Whatshan Project Water Use Plan

Revised for Acceptance by the Comptroller of Water Rights

15 June 2005

BC hydro

Whatshan Project
Water Use Plan

Revised for Acceptance by the Comptroller of Water Rights

BC hydro Generation 15 June 2005

Whatshan Project
Water Use Plan

Revised for Acceptance by the Comptroller of Water Rights

J Graeme Matthews

per

C.D. Matheson
Manager, Operations

Preface

The water use planning process for BC Hydro's Whatshan project was initiated in May 2002 and completed in May 2003.

The operational changes proposed in this Water Use Plan reflect the consensus recommendations of the Whatshan 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. The proposed conditions for the operation of BC Hydro's facilities will not come into effect until implemented under the *Water Act*.

Table of Contents

List of Figures

List of Appendices

1.0 INTRODUCTION

The operating conditions proposed in this Water Use Plan reflect the May 2003 recommendations of the Whatshan Water Use Plan Consultative Committee. The basis for the proposed terms and conditions to be authorized under the Water Act for the beneficial use of water at the Whatshan hydroelectric project are set out in this document. Future reference to the Whatshan project includes all the works including: Whatshan Dam, Saddle Dam, Whatshan Lake Reservoir and Whatshan generating station.

The proposed conditions will change current operations and are expected to improve the littoral productivity in Whatshan Lake Reservoir for the benefit of fish, improve habitat conditions for fish in the Whatshan River, and increase boating access on the Whatshan Lake Reservoir

A monitoring program and a review period are proposed in order to study key uncertainties to reinforce operational recommendations and to enhance future operating decisions. Refer to the *Whatshan Water Use Plan: Consultative Committee Report* dated August 2003 for details on the consultative process, interests, objectives, performance measures, key trade-offs, values associated with operating alternatives, expected benefits and the proposed monitoring program.

2.0 DESCRIPTION OF WORKS

2.1 Location

The Whatshan project is located within the Central Kootenay Regional District, near the community of Edgewood in south central British Columbia. The Whatshan River flows southerly into the Whatshan Lake Reservoir, which is impounded by a 7 metre (m) high earthfill saddle dam and a 12 m high concrete dam located at the south end of the reservoir. A 3.4-kilometre partially lined tunnel connects the power intake on Whatshan Lake Reservoir to the 50 MW powerhouse located on the west shore of Arrow Lakes Reservoir approximately 5 km north of the Needles-Fauquier ferry crossing. Below the Whatshan Dam, Barnes Creek joins the Whatshan River before flowing into the Upper Arrow Lakes Reservoir.

The Whatshan project is easily accessible via a secondary road off of Highway 6. A map showing the location of the Whatshan project is provided in Figure 2-1.

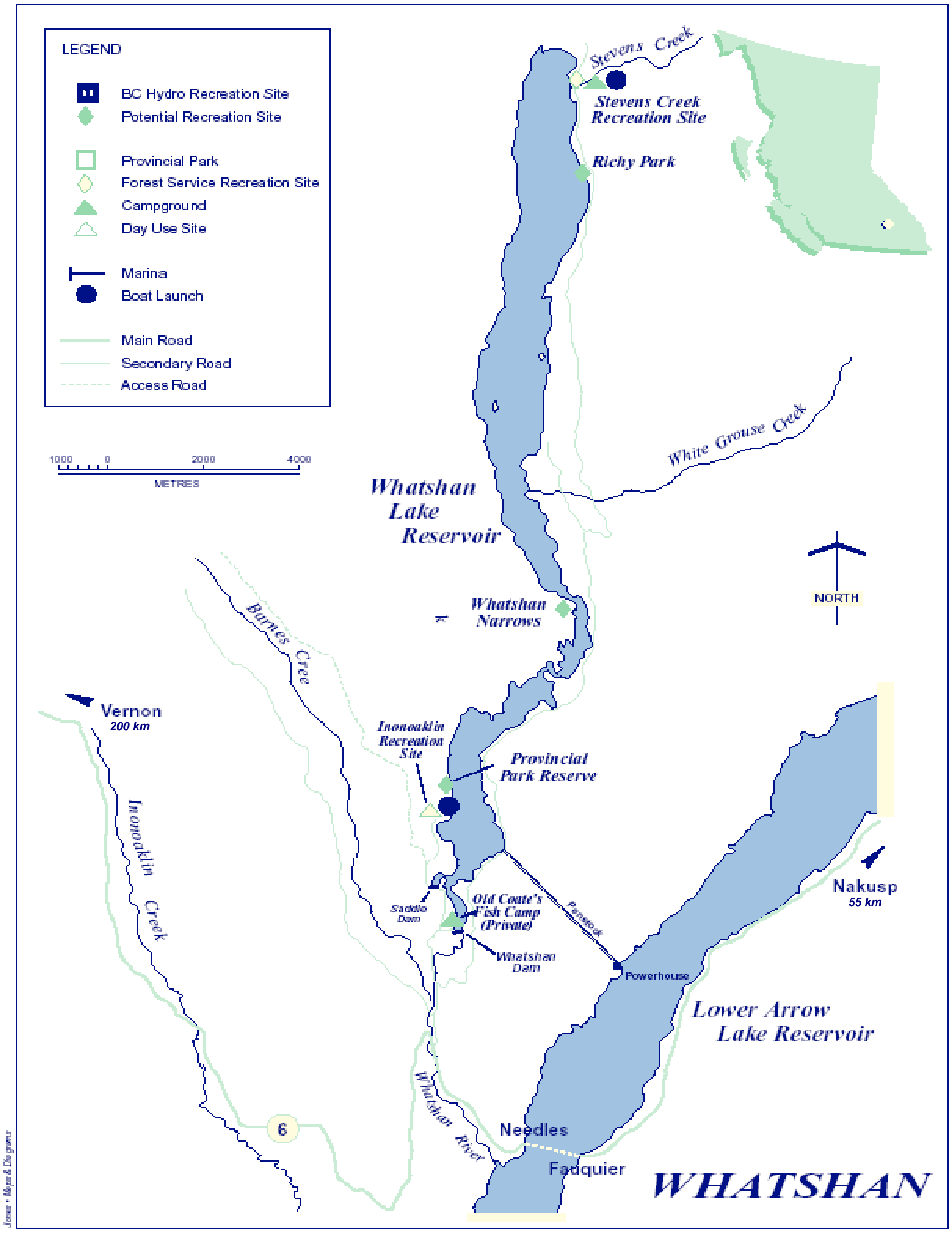

Figure 2-1: Map of the Whatshan Project

2.2 Existing Works

The original development was designed and constructed by the British Columbia Power Commission and came into service in 1951. In 1953 a rock and mud slide destroyed the original powerhouse and switchyard. Following slope stabilizing, the plant was rebuilt. In 1969, Arrow Lake levels were raised following completion of the Hugh Keenleyside Dam. The Whatshan generating station was rebuilt at its present location in 1972 at an elevation 12 metres higher than the previous generating station.

The existing works that comprise the current Whatshan hydroelectric project include the following components.

