BCH_REAP – Exhibit B-9

BC hydro

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June 29, 2005

Mr. Robert J. Pellatt
Commission Secretary
British Columbia Utilities Commission
Sixth Floor – 900 Howe Street
Vancouver, BC V6Z 2N3

Dear Mr. Pellatt:

RE: Project No. 3698388
British Columbia Hydro and Power Authority (BC Hydro)
Resource Expenditure and Acquisition Plan Application (REAP)

Further to BC Hydro's letter of June 3, 2005 (Exhibit B-5), and in particular, BC Hydro's response to IPPBC IR 1.8.0., we herewith enclose the draft Water Use Plan for the Columbia River, including the Mica and Revelstoke projects, that has been submitted to the Comptroller of Water Rights.

While consensus has been reached by the Consultative Committee and the draft Water Use Plan has been submitted to the Comptroller, the Consultative Committee Report is not yet finalized (although it is substantially complete). BC Hydro will produce a copy of the report in this proceeding if it is finalized prior to the close of evidence.

Yours sincerely,

Tony Morris
Acting Chief Regulatory Officer

Enclosure (1)

c. Project 3698388 Intervenors

Columbia River Project

Draft Water Use Plan

April 2005

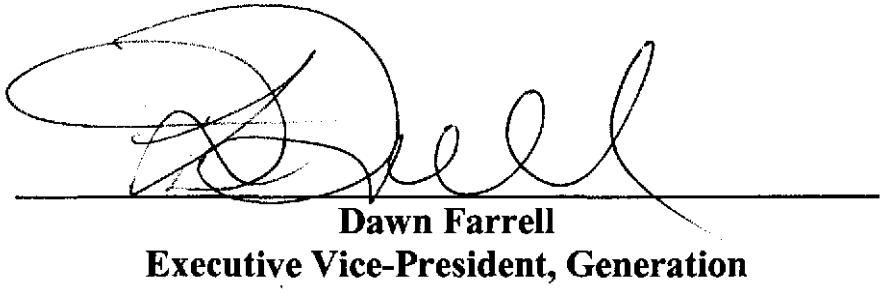
BC hydro

Columbia River Projects
Draft Water Use Plan

BC hydro Generation

April 2005

Columbia River Projects
Draft Water Use Plan



Dawn Farrell
Executive Vice-President, Generation

Preface

The water use planning consultative process for BC Hydro's mainstem Columbia River facilities was initiated in August 2000 and completed in June 2004.

The proposed conditions in this Water Use Plan, for the operation of BC Hydro's Mica, Revelstoke and Hugh Keenleyside hydroelectric facilities, reflect the consensus recommendations of the Columbia River Water Use Plan Consultative Committee.

BC Hydro thanks all those who participated in the process that led to the production of this Water Use Plan, for their effort and dedication. The proposed conditions for the operation of BC Hydro's facilities will not come into effect until implemented under the *Water Act*.

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Appendix 1 Columbia River Water Use Plan Hydrology Memo

1.0 INTRODUCTION

The conditions proposed in this Water Use Plan for operation of BC Hydro's Columbia River hydroelectric facilities reflect the June 2004 recommendations of the Columbia River Water Use Plan Consultative Committee.

The proposed terms and conditions to be authorized under the *Water Act* for the beneficial use of water at the Columbia River hydroelectric facilities are set out in this document. The Columbia River hydroelectric facilities include Kinbasket Reservoir, Mica Dam, Revelstoke Reservoir, Revelstoke Dam, Arrow Lakes Reservoir, and Hugh Keenleyside Dam.

The proposed conditions will change current operations and are expected to affect heritage and culture, fish and aquatic resources, erosion control, learning, power generation, recreation, wildlife and vegetation.

A monitoring program is proposed to study key uncertainties to enable improved operating decisions in the future. Physical works in lieu of operational changes are proposed where these are a more cost-effective means of achieving environmental and social benefits. Refer to the *Columbia River Water Use Plan: Consultative Committee Report* for details on the consultative process, interests, objectives, performance measures, values associated with operating alternatives, and details of the proposed monitoring program and physical works.

2.0 DESCRIPTION OF WORKS

2.1 BC Hydro's Columbia River Hydroelectric Facilities

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. This original facility was not constructed to have power generating capacity. However, under joint effort between the Columbia Power Corporation and Columbia Basin Trust, the Arrow Lakes Generating Station was constructed adjacent to Hugh Keenleyside Dam in 2002.

Figure 2-1 provides a map of the Columbia-Kootenay region, showing the location of BC Hydro's Columbia River hydroelectric facilities.

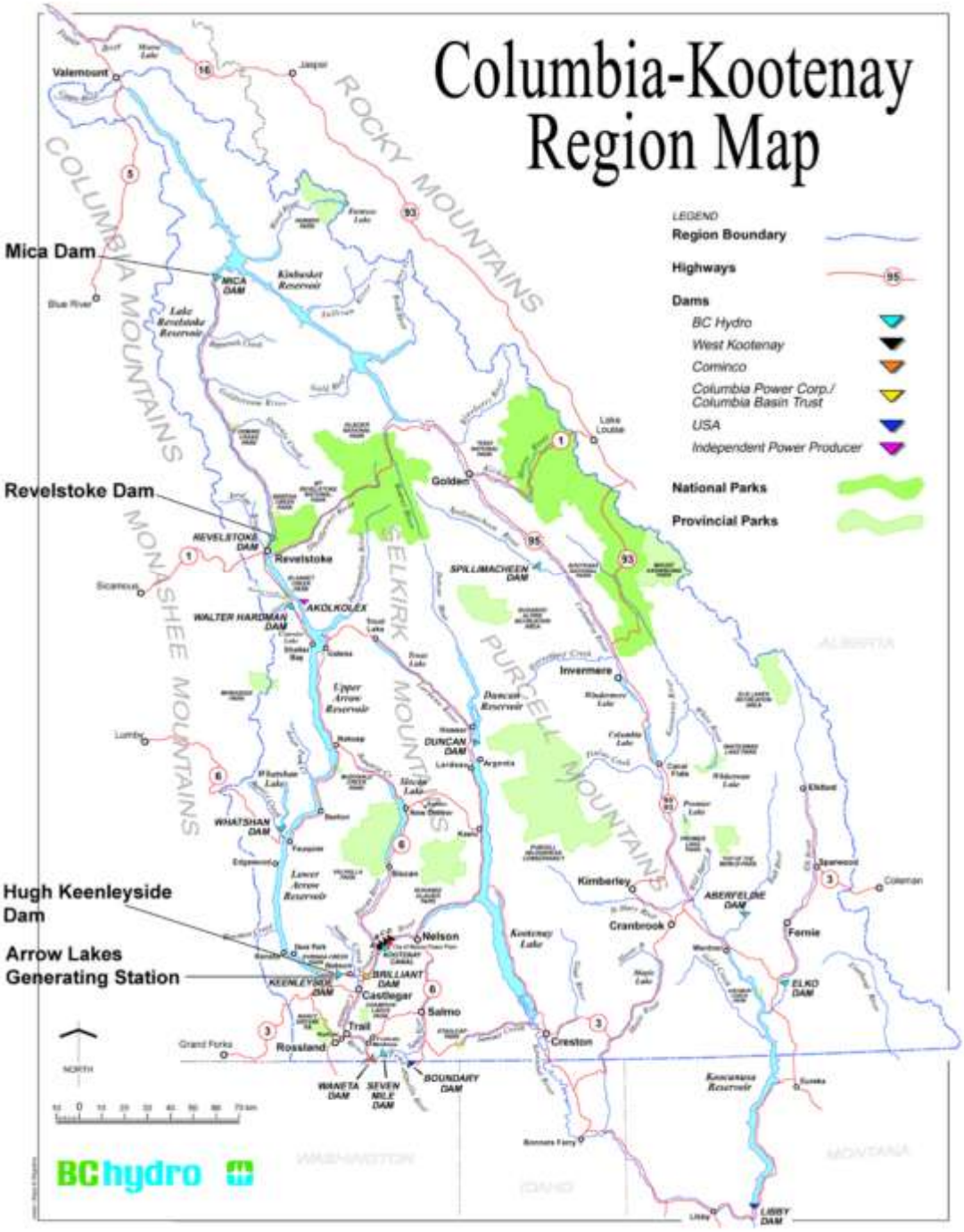

Figure 2-1: Columbia-Kootenay Region Map

2.2 Columbia River Treaty

The Columbia River Treaty was signed with the United States 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. The Treaty expires no earlier than September 2024.

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.

For Kinbasket and Arrow Lakes reservoirs, the Flood Control 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 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 the 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 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, 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 the 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 Duncan Reservoir to 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 United States. 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 Existing Works

2.3.1 Mica Project

Mica Dam is located on the Columbia River about 135 km north of Revelstoke. The dam was completed in 1973 and consists of an earthfill dam, low-level outlets, outlet works and a chute spillway. The generating station was completed in 1977, and contains an underground powerhouse.

The Mica Powerhouse has four operating units with a generating capacity of 1805 MW and the space for two additional units.

The Mica Dam outlet works are located on the left abutment (looking downstream) of the dam consisting of two outlet gates with sills set at El. 693.42 m. When Kinbasket Reservoir is at normal full pool level of 754.38 m (2475.0 ft), the outlet works have a maximum discharge capacity of approximately 1060 m^3/s. The outlet works are the preferred means of discharging water surplus to turbine needs.

The spillway control structure is located on the left abutment of the dam and consists of three radial gates with sills set at El. 741.88 m. The spillway structure is a low overflow weir that crests at El. 742.19 m. Flashboards of 0.3 m high have been installed on top of each spillway gate to prevent gate overtopping and to gain operating range and freeboard when surcharge permission up to 0.3 m is obtained.

To minimize spray and downstream erosion, the spillway is utilized only after the outlet works have reached their maximum capacity. The maximum discharge capacity of the spillway is 4290 m^3/s at reservoir El. 757.4 m (2484.9 ft), which represents the maximum encroachment on the dam freeboard.

2.3.2 Kinbasket Reservoir

Kinbasket Reservoir, formed by construction of Mica Dam, is 216 km long and has a licensed storage volume of 12 MAF. Of this, 7 MAF is operated under the terms of the Columbia River Treaty. The normal operating range of the reservoir is between El. 754.38 m (2475.0 ft) and 707.41 m (2320.9 ft). However, application may be made to the Comptroller of Water Rights for additional storage for environmental or other purposes if there is a high probability of spill (refer to Section 4.5.1).

2.3.3 Revelstoke Project

Revelstoke Dam and Generation Station are located on the Columbia River about 5 km upstream from the City of Revelstoke and about 130 km downstream from the Mica Project. The Revelstoke Project was completed in 1984, and consists of a concrete gravity main dam with an earthfill wing on the west bank, a gated spillway, a powerhouse and switchgear building. The main concrete dam

includes the power intakes in the middle, and the spillway facilities to the right. The powerhouse is located directly downstream of the power intakes, and currently has four operating units with a total generating capacity of 1980 MW and space to install two additional units in the future.

The spillway consists of two spillway overflow bays equipped with radial gates, two intermediate level outlets with operating and maintenance gates, and the spillway chute. The spillway gate structure is an overflow weir that crests at El. 556.27 m. The maximum discharge capacity of the spillway is 7110 m^3/s at reservoir El. 574.55 m (1885.0 ft), which represents the maximum encroachment on dam freeboard.

2.3.4 Revelstoke Reservoir

Revelstoke Dam impounds Revelstoke Reservoir, which is 130 km long and is licensed to storage 1.5 MAF. The licensed operating range of the reservoir is between El. 573.02 m (1880.0 ft) and 554.74 m (1820.0 ft). The reservoir is normally kept within 1.5 m of the maximum elevation throughout the year to maximize the turbine hydraulic head and maintain a small storage buffer for operational flexibility and short-term variations in inflow. This level is maintained by regulating output at Mica Dam and Revelstoke Dam so that the two facilities are operated in hydraulic balance.

Although Revelstoke Reservoir is rarely drafted below El. 571.50 m (1875.0 ft), there may occasionally be a need to draft the reservoir beyond the normal limit to the emergency limit of El. 568.76 m (1866.0 ft) as a result of operational or weather-related emergencies. Under extreme emergencies (i.e., as a last resort measure to meet firm loads), the reservoir can be drafted by 15.2 m to El. 557.78 m (1830.0 ft) in the event of prolonged periods of basin drought or an outage at the Mica Powerhouse.

Applications to the Comptroller of Water Rights for additional storage above El. 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 a high probability of spill (refer to Section 4.5.1).

2.3.5 Hugh Keenleyside Project

Hugh Keenleyside Dam is located on the Columbia River about 8 km upstream of Castlegar. The facility was completed in 1968, and consists of an earthfill dam, a concrete dam, four spillways, eight low-level outlets (ports) and a navigation lock. The reservoir formed by the dam is known as Arrow Lakes Reservoir. The total discharge capacity of Hugh Keenleyside Project is 10 500 m^3/s when the reservoir is at normal full pool. The mean annual discharge is approximately 1140 m^3/s.

2.3.6 Arrow Lakes Reservoir

Arrow Lakes Reservoir, formed from the former Upper and Lower Arrow Lakes, is about 240 km in length and has a live storage capacity of 7.1 MAF. The reservoir is licensed to operate between the normal full pool El. 440.1 m (1444.0 ft) and minimum pool El. 420.0 m (1377.9 ft). Any surcharge above the normal upper limit requires approval by the Comptroller of Water Rights. Even with this approval, the maximum allowable level is 440.75 m (1446.0 ft).

2.4 Arrow Lakes Generating Station

The Arrow Lakes Generating Station (ALH) is a 185 MW power plant constructed on the north bank about 400 m downstream of Hugh Keenleyside Dam. The powerhouse contains two turbine units with a generating capacity of 185 MW. Flows are diverted past the dam to the powerhouse by means of a 1500 m long approach channel.

Energy from ALH is fed into the BC Hydro Integrated System at 230 kV via a 50 km transmission line, which originally terminated at the Selkirk Substation. In March 2004, this line was interconnected to the Brilliant Terminal Station, such that ALH delivers its power into the FortisBC system en route to its final delivery to BC Hydro.

ALH is owned by the Arrow Lakes Power Corporation (ALPC), which is a joint venture of the Columbia Power Corporation and the Columbia Basin Trust. ALPC has overall operating responsibility for all ALH equipment. It is responsible for determining the maximum powerhouse generation and Powerplant Flow Capacity of ALH, local operation of ALH equipment and facilities, and maintenance of ALH equipment and facilities. ALPC has contracted with B.C. Transmission Corp (BCTC) for the remote dispatch and operation services under the Dispatch Operations Agreement.

3.0 HYDROLOGY OF THE COLUMBIA RIVER BASIN

Appendix 1, the Columbia River Water Use Plan Hydrology Memo, describes the physiography, climate and hydrology of the Mica, Revelstoke and Hugh Keenleyside drainage basins.

The memo also describes daily inflow and seasonal volume inflow forecasting procedures. A description of the supporting network of hydrometeorological stations in the area and a summary of the inflow hydrographs for the Kinbasket, Revelstoke and Arrow Lakes reservoirs is also provided in the memo.

