary polygons identified as having high potential for vegetation establishment through planting, based on modeling results, limited ground truthing, the analyzed results of the 2001 planting trials, and the professional judgement of the study team.

2. A report documenting the successful completion of the project components itemized above under Study Design.

Timeframe

The draft report is to be submitted by August 30, 2002.

The anticipated final report submission date is September 30, 2002.

Bidders List

Carr Environmental Consultants
AIM Ecological Consultants Ltd.

Budget

A budget of $9,000 has been assigned to this project.

Project Supervisors

Wayne Duval	604-528-1568
Ian Robertson	604-530-1080

Appendix AA: Proposed Revegetation Plan for Arrow Lakes Reservoir

Mica - Revelstoke - Keenleyside Water Use Plan:

Potential Areas for Vegetation Establishment In the Arrow Lakes Reservoir

Prepared for BC Hydro by:

Anne Moody

AIM Ecological Consultants Ltd.
Box 192
Knutsford, B.C. V0E 2A0

January 2005

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1.0 INTRODUCTION AND BACKGROUND

This study was initiated in July of 2002 in response to a request by BC Hydro and the MCA WUP Consultative Committee to assess the potential for wildlife habitat enhancement in Arrow Lakes Reservoir through promotion of reservoir vegetation via changes in operating regime and direct intervention (i.e. planting). It is known that vegetation occurs in the Revelstoke Reach portion of Arrow Lakes as a combination of the effects of the current operating regime and dust control revegetation programs. The WUP Committee is interested in developing planting programs compatible with both the current operating regime and proposed options that will maximize (or encourage) vegetation growth in the drawdown zone around the reservoir. This study was undertaken to provide a reservoir-wide perspective on revegetation options.

The draft report was presented to the WUP Committee in April 2003. Since that time, various vegetation-related issues were addressed at WUP Committee meetings. It was felt that the additional information presented to the Committee should be included in the final report. Also included in this revised report are: site photos obtained during brief field visitations in May 2003 and September 2004 (Appendices ____); new (2004) DEM elevation information for lower Revelstoke Reach sites; and water level data for the 2000-2004 period. These additions serve to provide a better perceptive on reservoir revegetation and habitat enhancement possibilities.

1.1 Objective/Approach

The objective of this study was to identify and plot those areas within the drawdown zone of Arrow Lakes Reservoir which, based on existing knowledge of drawdown zone vegetation limitations, had the highest potential for vegetation establishment and to suggest an operating regime(s) and revegetation programs that would facilitate development of this potential.

1.2 Working Plan

- Information Review - Review of available information, old topographic maps, historical reservoir operating regime, and available biogeoclimatic information

- Mapping Inputs and Report – Preparation of large scale maps showing the entire reservoir area, with excerpts of specific areas to be included in the report.

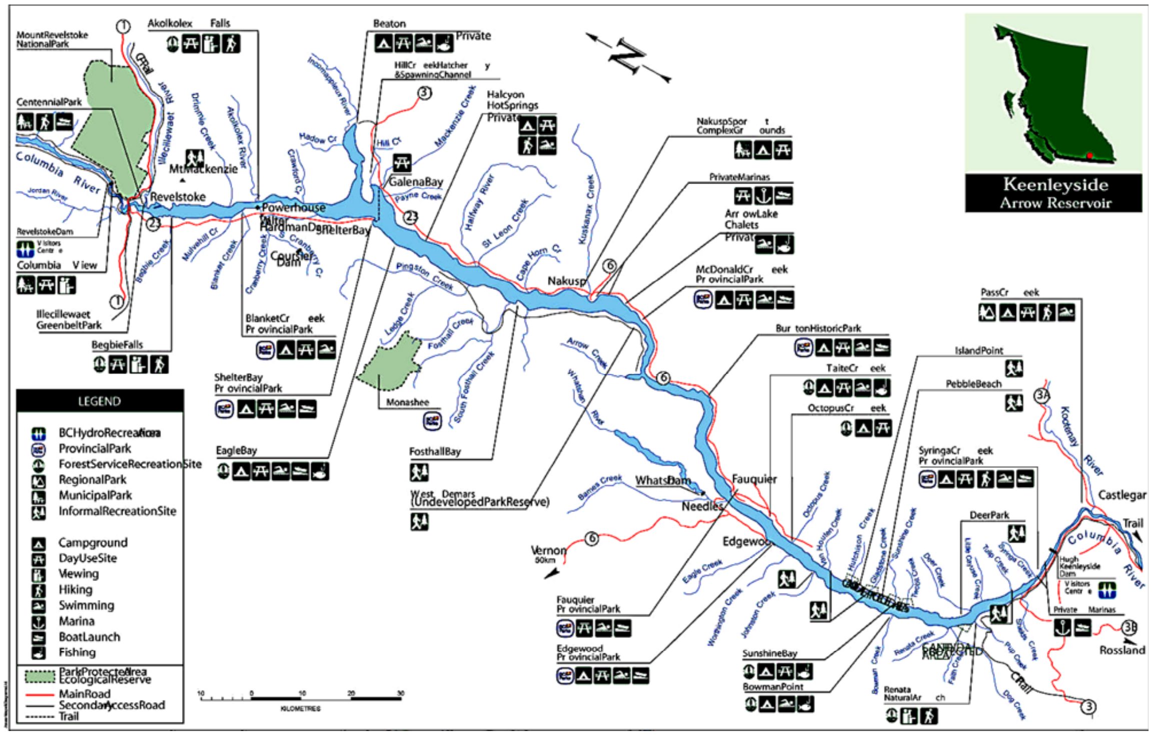
- Preparation of project report focused on identification of vegetated and potential vegetation development areas, including recommendations, and estimated cost for revegetation options.

1.3 Site Description

Arrow Lakes Reservoir is an approximately 200 km long impoundment of the Columbia River extending from Revelstoke dam upstream to the downstream control at Hugh

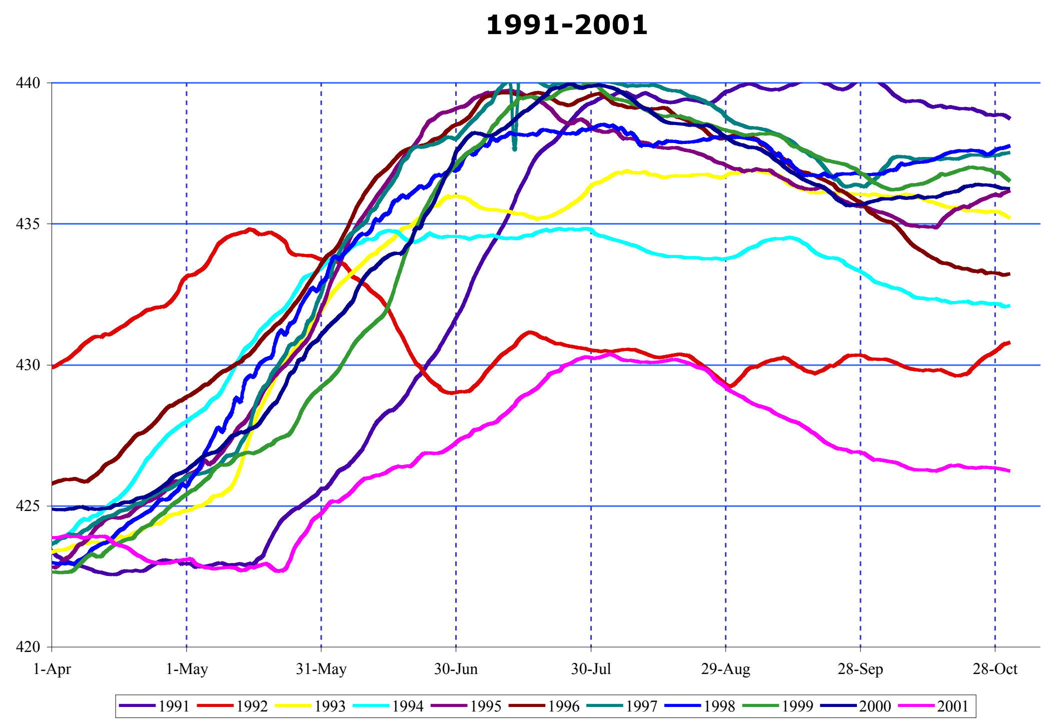
Keenlyside Dam (Figure 1). The major source of inflow is from snowmelt from April through June; refill generally begins in early April and the reservoir reaches full pool by the end of June (Figure 2). The operating range of the reservoir is from a low of approximately 422m to full pool at 440 m.

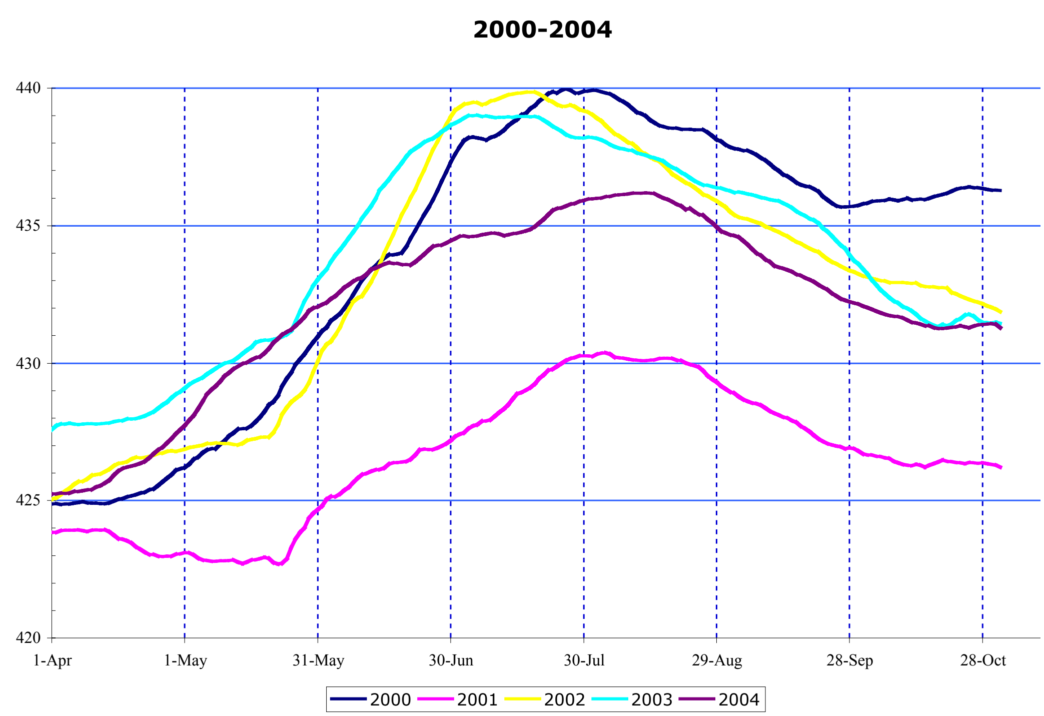
Figure 1: Location Map (modified from Arrow_Lake.pdf – BC Hydro website)



Since the late 1980's, significant portions of Revelstoke Reach at the northern end of Arrow Lakes Reservoir have been repeatedly seeded with fall rye to control erosion and wind borne sediments. The program was expanded over the years from an initial 200-350 ha fall rye seeding to over 1000 ha in 1991. The annual seeding has since been modified each year based on water levels, shifts in dust source locations, and the development of native vegetation on previously seeded areas. The establishment of native vegetation on large portions of the drawdown zone has allowed the annual seeding program to target priority dust source areas while allowing the expanding native vegetation to effectively control erosion. Vegetation mapping revealed that between 1991 and 2000, native vegetation had expanded in area by 275% (Moody 2002). Although significant revegetation efforts have been employed in Revelstoke Reach, the remainder of Arrow Lakes Reservoir has received little attention from a vegetation perspective. The studies related to Arrow Lakes Reservoir are summarized in the following section in order to provide an understanding of the basics leading to the assessments of potential vegetation enhancement opportunities.

Figure 2: Arrow Lake Reservoir Water Levels





2.0 SUMMARY OF PAST STUDIES[1]

2.1 Wetland values

Wetlands are acknowledged as important ecotones between the aquatic and terrestrial environments, contributing to each at different times of the growing season. During the non-inundated part of the season, the herbaceous wetland communities can serve as food sources for large mammals such as bear and deer, functioning as favourite feeding areas early in the spring when they green-up earlier than most non-wetland areas. They are also important habitats for a variety of bird life such as waterfowl, shorebirds and raptors, with different degrees of use according to season and water level. Small mammals use the upper drawdown zone areas for most of the year, retreating to drier ground, as the habitat is flooded with rising reservoir levels.

Herbaceous wetlands are extremely productive environments, with above-ground biomass values as great as 5 t/ha accumulated over a short, 3 month growing period. As the wetlands become inundated, the leaves of the herbaceous species begin to decompose and they become part of a rich organic mix that sustains a range of organisms from bacteria to beetles and eventually to fish. The below-ground organs of these plants remain alive and act as nutrient reserves, ready to produce new shoots for the next growing season. Below-ground biomass has been documented to be as great as 300% of the above-ground growth. Since the below-ground growth persists from year to year and breaks down very slowly, it has been suggested as a potential means of carbon sequestration.

Wetlands normally extend from just above the high water mark to approximately the low water mark of a natural lake. Regulated lakes typically have a much greater range of water level fluctuations than natural lakes and consequently have a much greater elevational range in which vegetation is able to establish. At Arrow Lakes reservoir, this can extend over 8 m in elevation. Plant growth at the higher end of the range is governed by desiccation and competition from terrestrial species, while the lower end of the range is controlled by the plants' tolerance of inundation. The drawdown zone is a harsh place for most plants. They must withstand desiccation for part of their growth span and inundation by several meters of water for the remainder. This is an environment where only a few very tolerant species are able to thrive. As water levels fluctuate from year to year, the vacillating lower vegetation zone displays the stresses it endures by reduced size and vigour of plants, and by a scattering of dead plants that have succumbed to the latest extreme stresses. These plants are capable of tolerating periods (up to several years) of harsh conditions, provided that they are interspersed with periods of favourable conditions. The duration of tolerance depends on the species of plant, biogeoclimatic factors and the severity (duration, depth and frequency) of the inundation period.

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[1] Modified from: Moody, Anne 2003. VEGETATION CHANGE IN THE ARROW LAKES RESERVOIR - A SUMMARY OF PAST STUDIES. A background document for the Mica - Revelstoke - Keenleyside Water Use Plan revegetation discussion May 26, 2003 at Revelstoke, B.C.

Research conducted at Upper Arrow Lake has become an important source of information for the understanding of vegetation tolerances of extreme water level fluctuations in regulated lakes. It is the variability of water levels that allows a broad band of vegetation to persist in the drawdown zone and it is the same variability that limits it.

2.2 Summary of Revegetation Efforts and Research Programs

Hugh Keenleyside Dam north of Castlegar was constructed in 1967 and the Arrow Lakes Reservoir was filled to the maximum operating level by mid-1969. Prior to impoundment, the predominant low-elevation land-classes in the valley (especially Revelstoke Reach) were agricultural and forested with some small areas of wetland. The decline in vegetation cover in response to the water impoundment was very dramatic between 1968 and 1977; an 89% reduction in the vegetated area was noted in the historic mapping of Revelstoke Reach (Moody 2002b). Consequently, large areas of de-vegetated substrates became sources of wind blown dust. This became an issue of great concern for local communities and spurred the first investigations into potential revegetation options. Initial attempts at revegetation were undertaken in limited trials by B.C.Hydro as early as 1975. A number of sites, including: Big Eddy, Revelstoke foreshore, Illecillewaet South, the Revelstoke airport, an unidentified area 7 miles south of Revelstoke, and sites near Burton and Nakusp, were seeded with fall rye and commercially available grasses. Good results were recorded above 437m (BCH file memos of B. Homewood and P.W.W. Mosby). Specific sites were not marked and subsequent monitoring does not appear to have occurred. The only records of these initial trials are file memos and rough sketches of locations. Photos of naturally occurring “weeds” were noted in the memos. These were mentioned because the “weeds” were removed from the test plots so as not to affect the success of the grasses. Examination of the photos has subsequently shown them to be native sedges, which are now highly successful in the reservoir area.

Beginning in the late 1980’s, significant portions of the Revelstoke Reach of Arrow Lakes Reservoir were repeatedly seeded with fall rye for wind erosion control and dust abatement. Based on early successes, the initial seeding of some 200-350 ha was expanded to over 1000 ha in 1991. The seeding has continued for dust control annually, with the program modified each year based on projected water levels, shifts in dust source locations, and the establishment of native vegetation on previously seeded areas. Although expansion of native vegetation was observed over time, the only quantification of the vegetation spread was from the monitoring of a limited number of long term vegetation plots established in 1992 (Moody 1998). A vegetation mapping study of the dust control areas of Revelstoke Reach undertaken in 2000, noted that between 1991 and 2000 vegetation cover increased by almost 200% (Moody 2002b).

The informal monitoring of the vegetation establishment within Upper Arrow conducted in association with dust control assessments in the 1990’s indicated that in addition to the annual seeded fall rye, three major perennial vegetation communities were evolving within the treated (i.e. seeded) portions of the reservoir:

- Sedge dominated communities, including few other wetland species (extending from 433 to 436 m)
- Reed canary grass community, including an understory of sedges and other wetland species (extending from 434 to 436+m)
- Horsetail dominated communities (occurring primarily at 435+m)

Wetland trials, including a total of 21 wetland species (including grasses, sedges, rushes etc.) were initiated in 1991 to 1993, to examine the feasibility of establishing a perennial cover of native wetland species for dust control in the drawdown zone (Carr, 1992; Carr and Moody, 1992, Carr, et. al. 1993). An additional monitoring program, for the naturally expanding native vegetation, was initiated when it was first observed that the native species were beginning to expand their range in conjunction with fall rye seeding. Permanent monitoring plots were established at the lowest limit of plant growth, in 1991, at approximately 435m. Monitoring of the survival and expansion of these seedlings occurred on an annual basis until 2001. At the conclusion of a decade of growth, of the plants established in 1991, four species of sedge remained: water sedge (C. aquatilis), slough sedge (C. obnupta,), beaked sedge (C. rostrata), and lenticulate sedge (C. lenticularis). Dramatic differences were apparent in the survival of these plants at the various elevations. Plant growth and survival at elevation 436m had resulted in more than a 2000% increase in vegetated area over the decade since the initial planting at the site. At 435m, there was a maximum 700% increase in five years until inundation stresses produced a decline in the vegetated area. The greatest survival was at 436m with a large proportion of the sedges surviving. All of the plants present at 436m, with the exception of beaked sedge were noted as being very vigorous, producing seed and spreading widely beyond their original plugs. Survival numbers, size and seed production declined by elevation 435m and continued to decrease with depth (Moody 2002a).

Due to the extreme stresses imposed on the plants by the inundation regime, the vegetation which has evolved in the reservoir is limited to a very few species which are tolerant of extreme flooding and exposure. Reed canary grass and lenticulate sedge are the two dominant wetland species throughout the permanently recolonized zone, with both species heavily influenced by reservoir elevation. As of 2000, 434 m (6 meters below full pool) appeared to be the lower boundary for extensive recolonization by wetland species. However, newly developing vegetated areas were noted extending to 432 m. Several consecutive higher than average water level years may raise the lower limit of plant growth, while several lower years may allow for extension of the permanent vegetation community to lower elevations (Moody 2002a).

Over the latter half of the 1990's, there were anecdotal reports of ecological and social benefits from the revegetated drawdown zone in Revelstoke Reach (often referred to as the Revelstoke wetlands), including increased wildlife usage, improved trout fishing, and a high level of associated recreational use. In 1999, BC Hydro initiated an evaluation of the potential benefits associated with the new wetland area under the Strategic Environmental Initiatives Program (SEIP). Initially focused on the quantification of the vegetation benefits to the local fishery, and possibly to overall fish habitat within Arrow Lakes Reservoir (Limnotek et. al. 2000, Korman 2002), additional studies addressing bird usage (Woods, J. and J. Jarvis. 2002) and recreational activities were added in 2001.

To help accomplish these objectives, a three-year study was undertaken with the following tasks:

- Quantify the distribution of vegetation and evaluate the colonization rates of native species within the revegetated areas in the Revelstoke Reach
- Quantify biomass, nutrients (N, P, & K) and carbon levels of the plant communities to determine the potential contribution of vegetation to the surrounding ecosystems
- Develop a system for a long term monitoring program that examines relative abundance, species composition, and biomass within the study area.

Results of the three-year study appear in several reports (AIM and Carr 2002; Carr and AIM 2002a; Carr and Moody 2002b). The growth performance of the vegetation (in terms of species distributions, biomass and nutrient status) appears to be sensitive to elevation change for all species. The bulk of the biomass production occurred in the 434 to 437m elevation zone. Overall, the 483 ha of perennial vegetation in the dust control treatment zones was estimated to produce a total annual aboveground biomass of 1615t, a remarkable feat considering the less than 3 month growing period prior to inundation. The effect of recolonization on soil development and carbon accumulation tends to parallel the biomass patterns of the vegetation.

2.3 Synthesis of Findings

The water level fluctuations experienced by vegetation in the Upper Arrow drawdown zone, far exceed any fluctuations tolerable by plants reported in the literature to date. Typically, plant tolerances are reported on a scale of centimeters rather than the several meters inundating the vegetation at Upper Arrow Reservoir. The establishment of vegetation trials and permanent plots has allowed development of an unparalleled understanding of vegetation responses to inundation stress.

The test plots established at Upper Arrow Reservoir provided information regarding individual species tolerances of water fluctuations within the reservoir. Many of the species tested, showed intolerance of the Upper Arrow Reservoir water regime almost immediately. As a group, the sedges showed a greater tolerance than other species, of the range of water level fluctuations. The grass group had minimal success in the elevations tested but offered some potential for higher elevations. The rush group had no success at all, probably due to their inability to tolerate the extended periods o exposure and drought. All of the species showed increasing survival with increasing elevation.

The elevation of a site represents an integration of flooding stresses to which the plants may be subjected. However, these stresses vary dramatically from year to year and the stress levels experienced at any given elevation may be reflected at a different elevation another year. Fertilization can enhance the growth rate and therefore should help increase survival and recovery of plants following inundation stress.

The establishment and continued survival of wetland species occurs as a balancing act between the conditions essential for germination and condition essential for growth. These two conditions are not necessarily the same. Sedge colonization varies depending on the annual water level. Seedling germination and establishment appears to be occurring at the annual median water level, but mortality of sedge seedlings is governed by the subsequent inundation. Seedlings able to establish during favourable germination years may be able to carry on growth during years when water levels are too high for germination to occur. Production of seeds from the established plants contributes to the seed supply, which if incorporated into the soil, will germinate during the next favourable drawdown.

Tests of seed germination have revealed that lenticulate sedge is the only one of the sedges tested that can be expected to produce viable plants from seed. Reed canary grass is able to expand by seed, rhizome extension and stem rooting but overall, is slightly less tolerant of inundation than lenticulate sedge. Other grasses offer potential for establishment by seeding, but are limited in their tolerance of inundation. Fertilization seems to be important in increasing the size of plants, thereby increasing their ability to withstand stress.

Natural plant establishment appears to have been enhanced by the process of drill seeding which incorporates seed into the soil and organic material into the substrate. An increase in native plant expansion is apparent in areas where drill seeding has been occurring regularly (Figure 3). It is evident; particularly when viewing the linear pattern of native plant development, that expansion of natural vegetation has been assisted by the drill-seeding program and supported by subsequent, favourable water levels.

Figure 3: Establishment of perennial vegetation (predominantly reed-canary grass with some lenticulate sedge) along drill-seeding rows.

Extended drawdown periods provide cost-effective and efficient opportunities to establish perennial vegetation that may be able to persist even through extended periods of flooding. During extended drawdown periods, seeding of perennial species may be feasible and may allow germination and establishment of seedlings that would otherwise be flooded in the first year. When seedlings have a long enough exposure to allow establishment, the prognosis for the established plants is good, despite average or slightly above average subsequent flooding. Taking advantage of extended drawdown conditions may provide the most cost-effective and efficient time during which to establish a self-perpetuating vegetation cover within the drawdown zone.

Options possible for enhancing natural colonization, include:

- harrowing of areas where a natural seed supply occurs;
- facilitating seed entrapment and incorporation into the soil by using nurse-crops;
- manipulation of water levels to enhance germination; and,
- fertilization of natural communities to enhance growth and flooding tolerance.

The revegetation program for the Upper Arrow drawdown zone has been considered a success not only in controlling dust generation, but also provided the basis for numerous spin-off benefits to the area generally associated with wetland development.

3.0 METHODS

Determination of potential vegetation planting areas and production of large scale maps of these sites required detailed photographic analysis of the reservoir. Aerial photography (June, 2000) and digital elevation modeling was available for most of Revelstoke Reach, but not for the remainder of Arrow Lake. In order to provide an overview of vegetated sites and potential sites for vegetation establishment in Arrow Lakes Reservoir, satellite imagery was utilized for vegetation analyses. Imagery was available from September 14, 2001 when the reservoir levels were at 428m, well below normal vegetation growth zones.

3.1 Satellite Imagery and Mapping

Satellite imagery was utilized to provide an overview assessment of vegetation resources and potential areas for vegetation establishment within the reservoir. Imagery from 2001 was available for the entire reservoir during relatively low water conditions (428m). Other than Revelstoke Reach, for which a DEM from 2000 is available, elevational information was only available from 1951 historical maps, which were based on 1944 aerial photos.

Landsat 7 data used for this project was supplied by the Ministry of Sustainable Resource Management, Government of British Columbia. The imagery was supplied via FTP for use in the BC Hydro Arrow Lake vegetation project as unenhanced orthorectified Landsat 7 data in BCAlbers projection, GeoTIFF format:

L7_4424_2001_BCAlb_30m_unenhanced_individual.Geotiff
L7_4425_2001_BCAlb_30m_unenhanced_individual.Geotiff
L7_4426_2001_BCAlb_30m_unenhanced_individual.Geotiff

Additional processing of these files was undertaken by Pacific Geomatics Ltd. as follows:
L7_4524_20010703_BCAlb_15m_enhance_fuse.tif enhanced IHS fuse as RGB
L7_4525_20010703_BCAlb_15m_enhance_fuse.tif enhanced IHS fuse as RGB
L7_4526_20010703_BCAlb_15m_enhance_fuse.tif enhanced IHS fuse as RGB

Satellite images, imported as TIFF files were examined at maximum resolution to assess presence of vegetation along exposed shorelines and to determine unvegetated sites suitable for planting or enhancement. Initial interpretations were supplemented with previous mapping of the Revelstoke Reach area (Moody 2002) and detailed knowledge of the vegetation composition within that area. Polygons were delineated for areas identified as vegetated and for those having potential for vegetation establishment. The potential for vegetation establishment was based on the spectral reflectance characteristics of the satellite imagery (revealing substrate textures) and cross-checking with the historical maps to evaluate slopes, elevations and probable energy characteristics at each location. Individual areas were numbered, measured and annotated for site characteristics and probable potential for enhancement (Table 2-4). Reduced versions of the completed maps were prepared for inclusion in this report (Figure 5-9).

Figure 4: Layout of Satellite Sheets

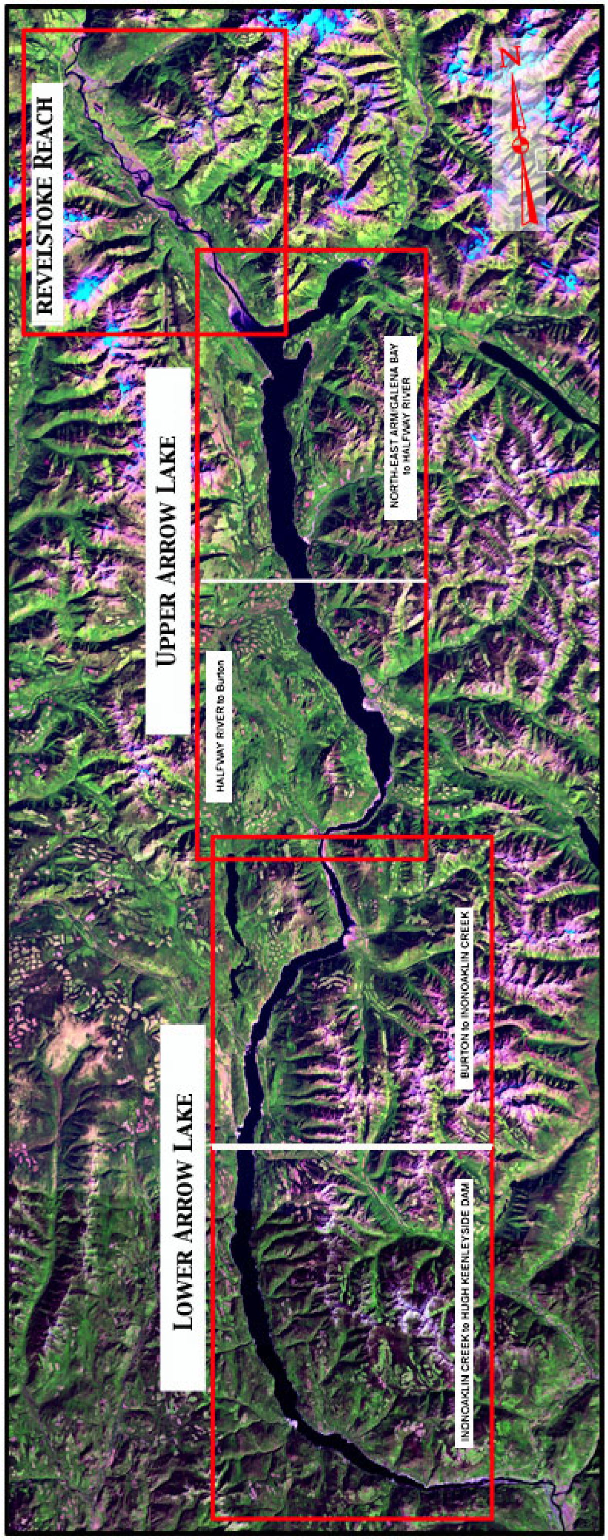


Figure 3: Layout of Satellite Sheets

4.0 RESULTS

The determination of existing vegetation and potential planting areas was based on:

- site characteristics interpreted from satellite imagery
- vegetation mapping for dust control areas of Revelstoke Reach (Moody 2002),
- elevation information from historical maps and the DEM for Revelstoke reach

The initial assessments of potential enhancement must be treated with caution, recognizing the limitations of the available information, particularly for those areas where assessments depended on historical elevation mapping, However, the mapping serves as a useful guide for future field verification of potential planting and vegetation enhancement sites.