Whatshan Dam: The 12 m high and 82 m long concrete dam with 91 m of earthfill embankments is located at the south end of Whatshan Lake Reservoir. Water release facilities consist of eleven overflow bays and a low level outlet (LLO), located between spillway Bays 10 and 11, which can divert water to the Whatshan River channel immediately downstream of the dam. The spillway discharge capacity is 257 m^3/s at El. 641.70 m, the top of the spillway piers. The top of the stoplogs is at El. 641.3 m, the maximum normal operating elevation, but they can be modified to accommodate reservoir elevations up to 641.45 m during high inflow events. Bays 1 through 10 have a crest elevation of 640.08 m while Bay 11 is at 638.86 m[1].

Whatshan Dam Low Level Outlet: The LLO has a sill elevation of 634.08 m. At the maximum normal operating elevation of 641.3 m, the LLO has a discharge capacity of 21.6 m^3/s. The LLO is operated manually and requires advance notice to arrange a site crew. The gate can be lifted manually, but normally is lifted with a heavy-duty drill and generator set-up located in the Whatshan powerhouse. There is no electricity on site. Water is rarely released through the Whatshan Dam into the Whatshan River. Occasional spills (3 times in the past 17 years of record – 1985, 1996, 1997) have been diverted through the LLO of the dam into the river channel that is otherwise wetted only by dam leakage and local inflows.

Saddle Dam: The 7 m high earthfill saddle dam is located 1.6 km northwest of the concrete dam. It is 104 m in length and like the Whatshan Dam, provides road access to the area. The saddle dam has no associated water release facilities.

---

[1] All datum relative to local project datum. Approximate conversion to Geological Survey of Canada datum requires a reduction of 0.19 m.

Whatshan Powerhouse: The Whatshan powerhouse is located on the west side of the Arrow Lakes Reservoir, approximately 5 km north of the Needles-Fauquier ferry crossing. The powerhouse contains one Francis turbine with a rated output of 50 MW and a discharge capacity of 33 m^3/s (discharge can reach 34.4 m^3/s at maximum generation and full pool). The most efficient operation is at 40 MW which has a discharge rate of 24.7 m^3/s.

The maximum head (the elevation difference between the reservoir and powerplant) is 215.6 m. Water from the powerhouse is discharged into the Arrow Lakes Reservoir. A 138 kV transmission line connects the generating station switchyard to nearby Monashee Substation.

Penstock Intake: A water intake is located on the southeast side of Whatshan Lake Reservoir that directs water through the 3.4 kilometre tunnel to the powerhouse. A 4.88 m by 4.27 m gate can be used to control flow to the tunnel.

Whatshan Lake Reservoir: The reservoir has a storage capacity of 122 million m^3 when it is at maximum operating elevation – enough storage for approximately 30–40 days of continuous operation at full capacity[1]. The reservoir is approximately 17 km long and has an average width of one kilometre. The normal maximum operating elevation is 641.3 m while the normal minimum elevation is 634.0 m – a range of about 7.3 vertical metres. The reservoir has a buffer of 0.4 m, equivalent to elevation of 640.9 m, which is the normal maximum operating target to allow for safe management of the inflow design flood. Excess inflows can normally be handled by operating the generating plant. During the September to February period, there is a low probability of high inflow events and the reservoir may be increased to 641.3 m to maximize winter generating capability.

The reservoir has three distinct basins that remain connected and passable by boat at all operational elevations. The upper basin contains around 74% of the total reservoir area (1255 hectares (ha)) and has a maximum depth of 116 m. The middle basin, containing "The Narrows" accounts for about 6% of the reservoir by area (99 ha) and has a maximum depth of 15.2 m. The lower basin accounts for about 20% of the total reservoir area (338 ha) and has a maximum depth of 33 m.

Operating Constraints

The generator should not be operated below 15 MW as this causes excessive cavitation, nor should it be operated between 30 and 40 MW as this causes excessive vibration. Generation loading must be reduced for low elevations in Whatshan Lake Reservoir.

1 Hypothetically assuming no inflow during this period.

• Below 634.4 metres:	Synchronous condenser only
• 634.4 to 634.75 metres:	20 MW
• 634.75 to 635.0 metres:	28 MW
• 635.0 to 635.35 metres:	40 MW
• Above 635.35 metres:	Full Load

3.0 HYDROLOGY OF THE WHATSHAN BASIN

The Whatshan River basin lies within the eastern range of the Monashee Mountains, just west of the Arrow Valley in south central British Columbia. The project drainage basin has an area of 390 km^2 and is located in the southeast interior climatic region, affected by both continental and modified maritime conditions. In general, the basin experiences large snow pack accumulations through the winter, warming conditions during the April–June period, and often heavy short-duration rainfall events in May through August. Snowmelt is the major source of runoff, with 60% of the annual runoff occurring in May and June. An additional 20% of the inflow is contributed in April and July. Rainfall is a minor contributor to the annual runoff volume, but it can produce high peak flows when coinciding with extreme snowmelt conditions. The average annual inflow is 9.3 m^3/s. More details on hydrology are provided in Appendix 1.

4.0 OPERATING CONDITIONS FOR FACILITY

4.1 Role of Facility in BC Hydro's System

The Whatshan project is part of BC Hydro's integrated generation system, which is described in *'Making the Connection'* published by BC Hydro in April 2000.

The average annual generation at the Whatshan project is approximately 121 GWh, enough electricity to serve 12 000 homes for one year. This is approximately 0.24 % of BC Hydro's total system production.

4.2 Water Use at Whatshan Facility

The Whatshan project is operated on an annual fill and release cycle with the majority of inflows resulting from spring snowmelt and seasonal storm events. Following the spring freshet, water is stored in the reservoir to it maximum elevation and held relatively constant through the summer months. During the fall and winter, stored water is used to generate electricity. The reservoir reaches its minimum elevation just prior to the spring freshet at which time the facility is operated to maximize the use of water for power generation.

The Whatshan project is operated as a “peaking plant” which means it is brought online to meet electrical demands during peak demand periods. As a result, the average daily turbine discharges from the Whatshan generating station varies seasonally and daily with the demand for electricity and the availability of water. It also plays a very important role in providing voltage control for the transmission network, and helps to offset the effects of transmission losses that may occur as a result of transmission failures (outages/losses) on the provincial transmission grid system.

BC Hydro uses all of the available inflow, within the storage and generation limits of the facilities. Spills occur when inflows exceed generation and storage capacity.

4.3 Emergencies and Dam Safety

Emergencies and dam safety requirements shall take precedence over the operational constraints outlined in this Water Use Plan. Emergencies include actual and potential loss of power to customers. Dam safety requirements for operations are outlined in the following document, which is issued by BC Hydro’s Director of Dam Safety:

- *Whatshan: Operation, Maintenance and Surveillance Requirements (OMS) for Dam Safety*.

4.4 Conditions for the Operation of Works for Diversion and Storage of Water

The conditions outlined in this section are proposed for the operations of the Whatshan hydroelectric project. It is recognized that BC Hydro may not be able to operate within these constraints during extreme hydrological events.

4.4.1 Whatshan Dam

No minimum flow releases are required from the Whatshan Dam. When reducing spillway releases from the dam into the Whatshan River, the necessity for fish salvages shall be assessed and implemented if appropriate.

4.4.2 Whatshan River

In lieu of providing minimum flow releases from Whatshan Dam, BC Hydro will construct a series of fish habitat enhancement structures in Reach W3 of the Whatshan River downstream of its confluence with Barnes Creek, as directed by the Comptroller of Water Rights, following review of the potential benefits of habitat complexing.

