



# Cheakamus Project Water Use Plan

*Revised for Acceptance  
by the Comptroller of  
Water Rights*

1 October 2005

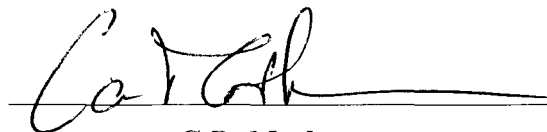


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A handwritten signature in black ink, appearing to read 'C.D. Matheson', written over a horizontal line.

**C.D. Matheson  
Manager, Operations**

## **Preface**

The water use planning process for BC Hydro's Cheakamus facilities was initiated in 1996. However, in May 1997 the project was put on hold when DFO placed a Flow Order that specified minimum flows to be discharged from Daisy Lake Dam. The Comptroller of Water Rights accepted an out of court interim flow settlement in December 1998.

The Water Use Plan project was again initiated in February 1999, by which time the November 1998 letter of direction for the Water Use Plan Program had been received from the Provincial Government and the Water Use Plan Guidelines had been published.

The project entered the implementation phase in mid April 1999 and consultation was completed in April 2002.

BC Hydro thanks all those who participated in the process for their effort and dedication. Unfortunately, consensus was not achieved at the Consultative Committee table.

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Appendix 1 Cheakamus River Basin Hydrology

## 1.0 INTRODUCTION

The consultative process undertaken during the development of this plan concluded without consensus being reached on the operating parameters.

Details of the consultative process and its outcomes are provided in the *Cheakamus Water Use Plan: Report of the Consultative Committee* dated May 2002.

## 2.0 DESCRIPTION OF WORKS

### 2.1 Location

The Cheakamus facilities, shown in Figure 2-1, Figure 2-2 and Figure 2-3, are located about 30 km north of Squamish, B.C.

Daisy Lake Reservoir is located adjacent to the Sea-to-Sky Highway (Highway 99) and impounds water flowing south from the headwaters of the Cheakamus River. A portion of that water is released from the Daisy Lake Dam down the 26 km stretch of Cheakamus River to its confluence with the Squamish River. The remainder of the water in Daisy Lake Reservoir is diverted through a tunnel that runs through Cloudburst Mountain to the Cheakamus Generating Station, located on the left bank of the Squamish River.