A total of 143 locations were identified from the satellite imagery; 84 vegetated and 59 with a potential for vegetation development (Figures 4 -8, Tables 1 - 4). The vegetated sites, ranging in size from 1 to 418 ha, represented a total area of 2455 ha around the periphery of Arrow Lakes Reservoir (Table 1). The sites identified as having a potential for vegetation development covered a total area of 1637 ha with the majority occurring in Revelstoke Reach (885 ha) and the remainder divided between the Upper and Lower Arrow Lakes (400 and 360 ha respectively). The area supporting the greatest amount of vegetation at present is Revelstoke Reach (1948 ha) followed by Upper Arrow Lake, 346 ha (Table 1). Lower Arrow Lake supports the least existing (161 ha) or potential for vegetation (360 ha) due to its steep shorelines.

Table 1: Summary of Vegetated and Potential Vegetation Areas According to Location

Sheet	Vegetated Area (ha)	Potential Vegetation (ha)	TOTAL
Revelstoke Reach	1948	885	2833
Upper Arrow Lake	346	400	746
Lower Arrow Lake	161	360	521
Total	2455	1637	4100

Satellite images with identified existing and potential vegetation sites are presented in Figures 4-8. Descriptions of the sites, presented in tabular form accompany the imagery.

4.1 Revelstoke Reach

The mapping of Revelstoke Reach is presented slightly differently from the remainder of Arrow Lakes Reservoir, due to existing vegetation mapping for a large portion of the area (Moody 2002). The previous mapping was undertaken from large scale colour aerial photographs from 2000 and offers a level of detail that cannot be achieved from the satellite imagery. However, that mapping focused on the dust control areas within Revelstoke Reach in order to address vegetation change in response to treatments. As such, the mapping did not cover the pre-existing vegetated areas, primarily in the vicinity of Revelstoke airport and did not extend beyond the limits of the DEM. The classification of areas followed that of the dust control treatment areas, in alphabetical sequence from north to south.

The year 2000 mapping has been included with the interpretation of the vegetated areas for Revelstoke Reach and the dust control classifications have been maintained for this area. The satellite mapping provides complete area coverage for Revelstoke Reach, albeit at lesser detail than the previous mapping. Nevertheless, it allows an assessment of the total area of vegetation within the drawdown zone.

The northern half of Revelstoke Reach is the most densely vegetated. Historically there has been a trend for increasing vegetation cover in the drawdown zone, much of which has occurred in the dust control treatment areas. The present mapping, in conjunction with the 2000 mapping, estimated that naturally occurring vegetation extends over 1119 ha in Revelstoke Reach. Vegetation coverage in the dust control treatment areas has grown to a total of 829 ha with potential expansion over a further 885 ha. Extrapolations of the total vegetated area coverage can be used to determine vegetation contributions to the aquatic and terrestrial ecosystems. Summaries of vegetation productivity, carbon and nutrient cycling in Revelstoke Reach can be found in CARR and AIM 2002a.

Figure 5: Revelstoke Reach Map

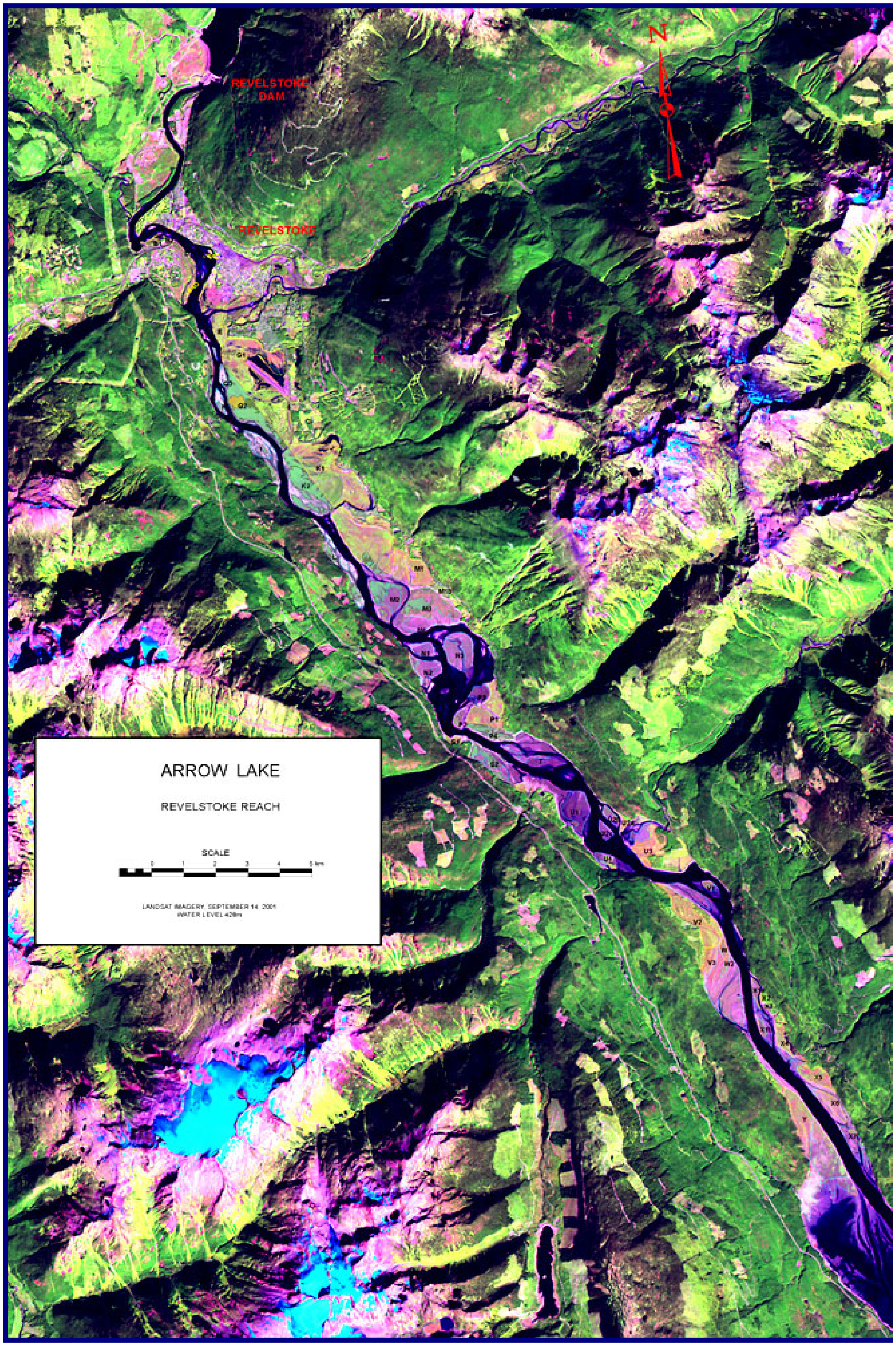


Table 2: Revelstoke Reach Sites

DUST CONTROL AREAS	ELEVATION RANGE (m)	VEGETATED TOTAL (ha)	POTENTIAL (ha)	DESCRIPTION	POTENTIAL FOR ENHANCEMENT
B		3.8		Available areas have been colonized by native vegetation	**n/a**
C		0		mostly above full pool	**n/a**
D		0		mostly above full pool	**n/a**
E	434-439	32.5		Available areas have been colonized by native vegetation	**n/a**
F	435-440	14.9		Available areas have been colonized by native vegetation	**n/a**
G	433-441	418.4	10	potential vegetation expansion on island (G3), high energy, clonal expansion progressing	**L**
H	435-437	4	8.5	potential vegetation expansion on island, high energy, clonal expansion progressing	**L**
I	433-438	14.1	26.2	potential vegetation expansion on islands, high energy, clonal expansion progressing	**L**
K	432-438	328.4		Most of available areas have been colonized by native vegetation, some channels, high energy low elev	**n/a**
L	433-440	20.1	15	potential vegetation expansion on islands, high energy, clonal expansion progressing	**L**
M	M1 436-440 M2 432-434	154.5	99	Natural colonization could be accelerated by fertilization & seeding, on M1,M2	**H**
M4	434-436			Coarse substrates and high energy on M4, established veg. eroding	**L**
M-north	436-440	246.7		Available areas have been colonized by native vegetation	**n/a**
N	N1 430-433 N3 430-434	3.8	130.3	N1, N3 probably too low, high energy	**H**
	N2 430-434			N2 - vegetation developing in patches, could be accelerated by fertilization & seeding	**H**
P	P2 430-431.5	136.1	30.1	low elev. Incipient growth in 2002.	**M**
S	430-436	38.5	22.2	partially/sparsely vegetated, could be accelerated by fertilization & seeding	**H**
T	T1 430-432.2 T2 430-431.6 T3 430-431.9	0	20.8	probably too high energy, low elev	**M**
U1	430-43	1	72.3	probably too high energy, low elev	**L**
U2a	430-439	6.2		Available areas have been colonized by native vegetation	**n/a**
U2b	430-431.4	0	14.6	some sign of veg development, could be accelerated by fertilization & seeding	**L**
U2c	429.5-430	0	15.5	some sign of veg development, probably high energy	**L**
U3	430-440	53.7	20.3	potential area adjacent to heavily grazed natural wetland - not recommended	**L**
U4	430-433	6.3	11.2	some sign of veg development, could be accelerated by fertilization & seeding	**M**

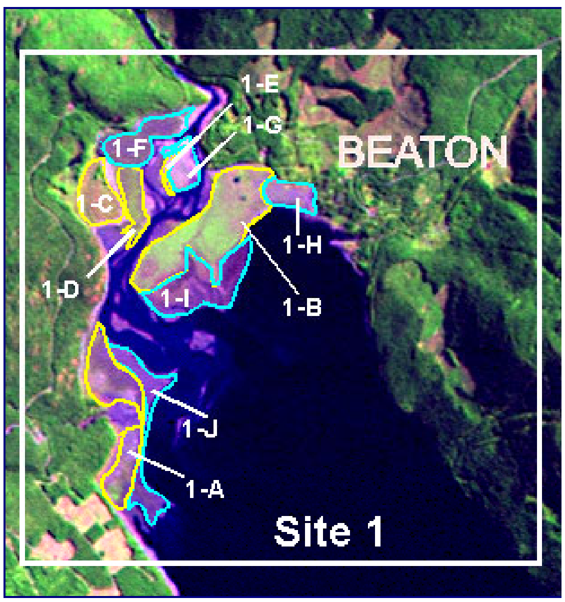
Table 2: continued

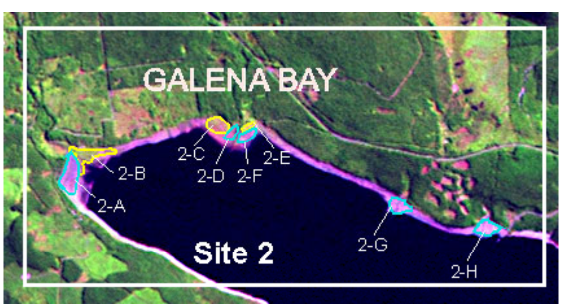
DUST CONTROL AREAS	ELEVATION RANGE (m)	VEGETATED TOTAL (ha)	POTENTIAL (ha)	DESCRIPTION	POTENTIAL FOR ENHANCEMENT
V1	430-430.5	5.8	3.6	some sign of veg development, could be accelerated by fertilization & seeding	**L**
V2	430-434	111	40.3	large natural high elev wetland bench, potential area is low elevation adjacent, probably high energy	**L-M**
V3	434-436	21.7		somewhat sparse natural wetland, could be enhanced with fertilization	**M**
W1	430-434	8.8	167	developing vegetation at edge of broad sheltered bay	**M-H**
W2	430-435	6.8		developing vegetation at edge of broad sheltered bay	**M-H**
X1A	430-433	9.7	24.9	developing sparse wetland, lower elev. area between two vegetated portions	**L**
X1B	430-431	7		low elev. area	**L**
X2	430-440	1		well developed bench wetland	**n/a**
X3	430-431	1		well developed bench wetland	**n/a**
X4	430-437	20	7.7	well developed bench wetland, some areas need infilling	**M**
X5	430-440	43.5	9.9	well developed bench wetland, low elev point has low potential	**L**
X6	430-435	35.4	6	sparse marsh, could be enhanced by fertilizer and seeding	**M-H**
X7	430-431.5	1.8	36.5	low elevation bench	**L**
Y	431-433	191.7	93.5	broad area showing good incipient growth, could be enhanced by fertilization & seeding	**M-H**
TOTAL		1948.2	885.4		

4.2 Upper Arrow Lake

Existing vegetation distribution in Arrow Lake is concentrated in a few specific sites were shorelines have a gradual slope and relatively fine substrates. The additional benefit of moisture input to sustain wetland vegetation during the drawdown phase is an added bonus. These criteria usually confine wetland development along the steep shorelines to bays and deltas. In Upper Arrow Lake, the main areas for wetland development are in the north-east arm near Beaton and at the narrows between Upper and Lower Arrow Lakes. Other sites are relatively small and insignificant by comparison.

As the identified existing and potential vegetation sites in the Arrow Lake outside of Revelstoke Reach occurred in clusters, they have been treated as such on the maps and in the text. Each site is identified numerically with specific locations defined alphabetically.





Galena Bay shoreline February 2003

Figure 6: Upper Arrow Lake Map – northern portion

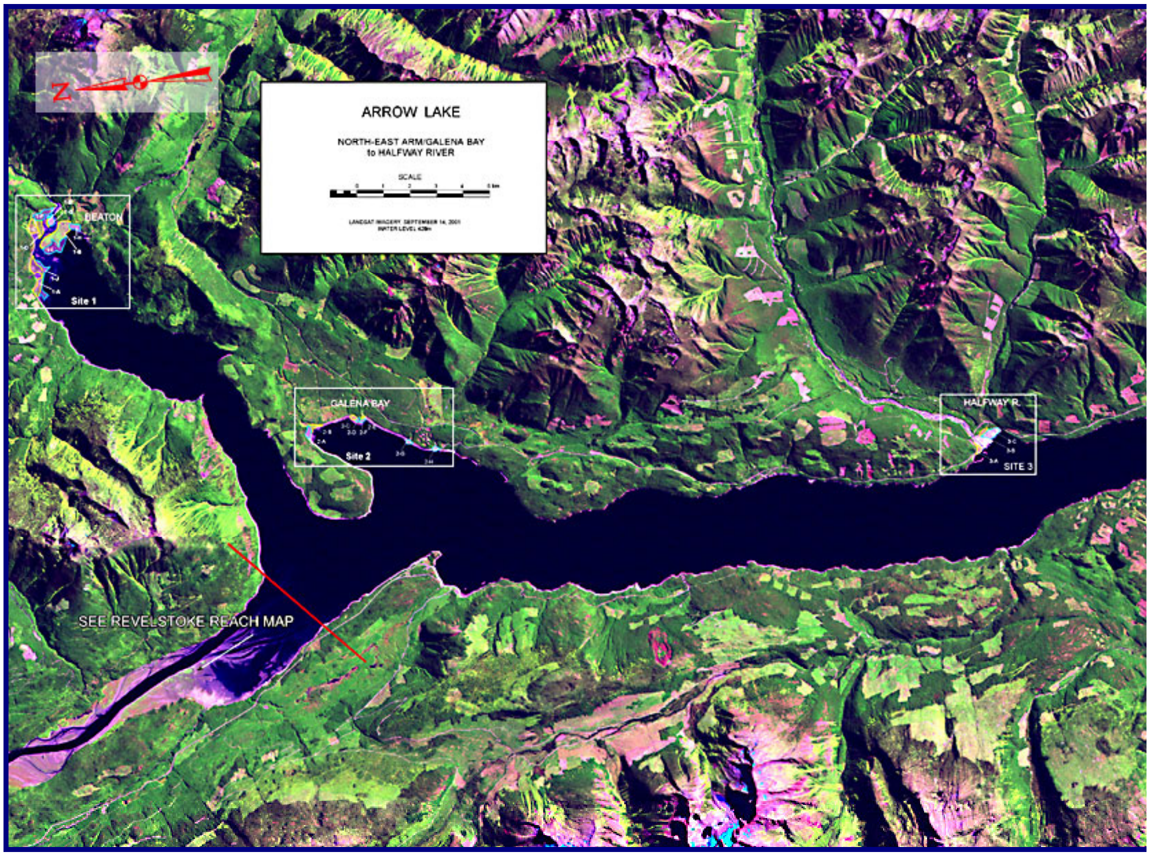


Figure 7: Upper Arrow Lake Map - southern portion

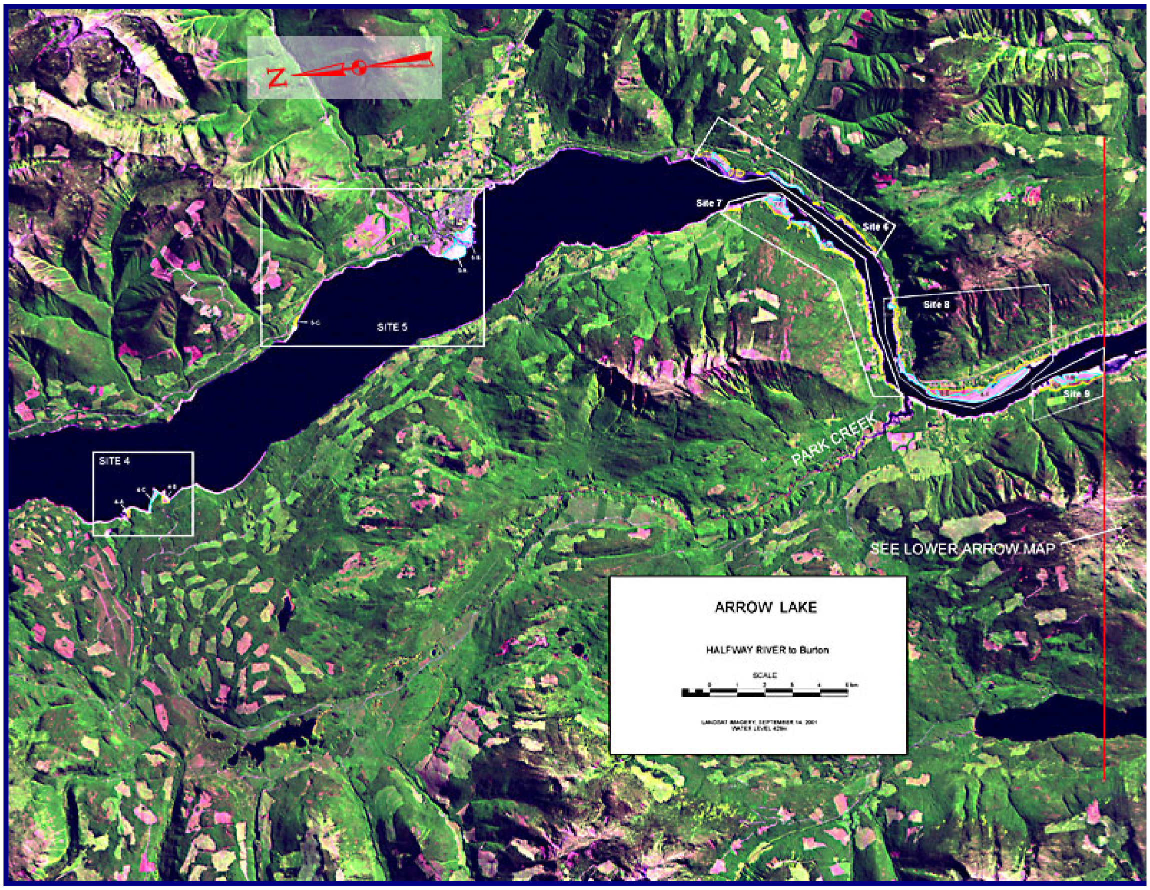


Table 3: Upper Arrow Lake Sites

Site	Location	Vegetated (ha)	Potential (ha)	Description	Potential for Enhancement
1	**A**	29.8		very sparsely vegetated area, delta mouth, well veg. in 2003	**M-H**
1	**B**	46.9		well vegetated delta area, potential for fertilizer enhancement, well veg. in 2003	**M-H**
1	**C**	12.1		high elevation bench, well vegetated, some shrub development, enhancement probably unnecessary	**n/a**
1	**D**	9.5		well vegetated delta area, potential for fertilizer enhancement well veg. in 2003	**M-H**
1	**E**	1.9		river bar growth on former levee, high energy area, sparse vegetation in 2003	**M**
1	**F**		15.6	unvegetated, post-impoundment deposits in old river channel, may be high energy, sediments need to be examined, sparse vegetation in 2003	**M**
1	**G**		7.6	adjacent to E, probably too high energy, low elev, patchy veg. 2003	**M**
1	**H**		8.6	sheltered bay, patchy veg. 2003	**M-H**
1	**I**		24.6	low elev adjacent to B, patchy veg. 2003	**M-H**
1	**J**		18.2	low elev adjacent to A, patchy veg. 2003	**M**
2	**A**		6.9	upper elevation substrates at stream mouth, adjacent to existing vegetation patchy veg. 2003; public sensitivity	**M**
2	**B**	5.3		upper elevation substrates at stream mouth, adjacent to 2-A; public sensitivity	**L**
2	**C**	3.6		higher elevation vegetated zone; public sensitivity	**L**
2	**D**		1.5	lower elevation unvegetated zone, coarse materials; public sensitivity	**L-M**
2	**E**	1		higher elevation vegetated zone; public sensitivity public sensitivity	**n/a**
2	**F**		1.9	lower elevation unvegetated zone, coarse materials; public sensitivity	**L-M**
2	**G**		3.1	stream mouth, coarse materials	**L**
2	**H**		3.4	stream mouth, coarse materials	**L**
3	**A**			Halfway River, upper elev fan, covered by log dump	**n/a**
3	**B**	3.7		Halfway River, upper elev fan	**n/a**
3	**C**		15.7	lower elevation fan, moderately coarse materials	**L**
4	**A**	2.6		vegetated creek mouth, west side reservoir	**n/a**
4	**B**	3.4		vegetated creek mouth, west side reservoir	**n/a**
4	**C**		7.3	unvegetated slope between 4A&B, probably too steep	**L**
5	**A**		31.6	Nakusp delta, probably too coarse; public sensitivity	**M**
5	**B**		22.6	Nakusp delta, probably too coarse; public sensitivity	**M**
5	**C**	2.1		small vegetated delta, north of Nakusp; public sensitivity	**n/a**
6	**A**	7.4		sparse vegetation, potential for fertilization	**M-H**
6	**B**	3.6		high elevation bench above B, well vegetated	**n/a**
6	**C**		15.7	vegetation on either side, may be high energy, good candidate for planting	**M**
6	**D**	3.9		sparse vegetation, potential for fertilization; public sensitivity	**M**
6	**E**	5.5		sparse vegetation, potential for fertilization; public sensitivity	**M**
6	**F**	1.4		high elevation bench, well vegetated; public sensitivity	**n/a**
6	**G**		13.7	shelf area, possibly too steep; public sensitivity McDonald Beach	**M**

Table 3 cont.

Site	Location	Vegetated (ha)	Potential (ha)	Description	Potential for Enhancement
6	**H**	1.1		high elevation pocket	**n/a**
6	**I**	12.2		narrow, upper elevation shelf	**n/a**
7	**A**	2		narrow, upper elevation bench, well vegetated	**n/a**
7	**B**	15.3		upper elevation vegetation, potential for fertilization	**M**
7	**C**		24	low elevation substrates below B, potential for fall rye planting, recommend sedge seeding on leeward side	**H**
7	**D**	7.2		upper elevation vegetation, potential for fertilization	**M**
7	**E**		17.5	low elevation, below D; recommend sedge seeding	**M-H**
7	**F**	9.5		upper elevation vegetation, potential for fertilization	**M**
7	**G**		5.2	low elevation, below F, recommend sedge seeding	**M**
7	**H**	9.7		narrow, upper elevation shelf	**n/a**
7	**I**	7.8		narrow, upper elevation shelf	**n/a**
7	**J**	2.5		narrow, upper elevation shelf	**n/a**
7	**K**	4.2		narrow, upper elevation shelf	**n/a**
7	**L**	1.4		narrow, upper elevation shelf	**n/a**
8	**A**		2.9	unveg point, adjacent to bench 8B, potential for sedge planting; public sensitivity	**M**
8	**B**	23.8		200 m wide bench with patchy veg, well vegetated 2003; public sensitivity	**M**
8	**C**	2.1		well vegetated upper elevation; public sensitivity	**n/a**
8	**D**		19.6	narrow, possibly steep bench; vegetated 2003; public sensitivity	**L-M**
8	**E**	38.1		well veg upper elev bench, could be fertilized if 8F undertaken; public sensitivity	**M-H**
8	**F**		101.2	current swept beach, may have incipient vegetation, selective planting; hard substrates, lots of annuals, patchy sedge and RCG; public sensitivity	**H**
8	**G**	26.7		well veg upper elev bench, potential fertilizer; public sensitivity	**M**
9	**A**	34.7		well veg upper elev bench, potential fertilizer	**M**
9	**B**		31.8	partly protected bench adjacent to 9A	**M-H**
Total Area		**345.9**	**400.2**		

4.3 Lower Arrow Lake

Vegetated areas within Lower Arrow Lake are very limited due to steep shorelines and coarse substrates in most locations. Potential enhancement areas include large fans such as those at Burton and Renata. Smaller pockets of vegetation and potential enhancement areas occur in the general vicinity of Fauquier. Due to a lack of current elevation information and site specific knowledge, it is recommended that site visits be conducted to the potential areas identified to determine their suitability for vegetation development.