4.4.3 Whatshan Lake Reservoir

BC Hydro will regulate Whatshan Lake Reservoir to respect the following minimum elevations:

- 15 May to 14 June: El. 639.10 m.
- 15 June to 1 October: El. 640.35 m.
- 2 October to 14 May: El. 636.50 m.

BC Hydro will extend the existing boat launch at the Inonoaklin Recreation Site to 636.50 m to allow for earlier boat access to the Whatshan Lake Reservoir in lieu of providing a higher minimum reservoir elevation. In order to facilitate this construction, the reservoir will be drawn down on a one-time basis below the minimum elevation of 636.50 m.

4.4.4 Whatshan Generating Station

In order to reduce the probability of spill events, BC Hydro typically operates the generating station at maximum capacity when the reservoir reaches elevation 640.90 m. There are no other restrictions on generation.

5.0 PROGRAMS FOR ADDITIONAL INFORMATION

Development of the operating recommendations for the Whatshan Hydroelectric Project was complicated by some uncertainties and information gaps.

The operating recommendations of the Consultative Committee are contingent on the implementation of a monitoring program to reduce these uncertainties over time. Upon direction from the Comptroller of Water rights, BC Hydro will undertake a monitoring program that will:

- Assess expected outcomes of the operational change being recommended.
- Provide improved information for future operating decisions.

The main elements of the monitoring program are described below. Estimated annual costs for these studies and associated tasks are summarized in the *Whatshan Water Use Plan: Consultative Committee Report*.

River Reach-Based Habitat Assessment and Fish Response: There is a need to undertake a rainbow trout population estimate and a reach-based assessment of Reach 3 of the Whatshan River in order to confirm design and plan the construction of the series of fish habitat enhancement structures. If the construction of the structures proceeds, the population monitoring study will continue to confirm fish response and the performance of the fish habitat complexing structures.

Wildlife Habitat Analysis: There is uncertainty whether the change in operations will influence submergent and emergent plant communities. This monitoring study will combine aerial photography of the reservoir and vegetation mapping to determine the location and extent of reservoir vegetation and then assess the effect of the operational change on reservoir vegetation. In addition to these components, it is also recommended that wildlife monitoring be undertaken to assess the relationship between reservoir vegetation and wildlife use.

First Nations Archaeological Study: There is uncertainty regarding the extent and location of archaeological sites within the reservoir. It is recommended that a study be undertaken to locate these archaeological sites within the normal operation range between 634.4 and 641.3 m. This information will assist in future decision-making and may result in changes to operations.

6.0 IMPLEMENTATION OF RECOMMENDATIONS

The proposed conditions and monitoring program 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

The implications for the provincial interests considered during the preparation of this Water Use Plan are expected outcomes based on the best available information. After BC Hydro has been directed to implement the operational changes, BC Hydro will be responsible for meeting the operational parameters but not for achieving the expected outcomes.

7.1 Other Licensed Uses of Water

Other licensed uses of water are not affected by the proposed conditions.

7.2 Riparian Rights

The proposed conditions are not expected to affect riparian rights associated with the reservoir or along the river below the facilities.

7.3 Fisheries

The proposed conditions are expected to improve habitat conditions for fish in the Whatshan Lake Reservoir and the Whatshan River.

7.4 Wildlife Habitat

The proposed conditions are not expected to change wildlife conditions significantly on the Whatshan Lake Reservoir.

7.5 Flood Control

The proposed conditions are not expected to affect flood control on the Whatshan River.

7.6 Recreation

The proposed conditions are expected to improve recreational use of the Whatshan Lake Reservoir, particularly boat access.

7.7 Water Quality

The proposed conditions are not expected to affect water quality in the Whatshan Lake Reservoir or the Whatshan River.

7.8 Industrial Use of Water

There are no other industrial uses of water on the Whatshan Lake Reservoir or the Whatshan River.

7.9 First Nations Considerations

The Whatshan project lies within the traditional territory of the Okanagan and Shuswap First Nations. Based on current information, the proposed conditions are expected to benefit fish and wildlife in the Whatshan Lake Reservoir and the Whatshan River which are important aspects of their traditional use of the area.

7.10 Archaeological Considerations

The proposed conditions are not expected to affect archaeological interests. Uncertainty regarding impacts in the normal operating range are addressed in a monitoring program.

7.11 Power Generation

The proposed conditions are expected to reduce power generation associated with the Whatshan project.

8.0 RECORDS AND REPORTS

8.1 Compliance Reporting

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

- Whatshan Lake Reservoir elevations; and
- Whatshan Dam releases.

8.2 Non-compliance Reporting

Non-compliance with any operating condition ordered by the Comptroller of Water Rights will be reported to the Comptroller in a timely manner.

8.3 Monitoring Program Reporting

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

9.0 PLAN REVIEW

BC Hydro will review the results of the monitoring program five years after implementation of this Water Use Plan. A formal review of the Water Use Plan is recommended in 10 years. A review could be triggered sooner if significant risks are identified through the analysis of monitoring results.

10.0 NOTIFICATION PROCEDURES

Notification procedures for floods and other emergency events are outlined in *Power Supply Emergency Plan (PSEP): Upper Columbia Generation Area*. This document is filed with the Office of the Comptroller of Water Rights.

Appendix 1
Whatshan Basin Hydrology

Inter-office memo

TO:	Eric Weiss	26 November 2002
FROM:	Kathy Groves	File: PSE 151.0 C-WGS-151.0
SUBJECT:	Whatshan Water Use Plan - Hydrology of Whatshan River Basin - REVISED	

1 INTRODUCTION

The Whatshan project is a single reservoir hydroelectric project with the following general characteristics:

- Whatshan Dam impounds Whatshan Lake.
- Spill and other non-power releases from the Whatshan Dam discharge into the Whatshan River.
- Power releases from Whatshan Lake (turbine discharge) are diverted via a 3.4 km penstock to the Whatshan Powerhouse (one unit, typical maximum output ~ 54 MW).
- Discharge from the Whatshan Powerhouse enters Lower Arrow Lake.
- Downstream project is Hugh Keenleyside.

This report highlights the hydrology of the Whatshan hydroelectric system. Physiography and climatology are reviewed for the Whatshan River watershed.

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 Whatshan system referred to in this report were used in power studies conducted for the Whatshan Water Use Plan.

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

2.1 Physiography[1]

The Whatshan River basin lies within the eastern ranges of the Monashee Mountains. The 390 km^2 tributary area to Whatshan Dam is bounded by the Gold Range on the east and the Whatshan Range on the west. The Whatshan Range is generally 300 m higher than the eastern range of the Monashee Mountains and reaches a maximum elevation of 2600 m at the Pinnacles. The average elevation of the Whatshan basin is 1220 m.

The drainage basin for the Whatshan system is shown in Figure 1.