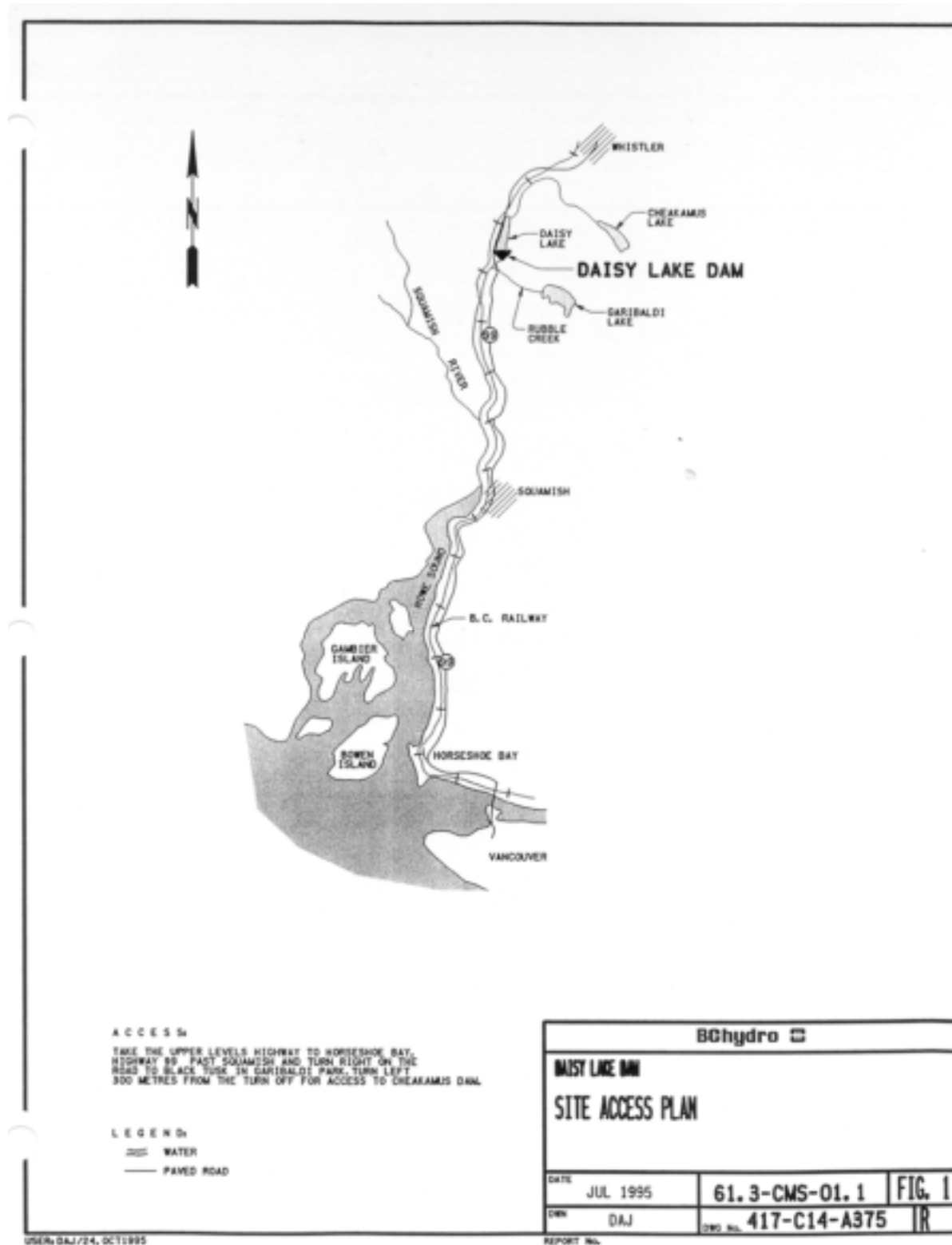


Figure 2-1: Daisy Lake Dam - Site Access Plan



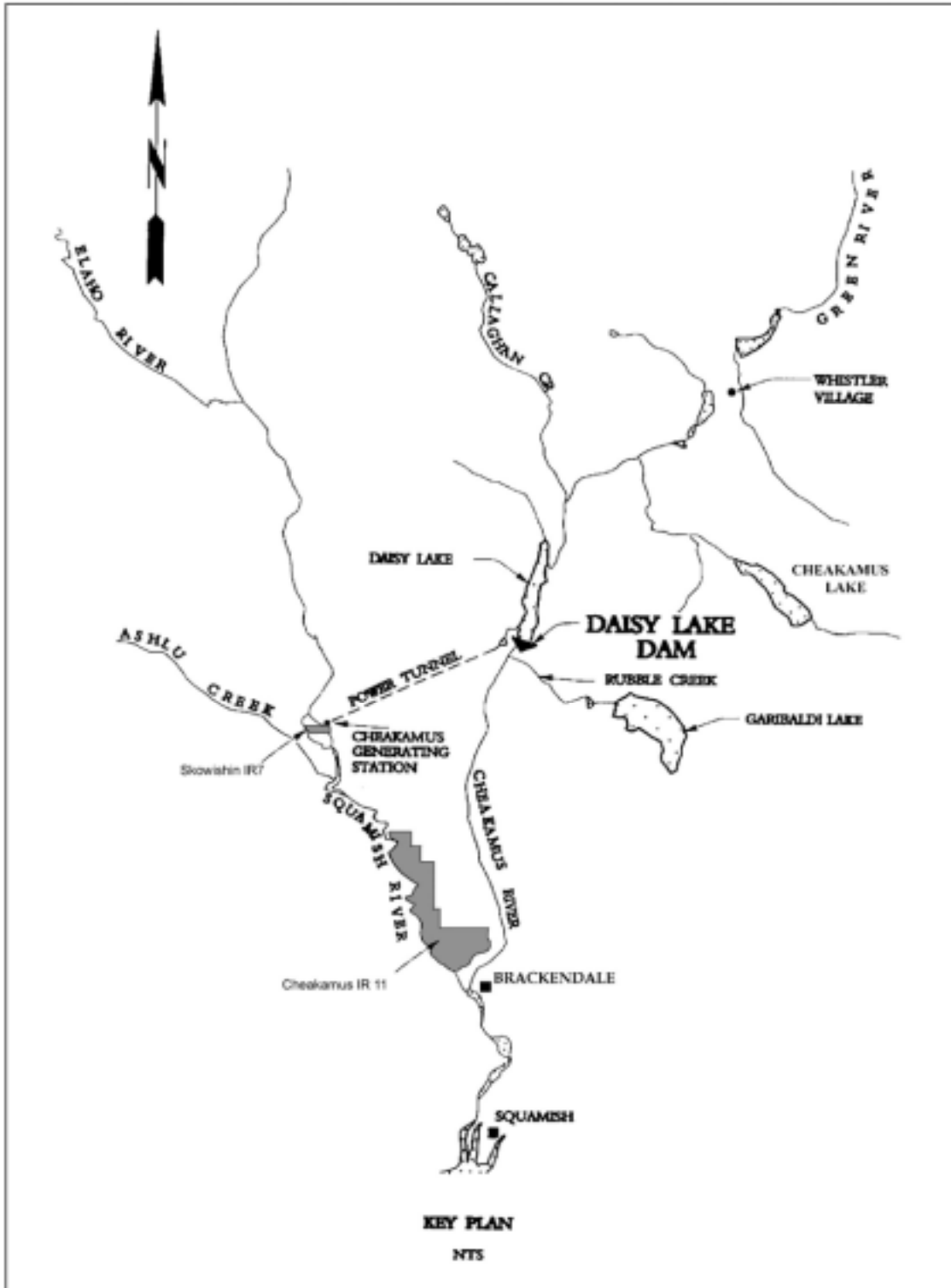


Figure 2-2: Map of Cheakamus

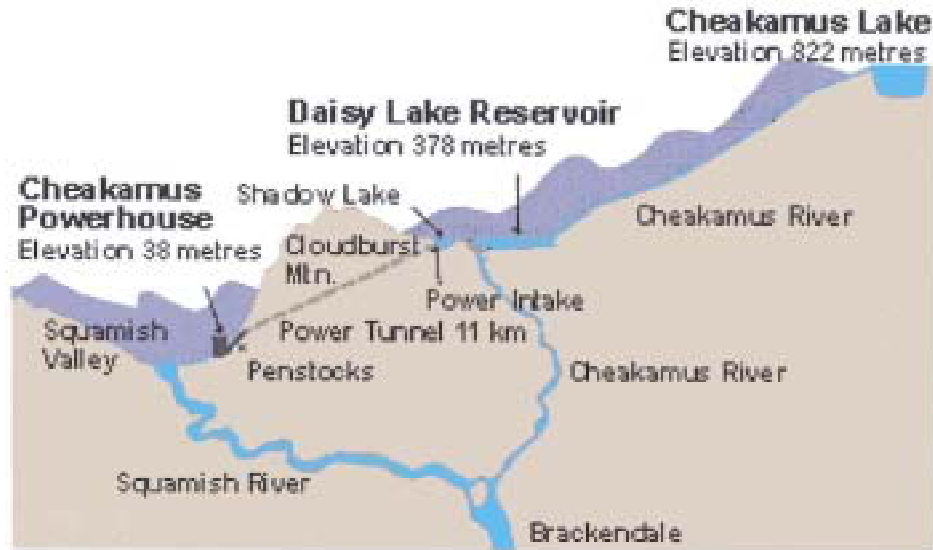


Figure 2-3: Cheakamus System

## 2.2 Existing Works

The Cheakamus generating system was completed in 1957 and is comprised of the Daisy Lake Dam and Reservoir, the 157 MW Cheakamus Powerhouse in the Squamish Valley, and a connecting tunnel through Cloudburst Mountain.

During normal operations Daisy Lake Reservoir has an operating range from 364.90 m to 377.25 m above sea level, a fluctuation of 12.35 m. The reservoir can store approximately 55 million cubic meters of water, which is only 3.5 per cent of average annual inflow.

Water for generating electricity is drawn from Daisy Lake Reservoir via a canal under the Sea-to-Sky Highway into Shadow Lake where it enters a 5.5 m diameter, 11 km long tunnel that runs through Cloudburst Mountain to the Squamish Valley. Twin penstocks carry the water from the tunnel exit to the Cheakamus generating station after which it is discharged into the Squamish River. The maximum flow from the generating station is 65 m<sup>3</sup>/s with a 340 m difference in elevation between Shadow Lake and the generating station.

## 3.0 HYDROLOGY OF THE CHEAKAMUS BASIN

The Cheakamus River originates in the Fitzsimmons Range of the Coast Mountains in Garibaldi Provincial Park, about 25 km southeast of Whistler, B.C. Its watershed has an area of 1070 km<sup>2</sup> and an elevation ranging from 30 m above sea level, where it meets the Squamish River, to 2300 m above sea level at its headwaters.