Figure 8: Lower Arrow Lake Map – northern portion

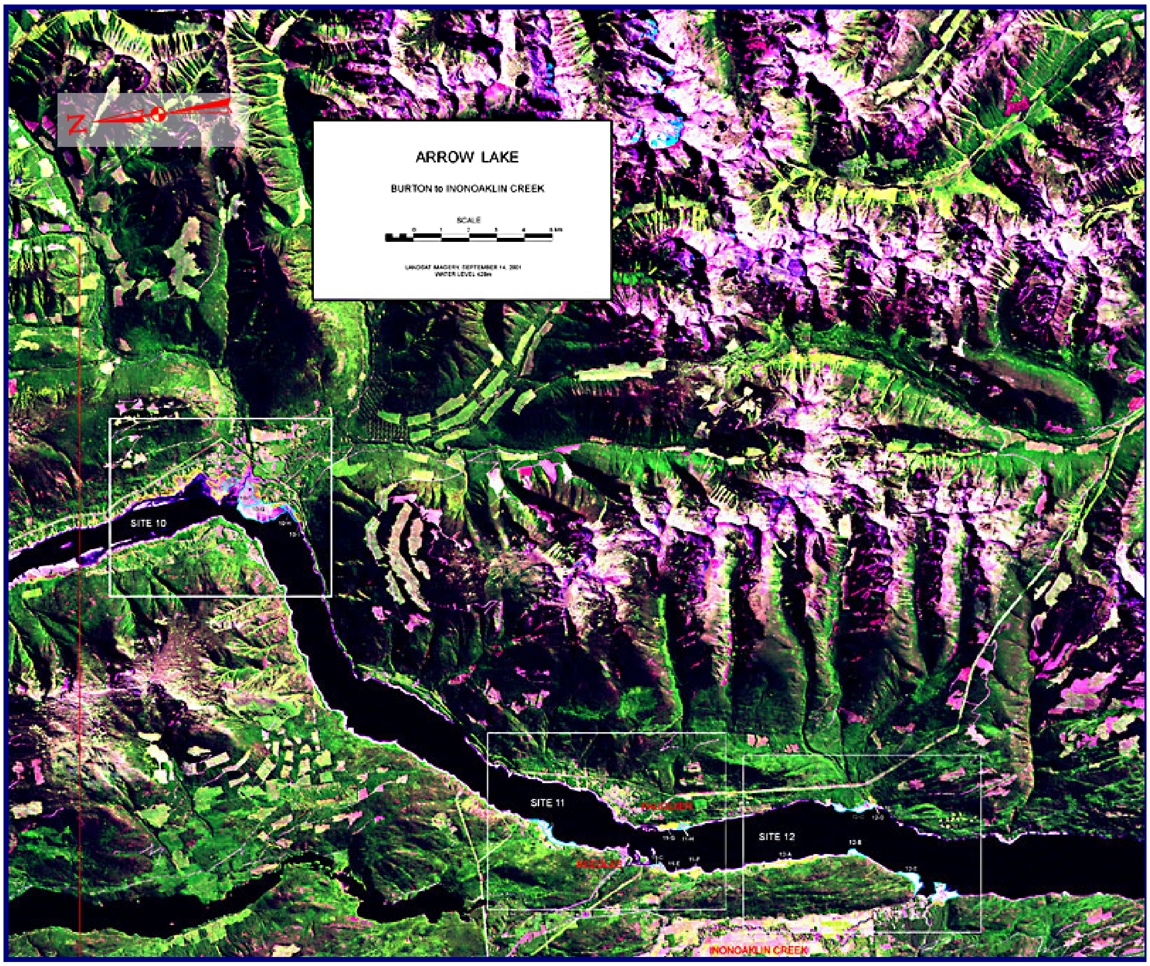


Figure 9: Lower Arrow Lake Map – southern portion

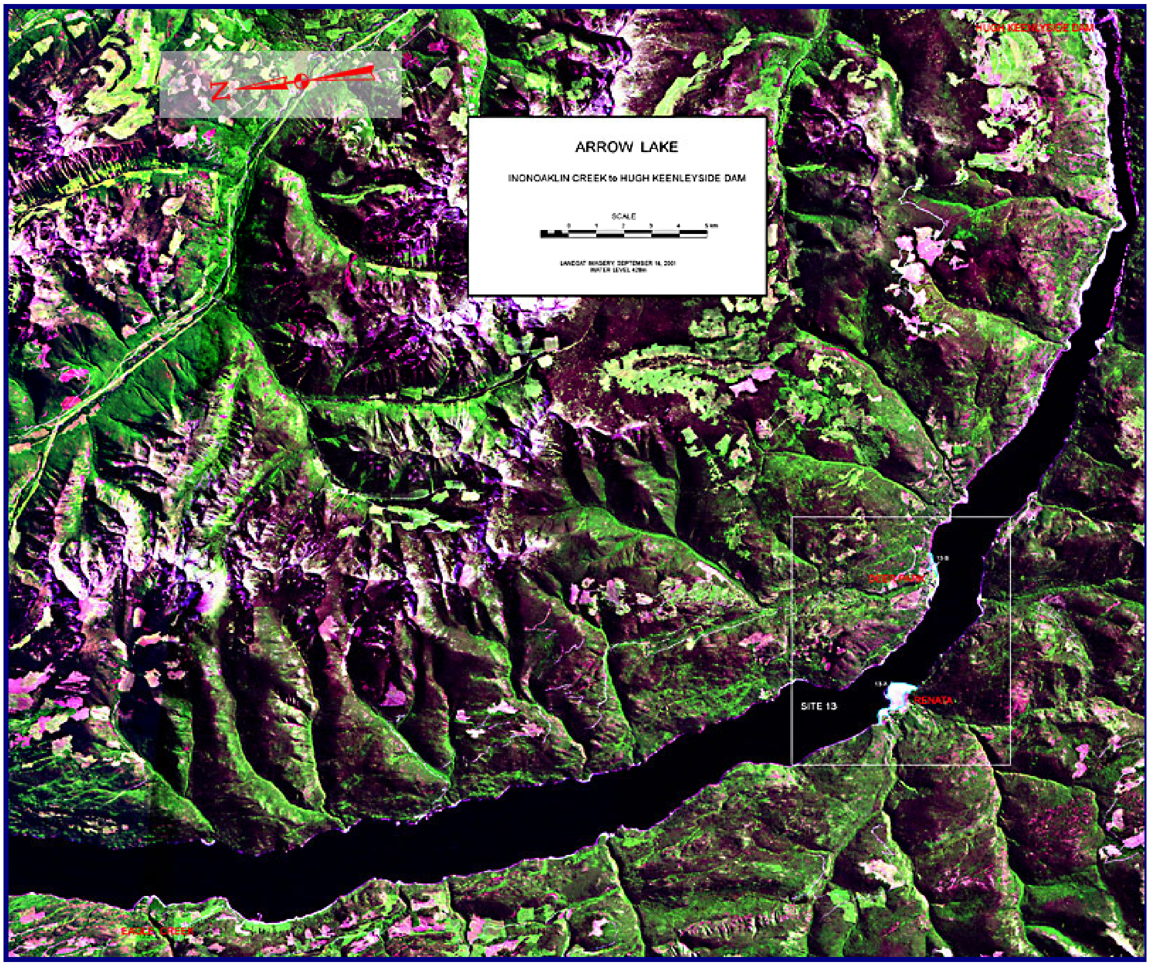


Table 4: Lower Arrow Lake Sites

Site	Location	Vegetated (ha)	Potential (ha)	Description	Potential for Enhancement
10	**A**	12.9		narrow upper bench	**n/a**
10	**B**	24.8		broad area in bay, may benefit from fertilizer	**M**
10	**C**	35.0		broad area in bay, may benefit from fertilizer; veg. 2003	**H**
10	**D**	10.6		well vegetated upper marsh	**n/a**
10	**F**		37.1	lower unvegetated slope below D, may be relatively coarse, adjacent to stream, should have sufficient moisture; boulders & pits, may need physical work	**L-M**
10	**E**		12.4	lower unvegetated slope below C, may be relatively coarse, adjacent to stream, should have sufficient moisture; as above	**L-M**
10	**G**		80.5	lower slope below F, some veg. patches, substrate may be relatively coarse, vegetated 2003	**H**
10	**H**	3.8		well vegetated upper marsh	**n/a**
10	**I**	4.3		well vegetated upper marsh	**n/a**
10	**J**		9.4	similar to G but narrow strip in bay	**L**
11	**A**		29.2	low elevation, coarse, steep; bare lower point, high energy, moderate substrates; seed & fertilize	**M**
11	**B**	13.4		sparse upper marsh, may benefit from fertilizer	**L-M**
11	**G**	9.3		well vegetated upper marsh; patchy growth lower elev.	**n/a**
11	**F**	7.8		well vegetated upper marsh	**n/a**
11	**D**	5.6		well vegetated upper marsh	**n/a**
11	**C**		8.3	lower slope below D, may be steep, coarse; high energy	**L**
11	**E**	3.8		well vegetated upper marsh	**n/a**
11	**H**		7.0	next to G, may have some patchy veg.	**M-H**
12	**A**	22.5		well vegetated upper bench	**n/a**
12	**C**		25.3	fan area, partially in bay below D	**M**
12	**D**	3.6		well vegetated, sheltered pocket above C	**n/a**
12	**B**		8.3	coarse steep point	**L**
12	**E**		23.6	coarse delta area, variable substrates, moisture input from stream	**M**
12	**F**		36.0	coarse delta area, variable substrates, moisture input from stream	**M**
12	**G**	3.7		well vegetated upper marsh	**n/a**
13	**A**		72.5	large fan, coarse	**L**
13	**B**		10.2	small fan, steep	**L**
Total Area		161.1	359.8		

5.0 ENHANCEMENT OPPORTUNITIES

Enhancement opportunities for reservoir wetlands occur in three major categories:

1. Water Level Modifications

Water level modifications are generally ruled out due to costs or corporate obligations. However, the WUP process has presented opportunities to consider the effects of operational changes on vegetated habitats. Vegetation communities that have evolved in the reservoir appear to have responded to long-term water level averages during the growing season. Any changes to the water levels during the growing season (approximately April 1- October 31) will influence the vegetation community. A lowering of the long-term median water level will allow the vegetation community to expand, whereas an increase in elevation will likely cause the vegetation to diminish in area and productivity over time.

Based on initial information, there appeared to be minimal opportunity for vegetation enhancement in Arrow Lakes Reservoir by water level manipulations. However, a fortuitous set of relatively low water years has allowed a retrospective of vegetation response to hydrologic change. This will be addressed further in the discussion section. In addition, the examination of the Arrow Lakes Reservoir shoreline using satellite imagery and historical maps revealed high and moderate potential enhancement opportunities for approximately 2191 ha of shoreline. This is comprised of 1007 ha of vegetated habitats (as of 2001), which could be enhanced by fertilization, infill seeding and/or planting. A total of 1184 ha of unvegetated shoreline (as of 2001) presented seeding and planting opportunities. These totals do not include low or low to moderate potential sites; thus, these area estimates are less than those presented in Table 1.

2. Vegetation Establishment by Seeding or Planting

Vegetation seeding and planting allows the establishment of vegetation in those areas where natural establishment is difficult or impossible. This may be the case in certain creek fans or in other substrates where moisture conditions are too severe for seedlings to establish. Planting of vegetation is a labour-intensive, costly process. However, it has the potential for great success in well-chosen locations and when water levels are not drastically changed. It is also particularly useful for sites where erosion may be a concern. Any planting program must take into consideration the potential of disturbance to sensitive environments or archaeological sites. Mechanical seeding must be planned to avoid these areas. In such cases, manual planting would be the most appropriate option.

The studies at Revelstoke have indicated the potential to expand vegetation approximately 2m deeper into the reservoir drawdown zone than natural establishment has allowed to date. Site-specific assessments are required for determination of site suitability.

3. Enhancement of Existing Vegetation Growth by Fertilization.

The highest potential is attributed to enhancement of existing vegetated sites by fertilizer applications to increase biomass and vigour of the vegetation. This represents the lowest enhancement cost per area with potentially the greatest habitat gains. Fertilization offers an opportunity to enhance existing or incipient vegetation communities and to boost chances for survival. Fertilization studies at Revelstoke Reach indicated an average 20% increase in size of plants in one year as a result of fertilizer applied to the substrate. Similar results have been obtained for foliar applications of fertilizer in both Stave and Williston reservoirs. Arrow Lakes Reservoir appears to offer numerous locations where vegetation is currently established or establishing and where fertilizer applications could benefit the continued development of the vegetation communities.

5.1 Proposed Enhancement Approach for Arrow Lakes Reservoir

The general approach for reservoir revegetation has been to recommend a multi-year revegetation program, with the first year in planning and acquisition of plant material (willow and native wetland plants) followed by implementation of various planting programs (treatments) and a subsequent monitoring program. It must be recognized that the development of a ‘permanent’ riparian/wetland cover in reservoirs is not a single year operation, but one of intervention (planting) over several years that facilitates the long-term vegetation cover. Revelstoke Reach has benefited from over a decade of vegetation programs, primarily focused on dust control. It was only in retrospect that the multiple benefits of the fall rye seeding program came into focus. Detailed knowledge of the plant responses to environmental variables within Revelstoke Reach allows recommendations to be made for enhancement of vegetation in specific sites. These recommendations can be extrapolated to the remainder of Arrow Lakes Reservoir, with considerably greater confidence than for other reservoirs due to the relevancy of the knowledge base.

There are five basic treatments applicable for this area, each with a specific objective, timeframe, and cost. The treatments are as follows:

- T1 – Fall rye seeding to promote surface substrate stabilization, provide organic matter for improvement of soil fertility, and promote native species colonization via ‘accidental’ incorporation of seed trapped in fall rye stubble. This approach was highly successful in Upper Arrow Reservoir.

- T2 – Direct seeding of lenticulate sedge (*Carex lenticularis*) in conjunction with fall rye drill seeding application. Direct seeding of lenticulate sedge at Revelstoke Reach and Williston Reservoirs has been highly successful in small-scale trials and is viewed as having significant potential for more widespread use.

- T3 – Willow planting using either hardwood cuttings and/or container stock. Willow has been successfully established at Revelstoke Reach, Upper Campbell and Carpenter Reservoirs in higher elevation areas.

- T4 – Wetland planting using container grown native species from locally collected seed. This technique has been successful in promoting native wetland development in numerous BCH reservoirs.
- T5 – Aerial foliar fertilization of existing vegetation areas to promote a more vigorous plant community in this nutritionally stressed environment. This approach was successful in Williston and Stave Reservoirs.

5.2 Treatment Options and Costing Assumptions

T1 - Fall Rye Seeding

Fall rye seeding (at 100 kg/ha plus 10 kg/ha of a permanent grass mix) for micro site modification (control of wind erosion and enhancement of soil characteristics) is seen as the initial step in the program, and will be conducted for at least four years. Due to soil characteristics observed in Arrow on previous visits, it is assumed that we can only operationally seed 50% of available area. In addition, given the dispersed nature of the areas to be seeded, whether by seed drill or ATV and harrowing, barging of equipment will be a major factor in final costs. However, due to issues of scale, this cost is very difficult to estimate.

Given the above factors, an initial estimate of costs is derived as follows:

- Basic seeding –100 kg/ha fall rye seed plus 10 kg/ha of a permanent grass seed mix (inundation tolerant agronomic species), 100 kg/ha fertilizer with seed drill application – estimated average basic cost of $150/ha.
- Though barging or mobilization to sites could increase costs by 100% for smaller areas (<25 ha), we will use a 50% average mobilization factor, thus $75/ha.
- Average estimated seeding cost is $225/ha/yr for four years, or $900/ha for program.
- Remember that it is assumed that this treatment is applicable to only half of the identified treatment site due to operational limitations.

T2 – Lenticulate Sedge Seeding (with Fall Rye as carrier)

Direct lenticulate sedge seeding with fall rye seeding (at 100 kg/ha plus 10 kg/ha of a permanent grass mix) as a carrier for drill seeding application. This is a one-time application to get the sedge seed into the soil substrate where it will stay until suitable conditions occur for germination and growth. This may take several years, but the seed will remain viable for many years. The fall rye application is needed to facilitate the drilling operation.

Given the above, and initial estimate of treatment cost is derived as follows:

- Lenticulate sedge seed cost (custom collection as none is available commercially) is projected at $500/ha (10 kg/ha application rate).
- Fall rye seeding cost as normal for one year, i.e. $150/ha.

- Remember that it is assumed that this treatment is applicable to only half of the identified treatment site due to operational limitations.

T3 - Willow Planting

Willow planting will be applied only in the upper 3 meters (possibly 4 or more if analysis of the water levels deems appropriate). Native willow is to be collected each year for planting the following year. This planting will be a progressive program with:

Year One - cutting collection and propagation

Year Two through Four - planting of previous year's material and more collection (for next year)

Year Five - planting only of material from previous year.

For costing purposes, the following assumptions are used:

- Only 20% of the treatment area will be affected by the willow planting (but high density planting in that portion, with linear bands spaced 3m apart and cuttings spaced 2m apart in the bands)
- With the estimated average cost of this type of planting at $5000/ha plus 25% for fill planting in second year, the cost is $7500/ha for planting.
- A reasonable mobilization cost is included in the $5000, and could be higher if areas are very remote.
- This treatment will be applied to only 20% of the identified treatment site.

T4 - Sedges and Wetland Plants

For sedges and wetland planting, the type of planting and total percentage of affected areas will drive the costing. In small areas, employing high-density plantings on a portion of the total area (the inoculation approach) will result in a smaller cost on a treatment area basis compared to an expansive planting approach.

For costing purposes, the following assumptions are used:

- The basic cost is $15,000/ha using 1m spacing of custom container stock.
- To achieve an inoculation level of establishment that will provide a material base for expansion throughout the treatment area, only 20% of total treatment site will be planted.

T5 - Aerial Fertilization of existing plant communities

On those areas of existing wetlands that we want to promote, aerial fertilization using the AgAir Enhanced Foliar Fertilizer is the best approach. Conducted early in the growing season, this approach has been shown to improve performance of reservoir remnant wetlands significantly (over 40% in height and 25% in biomass). Increases in plant size and biomass improve plant survival under stressful conditions and increase nutrient contributions to the adjacent ecosystems.

As with all field operations, the issue of scale is important. However, for this costing exercise the following assumptions are used:

- The operation is $50/ha per treatment, with a 10 ha minimum per site.
- Fertilizer will be applied for three years to effectively change site production, yielding a treatment cost of $150/ha.

Due to the limited information we have had available upon which to base the area cost estimates, these initial assumptions and area costs will likely change as site specific information becomes available.

5.3 Site Specific Descriptions

The evaluation of enhancement potential was based primarily on satellite imagery; further analysis was recommended to confirm the substrate, slope and elevations of the sites. A brief overview field visit was conducted May 24-25, 2003; photos taken at that time are included in Appendices 2 and 3. Further information was gained in 2004 when the DEM was completed for lower Revelstoke Reach and from photography obtained during a helicopter flight (September 2004), which Parks Canada generously allowed us to use (Appendix 1). Amendments made to the initial assessments of enhancement potential reflect all of the additional information gathered for the sites to date. Additional information that can be anticipated, such as elevation data for Upper and Lower Arrow Lakes and more detailed site inspections (particularly for those sites not accessible by road) may result in reclassification of some sites.

Sites identified as having a high probability for enhancement success, reflect a high degree of confidence in the interpretations and in the suitability of the available techniques for enhancement. Three sites were identified as having a high probability in Revelstoke Reach (Table 5). These represent 197 ha of currently vegetated areas and 252 hectares of predominantly unvegetated or sparsely vegetated substrates. Seven high priority sites were identified for Upper Arrow Lake (86.2 ha of vegetated; 160.4 ha of partially vegetated or unvegetated). One potential vegetation site (80.5 ha) was identified as high priority in Lower Arrow Lake.

Many of these sites have a history of drill seeding and some are showing signs of the initial stages of vegetation development. We have recommended further drill-seeding at some sites, but with the inclusion of a perennial sedge in the seed mix. Lenticulate sedge is a commonly occurring species throughout reservoirs in BC and has proven to be the most inundation tolerant of the species tested at Revelstoke Reach. It is capable of maintaining viability in the substrate until appropriate conditions for germination occur. Once established at a site, it produces large quantities of seed, which adds to the seed bank and allows further natural vegetation of the site. Substantial colonization of these sites may occur without intervention, but the progress of vegetation expansion can be expected to be much slower than with planting.

An additional 20 sites have been identified as having a moderate to high probability of enhancement with 6 in Revelstoke Reach, 4 in Upper Arrow Lake and 10 at Lower Arrow Lake. Overall, these represent 348ha of currently vegetated areas and 430 hectares of primarily unvegetated sites. A further 29 sites have been identified as having a moderate probability of enhancement success, with 4 in Revelstoke Reach, 23 in Upper Arrow Lake and 2 at Lower Arrow Lake. These represent 377ha of currently vegetated areas and 262 hectares of primarily unvegetated sites. Details regarding the High, Moderate to High and Moderate probability sites are presented in Table 8. Further consideration of low to moderate and low potential sites is not being pursued at this stage.

The proposed planting and enhancement options will be strongly influenced by the operating regime in effect after the treatments. Since the first iteration of determining potential vegetation planting areas, we now know that much of the proposed elevation range identified as potential planting area has become partially vegetated since the extended drawdown in 2001. This necessitated a re-consideration of the proposed planting prescriptions and areas.

Three basic prescriptions were recommended for the high (>434m) and low (<434m) elevation sites. For sites where elevation is unknown, the "potential" sites are assumed to be below 434m. Existing High Elevation Vegetation sites are likely to remain intact regardless of hydrologic change. Fertilization of these areas is recommended to enhance survival and production. Low elevation (434m- 430m) vegetation viability is questionable. Ultimately, viable areas will be able to benefit from infill seeding and fertilization. The elevation range of such areas cannot be predicted at this time. Neither can area calculations by elevation band be provided due to the incomplete DEM.

Shrub and wetland planting has been identified for the currently vegetated elevation range (434m+) for riparian habitat, erosion control and heritage resource protection. An area figure of 5% of the vegetated area has been used to calculate these costs.

Although the total area figures have been used to calculate the costs, these must be considered as estimates only. Vegetation responses to water levels post 2001 will determine the amount of vegetated area available for enhancement. Site specific information will be required to determine actual areas that will benefit from shrub and wetland planting.

Table 5: Wetland Enhancement Opportunities and Estimated Costs

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE [i]	ENHANCE LOW ELEVATION PLANT VIGOUR [ii]	SHRUB & WETLAND PLANTING [iii]	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	M		154.5	99	Natural colonization could be accelerated by fertilization & seeding, on M1, M2	$23,175	$47,025	$34,763	$104,963	H	Part of potential vegetation area has become vegetated	
RR	N		3.8	130.3	Low elev. could be accelerated by fertilization & seeding	$570		$855	$1,425	H	Much of the potential area is sparsely vegetated	low elevation in most areas (430-432m)
RR	S		38.5	22.2	partially/sparsely vegetated, could be accelerated by fertilization & seeding	$5,775	$10,545	$8,663	$24,983	H	much of the potential area is vegetated	public sensitivity; resort
UA	1	A	29.8		very sparsely vegetated area, delta mouth	$4,470		$6,705	$11,175	H	well vegetated	
UA	1	B	46.9		well vegetated delta area, potential for fertilizer enhancement	$7,035		$10,553	$17,588	H	well vegetated	
UA	1	D	9.5		well vegetated delta area, potential for fertilizer enhancement	$1,425		$2,138	$3,563	H	well vegetated	
UA	1	F		15.6	unvegetated, post-impoundment deposits in old river channel, may be high energy, sediments need to be examined		$7,410		$7,410	H	part of potential vegetation area has become vegetated	
UA	7	C		24	low elevation substrates below B, potential for seeding		$11,400		$11,400	H	has been fall rye seeded, suggest lenticulate seeding, coarse sand, high potential on leeward side	public sensitivity
UA	8	D		19.6	narrow, possibly steep bench		$9,310		$9,310	H	appears well vegetated, potential for fertilizer	public sensitivity
UA	8	F		101.2	current swept beach, may have incipient vegetation, combination seeding, selective planting		$48,070		$48,070	H	hard substrates, lots of annuals, patchy sedge and RCG - excellent potential	public sensitivity
LA	10	G		80.5	lower slope below F, some veg. patches, substrate may be relatively coarse, low elevation?		$38,238		$38,238	H	establishing vegetation, has great potential for expansion	public sensitivity
						$42,450	***$171,998***	***$63,675***	***$278,123***	***H Total***		

i -fertilize existing high elevation vegetation (treatment 5)
ii-enhance low elevation plant vigour - fertilization & manual seeding in specific sites (treatment 2,5)
[iii]-shrub & wetland planting for erosion control assuming treatment of 5% of existing high elevation wetland area (treatment 3,4)

Table 5: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE [i]	ENHANCE LOW ELEVATION PLANT VIGOUR [ii]	SHRUB & WETLAND PLANTING [iii]	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	T		0	20.8	low elev. could be accelerated by fertilization & seeding		$9,880		$9,880	M-H	much of the potential area is sparsely vegetated	low elevation (430-431.9m)
RR	U2a		6.2		Available areas have been colonized by native vegetation	$930		$1,395	$2,325	M-H	much of the potential area is vegetated	
RR	W1		8.8	167	developing vegetation at edge of broad sheltered bay	$1,320	$79,325	$1,980	$82,625	M-H	part of potential vegetation area has become vegetated	
RR	W2		6.8		developing vegetation at edge of broad sheltered bay	$1,020		$1,530	$2,550	M-H	part of potential vegetation area has become vegetated	
RR	X6		35.4	6	sparse marsh, could be enhanced by fertilizer and seeding	$5,310	$2,850	$7,965	$16,125	M-H	sparse vegetation, could be enhanced	goose use
RR	Y		191.7	93.5	broad area showing good incipient growth, could be enhanced by fertilization & seeding	$28,755	$44,413	$43,133	$116,300	M-H	part of potential vegetation area has become vegetated	
UA	1	H		8.6	sheltered bay, may have some sparse veg		$4,085		$4,085	M-H	part of potential vegetation area has become vegetated	
UA	1	I		24.6	low elev adjacent to B, may have some veg		$11,685		$11,685	M-H	part of potential vegetation area has become vegetated	
UA	6	A	7.4		sparse vegetation, potential for fertilization	$1,110		$1,665	$2,775	M-H	fertilize	
UA	7	E		17.5	low elevation, below D potential for seeding		$8,313		$8,313	M-H	has been fall rye seeded, suggest lenticulate seeding and fertilizer	
LA	10	A	12.9		narrow upper bench	$1,935		$2,903	$4,838	M-H		public sensitivity
LA	10	B	24.8		broad area in bay, may benefit from fertilizer	$3,720		$5,580	$9,300	M-H	has been drill seeded	public sensitivity
LA	10	C	35		broad area in bay, may benefit from fertilizer	$5,250		$7,875	$13,125	M-H	high marsh, abundant RCG, & sedge	public sensitivity
LA	10	D	10.6		well vegetated upper marsh	$1,590		$2,385	$3,975	M-H		public sensitivity
LA	10	H	3.8		well vegetated upper marsh	$570		$855	$1,425	M-H		public sensitivity
LA	10	I	4.3		well vegetated upper marsh	$645		$968	$1,613	M-H		public sensitivity
LA	11	H		7	next to G, may have some patchy veg.		$3,325		$3,325	M-H	patchy vegetation	public sensitivity
LA	12	C		25.3	fan area, partially in bay below D		$12,018		$12,018	M-H	viewed from across reservoir	public sensitivity
LA	12	E		23.6	coarse delta area		$11,210		$11,210	M-H	variable substrates	public sensitivity
LA	12	F		36	coarse delta area		$17,100		$17,100	M-H	variable substrates, moisture input from stream	public sensitivity
						$52,155	***$204,203***	***$78,233***	***$334,590***	***M-H Total***		

Table 5: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE	ENHANCE LOW ELEVATION PLANT VIGOUR	SHRUB & WETLAND PLANTING	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	P		136.1	30.1	low elev. Incipient growth in 2002.	$20,415	$14,298	$30,623	$65,335	M	much of the area is well vegetated, potential area is low elevation	low elevation (430-431.5m) portion has Low Potential
RR	U4		6.3	11.2	some sign of veg development, could be accelerated	$945	$5,320	$1,418	$7,683	M	part of potential vegetation area has become vegetated	
RR	V3		21.7		somewhat sparse natural wetland, could be enhanced with fertilization	$3,255		$4,883	$8,138	M	somewhat sparse natural wetland, could be enhanced with fertilization	
RR	X4		20	7.7	well developed bench wetland, some areas need infilling	$3,000	$3,658	$4,500	$11,158	M	part of potential vegetation area has become vegetated	
UA	2	A		6.9	upper elevation substrates at stream mouth, adjacent to existing vegetation		$3,278		$3,278	M	patchy vegetation	public sensitivity
UA	5	A		31.6	Nakusp delta, probably too coarse		$15,010		$15,010	M	patchy vegetation, selective planting possible	public sensitivity
UA	5	B		22.6	Nakusp delta, probably too coarse		$10,735		$10,735	M	patchy vegetation, could be enhanced	public sensitivity
UA	5	C	2.1		small vegetated delta, north of Nakusp	$315		$473	$788	M	patchy vegetation	public sensitivity
UA	6	C		15.7	vegetation on either side, substrates may be coarse		$7,458		$7,458	M		
UA	6	D	3.9		sparse vegetation, potential for fertilization	$585		$878	$1,463	M	patchy vegetation, could be enhanced	public sensitivity
UA	6	E	5.5		sparse vegetation, potential for fertilization	$825		$1,238	$2,063	M	patchy vegetation, could be enhanced	public sensitivity
UA	6	G		13.7	shelf area, possibly too steep		$6,508		$6,508	M	coarse sand, patchy veg-MacDonald Beach	public sensitivity
UA	7	B	15.3		upper elevation vegetation, fert.	$2,295		$3,443	$5,738	M	potential for enhancement	
UA	7	D	7.2		upper elevation vegetation,	$1,080		$1,620	$2,700	M	fertilizer probably not required	
UA	7	F	9.5		upper elevation vegetation, fert.	$1,425		$2,138	$3,563	M	well vegetated	
UA	7	G		5.2	low elevation, below F, potential for seeding		$2,470		$2,470	M	has been fall rye seeded, suggest lenticulate seeding and fertilizer	
UA	7	H	9.7		narrow, upper elevation shelf	$1,455		$2,183	$3,638	M	well vegetated	
UA	7	I	7.8		narrow, upper elevation shelf	$1,170		$1,755	$2,925	M	well vegetated	
UA	7	J	2.5		narrow, upper elevation shelf	$375		$563	$938	M	well vegetated	
UA	7	K	4.2		narrow, upper elevation shelf	$630		$945	$1,575	M	well vegetated	
UA	7	L	1.4		narrow, upper elevation shelf	$210		$315	$525	M	well vegetated	
UA	8	A		2.9	unveg point, adjacent to bench 8B, potential for sedge planting		$1,378		$1,378	M	not visited	public sensitivity