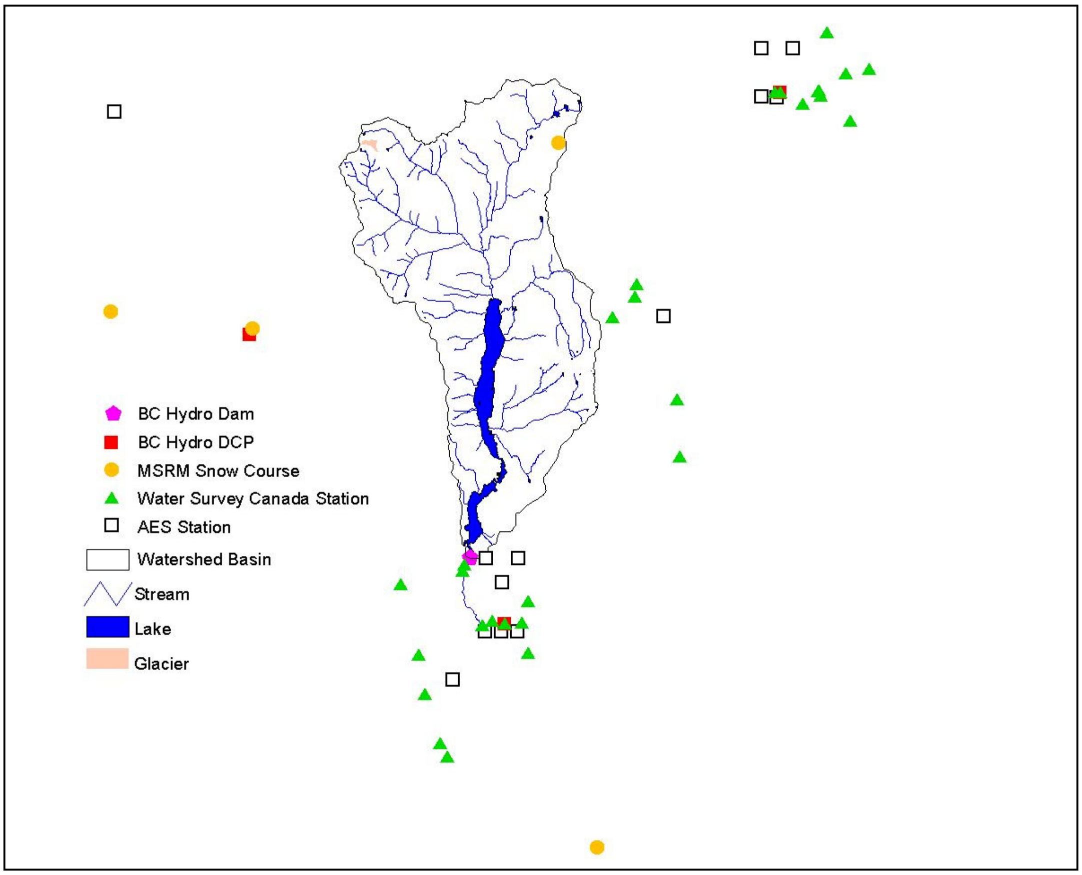

Figure 1: Watershed Map and Hydrometeorological Stations

The Whatshan basin is heavily forested. The vegetation thins above El. 1500 m and the tree line lies in the range of 1800 to 1900 m.

[1] Basin information obtained from BC Hydro, "Whatshan Dam Probable Maximum Flood", Hydroelectric Engineering Division report no. H1785, February 1985

The Whatshan River valley, particularly upstream of Whatshan Lake, is characterized by steep valley side slopes and short tributary streams, which flow into Whatshan River almost at right angles. There is insignificant natural lake storage within the basin other than at Whatshan Lake.

The basin hypsometric (area-elevation) curve is shown in Figure 2.

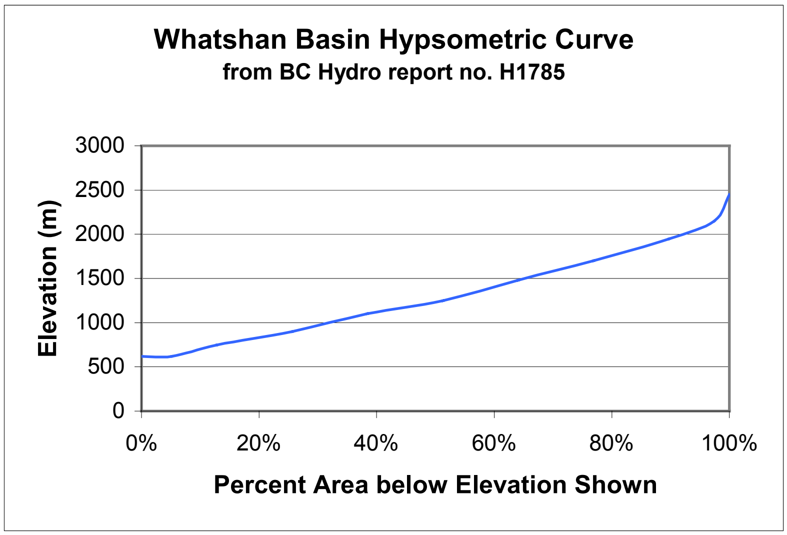

Figure 2: Hypsometric curve for the Whatshan System

Figure 3 shows the elevation-storage relationship for Whatshan Lake Reservoir within its normal reservoir operating ranges. Between its normal maximum and minimum operating elevations Whatshan Lake has a storage capacity of approximately 1400 cms-days (121.5 million m^3).

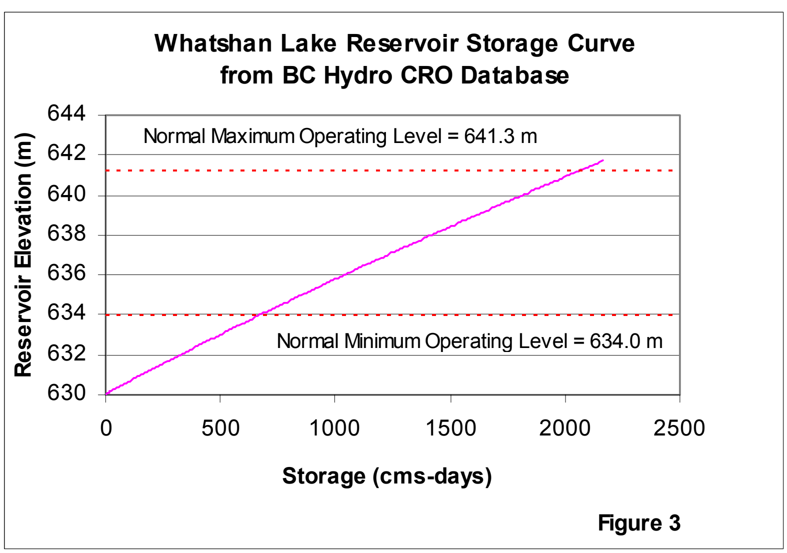

Figure 3: Stage-storage relationship for Whatshan Lake Reservoir

2.2 Climatology[2]

The Whatshan River basin is within the southeast interior climatic region, which is affected by both continental and modified maritime conditions. The Monashee Mountains are the first range of mountains to be encountered by maritime air after losing much of its moisture over the Coast Mountains and then descending over the southern interior plateau. Thus, precipitation is higher than in the plateau region but considerably less than on the coastal areas. Temperatures in the basin are also affected by continental air from the south (warm) and from the north (cold Arctic air). These general climatic conditions produce large snowpacks in the mountains, warming conditions in April to June and often heavy short duration rainfall in May through August. The presence of small glaciers along the western ridge of the Monashees reflects the heavy winter precipitation and relatively cool temperatures.