3.1 Drainage Basin

The Columbia basin is situated in southeastern British Columbia. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench. The river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam. From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam. The river then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36 500 km^2. The Columbia basin is characterized by steep valley side slopes and short tributary streams that flow into Columbia River from all directions.

Precipitation in the basin occurs from the flow of moist low-pressure weather systems that move eastward through the region from the Pacific Ocean. Large snow packs accumulate on the middle and upper elevations in the watersheds during the cool winter period. Summer snowmelt is reinforced by rain from both frontal storm systems and local convective storms. More than two-thirds of the annual precipitation in the basin falls as winter snow.

3.2 Run-off Distribution

The major source of streamflow in the Columbia River in the spring and summer months is water stored in large snow packs that were developed during the previous winter months. Snow packs often accumulate at above 2000 m elevation through the month of May and continue to contribute runoff long after snow pack depletion at lower elevations. Runoff begins to increase in April or May and usually peaks in June to early July. Approximately 45 per cent of the runoff occurs in the months of June and July. Severe summer rainstorms are not unusual in the Columbia basin. Summer rainfall contributions to runoff generally occur as short-term peaks superimposed upon high river levels caused by snowmelt. These rainstorms may contribute to annual flood peaks dealt with under the current Columbia River Treaty operations.

The mean annual local inflow for the Mica, Revelstoke and Hugh Keenleyside projects is 577 m^3/s, 236 m^3/s, and 355 m^3/s, respectively.

4.0 OPERATING CONDITIONS FOR FACILITIES

4.1 Role of Facility in BC Hydro's System

The Columbia River hydroelectric facilities are described in *Making the Connection*, published by BC Hydro in April 2000.

The combined power generation at the Mica and Revelstoke facilities produce approximately 38 per cent of BC Hydro's annual energy. The Mica and Revelstoke facilities currently support ancillary services that help maintain the reliability of the interconnected power systems. The most important services include voltage control, supplemental reserves and load following.

4.2 Use of Water for Power Generation at the Columbia River Hydroelectric Facilities

The Columbia River hydroelectric facilities are managed to meet electricity demand. Mica and Revelstoke are operated in hydraulic balance. That is, Revelstoke is normally operated as a run-of-river plant, with Revelstoke Reservoir varying in elevation within the top 1.5 m by using the storage capability of Kinbasket Reservoir behind Mica Dam. About 70 per cent of the annual river flow at Revelstoke is controlled discharge from Mica, with the remaining 30 per cent from unregulated local inflow.

Hugh Keenleyside Dam impounds 7.1 MAF in Arrow Lakes Reservoir, which is operated as a storage reservoir under the Columbia River Treaty. Under most operating conditions, flows into Arrow Lakes Reservoir from Mica Dam can be adjusted to address environmental, social and economic considerations that are not reflected in the Treaty (refer to Section 2.2.5).

Spills at Revelstoke and Mica dams occur infrequently when inflows exceed generation discharge capability and reservoir storage capacity.

4.3 Emergencies and Dam Safety

Emergencies and dam safety requirements shall take precedence over the operational conditions outlined in this Water Use Plan. Emergencies include, but are not limited to, actual and potential loss of power to customers, spill avoidance, mechanical failures and environmental incidents. Dam safety requirements for operations are outlined in the *Columbia River: Operation, Maintenance and Surveillance Manual (OMS) for Dam Safety*, issued by BC Hydro's Director of Dam Safety.

4.4 Proposed Conditions for the Operation of Works for Diversion and Use of Water

BC Hydro proposes to operate the Columbia River hydroelectric facilities in accordance with the conditions outlined below, subject to requirements of the Columbia River Treaty. BC Hydro may not be able to operate within these conditions during extreme hydrological events.

4.4.1 Kinbasket Reservoir

4.4.1.1 Reservoir Elevation

The Consultative Committee did not recommend any operational constraints on Kinbasket Reservoir.

4.4.1.2 Revegetation of the Drawdown Zone

A revegetation program is recommended for Kinbasket Reservoir, in lieu of maintaining a lower elevation during the growing season than is provided under current operation, to maximize vegetation growth in the drawdown zone and provide benefits to littoral productivity, wildlife habitat, shoreline erosion and archaeological site protection.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement a multi-year revegetation program for Kinbasket Reservoir in areas that have a good potential to become self-sustaining after five years of treatment. This program will involve:

- Planting approximately 1800 ha of currently unvegetated shoreline through seeding of fall rye and sedge, and planting of willow and native wetland plants.

- Enhancing approximately 1500 ha of currently vegetated shoreline through fertilization and infill seeding and/or planting of willow and native wetland plants.

Final development of revegetation strategies for Kinbasket Reservoir will be based on results of the *Inventory of Vegetation Resources in Kinbasket Reservoir* noted in Table 5-1. A maximum expenditure of $4.1 million will be made for revegetation efforts in Kinbasket Reservoir, the mid Columbia River and Arrow Lakes Reservoir (refer to Section 4.4.4.3).

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.1.3 Archaeological Site Protection

An archaeological site protection program is recommended for Kinbasket Reservoir, in lieu of operational constraints that would maintain the reservoir at preferable elevations, as a means of protecting cultural sites and resources in the drawdown zone. This program includes an archaeological inventory, exploratory excavations, a management strategy, mitigation and effectiveness monitoring.

BC Hydro will work with the First Nations to develop a management strategy to address protection of cultural sites in Kinbasket Reservoir. BC Hydro will meet the obligations required under the *BC Heritage Conservation Act.*

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.1.4 Debris Management

A woody debris management plan is recommended for Kinbasket Reservoir, in lieu of operational constraints that would maintain the reservoir at preferable elevations year round, as a means of maximizing the quality of recreation on the reservoir and improving navigational safety. This plan will address new debris that enters the system either from tributaries or sloughing of the reservoir banks during high water events, which becomes stranded in "bathtub rings" around the reservoir and then is re-introduced to the reservoir during subsequent high water events.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement a Kinbasket Reservoir debris management plan, conditional on the results of an environmental review to address potential impacts on other interests (fish and wildlife habitat, vegetation, archaeological site protection, erosion). The debris management plan will involve development of strategies and targets for debris removal, inventory of existing debris accumulations, annual shoreline debris removal and periodic removal of floating debris mats.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.1.5 Recreational Boat Access

Boat access improvements are recommended for Kinbasket Reservoir, in lieu of maintaining higher elevations through the recreation season than is provided under the current operation, as a means of providing safe access to and from the reservoir and increasing accessibility for water-based recreation at different times and reservoir elevations.

It is recommended that the Comptroller of Water Rights direct BC Hydro to construct and maintain on an annual basis a new boat ramp at Bulldog Creek and extend the three existing boat ramps located at Valemount Marina, Nixon Creek and Bush Harbour, conditional on the results of studies to address the feasibility of these works and potential impacts on other interests (fish habitat and archaeological sites).

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.2 Revelstoke Reservoir

4.4.2.1 Reservoir Elevation

The Consultative Committee did not recommend any operational constraints on Revelstoke Reservoir.

4.4.2.2 Archaeological Sites

An archaeological site protection program is recommended for Revelstoke Reservoir, in lieu of operational constraints that would maintain the reservoir at preferable elevations, as a means of protecting cultural sites and resources in the drawdown zone. This program includes an archaeological inventory, exploratory excavations, a management strategy, mitigation and effectiveness monitoring.

BC Hydro will work with the First Nations to develop a management strategy to address protection of cultural sites in Revelstoke Reservoir. BC Hydro will meet the obligations required under the *BC Heritage Conservation Act.*

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.3 Revelstoke Dam

4.4.3.1 Year-Round Minimum Flow Release

A year-round minimum flow release of 5 kcfs (140 m^3/s) from Revelstoke Dam is recommended to increase ecological productivity and juvenile fish use, maximize adult fish abundance, condition and growth, and trigger rainbow trout spawning in the mid Columbia River.

It is recommended that the Comptroller of Water Rights direct BC Hydro to provide the year-round 5 kcfs minimum flow release from Revelstoke Dam. The minimum release is to be implemented two years after BC Hydro receives direction from the Comptroller of Water Rights, and will continue for the life of the Water Use Plan. Future decisions around the minimum flow magnitude will be reviewed based on results of the *Mid Columbia Physical Habitat Monitoring, Ecological Productivity Monitoring, Juvenile Fish Habitat Use Monitoring, Fish Population Index Surveys and Adult Habitat Use Monitoring* noted in Table 5-1.

It is expected that maintenance of this minimum release will not be possible in the event of a forced outage at Revelstoke Generating Station due to transmission problems or acute equipment failure and that this may cause dewatering of the downstream channel for periods of up to several hours. It is not recommended that the minimum release be provided through spill at Revelstoke Dam during these unusual events.

4.4.3.2 Seasonal Minimum Flow Release

It is recommended that BC Hydro provide an experimental minimum flow release from Revelstoke Dam during the 1 July to 31 August period to improve white sturgeon spawning habitat condition and performance, and increase the survival of naturally spawned individuals during the egg and larval stages in the mid Columbia River. A maximum total power generation cost of $5 million will be incurred over 10 years to provide a higher minimum flow release than proposed in Section 4.4.3.1. Estimates of what could be achieved on average, depending on water conditions, within the $5 million ceiling plus the 5 kcfs year-round release include:

i) 30 kcfs for 4 weeks in August in years when probable spawning of white sturgeon is detected in the mid Columbia River (expected 5 years out of 10),

ii) 15 kcfs for 8 weeks in July and August every year, or

iii) 24 kcfs for 4 weeks in August every year.

Selection of the minimum flow release strategy (frequency, duration and magnitude) will be determined based on results of the *Mid Columbia River Sturgeon Egg Substrate Mat Monitoring and the Underwater Videography Feasibility Study* noted in Table 5-1, consultation with federal and provincial fisheries agencies, and direction from the Comptroller of Water Rights.

It is recommended that the Comptroller of Water Rights direct BC Hydro to undertake the aforementioned studies to better define an appropriate flow release strategy. The seasonal minimum flow release will be implemented two years after implementation of this Water Use Plan. Provision of this minimum flow release will cease prior to reaching the maximum expenditure limit if wild production and egg/larval benefits cannot be conclusively demonstrated based on results of the *Mid Columbia River Juvenile Sturgeon Detection and Habitat Use Program* noted in Table 5-1.

Details regarding this recommendation are provided in *the Columbia River Water Use Plan: Consultative Committee Report*.

4.4.4 Mid Columbia River and Arrow Lakes Reservoir

4.4.4.1 Reservoir Elevation

The Consultative Committee did not recommend any operational constraints on Arrow Lakes Reservoir (refer to Section 4.5.2).

4.4.4.2 White Sturgeon Conservation Aquaculture

A conservation aquaculture program is recommended for the Arrow Lakes Reservoir white sturgeon population, in lieu of providing higher more optimal spawning, incubation and rearing flows than proposed in Section 4.4.3, as a means of addressing key uncertainties regarding the availability/suitability of juvenile rearing habitat in the mid Columbia River, and assessing the effectiveness of the minimum flow releases on larval and juvenile survival over the short term. Over the long term, the conservation aquaculture program will help to support the Arrow Lakes Reservoir population until such a time as stock abundance and age structure and habitat conditions can support a self-sustaining white sturgeon population. If spawning and early life stage survival in the mid Columbia River is not possible, all or part of the conservation aquaculture effort may be directed to an alternative recovery area (Kinbasket Reservoir/upper Columbia River).

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement the white sturgeon conservation aquaculture program, which will involve experimental releases of juveniles and yearlings near Revelstoke, development of aquaculture facilities for juvenile production at the Kootenay Hatchery, and implementation of conservation aquaculture in Arrow Lakes Reservoir and or Kinbasket Reservoir.

Details regarding this recommendation are provided in *the Columbia River Water Use Plan: Consultative Committee Report.*

4.4.4.3 Revegetation of the Drawdown Zone

A revegetation program is recommended for Arrow Lakes Reservoir and the mid Columbia River, in lieu of maintaining elevations at or below 436 m during the spring/early summer, to maximize vegetation growth in the drawdown zone and provide benefits to littoral productivity, large river habitat, wildlife habitat, shoreline erosion and archaeological site protection.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement a multi-year revegetation program in areas between elevations 434 m and 440 m that have a good potential to become self-sustaining after five years of treatment. This program will involve:

- Planting approximately 700 ha of currently unvegetated shoreline in Arrow Lakes Reservoir and approximately 530 ha in the mid Columbia River through seeding of fall rye and lenticulate sedge, and planting of willow and native wetland plants.

- Enhancing approximately 500 ha of currently vegetated shoreline in Arrow Lakes Reservoir and approximately 1000 ha in the mid Columbia River through foliar fertilization and infill seeding and/or planting of willow and native wetland plants.

Final development of revegetation strategies for Arrow Lakes Reservoir and the mid Columbia River will be based on results of the *Inventory of Vegetation Resources in Arrow Lakes Reservoir,* and the *Digital Elevation Model (DEM) for Upper and Lower Arrow Lakes Reservoir* noted in Table 5-1.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.4.4 Wildlife Habitat

Wildlife habitat physical works are recommended for Arrow Lakes Reservoir and the mid Columbia River, in lieu of maintaining lower elevations during the spring/early summer and fall periods, to improve conditions for nesting and migratory bird habitat and wildlife habitat within the drawdown zone.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement the wildlife habitat physical works, which will follow an adaptive experimental approach using small-scale, soft-engineered structures that exploit the existing landforms in the drawdown zone to improve the functioning of existing habitat areas. An annual maximum expenditure of $100,000 will be made in Year 1 and $250,000 in Years 2 through 10 for undertaking feasibility and planning studies, administration and implementation of these works.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report.*

4.4.4.5 Recreational Boat Access

Boat access improvements are recommended for the mid Columbia River and Arrow Lakes Reservoir, in lieu of maintaining higher elevations through the recreation season than is provided under current operation, as a means of providing safe access to and from the reservoir, and increasing accessibility for water-based recreation.

It is recommended that the Comptroller of Water Rights direct BC Hydro to construct and maintain on an annual basis a new boat ramp at Burton, and extend the existing boat ramps at Edgewood, Fauquier and MacDonald Creek Park, conditional on the results of studies to address the feasibility of these works and potential impacts on other interests (fish habitat and archaeological sites).

It is also recommended that the Comptroller of Water Rights direct BC Hydro to construct a new boat ramp in the vicinity of the City of Revelstoke, conditional on the results of a feasibility study to determine the need for a substitute site to the existing ramp. This will include identification of the best location for this site considering proximity to the city, potential hazards in the river, the level of use if a new ramp is constructed, and the design and costs of a new ramp. A maximum expenditure of $200,000 will be made to construct a new boat ramp at Revelstoke, conditional on results of the feasibility study.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report.*

4.4.4.6 Debris Management

A woody debris management plan is recommended for Arrow Lakes Reservoir, in lieu of operational constraints that would maintain the reservoir at preferable elevations year round, as a means of maximizing the quality of recreation on the reservoir and improving navigational safety. This plan will address new debris that enters the system either from tributaries or sloughing of the reservoir banks during high water events, which becomes stranded in "bathtub rings" around the reservoir and then is re-introduced to the reservoir during subsequent high water events.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement an Arrow Lakes Reservoir debris management plan, conditional on the results of an environmental review to address potential impacts on other interests (fish and wildlife habitat, vegetation, archaeological site protection). The debris management plan will involve development of strategies and targets for debris removal, inventory of existing debris accumulations, and annual shoreline debris removal.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.4.7 Archaeological Site Protection

An archaeological site protection program is recommended for Arrow Lakes Reservoir, in lieu of operational constraints that would maintain elevations at 436 m or below year round, as a means of protecting cultural sites and resources in the drawdown zone. This program includes an archaeological inventory, exploratory excavations, a management strategy, mitigation and effectiveness monitoring.