Table 5: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE	ENHANCE LOW ELEVATION PLANT VIGOUR	SHRUB & WETLAND PLANTING	TOTAL	Potential for Enhancement	Field observations	Special Concerns
UA	8	B	23.8		200 m wide bench with patchy veg, potential for seeding & fertilizer to infill	$3,570		$5,355	$8,925	M	appears well vegetated, potential for fertilizer	public sensitivity
UA	8	E	38.1		well veg upper elev bench, could be fertilized if 8F undertaken	$5,715		$8,573	$14,288	M	well vegetated	public sensitivity
UA	8	G	26.7		well veg upper elev bench, potential fertilizer	$4,005		$6,008	$10,013	M	potential for enhancement by fertilization	public sensitivity
UA	9	A	34.7		well veg upper elev bench, potential fertilizer	$5,205		$7,808	$13,013	M	not visited	
UA	9	B		31.8	partly protected bench adjacent to 9A		$15,105		$15,105	M	appears promising- viewed from across reservoir	
LA	13	A		72.5	large fan, coarse		$34,438		$34,438	M	not visited	public sensitivity
LA	13	B		10.2	small fan, steep		$4,845		$4,845	M	not visited	public sensitivity
						$56,475	***$124,498***	***$84,713***	***$265,685***	***M Total***		

Table 5: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE	ENHANCE LOW ELEVATION PLANT VIGOUR	SHRUB & WETLAND PLANTING	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	V2		111	40.3	large natural high elev wetland bench, potential area is low elevation adjacent, probably high energy	$16,650	$19,143	$24,975	$60,768	L-M	part of potential vegetation area has become vegetated	
RR	X1		16.7	24.9	developing sparse wetland, lower elev. area between two vegetated portions	$2,505	$11,828	$3,758	$18,090	L-M	part of potential vegetation area has become vegetated	low elevation (430-433m)
RR	X5		43.5	9.9	well developed bench wetland, lower elev point has low potential	$6,525	$4,703	$9,788	$21,015	L-M	well developed bench wetland, lower elevation point (approx 432m) has potential	
UA	1	J		18.2	low elev adjacent to A, possibly too low		$8,645		$8,645	L-M	part of potential vegetation area has become vegetated	
LA	10	F		37.1	lower unvegetated slope below D, may be relatively coarse, adjacent to stream, should have sufficient moisture		$17,623		$17,623	L-M	boulder area, pits, will need physical work	public sensitivity
LA	10	E		12.4	lower unvegetated slope below C, may be relatively coarse, adjacent to stream, should have sufficient moisture		$5,890		$5,890	L-M	boulder area, pits, will need physical work	public sensitivity
LA	11	A		29.2	low elevation, coarse		$13,870		$13,870	L-M	bare lower point, high energy, moderate substrates	public sensitivity
LA	11	B	13.4		sparse upper marsh, may benefit from fertilizer	$2,010		$3,015	$5,025	L-M	appears well vegetated, potential for fertilizer	public sensitivity
						$27,690	***$81,700***	***$41,535***	***$150,925***	***L-M Total***		

Table 5: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE	ENHANCE LOW ELEVATION PLANT VIGOUR	SHRUB & WETLAND PLANTING	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	G		418.4	10	potential vegetation expansion on island (G3), high energy	$62,760	$4,750	$94,140	$161,650	L	part of potential vegetation area has become vegetated	
RR	H		4	8.5	potential vegetation expansion on island, high energy	$600	$4,038	$900	$5,538	L	part of potential vegetation area has become vegetated	
RR	I		14.1	26.2	potential vegetation expansion on islands, high energy	$2,115	$12,445	$3,173	$17,733	L	part of potential vegetation area has become vegetated	
RR	L		20.1	15	potential vegetation expansion on islands, high energy	$3,015	$7,125	$4,523	$14,663	L	part of potential vegetation area has become vegetated	
RR	U1		1	72.3	low elev. could be accelerated by fertilization & seeding	$150	$34,343	$225	$34,718	L	High energy, low elevation	low elevation (430-431m)
RR	U2b		0	14.6	some sign of veg development,		$6,935		$6,935	L	part of potential area veg.	low elevation (430-431.4m)
RR	U2c		0	15.5	some sign of veg dev. high energy		$7,363		$7,363	L	part of potential vegetation area has become vegetated	low elevation (429-430m)
RR	U3		53.7	20.3	adjacent to heavily grazed natural wetland - not recommended	$8,055	$9,643	$12,083	$29,780	L	low potential due to cows	
RR	V1		5.8	3.6	some sign of veg development, could be accelerated by fertilization & seeding	$870	$1,710	$1,305	$3,885	L	part of potential vegetation area has become vegetated	low elevation (430-430.5m)
RR	X3		1		well developed bench wetland	$150		$225	$375	L	low elevation (430-431m) bay	
RR	X7		1.8	36.5	low elevation bench	$270	$17,338	$405	$18,013	L	part of potential vegetation area has become vegetated	
UA	1	E	1.9		river bar, former levee, high energy	$285		$428	$713	L	vegetated	
UA	1	G		7.6	adjacent to E, high energy, low elev		$3,610		$3,610	L	part of potential vegetation area has become vegetated	
UA	2	B	5.3		upper elevation substrates at stream mouth, adjacent to 2-A	$795		$1,193	$1,988	L	patchy vegetation	public sensitivity
UA	2	C	3.6		higher elevation vegetated zone	$540		$810	$1,350	L	patchy vegetation	public sensitivity
UA	2	D		1.5	lower elevation unveg. zone, coarse		$713		$713	L	coarse	public sensitivity
UA	2	F		1.9	lower elevation unveg. zone, coarse		$903		$903	L	coarse	public sensitivity
UA	2	G		3.1	stream mouth, coarse materials		$1,473		$1,473	L	coarse, high energy	
UA	2	H		3.4	stream mouth, coarse materials		$1,615		$1,615	L	coarse, high energy	
UA	3	C		15.7	lower elevation fan, coarse materials		$7,458		$7,458	L	coarse, high energy	
UA	4	C		7.3	Unveg. slope between 4A&B, probably too steep		$3,468		$3,468	L	not visited, lack of road access	
LA	10	J		9.4	similar to G but narrow strip in bay		$4,465		$4,465	L		public sensitivity
LA	11	C		8.3	lower slope below D, steep, coarse		$3,943		$3,943	L	high energy	public sensitivity
LA	12	B		8.3	coarse steep point		$3,943		$3,943	L	not visited	public sensitivity
						$79,605	***$137,275***	***$119,408***	***$336,288***	***L Total***		

Table 6: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	Site	Loc.	Vegetated (ha)	Potential (ha)	Description	FERTILIZE	ENHANCE LOW ELEVATION PLANT VIGOUR	SHRUB & WETLAND PLANTING	TOTAL	Potential for Enhancement	Field observations	Special Concerns
RR	B		3.8		Available areas have been colonized by native vegetation	$570		$855	$1,425	n/a	well vegetated	
RR	C		0		mostly above full pool					n/a	well vegetated	
RR	D		0		mostly above full pool					n/a	well vegetated	
RR	E		32.5		Available areas have been colonized by native vegetation	$4,875		$7,313	$12,188	n/a	well vegetated	
RR	F		14.9		Available areas have been colonized by native vegetation	$2,235		$3,353	$5,588	n/a	well vegetated	
RR	K		328.4		Most of available areas have been colonized by native vegetation, some channels, high energy low elev	$49,260		$73,890	$123,150	n/a	well vegetated	
RR	M	NORTH	246.7		Available areas have been colonized by native vegetation	$37,005		$55,508	$92,513	n/a	well vegetated	
RR	X2		1		well developed bench wetland	$150		$225	$375	n/a	well vegetated	
RR	X3		1		well developed bench wetland	$150		$225	$375	n/a		
UA	1	C	12.1		high elevation bench, well vegetated, some shrub development, enhancement probably unnecessary	$1,815		$2,723	$4,538	n/a	well vegetated	
UA	2	E	1		higher elevation vegetated zone near ferry landing	$150		$225	$375	n/a	vegetated	public sensitivity
UA	3	A	3.9		Halfway River, upper elev fan	$585		$878	$1,463	n/a	log dump	
UA	3	B	3.7		Halfway River, upper elev fan	$555		$833	$1,388	n/a	coarse, high energy	
UA	4	A	2.6		vegetated creek mouth, west side reservoir	$390		$585	$975	n/a	not visited, lack of road access	
UA	4	B	3.4		vegetated creek mouth, west side reservoir	$510		$765	$1,275	n/a	not visited, lack of road access	
UA	5	D	2		small vegetated bay south of Nakusp	$300		$450	$750	n/a	patchy vegetation	public sensitivity
UA	6	B	3.6		high elevation bench above C, well vegetated	$540		$810	$1,350	n/a		
UA	6	F	1.4		high elevation bench, well vegetated	$210		$315	$525	n/a	well vegetated	
UA	6	H	1.1		high elevation pocket	$165		$248	$413	n/a	well vegetated	public sensitivity
UA	6	I	12.2		narrow, upper elevation shelf	$1,830		$2,745	$4,575	n/a	well vegetated	public sensitivity
UA	7	A	2		narrow, upper elevation bench, well vegetated	$300		$450	$750	n/a	well vegetated	
UA	8	C	2.1		well vegetated upper elevation	$315		$473	$788	n/a	well vegetated	public sensitivity
LA	11	G	9.3		well vegetated upper marsh	$1,395		$2,093	$3,488	n/a	patchy growth at lower elevations	public sensitivity
LA	11	F	7.8		well vegetated upper marsh	$1,170		$1,755	$2,925	n/a	patchy growth at lower elevations	public sensitivity

Table 7: Wetland Enhancement Opportunities and Estimated Costs (cont.)

AREA	*Site*	*Loc.*	*Vegetated (ha)*	*Potential (ha)*	*Description*	*FERTILIZE*	*ENHANCE LOW ELEVATION PLANT VIGOUR*	*SHRUB & WETLAND PLANTING*	*TOTAL*	*Potential for Enhancement*	*Field observations*	*Special Concerns*
LA	11	D	5.6		well vegetated upper marsh	$840		$1,260	$2,100	n/a		public sensitivity
LA	11	E	3.8		well vegetated upper marsh	$570		$855	$1,425	n/a		public sensitivity
LA	12	A	22.5		well vegetated upper bench	$3,375		$5,063	$8,438	n/a	not visited	public sensitivity
LA	12	D	3.6		well vegetated, sheltered pocket above C	$540		$810	$1,350	n/a	viewed from across reservoir	public sensitivity
LA	12	G	3.7		well vegetated upper marsh	$555		$833	$1,388	n/a		public sensitivity
						$110,205		***$165,308***	***$275,513***	***n/a Total***		

						$368,580	***$719,673***	***$552,870***	***$1,641,123***	***Grand Total***		

6.0 DISCUSSION

> *The main objective of the study will be to identify and plot those areas within the drawdown zone which have the highest potential for vegetation establishment.*
>
> *This study will identify cost-effective alternatives to operating changes as a means of improving vegetation around the Arrow Lakes Reservoir.*

Although we know more about the vegetation in Arrow Lakes Reservoir than in any other reservoir within BC Hydro's system, all of Canada and possibly North America, the vegetation studies in the Arrow drawdown zone have been primarily related to dust control issues. Therefore, they are of somewhat limited value when it comes to predicting change in response to altered hydrology. The survival of vegetation across a 10m range in elevation is unparalleled in fresh-water environments, hence there is almost no existing literature to draw upon for comparison. Studies that have been conducted in other wetland environments, for example the Delta Research facility in Manitoba, have studied the effects of several centimeters of water change on plant survival rather than the several meters at issue in Arrow Lakes Reservoir.

Reservoir elevations are generally used as indicators of vegetation distribution and abundance, but as hydrologic conditions vary annually, so do the stresses imposed on the vegetation at each elevation band. These variations are greater than those in natural lake or wetland conditions, especially since many of the factors controlling reservoir water levels are unrelated to climatic variables. However, root reserves allow perennial plants to survive extreme conditions, thereby responding to long-term hydrologic conditions rather than annual fluctuations. The long-term water level average during the growing season has therefore become a useful tool for determining vegetation tolerances and appears to be a reasonable predictor of the lower limit of vegetation growth.

In the absence of strong scientific background data from comparable environments, two major assumptions have been used for establishing vegetation performance measures in Arrow Lakes Reservoir:

a. the vegetation distribution in Revelstoke Reach has evolved in response to the historic water levels, and

b. the current vegetation distribution Revelstoke Reach is representative of conditions in the remainder of the reservoir.

A change in the hydrologic pattern (compared to historic) should dictate vegetation trends by influencing the amount of vegetated area at lower elevations, or by affecting vegetation biomass and diversity at upper elevations.

6.1 Predicting Vegetation Response to Altered Hydrology

The vegetation in Arrow Lakes Reservoir, at present, extends over an elevation range of approximately 10m (440 to 430). Prior to 2001, the lower limit of vegetation was at approximately 434m and prior to 1992, the lower limit was at about 436m. Two main hypotheses have been put forward to explain the expansion of the vegetation:

1. the fall rye seeding program has facilitated the spread of natural vegetation (sedge and grass) by; the mechanical action of drill seeding inadvertently incorporating natural vegetation seed into the substrate, and by fall rye functioning as a nurse crop.
2. the extended drawdown years of 1992 and 2001 have facilitated the establishment of natural vegetation by allowing the seedlings sufficient growing time to develop into mature plants capable of tolerating subsequent extended inundation. Relatively favourable water levels in the years following seedling establishment have allowed the expanded vegetation areas to persist.

These factors have worked in concert over the past decade to allow the establishment and persistence of the extensive areas of natural vegetation currently dominating the drawdown zone of Revelstoke Reach and smaller locations in the main body of the reservoir.

For WUP purposes, four general groupings of vegetation, were recognized and characterized by elevation bands and growth characteristics (information derived from SEIP studies):

1. Below 434m, low elevation, sparse vegetation, dominated by perennial sedge and reed canary grass which has developed primarily since the 2001 drawdown. **Large area, low biomass, very low diversity.**
2. 434-436m low density vegetated area, dominated by perennial sedge and reed canary grass. **Moderate area, low biomass, low diversity.**
3. 436-438m high biomass, dominated by perennial sedge and reed canary grass but supports a number of other species. **Moderate area, high biomass, moderate diversity.**
4. 438-440 high diversity of species, becoming more terrestrial in nature, significant component of shrubs, lower biomass of herbaceous species than in the 436 to 438m range. **Moderate area, moderate biomass, high diversity.**

Each of the zones can be characterized by the 3 factors identified above; the overall area of vegetation, the biomass and diversity. **Area** is a simple expression of the amount of land that is vegetated. **Biomass** describes the amount of growth produced per unit area of land and has been found to be related to elevation and consequently to the stresses that the vegetation is subject to. **Diversity** accounts for the number of species in the area. This too is related to elevation and the stresses on the plants.

These categories were used in conjunction with the Arrow historical water level records and the modeled results to evaluate the potential effects of the operating alternatives on the established vegetation within Arrow Lakes Reservoir. Two major factors were considered, the duration of inundation and the first week of flooding. The primary assumption for this analysis was that vegetation distribution in Revelstoke Reach evolved in response to the historic water levels. Therefore, a change in the average conditions should dictate trends in vegetation change. These trends can be considered in terms of the characteristics discussed above; area, biomass and diversity. Earlier inundation and longer duration of inundation can be expected to result in a decrease in the vegetated area. In contrast, a reduced period of flooding, could create a shift in the vegetation towards greater diversity and probably a reduction in biomass at higher elevations. There is currently insufficient information to determine the relative importance of duration versus timing of inundation in terms of vegetation trends and overall survival. The different vegetation criteria within the various elevation bands, respond individually to altered hydrology. In some situations, factors that encourage increased biomass, may result in reduced diversity within that zone. The most consistent relationship is that factors that will cause a reduction in area will also cause a reduction in biomass and diversity, but the opposite is not necessarily true.

The mapping of potential planting areas was based on 2001 satellite imagery. With subsequent field observations, we now know that the extremely low water levels during 2001 facilitated seedling establishment in many of the previously unvegetated low elevation sites identified for planting. The question of how the establishing seedlings would fare under subsequent water regimes was an important issue for deciding potential planting options. The alternate scenarios (Table 8) cover the range of options available for vegetation enhancement. The revised cost estimates for planting (Table 5) followed scenario 1, with the presumption that areas available for planting are now vegetated and that only minimal enhancement would be required. Alternate scenarios may result in higher costs due to the need for site specific manual planting or erosion control activities.

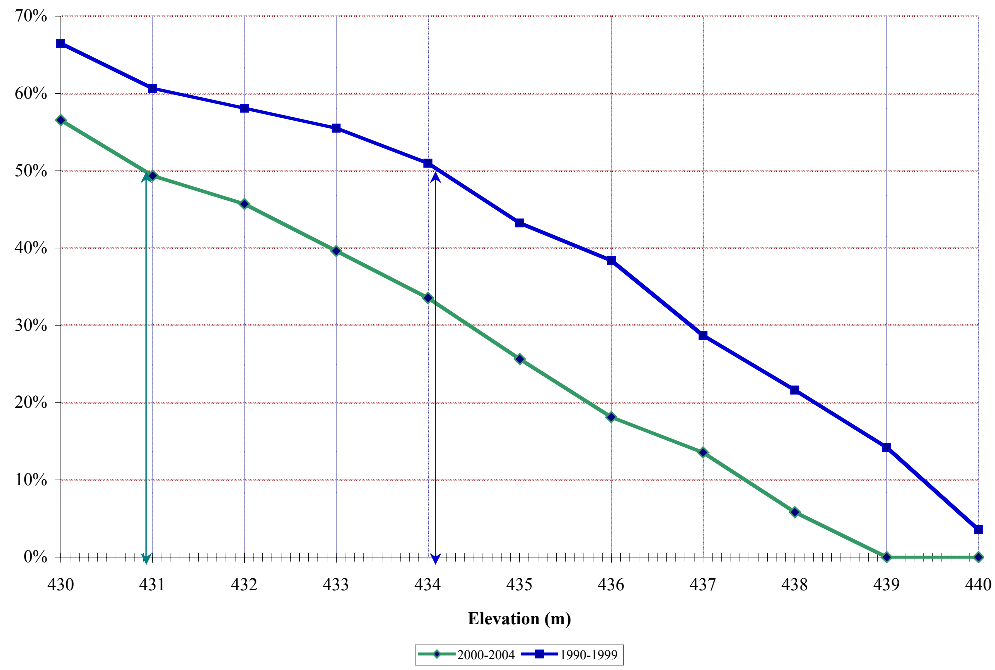
Table 8: Low Elevation (430-434m) Perennail Plant Scenarios for Arrow Lakes Reservoir

	Scenario 1	Scenario 2	Scenario 3
PLANT TOLERANCE OF post-2001 WATER LEVELS	**TOLERANT**	**INTOLERANT**	**INTOLERANT**
PROJECTED PLANT GROWTH	Perennial vegetation survives over entire established range (430-434m)	Perennial vegetation dies below tolerance level (elevation to be determined).	Perennial vegetation dies below tolerance level (elevation to be determined).
ENHANCEMENT OPPORTUNITIES FOR STATUS QUO	Enhancement options for naturally expanded vegetation include fertilization to enhance vigour and infill sparse areas. Site specific plantings of cultured native plants for erosion control.	Enhancement options for surviving vegetation are as for scenario 1. Below tolerance level, remaining organics will provide erosion protection until decayed. Fall rye planting for erosion control can be delayed until organic layer is gone.	Enhancement options for surviving vegetation are as for scenario 1. Below tolerance level, remaining organics will provide erosion protection until decayed. Fall rye planting for erosion control can be delayed until organic layer is gone.
WATER MANAGEMENT ALTERNATIVE	Favours low elevation plant growth	Favours low elevation plant growth	Discourages low elevation plant growth
ENHANCEMENT OPPORTUNITIES AFTER IMPLEMENTATION OF CHOSEN ALTERNATIVE	Enhancement options for naturally expanded vegetation include fertilization to enhance vigour and infill sparse areas. Site specific plantings of cultured native plants for erosion control.	Re-establishment of vegetation losses in intervening years. Planting in specific sites, fertilization, planning for low-water possibilities.	Planting opportunities limited to specific sites to control erosion (banks, heritage resource sites etc.)
PLANTING COSTS	Significantly lower than initial estimate	Probably somewhat lower than initial estimate, depending on amount of plant survival	Probably similar to original cost estimate. Depends on site needs, areas more limited but costs may be higher due to costly planting techniques.

6.2 A review of predictions based on 2003-2004 field observations.

Based on the assumptions outlined above, it was concluded that if changes to the water regime do not impose more severe conditions than that experienced historically at any given elevation, the vegetated area should remain the same. Conversely, reduced inundation can result in an increased vegetated area. Based BC Hydro water level records from January 2000 to the end of 2004, the average pattern during the growing season has been one of reduced inundation (10 to 20% less inundation than historic 90-99) at all of the vegetated elevations within Arrow Lakes Reservoir (Figure 10). Much of this has come about not due to a delay in fill, but due to a more rapid fall draw-down (Figure2).

Figure 10: Wetted Weeks as a Percentage of the Growing season (April 1-October 31).



The hypothesis for inundation and the lower limit of plant growth discussed earlier postulates that plant growth is limited to areas inundated for less than 50% of the growing season. Based on BC Hydro water level records, the 50% wetted week average during the 1990-99 period (historic) occurred in the vicinity of 434m, coinciding with field observations of the lower limit of plant growth at that time. In the 2000-2004 period, the 50% wetted week average occurred at approximately 431m (Figure 10). Field observations in 2004 (see Appendices 1-3) revealed that plant growth now extends below 432m, supporting the above hypothesis. Observations at long term monitoring sites confirmed a substantial increase in biomass at lower elevation sites supporting the prediction that a shift in vegetated zones could be anticipated with reduction of inundation.

Of further significance is the observation that upper elevation plants, particularly the wet shrub communities at 438m and above have been showing stress (Susan Hall, Janice Jarvis pers. com.). During the 2000-2004 period, these sites were inundated far less than historically (Figure 10). Elevations 438m and above were inundated on average for less than 5% of the growing season, whereas historically, they would have been inundated for up to 22% of the growing season.

Vegetation establishment in many of the identified potential planting sites has already occurred due to a fortuitous occurrence of a low water year and subsequent low water years. Monitoring of this establishment during subsequent years will disclose the long-term success of this natural establishment.

7.0 RECOMMENDATIONS FOR FURTHER WORK

Regardless of future water cycles, it can be anticipated that some degree of vegetation change will occur in Revelstoke Reach. The direction and magnitude of such change will need to be determined by a monitoring program. Specific needs for additional information have been identified in the report. Since elevation information is essential for assessing the potential for vegetation success, the completion of DEM coverage in Arrow Lakes Reservoir is a high priority. However, now that specific sites have been identified for further examination, additional aerial photography and preparation of elevational models can be focused on specific sites for cost effectiveness. It is recommended that a DEM be used in a GIS analysis to further refine the potential vegetation establishment locations discussed in this report.

Vegetation mapping is essential for the determination of up to date vegetation distribution in the reservoir and as a basis for performance measures. The specific sites identified in this report are recommended for further, detailed vegetation mapping. Field verification of mapping results is an essential aspect of such a program. In addition to the field verification, it is also recommended that field assessments be conducted to determine:

- the species composition of existing wetlands outside of Revelstoke Reach
- density of vegetation communities in relation to elevation in Arrow Lake wetlands
- biomass of communities in relation to elevation
- potential for fertilization benefit.

All of these items relate to the measure of success (and performance measures) if enhancement is implemented.

One of the greatest lessons learned from a decade of vegetation work at Revelstoke Reach was that the lack of baseline data made it impossible to measure the long-term success of the re-vegetation program or to determine which were the most important elements of the program. We know it worked, we think we know why, but we can’t prove it. This limits the applicability of the data to other reservoirs and for developing operational plans. Based on this experience, prior to undertaking any enhancement activity, we strongly recommend the assessment of baseline environmental data against which subsequent change can be measured. Regular monitoring should be established once enhancement activity has begun, and the planning process should include budgeting for the long-term. Further details for recommended studies were presented in the MCA WUP – Arrow Vegetation Monitoring Recommendations.

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APPENDIX BB: BRIEFING NOTE – MCA WUP FISH TECHNICAL SUBCOMMITTEE TELECONFERENCE, NOVEMBER 2004

1.0 INTRODUCTION

A meeting of the Fish Technical Subcommittee (FTC) was held on 5 November 2004 to follow-up on a number of outstanding action items from the May 2004 FTC meeting and the final June 2004 Consultative Committee meeting. Specifically, this included the need to:

1. Define decision rules for triggering opportunistic assessments of high flow events for white sturgeon in the lower Columbia River;

2. Revise the scope of the Arrow Lakes Reservoir burbot study to include rainbow trout, if deemed appropriate; and

3. Follow-up on recent survey work undertaken to examine potential impacts of Arrow Reservoir levels on tributary access by fall spawners, and determine whether additional monitoring should be undertaken as part of the Columbia River Water Use Plan.

The following summarizes the key discussions and decisions of the FTC with respect to these items.

2.0 OPPORTUNISTIC ASSESSMENT OF HIGH FLOW EVENTS IN THE LOWER COLUMBIA RIVER

Given uncertainty about responses of white surgeon to a higher base flow in the lower Columbia River, the Fish Technical Subcommittee considered a flow augmentation experiment involving a flow target of 200+ kcfs at the Canada-U.S. border for 4 weeks during the late June to late July period to reduce predation pressures on larvae and juveniles. This would involve supplementing flows in years when the Pend d'Oreille River is expected to provide high and late flows based on snowpack measurements. Through further discussions of this option, it became apparent that achieving this target would require a large shift in current operations of Arrow Lakes Reservoir to supplement flows in most years, and could be very costly ($15–20 million) due to implications on spill downstream in high flow years. Further, there was considerable uncertainty around the ability of BC Hydro to deliver the required flow dependably, the willingness of US to accept extra water during a high water period, and the potential risk to infrastructures in and around the Trail and Genelle areas. Consequently, the Consultative Committee recommended the high flow option only on an opportunistic basis, as opposed to through an operational change, and an assessment in those years when it occurs naturally. Based on historical frequency of occurrence, it was estimated that these high flow events would occur naturally in 2 out of 10 years.

During the May 2004 FTC meeting, the Subcommittee recommended a contingency fund of $75,000/year for 2 years to cover the planning, co-ordination and implementation of the opportunistic assessments. While there was some discussion around the scope of this work, the Subcommittee recognized that further work would be required to further define the objectives of the assessments, and to develop an appropriate trigger to initiate this work.

2.1 Scope of the Opportunistic Assessment

During the November 2004 teleconference, the FTC agreed that the opportunistic assessment should be focused on gaining a better understanding around the relationships between high flows and egg, larval and juvenile survival. It was agreed that the program should include the following elements.

- A spawn detection program using substrate egg mats. It was estimated that this program would cost roughly $55,000/year.
- A juvenile sturgeon detection program. The Consultative Committee already supported such a program as part of the lower Columbia white sturgeon monitoring plan, at an estimated annual cost of $125,000 (over 10 years).
- Water quality sampling (water temperature, TGP, turbidity). This will be covered off with the lower Columbia physical habitat monitoring program, which was supported by the Consultative Committee for an estimated cost of $25,000/year over 10 years.
- Monitoring of erosion and flooding impacts. BC Hydro currently undertakes monitoring at several sites in the lower Columbia River that have been identified as prone to flooding and erosion at high flows to specifically address issues of public safety and property damage. While annual reports would be made available to the WUP, it was agreed that more systematic field measurements would be needed. It was felt that the remaining budget of $20,000 (i.e., from the agreed upon $75,000) would be adequate to undertake a flooding impact study.

As there is presently no reliable technique for larval sampling that would provide quantitative data, the FTC agreed that there would be little value in conducting a larval detection program as part of the opportunistic assessment.

2.2 Decision Rule for Initiating Studies

Forecasts for the Mica, Revelstoke, Arrow, Duncan and Kootenay basins are combined with the U.S. forecasts for Libby and the Pend d'Oreille River, and are available through the U.S. River Forecast Center. The published runoff volume forecasts for the Columbia River at the International boundary are for January–September, April–September, and April–July. It is recommended that the April–July forecasts be used as the best indicator for decision-making around initiation of the opportunistic assessments. It was noted that the first reliable runoff forecast is available by 1 April. This would provide the one-month lead-time required for planning and mobilization of field crews for setting of the egg collection mats.

Based on long-term (1929–1999) flow records for the Columbia River at the International Boundary, the April–July runoff volume has an average runoff of 55.0 MAF. If, on average, the wettest 20 per cent of the years are selected for the sturgeon studies, then the studies should be initiated whenever the April–July runoff forecast is at or above 15 per cent above normal. The problem with this simplistic approach is that, if this rule was applied to the decade 1990–1999, the studies would have been initiated in 4 out of 10 years. If it was applied to the decade 1934–1943, no studies would be have initiated. It is, therefore, recommended that we go “on alert” whenever the runoff forecast is 10 per cent above normal and a decision to initiate the studies be based on consultation with other stakeholders. In the event that there has not been a high runoff year for 4–5 years, consideration should be given to reducing the threshold value.