During winter it is common for westerly or southwesterly air streams aloft to transport maritime moisture into the area. The higher land barriers of the Monashee Mountains, combined with this upper airflow direction, produce increased seasonal basin precipitation during the winter months.

The snowpack in the Whatshan valley bottom is usually depleted by the end of April, yet small permanent snowfields exist at the highest elevations. The rapid snowpack depletion in the lower and middle elevation ranges during the late spring is the dominant influence on the yearly hydrologic cycle. The magnitude of the river response in the early summer depends on the warming temperature pattern, the distribution of the snowpack with elevation and the presence of contributing rainstorms.

Cold-low pressure systems normally cross over the Coast Mountains into the area from a westerly direction (ranging from northwest to southwest). Heavy, short duration summer storms are often associated with these pressure systems.

[2] Climate information obtained from BC Hydro, “Whatshan Dam Probable Maximum Flood”, Hydroelectric Engineering Division report no. H1785, February 1985

Forecasting and watershed modelling procedures have determined that the precipitation within the Whatshan basin is best represented by a weighted average computed from the Fauquier AES and Barnes Creek DCP stations. The resulting precipitation record is referred to as the Whatshan Indexed station. Figure 4 shows the maximum, mean, and minimum monthly precipitation for the basin as represented by the Whatshan Indexed station.

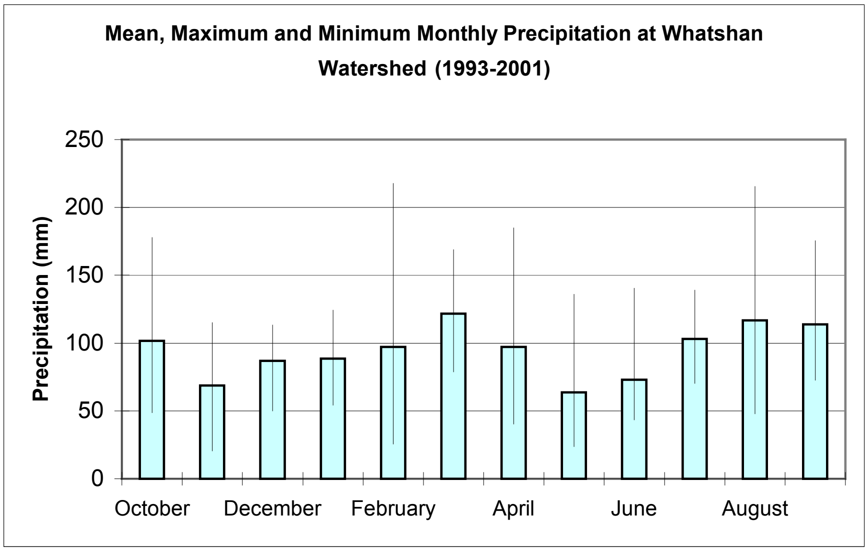

Figure 4: Maximum, mean and minimum monthly precipitation for the Whatshan Indexed station.

Figure 5 shows the maximum, mean, and minimum daily temperatures at Fauquier AES and Barnes Creek DCP.

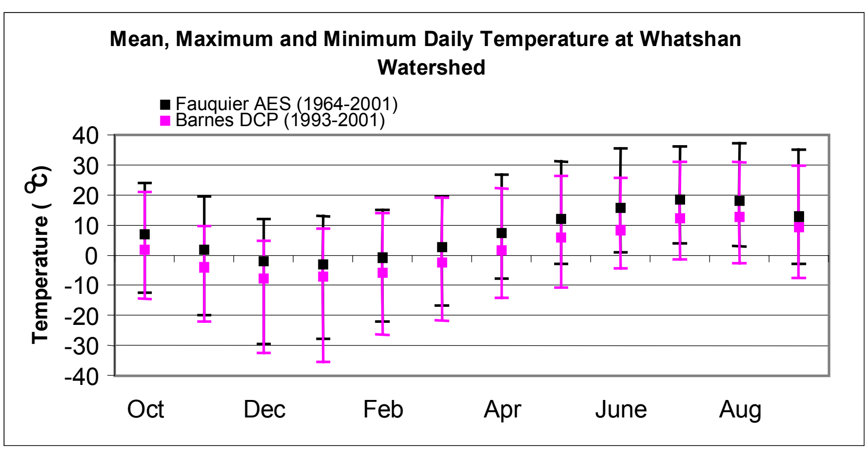

Figure 5: Maximum, mean and minimum daily temperature at Fauquier AES and Barnes Creek DCP

Figure 6 shows the normal monthly snow water equivalent at Barnes Creek snow course (1D09), located at El. 1620 m.

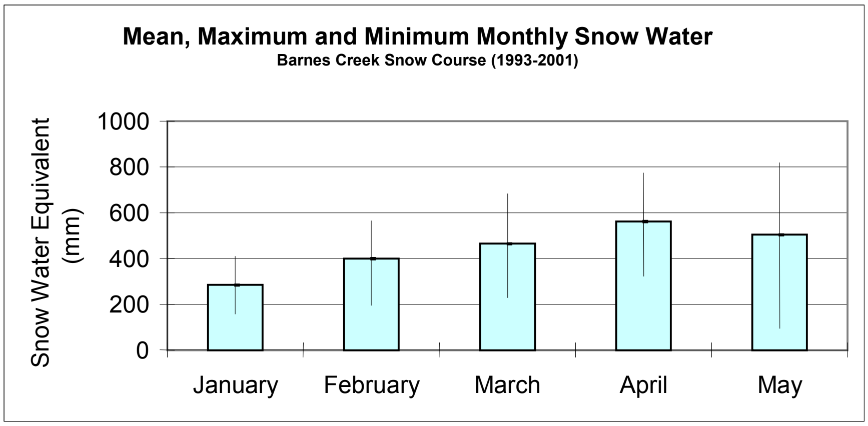

Figure 6: Maximum, mean and minimum monthly snow water equivalent at Barnes Creek snow course (2B06P)

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:

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

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 Whatshan Lake Reservoir is shown in Figure 3.

Outflow relationships: Flow through turbines at the Whatshan powerhouse 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.

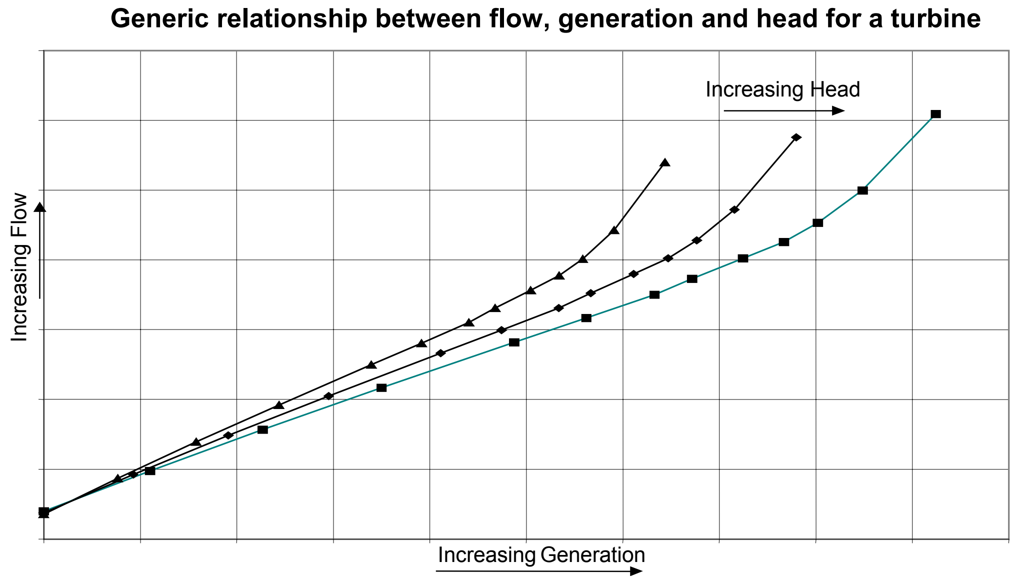

Figure 7: Generic relationship between flow, generation, and head for a turbine

"Rating curves" show the relationship between flow, opening, and elevation for a given release device. A rating curve for spill facilities at Whatshan Lake is shown in Figure 8.