BC Hydro will work with the First Nations to develop a management strategy to address protection of cultural sites in Arrow Lakes Reservoir. BC Hydro will meet the obligations required under the *BC Heritage Conservation Act.*

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.5 Lower Columbia River

4.4.5.1 Turbidity Augmentation

A turbidity augmentation experiment is recommended for the lower Columbia River, in lieu of providing a 200 kcfs flow at the Canada/U.S. border (which would require agreement with the U.S. Entity), as a means of reducing predation pressures on larval and juvenile white sturgeon and increasing the probability of successful natural recruitment to the population.

It is recommended that the Comptroller of Water Rights direct BC Hydro to undertake the turbidity experiment in the lower Columbia River, conditional on the results of a feasibility study to address regulatory concerns and associated fisheries and related ecosystem issues. This experimental program will involve increasing turbidity in the river to 10 NTU over 30 days during the late June to late July period when flows at the Canada/U.S. border are expected to be at or below 90 kcfs.

In the event that turbidity augmentation is found to be unfeasible, it is recommended that the Comptroller of Water Rights direct BC Hydro to provide an annual contribution of $188,000 to the existing lower Columbia River white sturgeon conservation aquaculture program, as a means of preventing further sturgeon population degradation while allowing time to investigate causes of recruitment failure and identify other more feasible mitigative measures.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.5.2 Dredging of Indian Eddy

An annual dredging program is recommended at the Indian Eddy boat launch, in lieu of reducing flow fluctuations at Hugh Keenleyside Dam, to maintain access to the lower Columbia River for emergency boats.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement the dredging program, conditional on the results of an engineering study to determine the mechanism causing transport of sand from Gyro Park Beach to Indian Eddy, and the extent of transport and deposition affected by Hugh Keenleyside Dam operations versus Brilliant Dam operations.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.4.5.3 Debris Removal at Indian Eddy

A woody debris removal program is recommended at the Indian Eddy boat launch, in lieu of reducing flow fluctuations at Hugh Keenleyside Dam, to maintain access to the lower Columbia River for emergency boats.

It is recommended that the Comptroller of Water Rights direct BC Hydro to implement the debris program, conditional on the results an environmental review to address potential impacts on other interests in the lower Columbia River (fish and wildlife habitat).

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.5 Non-Licence Water Use Plan Recommendations

The Consultative Committee recognized that some 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 recommendations when making water management decisions.

4.5.1 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 as described in Section 2.3.

On rare occasions, BC Hydro may also wish to surcharge the reservoirs to address other environmental or economic considerations. Under these circumstances, BC Hydro acknowledges that there may be impacts and would propose mitigation and/or compensation measures and seek direction from the Comptroller of Water Rights prior to initiating surcharging on the reservoirs.

4.5.2 Arrow Lakes Reservoir Operation

The Consultative Committee acknowledged that in the absence of a replacement to the Non-Treaty Storage Agreement, it would not be possible for BC Hydro to unilaterally implement all of the monthly constraints that were recommended for Arrow Lakes Reservoir under the proposed operating alternatives across all water years. The Committee agreed to developing specific objectives for their interests in the reservoir to help guide operational decisions each year. There are a number of conflicting objectives, and the degree to which they are met will vary by water year.

Table 4-1 describes the objectives developed by the Consultative Committee for Arrow Lakes Reservoir.

Table 4-1: Objectives for Arrow Lakes Reservoir

Interests	Objectives
Vegetation	
	• Maintain the current extent, biomass and diversity of vegetation in the drawdown zone through maintaining lower reservoir water levels during the growing season. No specific operating targets were identified around 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 water 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 (1425 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 (1425 ft) and above over the 1984–1999 period, which were used to produce the average historic performance measure score for short-eared owl. • Ensure that availability of migratory bird habitat in 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, targeting a reservoir level of 438 m (1438 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 (1425 ft) could cause tributary access to be restricted. Proposed monitoring study aimed at determining reservoir level thresholds under range of tributary streamflow conditions below which spawner access becomes a problem (refer to Table 5-1).
Recreation	
	• Target reservoir water levels between 437.4 m and 438.9 m (1435 ft and 1440 ft) from 24 May to 30 September. • A lower level of 434 m (1425 ft) during the recreation season would be acceptable with construction/upgrade of boat ramps for recreation interests served by these formal access points.
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.
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.
Power Generation	
	• Optimize power values.

BC Hydro will convene a multi-party review five years after the initiation of the Columbia River Water Use Plan to evaluate the performance of operations and physical works in meeting the Consultative Committee's interests and objectives in Arrow Lakes Reservoir, and to report out on the results of the concluded Non-Treaty Storage Agreement discussions. The outcomes of the 5-year review will be used to assess the need for a review of the Arrow Lakes Reservoir operations component of this Water Use Plan.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.5.3 Lower Columbia River Fish Stranding

BC Hydro will conduct communications, environmental response strategies, monitoring and mitigation activities and reporting in response to flow reduction events at Hugh Keenleyside Dam in accordance with the *Strategy for Managing Fish Impacts Associated with Flow Reductions at Keenleyside Dam (August 2003).*

BC Hydro will follow the interim ramping rate criteria and decision factors set out in the *Strategy for Managing Fish Impacts Associated with Flow Reductions at Keenleyside Dam (August 2003)*, in conjunction with past stranding data, to determine appropriate ramping rates for individual flow reduction events at Hugh Keenleyside Dam to minimize the incidence of fish pool stranding in the lower Columbia River. BC Hydro will use the interim ramping rate criteria and decision factors to determine appropriate ramping rates until such a time that further information is gained through ongoing fish salvage, survey activities and the proposed ramping rate study (refer to Table 5-1) that a defined ramping rate matrix can be developed to the satisfaction of BC Hydro and the fisheries regulatory agencies.

In the interim, the Consultative Committee agreed that implementation of the stranding protocol and interim ramping rate criteria, in conjunction with planned ramping rates tests, monitoring and appropriate mitigation, were an acceptable approach to addressing fish stranding in the lower Columbia River.

4.5.4 Mountain Whitefish Flows

BC Hydro will continue to pursue the mountain whitefish flows in the lower Columbia River every year through annual negotiations with the United States. An active adaptive approach will be taken to implementing and monitoring the whitefish flows to test the effectiveness of the current flow regime in protecting the current population below Hugh Keenleyside Dam, and provide better information for future decision making. Past agreements for whitefish flows have focused on reducing outflows from Arrow Lakes Reservoir during the peak spawning period (1 January to 21 January) and reducing the dewatering of whitefish eggs during the incubation period (21 January to 31 March). The objective is to reduce the difference between the maximum peak spawning flow and the minimum incubation flow.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

4.5.5 Rainbow Trout Flows

BC Hydro will continue to pursue the rainbow trout protection flows for the lower Columbia River every year through annual negotiations with the United States. Priority items for consideration include:

- Avoid decreasing river levels from 1 April to 30 June and consult with the federal and provincial fisheries agencies on an annual basis regarding timing and rampdown from mountain whitefish flows in March to rainbow trout flows in April.

- Minimize the required volume and duration of water stored in Arrow Lakes Reservoir as a trade off for the U.S. Entity to achieve its fish management objectives.

Details regarding this recommendation are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

5.0 PROGRAMS FOR ADDITIONAL INFORMATION

Development and evaluation of the proposed operating conditions for the Columbia River hydroelectric facilities was complicated by a lack of quantitative data on key resources and operational-related impacts on interests of the Consultative Committee. The June 2004 recommendations of the Committee were, therefore, contingent on implementation of a monitoring program to address these uncertainties and inform on the effectiveness of the operational changes and non-operational physical works in meeting the stated objectives of the Committee.

Accordingly, it is recommended that the Comptroller of Water Rights direct BC Hydro to undertake a monitoring program that will:

- Assess expected outcomes of the operational and non-operational changes being recommended.

- Provide improved information for decision-making for future operating conditions.

Details and costs of the proposed monitoring program are provided in the *Columbia River Water Use Plan: Consultative Committee Report*.

The monitoring programs are designed to address key questions that affected decision-making throughout the consultative process. Table 5-1 provides a summary of the monitoring program components.

Table 5-1: Monitoring Program Components and Key Objectives

Component	Objective
Mica Dam Total Gas Pressure Monitoring and Abatement Program	Monitoring of total gas pressure (TGP) production from Mica Dam and controlled operating tests to determine the downstream extent of TGP impacts, and whether current best management practices are most effective in maintaining local TGP levels below acceptable thresholds.
Kinbasket and Revelstoke Reservoir Kokanee Population Monitoring	Annual surveys to estimate trends in abundance and biological characteristics of kokanee populations in Kinbasket and Revelstoke reservoirs to address uncertainty whether the lack of operational constraints in Kinbasket impact the productivity of key pelagic fish populations, and whether operational impacts (such as entrainment, tributary access) impact the abundance of these populations.
Kinbasket Reservoir Fish Stranding Surveys	Assessment of fish stranding due to drawdown of Kinbasket Reservoir to address uncertainty related to the extent, spatial location and timing of stranding, key areas of concern, and to develop feasible mitigative options for future consideration.
Kinbasket Reservoir Burbot Life History and Habitat Use Assessment	Multi-year life history and habitat use study to address data gaps on the potential for reservoir operations to impact burbot populations in Kinbasket Reservoir (i.e., dewatering of spawning areas during winter drawdown), and develop mitigative strategies to minimize adverse impacts for future consideration.
Kinbasket Reservoir Bull Trout Life History and Habitat Use Assessment	Multi-year life history and habitat use studies to address data gaps on the potential for Mica Dam and Kinbasket Reservoir operations to impact bull trout populations in Kinbasket (i.e., entrainment of juvenile bull trout), and develop mitigative strategies for minimizing adverse impacts for future consideration.
Kinbasket Reservoir Rainbow Trout Life History and Habitat Use Assessment	Multi-year life history and habitat use studies to address data gaps on the potential for Kinbasket Reservoir operations to impact rainbow trout populations in Kinbasket (i.e., tributary access, and redd backwatering during spring refill), and develop mitigative strategies to mitigate adverse impacts for future consideration.
Kinbasket Reservoir Sturgeon Inventory and Habitat Use Assessment	Multi-year sampling program to establish whether sturgeon are present in Kinbasket Reservoir and the upper Columbia River, and document patterns of habitat use of adult and juvenile sturgeon to address uncertainty regarding the impact of operations on natural recruitment processes.
Monitoring/Stabilization of Peatland in Kinbasket Reservoir	Investigation to determine the functionality of a peatland in the Valemount end of Kinbasket Reservoir, and whether reservoir operations affect the plant and wildlife communities that it supports. Possibility of an additional year of study to evaluate the need for stabilization as a result of reservoir operations.
Kinbasket and Revelstoke Reservoir Ecological Productivity Monitoring	Annual surveys of physical, chemical and biological conditions in the pelagic and littoral zones of Kinbasket and Revelstoke reservoirs to address uncertainty whether the lack of operational constraints on Kinbasket impact trophic productivity and the overall ecological health of the system.
Inventory of Vegetation Resources in Kinbasket Reservoir	Vegetation mapping and GIS analysis to assess vegetation distribution by elevation band and to identify pocket riparian habitat as potential wildlife habitat within Kinbasket Reservoir. This will allow determination of subsequent vegetation status and trends in relation to planting efforts, validation of assumptions used in modeling of hydrologic impacts of operating alternatives on vegetation, and identification of sites with potential to support wildlife habitat through enhancement works and vegetation management.
Monitoring of Revegetation Efforts in Kinbasket Reservoir	Annual monitoring to evaluate plant survival and development of representative planting sites under the various revegetation options, and to address uncertainty about species survival under existing operating conditions of Kinbasket Reservoir.

Component	Objective
Kinbasket and Arrow Lakes Reservoir Effectiveness Monitoring of Wildlife Physical Works and Revegetation	Seasonal surveys to document changes in wildlife utilization patterns in response to revegetation efforts and the effectiveness of revegetation in improving habitat quality and quantity in Kinbasket and Arrow reservoirs. This will also help to inform on the effectiveness of wildlife physical works in improving habitat quality and quantity in Arrow Lakes Reservoir (e.g., bird nest habitat).
Monitoring of Revegetation Efforts in Arrow Lakes Reservoir	Annual monitoring to evaluate plant survival and development of representative planting sites under the various revegetation efforts in Arrow Lakes Reservoir.
Monitoring of Mosquito Distributions in the Revelstoke Area	Survey of low bench and littoral areas of the mid Columbia River in the Revelstoke area to monitor the distribution of mosquito species, particularly *Aedes vexans* and *Aedes stisticus* (May-September). This study is considered one component of a larger overall study (see three other study components below) to gain a better understanding around the current status of mosquito populations to better inform on how current operating conditions of Revelstoke Dam and Arrow Lakes Reservoir affect these populations. These studies are required to enable wildlife physical works and revegetation to proceed.
Monitoring of Mosquito Populations in the mid Columbia River	Monitoring to quantify dispersal and aggregation of adult mosquitoes and identify breeding grounds within 10 km of Revelstoke.
Monitoring of Effects of Hydrologic Regime on Mosquito Production	Monitoring to evaluate the effects of Revelstoke Dam discharge on mosquito production at different reservoir levels and under different climatic conditions. Investigation will help to inform on effects of water elevation on vegetation type and mosquito breeding grounds.
Monitoring and Management of Potential West Nile Virus Hotspots in the mid Columbia River	Monitoring to identify locations of potential West Nile Virus risk and prepare an Integrated Mosquito Management Plan for Revelstoke.
Complete Digital Elevation Model (DEM) for Upper and Lower Arrow Lakes Reservoir	Completion of the DEM for upper and lower Arrow Lakes Reservoir to confirm that modelling results in Revelstoke Reach are applicable to the entire reservoir, allow for assessment of vegetation distribution by elevation band, and provide essential information for undertaking physical works for wildlife and archaeological site protection.
Aerial Photographs of Upper and Lower Arrow Lakes Reservoir	Obtain colour aerial photographs to complete baseline vegetation mapping of Revelstoke Reach and vegetated areas of the upper and lower Arrow Lakes Reservoir.
Inventory of Vegetation Resources in Arrow Lakes Reservoir	Mapping of vegetation and GIS analysis to assess vegetation distribution by elevation band, and to identify pocket riparian habitat within Arrow Lakes Reservoir. This will allow determination of subsequent changes in vegetation status in relation to reservoir hydrologic conditions and revegetation efforts, validation of assumptions used in modeling impacts of operating alternatives on vegetation, and identification of sites with potential to support wildlife habitat through physical works and vegetation management. This study will require the completion of the DEM and collection of aerial photography (as noted above).
Engineering Study in Support of Dredging at Indian Eddy	Define the relative contributions of the Kootenay River and Arrow Lakes Reservoir discharge during periods of problematic high and low flows to determine whether there is a link between flow fluctuations at Hugh Keenleyside Dam and sand erosion from Gyro Park Beach and subsequent deposition downstream at Indian Eddy.
Environmental Assessment of Dredging at Indian Eddy	Assess the potential environmental impacts of dredging sand from Indian Eddy to maintain emergency boat access to the lower Columbia River.