From its headwaters it flows through Cheakamus Lake and runs northwest towards Whistler then turns south for 46 km, travelling parallel to the Squamish River, to the Daisy Lake Reservoir.

The Cheakamus watershed is transitional between the milder Pacific Coast and colder interior, climatic regimes. The valley is oriented such that it receives the predominant winter southwesterly winds that transport moist air up Howe Sound and far up the valley. A series of fall and winter storms commonly occur from late September until March. Summer storms also occur but are usually small, though intense. Infrequent, large, summer storms can produce extreme flooding. Annual precipitation tends to decline along the valley bottom moving inland where a greater proportion also falls as snow due to the colder inland climate and higher elevations. At Garibaldi and Alta Lake climate stations, over half the annual precipitation falls between October and January. Snow accumulates rapidly in the watershed during the fall, especially at the higher elevations.

The natural flow regime of the Cheakamus River follows a cyclical seasonal pattern driven by climatic factors. Generally, the flows rise in April as temperatures increase and the snowpack begins to melt. The snowmelt peaks in June or July and flows decrease noticeably through August and September. The highest daily flows typically occur from September to January due to the combination of intense precipitation and melting snow.

Approximately 75 per cent of the total inflow to the Cheakamus River originates upstream of Daisy Lake Dam.

## **4.0 OPERATING CONDITIONS FOR FACILITY**

### **4.1 Role of Facility in Provincial System**

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

The Cheakamus facilities currently generate approximately 590 GWh/year, which is approximately 1.5 per cent of BC Hydro's total system production. Electricity is delivered to the system grid by a 230 kV transmission line to the Cheekye Substation located 19 km south of the generating station.

Cheakamus normally operates as a peaking plant during the daytime. It is often shut down at night because the amount of water entering the reservoir is insufficient to run the plant continuously, especially during the low flow winter period from January to April.

## 4.2 Water Use at Cheakamus Facilities

Under an Order issued April 6, 1999, BC Hydro was required to release into the Cheakamus River the greater of 5 m<sup>3</sup>/s or 45 per cent of the previous 7 days average inflows to the reservoir (within a range of 37 to 52 per cent). The remaining portion of the water may be diverted to the powerhouse, to a maximum of 65 m<sup>3</sup>/s, to produce electricity and is released into the Squamish River. Inflow that cannot be used by generating facilities or stored in Daisy Lake Reservoir is released down the Cheakamus River.

## 4.3 Emergencies and Dam Safety

Emergencies and dam safety requirements take precedence over the constraints outlined in this Water Use Plan. Emergencies include actual and potential loss of power to customers. Dam safety requirements for operations, including procedures for surcharging the reservoirs and undertaking special drawdowns of the reservoirs, are outlined in the Operation, Maintenance and Surveillance Requirements (OMS) Manual for Dam Safety.

## 4.4 Operation of Works for Diversion and Storage of Water

The following operating parameters are proposed for the Cheakamus facilities. BC Hydro may not be able to operate within these parameters during extreme hydrological events.

### 4.4.1 Daisy Lake Reservoir - Downstream Flood Routing

From 1 October to 31 December the target maximum reservoir level will be limited to El. 373.5 m to provide additional storage space in the reservoir to assist in managing high inflow events.

During the routing of flood events, BC Hydro will co-ordinate operations with the District of Squamish.

### 4.4.2 Minimum Flow Releases

BC Hydro shall:

- (a) Release a minimum flow from Daisy Lake Dam of:
  - 3 m<sup>3</sup>/s from 1 November to 31 December,
  - 5 m<sup>3</sup>/s from 1 January to 31 March; and
  - 7 m<sup>3</sup>/s from 1 April to 31 October.
- (b) Release additional flow from Daisy Lake Dam beyond that noted in (a) above, when required to maintain a minimum flow measured at the Brackendale gauge (08GA043) of:

- i. 15 m<sup>3</sup>/s from 1 November to 31 March;
- ii. 20 m<sup>3</sup>/s from 1 April to 30 June;
- iii. 38 m<sup>3</sup>/s from 1 July to 15 August;
- iv. 20 m<sup>3</sup>/s from 16 August to 31 August, unless otherwise directed by the Comptroller to increase flows to 38 m<sup>3</sup>/s for the benefit of recreation.
- v. 20 m<sup>3</sup>/s from 1 September to 31 October.

#### 4.4.3 Ramping Rates

Total Discharge from Daisy Lake Dam	Maximum Rate of Increase	Maximum Rate of Decrease
Less than 10 m <sup>3</sup> /s	13 m <sup>3</sup> /s per 15 minutes	1.0 m <sup>3</sup> /s per 60 minutes
10-62 m <sup>3</sup> /s	13 m <sup>3</sup> /s per 15 minutes	13 m <sup>3</sup> /s per 60 minutes
Greater than 62 m <sup>3</sup> /s	13 m <sup>3</sup> /s per 10 minutes	13 m <sup>3</sup> /s per 10 minutes

The foregoing target maximum ramping rates will be reviewed following the proposed *Stranding Downstream of Daisy Lake Dam* study noted in Table 5-1.

During reduction of load at the Cheakamus powerplant between loads of 40 MW and 10 MW, the rate of reduction shall not exceed 10 MW every 5 minutes. Turbine ramping rates will be reviewed following the proposed *Stranding Downstream of Generating Station* study noted in Table 5-1.

## 5.0 PROGRAMS FOR ADDITIONAL INFORMATION

Development of an operating regime for the Cheakamus River was complicated by some uncertainties, which will be addressed by the monitoring plan. The monitoring plan is expected to verify that operations are helping to achieve the objectives for recreation, fish and aquatic ecosystem and to provide information on which to base future operating decisions.

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 changes being recommended.
- Provide improved information on which to base future operating decisions.

The main elements of the monitoring program are described in Table 5-1. Estimated annual costs for these studies are summarized in the Cheakamus Water Use Plan Consultative Committee Report.