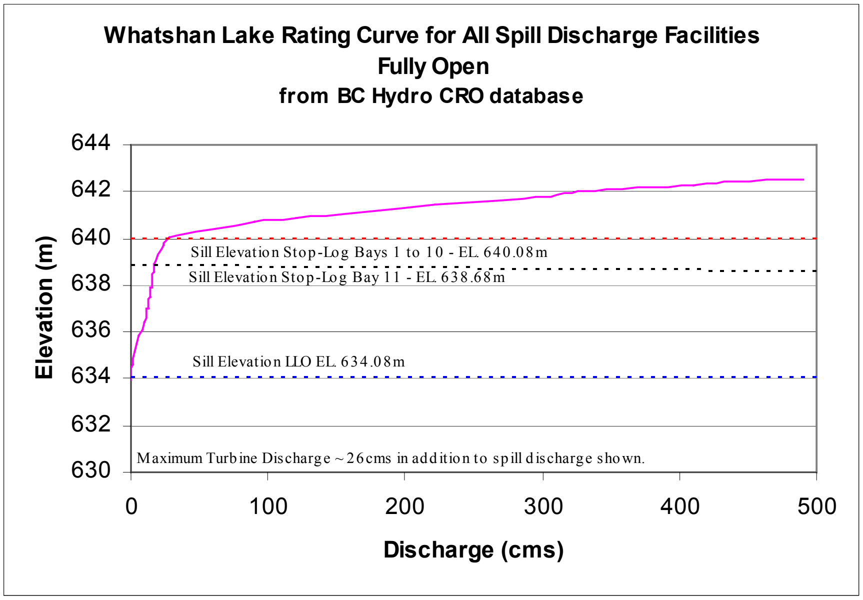

Figure 8: Rating curve for Whatshan Lake with all spill discharge facilities fully open

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

Inflows to Whatshan Lake Reservoir are computed based on equation (1).

Various information, including gate openings, reservoir and tailwater elevations, energy, spill, turbine flows, and inflows are stored in FLOCAL. A FLOCAL configuration for the Mica – Arrow system including the Whatshan project is shown in Figure 9.

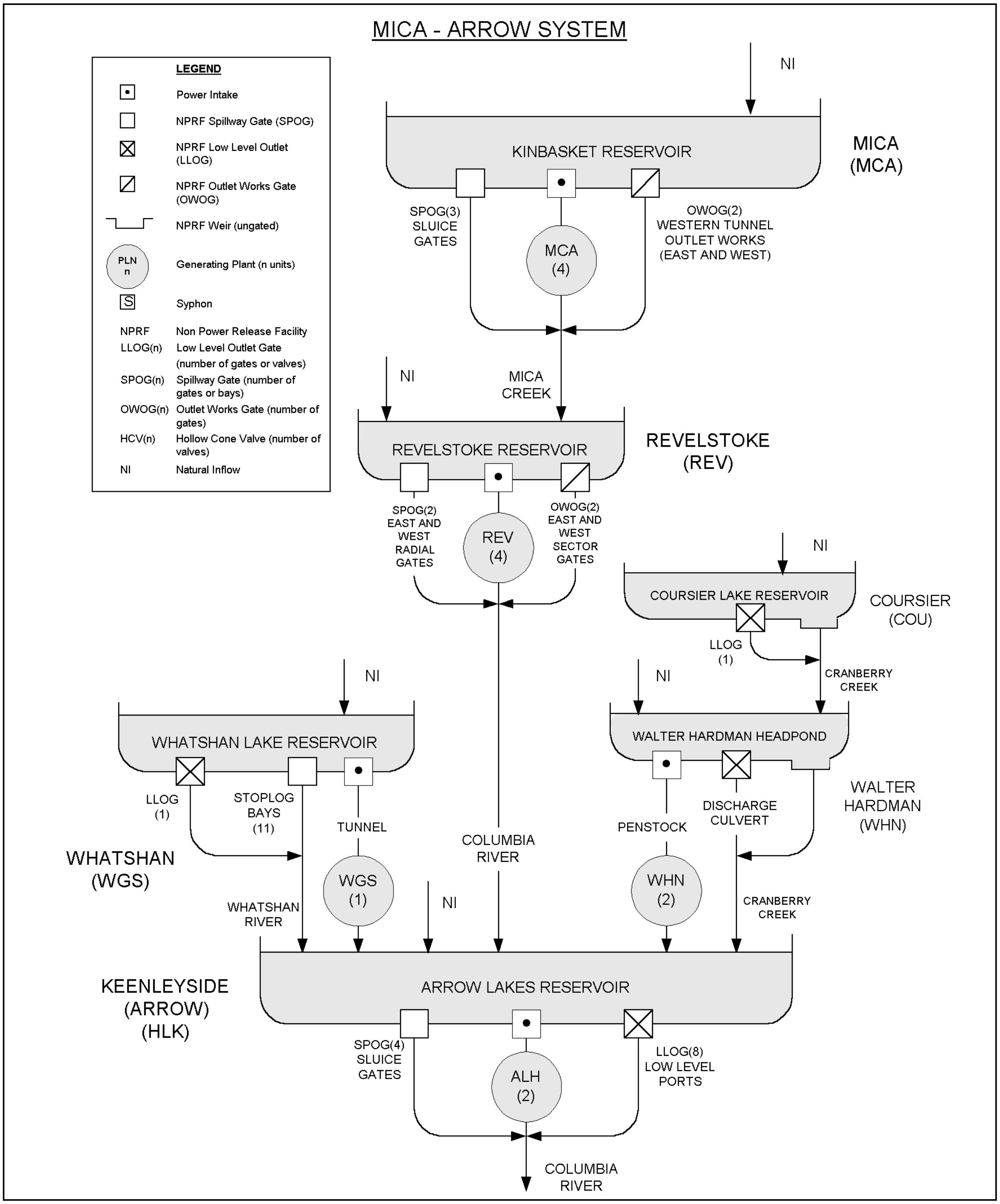

Figure 9: Schematic of the FLOCAL configuration for the Mica - Arrow system

3.2 Reservoir inflow characteristics

Figure 10 shows "spaghetti plots" of historical inflows to the Whatshan project. The 10th, 50th and 90th percentile inflows are shown in bold.