Component	Objective
Environmental Review of Debris Removal in Kinbasket and Arrow Lakes Reservoirs	Assess the potential impacts of the debris management program on other interests (e.g., fish and wildlife habitat, vegetation, archaeological site protection), and identify potential uses of debris for fish and wetland habitat restoration.
Environmental Review of Debris Removal from Indian Eddy	Assess the potential impacts of debris removal on other interests (e.g., fish and wildlife habitat, and vegetation).
Feasibility Study of Boat Ramps (new/upgrades)	Investigate the feasibility of construction of new ramps and extensions to existing ramps in Kinbasket and Arrow reservoirs and the mid Columbia River (including current condition assessment, performance assessment, adequacy of site characteristics, and design parameters) to enable physical works to proceed.
Boat Ramp Use Study	Multi-year public use measurement study at improved boat launches in Kinbasket and Arrow reservoirs to establish the link between level of use and boat launch improvements, and to monitor use levels for future decision-making for recreational interests.
Recreation Demand Study	Dynamic reservoir recreational demand estimation to develop performance measures scores that link all aspects of recreation (shoreline and boating) to reservoir levels, by local/tourist ranking for future decision-making. Dynamic model enables modeling of preference changes across operating alternatives.
Management Strategy for Four Known Archaeological Sites in Arrow Lakes Reservoir	Determine preferences of interested First Nations in treatment options and develop an effective strategy to manage the four areas identified within the drawdown zone of Arrow Lakes Reservoir that contain intact archaeological material and are actively being eroded as a result of reservoir operations.
Effectiveness Monitoring of Active Intervention at the Four Known Archaeological Sites in Arrow Lakes Reservoir	Monitoring to assess the effectiveness of treatment options undertaken at the four known archaeological sites in Arrow Lakes Reservoir. Monitoring will help built on knowledge regarding best approaches to managing and protecting the remaining, as yet discovered archaeological sites in Kinbasket and Arrow reservoirs.
Monitoring of Impact of Wave/Wind Erosion on Scarp Stability in Arrow Lakes Reservoir	Monitoring of wave and wind erosion impacts on the stability of a major escarpment in Arrow Lakes Reservoir that likely contains a large number of intact and actively eroding archaeological sites.
Archaeological Site Survey and Inventory in Arrow Lakes Reservoir	Complete survey and inventory of archaeological sites eroding or at risk of eroding in Arrow Lakes Reservoir. Information on numbers, location and characteristics of these sites is required to enable physical works (i.e., archaeological site protection, revegetation, boat ramp improvements, wildlife physical works) to proceed.
Inventory of Archeological Sites in Kinbasket and Revelstoke Reservoirs	Stratified survey and inventory of archaeological sites eroding or at risk of eroding in Kinbasket and Revelstoke reservoirs. Information on numbers, location and characteristics of these sites is required to enable physical works (i.e., archaeological site protection, revegetation, boat ramp improvements) to proceed.
Exploratory Excavations at Newly Discovered Archaeological Sites in Kinbasket, Revelstoke and Arrow Lakes Reservoirs	Some limited excavations at each newly discovered archaeological site to determine the depth (i.e., the amount of intact archaeological material) and importance of the site to help in prioritizing sites for intervention.
Development of a Multi-year Strategy to Address Access and Monitoring of Newly Discovered Archaeological Sites in Kinbasket, Revelstoke and Arrow Lakes Reservoirs	Determine First Nation preferences for treatment options for newly discovered archaeological sites and develop an effective management plan. The extent of the archaeological information and the dynamics of the erosion process will determine the best approach for site protection.

Component	Objective
Effectiveness Monitoring of Active Intervention at Newly Discovered Archaeological Sites in Kinbasket, Revelstoke and Arrow Lakes Reservoirs	Monitoring to assess the effectiveness of treatment options undertaken at newly discovered sites in Kinbasket, Revelstoke and Arrow reservoirs to mitigate impacts of reservoir operations. Knowledge gained through monitoring of these interventions will help to inform on what operations (or physical works in lieu of operations) are best suited to preserve these sites in the future.
Mid Columbia Physical Habitat Monitoring	Annual monitoring of the physical habitat impacts of Revelstoke Dam and Arrow Lakes Reservoir operations (temperature, stage, TGP, electrochemistry and nutrients). This information is required to complete the linkage between operational change, physical habitat change, and ecological change for the experimental testing of baseflow releases from Revelstoke Dam.
Mid Columbia Ecological Productivity Monitoring	Annual monitoring of periphyton and benthic invertebrates to determine ecological health of the mid Columbia River. This will address uncertainty regarding the net change in trophic productivity and overall ecological health resulting from baseflow releases from Revelstoke Dam, and the benefits of revegetation in increasing availability of terrestrial fish food organisms.
Mid Columbia River Juvenile Fish Habitat Use	Assess changes in habitat use by juvenile and subadult fish in the mid Columbia River in response to baseflow releases from Revelstoke Dam. This will address uncertainty related to current utilization of the mainstem and tributaries to the mid Columbia to meet critical life history requirements (juvenile fish rearing), and whether changes to baseflow releases from the dam result in habitat improvements that increase the quality of physical habitats for juvenile fish rearing.
Mid Columbia Fish Population Index Surveys	Annual monitoring of the abundance and biological characteristics of key index fish populations (mountain whitefish, bull trout) in the mid Columbia River to assess the response of these populations to changes in baseflow releases from Revelstoke Dam. Compliance monitoring to ensure no decline in abundance of selected key species resulting from Water Use Plan recommended operational change.
Mid Columbia River Adult Habitat Use Assessment	Annual surveys to document behavioural (diel and seasonal) responses of key adult fish species to baseflow releases from Revelstoke Dam. This will address uncertainties related to the extent to which fish populations rely on the mid Columbia River to satisfy critical life history functions.
Mid Columbia River Sturgeon Spawning Habitat Assessment	Hydrometric surveys of the mid Columbia River in locations of known white sturgeon spawning to validate assumptions used in setting sturgeon spawning flows, and to determine spawning ground habitat requirements for possible rehabilitation activities in the future. This will address uncertainties related to the accuracy and precision of hydraulic models and habitat suitability models used in Water Use Plan assessments of sturgeon spawning requirements and larval dispersal associated with experimental releases, and for future rehabilitation studies.
Mid Columbia River Juvenile Sturgeon Detection and Habitat Use Program	Annual surveys and telemetric assessment of patterns of habitat use by juvenile white sturgeon in the mid Columbia River. This will address uncertainties related to the presence of juvenile sturgeon in the mid Columbia River, whether habitats are sufficient to allow recruitment of larvae to age 1+, and whether seasonal flow releases from Revelstoke Dam provide suitable habitat for the successful recruitment of sturgeon.
Mid Columbia River Tracking of Existing Sonic Tagged Sturgeon	Seasonal tracking of existing tagged white sturgeon to determine staging and spawning habitat preferences, and identify movements into staging and spawning areas near Revelstoke.

Component	Objective
Mid Columbia River Sturgeon Egg Substrate Mat Monitoring & Underwater Videography Feasibility Study	Expansion of the existing substrate mat program to assess the longitudinal and cross-sectional distribution of sturgeon eggs to assist in evaluating the impacts of the minimum flow treatment on egg and larval stranding. Assess the feasibility of using underwater videography to detect pre-spawning and spawning sturgeon. If feasible, this would provide an alternative method of spawner detection to capture and tagging of females.
Mid Columbia River Sturgeon Genetic Assessment	Continuation of ongoing genetic assessment work to determine levels of stock differentiation in the Arrow Lakes Reservoir and lower Columbia River white sturgeon populations. This work is a prerequisite to large-scale fish culture operations targeting release to Arrow Lakes Reservoir.
Kinbasket Reservoir Sturgeon Recolonization Risk Assessment and Habitat Suitability Study	Investigation of the ecological risks of conservation aquaculture for white sturgeon in Kinbasket Reservoir. This would include assessment of habitat suitability for all life phases and development of an aquaculture strategy.
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/facilities required for lab-based experiments for implementation in Phase 2.
Kinbasket Reservoir Juvenile Sturgeon Detection and Habitat Use Program	Annual surveys and telemetric assessment of patterns of habitat use by juvenile white sturgeon in Kinbasket Reservoir (including tagging and tracking of hatchery juvenile releases). This study would required if the decision is made that efforts at rebuilding the sturgeon population should shift from Arrow Lakes Reservoir to an alternate recovery area.
Arrow Lakes Reservoir Burbot Life History and Habitat Use Assessment	Multi-year life history and habitat use study to address data gaps related to the potential for reservoir operating impacts on burbot populations in Arrow (i.e., dewatering of spawning habitats), and develop mitigative strategies to minimize adverse impacts for future consideration.
Arrow Lakes Reservoir Tributary Fish Migration Access Assessment and Monitoring	Physical assessment of passage conditions at tributaries to Arrow Lakes Reservoir under a range of operating levels and streamflow conditions. This will address uncertainties related to threshold reservoir levels below which passage of fish is prevented, whether high stream flows mitigate impacts of lower reservoir elevation, and 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.
Vegetation Composition and Analysis in Arrow Lakes Reservoir	Annual monitoring of changes in plant size, biomass, species composition and vigour in Arrow Lakes Reservoir in response to altered hydrologic conditions. This will address uncertainty related to the relative importance of timing, duration and depth of inundation, and multi-year stresses on vegetation survival within the drawdown zone.
Plant Response to Timing and Duration of Inundation in Arrow Lakes Reservoir	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 in Arrow Lakes Reservoir. This will address uncertainty related to the relative importance of timing and duration of inundation on plant survival at different sizes and ages, the importance of recruitment of seedlings in overall survival of the plant community, regeneration of a plant community after being decimated by extreme inundation, and the role of an established seed bank in its re-establishment.

Component	Objective
Nest Mortality of Migratory Birds due to Arrow and Kinbasket Reservoir Operations	Annual monitoring to determine the effect of reservoir operations in spring/summer on nesting success of breeding birds (including Species at Risk). This will inform on the magnitude and significance of nest mortality due to reservoir operations, and the scope of physical works required to mitigate adverse impacts, and the effectiveness of these works in mitigating nesting failure.
Reptile and Amphibian Life History and Habitat Use Assessment in Arrow and Kinbasket Reservoirs	Multi-year life history and habitat use study to evaluate operational impacts on reptiles and amphibians. This will address data gaps related to the relative abundance, distribution and seasonal patterns of habitat use by herptiles, and provide information on possible mitigation strategies (if required) for future consideration. This study needs to be undertaken concurrently with the development of pond designs for Arrow Lakes Reservoir and to include effectiveness monitoring of wildlife physical works on reptile and amphibian habitat.
Fall Migrating Shorebird Use of the Drawdown Zone of Arrow Lakes Reservoir	Multi-year life history and habitat use studies of migrating shorebirds in Revelstoke Reach. This will address data gaps related to the relative abundance, distribution and seasonal patterns of habitat use by migrating shorebirds, and provide information on the magnitude of impact of reservoir operations and possible mitigation strategies for future consideration.
Neotropical Migrant Use of the Drawdown Zone of Arrow Lakes Reservoir	Continuation of the multi-year banding study of neotropical migrants at the Revelstoke Banding Station located at Machete Island. This will address data gaps related to the relative abundance, distribution and seasonal patterns of habitat use by neotropical migrants, and inform on potential impacts of reservoir operations and possible mitigation strategies for future consideration.
Waterbird Monitoring in Arrow Lakes Reservoir	Continuation of collection of long-term trend data on the relative abundance, distribution and seasonal pattern of habitat use water birds in Revelstoke Reach. This will address data gaps related to the potential impacts of reservoir operations on waterbirds and possible mitigation strategies for future consideration.
Feasibility and Planning Studies for Wildlife Physical Works in the Mid Columbia River and Arrow Lakes Reservoir	Planning and feasibility studies to enable implementation of wildlife physical works and to identify feasible small-scale experimental options. These studies are required to address potential impacts on private lands, vegetation and fish habitat, as well as any incompatibility risks with archaeological site protection and recreational use of the drawdown zone.
Study of High Value Wildlife Habitat Sites for Potential Enhancement in Arrow Lakes Reservoir	Surveys of specific areas identified as providing high value wildlife habitat to determine potential opportunities for protection and enhancement. Lack of data precluded inclusion of these areas into the wildlife physical habitat works.
Lower Columbia River Fish Stranding Assessment and Ramping Protocol Development	Planned and opportunistic tests and monitoring to establish impacts of flow reductions on fish populations below Hugh Keenleyside Dam and the required operational procedures to mitigate ramping impacts.
Lower Columbia River Physical Habitat Monitoring	Annual monitoring of the physical habitat impacts of operations (temperature, stage, TGP, electrochemistry and nutrients). Study required to complete the linkage between flow conditions, physical habitat and ecological health.
Lower Columbia River Ecological Productivity Monitoring	Annual monitoring of periphyton and benthic invertebrates to determine trophic status of the lower Columbia River. This will address uncertainty regarding the net change in trophic productivity and overall ecological health of the lower Columbia River resulting from implementation of rainbow trout and mountain whitefish flow agreements.

Component	Objective
Lower Columbia River Fish Population Index Surveys	Annual monitoring of the abundance and biological characteristics of key index fish populations (mountain whitefish, rainbow trout and walleye) in the lower Columbia River in response to winter and spring flow agreements for whitefish and rainbow trout.
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. This information 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 mountain whitefish.
Lower Columbia River Sculpin and Dace Life History Assessment	Synoptic study to establish the relative abundance, distribution, life history and patterns of habitat use of sculpin and dace. The lack of biological information precluded explicit consideration of shallow-water dwelling threatened and endangered fish species during Water Use Plan development.
Lower Columbia River Whitefish Spawning Grounds Topographic Surveys	Detailed topographic surveys of index spawning locations to update the HEC RAS model and improve its predictive capability for estimating the physical effects of daily flow changes on whitefish egg loss. Required for experimental testing of the effectiveness of the current whitefish flow regime on protecting the whitefish population (i.e., test specific hypotheses and inform on critical data gaps regarding the relationship between flow conditions and egg mortality).
Lower Columbia River Whitefish Egg Monitoring	Weekly egg mat sampling at index spawning locations during the whitefish spawning season to quantify annual variation in key assumptions of the egg loss model and to refine biological parameter estimates. Required for experimental testing of the effectiveness of the current whitefish flow regime on protecting the whitefish population (i.e., test specific hypotheses and inform on critical data gaps regarding the relationship between flow conditions and egg mortality).
Lower Columbia River Whitefish Life History Study	Multi-year life history study of whitefish in the lower Columbia River. Required for experimental testing of the effectiveness of the current whitefish flow regime on protecting the whitefish population (i.e., test specific hypotheses and inform on critical data gaps regarding the functional relationship between young-of-year recruitment and surviving eggs, and between adult population and recruitment).
Monitoring the effects of Whitefish Flows on Great Blue Heron Winter Use of Waldie Island	Monitoring of the effects of winter flows and river stage (15 November – 1 March) for mountain whitefish spawning protection on the availability of shallow-water foraging and winter refuge habitat for Great Blue Heron. This information will inform on the need for future mitigative actions.
Winter Use of Waldie Island by Great Blue Heron Nesting adjacent to Revelstoke Reach	Mark/recapture study of juvenile Great Blue Heron nesting in a colony adjacent to Revelstoke Reach to determine whether birds from this population winter at Waldie Island (15 November – 1 March). This information will help to inform on the importance of Waldie Island as a wintering area and whether these individuals are susceptible to influences of both reservoir and downstream flow operations.
Lower Columbia River Adult Sturgeon Population Monitoring	Annual monitoring of the abundance, biological characteristics and reproductive status of white sturgeon in the lower Columbia River to better understand factors influencing population processes, and ensure that implementation of physical works does not result in a decline in population abundance.
Lower Columbia River Juvenile Sturgeon Detection Program	Annual monitoring of the relative abundance and distribution and habitat use patterns of juvenile white sturgeon in the lower Columbia River to better understand potential causes of recruitment, and determine if implementation of physical works results in natural recruitment of age 1+ sturgeon.