**Table 5-1: Recommended Monitoring Program for the Cheakamus Water Use Plan**

Study	Description	Uncertainty/Data Gap	Certainty <sup>1</sup>	Operational Implications	Duration
Refine Statistical Methodology	Refine Statistical Methodology (Integrated into each of the following studies).	Precisely determine sampling methods and data analyses that will yield best learning benefits.	n.a.	none	2 months
Salmon populations	Assess salmonid spawner abundance and smolt output in the Cheakamus River for both mainstem and side channel populations.	Do operations affect salmonid spawner abundance and smolt output?	<b>Low</b>	None until review period	10–20 years
Rainbow Fish populations	Assess abundance of juvenile and adult rainbow; relate to habitat features.	How do operations affect rainbow trout habitat?	<b>Low</b>	None until review period	10–20 years
Stranding Downstream of Generating Station	(A) Install staff gauge at the Ashlu River bridge to accurately monitor stage changes, (B) conduct additional stranding surveys during fish life history stages when there is an elevated risk of stranding in the tailrace or the Squamish River.	Do operations affect adult or juvenile stranding below Cheakamus Powerhouse?	<b>High</b>	Possible adjustment to operational regime	1 year
Groundwater in side channels	Monitor groundwater in side channels and characterise the linkage between mainstem low flows, floodplain groundwater systems and side channel upwelling.	What is the link between mainstem flows and groundwater in side channels at flows less than 20 m <sup>3</sup> /s at Brackendale?	<b>High</b>	Adjustment to winter flows may be required between 15 and 20 m <sup>3</sup> /s. <sup>2</sup>	1 year intensive, subsequent years synoptic

<sup>1</sup> Physical works may be more cost effective.

<sup>2</sup> **High** - Monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.

**Medium** - Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses.

**Low** - Likely to allow only qualitative comparisons among a few competing hypotheses.

**Table 5-1: Recommended Monitoring Program for the Cheakamus Water Use Plan (cont'd)**

Study	Description	Uncertainty/Data Gap	Certainty <sup>1</sup>	Operational Implications	Duration
Benthos/ Periphyton/ Nutrients	Monitor nutrients, periphyton (epibenthic algae), and benthos at existing sites in Cheakamus River monitored during 1996 and 2000 and at control sites in Mamquam River.	Are Benthos/Periphyton/Nutrients affected by dam operations?	<b>Low</b>	None until review period	5 years, then reassess
Channel morphology	Monitor changes in channel form, gravel quantity and quality, vegetation distribution	Is channel morphology affected by dam operations?	<b>Medium</b>	None until review period	10-20 years
Stranding downstream of Daisy Lake Dam	Accurately monitor stage changes when flows are new target minimum	Do operational changes between 7 m <sup>3</sup> /s to 3 m <sup>3</sup> /s affect juvenile stranding downstream of Daisy Lake Dam?	<b>High</b>	Possible adjustment to operational regime	1 year
Steelhead Spawning and Emergence	Determine Steelhead spawning abundance and timing and daily stream temperatures from the beginning of spawning to the end of fry emergence to assess the impacts of the flow release changes from Daisy Dam				
Recreational Angling Access	Determine the benefits to recreational fishing access associated with increasing flows from 3.0 to 5.0 cubic meters per second between January 1 to March 31				

<sup>1</sup> **High** - Monitoring study will definitely lead to quantitative discrimination among all of the competing hypotheses.  
**Medium** - Monitoring study will likely lead to the ability to discriminate quantitatively among some of the competing hypotheses.  
**Low** - Likely to allow only qualitative comparisons among a few competing hypotheses.

## **6.0 IMPLEMENTATION OF RECOMMENDATIONS**

The operational changes and the monitoring program proposed in this Water Use Plan will be implemented after BC Hydro receives direction from the Water Comptroller.

## **7.0 EXPECTED WATER MANAGEMENT IMPLICATIONS**

BC Hydro will be responsible for meeting the operational parameters ordered but not for achieving the expected outcomes.

It is expected that the proposed operational changes in this Water Use Plan will have the following implications for water use interests.

### **7.1 Other Licensed Uses of Water**

The recommended operation is not expected to impact other licensed uses of Cheakamus water.

### **7.2 Riparian Rights**

The operational changes proposed in this Water Use plan are not expected to affect riparian rights associated with the reservoir or along the streams below the facilities.

### **7.3 Fisheries**

The effective spawning area of Chum will increase significantly. The Rated Habitat for resident fish, using the measurement of rated usable area, will increase slightly as well.

The area and integrity of aquatic ecosystem, using the measurement of resident riffle benthic biomass, will increase significantly.

### **7.4 Wildlife Habitat**

This was not directly represented in the Water Use Plan performance measures. However, when considered indirectly through performance measures for benthos and fish (e.g. chum production related to food for eagles and other wildlife), the wildlife habitat value increases significantly.

Performance measures were not developed to link riparian vegetation to flow due to the presence of dykes. The Fish Technical Committee felt that higher flows would not improve riparian vegetation in most reaches because this water will not reach the original floodplain.



## 7.5 Flood Control

The recommended operation is expected to provide the same level of flood protection as the current operation.

## 7.6 Recreation

Recreation within Daisy Lake Reservoir was not considered because the area is off-limits for commercial recreation. (Order in Council – Garibaldi Civil Defence Zone).

Recreational values associated with rafting, kayaking and sport fishing within the Cheakamus River are expected to change. The number of opportunities may be less but, because opportunities will be pre-scheduled, the value is expected to increase.

## 7.7 Water Quality

The proposed conditions in this Water Use Plan are not expected to affect water quality associated with Daisy Lake, the Cheakamus River, or the Squamish River.

## 7.8 Industrial Use of Water

No industrial use is made of the Cheakamus River.

## 7.9 Archaeological Considerations

The recommended operation is expected to provide the same level of protection as the current operation.

## 7.10 Power Generation

Average annual power revenue is expected to increase significantly.

## 7.11 First Nations

The Cheakamus facility is located within the claimed traditional territory of the Squamish Nation. The proposed conditions in the Water Use Plan are expected to benefit fish and wildlife in the Cheakamus River, an objective of the First Nations.

# 8.0 RECORDS AND REPORTS

## 8.1 Compliance Reporting

- BC Hydro will submit data to the Comptroller of Water Rights as required to demonstrate compliance with the conditions conveyed in the Water Licenses.

## **8.2 Non-compliance Reporting**

Non-compliance with any operation 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**

A review of this Water Use Plan is recommended within 5 years of its implementation and may be triggered sooner if significant new risks are identified through analysis of the monitoring results.

## **10.0 NOTIFICATION PROCEDURES**

Notification procedures for floods and other emergency events are outlined in the *Cheakamus Dam Emergency Planning Guide* and the *Power Supply Emergency Plan*. Both these documents are filed with the Office of the Comptroller of Water Rights.