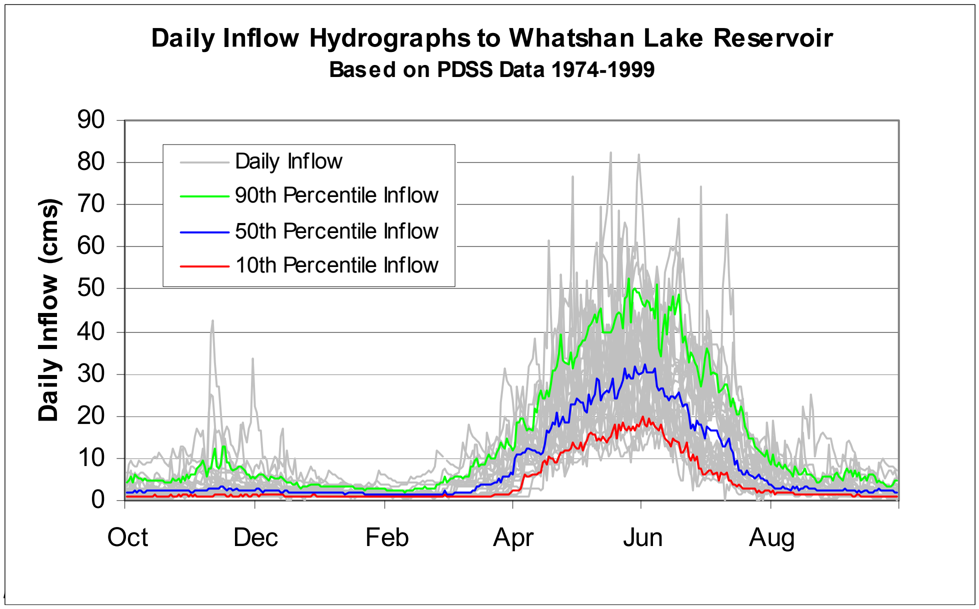

Figure 11 and Table 1 summarizes the daily inflows by month. Average monthly and maximum and minimum daily inflows are shown to highlight the variability of inflows to the project.

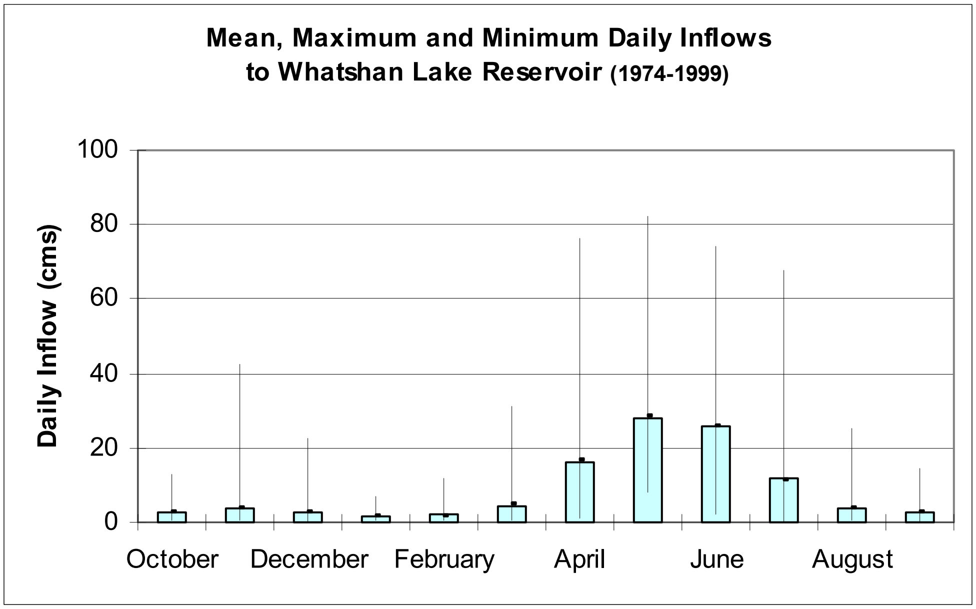

Figure 11: Variability in Whatshan Project's daily inflows

Table 1: Whatshan Project's daily inflows (1974-1999)

	Mean	Maximum	Minimum
October	2.8	12.8	0.4
November	4.0	42.4	0.8
December	2.6	22.5	0.0
January	1.9	7.2	0.7
February	1.8	11.6	0.7
March	4.5	31.3	0.4
April	16.0	76.6	0.8
May	28.2	82.2	7.9
June	25.9	74.3	2.3
July	11.9	67.5	0.0
August	3.8	25.3	0.6
September	2.9	14.4	0.2

A "flow duration curve" indicates the percent of time that a flow is greater than a given discharge. Figure 12 shows a flow duration curve of daily inflows for the years 1974-1999; it illustrates the large range and variability of inflows.

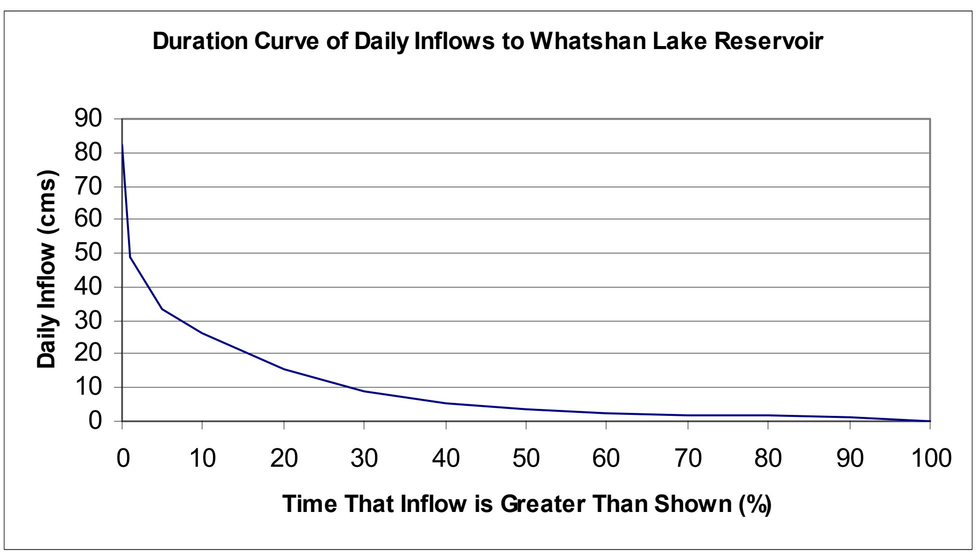

Figure 12: Duration curves of daily inflows to Whatshan Lake Reservoir

Figure 13 shows a duration curve for annual flows.