3.0 ARROW LAKES RESERVOIR BURBOT STUDY

During the June 2004 Consultative Committee meeting, it was suggested that the scope of the Arrow Lakes Reservoir burbot study be revised to include other species to address uncertainty around the operational impacts on reservoir fish populations. It was noted that some concern has been identified around the large piscivorous species of rainbow trout. The BC Hydro project team was tasked with following up on this item after the Committee meeting.

During the November teleconference, there was discussion of a proposal prepared by the Ministry of Lands, Water and Air Protection to undertake a telemetry study to gain a better understanding around the importance of Revelstoke Reach to piscivorous rainbow trout production. Specifically, the objectives of the proposed work would be to determine the location of spawning grounds, and the degree to which habitats within the Revelstoke Reach are used for rearing by this species. The FTC agreed that these data gaps would be adequately addressed through existing studies supported by the Consultative Committee for the mid Columbia River (i.e., juvenile and adult habitat use assessments), and that additional study was not required as part of the Columbia River Water Use Plan.

The FTC discussed whether additional studies should be considered to assess possible impacts of Arrow Lakes Reservoir operations on the rainbow trout population, such as drawdown effects on tributary access and stranding. It was noted that these issues were considered early on in the WUP process, and it was agreed that they did not represent significant areas of concern and were dropped from further consideration. It was concluded that neither loss of fish through stranding or reduced spawning success through blockage of access to spawning tributaries would likely have a population-level effect on rainbow trout.

However, during the teleconference, the FTC acknowledged that there is uncertainty regarding the degree to which increased streamflow during tributary freshet mitigates the effects of low spring reservoir levels on rainbow trout spawner access to tributary streams.

4.0 ARROW LAKES TRIBUTARY FISH ACCESS

During both the May 2004 FTC and June 2004 CC meetings, concern was expressed over the strict constraints that operating alternatives 11D2 and 11D3 would impose on Arrow Lakes Reservoir during the fall. While maintaining lower elevations during the August–October period would provide more habitat for migratory birds and improve conditions for vegetation in the drawdown zone, it could adversely affect fish interests in the reservoir. Particular concern was noted with Alt 11D3, which represented a large deviation from historical operations (i.e., maximum elevation of 1430 ft by end August; 1425 ft by end September). By reducing reservoir levels below 1425 ft by 15 September, small tributaries could become inaccessible to kokanee spawners. (The peak spawning period generally occurs around Labour Day). During years of low water when most of the tributaries are inaccessible, escapements tend to stay constant with spawners re-distributing themselves into the streams that are accessible. However, this may cause many more (2 to 3 times) spawners to utilize those streams, thereby causing overspawning and reducing spawning success. If this occurs every year, it could have a significant impact on kokanee populations.

As part of the soft constraints developed for Arrow Lakes Reservoir, the Consultative Committee recommended that appropriate reservoir elevations be maintained to provide tributary access during the kokanee spawning period. Based on available data, it appears that access starts to be a problem at a reservoir level of 1425 ft. However, it was recognized that this could potentially conflict with recommendations for other interests in the reservoir (e.g., elevations to be kept at or below 1430 ft for 80 per cent of the time for archaeological site protection). It was suggested that monitoring would be required to evaluate the performance of the soft constraints over the five-year review period to ensure that reservoir operations provide acceptable conditions to ensure upstream passage during the spawning period.

On 8 September 2004, an aerial survey of Arrow Lakes Reservoir tributaries was carried out to further assess the potential impact of reservoir operations on kokanee spawner access. During the overflight survey, the reservoir water level was at 1423.6 ft at Fauquier, which is more than 6 ft below the optimal water levels for spawner access. The data collected during this survey followed data collected in April 2001, which showed that 30 per cent of the tributaries surveyed were inaccessible at elevations 1416–1418 ft.

During the September 2004 survey, almost all of the streams were found to be flowing to the reservoir and had water depths suitable for fish passage up to and into the riparian zone. Included were the streams on the west side of the reservoir from Eagle Creek (Edgewood) south, which have not supported spawning for most of the past five years. Eagle Creek, which once supported thousands of spawners, was supporting fish although not in as high numbers as occurred in the mid 1990s. Further, a number of streams on the east side of the reservoir in the lower basin, which have been inaccessible to varying degrees in the past, were all found to be supporting some spawners. It was noted that the timing of this survey coincided with about one month of higher than average precipitation (mid August to mid September), which appeared to be sufficient to recharge the groundwater aquifer and keep streams flowing to the reservoir.

The FTC agreed that more comprehensive observations would be required to determine whether there are elevation thresholds below which spawner access becomes a problem. It was recommended that physical assessments of passage conditions at tributaries to the Arrow Lakes Reservoir be made under a range of reservoir operating levels and streamflow conditions to determine:

1. Reservoir water levels and streamflow conditions required to provide acceptable upstream passage conditions,

2. Whether high stream flows mitigate impacts of lower reservoir elevation, and

3. Whether there is a relationship between precipitation (annual, seasonal or monthly), groundwater recharge and stream flow that could be used to predict within-season mitigation effects of stream flow on reservoir water level impacts.

The FTC has proposed that three annual surveys be conducted five times during the next 12 years to qualitatively document upstream passage conditions for three key fish species (kokanee, bull trout and rainbow trout). Overflights would be conducted between April and November to coincide with the peak migration periods for the three target species. Observations would be strategically distributed over a range of streamflow and reservoir elevation conditions to inform on the potential for reservoir operations to negatively impact upstream migration of these fish populations, and thus better inform on whether there are seasonal reservoir elevation thresholds that should be considered for future operations. The total cost of the monitoring program over the 12-year period is estimated at about $286,000.

APPENDIX CC: PROPOSED COLUMBIA WATER USE PLAN MONITORING PROGRAMS

Table CC-1: Proposed Revegetation Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Kinbasket Reservoir Monitoring of Revegetation Efforts	Annual monitoring to evaluate plant survival and development of representative planting sites under the various revegetation efforts.	Will address uncertainty related to the effectiveness of planting options (e.g., manual vs. mechanical planting, fertilization) and species survival under current reservoir operating conditions.	High	6	$50,000 (Years 1 to 5 and 10)	$26,029
Kinbasket Reservoir Inventory of Vegetation Resources	Mapping of vegetation and GIS analysis to assess vegetation distribution by elevation band in Kinbasket Reservoir. Year 1 to include identification and mapping of pocket riparian habitat around reservoir as potential wildlife habitat.	Vegetation mapping of Kinbasket Reservoir is incomplete due to lack of topographic information. The inventory will allow determination of subsequent vegetation status and trends in relation to planting efforts, and the validity of untested assumptions used in the modelling of hydrologic impacts of operating alternatives on vegetation. It will also allow identification of sites with potential to support wildlife habitat through enhancement works and vegetation management.	High	6	$150,000 (Year 1) $100,000 (Years 2 to 5 and 10)	$57,467
Kinbasket and Arrow Lakes Reservoirs Effectiveness Monitoring of Revegetation and Wildlife Physical Works	Seasonal wildlife surveys (point counts, nest searches, ground track counts) to document use of wildlife (birds, ungulates, bears) of revegetated areas. To also include effectiveness monitoring of wildlife physical works in Arrow. Monitoring of Arrow to include upper Arrow from Drimmie Creek to Arrowhead.	There is uncertainty about current utilization of the drawdown zone by wildlife species and the effects of reservoir operations. Monitoring will inform on the effects of revegetation efforts in Kinbasket and Arrow Lakes reservoirs on wildlife utilization patterns, and the effectiveness of Arrow Lakes Reservoir physical works on wildlife habitat quality and quantity. Lack of data on the use by wildlife from the initiation of revegetation.	High	12	$250,000 (2 years baseline followed by monitoring every other year over 10 years)	$132,866
Arrow Lakes Reservoir Monitoring of Revegetation Efforts	Annual monitoring to evaluate plant survival and development of representative planting sites under the various revegetation efforts. (Estimated costs of monitoring may be lower if options for planting and enhancement are found to less than anticipated).	Will address uncertainty related to the effectiveness of planting options (e.g., manual vs. mechanical planting, fertilization) and species survival under soft operational constraints.	High	6	$25,000 (Years 1 to 4) $50,000 (Years 5 and 10)	$16,355

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Arrow Lakes Reservoir Inventory of Vegetation Resources	Mapping of vegetation and GIS analysis to assess vegetation distribution by elevation band. Year 1 to include identification and mapping of pocket riparian habitat around reservoir as potential wildlife habitat. This study would require the collection of aerial photography (as proposed below).	Vegetation mapping of Arrow Lakes Reservoir is incomplete due to lack of aerial photography and topographic information. The inventory will allow determination of subsequent vegetation status and trends in relation to altered hydrologic conditions, and revegetation efforts. It will also allow identification of sites with potential to support wildlife habitat through enhancement works and vegetation management.	High	**Study Costs included under the Arrow Lakes Reservoir Operations Monitoring Program**		
Arrow Lakes Reservoir Aerial Photographs	Undertake colour aerial photographs at a scale of 1:5,000 for baseline vegetation mapping of Revelstoke Reach and vegetated areas of the upper and lower Arrow Lakes Reservoir.	Vegetation mapping of Arrow Lakes Reservoir is incomplete. Collection of colour photographs later in the growing season is required to map and measure vegetation density and distribution.	High	**Study Costs included under the Arrow Lakes Reservoir Operations Monitoring Program**		
Arrow Lakes Reservoir Complete Digital Elevation Model	Obtain a complete DEM for upper and lower Arrow Lakes Reservoir, including aerial photographs (1:10,000 black and white).	Proposed planting and enhancement areas were based on the DEM that is available for about ¾ of Revelstoke Reach. As there is no DEM for the upper and lower Arrow Lakes Reservoir, completion of the DEM for all of Arrow Lakes Reservoir would be required to provide more information on the elevations of proposed planting zones.	High	**Study Costs included under the Arrow Lakes Reservoir Operations Monitoring Program**		
Mid Columbia Monitoring of Mosquito Distribution in Revelstoke Area	Survey low bench and littoral areas surrounding Arrow Lakes Reservoir in the Revelstoke area.	Study will assist in determining link between reservoir and dam operations and vegetation type to mosquito production.	High	1	$15,000	$1,623
Mid Columbia Monitoring of Mosquito Populations	Study adult mosquito population to investigate dispersal and migration patterns.	Study will assist in determining link between reservoir and dam operations and vegetation type to mosquito production.	Low	1	$15,000	$1,623
Mid Columbia Monitoring and Management of Potential West Nile Virus Hotspots	Identify West Nile Virus risk and prepare Integrated Mosquito Management Plan for Revelstoke.	Study will assist in determining link between reservoir and dam operations and vegetation type to mosquito production.	Low	1	$25,000	$2,704
Mid Columbia Monitoring of Effects of Hydrologic Regime on Mosquito Production	Investigate hydrology relating elevation to vegetation type and mosquito breeding grounds and compile historical climate data.	Study will assist in determining link between reservoir and dam operations and vegetation type to mosquito production.	High	**Study costs included under the Arrow Lakes Reservoir Operations Monitoring Program**		
Total Estimated Cost						**$238,667**

Table CC-2: Proposed Recreation Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Boat Ramp Use Study	Multi-year public use measurement study at Water Use Plan improved boat launches in Kinbasket and Arrow Lakes reservoirs.	Study required to establish the link between level of use and boat launch improvements, and to monitor use levels for future Columbia River Water Use Plan decisions related to recreation.	High	15	$20,000 (Year 1) $10,000 (Year 2 to 15)	$11,081
Total Estimated Cost						**$11,081**

Table CC-3: Proposed Heritage Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Program 1						
Arrow Lakes Reservoir Development of a management strategy for the four known archaeological sites	Determine preferences of interested First Nations in treatment options for discovered archaeological sites and develop an effective, acceptable management plan.	Each approach to preserving archaeological sites has different drawbacks, benefits and long-term consequences. Interested First Nations will be involved in developing the appropriate approaches.	N/A	Years 1 and 2	$10,000	$1,000
Arrow Lakes Reservoir Monitor impact of wave and wind erosion on scarp stability	Determine the dynamic between reservoir activity and the stability of the scarps supporting archaeological sites.	A set of transects at archaeological sites and in other areas could determine the link between reservoir operations, erosion by wind, waves, and underwater action.	High	Years 1 to 5	$33,000	$26,000
Arrow Lakes Reservoir Effectiveness monitoring at sites of active intervention	Establishment of transects and ongoing monitoring to determine the effectiveness of interventions in protecting the known archaeological sites from wind and wave erosion.	Monitoring will be required to assess the effectiveness of interventions, and allow knowledge to be transferred to additional works as new sites are discovered.	High	Years 1 to 5	$6,000 per site to establish transects, $3,000 per site per year data collection, done intermittently.	$10,000
Program 1 - Total Estimated Cost						**$39,692**
Program 2						
Kinbasket and Revelstoke Reservoirs Archaeological Site Survey and Inventory	Stratified survey and inventory of potential archaeological sites (and sites of all physical works) for sites at risk of reservoir operations.	Reservoir operations and physical works (revegetation, boat ramp building) may impact archaeological sites. Number, location and characteristics of sites are presently unknown.	Moderate	1 to 3	$35,000 (in total)	$4,000
Arrow Lakes Reservoir Archaeological Site Survey and Inventory	Survey and inventory of potential archaeological sites (and sites of all physical works) for sites at risk of reservoir operations.	Reservoir operations and physical works (revegetation, boat ramp building) may impact archaeological sites. Number, location and characteristics of sites are presently unknown.	Moderate	1 to 3	$75,000 (in total)	$9,000
Kinbasket and Arrow Lakes Reservoirs Exploratory Excavations	Obtain baseline archaeological data to determine importance of sites.	Erosion and scatter of archaeological materials may be the last of an archaeological site, or the "tip of the iceberg". Determining how much material is there will help prioritize physical works approaches. Monitoring of these sites will develop link between operations erosion and will assess effectiveness of protection strategies. Will provide partial representation of archaeological record if protective measures are not successful.	High	Years 5 to 10	Years 6 to 8 $90,000 for excavation $12,000 for 3 years of monitoring.	$21,000

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Kinbasket, Revelstoke, and Arrow Lakes Reservoirs Multi-Year Management Strategy to Address Access to and Monitoring of Significant Sites	Determine preferences of interested First Nations in treatment options for discovered archaeological sites and develop an effective, acceptable management plan.	Each approach to preserving archaeological sites has different drawbacks, benefits and long term consequences. Interested First Nations will need to be involved in developing the appropriate approaches.	N/A	Years 5 to 7	$10,000	$1,600
Program 2 - Total Estimated Cost						**$35,600**

Table CC-4: Proposed Revelstoke Flow Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Mid Columbia River Physical Habitat Monitoring	Annual monitoring of the physical habitat impacts of operations (temperature, stage, total gas pressure (TGP), electrochemistry and nutrients). Includes installation of data logger in Revelstoke Reach. (Includes temp and TGP monitoring in the Revelstoke sturgeon spawning area and in locations above and below major tributaries.)	Monitoring required to complete the linkage between operational change, physical habitat change, and ecological change for the experimental test of base flow releases from Revelstoke Dam.	Moderate	10 to 15	$40,000	$40,000
Mid Columbia River Ecological Productivity Monitoring	Annual monitoring of periphyton and benthic invertebrates to determine ecological health of the system.	Monitoring required to determine trophic status of mid Columbia River, and address uncertainty around the net change in trophic productivity and overall ecological health resulting from a min flow constraint. Will also address uncertainty about benefits of vegetation to increasing availability of terrestrial fish food organisms.	High to Moderate	10 to 15	$125,000	$125,000
Mid Columbia River Fish Population Index Surveys	Annual monitoring of abundance and biological characteristics of key index fish populations in the mid Columbia River (mountain whitefish, bull trout) during an experimental test of Revelstoke base flows.	Compliance monitoring to ensure no decline in abundance of selected key species resulting from min flow constraint. Will provide for experimental assessment of the response of whitefish and bull trout populations to base flow releases from Revelstoke Dam.	High	10 to 15	$150,000	$150,000
Mid Columbia River Juvenile Fish Habitat Use	Assessment of changes in the use of habitats in the mid Columbia River by juvenile and sub-adult fish associated with the changes to Revelstoke base flows and Arrow Lakes Reservoir maximum elevation.	Monitoring required to address uncertainty about current utilization of mainstem and tributaries to mid Columbia River to meet critical life history requirements (juvenile fish rearing). Will also address uncertainty around whether the minimum flow results in habitat improvements that increase the quality of physical habitats for juvenile fish rearing.	Moderate	5	$70,000	$37,806

Study	**Description**	**Rationale**	**Expected Amount of Learning**	**Estimated Duration (years)**	**Estimated Annual Cost**	**Annualized Cost (over 15 years)**
Mid Columbia River Adult Habitat Use Assessment	Annual surveys to document behavioural (diel and seasonal) response of key adult fish species to flow changes from Revelstoke Dam. Determine utilization of the mainstem and tributaries to mid Columbia to meet critical life history requirements (rainbow trout spawning).	Study required to determine extent to which fish populations are open/closed (i.e., how much they rely on the mid Columbia River to satisfy critical life history functions), and to assess flow dependent catchability of fish to allow more precise estimates of fish abundance to be obtained.	High	5 2 years baseline followed by 3 years post treatment	$150,000	$69,970
Total Estimated Cost						**$422,776**

Table CC-5: Proposed Mid Columbia River White Sturgeon Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Option A						
Mid Columbia River White Sturgeon Spawning Habitat Assessment	Conduct detail hydrometric surveys of the mid Columbia River in locations of known sturgeon spawning and other locales.	Study required to validate assumptions used in setting sturgeon spawning flows, and to determine spawning ground habitat requirements for sturgeon for future rehabilitation activities.	Moderate	2	$80,000	$16,667
Mid Columbia River Juvenile Sturgeon Detection and Habitat Use Program	Annual surveys and telemetric assessment of patterns of habitat use to determine the presence or absence of juvenile sturgeon in the mid Columbia River. Includes tagging and tracking of hatchery juveniles.	Study required to address uncertainty about presence of juvenile sturgeon in mid Columbia River, and whether habitats are sufficient to allow recruitment of larvae to age 1+. Will also address uncertainty whether the flow treatment provides for suitable habitats for the successful recruitment.	High	10	$125,000	$97,992
Mid Columbia River Tracking of existing sonic tagged sturgeon	Seasonal (June to September) tracking of existing tagged sturgeon to determine staging and spawning habitat preferences and identify movements into staging and spawning areas near Revelstoke.	Existing sonic tags will require additional seasonal tracking until transmitters are no longer functional. Expected life span of these tags suggests this work will be required from 2004 through until 2007/08.	High	1 to 2	$55,000	$11,459
Mid Columbia River Sturgeon Egg Substrate Mat Monitoring and Underwater Videography Feasibility Study	Expansion of the existing substrate mat program to assess the longitudinal and cross-sectional distribution of eggs. Will be required beyond Phase I to detect spawning and possibly for egg collection purposes related to research and conservation aquaculture. Feasibility and design assessment of underwater videography for detecting pre-spawning and spawning sturgeon.	Substrate mats have been deployed in recent years to determine if spawning occurs. Information from the expanded program will assist in evaluating the impact of different flow scenarios on egg and larval stranding. Underwater videography requires additional feasibility and design assessment, focusing on fixed cameras as opposed to mobile ROV. If feasible, this would provide an alternative non-invasive method of spawner detection to capture and tagging of females.	High	10	Years 1 to 2 $80,000 + $55,000 Years 3 to 10 $30,000 to $80,000	$74,173
Mid Columbia River Sturgeon Genetic Assessment	Continuation of ongoing genetic assessment work to determine levels of stock differentiation in Arrow Lakes Reservoir and the lower Columbia River. This work is a prerequisite to large-scale fish culture operations targeting release to the Arrow Lakes Reservoir.	Ongoing genetic assessment work expected to be complete by spring 2004. However, there is a possibility that inconclusive results will suggest the need for additional sampling and/or related lab work to finalize direction on the need to address Arrow Lakes Reservoir separately.	High	1	$30,000	$3,246

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Kinbasket Reservoir Sturgeon Recolonization Risk Assessment and Habitat Suitability Study	Investigation of the ecological risks of conservation aquaculture efforts in Kinbasket Reservoir. This would include assessment of habitat suitability for all life phases and development of an aquaculture strategy.	Assessment required to support decision making around whether Kinbasket Reservoir and upper Columbia River is a suitable alternative recovery area.	High	3	Years 3 to 5 $50,000	$12,906
Mid Columbia River Sturgeon Incubation and Rearing Study	Assess impacts of low water temperatures on sturgeon egg and larval development with in situ and/or lab studies. Year 1 would include in situ work and development of plans and facilities required for lab-based experiments for implementation in Phase 2.	Will help to address uncertainty around factors limiting sturgeon recruitment in the mid Columbia River.	High	2	$90,000	$18,750
Total Estimated Cost						**$235,193**
Option B – Same as under Option A monitoring except for following additions and modifications of study duration						
Mid Columbia River Juvenile Sturgeon Detection and Habitat Use Program	Annual surveys and telemetric assessment of patterns of habitat use to determine the presence or absence of juvenile sturgeon in the mid Columbia River. Includes tagging and tracking of hatchery juveniles.	Program may need to be continued over the entire 10-year period if the decision is made to release juveniles in both the mid Columbia River and Kinbasket Reservoir.	High	8 to 10	$125,000	$97,992
Mid Columbia River Sturgeon Egg Substrate Mat Monitoring and Underwater Videography Feasibility Study	Expansion of the existing substrate mat program to assess the longitudinal and cross-sectional distribution of eggs to assist in evaluating the impacts of the minimum flow treatment on egg and larval stranding. Will be required beyond Phase I to detect spawning and possibly for egg collection purposes related to research and conservation aquaculture. Feasibility and design assessment of underwater videography for detecting pre-spawning and spawning sturgeon.	Substrate mat program or underwater videography required only as long as flow treatment is provided.	High	5 to 8	Years 1 to 2 $80,000+ $55,000 Years 3 to 8 $30,000 to $80,000	$65,169
Kinbasket Reservoir Juvenile Sturgeon Detection and Habitat Use Program	Annual surveys and telemetric assessment of patterns of habitat use of juvenile sturgeon in Kinbasket Reservoir. Includes tagging and tracking of hatchery juveniles.	Study required to address uncertainty about whether habitats are sufficient to allow recruitment of larvae to age 1+.	High	3	Years 8 to 10 $125,000	$21,960
Total Estimated Cost						**$248,149**

Table CC-6: Proposed Arrow Lakes Reservoir Operations Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Arrow Lakes Reservoir Burbot Life History and Habitat Use Assessment	Multi-year life history and habitat use studies to 1) fill data gaps on potential operating impacts on burbot populations in Arrow Lakes Reservoir, and 2) develop mitigative strategies to minimize adverse impacts.	Lack of data on the relative abundance, distribution, life history and seasonal patterns of habitat use of burbot precluded incorporation of concerns for burbot in the Columbia River water use planning process. Study will inform on the key hypothesized impact of reservoir operations (i.e., dewatering of spawning areas during drawdown in winter).	Low to Moderate	5	$100,000	$46,647
Arrow Lakes Reservoir Complete Digital Elevation Model	Obtain a complete Digital Elevation Model (DEM) for upper and lower Arrow Lakes Reservoir, as existing DEM covers only 3/4 of Revelstoke Reach, including aerial photographs (1:10,000 black and white).	Completion of the DEM will confirm that modelled results for Revelstoke Reach are applicable to the entire reservoir. It will also allow assessment of vegetation distribution by elevation bands (which will aid in determining subsequent vegetation status and trends and changes in fish and wildlife habitat quality under altered hydrologic conditions), and will provide essential information for other interests such as heritage and aquatic resources.	High	1	$280,000 (costs include aerial photography) (Year 1)	$30,289
Arrow Lakes Reservoir Aerial Photographs	Undertake colour aerial photographs at a scale of 1:5,000 for baseline vegetation mapping of Revelstoke Reach and vegetated areas of the upper and lower Arrow Lakes Reservoir.	Vegetation mapping of Arrow Lakes Reservoir is incomplete. Collection of colour photographs later in the growing season is required to map and measure vegetation density and distribution.	High	6	$35,000 (Years 1 to 5 and 10)	$18,220
Arrow Lakes Reservoir Inventory of Vegetation Resources	Mapping of vegetation and GIS analysis to assess vegetation distribution by elevation band. Year 1 to include identification and mapping of pocket riparian habitat around reservoir as potential wildlife habitat. This study would require the collection of aerial photography (as proposed above).	Vegetation mapping of Arrow Lakes Reservoir is incomplete due to lack of aerial photography and topographic information. The inventory will allow determination of subsequent vegetation status and trends in relation to altered hydrologic conditions, and the validity of untested assumptions about hydrologic impacts on vegetation. It will also allow identification of sites with potential to support wildlife habitat through enhancement works and vegetation management.	High	6	$125,000 (Year 1) $100,000 (Years 2 to 5 and 10)	$54,763
Arrow Lakes Reservoir Vegetation Composition and Analysis	Annual monitoring of changes in plant size, biomass, species composition and vigour in Arrow Lakes Reservoir in response to altered hydrologic conditions.	Monitoring will address uncertainties related to the relative importance of timing, duration and depth of inundation on vegetation within the drawdown, and multi-year stresses on vegetation survival.	High	6	$100,000 (Years 1, 5 and 10) $50,000 (Years 2 to 4)	$38,119

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Arrow Lakes Reservoir Plant Response to Timing and Duration of Inundation	Experimental study involving reciprocal field transplants and greenhouse culture to evaluate responses of plants of different ages (seedlings to mature plants) and species to altered hydrologic conditions.	Currently, insufficient data to determine the relative importance of timing and duration of inundation on plant survival at different sizes and ages. Study will address uncertainty related to importance of recruitment of seedlings in overall survival of plant community, and how a plant community can regenerate after being decimated by extreme inundation and the role of an established seed bank in its re-establishment.	High	5	$25,000 (Years 1 to 4) $50,000 (Year 5)	$13,650
Kinbasket and Arrow Lakes Reservoirs Nest Mortality of Migratory Birds due to Reservoir Operations	Annual monitoring in Arrow Lakes Reservoir to determine effects of reservoir operations in spring and summer on nesting success of breeding birds (including Species at Risk). To include nest searches in spring and summer. Monitoring Avian Productivity and Survivorship (MAPS) program proposed to be implemented concurrently to assess significance of mortality and allow a phasing in of physical works. Study in Kinbasket Reservoir will inform on impacts of current operations on nesting birds. Study would also inform on effectiveness of physical works on nesting success.	Currently, uncertainty related to magnitude and significance of nest mortality due to reservoir operations. Monitoring will inform on scope of physical works required to mitigate impact.	High	10	$300,000	$235,181
Arrow Lakes and Kinbasket Reservoirs Amphibian and Reptile Life History and Habitat Use Assessment	Multi-year life history and habitat use studies to evaluate operational impacts and effectiveness of wildlife physical works on reptiles and amphibians. This study needs to be undertaken concurrently with the development of pond designs for Arrow Lakes Reservoir.	Lack of data on the relative abundance, distribution, life history and seasonal patterns of habitat use by herptiles precluded incorporation of concerns for these species in the Columbia River water use planning process. Studies will provide information on operation-related impacts and possible mitigation strategies.	High	5	$75,000	$34,985
Arrow Lakes Reservoir Fall Migrating Shorebird Use of the Drawdown Zone	Multi-year life history and habitat use studies of migrating shorebirds in Revelstoke Reach. (Monitoring to include upper Arrow Lakes Reservoir from Drimmie Creek to Arrowhead.)	Currently, lack of data on the relative abundance, distribution and seasonal patterns of habitat use by migrating shorebirds. Studies will provide information on magnitude of impact of reservoir operations and possible mitigation strategies, if required.	High	10	$125,000	$97,992

Study	**Description**	**Rationale**	**Expected Amount of Learning**	**Estimated Duration (years)**	**Estimated Annual Cost**	**Annualized Cost (over 15 years)**
Arrow Lakes Reservoir Neotropical Migrant Use of the Drawdown Zone	Multi-year banding study of neotropical migrants at the Revelstoke Banding Station located at Machete Island. This would be a continuation of the Revelstoke Reach banding program and reporting.	Lack of data on the relative abundance, distribution and seasonal patterns of habitat use by neotropical migrants hindered incorporation of concerns for these species in Columbia River water use planning process. Study will inform on impacts of reservoir operations on neotropical migrants and possible mitigation strategies.	High	10	$80,000	$62,715
Arrow Lakes Reservoir Waterbird Monitoring	Continuation of collection of long-term trend data on the presence and relative abundance of waterbirds in Revelstoke Reach.	Lack of data on the relative abundance, distribution and seasonal patterns of habitat use by waterbirds precluded incorporation of concerns for these species in the Columbia River water use planning process. Study will inform on impacts of reservoir operations on waterbirds and possible mitigation strategies.	High	10	$20,000	$15,679
Arrow Lakes Reservoir Monitoring of effects of hydrologic regime on mosquito production	Investigate hydrology relating elevation to vegetation type and mosquito breeding grounds and compile historical climate data.	Monitoring required to evaluate effects of dam discharge on mosquito production at different reservoir levels and under different climatic conditions.	High	1	$20,000	$2,164
Arrow Lakes Reservoir Recreation Demand Study	Dynamic reservoir recreational demand estimation to develop performance measure scores that link all aspects of recreation (shoreline and boating) to reservoir levels, by local/tourist ranking.	Dynamic model will enable modelling of preference changes with alternatives.	High	5	$24,000 (Years 1 and 5) $85,000 (Years 2 to 4)	$28,201
Arrow Lakes Reservoir Monitoring Erosion Processes for Soils and Sediments Typifying Areas Containing Cultural Materials	Monitor rate of erosion of fine sediment cap in drawdown zone terrace. This work would be done in areas typifying sites of cultural resources.	Reservoir operation is causing deflation of cultural deposits in fine sediment cap of terraces in upper part of drawdown zone. Specific erosive and depositional processes and effects are not known.	High to Moderate	13	$18,000 set-up of 3 sites $135,000 data acquisition	$9,974
Total Estimated Cost						**$688,579**