**Appendix 1**  
**Cheakamus River Basin Hydrology**

## Inter-office memo

TO: Eric Weiss 20 December 2001  
FROM: Lara Taylor File: PSE 151.0  
C: Kathy Groves C-CMS-151.0  
SUBJECT: Cheakamus WUP - Hydrology of the Cheakamus Watershed

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### 1 INTRODUCTION

The Daisy Lake / Cheakamus project is a single reservoir hydroelectric project with the following general characteristics:

- Daisy Lake Dam impounds Daisy Lake Reservoir
- Spill and all other non-power releases from Daisy Lake Dam discharge into the Cheakamus River and flow down the natural river course a distance of approximately 20 km to the confluence with the Squamish River
- Power releases (turbine discharge) are diverted via 10.9 km power tunnel to the Cheakamus Power Plant
- Discharge from the Cheakamus Power Plant enters the Squamish River upstream of its confluence with the Cheakamus River
- Downstream of the Cheakamus River confluence, the Squamish River flows into Howe Sound (Pacific Ocean)

This report highlights the hydrology of the Cheakamus River hydroelectric system.

Physiography and climatology are reviewed for the Cheakamus watershed.

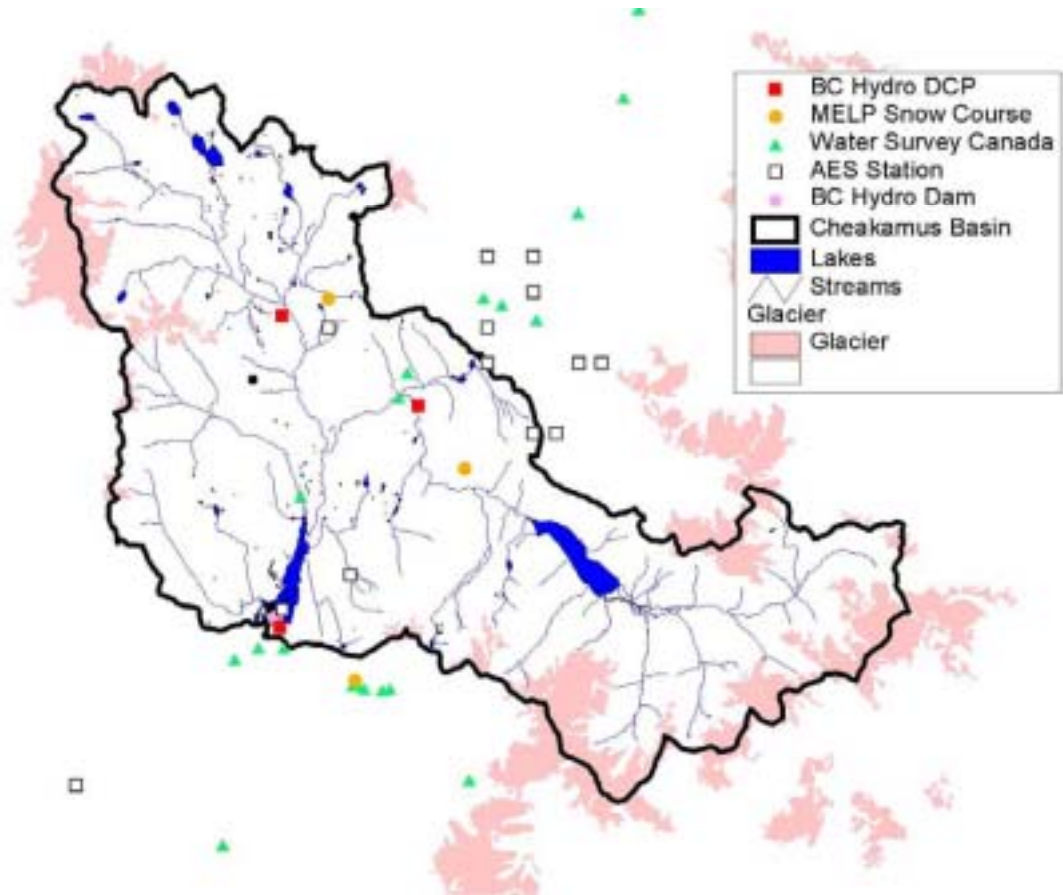
Methods used to calculate reservoir inflows, such as BC Hydro's FLOCAL program, are discussed. Typical inflow hydrographs and summaries are provided. Flow records for the Cheakamus River system referred to in this report were used in power studies conducted for the Cheakamus River Water Use Plan.

Procedures used to provide daily inflow, such as FLOCAST, and seasonal volume inflow forecasts are also described.

## 2.1 Physiography

The Cheakamus River basin is situated in the southern coastal mountains. It lies approximately 100 km north of Vancouver and discharges into the Squamish River. The drainage area behind Daisy Lake Dam is 780 km<sup>2</sup>.<sup>1</sup>

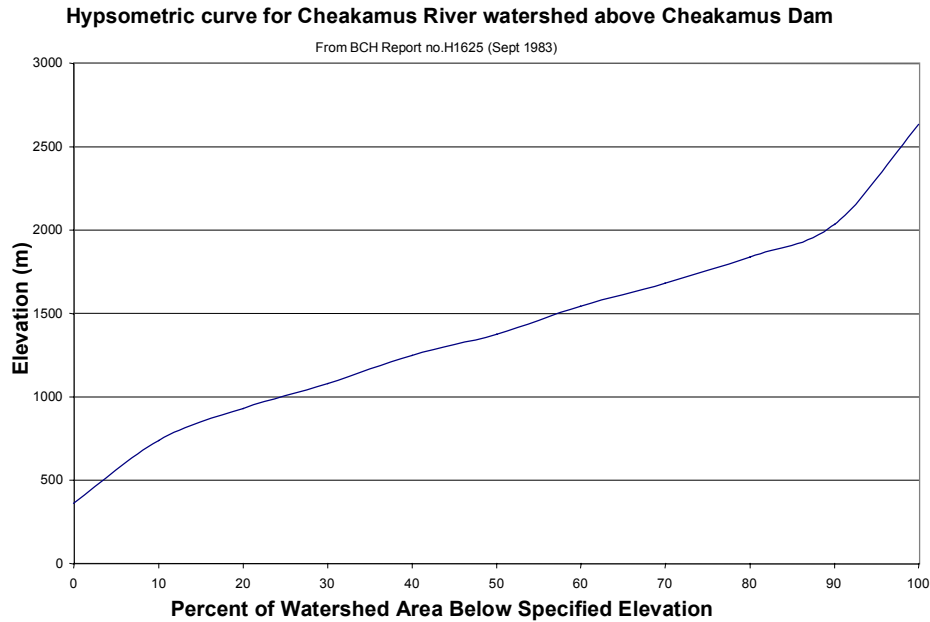
The drainage basin for the Cheakamus system is shown in figure 1.