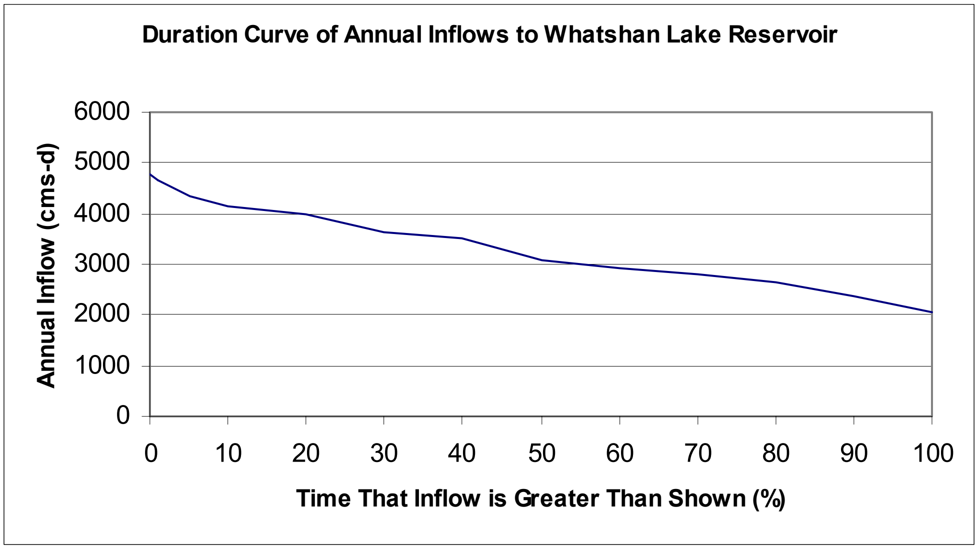

Figure 13: Duration curve of annual inflows to Whatshan Lake Reservoir

For reference, Figure 14 shows a comparison between the mean annual local inflow and total live storage available for selected BC Hydro and other hydroelectric projects. Whatshan Lake Reservoir is highlighted and shows that the average annual inflow is approximately 3 times greater than the available project storage.

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 14 also shows the relative contribution of Whatshan Lake Reservoir to BC Hydro's total reservoir storage capacity.

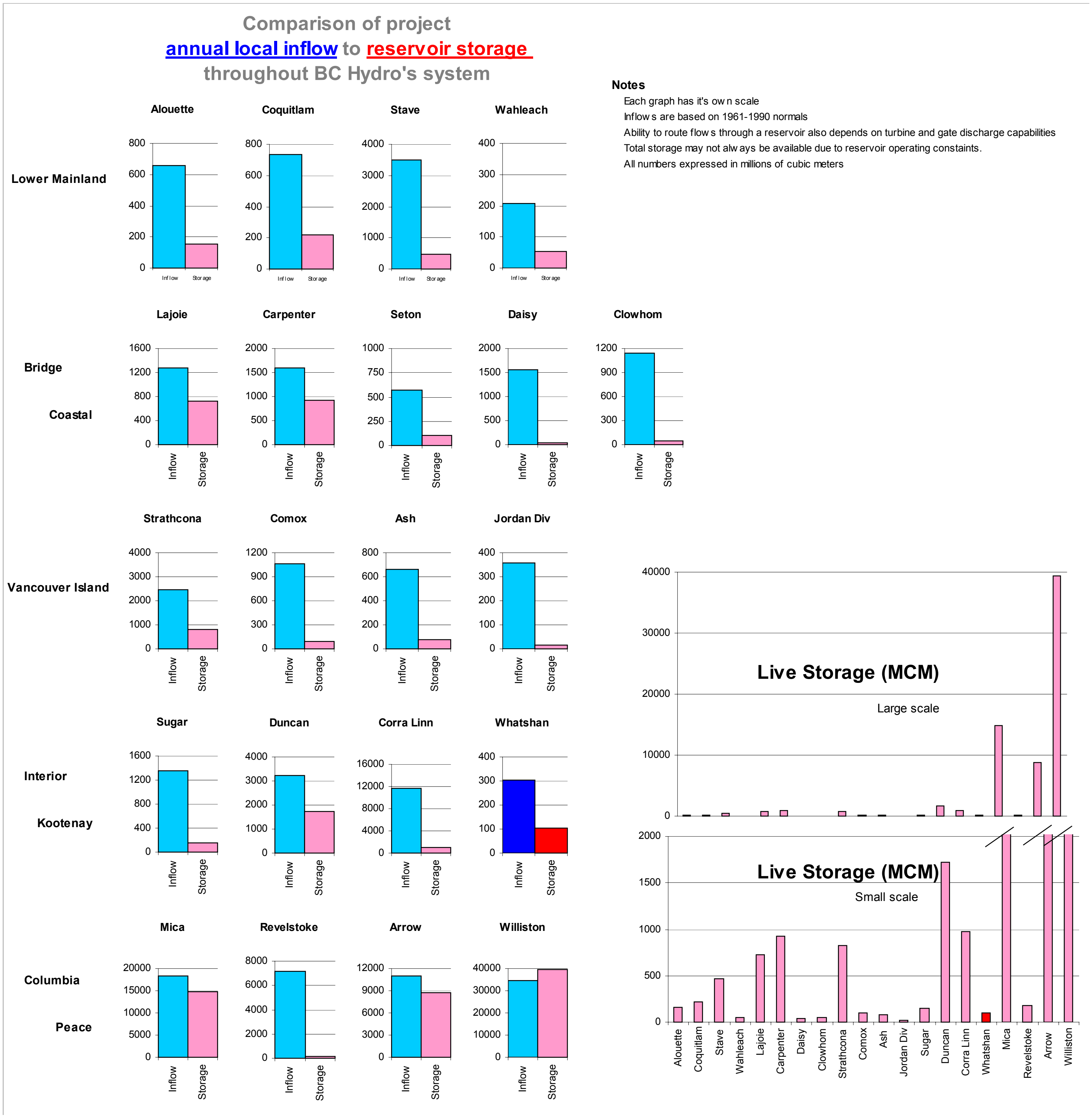

Figure 14: Comparison of project annual inflows to reservoir storage throughout BC Hydro's system

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 Whatshan projects.

Daily inflow forecasts: Daily inflow forecasts are short-term forecasts that indicate the inflow expected over the next few days. An in-house conceptual watershed model, FLOCAST, is currently used to produce these forecasts. Each morning of each working day, Resource Management enters observed and forecast precipitation, temperature, and freezing level 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 Whatshan system during a given period. BC Hydro typically produces volume forecasts for the period 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 Whatshan system's watershed. Characteristics of the hydrometeorological data collection stations referenced for Whatshan operation are summarized in Table 2. Locations of hydrometeorological stations within the watershed are shown in Figure 1.

Table 2: Hydrometeorological stations used for forecasting, operations and planning

Station	Type	ID	Elev (m)	Latitude	Longitude	Characteristics
Fauquier	AES	1142820	490	49.52	118.06	Temp/Precip.
New Denver	AES	1145460	564	49.59	117.23	Temp/Precip.
Nakusp	AES	1145300	457	50.14	117.49	Temp/Precip.
Barnes Creek	DCP	BAR	1620	50.04	118.21	Temp/Precip.
Whatshan (Upper)	MWLAP	2B05	1480	50.12	118.02	Snowcourse
Monashee Pass	MWLAP	2E01	1370	50.05	118.30	Snowcourse
Barnes Creek	MWLAP	2B06P	1620	50.04	118.21	Snowcourse
St. Leon	MWLAP	2B08	1800	50.26	117.42	Snowcourse
Koch Creek	MWLAP	2B07	1860	49.43	117.59	Snowcourse
Sandon	MWLAP	2D03	1070	49.59	117.14	Snowcourse

Report prepared by: Chris Caryula, Engineering Co-op student

Reviewed and Issued by: K. Groves, P. Eng.

C:
Vesta Filipchuk
Kim Meidal