Table CC-7: Proposed Arrow Lakes Reservoir Wildlife Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Study of High Value Wildlife Habitat Sites for Potential Enhancement	Surveys of specific areas identified as providing high value wildlife habitat to determine potential opportunities for protection and enhancement.		High	4	$100,000	$38,695
See also mosquito studies proposed under Arrow Lakes Reservoir Operation Monitoring Program. Need to address mosquito issue to enable habitat enhancement works to go forward.						
Effectiveness monitoring of physical works included within the study of Nest Mortality of Migratory Birds due to Arrow Lakes and Kinbasket Reservoir Operations (under Arrow Lakes Reservoir Operation Monitoring Program).						
Effectiveness monitoring of physical works included within Amphibian and Reptile Life History and Habitat Use Assessment in Arrow Lakes and Kinbasket reservoirs (under Arrow Lakes Reservoir Operation Monitoring Program).						
Effectiveness monitoring of physical works included within Kinbasket Reservoir and Arrow Lakes Reservoir Effectiveness Monitoring of Wildlife Physical Works and Revegetation (Kinbasket Reservoir Revegetation Monitoring Program).						
Total Estimated Cost						**$38,695**

Table CC-8: Proposed Lower Columbia Fish Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Lower Columbia River Fish Stranding Assessment and Ramping Protocol Development	Planned and opportunistic tests and monitoring to establish Hugh Keenleyside Dam down ramping impacts and mitigative procedures. The goal of this study is to examine alternative ramping rates during declining flows from Hugh Keenleyside Dam to determine the biological significance of interstitial fish stranding. A broad range of ramping rates will be explored during the first phase of this study and, if definitive results are achieved from this range of flows, subsequent trials will be completed to narrow this range.	Uncertainty about the impacts of flow reductions on fish populations. Study to inform on operational procedures to mitigate ramping impacts.	Moderate	10 to 15	$180,000	$180,000
Lower Columbia River Sculpin and Dace Life History Assessment	Synoptic study to establish relative abundance, distribution, life history and patterns of habitat use of sculpin and dace. Field work to establish spawning timing, and lab studies to determine how physical factors alter diel behaviour with field verification.	Lack of appropriate biological information precluded explicit consideration of shallow water dwelling threatened and endangered fish species during the Columbia River water use planning process.	Moderate	5	$75,000	$34,985
Lower Columbia River Physical Habitat Monitoring	Annual monitoring of the physical habitat impacts of operations (temperature, stage, total gas pressure (TGP), electrochemistry and nutrients).	Monitoring required to complete linkage between operations, physical habitat and ecological health.	Moderate	10 to 15	$25,000	$25,000
Lower Columbia River Ecological Productivity Monitoring	Annual monitoring of periphyton and benthic invertebrates to determine ecological health of system.	Monitoring will inform on trophic status of the lower Columbia River. Will address uncertainty regarding the net change in trophic productivity and overall ecological health of river resulting from operations.	High to Moderate	10 to 15	$100,000	$100,000

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Lower Columbia River Fish Population Index Surveys	Annual monitoring of abundance and biological characteristics of key index fish populations in the lower Columbia River (mountain whitefish, rainbow trout and walleye).	Compliance monitoring to ensure no decline in abundance of selected key species. Monitoring also linked to assessing response of whitefish and rainbow trout populations to flow modifications. Allows evaluation of interannual trends in growth and distribution, quantification of annual recruitment rates and anomalies, and development of functional relationships between recruitment and seasonal flow indices.	High	10 to 15	$150,000	$150,000
Lower Columbia River Rainbow Trout Spawning Assessments	Annual monitoring of the relative abundance, distribution, spawning site selection, and timing of rainbow trout spawning in the lower Columbia River.	Annual monitoring is required to assess the response of rainbow trout to variable flows prior to and during the spring spawning period to optimize winter-spring flow changes that optimize survival of rainbow trout and whitefish.	High	10 to 15	$35,000	$35,000
Lower Columbia River Whitefish Spawning Grounds Topographic Surveys	Detailed topographic surveys of index spawning locations.	Current topographic survey data are crude, which reduces precision and accuracy of egg loss estimates. Data would be used to refine the hydraulic component of egg loss model.	High	2	$100,000	$20,834
Lower Columbia River Whitefish Egg Monitoring	Weekly egg mat sampling during spawning season at index spawning locations to quantify annual variation in key assumptions of the egg loss model and to refine biological parameter estimates.	Will inform on key hypothesis that flow stabilization reduces egg loss rates. Data will refine understanding of spawning timing and seasonal changes in vertical distribution of developing eggs.	High	5	$75,000	$34,985
Lower Columbia River Whitefish Life History Study	Multi-year life history study to fill data gaps on the impacts of the flow regime on whitefish in the lower Columbia River.	Currently, a lack of information on distribution patterns and life history of whitefish. Better data required to assess link between flow regime and adult population abundance.	High	5	$75,000	$34,985

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Lower Columbia River Effect of Whitefish Flows on Great Blue Heron Winter Use of Waldie Island	Monitoring of the effects of winter flows and river stage (15 November to 1 March) on Great Blue Heron use of the Waldie Island Area (replication of Pandion Study).	Monitoring required to assess the response of heron to flow and stage regime from the Hugh Keenleyside Dam during the winter period due to its potential effects on availability of shallow-water foraging and winter refuge habitats. Will provide information on habitat use and feasible mitigative actions.	High	3 (opportunistic when elevation at Waldie Island expected to exceed 421 m)	$30,000	$8,413
Lower Columbia River Winter Use of Waldie Island by Great Blue Herons Nesting adjacent to Revelstoke Reach	Mark and recapture study of Great Blue Herons (juveniles) nesting in colony adjacent to Revelstoke Reach to determine whether birds from this population winter at Waldie Island (15 November to 1 March).	Uncertainty related to the importance of Waldie Island as a wintering area for the Great Blue Herons that nest near Revelstoke. Address question around whether these represent the same individuals that may be susceptible to influences of both reservoir and downstream flow operations.	High	5	$50,000	$23,323
Total Estimated Cost						**$647,525**

Table CC-9: Proposed Lower Columbia White Sturgeon Monitoring Program

Study	Description	Rationale	Expected Amount of Learning	Estimated Duration (years)	Estimated Annual Cost	Annualized Cost (over 15 years)
Lower Columbia River Adult Sturgeon Population Monitoring	Annual monitoring the abundance, biological characteristics and reproductive status of sturgeon in the lower Columbia River.	Monitoring is required to follow trends in abundance resulting from non-operational changes to ensure that adopted change does not result in a decline in population abundance. Also required to document the reproductive status and frequency of spawning events in the lower Columbia River to better understand factors influencing population processes.	High	10 to 15	$150,000	$150,000
Lower Columbia River Juvenile Sturgeon Detection Program	Annual monitoring the relative abundance and distribution of juvenile sturgeon in the lower Columbia River.	Monitoring is required to determine if adopted non-operational change results in the natural recruitment of age 1+ sturgeon. Monitoring to determine abundance and survival of hatchery supplemented juvenile sturgeon under the adopted change. Will also provide information on the patterns of habitat use of juvenile sturgeon to better understand potential cause of recruitment failure and feasible mitigative actions.	High	10	$125,000	$97,992
Planning and Assessment of White Sturgeon Turbidity Experiment in the Lower Columbia River	Studies in support of implementing the turbidity experimental plan in the lower Columbia River (regulatory issues, feasibility assessment, toxicity tests, turbidity modelling).	Review and consultation will be required to ensure that legal and regulatory issues around adding bentonite to the river are considered before a decision is made on the feasibility of the experimental program. Feasibility assessment will be required to ensure that impacts on other interests are considered in decision making.	High	2	$50,000	$10,417
Opportunistic Assessment of high flow events (200 kcfs at the United States border)	Studies undertaken on an opportunistic basis to assess the impacts on high flow (spawn detection, water quality sampling). Costs would include planning and co-ordination.	Study required to assess response of sturgeon to high flow events.	High	2	$75,000	$15,625
Total Estimated Cost						**$274,034**

APPENDIX DD: PHYSICAL WORKS FOR WILDLIFE IN THE REVELSTOKE WETLANDS

1.0 Background

At the November 2003 meeting, the Consultative Committee agreed that physical works options needed to be developed to help mitigate impacts associated with nest inundation caused by rising Arrow Lakes Reservoir water levels during the late spring/early summer period. To address this, members of the Fish and Wildlife Technical Subcommittee (Susan Hall, Janice Jarvis) and a BC Hydro natural resource specialist (Brian Gadbois) identified 42 potential sites within the Revelstoke Wetlands (from the Revelstoke townsite to Shelter Bay) where habitat enhancement works could be undertaken to benefit wildlife habitat in general and, more specifically, improve habitat condition for nesting and migratory birds. Four different types of physical works were proposed:

- Stabilization of areas through development of berms.
- Creation of pocket wetland habitat and backchannel habitat through installation of water control structures.
- Protection of nesting habitat through creation of higher elevation points of land.
- Non-traditional terracing.

The intent of the latter works is to try small-scale experimental terracing to create wetland habitat. A number of areas were also identified for potential enhancement based on the fact that they provide high value wildlife habitat. However, it was recognized that without further study of these areas, it remained uncertain what specific works could be reasonably undertaken.

This appendix outlines the intended objective of each of the proposed concepts with estimated costs, and their potential benefits and risks. Location-specific information is provided in an accompanying table (Table 2), and map set. It should be noted that these concepts are considered preliminary in nature. Further discussions with experts will be required to identify and develop other feasible cost-effective approaches to improving wildlife habitat in the area.

2.0 Proposed Physical Works Options

Berms

A series of berms have been proposed along the east and west banks of mid Columbia River as a means of stabilizing water levels in areas of known/suspected nesting use by waterbirds and general wildlife values (winter and spring ungulate range). The intent would be to delay the ingress of water by about two weeks until late June/early July, with the primary goal of enhancing small areas of nesting habitat and improving nest survival for early to mid season breeding birds. This would provide for a diversity of wildlife habitat through creation of both elevated lands along the berm itself, as well as productive ponds/riparian habitat behind the berm created by the removal of material for berm construction.

At present, there is considerable uncertainty around the feasibility of such a system given the permeability of the substrates and the effectiveness of the berm in holding water back as reservoir levels rise. There is also uncertainty related to permitting requirements and other regulatory issues associated with its construction. It was agreed by members of the Fish and Wildlife Technical Subcommittee that the berm concept would only be an acceptable enhancement option if use was made of existing structures (e.g., old railbed).

Water Control Structures

Some 25 sites have been identified as having the potential for enhancement of wetland, riparian and large river habitats through backflooding using a variety of water control structures (e.g., culverts and other passive designs). The intent would be to retain water in natural backchannel areas that tend to dewater during low water periods and low water years. It is expected that these types of works would provide benefits to fish, birds and other wildlife species.

Unlike berm development that would only protect the small area behind the berm for a short period of time, water control structures would provide more permanent wetland areas. However, these would only be productive if the adjacent grasslands continue to survive and provide the needed associated habitat (i.e., an annual reservoir operation that maintains existing grasslands).

Creation of Elevated Lands

It was agreed that major engineered structures would not be a feasible approach to mitigate nesting failure as a result of rising Arrow Lakes Reservoir water levels, and that there was a need to focus on smaller scale works that would be less intrusive than development of nesting islands. A select number of site-specific areas have been identified as high priority sites for protection/enhancement based on either known or suspected nest mortalities in past years or high nesting use, recognizing that further study would likely identify additional opportunities for similar works elsewhere in the mid Columbia River. Numerous areas within the valley could be reshaped to raise some of the land while lowering other portions to benefit bird habitat.

The intent of these proposed works is to create source nesting habitat by increasing the elevation of existing high points of land by several metres. While it is uncertain how many species and birds are likely to benefit from creating higher elevation nesting habitat, it is estimated that only one to two breeding pairs of Northern Harriers or Short-Eared Owl, or five to six pairs of a smaller waterbird species per site would likely benefit, given the small size of these areas.

3.0 Adaptive Approach to Implementing Physical Works

Given the high degree of uncertainty related to the feasibility of the proposed concepts, it was recommended that an adaptive approach be adopted to provide flexibility and opportunity for ongoing discussions in the formulation and implementation of the wildlife physical works. It was suggested that a committee be established to further develop options for physical works beyond those proposed to date. Further, it was acknowledged that feasibility/risk assessments, detailed planning studies and public consultation would need to be undertaken to address engineering design, questions around soil permeability and potential impacts on other interests (i.e., private lands, recreation, vegetation, wildlife, fish, mosquito production), and regulatory and permitting issues.

If found to be feasible and cost effective, pilot projects could be implemented to determine the success/benefits of these works in providing wildlife, nesting/migratory bird and fish habitat. Sites considered having a high probability of success were identified as potential candidates for the experimental trials; however, it was recognized that alternate more preferable areas might be identified through additional study. These included:

- Sites #9, 10, 19 and 20: Protection of nesting habitat through creation of higher elevation land.
- Site #5: Development of a small section (about 3 km) of berm from Montana Slough to Cartier Bay.
- Sites #12, 15 and 16: Installation of water control structures to demonstrate success in developing/enhancing backchannel habitat.

4.0 Estimated Costs

Construction of Works

BC Hydro Engineering provided cost estimates for construction of each of the proposed physical works options (Attachment 1).

1. Berms: $4–6 million/km

   This was based on the assumption that the structures would need to be protected by rockfill (from a local quarry), which would be delivered to the sites by tow barge from the Revelstoke area.

2. Water Control Structures: $25,000–35,000/site

   This assumes that the structures would be in the form of a small berm or dike located at the entrance of inlets of the backchannels, and would be typically no more than 1.5 m high by about 4–5 m wide (although a few areas may require berms 10–15 m in width). It also assumes that the structures would need to be protected by rockfill provided by a local quarry, and that delivery of the rockfill may need to be made by tow barge from the Revelstoke area.

3. Creation of Elevated Lands: $20,000–30,000/1,000 m^2 per 1 m of height

   Estimated costs assumed use of local materials (i.e., removed from adjacent areas as part of other habitat enhancement works), and the need for protection using rockfill. This would be delivered to the sites by tow barge from the Revelstoke area.

Feasibility and Planning Studies

Based on information provided by BC Hydro Engineering, the planning/feasibility studies are estimated to cost about one to two per cent of the total capital cost of the works if these works are assessed as one package. (Costs could be as high as 15–20 per cent of total project cost if assessed as individual projects.) The study would include engineering (geotechnical, civil and hydrotechnical), environmental, and economic benefit and cost analysis at a minimum.

These cost estimates are based on hard-engineered structures and, therefore, are considered conservative. While effective lower cost options might be identified through the planning/feasibility studies, implementing these physical works for substantially lower costs would only be possible if a third party was to assume responsibility for the construction, maintenance and liability of these works. Rough cost estimates for more soft-engineered structures were provided by Janice Jarvis, Susan Hall and Brian Gadbois, as follows:

Berm: $1–2.5 million/km

Water Control Structures: $5,000–10,000 (depending on the site)

Creation of Higher Land: $5,000–20,000 (depending on the site)

Terracing: $5,000–50,000

Table 1: Proposed Wildlife Physical Works for Revelstoke Wetlands

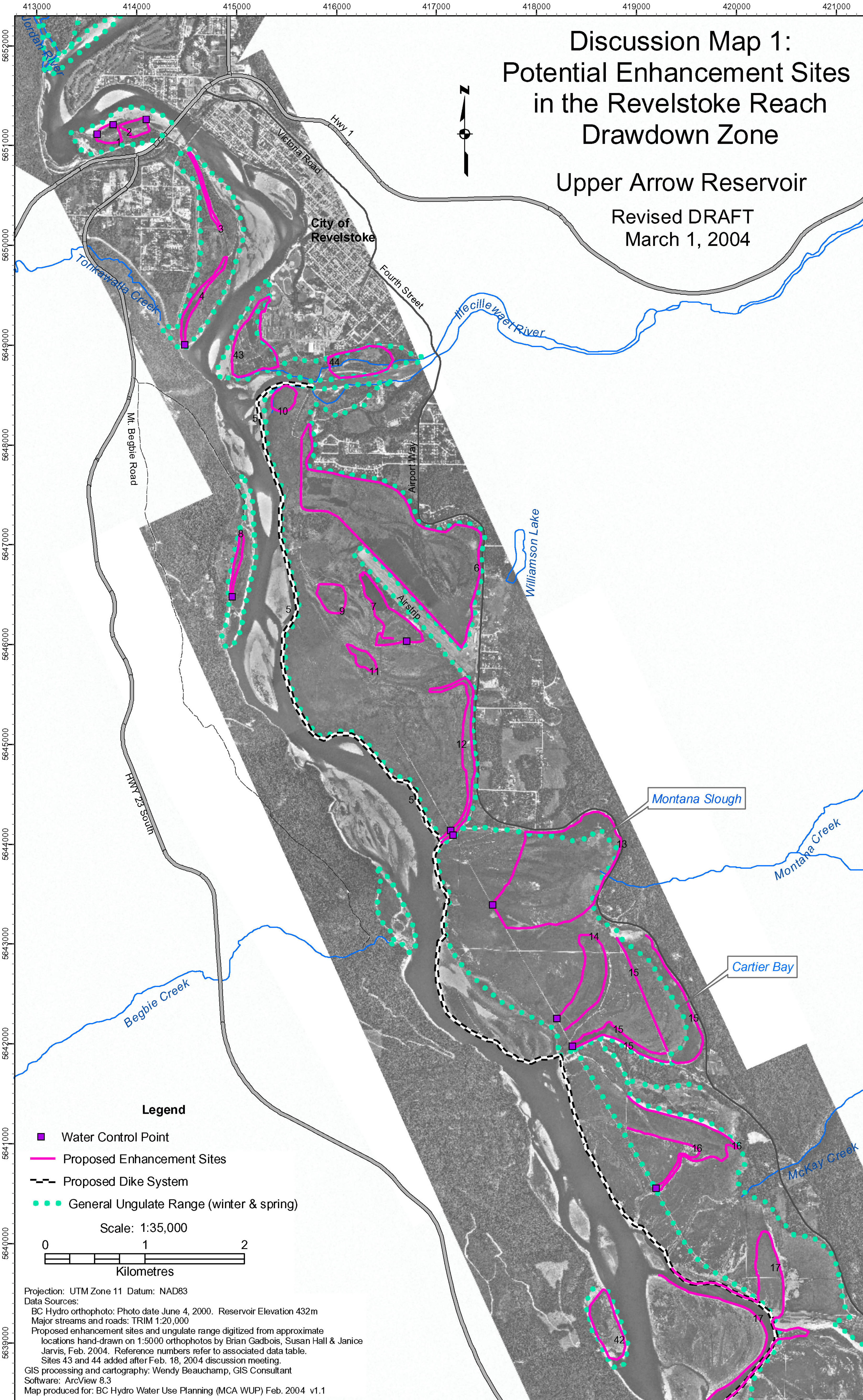
Importance	Number	Enhancement Option	Potential Benefits	Est. Area (ha)	Est. Length (km)	Risks/Issues
BERM DEVELOPMENT (Considered works in lieu of keeping reservoir lower for longer)						
	2	Small dike to link up to existing dike in river.	Create small pond habitat in drawdown zone by completing dike in area with a water control structure to retain water. Considered works in lieu of keeping reservoir higher longer.	3.5		Need to consider permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water. Permit would be required.
	5	Berm from Illecillewaet River to Greenslide Creek – Potential length of 24 km; could be divided into 6 sections for development with first section roughly 4.5 km. Would increase present elevation by about 4 m. Would require managed control structure.	Stabilize the Revelstoke Reach area, while providing various elevated lands and productive ponds year round. Berm would delay inundation until late June/early July (about 2 weeks) to improve nesting habitat for early and mid season breeding birds, as well as to create diversity of wildlife habitat. Use material in area to create higher elevations along dike area, while creating ponds. Design would include ponds/riparian habitat that would benefit all wildlife (e.g., contours that allow access for mammals and habitat for foraging and nesting water birds). Could utilize old railway bed as opposed to following old river bank.		16.7	Engineering feasibility and hydrology review required. Need to consider effect of tributary inflow on water levels, as well as permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water. Has not been discussed with the airport authority. Unlikely to get approval to undertake bird habitat enhancement around airport.
	21	Berm to protect area – Potential length of 6 km. Would require managed control structure.	Stabilize area while providing various elevated lands and productive ponds year round. Berm would delay inundation until late June/early July (about 2 weeks) to improve nesting habitat for early and mid season breeding birds, as well as to create diversity of wildlife habitt. Use material in area to create higher elevations along dike area, while creating ponds. Design would include ponds/riparian habitat that would benefit all wildlife (e.g., contours that allow access for mammals and habitat for foraging and nesting water birds).		6.5	Crown land, approval required. Need to consider permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water.
	25	Berm – Would require managed control structure.	Enhance existing backchannel.		4.5	Management of cattle grazing in area needs to be examined. Need to consider permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water.
	31	Berm – Would require managed control structure.	Stabilize willow/grassland complex, while providing various elevated lands and productive ponds year round. Berm would delay inundation until late June/early July (about 2 weeks) to improve nesting habitat for early and mid season breeding birds, as well as to create diversity of wildlife habitat. Use material in area to create higher elevations along dike area, while creating ponds.		4.7	Little known about the area. Next mortality not studied. Need to consider permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water.

Importance	Number	Enhancement Option	Potential Benefits	Est. Area (ha)	Est. Length (km)	Risks/Issues
	37	Berm – Would require managed control structure.	Create/protect vital river valley bottom habitat.		3.2	Need to consider permeability of substrates in determining feasibility of dike. Uncertainty around whether structure would be effective in retaining water.
WATER CONTROL STRUCTURES (Considered a works in lieu of operation to keep reservoir higher longer						
1	1	Two water control structures (culverts) – Area has two channels that allow flooding/dewatering of area. Structures would retain water in the backchannel.	Create wetland/sidechannel habitat in this area year round for fish, birds and other wildlife. Currently there is some fish stranding that occurs in this area, which could also be mitigated through backflooding. Neither sedimentation or erosion should be an issue.	3.6		Ownership and maintenance – recontouring of existing land required. Crown land, approvals required.
	4	Install water control structure at downstream end to retain water in channel	Create more wetland/sidechannel habitat by providing constant water in area. Would provide permanent year round wetted area for fish and waterfowl habitat.			
	6	Stabilize road with culvert.	Area dewaters at 2–3 locations where old roadway has washed out. Wetland area dries up in low water years. Culvert on roadway would retain water to enhance pond habitat.	132.2		Has not been discussed with the airport authority. Unlikely to get approval to undertake bird habitat enhancement around airport.
	7	Culvert to hold water.	Enhancement of existing ponds through stabilization of water levels during dry years.	15.8		Has not been discussed with the airport authority. Unlikely to get approval to undertake bird habitat enhancement around airport.
	8	Culvert to hold water.	Stabilize ponds in dry years. Potential to create backchannel through recontouring of outflow of channel to hold back water.	2.6		Uncertainty around permeability of substrates.
	12	Water control structure – Placement of passive control structure in existing culvert to retain water.	Area naturally fed by drainage from around airport (lake water and local inflow). Control structure would protect and enhance wetland by keeping water in area in low water years.	12.1		Uncertainty around permeability of substrates.
	13	Water control structure – At old railway bed to hold water back.	Protect and enhance wetland by managing water in low water years.	94		
	15	Water control structure with potential to undertake some experimental terracing in area.	Natural backchannel fed by small tributaries in spring, but dewaters in low water years. Control structure would provide for more stable water levels and enhance wetland in area.	54.4		Some privately owned land in south corner of site.
	16	Water control structure – At old railway bed to hold water back.	Natural backchannel fed by small tributaries in spring, but dewaters in low water years. Control structure would provide for more stable water levels and enhance wetland in area.	28.6		

Importance	Number	Enhancement Option	Potential Benefits	Est. Area (ha)	Est. Length (km)	Risks/Issues
	17	Water control structure – At old railway bed to hold water back.	Natural backchannel of the Columbia River. Control structure would limit outflow of water to maintain permanent wetted area during low water areas. Would create wetland/sidechannel habitat.	42.3		
	18	Water control structure.	Backchannel outflows under the old railway tracks through an old wooden culvert. Control structure would maintain permanent wetted area during low water areas. Would create wetland/sidechannel habitat.	6.4		
	22	Water control structure.	Elevation of site is below 434 m. Control structure would create wetland/sidechannel habitat during low water years. Deep backchannel along the base of the mountain.	5.1		
	23	Water control structure.	Small drainage area fed by Blanket Creek, which receives considerable use by staging waterfowl. Control structure would maintain wetted area.	9.8		
	27	Water control structure – Linked with #28 to backwater area.	Backwater area to create wetland/sidechannel habitat.	42.3		
	28	Water control structure – Linked with #27 to backwater area.	Backwater area to create wetland/sidechannel habitat.	1.9	1.9	
	29	Water control structure – Old railway bed along the east side of reservoir. Needs to be done in conjunction with #30.	Backwater area to create wetland/sidechannel habitat.	2.3	2.3	
	30	Water control structure – Old railway bed along the east side of reservoir. Needs to be done in conjunction with #29.1	Backwater area to create wetland/sidechannel habitat.	2.2	2.2	
	32	Water control structure.	Control structure would provide for more stable water levels and enhance existing wetland in low water years. Considered a works in lieu of operation to keep reservoir higher.	4.5		
	33	Water control structure.	Control structure would improve riparian area through backwatering. Considered a works in lieu of operation to keep reservoir higher.	17.4		
	35	Water control structure.	Natural backchannel along side of the mountain. Control structures would create a more permanent wetted area.	4.5		
	36	Water control structure.	Natural backchannel along side of the mountain. Control structures would create a more permanent wetted area.	11.9		

Importance	Number	Enhancement Option	Potential Benefits	Est. Area (ha)	Est. Length (km)	Risks/Issues
	38	Water control structure.	Control structure would create a more permanent wetted area in a natural backchannel area during low water years.	1.4		
	39	Water control structure.	Control structure would create a more permanent wetted area in a natural backchannel area during low water years.	3.8		
	40	Water control structure – At old railway bed to hold water back.	Control structure would create a more permanent wetted area in a natural backchannel area during low water years.	8.1		
	43	Water control structure and shoreline profiling.	Water management technique to elevate water levels in existing basin over short term. Shoreline profiling to improve development of wetland vegetation. Area used extensively by waterfowl during migration period.	19.4		
	44	Partial stream diversion.	Partial diversion of the Illecillewaet to elevate water levels in some existing basins to provide conditions for wetland development.	15.1		Illecillewaet Greenbelt Society holds Crown lease. Would require regulatory approval and permitting.
RAISE LEVEL OF LAND (Considered works in lieu of keeping reservoir lower for longer)						
1	9	Increase elevation by 1–2 m to achieve target of 440 m.	Raise level of existing high elevation land to protect important nesting habitat for short-eared owls (area of past nesting mortality). Less intrusive than nesting islands.	6.7		
1	10	Increase elevation by about 1 m to achieve target of 438 m.	Enhance nesting area for ground nesting owl, raptors and other birds. Less intrusive than nesting islands.	4.8		
1	19	Raising level of land.	Could create nesting habitat for ground nesting birds (e.g., owls, sparrows, meadowlarks). Less intrusive than nesting islands. Riprap may not be necessary as site is in backchannel area where wind and wave action may not be as much of a concern. Could provide habitat for one owl nest or 5–6 nests of smaller birds.	13.6		Uncertainty around number of breeding pairs this would benefit. Need for breeding bird surveys.
1	20	Raising level of land.	Could create nesting habitat for ground nesting birds (e.g., owls, sparrows, meadowlarks). Less intrusive than nesting islands. Riprap may not be necessary as site is in backchannel area where wind and wave action may not be as much of a concern. Could provide habitat for one owl nest or 5–6 nests of smaller birds.	10.4		Uncertainty around number of breeding pairs this would benefit. Need for breeding bird surveys.
NON-TRADITIONAL TERRACING						
1	14	Non-traditional terracing – Raise land around existing terrace and deepen to create wetland.	Enhance wetland in area. Considered a works in lieu of operation to keep the reservoir higher.	20.2		
		See also Site #15.				