*Figure 1: Watershed Map and Hydrometeorological Stations*

<sup>1</sup> BC Hydro. May 1983. "Cheakamus Project: Probable Maximum Precipitation Study", BC Hydro Hydroelectric Generation Projects Division, Report No. H1591

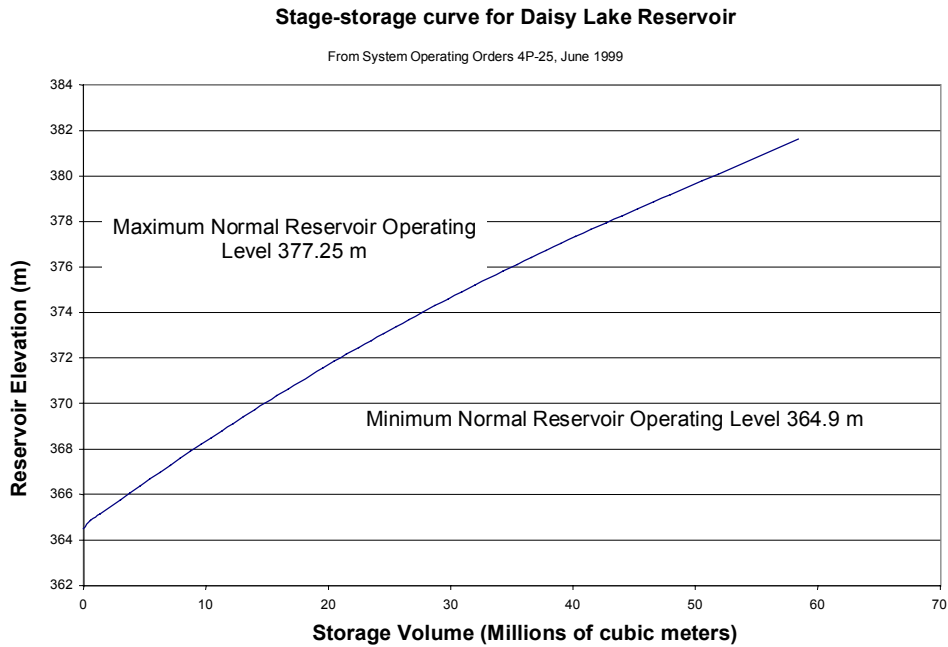
Elevation within the Cheakamus basin ranges from 378 m to 2634 m. The median basin elevation is 1375 m as indicated in the hypsometric curve shown in Figure 2.



*Figure 2: Hypsometric curve for Cheakamus River Watershed*

The hypsometric curve defines the percentage of the watershed area above or below a given elevation.

Daisy Lake Reservoir is approximately 6 km long. The stage-storage relationship shown in Figure 3 indicates the storage capacity of the reservoir at different reservoir elevations. Storage available within the normal reservoir operating range of El. 364.9 m to El. 377.25 m is estimated from the stage-storage curve at about 40 million cubic meters.

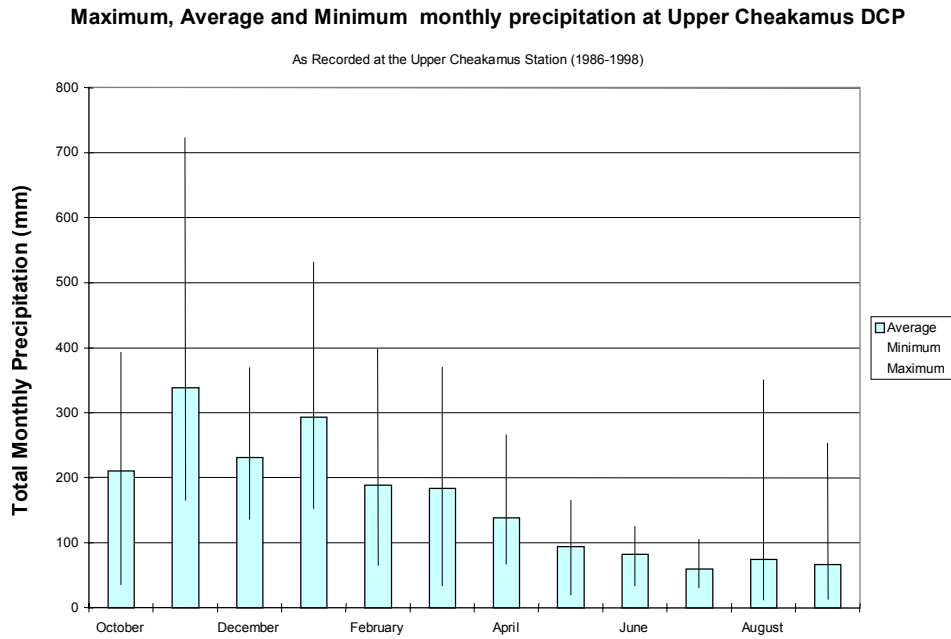


*Figure 3: Stage-Storage curve for Daisy Lake Reservoir*

## 2.2 *Climatology*

There are three variants of the Pacific Coast climate in the Cheakamus basin. The dominant type is a result of the confrontation of the pacific air masses with the west-facing mountain slopes all along the coast. This results in extremely prolonged and sometimes heavy rainfalls on the slopes due to the upward drift of moist air whenever a pacific cyclone approaches. The second variant occurs on the eastern faces of the mountains that have a much less rainy climate as the pacific air-streams are usually descending, thus dispersing cloud and lessening rainfall. The third variant exists because of the rain shadow of the Olympic Mountains in Washington state and is characterized by hot sunny summers and rain confined to the cooler seasons.

Figure 4 shows a bar chart of normal monthly precipitation as recorded at the Upper Cheakamus data collection platform (DCP) located at El. 880 m within the basin. Minimum and maximum monthly precipitation is indicated to illustrate the variability in the data. As can be seen from the plot, about half of the annual precipitation normally falls between October and January.



**Figure 4: Average total monthly precipitation at Upper Cheakamus DCP**

Figure 5 shows maximum, mean, and minimum daily temperatures at Upper Cheakamus DCP.