Component	Objective
Planning and Assessment of Turbidity Experiment in the Lower Columbia River	Studies to enable implementation of the turbidity experimental plan for white sturgeon in the lower Columbia River (e.g., regulatory issues, feasibility assessment, environmental and social assessment). 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.
Opportunistic Assessment of High Flow Events (200 kcfs at the International Boundary) in the Lower Columbia River	Studies undertaken on an opportunistic basis to assess the impacts of high flow events (sturgeon spawn detection, juvenile sturgeon detection, water quality sampling, flooding/erosion), and provide a better understanding of the relationships between high flows and egg, larval and juvenile sturgeon survival.

6.0 IMPLEMENTATION OF RECOMMENDATIONS

The operating conditions, the monitoring program, and the non-operational physical works proposed in this Water Use Plan will be implemented after BC Hydro receives direction from the Comptroller of Water Rights.

7.0 EXPECTED WATER MANAGEMENT IMPLICATIONS

Implications for the provincial interests that were considered during the preparation of this Water Use Plan are expected outcomes relative to current operations based on the best available information used to derive this plan.

After BC Hydro has been directed to implement the proposed conditions, BC Hydro will be responsible for meeting the operational parameters, but not for achieving the expected outcomes.

7.1 Erosion Control

The proposed conditions in this Water Use Plan are expected to decrease shoreline erosion and dust control problems in the mid Columbia River and Arrow Lakes Reservoir through revegetation of the drawdown zone and operations to meet erosion control objectives for the reservoir.

The proposed conditions in this Water Use Plan are not expected to increase erosion potential in the mid Columbia River as a result of minimum flow releases from Revelstoke Dam for white sturgeon spawning/incubation, as provision of a 30 kcfs minimum flow will reduce the daily flow differential below the dam during this period (i.e., 0–60 kcfs to 30–60 kcfs).

7.2 First Nations Considerations

BC Hydro's Columbia River hydroelectric facilities are located within the claimed traditional territories of the Ktunaxa-Kinbasket Tribal Council, the Shuswap Nation Tribal Council, the Little Shuswap Indian Band, the Okanagan Nation Alliance, and the Spallumacheen Indian Band First Nations. First Nations interests included:

- Minimizing erosion impacts of water and wind on potential archaeological zones.
- Minimizing the impact of destructive human behaviour (e.g., traffic, pot hunting, etc.) on potential archaeological zones.
- Allowing access to archaeological sites by appropriate people.
- Maintaining the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.
- Providing access to traditionally harvested plants.
- Maximizing abundance and diversity of fish and wildlife populations to support First Nations harvesting and associated activities.

The proposed conditions in this Water Use Plan are expected to:

- Increase knowledge and understanding of the characteristics of known archaeological sites in Arrow Lakes Reservoir and as of yet undiscovered sites in Kinbasket, Revelstoke and Arrow Lakes reservoirs, and increase understanding of feasible options for effective protection of these sites through implementation of monitoring studies.
- Provide protection to the known and newly discovered archaeological sites that are eroding or are at risk of eroding due to operation of Arrow Lakes Reservoir through active intervention, revegetation of the drawdown zone, and operations to meet cultural/heritage objectives for the reservoir.
- Provide protection to newly discovered archaeological sites in Kinbasket Reservoir that are eroding or are at risk of eroding due to reservoir operation through active intervention and revegetation of the drawdown zone.
- Provide protection to newly discovered archaeological sites in Revelstoke Reservoir that are eroding or are at risk of eroding due to reservoir operation through active intervention.

7.3 Fish and Aquatic Habitat

The proposed conditions in this Water Use Plan are expected to:

- Increase knowledge and understanding of fish habitat capability, fish populations and operational-related impacts on aquatic productivity in Kinbasket, Revelstoke and Arrow Lakes reservoirs and the mid and lower Columbia River through implementation of monitoring studies.

- Increase littoral productivity in Kinbasket Reservoir through revegetation efforts in the drawdown zone of the reservoir.

- Increase ecological productivity, increase juvenile fish use, trigger rainbow trout spawning, and increase adult fish abundance, condition and growth in the mid Columbia River through provision of minimum flow releases from Revelstoke Dam.

- Improve habitat condition for white sturgeon and increase the chance of building a self-sustaining population in Arrow Lakes Reservoir through provision of a seasonal minimum flow release from Revelstoke Dam and conservation aquaculture. If wild production is not possible, the proposed conditions in this Water Use Plan are expected to increase the chance of building either failsafe populations in Arrow Lakes Reservoir and or Kinbasket Reservoir, or a self-sustaining population in Kinbasket Reservoir through conservation aquaculture.

- Increase overall aquatic productivity in Arrow Lakes Reservoir through revegetation of the drawdown zone and operations to meet fish objectives for the reservoir.

- Increase the probability of successful natural recruitment of white sturgeon in the lower Columbia River through introduction of a turbidity agent to the river, conditional on the results of a feasibility study to address regulatory concerns and associated fisheries and related ecosystem issues. If turbidity augmentation is not feasible, maintain the sturgeon population while allowing time for investigating mitigation options and causes of recruitment failure.

- Increase the abundance of wild, indigenous fish populations in the lower Columbia River through implementation of a flow reduction protocol to manage fish stranding impacts, and interim ramping rates to minimize fish pool stranding.

- Maintain or improve current populations of mountain whitefish below Hugh Keenleyside Dam through implementation of the whitefish flow agreement, which BC Hydro will pursue through annual negotiations with the United States.

- Increase current populations of rainbow trout below Hugh Keenleyside Dam through implementation of the rainbow trout protection flow agreement, which BC Hydro will pursue through annual negotiations with the United States.

The proposed conditions in this Water Use Plan are not expected to affect aquatic productivity in Revelstoke Reservoir, as no new operational constraints are recommended for this reservoir. Further, pelagic and littoral productivity of Revelstoke Reservoir are not expected to be affected by provision of flow releases from Revelstoke Dam

7.4 Flood Management

The proposed conditions in this Water Use Plan are not expected to increase the frequency or severity of flooding in Kinbasket, Revelstoke and Arrow Lakes reservoirs, or the mid and lower Columbia River.

7.5 Industrial Use of Water

The proposed conditions in this Water Use Plan are not expected to affect industrial use of water associated with Kinbasket, Revelstoke and Arrow Lakes reservoirs, or the mid and lower Columbia River.

7.6 Other Licensed Uses of Water

The proposed conditions in this Water Use Plan are not expected to affect other current licensed uses of water associated with Kinbasket, Revelstoke and Arrow Lakes reservoirs, or the mid and lower Columbia River.

7.7 Power Generation

The proposed conditions in this Water Use Plan are expected to decrease power generation revenues associated with the Columbia River hydroelectric facilities.

7.8 Recreation

The proposed conditions in this Water Use Plan are expected to:

- Increase understanding of recreational use patterns in Kinbasket and Arrow Lakes reservoirs through implementation of monitoring studies.

- Improve accessibility and increase opportunities for water-based recreation in Kinbasket and Arrow Lakes reservoirs and the mid Columbia River through improvements to existing boat ramps and construction of new ramps, conditional on the results of feasibility and environmental studies.

- Improve boat access to Arrow Lakes Reservoir through operations to meet recreation objectives for the reservoir.

- Increase opportunities for water-based recreation in Kinbasket and Arrow Lakes reservoirs through implementation of a debris management program, conditional on the results of an environmental review to address potential impacts on other interests (fish and wildlife habitat, vegetation, archaeological site protection, erosion).

- Improve boat access to the lower Columbia River through dredging at the Indian Eddy boat ramp, conditional on the results of an engineering study to determine the mechanism causing transport of sand from Gyro Park Beach to Indian Eddy, and the extent of transport and deposition affected by Hugh Keenleyside Dam operations versus Brilliant Dam operations.

- Improve boat access to the lower Columbia River through woody debris removal at the Indian Eddy boat ramp, conditional on the results an environmental review to address potential impacts on other interests in the lower Columbia River (fish and wildlife habitat).

- Increase navigational safety for water-based recreation in the mid Columbia River as a result of the year-round flow release and the seasonal sturgeon minimum flow release from Revelstoke Dam, as this will reduce daily flow variation below the dam.

The proposed conditions in this Water Use Plan are not expected to conflict with other land uses (e.g., motorized and non-motorized recreation, beach areas) in the mid Columbia River or Arrow Lakes Reservoir as a result of revegetation of the drawdown zone, as development of the final revegetation plan will be integrated and co-ordinated with BC Hydro's Arrow Lakes Reservoir Drawdown Management Plan.

7.9 Water Quality

The proposed conditions in this Water Use Plan are not expected to affect water quality in Kinbasket, Revelstoke or Arrow Lakes Reservoir, or the mid and lower Columbia River.

7.10 Wildlife Habitat

The proposed conditions in this Water Use Plan are expected to:

- Improve understanding and knowledge of wildlife habitat capability, wildlife populations and operational-related impacts along Kinbasket and Arrow Lakes reservoir and the mid and lower Columbia River through implementation of monitoring studies.

- Improve wildlife habitat and increase wildlife habitat utilization along Kinbasket Reservoir through revegetation of the drawdown zone.

- Improve wildlife habitat and increase wildlife habitat utilization along Arrow Lakes Reservoir and the mid Columbia River through implementation of wildlife physical works and revegetation in the drawdown zone, and operations to meet wildlife objectives for the reservoir.

- Maintain lower than optimal vegetation and wildlife habitat values in Arrow Lakes Reservoir through continued implementation of the rainbow trout flow agreement for the lower Columbia River.

The proposed conditions in this Water Use Plan are not expected to decrease vegetation and wildlife habitat in the mid Columbia River as a result of minimum flow releases from Revelstoke Dam, as it is the maximum river flow and reservoir levels that determines vegetation and wildlife values.

7.11 Riparian Rights

The proposed conditions of this Water Use Plan are not expected to affect riparian rights associated with Kinbasket, Revelstoke and Arrow Lakes reservoirs, or the mid and lower Columbia River.

8.0 RECORDS AND REPORTS

8.1 Compliance Reporting

BC Hydro will submit data as required to the Comptroller of Water Rights to demonstrate compliance with the conditions conveyed in the Water Licences. The requirements include:

a) Records of:

- Kinbasket Reservoir elevation
- Mica Generating Station discharge
- Total discharge downstream of Mica Dam
- Revelstoke Reservoir elevation
- Revelstoke Generation Station (facility) discharge
- Total discharge downstream of Revelstoke Dam
- Arrow Lake Reservoir elevation
- Discharge from Hugh Keenleyside Dam

b) A written report to the Comptroller of Water Rights on or before 1 February of each year summarizing the exceptions to a) from the previous calendar year, and

c) On request of the Comptroller of Water Rights, records collected under a).

8.2 Non-compliance Reporting

Non-compliance with operating conditions required by the water licence, or anticipation thereof, will be reported to the Comptroller of Water Rights in a timely manner.

8.3 Monitoring Program Reporting

Reporting procedures will be determined as part of the detailed terms of reference for each study or undertaking.

9.0 PLAN REVIEW

A full review of the Columbia River Water Use Plan is recommended 13 years after implementation, unless results of the monitoring program suggest an earlier review is appropriate or significant risks are identified that could result in a recommendation to change operations.

BC Hydro will convene a multi-party panel five years after implementation of this Water Use Plan to evaluate the effectiveness of operations and physical works in meeting the stated objectives for Arrow Lakes Reservoir and the lower Columbia River. The outcomes from this process will be used to assess any potential need to review the Arrow Lakes Reservoir component of this Water Use Plan. If a replacement Non-Treaty Storage Agreement is negotiated within this 5-year period, it is also recommended that agreement provisions and implications be reported out through this panel. Signing of a new NTSA is not a trigger for a panel evaluation or a review of this Water Use Plan.

10.0 NOTIFICATION PROCEDURES

Notification procedures for floods and other emergency events are outlined in the following:

- *Columbia Basin Generation Emergency Plan – Mica and Revelstoke Generating Stations and Dams*
- *Mica Dam Operation, Maintenance, and Surveillance Manual for Dam Safety*
- *Columbia River Upstream Dam Breach Emergency Study Report*

- *Columbia Basin Generation Emergency Plan - Hugh Keenleyside and Duncan Dams*
- *Hugh Keenleyside Dam Operation, Maintenance, and Surveillance Manual for Dam Safety*
- *Revelstoke Dam Operation, Maintenance, and Surveillance Manual for Dam Safety.*

These documents are filed with the Office of the Comptroller of Water Rights.

Appendix 1
Columbia River Water Use Plan Hydrology Memo

Inter-office memo

TO: Allan Woo 27 April, 2005

FROM: Chris Caryula File: MCAWUP C510

SUBJECT: Columbia River Water Use Plan
Hydrology of Columbia River Basin

This memo supercedes WR236 and includes minor edits to project storage and operating levels as requested by A. Woo (26 April 2005).

1 INTRODUCTION

The Canadian portion of the Columbia River is regulated by hydroelectric projects at Mica, Revelstoke and Hugh Keenleyside Dams. The Mica and Hugh Keenleyside Dams, along with the Duncan Dam on the Kootenay River, are operated under the terms of the Columbia River Treaty. The Columbia River projects have the following general characteristics:

Mica Project

- Mica Dam is located on the Columbia River approximately 135 km north of Revelstoke
- Mica Dam impounds Kinbasket Reservoir
- Spill and all other non-power releases from Mica Dam discharge into the Columbia River upstream of Revelstoke Dam
- Power releases (turbine discharge) are at the Mica Power Plant (4 units, max output ~ 1805 MW) below the dam. There is provision for two additional generation units.
- Discharge from the Mica Power Plant also enters the Columbia River upstream of Revelstoke Dam

Revelstoke Project

- Revelstoke Dam is located on the Columbia River approximately 5km north of Revelstoke
- Revelstoke Dam impounds Revelstoke Reservoir
- Spill and all other non-power releases from Revelstoke Dam discharge into the Columbia River upstream of Hugh Keenleyside Dam
- Power releases (turbine discharge) are at the Revelstoke Power Plant (4 units, max output ~ 1980 MW) at the toe of the dam. There is provision for two additional generation units.
- Discharge from the Revelstoke Power Plant also enters the Columbia River upstream of Hugh Keenleyside Dam

Hugh Keenleyside Project

- Hugh Keenleyside Dam is located on the Columbia River approximately 10km upstream of its confluence with the Kootenay River near Castlegar
- Hugh Keenleyside Dam impounds Arrow Lakes Reservoir

- Spill and all other non-power releases from Hugh Keenleyside Dam discharge into the Columbia River upstream of the Kootenay River confluence
- Power releases (turbine discharge) are diverted via a headpond at the Arrow Lakes Generating Station (2 units, max output ~ 185 MW).
- Discharge from the Arrow Lakes Generating Station also enters the Columbia River upstream of the Kootenay River confluence.