Importance	Number	Enhancement Option	Potential Benefits	Est. Area (ha)	Est. Length (km)	Risks/Issues
GENERAL ENHANCEMENT						
	3	Deepen channel.	Create more wetland/sidechannel habitat by providing constant water in area. Would provide for fish and waterfowl habitat.	2.1		Requires RCMP review. RCMP have proposed works in efforts to reduce access and vandalism to area.
1	11	Enlarge pond (to be done in conjunction with Sites #9 and 10).	Improve riparian habitat. Material removed from area could be used to increase elevation of Sites #9 and 10 for enhancement of owl nesting habitat.	3.6		
	24	Enhancement of area – Work with BC Hydro lease holder to encourage wildlife use of area.	High elevation terrace of land that does not flood. High wildlife valued area, but uncertain what can be done.	32.6		BC Hydro, Private and Crown lands. BC Hydro has leased land for grazing. Off-site enhancement – outside scope of Water Use Plan.
	26	Enhancement of area.	Low elevation grassland and backchannel area that could possibly be enhanced through installation of water control structures, elevating some land, or vegetation enhancement. Equivalent to Machete Island. Considered to be a higher priority area. No public use of this area.	102.8		Uncertain around what habitat enhancement works could be undertaken. Needs further study.
	34	Enhancement of area.	Create better riparian zone, which is used by numerous wildlife at various times of year.	21.7		Uncertain around what habitat enhancement works could be undertaken. Needs further study.
	41	Enhancement of area.	High value grassland area for wildlife. Potential to work with landowner.	7.4		Private land owners. High wildlife value, but uncertain what potential opportunities exist for enhancement. Needs to be studied further. Inaccessible for most of the time.
	42	Enhancement of area.	High value wildlife area. Potential to work with landowner to enhance wetland area through re-design of banks or creation of backwater area.	14		Private land owners. High wildlife value, but uncertain what potential opportunities exist for enhancement. Needs to be studied further. Inaccessible for most of the time.
	43	Enhancement of area.	Downie Mill.	19.4		
	44	Enhancement of area.	Illecillewaet Greenbelt Belt	15.1		


Discussion Map 1:
Potential Enhancement Sites
in the Revelstoke Reach
Drawdown Zone
Upper Arrow Reservoir
Revised DRAFT
March 1, 2004
N
City of Revelstoke
Hwy 1
Victoria Road
Fourth Street
Airport Way
Airstrip
Mt. Begbie Road
HWY 23 South
Jordan River
Tonkawatla Creek
Illecillewaet River
Williamson Lake
Montana Slough
Montana Creek
Cartier Bay
Begbie Creek
McKay Creek
Legend
Water Control Point
Proposed Enhancement Sites
Proposed Dike System
General Ungulate Range (winter & spring)
Scale: 1:35,000
0
1
2
Kilometres
Projection: UTM Zone 11 Datum: NAD83
Data Sources:
BC Hydro orthophoto: Photo date June 4, 2000. Reservoir Elevation 432m
Major streams and roads: TRIM 1:20,000
Proposed enhancement sites and ungulate range digitized from approximate locations hand-drawn on 1:5000 orthophotos by Brian Gadbois, Susan Hall & Janice Jarvis, Feb. 2004. Reference numbers refer to associated data table.
Sites 43 and 44 added after Feb. 18, 2004 discussion meeting.
GIS processing and cartography: Wendy Beauchamp, GIS Consultant
Software: ArcView 8.3
Map produced for: BC Hydro Water Use Planning (MCA WUP) Feb. 2004 v1.1
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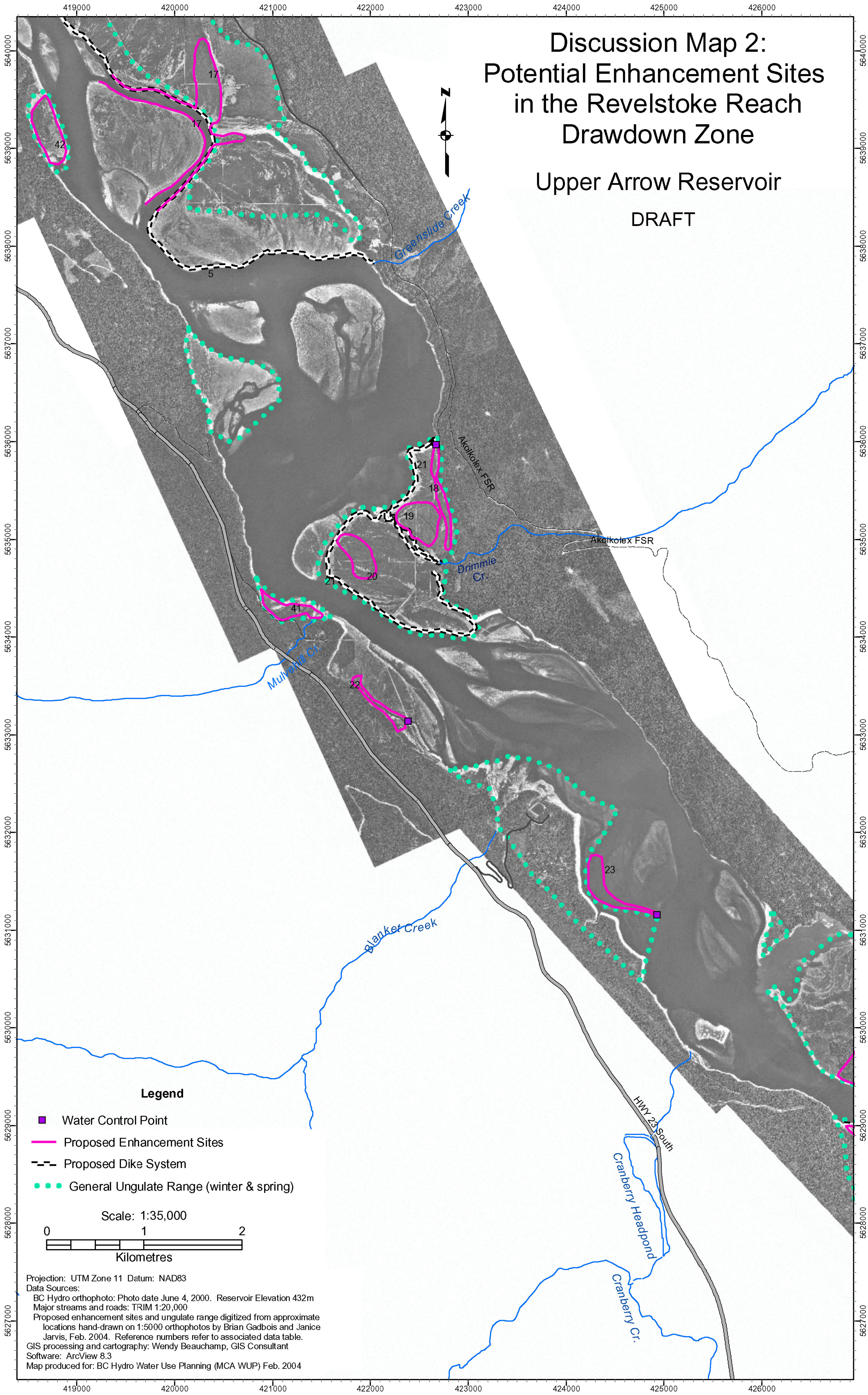
Discussion Map 2:
Potential Enhancement Sites
in the Revelstoke Reach
Drawdown Zone
Upper Arrow Reservoir
DRAFT
N
Greenslide Creek
Akolkolex FSR
Akolkolex FSR
Drimmie Cr.
Mulvehill Cr.
Blanket Creek
HWY 23 South
Cranberry Headpond
Cranberry Cr.
17
17
42
5
21
18
19
20
21
41
22
23
Legend
Water Control Point
Proposed Enhancement Sites
Proposed Dike System
General Ungulate Range (winter & spring)
Scale: 1:35,000
0
1
2
Kilometres
Projection: UTM Zone 11 Datum: NAD83
Data Sources:
BC Hydro orthophoto: Photo date June 4, 2000. Reservoir Elevation 432m
Major streams and roads: TRIM 1:20,000
Proposed enhancement sites and ungulate range digitized from approximate locations hand-drawn on 1:5000 orthophotos by Brian Gadbois and Janice Jarvis, Feb. 2004. Reference numbers refer to associated data table.
GIS processing and cartography: Wendy Beauchamp, GIS Consultant
Software: ArcView 8.3
Map produced for: BC Hydro Water Use Planning (MCA WUP) Feb. 2004
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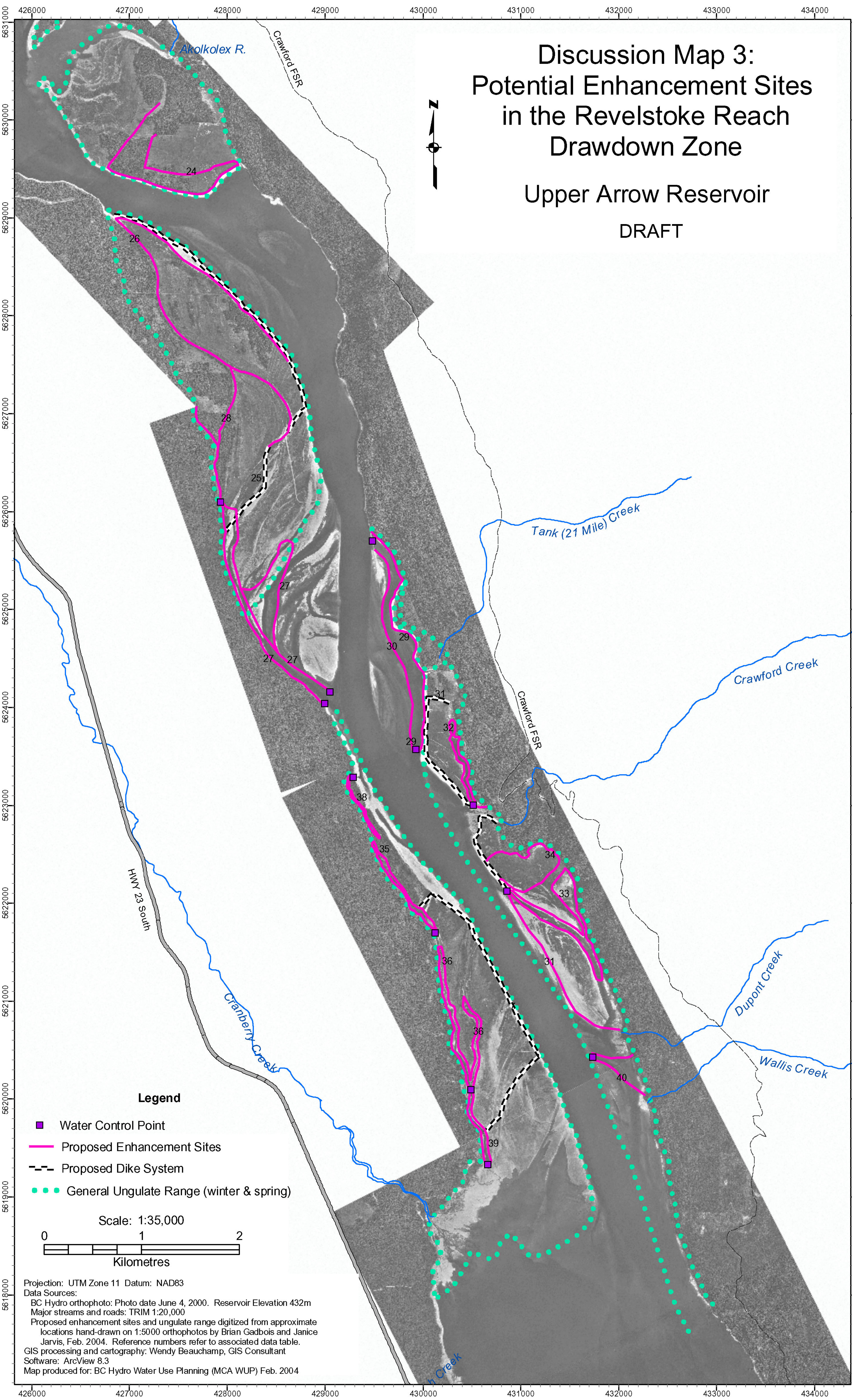
Discussion Map 3:
Potential Enhancement Sites in the Revelstoke Reach Drawdown Zone
Upper Arrow Reservoir
DRAFT
N
Akolkolex R.
Crawford FSR
Tank (21 Mile) Creek
Crawford Creek
Dupont Creek
Wallis Creek
Cranberry Creek
HWY 23 South
Legend
Water Control Point
Proposed Enhancement Sites
Proposed Dike System
General Ungulate Range (winter & spring)
Scale: 1:35,000
0 1 2
Kilometres
Projection: UTM Zone 11 Datum: NAD83
Data Sources:
BC Hydro orthophoto: Photo date June 4, 2000. Reservoir Elevation 432m
Major streams and roads: TRIM 1:20,000
Proposed enhancement sites and ungulate range digitized from approximate locations hand-drawn on 1:5000 orthophotos by Brian Gadbois and Janice Jarvis, Feb. 2004. Reference numbers refer to associated data table.
GIS processing and cartography: Wendy Beauchamp, GIS Consultant
Software: ArcView 8.3
Map produced for: BC Hydro Water Use Planning (MCA WUP) Feb. 2004

Attachment 1:

BChydro **ENGINEERING**

Inter-office memo

TO: Sue Foster **DATE:** 26 February 2004

FROM: John Boots **FILE:** MCAWUP–F600

SUBJECT: **WUP –Structure Costs for Enhancing Wildlife along Upper Arrow Reservoir**

As requested, please find attached our Estimate Synopsis of an overview level estimate for four types of structures to enhance wildlife 30km along the Upper Arrow Reservoir south of Revelstoke, B.C. The cost estimates are as follows:

Typical Structure Description	Cost Range
1. Dikes	**$4 to 6 million/km**
2. Water Control Structure	**$25 to 35k/each**
3. Non-Traditional Terracing	**$30 to 45k/1000m2 (0.1hectare)**
4. Raising Level of Land	**$20to 30k/1000m2 (0.1hectare) per 1m height**

These cost estimates are based on discussions with Brian Gadbois, Ian MacLean and you. The cost basis is described in our Estimate Synopsis. The estimates are at a conceptual level of design, however, are more realistic than the costs included in the table you provided to us.

Please note that all the figures stated are in Feb 2004 constant dollars and the estimate excludes Interest during Construction (IDC), Corporate Overhead, Inflation, and GST.

You had also asked us what would a feasibility study cost. This is difficult to estimate, as we really don't know the scope of the work to be undertaken. I would assume that this study would include engineering (ie Geotechnical, Civil and Hydrotechnical), environmental (i.e. wildlife and fish studies) and economic benefit and cost analysis at a minimum. If a feasibility study was to be done for a single structure it could cost 15 – 20% of the value of the project capital cost. If you could put out a large study package then the feasibility study costs could be in the 1 – 5% ranges.

Thank you for the opportunity to prepare these estimates and please contact Patricio Bustamante or myself if you need any further information.

John Boots
John Boots, P.Eng.

JMB/lac
Attachment

c: Patricio Bustamante
Ian MacLean
Ed Hill
Brian Gadbois
Fred Bonn

ENGINEERING
ESTIMATING & SCHEDULING
COST ESTIMATE SYNOPSIS

Job No: 201A-1228.10-0201-01

File: MCAWUP Task F600

DESCRIPTION

Project	: Water Use Plan
Project Classification	: Hydro-Electric
Study Type	: Overview Estimate
Details	: Physical Works Columbia River
Assignment No	: MCAWUP Task F600
Request Reference	: Note from Sue Foster, 10 February 2004
Date Prepared	: February 2004

AMOUNT OF ESTIMATE

Amount : Total Construction Cost (Range)

- Dikes : $4 to $6 million /Km
- Water Control Structures:$25 to $35k/ each
- Non-Traditional Terracing : $30 to $45k/1,000 m2
- Raising Level of Land : $20 to $30k/1,000 m2 per 1m of height.

Cost Level	: Direct Construction Cost
Cost Base	: February 2004 Dollars

Prepared by	26/Feb/2004 Date
Reviewed by	26/Feb 2004 Date

2004-02-26 MCAWUPSynopsisFeb2004.doc Page 1

EXCLUSIONS

The estimate excludes corporate overhead, interest during construction, inflation and GST.

BASIS OF ESTIMATE

a) Labour rates: The labour rates used are similar to those contained in the CHC labour rate listings.
b) Site visit : no site visit done by estimating to assess site conditions.

DESIGN INFORMATION

No detailed design drawings or sketches were provided for this estimate.
The estimate is based on a concept of the work to be done as per information provided over the phone by Mr. Brian Gadbois, as follows:
Water Control Structures. Are like a berm or dike to be located at the entrance of selected "inlets" of back channels. Will be no more than 1.5 m high by about 4 to 5 m wide. Only a few entrances are wider of about 10 to 15 m.
Non-traditional terracing. This mean, at selected locations, stripping the top 0.3m layer of soil and grass and placing it aside. Take material from adjacent areas to raise the elevation by 1.0 to 1.5m. Then replace the top layer.

Location of the structures are shown in 3 drawings "Discussion Map, Potential Enhancement Sites in the Revelstoke Reach" and Table listing the options.

For all structures, it has been assumed that slopes are subject to water fluctuations and will be protected by rockfill (diam. 10 cm to 30 cm). The fill will be placed over a geo-textile mat, similar to that used for Coursier site earthfill cofferdam.

ASSUMPTIONS

A local Contractor would carry out the work.
Rockfill would be provided locally from a quarry or/and natural rounded rock if available.
Site construction would take place in Spring, Summer or Fall, when lake levels are appropriate. Winter work was not factored into the cost.
It is not clear that there are suitable access roads to bring the rockfill and fill material to each of the potential sites. It has been assumed that delivery of rockfill/fill materials may be made by tow barge from the Revelstoke area.

BASIS OF QUANTITIES

Quantities were base on dikes 5m crest width and 2:1 rockfill slopes. Water control structures of 3m crest width, same slopes.

BASIS OF PRICING

Civil Costs
Direct cost prices were calculated from first principles.
Rockfill cost was provided by Jake & Jay Holdings quarry, located at Revelstoke, at $23.50/m3 loaded on trucks or onto a barge.
BC Hydro owns several barges 8x17 feet (Vernon) which may be bolted together and used for this work.

BASIS OF MGMT AND ENGINEERING COST

Management and Engineering cost has been included as 30% of the direct construction cost.

CONTINGENCY ALLOWANCES

Contingency included is 20% of the Total Construction Cost.

SCHEDULE

Construction schedule can not be prepared until definition of the project is known.

CASH FLOW

Not applicable

APPENDIX EE: COMMITMENT TO NEGOTIATE MOUNTAIN WHITEFISH AND RAINBOW TROUT FLOWS

BC hydro THE POWER IS YOURS

22 September 2004

Mr. Steve Macfarlane
Regional Water Use Manager
Ocean, Habitat and Enhancement Branch
Department of Fisheries and Oceans

Dear Steve:

Re: **Commitment to Negotiate Mountain Whitefish and Rainbow Trout Flows**

This letter is in response to a request made at a Columbia Water Use Plan meeting in February 2004 regarding BC Hydro's commitment to negotiate Mountain Whitefish (MWF) and Rainbow Trout (RBT) flows with the U.S. Section of the Columbia River Treaty Operating Committee. While it has been acknowledged that the flows below Keenleyside Dam are subject to the terms of the Columbia River Treaty and therefore cannot be unilaterally directed by BC Hydro, the corporation can and does work with the US Entity to implement mutually beneficial changes to Treaty flows. Mutually beneficial flow changes for MWF and RBT are dealt with separately in the following.

1) Mountain Whitefish Flows

Treaty specified releases from Arrow reservoir are typically high in January, a time of peak MWF spawning, and significantly lower in February and March. This reduction in flow after the peak spawning period has resulted in the dewatering and destruction of significant numbers of MWF eggs that were deposited in the shallower water along the river banks. Over the last 10 years BCH has attempted, with varying levels of success, to reduce the peak flows between 1 Jan and 21 Jan to minimize the difference between the peak spawning flow (Qs) and the minimum incubation flow (Qi). The results of this effort over the period 1994 – 2003 are summarized in the following:

Seasonal Flow Index = Qs(1 Jan to 21 Jan) – Qi	Occurrence Frequency over 10 years	**Pro-rated (Adjusted) Occurrence over next 5 years**
0 – 19.9 kcfs	30%	2
20 – 39.9 kcfs	40%	2
40 – 59.9 kcfs	20%	1
60 – 80 kcfs	10%	0

British Columbia Hydro and Power Authority, 6911 Southpoint Drive, Burnaby BC V3N 4X8
www.bchydro.com

water years and 20 - 30% of the highest water years the U.S. has no requirement to store additional water in Canada, and our bargaining position is significantly reduced. Under these relatively less frequent water conditions when the U.S. does not plan on implementing the 1 maf FA operation, the probability of successfully negotiating the RBT operation is reduced to ~50%.

3) Identification of Risk Factors

While the following risk factors have been qualitatively included in the probabilities provided above, it is important to specifically recognize the uncertainties associated with the negotiation process with the US. The more significant risk factors include:

- All MWF agreements to date have included a "cold snap" provision that allows the US to increase January flows above those specified in the agreement. The provision is triggered by specific temperature departures that have not been realized to date.
- Treaty flood control provisions can be triggered at any time of the year, and take precedence over environmental and power interests.
- BCH Treaty staff are currently negotiating a number of issues with their US counterparts (e.g. Non-Treaty Storage Agreement, Libby VARQ Flood Control, Entitlement Return Provisions). US agreement on MWF and RBT flows could be intentionally withheld for use as a "negotiating pawn" for any of these issues.
- Changes to US values / legislation can directly impact the negotiation process. As an example, the BiOp initially required the 1 maf of Flow Augmentation storage in all water conditions. Due largely to the California power crisis and a change in administration, this requirement was reduced to exclude the very lowest and highest water years.

In summary, BC Hydro and the Canadian Entity will commit to pursuing the MWF and RBT flows as a high priority. Further, BC Hydro commits to meeting with DFO at the earliest point possible to discuss operating strategies when it appears that there may be difficulty in reaching agreement with the US Entity. While success can not be guaranteed due to the risk factors identified, we believe there is a high probability of success over the expected term of the Columbia Water Use Plan.

Please advise if you require anything further.

Yours truly,

Kelvin Ketchum

Kelvin Ketchum P.Eng.
Canadian Chair,
Columbia River Treaty Operating Committee

Paul Adams P.Eng.
Manager, Operations
BC Hydro

c: Dawn Farrell, Executive Vice President, Generation
Terry Anderson, Ministry of Water, Land and Air Protection
Sue Foster, Project Manager, Columbia Water Use Plan

To establish a base-line for experiment and monitoring purposes, the Department of Fisheries and Oceans has requested a continuance of the recent historical winter flow reductions (i.e. Qs – Qi) over the next 5 years, and the associated Pro-rated Occurrences are specified in the above table. BC Hydro believes there is a high probability of achieving these results, in the order of 80+%, as long as the Fall Treaty flow flexibility (provisional draft / storage) remains available to be provided to the US in compensation, and unusual flood control requirements do not dictate a different operation.

The Department of Fisheries and Oceans has acknowledged and accepted that this operation is expected to result in the following impacts upon MWF eggs. In efforts to maintain status quo conditions (i.e. last 10 years), BC Hydro will endeavor to provide flow reductions that are predicted to result in 30-40% egg mortality only once over the next 5 years. Further, it is understood that BC Hydro will undertake consultation with the Department of Fisheries and Oceans in the event that flow releases are expected to deviate from the specified flow regime and result in greater than 40% egg mortality.

Expected MWF Egg Mortality	Calculated 5-year Frequency	Adjusted 5-year Occurrence
0 – 20%	60%	3
20 – 40%	30%	2
40 – 60%	10%	0

2) Rainbow Trout Flows

Rainbow trout begin to spawn in the gravel bars below Keenleyside Dam in March, with the peak spawning occurring in April. To avoid dewatering RBT redds when the Treaty rule curves direct flow reductions from Arrow reservoir in May and June (when snowmelt peaks and the US has all the water it needs), BC Hydro has typically negotiated an Arrow flow smoothing operation with the US. This includes:

- Negotiating a sustainable base Arrow release that can be maintained (or increased) by the water volume expected to be available for release between 1 April and 30 June.
- Negotiating with Fisheries agencies on the ramp-down from MWF flows in March, to RBT protection flows in April. The treatment of early-spawning RBT redds is typically included in these negotiations.
- Providing the US with the right to store up to 1 million acre feet (maf) of Flow Augmentation water in Arrow above Treaty specified levels, as directed by their Biological Opinion.
- Negotiating the conditions under which the US releases Flow Augmentation water.
- Maintaining non-decreasing river levels below Arrow, generally by holding Arrow discharges steady or slowly increasing them.
- Monitoring Kootenay River flows, to permit some Arrow discharge reductions when Kootenay backwatering conditions allow.

This operation has worked very well over the years, has provided benefits to all parties and has a high probability (80+%) of working well in the future whenever the US is motivated to store FA water in Canadian Treaty projects. The US, however, may not be required by their Biological Opinion to store the specified 1 maf in all water conditions. Based on BPA's interpretation of the BiOp, in the very lowest

APPENDIX FF: DEVELOPMENT OF THE MID COLUMBIA RIVER WHITE STURGEON EXPERIMENTAL PLAN

1.0 Proposed Experimental Design

A white sturgeon experimental plan for the mid Columbia River was initially developed based on discussions during a Columbia River Water Use Plan White Sturgeon meeting held in July 2003. This involved two treatment options:

- The release of a 30 000–40 000 cfs minimum flow from Revelstoke Dam for four weeks during the mid July to mid August period in selected low cost years; and

- Turbidity augmentation through the addition of bentonite to the river, in combination with the minimum flow release over a 30-day period.

Under the minimum flow option, one group of fertilized eggs (200 000+) would be released within the known spawning and egg deposition zone at the onset of the minimum flow period. The experiment would involve two treatments (Treatment A: egg releases in combination with four weeks of minimum flow; and Treatment B: egg releases without minimum flow). The turbidity treatment would involve increasing turbidity levels in the river over a 30-day period to provide what was considered to be a high level of protection from predators for incubating, drifting and early stages of settled sturgeon larvae, thus increasing the likelihood of achieving juvenile recruitment into the population. Based on historical flow data (1975 to 1985), it was determined that there would be a high probability of achieving the 30 000 cfs minimum flow target in six out of 10 years. Over a 10-year period, BC Hydro could select three years in which to provide an experimental treatment of either the flow or the flow plus turbidity intervention.

A feasibility study was undertaken on behalf of the Fish Technical Subcommittee (Hildebrand et al., 2003) to assess the likely benefits and costs of providing the minimum spawning/incubation flow and turbidity treatments in the mid Columbia River. The results of this study were provided to the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) to solicit their expert opinion on the proposed experiment.

The Recovery Team reviewed the proposed experimental plan, and made the following recommendations for consideration by the Columbia River Water Use Plan Consultative Committee.

- While the Recovery Team was not supportive of an experimental flow treatment with the release of large numbers of eggs or larvae, it was supportive of conducting the minimum flow treatment in years when pre-spawning females are identified as present in the system. This would help determine whether a 30 000 cfs flow is sufficient to improve spawning conditions and performance for natural spawners in the mid Columbia.

- Due to the high costs associated with a flow + turbidity experiment, it was recommended that turbidity augmentation not be implemented in the mid Columbia. This was based on the likelihood that predation rates are not as high and, therefore, likely not as much of a limiting factor in juvenile recruitment as in the lower Columbia, where the likelihood of producing a detectable recruitment signal through increased turbidity is much higher (50 per cent).

- In lieu of the turbidity experiment or a higher minimum flow, the Recovery Team recommended that the Columbia River Water Use Plan support the development of an experimental hatchery-based supplementation program involving the release of either larvae or 1-year old juvenile sturgeon. It was felt that there is not sufficient genetic diversity or number of individuals in the Arrow sturgeon population to support a unique stock rebuilding effort, and best chances for development of a self-sustaining population would require conservation fish culture.

The Columbia River Water Use Plan Project Team put forward the mid Columbia sturgeon plan and the Recovery Team's recommendations to the Consultative Committee at their November 2003 meeting. The Committee agreed in principle with the revised experimental plan, but highlighted the need to further define the experiment with respect to frequency of flow treatment, and cost of hatchery supplementation, flow release and monitoring. In principle, the Committee agreed to the following main components of the plan:

- A $5 million water budget over 10 years, to provide a 30-day minimum flow of 30 000 cfs during the summer spawning period when spawners are detected in the area.

- Monitoring Costs: $190,000 (annualized cost over 25 years).

- A flow + turbidity experiment not be implemented due to the high costs and uncertain additional benefits that turbidity would provide.

2.0 Revised Experimental Plan

The Fish Technical Subcommittee continued to work with members of the UCWSRI to develop final recommendations related to treatment options and monitoring within the funding envelope recommended by the Consultative Committee. Specifically, better clarity was sought around costs of each component of the experiment and expected benefits to the white sturgeon population.