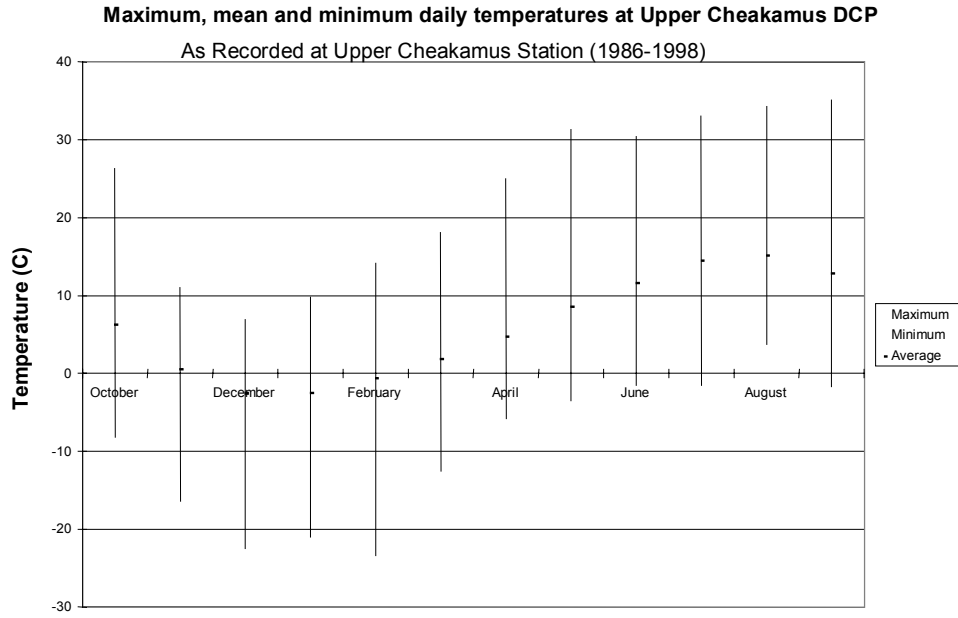


Figure 5: Maximum, mean and minimum daily temperatures at Upper Cheakamus DCP

Figure 6 shows the maximum, mean, and minimum snow water equivalent for Callaghan Creek snow course (3A20) located at 1040 m elevation.

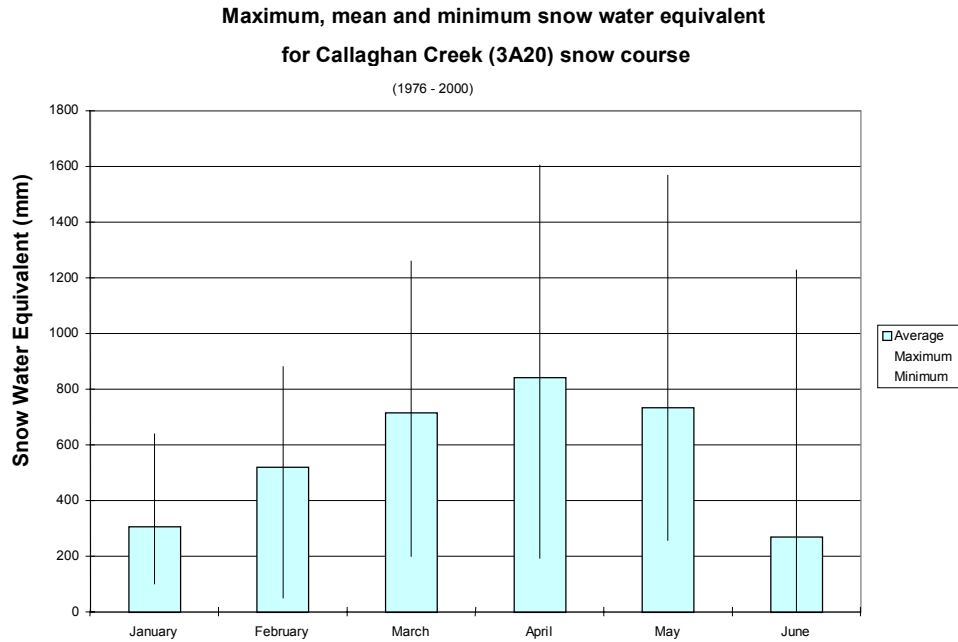


Figure 6: Maximum, mean and minimum snow water equivalent for Callaghan (3A20) snow course

### 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 than 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:

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

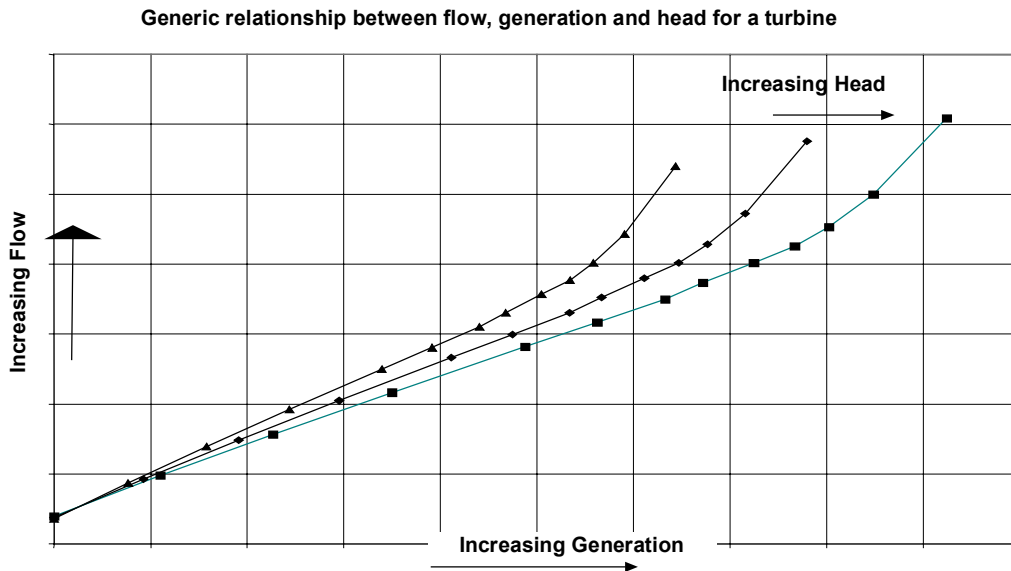
- where INFLOW = average inflow over a one - day period
- OUTFLOW = average outflow over a one - day period
- $\Delta \text{ STORAGE} = S2 - S1$ , where
  - S2 = reservoir storage at the end of the day
  - S1 = reservoir storage at the end of the previous day

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 relationship used to determine the volume of water in Daisy Lake Reservoir is shown in Figure 3.

**Outflow relationships:** Turbine flow at the Cheakamus 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 discharge through the turbines. A generic relationship between these variables is shown in figure 7.