This report highlights the physiography, climatology and hydrology of the Mica, Revelstoke and Hugh Keenleyside (Keenleyside) drainage basins.

Methods used to calculate reservoir inflows, such as BC Hydro's FLOCAL program, are discussed. Typical inflow hydrographs and summaries are provided. Flow records for the Columbia system referred to in this report were used in power studies conducted for the Columbia Water Use Plan.

Procedures used to provide daily inflow and seasonal volume inflow forecasts are also described.

2.1 Physiography[1]

The Columbia basin is situated in southeastern British Columbia. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench. The river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam. From Mica dam, the river continues southward for about 130 km to Revelstoke Dam. The river then flows almost immediately into the 230 km long Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2. Steep valley side slopes and short tributary streams that flow into Columbia River from all directions characterize the Columbia Basin. The drainage basin for the Columbia River system is shown in Figure 1.

[1] Basin information obtained from BC Hydro, "Keenleyside Power Plant Project - Review of Design Flood Criteria", Hydroelectric Engineering Division report no. H1497, March 1983

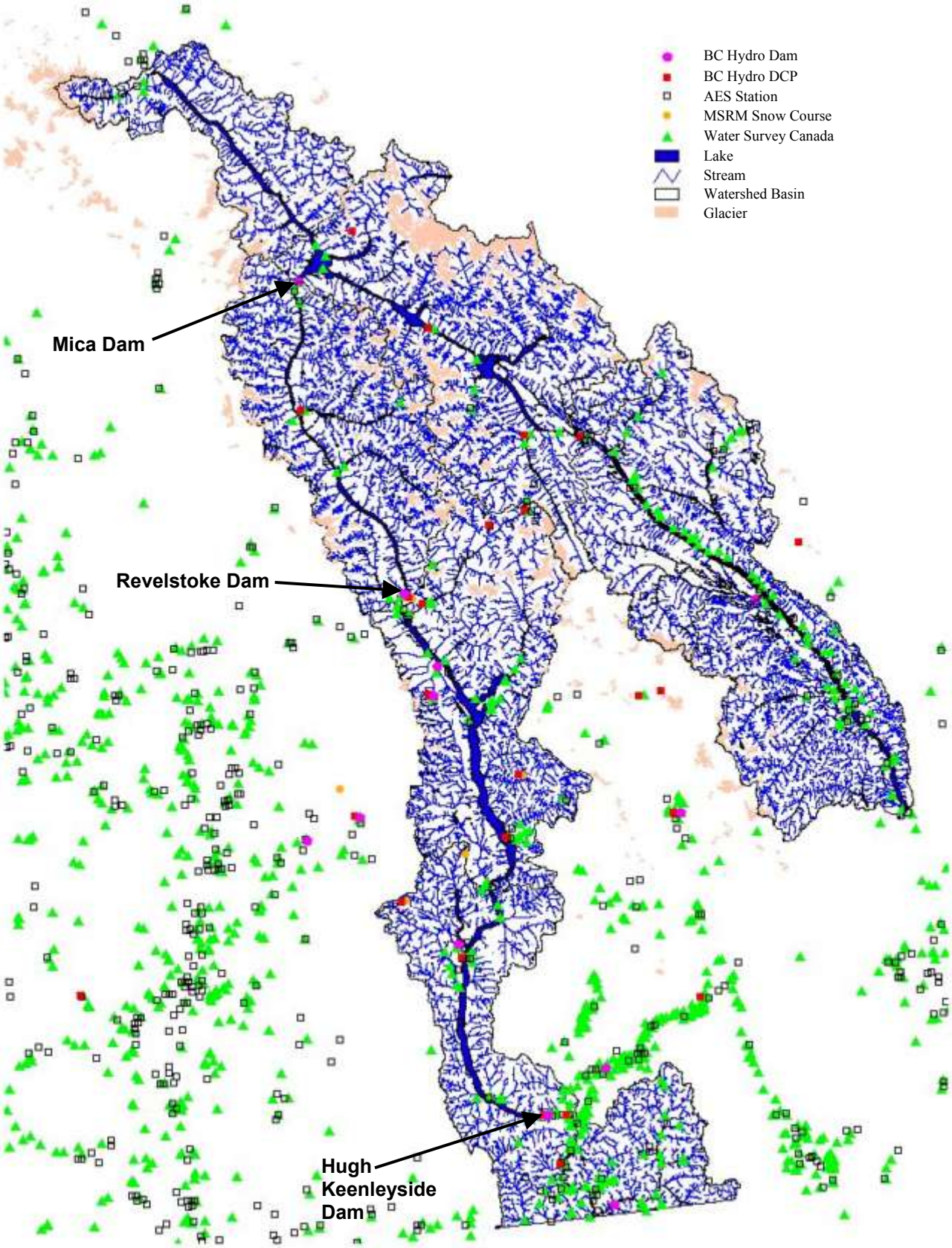

Figure 1: Watershed Map and Hydrometeorological Stations

The Columbia River valley floor elevation falls from approximately 800m near Columbia Lake to 420m near Castlegar. Approximately 40 percent of the drainage area within the Columbia River basin is above 2000m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2500m elevation, and about 10 percent of the Columbia River drainage area above Mica Dam exceeds this elevation. Most of the watershed remains in its original forested state. Dense forest vegetation thins above 1500m elevation and tree lines are generally at about 2000m elevation. The basin hypsometric (area-elevation) curve is shown in Figure 2.

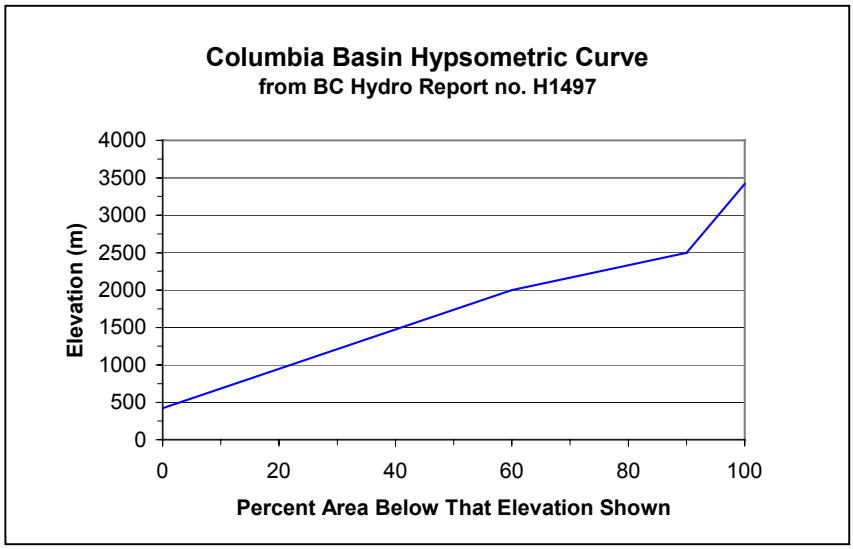

Figure 2: Hypsometric curve for the Columbia Basin upstream of Hugh Keenleyside Dam

Figures 3a, 3b and 3c shows the elevation-storage relationship for the reservoirs within their normal reservoir operating ranges.

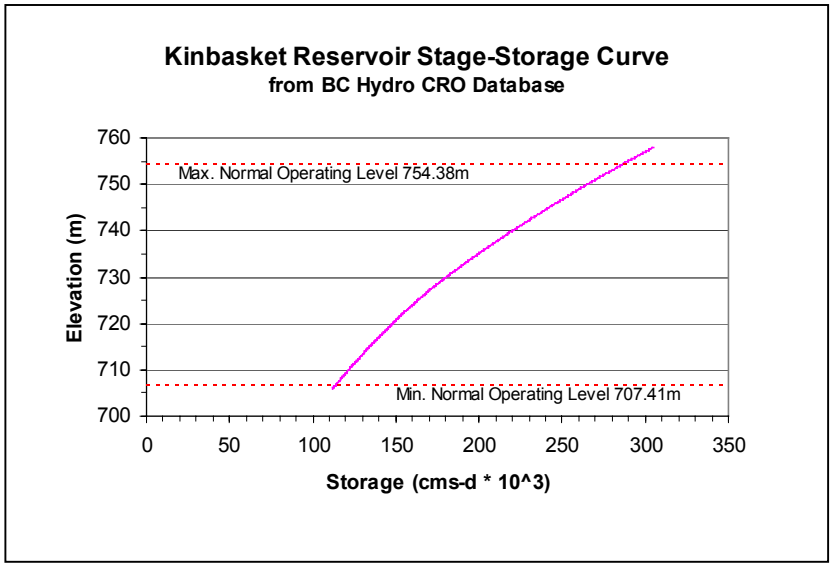

Figure 3a: Stage-storage relationship for Kinbasket Reservoir

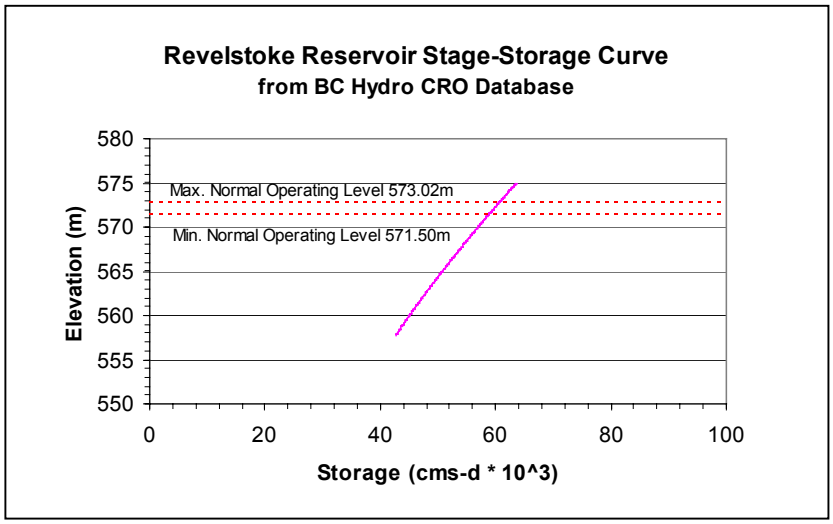

Figure 3b: Stage-storage relationship for Revelstoke Reservoir

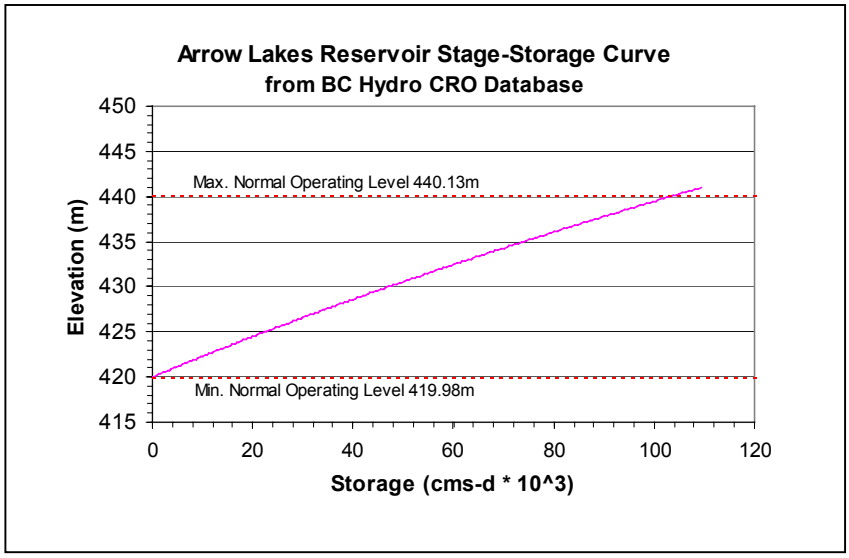

Figure 3c: Stage-storage relationship for Arrow Lakes Reservoir

Between their normal maximum and minimum operating elevations the reservoirs have their storage capacities summarized in Table 1.

Table 1: Columbia Project's Reservoir Storage Capacities

Reservoir	Storage Capacity (cms-d)
Kinbasket Reservoir (Mica)	171,300 (14 800 million m^3)
Revelstoke Reservoir (Revelstoke)	2,000 (173 million m^3)
Arrow Lakes Reservoir (Keenleyside)	101,400 (8760 million m^3)

2.2 Climatology[2]

Precipitation in the basin occurs from the flow of moist low-pressure weather systems that move eastward through the region from the Pacific Ocean. Large snow packs accumulate on the middle and upper elevations in the watersheds during the cool winter period. Summer snowmelt is reinforced by rain from both frontal storm systems and local convective storms.

The primary feature of the winter period is the persistence of below freezing temperatures that result in substantial snow accumulations throughout the region each year. More than two-thirds of the precipitation in the basin falls as winter snow on and annual basis.

Temperatures over the basin tend to be more uniform than precipitation; with allowances for temperature lapse rates, station temperature records from the valley can be used to estimate temperatures at higher elevations. The summer climate is usually warm and dry, with the average daily maximum temperature for June and July ranging from 20°C to 32°C. The average daily minimum temperature ranges from 7°C to 10°C. The coldest month is January when the average daily maximum temperature in the valleys is near 0°C and average daily minimum is near -5°C.

The major source of streamflow in the Columbia River in the spring and summer months is water stored in large snow packs that were developed during the previous winter months. Snow packs often accumulate at above 2000m elevation through the month of May and continue to contribute runoff long after snow pack depletion at lower elevations. Runoff begins to increase in April or May and usually peak in June to early July. Approximately 45 percent of the runoff occurs in the months of June and July. Severe summer rainstorms are not unusual in the Columbia basin. Summer rainfall contributions to runoff generally occur as short-term peaks superimposed upon high river levels caused by snowmelt. These rainstorms may contribute to annual flood peaks under the current Treaty operations.

[2] Climate information obtained from BC Hydro, "Keenleyside Power Plant Project - Review of Design Flood Criteria", Hydroelectric Engineering Division report no. H1497, March 1983

Figure 4 shows the maximum, mean, and minimum monthly precipitation at various locations in the Columbia basin.