In keeping with elements of the plan as agreed to by the Consultative Committee, members of the UCWSRI proposed a 4-phase workplan extending over 10 years of the Columbia Water Use Plan. The primary objectives of this plan are to better understand juvenile habitat capabilities in the mid Columbia River, and begin rebuilding the Arrow population through flow treatments and conservation aquaculture.

The workplan was designed to learn as much as possible from the remaining adults in the Arrow population and provide the best chances at rebuilding the population in the future, while providing the flexibility to consider alternative areas if efforts to build a self-sustaining population in the mid Columbia are unsuccessful. Specifically, the workplan will address three key uncertainties related to the recovery:

1. Can we produce wild yearling white sturgeon by providing a minimum spawning and incubation flow in the mid Columbia?

2. Can stocking of yearling (or older) sturgeon provide for rebuilding of the Arrow sub-population and mitigate low minimum flow/reservoir impacts?

3. Can stocking of yearling (or older) sturgeon provide for either recovery of a self-sustaining sub-population or development of a failsafe (non-reproducing) population in the Kinbasket Reservoir/upper Columbia reach?

Based on the outcome of research/monitoring, flow tests and experimental releases of hatchery larvae during early phases of the program, a decision will be made whether to maintain efforts in the mid Columbia over the 10-year program (Option A) (**Error! Reference source not found.**). Under Option A, efforts would be made to develop a self-sustaining population through continuation of the minimum spawning/incubation flow and implementation of conservation aquaculture. If it were conclusively demonstrated after Phases 2 or 3 that wild reproduction is not possible within Arrow Reservoir, flow treatments would be discontinued and there would be three possible directions that could be followed (Option B).

(i) Initiate a conservation aquaculture program for development of an Arrow failsafe population.

(ii) Develop a self-sustaining (in the long term) population in a Kinbasket/upper Columbia recovery area;

(iii) Initiate a conservation aquaculture program for development of a Kinbasket failsafe populations.

As it is unlikely, within the term of the Columbia Water Use Plan, that a determination could be made around whether spawning and early lifestage survival is possible within the Kinbasket/upper Columbia area, the conservation aquaculture strategy will have to be robust to either (i) wild production is possible, or (ii) wild production is not possible. It should be possible to determine within the term of this Water Use Plan whether recovery efforts should be made in Arrow, Kinbasket or both.

It was recognized that each phase of the workplan might take longer than the timeframe presented below, and this variability must be built into planning schedules. Decisions around size, age and numbers of fish releases also need to remain flexible to ensure best use of funds as we learn from the research.

Table FF-1: Mid Columbia White Sturgeon Experimental Plan

Phase	Year	Key Tasks
Phase I	1	***Spawning Investigations*** • Expand egg substrate mat work to detect spawning and possibly for egg collection purposes. • Monitor temperature/TGP to assess habitat conditions during periods of normal and experimental treatment operations. • Continue tracking of existing sonic tagged fish to determine staging and spawning habitat preferences and identify movements into staging/spawning areas. • Investigate feasibility of underwater videography for detecting pre-spawning and spawning sturgeon and triggering flow treatment and egg substrate deployment. • Assess spawning habitat requirements. • Complete genetic assessment work aimed at determining levels of stock differentiation in the Arrow and lower Columbia, and importance of flow treatments relative to other recovery actions. ***Incubation/Rearing Studies*** • Assess low water temperatures on egg and larval development with *in situ* studies. • Develop plans and facilities required for lab-based incubation/early rearing temperature experiments in Phase II.
	2	Continue as above . ***Juvenile Habitat Suitability*** • Experimental release of 50 nanotagged juveniles and 3000 marked yearlings near Revelstoke Dam. • Follow-up monitoring of releases (tracking, gill netting, video).
End of Phase Review		Determine recommended minimum flow treatment based on feasibility of videography (within $5million funding cap)*. • 30 kcfs (4 weeks in August) – in years when probable spawning up to $5 million cap over 10 years if videography trials successful. • 15 kcfs (8 weeks in July to August) – every year. • 24 kcfs (4 weeks in August) – maximum attainable min flow every year within $5 million cap over 10 years.

Phase	Year	Key Tasks
Phase II	3	***Spawning Investigations*** • Egg substrate mat monitoring. • Temp/TGP monitoring. • Continue with videography if feasible or continue with substrate mat monitoring. ***Juvenile Habitat Suitability*** • Experimental release of 50 nanotagged juveniles and large #s (10s of 1000s)of smallest size 0+ juveniles (marking mandatory and TBD; possibly DNA, scute, etc.). • Juvenile telemetry monitoring and follow-up monitoring of releases (tracking, gill netting, video?) to assess presence, abundance and habitat selection. ***Kinbasket Sturgeon Recolonization*** • Initiate Kinbasket Ecological Risk Assessment and Habitat Suitability studies. ***Flow Treatments*** • Begin selected flow treatment.
	4	Continue as above.
	5	Continue as above but no hatchery release – monitor juveniles via gill netting, video (?).
End of Phase Review		Review information from Phases I and II to develop conservation aquaculture strategy. If wild production detected or outcome of flow tests is uncertain, continue flow treatment and initiate Arrow conservation aquaculture program (Option A). If no wild production and no egg/larval benefit conclusively demonstrated, discontinue flow treatment and initiate conservation aquaculture program for Arrow and/or Kinbasket failsafe population(s), OR Kinbasket recovery area (go to Option B).
Phase III	6–7	**Option A** ***Spawning Investigations*** • Continue videography or substrate mat monitoring until adult abundance and spawning event frequencies suggest it is statistically inappropriate to continue. ***Conservation Aquaculture*** • Implement and refine program based on Phases I and II review. ***Juvenile Survival and Growth*** • Continue monitoring of hatchery and/or wild juveniles. ***Flow Treatment*** • Continue until juvenile monitoring conclusively demonstrates no wild contribution.
End of Phase Review		If wild production detected or outcome of flow tests is uncertain, continue flow treatment and initiate Arrow conservation aquaculture program (go to Phase IV, Option A). If no wild production and no egg/larval benefit conclusively demonstrated, discontinue flow treatment and initiate conservation aquaculture program for Arrow and/or Kinbasket failsafe population(s), OR Kinbasket recovery area (go to Phase IV, Option B).

Phase	Year	Key Tasks
	6–7	**Option B** ***Alternative Recovery Area*** Complete investigations of ecological risks and habitat suitability for all life phases in other potential recovery areas and develop conservation aquaculture strategy for those locations (e.g., Kinbasket). ***Conservation Aquaculture*** Begin experimental releases of juveniles in Kinbasket. Release large numbers (10s of 1000s) of smallest size age 0+ juveniles possible (marking mandatory and TBD; possibly DNA, scute, etc.). Follow-up monitoring of juvenile releases (tracking, gill netting, video) to assess presence, abundance and habitat selection by released fish.
End of Phase Review		If suitable alternative area cannot be located to meet all life stage requirements, begin consideration of long-term stocking program to meet failsafe population requirements.
Phase IV	8–10	**Option A** ***Spawning Investigations, Conservation Aquaculture, Juvenile Survival and Growth*** Same as above in Phase III. ***Flow Treatments*** Indefinite continuation of minimum flow treatment until existing population of wild adults is no longer able to effectively reproduce. (Re-implementation of spawning flows would occur when young fish mature and age class gap is passed.)
Phase IV	8	**Option B** Continue monitoring of juveniles released in Years 6–7. If suitable alternative area cannot be located to meet all life stage requirements, begin consideration of long-term stocking program to meet failsafe population requirements.
	9–10	***Alternative Recovery Area*** Begin conservation aquaculture and related research in new recovery area. ***Alternative Recovery Approaches*** Develop plan for aquaculture-supported Arrow or Kinbasket failsafe population if habitat for yearling and older juveniles is suitable but spawning success and larval survival is expected to be nil.

* The Recovery Team recommended three possible options for a minimum spawning/incubation flow from Revelstoke Dam, depending on results of the underwater videography feasibility study. A description of these flow options is provided in a letter from the UCWSRI to the Columbia River Water Use Plan Project Team (attached).

Upper Columbia White Sturgeon Recovery Initiative
c/o Ministry of Water, Land and Air Protection
401 – 333 Victoria Street
Nelson, BC V1L 4K3

May 1, 2004

BC Hydro
6911 Southpoint Drive,
Burnaby, BC V3N 4X8
Attention: Pat Vonk, BC Hydro

Re: Mid-Columbia River White Sturgeon Recovery Team Recommendations

Members of the Upper Columbia White Sturgeon Recovery Initiative Recovery Team have held a number of teleconferences to discuss possible Columbia Water Use Plan (WUP) Arrow Reservoir white sturgeon operational treatments, monitoring plans and works-in-lieu. This letter summarizes the results of those meetings, and provides additional clarification on proposed sturgeon recovery direction to the Consultative Committee (CC).

General Comments

The RT is recommending a phased program, underscoring the critical need for related flexibility in annual fund allocations for research, experimental treatments and monitoring. The program must be responsive to future learning and related changes to priorities and recommendations. We suggest facilitating this through comprehensive program reviews scheduled at the end of each phase.

Proposed research related to spawning and larval/fry survival is condensed in recognition of the need to obtain as much of this data as possible before remaining Arrow white sturgeon adults die or become senescent. We believe that taking advantage of wild spawning events while we still have that option will provide a more cost effective and realistic assessment of issues and potential solutions than aquaculture-based *in situ* studies of egg and larval survival.

Previously documented provisions for expanding and/or developing new hatchery facilities will be required, although the details of the conservation aquaculture program depend on results of proposed research and monitoring. Costs may be reduced, depending on the outcome of proposed hatchery developments in the US that might be used to support a portion of the culture requirements for releases downstream of HLK. We currently anticipate implementing a fully-developed conservation aquaculture program for the Revelstoke-Arrow recovery area beginning in Year 6 of the 10 year program outlined below.

10 Year Plan

The RT proposes the following four phase, 10 Year Plan to understand juvenile habitat capabilities, learn as much as possible from the remaining adults and (assuming habitat suitability is proven) begin population rebuilding through conservation aquaculture. The plan reflects RT consensus that the greatest learning is likely to be achieved if the remaining wild adults are allowed to spawn without interference. It should be noted that, depending on results and end-of-phase reviews, each phase may take longer than the time frame listed, and this variability must be built into planning schedules. Decisions related to the size, age and numbers of fish released also need to remain flexible to ensure best use of funds as we learn from the research.

In the plan, cost estimates are provided in the first year that a particular study or project is implemented; cost estimates are not indicated for subsequent years except where costs are expected to change significantly. Reference is also provided to currently proposed MCA WUP monitoring studies. It is important to note that management costs associated with these projects are not included in the estimates.

Phase I

Year 1
Spawning investigations
- expand and modify substrate mat work at Revelstoke to investigate potential stranding and collect eggs required for research (estimated cost: $80,000)
- temperature monitoring below REV and in locations above and below major tributaries such as Illecillewaet and Jordan (incorporate within Aquatic MCA-11)
- track existing sonic tagged fish, concentrating on spawning movements and determination of staging and spawning habitat preferences (estimated cost: $55,000)
- investigate feasibility of videography to assess adult presence in spawning area; likely utilizing fixed cameras similar to Brilliant expansion monitoring system (estimated cost: $55,000)
- conduct detailed hydrometric surveys of the MCR in locations of known white sturgeon spawning and other locales to: (i) validate assumptions used in setting WSG spawning flows; (ii) determine spawning habitat requirements for sturgeon for future rehabilitation activities (Aquatic MCA-18; $80,000 per year, 2 years)
- complete genetics assessments to determine levels of stock differentiation in the Arrow sub-population; information from these assessments is required to determine the significance of the remnant Arrow population and the importance of Revelstoke flow treatments relative to other recovery actions (estimated cost: $30,000)

Incubation and rearing studies
- assess impacts of low water temperatures on egg and larval development with in situ studies (estimated cost $55,000)
- develop plans and facilities required for lab-based incubation/early rearing temperature experiments in Phase II (estimated cost $35,000)

Year 2
Spawning investigations
- substrate mat monitoring
- temperature and TGP monitoring below REV and in locations above and below major tributaries (e.g. Illecillewaet and Jordan)
- tracking of existing tagged fish concentrating on spawning movements
- completion of videography feasibility assessment

Incubation and rearing studies
- assess impacts of low water temperatures on egg and larval development with in situ and/or lab studies

Juvenile habitat suitability
- release 50 nanotagged juveniles and 3000 marked yearlings near REV(estimated cost: $350,000 for aquaculture, $20,000 for tags)
- follow up monitoring of releases with tracking and gill netting, video (Aquatic MCA-19, $125,000)

Review and decisions
- review information from Phase I to determine recommended spawning/incubation flow treatment

<u>Phase II</u>

Year 3
Spawning investigations
- substrate mat monitoring
- temperature and TGP monitoring
- continue tracking of existing tagged fish if necessary
- if videography is successful then continue to use as a method for detecting fish in spawning area (estimated cost: $30,000)

Juvenile habitat suitability
- release another 50 nanotagged juveniles and large numbers (10's of 1000's) of smallest sized age 0+ juveniles possible (marking mandatory and TBD; possibly DNA, scute, etc.)
- juvenile telemetry monitoring and follow up monitoring of releases with tracking and gill netting, video to assess presence, abundance and habitat selection (Aquatic MCA-19, $125,000)

Flow treatments

- begin flow experiments based on one of three options as outlined in Attachment 1
- if videography trials are successful, suggest application of a flow of 30 Kcfs triggered by spawner detection, tempered by water availability considerations
- if videography is unsuccessful, either 15 Kcfs (8 weeks) or 24 Kcfs (4 weeks) are suggested as annual treatments (option chosen will depend on results of Phase I research);
- flow treatments will remain within the 10 year, $5 M total foregone generation revenue cap
- timing of flow treatments will be optimized as much as possible to encourage earliest possible spawning

Alternate recovery area

- initiate Kinbasket sturgeon re-colonization risk assessment and habitat suitability studies ($50,000 per year, year 1 of 2)

Year 4

Spawning investigations

- substrate mats, videography, temperature and TGP monitoring

Flow treatments

- continue flow treatments as above

Juvenile habitat suitability

- release large numbers (10's of 1000's) of smallest sized age 0+ juveniles possible (marking mandatory and TBD; possibly DNA, scute, etc.)
- additional juvenile telemetry monitoring, gill netting, video surveys to assess presence, abundance and habitat selection by fish released in preceding years (Aquatic MCA-19, $125,000)

Alternate recovery area

- complete Kinbasket sturgeon re-colonization risk assessment and habitat suitability studies ($50,000 per year, year 2 of 2)

Year 5

Spawning investigations

- substrate mats, videography, temperature and TGP monitoring

Juvenile habitat suitability

- juvenile monitoring via gill netting, video (Aquatic MCA-19, $125,000)

Flow treatments

- continue flow treatments as above

Review and decisions

- review information from Phase I and II to develop conservation aquaculture strategy
- if wild production detected or outcome of flow tests is uncertain, flow experiments will be continued (go to Phase III, Option A); if no wild production and no egg/larval benefit, discontinue flow tests (go to Phase III, Option B)

<u>Phase III – Option A</u>

Years 6 and 7

Spawning investigations

- continued videography and/or substrate mat investigations until adult abundance and spawning event frequencies suggest it is statistically inappropriate to continue

Aquaculture program

- implement and refine conservation aquaculture program based on Phase I–II review
- develop aquaculture facilities for juvenile production (estimated cost: one time expenditure of $500,000 to upgrade facilities at Kootenay Sturgeon Conservation Hatchery)

Juvenile survival and growth

- continued monitoring of juveniles produced from hatchery releases and/or wild spawning (Aquatic MCA-19, $125,000)

Flow treatments

- possible continuation of the minimum flow treatment until juvenile monitoring conclusively demonstrates no wild contribution

Review and decisions

- if wild production detected or outcome of flow tests is uncertain, flows experiments will be continued (go to Phase IV, Option A); if no wild production and no egg/larval benefit, discontinue flow tests (go to Phase IV, Option B)
- redirect effort to other suitable locations (e.g. Kinbasket) if flow and/or juvenile habitat experiments indicate population recovery not possible

<u>Phase III – Option B</u>

Years 6 and 7

Alternative recovery areas

- if program review at end of Phases I–II recommends discontinuation of further flow tests and juvenile research work on Arrow system, complete investigations of ecological risks and habitat suitability for all life phases in other potential recovery areas and develop conservation aquaculture strategy for those locations (e.g. Kinbasket; estimated cost: $25,000)

Juvenile habitat suitability – Kinbasket

- release large numbers (10's of 1000's) of smallest sized age 0+ juveniles possible (marking mandatory and TBD; possibly DNA, scute, etc.)
- juvenile telemetry monitoring, gill netting, video surveys to assess presence, abundance and habitat selection by fish released ($125,000)

Flow treatments (Arrow)

- none

Year 8

Juvenile habitat suitability

- juvenile gill net and video monitoring of juveniles released in Years 6–7

Review and decisions

- if suitable alternative area cannot be located to meet all life stage requirements, begin consideration of long term stocking program to meet failsafe population requirements

Phase IV – Option A

Years 8–10
Spawning, aquaculture, juvenile survival and growth

- same as Phase III, Option A

Flow treatments

- effective, indefinite continuation of the minimum flow treatment until existing population of wild adults is no longer able to effectively reproduce
- reimplementation of spawning flows would occur when young fish mature and age class gap is passed

Phase IV – Option B

Years 9–10
Alternative recovery areas

- begin stocking and related research in new recovery area (estimated cost: $350,000/yr for aquaculture; $125,000/yr for juvenile monitoring)

Alternative recovery approaches

- develop plan for aquaculture-supported Arrow or Kinbasket "failsafe" population if habitat for yearling and older juveniles is suitable but spawning success and larval survival is expected to be nil (estimated cost: $25,000)

Flow treatments

- none

The following detailed descriptions are provided to assist in understanding key activities in the 10 Year Plan:

i) *Tracking of existing sonic tags*
Existing sonic tags in the Arrow Lakes Reservoir/Columbia Reach area will require additional seasonal tracking until these transmitters are no longer functional. The expected life span of existing tags suggest this work will be required from 2004 through until 2007/08. The work will focus on determination of staging and spawning habitat preferences and identification of movements into the staging and spawning areas near Revelstoke and will therefore target the period from June–September.

ii) *Substrate mats*
Substrate mats have been deployed in recent years to determine if spawning occurs. This program needs to be refined and expanded to assess the longitudinal and cross-sectional distribution of eggs. Information from the substrate mat program will assist in evaluating the impacts of different minimum flow scenarios on egg and larval stranding. However, substrate mat monitoring will be required (possibly at a reduced scale) beyond Phase I to detect spawning and possibly for egg collection purposes related to research and conservation aquaculture.

iii) *Genetics assessments*
Genetics work aimed at determining levels of stock differentiation in the Arrow and lower Columbia is currently underway. This work is expected to be complete in spring 2004. However, there is a possibility that inconclusive results will suggest the need for additional sampling and/or related lab work to finalize direction on the need to address the Arrow population separately. This work is a prerequisite to large scale fish culture operations targeting releases to the Arrow and should be slated for completion by the end of 2005 at the latest.

iv) *Videography methods development*
Underwater videography has been attempted in spawning and staging habitats near Revelstoke but requires additional feasibility and design assessment, focusing on fixed (as opposed to mobile/ROV) cameras as used downstream of the Brilliant Dam. If feasible, underwater videography can be used for detecting pre-spawning and spawning sturgeon, and thereby triggering experimental flow treatments, deployment of egg mats, etc. The alternative method of spawner detection (capture, implantation of sonic tags and tracking) has been determined to be infeasible given the near-impossibility of capturing and tagging all female white sturgeon and the potential impacts of a very intensive capture and tagging program on their survival and sexual maturation. A video-based system would provide critical, non-invasive background information on spawning activity in the area and should be explored over the next 2 years to determine costs and logistics. Preliminary studies and decision on the applicability of the system

should be in place by the end of 2005. If this system can be developed, potential for spawning studies is greatly enhanced.

v) *TGP and temperature monitoring*
Measurement of TGP and temperature in the Revelstoke spawning area will be required on an ongoing basis beginning in Year 2 to assess habitat characteristics and suitability during periods of normal and experimental treatment operations. Temperature monitoring is required in the spawning area as well as in a variety of locations both above and below major tributaries downstream to Arrowhead.

vi) *Conservation aquaculture*
A conservation aquaculture program is required in the short term to provide juveniles for assessment of the impacts of: (i) flow treatments on larval and juvenile sturgeon survival (i.e., hatchery-produced juveniles demonstrate reasonable survival rates vs. no or very low survival of wild-spawned progeny); and (ii) Arrow reservoir operations on juvenile habitat availability and suitability and juvenile survival. The conservation aquaculture program and associated experiments and monitoring will provide important information for future decisions regarding Revelstoke discharges and Arrow Reservoir operations.

In the longer term, a conservation aquaculture program is required to: (i) support the population until such time as stock abundance/age structure and habitat conditions (including spawning, incubation and rearing flows and reservoir levels) can support a self-sustaining population; and (ii) address residual impacts from providing lower than optimal spawning, incubation and rearing flows. That is, to provide historical benefits for sturgeon early life stage survival in lieu of a natural freshet (i.e. 60,000 cfs maximum plant capacity or higher minimum flow) during the spawning and incubation period, a conservation aquaculture program is proposed (in part) to replace juvenile production.

If, in the future, the Recovery Team concludes that flow and Arrow Lake stage conditions required to support a self-sustaining (or even hatchery-supplemented) are not economically feasible, a decision may be made to direct a part or all of the Upper Columbia (Arrow-Kinbasket) conservation aquaculture effort to Kinbasket.

It is our strong view that the above program is both substantial and complex, and as such will require effective and dedicated coordination efforts. To this end, we recommend an additional budgetary provision of $100,000 to enable coordination of all WUP-supported elements of the MCR white sturgeon recovery program.

In view of the observed small size, decline and advanced age of the Arrow sub-population, the RT strongly recommends that pre-WUP funding be provided for the first 2 years of work in the 10 Year Plan. If pre-WUP or other funding is not available to address these issues, some of the work may need to be delayed and addressed once the WUP is implemented.

We hope that this additional information will assist the CC in reaching a decision regarding MCR white sturgeon recovery actions under the WUP program. Please let me know you have any questions or require additional information.

Yours truly,

Colin Spence
Co-Chair, Recovery Team
Upper Columbia White Sturgeon Recovery Initiative
colin.spence@gems3.gov.bc.ca

cc. Recovery Team members

encl.

Attachment 1. Detailed description of white sturgeon flow treatment options, advantages and disadvantages for the MCR WUP.

Option One: Current proposed WUP treatment

This involves a four week period of 30,000 cfs minimum flow during the month of August, coinciding with the observed spawning events and egg incubation period (and part of the larval incubation period) in 1999 and 2003. This treatment would only be implemented in years with probable sturgeon spawning (based on videography), up to a total cost (foregone revenues) of $5 million.

Advantages

- Likely greatest biological benefit (maximum egg dispersal and avoided egg/larval stranding):dollar cost ratio;

Disadvantages

- Probably exceeds flow required to trigger spawning;
- May not provide protection against stranding for larvae produced from mid to late August spawning events;
- May preclude the possibility of earlier (more optimal?) spawning which might occur with an earlier minimum flow period;
- Difficult for BC Hydro to implement (planning costs).
- No egg dispersal or stranding protection provided in years with undetected spawners.

Option Two: 15,000 cfs minimum summer flow – all years

This option is based on: (i) observations of the association between sturgeon spawning events and periods with minimum flows exceeding 8,500 cfs; and (ii) WUP consideration of minimum flow alternatives for other fish species/life history stages, including a 5,000–10,000 cfs regime proposed to provide higher minimum flows through the May–July period. The cost (foregone revenue) increment for the 5,000 cfs May–July treatment is estimated at $2 million per year. Costs may be considerably lower for a shorter (two vs. three months) and later (July–August vs. May–July) period, particularly as peak costs are associated with the April–June period.

Advantages

- May support earlier spawning;
- Provides certainty of some degree of protection against stranding throughout spawning and egg and larval incubation periods;
- Does not require successful videography program or harmful capture, handling and tagging of adult sturgeon.

- Provides some egg dispersal and stranding protection for undetected spawners.
- Easier for BC Hydro to implement.

Disadvantages

- Provides less egg/larval dispersal and stranding protection than 30,000 cfs minimum flow;

<u>Option Three: Maximum minflow attainable every year within $5 million cap</u>

This option would be designed to provide the highest possible minimum flow for a four week period (August) in all years within the ceiling established by the WUP Consultative Committee of $5 million. For example, a 24,000 cfs minimum flow is estimated to be achievable (on average) within the $5 million, ten year ceiling.

Advantages

- Does not require successful videography program or harmful capture, handling and tagging of adult sturgeon.
- Provides some egg dispersal and stranding protection for undetected spawners.
- Provides moderate degree of egg dispersal and stranding protection in comparison to above options.
- Easier for BC Hydro to implement (in comparison to minimum flow triggered by spawner detection).

Disadvantages

- May not provide protection against stranding for larvae produced from mid to late August spawning events;
- May preclude the possibility of earlier (more optimal?) spawning which might occur with an earlier minimum flow period.

APPENDIX GG: CORRESPONDENCE FROM BC HYDRO TO THE COLUMBIA BASIN TRUST AND THE REGIONAL DISTRICT OF CENTRAL KOOTENAY

COPY

BC hydro THE POWER IS YOURS

Terry K. Molstad, P.Eng.
General Manager
Coastal Generation
Tel: 604-528-2892
E-mail: Terry.Molstad@bchydro.com

2 November 2004

Josh Smienk, Chair & Board of Directors
Columbia Basin Trust
Suite 300, 445 – 13th Avenue
Castlegar, BC
V1N 1G1

Hans Cunningham, Chair & Board of Directors
Regional District Central Kootenay
P.O. Box 590
Nelson, BC
V1L 5R4

Dear Sirs:

Subject: Arrow Access & Nakusp Boat Launch

We appreciated the opportunity to meet with several directors from the Regional District of Central Kootenay (RDCK), the Columbia Basin Trust (CBT), elected officials and others, at the Union of BC Municipalities conference in Kelowna on 21 September 2004. This letter is to confirm BC Hydro's proposal related to boat launches in the Arrow Lakes outlined at that meeting.

We believe that BC Hydro has met all of its obligations under Clause M of its water license for providing access to Arrow Lakes reservoir, but the Comptroller of Water Rights may decide that further investments in boat launches are required. In addition, the Consultative Committee for the Columbia Water Use Plan has reached consensus and proposed $2.246 million investment for one new boat launch at Burton and extensions to existing boat launches for low water conditions, plus $50k in annual maintenance.

The Columbia Water Use Plan Consultative Committee also proposed replacement of the Nakusp boat launch at a cost of $1.4 Million plus $12.5k in annual maintenance, and other boat launches at Galena Bay and Deer Park for a cost of $1.56 million. However, there may not be an operational link that would establish these within the scope of Water Use Plans.

BC Hydro will take responsibility for the construction and maintenance for all new facilities directed by the Comptroller of Water Rights either under Clause M or through approving the

Columbia Water Use Plan. We would proceed primarily through contracting for these services from others, and this may be of interest to the CBT and/or the RDCK.

We believe that BC Hydro has met all its obligations related to the Nakusp boat launch. However, if the Comptroller of Water Rights decides that BC Hydro is not obligated to replace this boat launch, we are still prepared to discuss a possible partnership approach with local government, CBT and others towards a resolution. BC Hydro is willing to contribute existing land in the reservoir zone owned by BC Hydro adjacent to the existing Nakusp boat ramp, a maximum of one-third of the redevelopment cost, and one-third of ongoing maintenance/repair costs providing long term management plans and cost-sharing agreements are in place. BC Hydro has already given a number of properties to the Village of the Nakusp including the Nakusp Marina property in 1982 for $1.00, the Nakusp wharf property in 1996 for $1.00, and is in the process of transferring the Nakusp Island properties directly southeast of the wharf for $1.00.

We discussed the need for a preliminary study, the costs of which would be shared equally by the partners, at a cost of about $60,000. The study would assess the scope of the costs and agreement to proceed as soon as there is an agreement in principle for this partnership approach and cost sharing of the study.

If you wish to pursue this partnership for the Nakusp boat launch, please contact Willi Friml, General Manager, Columbia Generation, at 250-365-4552 or Diane Tammen, Community Relations Manager, at 250 489-6862.

Yours truly,

Terry Molstad

Terry K. Molstad

cc: Willi Friml, General Manager, Columbia Generation
Diane Tammen, Community Relations Manager, Kootenay/Lower Columbia
Ted White, Deputy, Comptroller of Water Rights
Paul Petersen, RDCK Director, Area K
John Voykin, RDCK Director, Area I
Gordon Zaitsoff, RDCK Director, Area J
Mike O'Connor, Mayor of Castlegar
Loni Parker, Columbia Shuswap RD
Bill Cowan, Mayor of Nakusp and RDCK Director
Blair Suffredine, MLA Nelson-Creston
Sandy Santori, MLA West Kootenay-Boundary