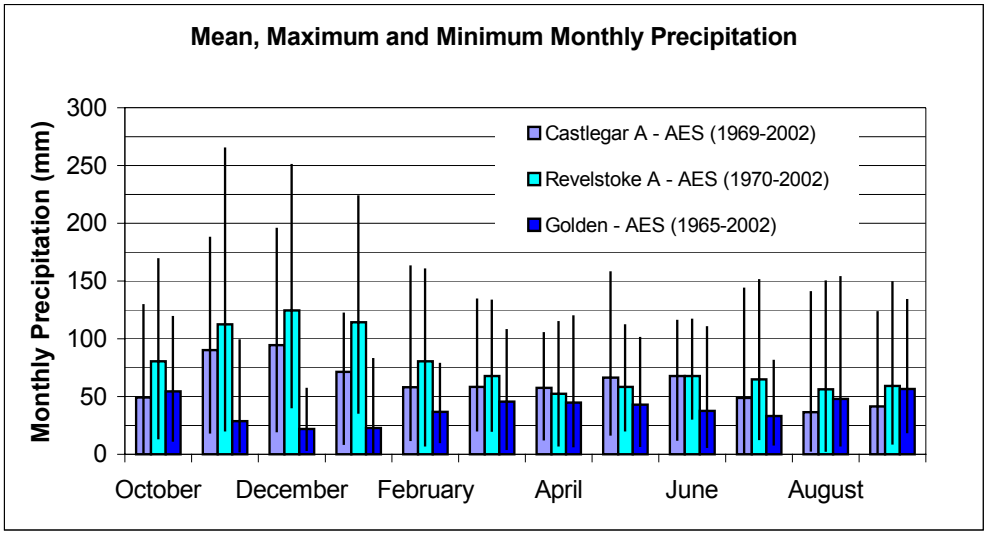

Figure 4: Maximum, mean and minimum monthly precipitation

Figure 5 shows the maximum, mean, and minimum daily temperatures at Revelstoke A – AES situated in the Columbia basin.

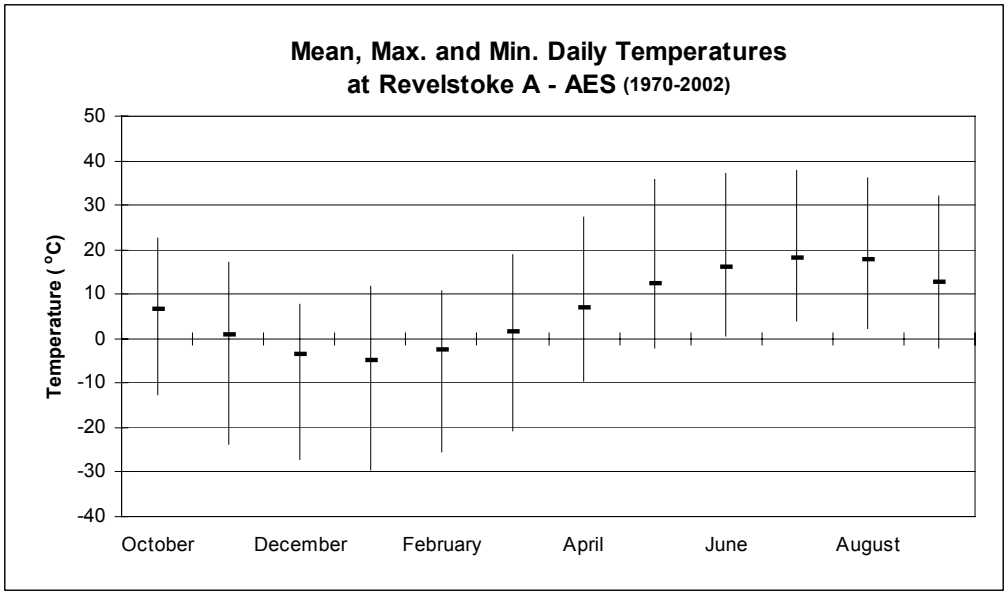

Figure 5: Maximum, mean and minimum daily temperature

Figure 6 shows the monthly snow water equivalent at several locations in the Columbia basin.

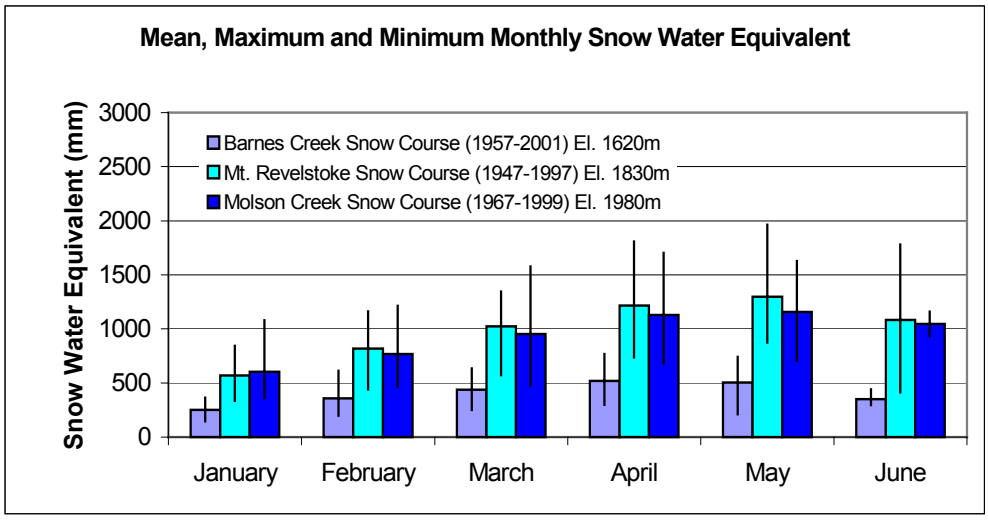

Figure 6: Maximum, mean and minimum monthly snow water equivalents

3.1 Inflow calculations

Reservoir inflow calculations: Inflow is the volume of water entering a reservoir within a given period of time. Reservoir inflows are calculated rather measured directly. Daily inflows may be derived from mean daily discharge from the reservoir and change in reservoir storage over a period of 24 hours. The generic formula is:

$$\text{INFLOW} = \text{OUTFLOW} + \Delta\ \text{STORAGE} \quad \ldots\ldots (1)$$

where INFLOW = average inflow over a one - day period
OUTFLOW = average outflow over a one - day period
Δ STORAGE = S2 - S1, where
S2 = reservoir storage at the end of the day
S1 = reservoir storage at the end of the previous day

Reservoir storage for a specific reservoir elevation is derived from a stage – storage curve unique to each reservoir.

The nature of the calculation of inflows can result in “noisier” hydrographs than observed at unregulated, natural river channels. Noisy inflows can arise due to various sources of error, such as wind set up on the reservoir, resolution of elevation measurements, errors in reservoir elevation readings, errors in outflow measurements through turbines, spillways or

valves, errors in stage-storage curves and errors in the rating curves for various outlet facilities. The impact of noise tends to reduce as the time interval over which inflow is computed increases.

Storage relationships: The storage relationships used to determine the volume of water in each Lake Reservoir are shown in Figures 3a, 3b and 3c.

Outflow relationships: Flow through turbines at the various powerhouses is computed based on megawatt output and hydraulic head. "Hydraulic head" is a measure of the vertical distance between the water level in the reservoir and the water level immediately below the turbine outlet. Power output is proportional to head and turbine discharge. A generic relationship between these variables is shown in Figure 7.

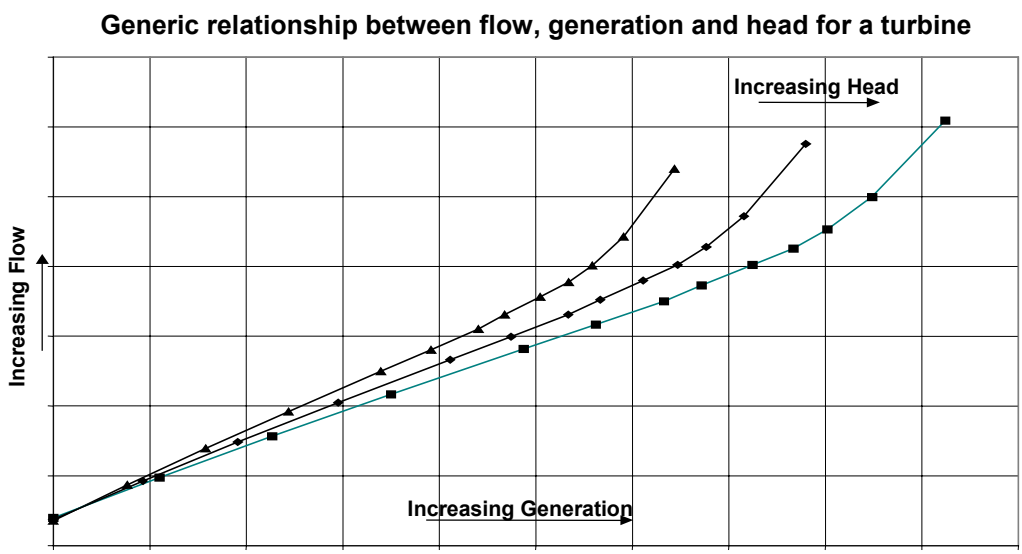

Figure 7: Generic relationship between flow, generation, and head for a turbine

Data records: BC Hydro computes inflow using a computer program called FLOCAL.

Specifically;

Inflow to Kinbasket Reservoir (Mica Dam) is computed based on equation (1).

Total inflow to Revelstoke Reservoir (Revelstoke Dam) is computed using equation (1). Local inflow to Revelstoke Reservoir is equal to the total inflow to the reservoir less the regulated outflows from the Mica project.

Total Inflow to Arrow Lakes Reservoir is computed using equation (1). Local inflow to Arrow Lakes Reservoir is equal to the total inflow to the reservoir less the regulated outflows from the Revelstoke and Whatshan projects. Outflow from the Walter Hardman project is generally not significant and is ignored.

Various information, including gate openings, reservoir and tailwater elevations, energy, spill, turbine flows, and inflows are stored in FLOCAL. A FLOCAL configuration for the Columbia system is shown in Figure 8.

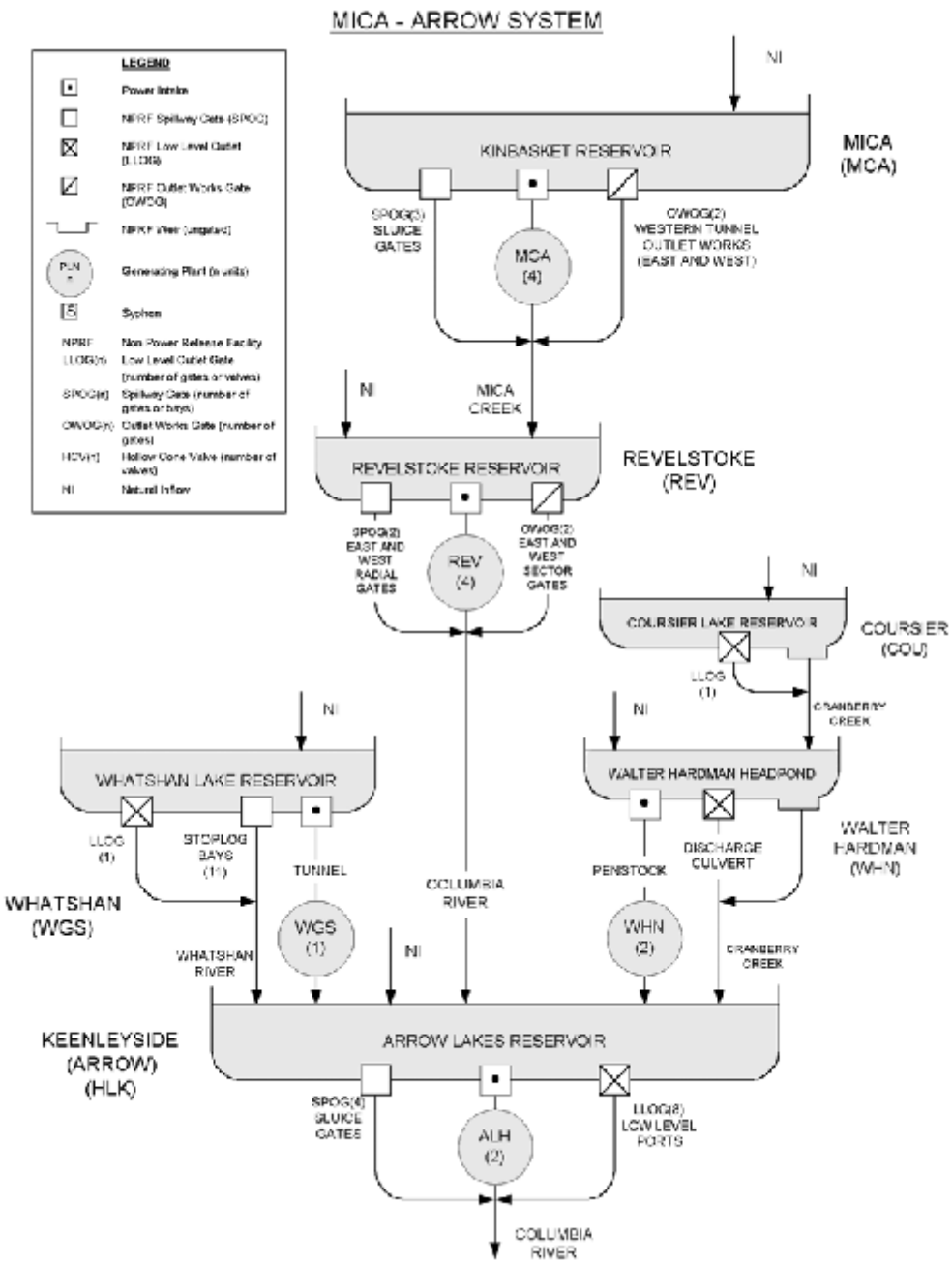

Figure 8: Schematic of the FLOCAL configuration for the Columbia system

3.2 Reservoir inflow characteristics

Figures 9a, b, c and Table 2a, 2b, 2c summarizes the monthly inflows.

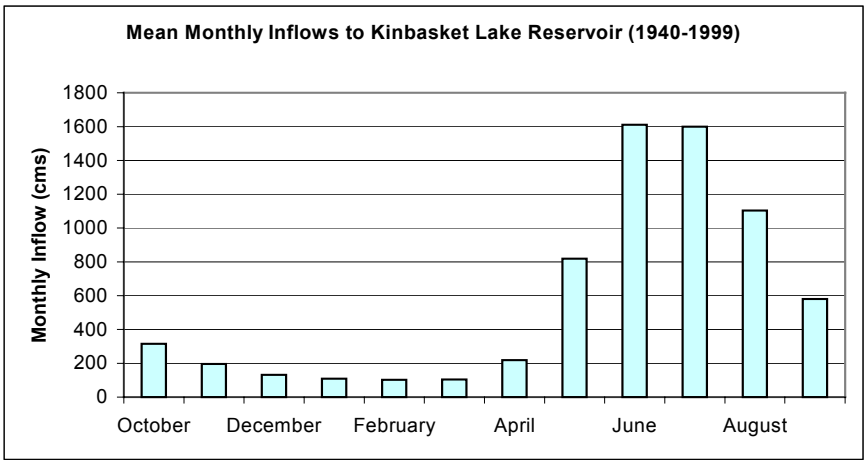

Figure 9a: Mica Project monthly inflows

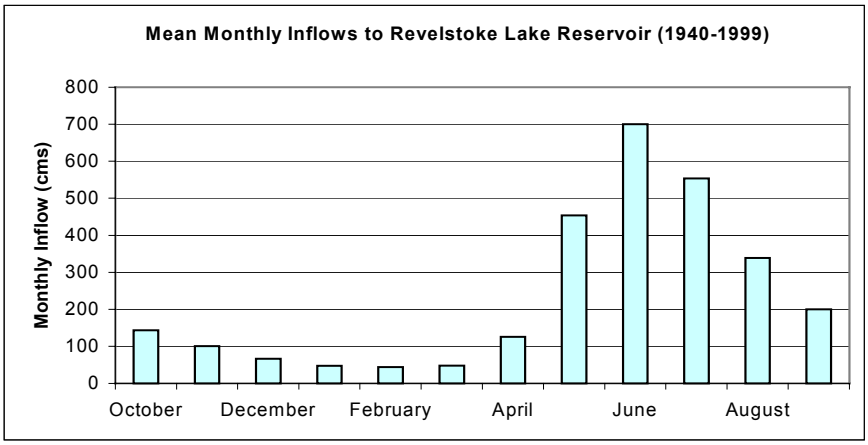

Figure 9b: Revelstoke Project monthly inflows

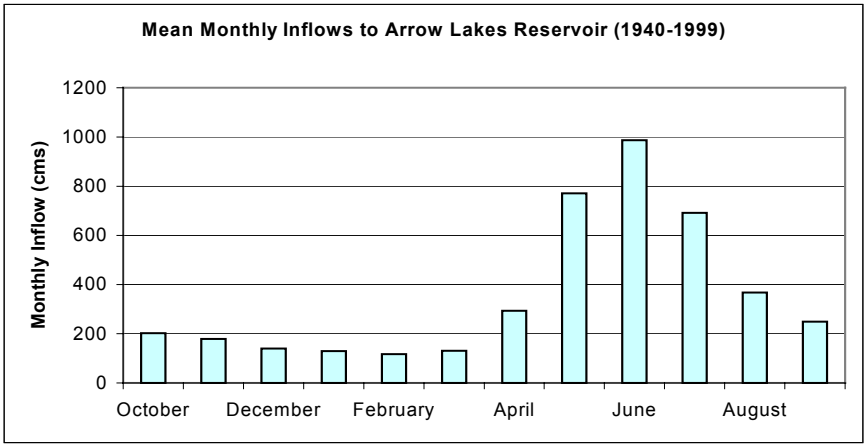

Figure 9c: Hugh Keenleyside Project monthly inflows

Table 2a: Mica Project monthly inflows (1940-1999)

	Mean Monthly Inflow (cms)	Maximum Monthly Inflow (cms)	Minimum Monthly Inflow (cms)
October	314	662	194
November	196	341	101
December	132	191	86
January	108	150	69
February	103	186	67
March	104	194	64
April	219	383	101
May	819	1502	323
June	1611	2562	1107
July	1600	2318	947
August	1104	1626	768
September	581	916	373

Table 2b: Revelstoke Project monthly inflows (1940-1999)

	Mean Monthly Inflow (cms)	Maximum Monthly Inflow (cms)	Minimum Monthly Inflow (cms)
October	143	325	70
November	100	189	25
December	66	143	27
January	47	98	13
February	44	137	9
March	48	110	1
April	125	254	34
May	454	699	253
June	700	1116	421
July	554	904	299
August	339	824	213
September	200	524	123

Table 2c: Keenleyside Project monthly inflows (1940-1999)

	Mean Monthly Inflow (cms)	Maximum Monthly Inflow (cms)	Minimum Monthly Inflow (cms)
October	202	375	72
November	178	420	50
December	139	255	9
January	130	285	5
February	117	268	40
March	131	297	26
April	293	486	125
May	771	1285	390
June	987	1598	486
July	691	1164	215
August	367	644	126
September	250	467	61

A “flow duration curve” indicates the percent of time that a flow is greater than a given discharge. Figures 10a, 10b and 10c shows a duration curve for annual flows.

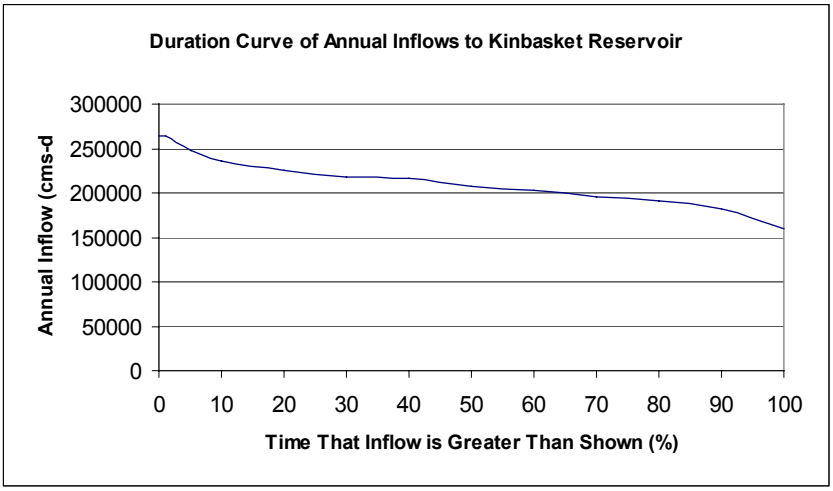

Figure 10a: Duration curve of annual inflows to Kinbasket Reservoir

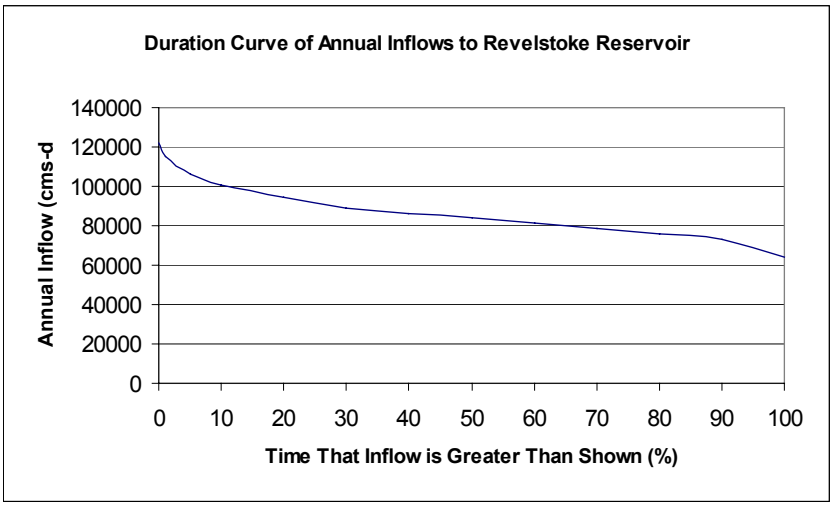

Figure 10b: Duration curve of annual inflows to Revelstoke Reservoir

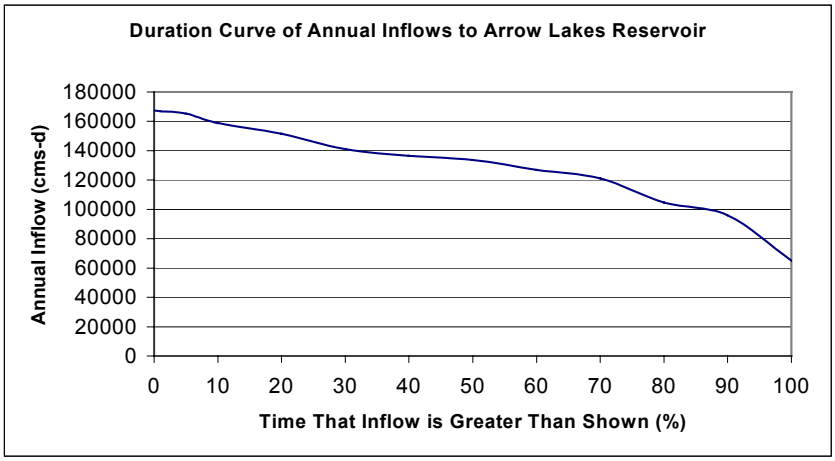

Figure 10c: Duration curve of annual inflows to Arrow Lakes Reservoir

For reference, Figure 11 shows a comparison between the mean annual local inflow and total live storage available for selected BC Hydro and other hydroelectric projects. The Columbia Projects are highlighted.

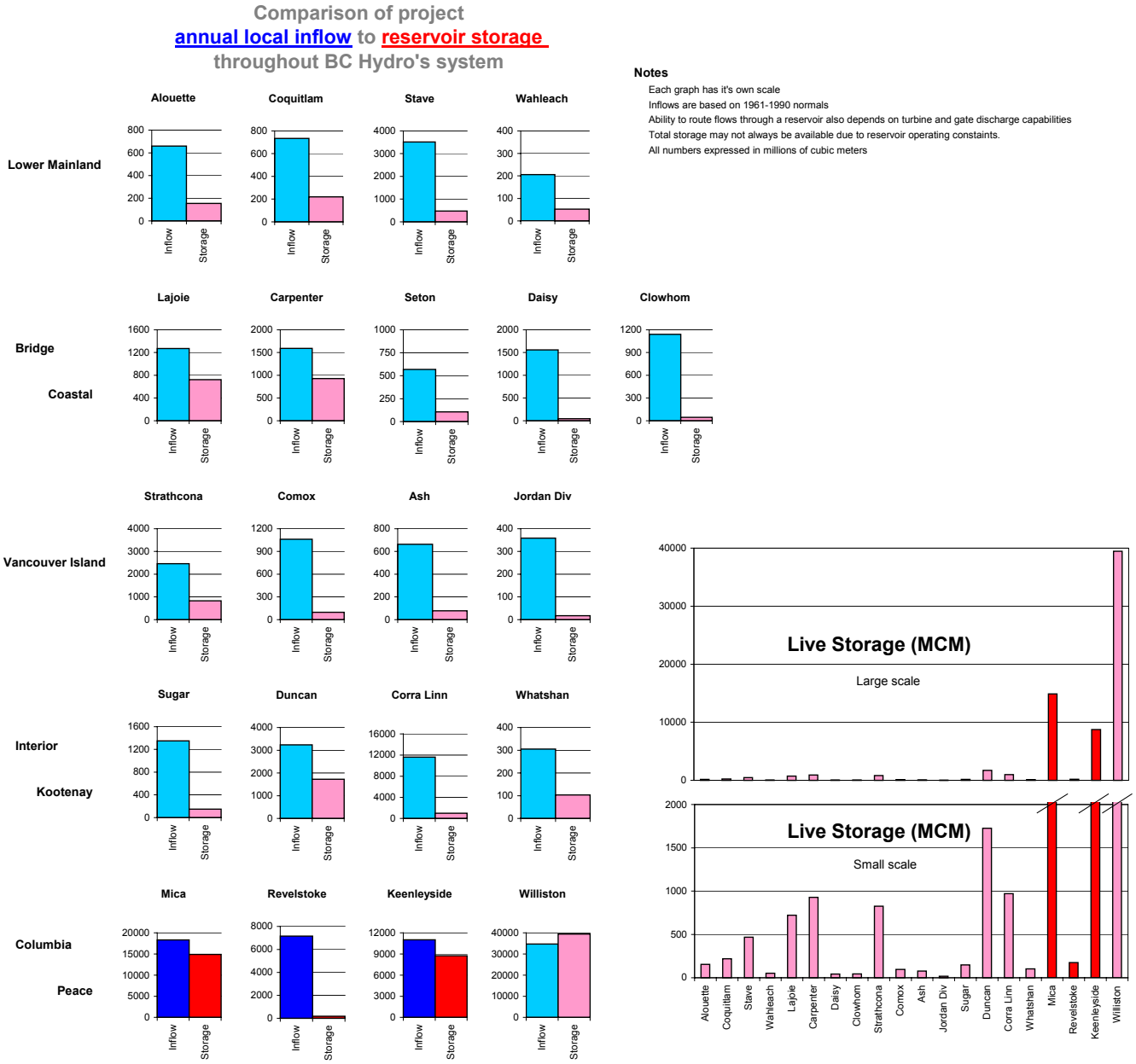

Figure 11: Comparison of Columbia Project annual inflows to reservoir storage throughout BC Hydro's system

The ratio of average annual inflow to available reservoir storage provides a qualitative indication of how the inflow regulation and spill management capability varies from project to project: the higher the ratio, the lower the regulation capability. Figure 11 also shows the relative contribution of the Columbia River reservoirs to BC Hydro's total reservoir storage capacity.

4 Operational Inflow Forecasting

BC Hydro's Resource Management produces two main types of hydrologic forecasts: daily inflow and seasonal volume inflow forecasts for the Columbia River projects.

Daily inflow forecasts: Daily inflow forecasts are short-term forecasts that indicate the inflow expected over the next few days. The UBC Watershed Model is currently used to produce these forecasts. Each morning of each working day, Resource Management enters observed and forecast precipitation and temperature data into the model to forecast inflow over each of the next five days.

Volume inflow forecasts: Volume inflow forecasts estimate the volume of water that is expected to flow in to the Columbia River system during a given period. BC Hydro typically produces volume forecasts for the period of February through September. The ability to forecast seasonal runoff for this period lies in the fact that much of the runoff during the forecast period is the product of snowmelt runoff. By measuring snow water equivalent in the mountain snowpack, as well as other parameters such as precipitation and streamflow up to the forecast date, a more accurate estimate of future runoff can be made than one based on historical inflow data alone. Volume inflow forecasts are issued beginning January 1 of each year. The forecasts are updated on the first of each month until August 1st.

5 Hydrometeorologic Network

Hydrometeorological data is required to plan, monitor, and operate facilities in the Columbia system's watershed. Characteristics of the hydrometeorological data collection stations that are commonly referenced for the Columbia basin are summarized in Table 3. Locations of hydrometeorological stations within the watershed are shown in Figure 1.

Table 3: Hydrometeorological stations referenced for forecasting, operations and planning.

Station	Type	ID	Elev (m)	Latitude	Longitude	Characteristics
Blue River	AES	1160900	689	52° 09'	119° 17'	Temp./Precip.
Brisco	AES	1171020	823	50° 49'	116° 15'	Temp./Precip.
Castlegar A	AES	1141455	494	49° 18'	117° 38'	Temp./Precip.
Fauquier	AES	1142820	490	49° 52'	118° 04'	Temp./Precip.
Glacier – Mt. Fidelity	AES	117CA90	1875	51° 14'	117° 43'	Temp./Precip.
Glacier Roger Pass	AES	1173191	1323	51° 17'	117° 31'	Temp./Precip.
Golden	AES	1173210	787	51° 18'	116° 59'	Temp./Precip.
Revelstoke A	AES	1176751	443	50° 58'	118° 11'	Temp./Precip.
South Slocan	AES	1147620	457	49° 28'	117° 32'	Temp./Precip.
Barnes Creek	MWLAP	2B06	1620	50° 04'	118° 21'	Snow survey
Ferguson	MWLAP	2D02	880	50° 41'	117° 29'	Snow survey
Kicking Horse	MWLAP	2A07	1650	51° 26'	116° 21'	Snow survey
Molson Creek	MWLAP	2A21	1980	52° 14'	118° 14'	Snow survey
Mt. Abbot	MWLAP	2A14	1980	51° 42'	117° 30'	Snow survey
Mt. Fidelity	MWLAP	2A17	1870	51° 14'	117° 42'	Snow survey
Mt. Revelstoke	MWLAP	2A06	1830	51° 02'	118° 09'	Snow survey
Sunbeam Lake	MWLAP	2A22	2010	51° 35'	117° 39'	Snow survey

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