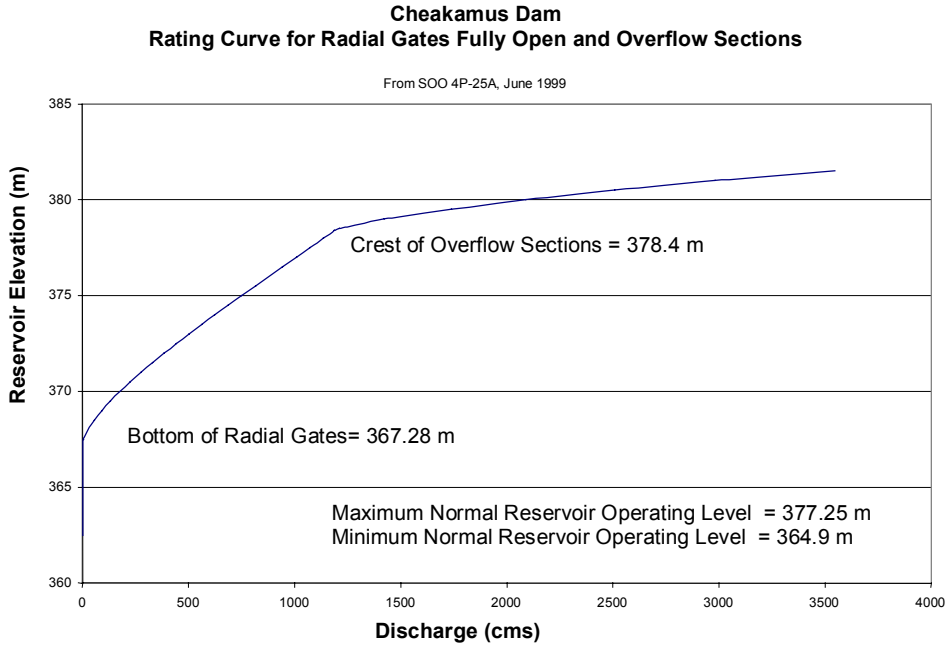
**Figure 7: Generic relationship between flow, generation, and head for a turbine**

Rating curves are used to compute flow passed over or through a discharge facility. “Rating curves” show the relationship between discharge, gate opening (if appropriate), and reservoir elevation for a given release device.

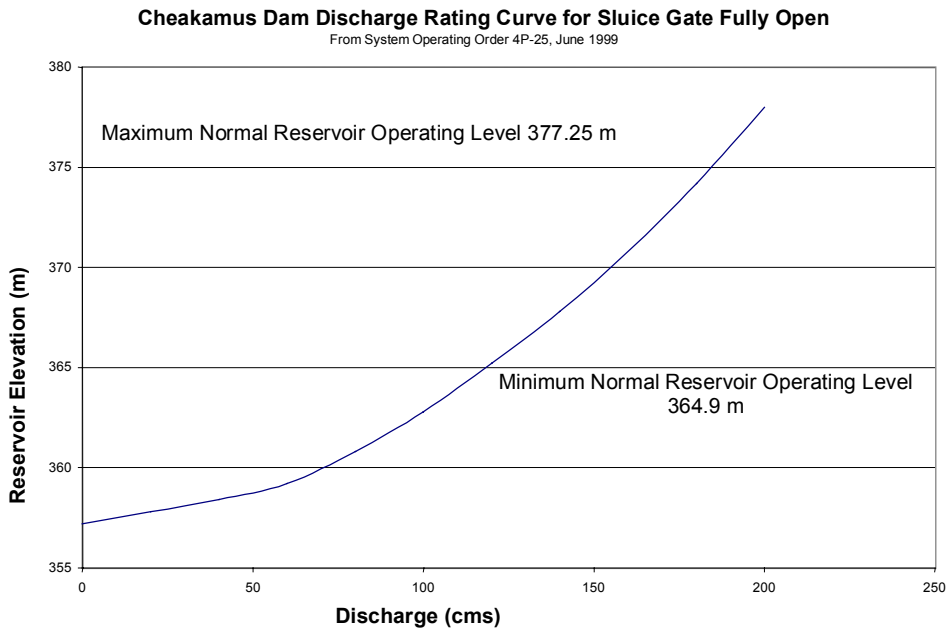
The Cheakamus Project has the following spill discharge facilities:

- 4 free crest (overflow) spillway sections
- 2 radial gates
- 1 low level sluice gate
- 1 low level hollow cone valve (HCV)

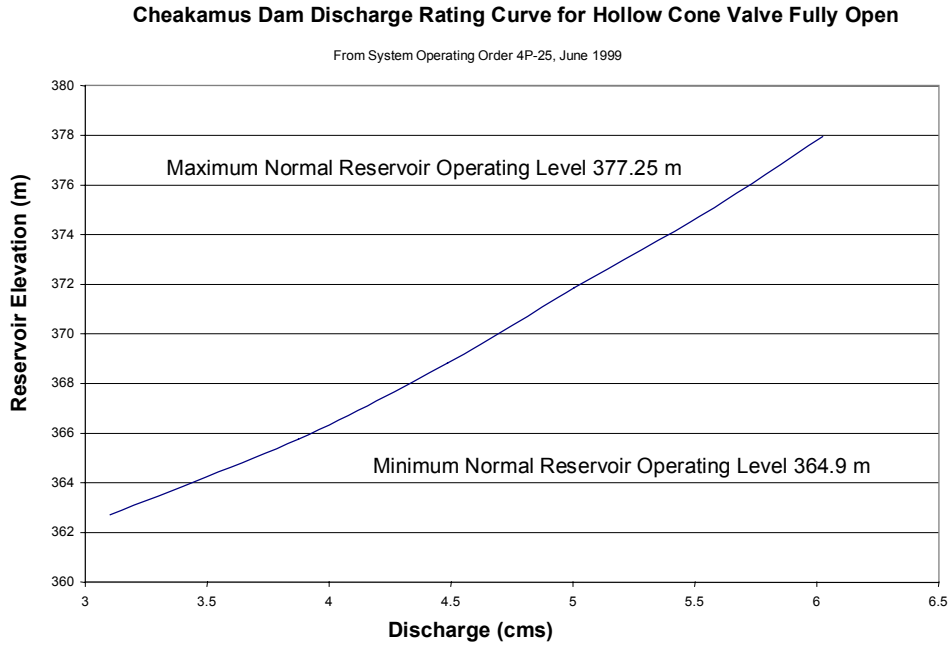
Figures 8 - 10 show the rating curves for the maximum discharge that can be released through the spill facilities (i.e. controlled facilities are fully open). In addition to the facilities noted above, a discharge of approximately 0.5 cms can be released via the station service generation facilities.



**Figure 8: Rating curve for Cheakamus Dam radial gates and overflow sections**



**Figure 9: Sluice gate rating curve for Cheakamus Dam**



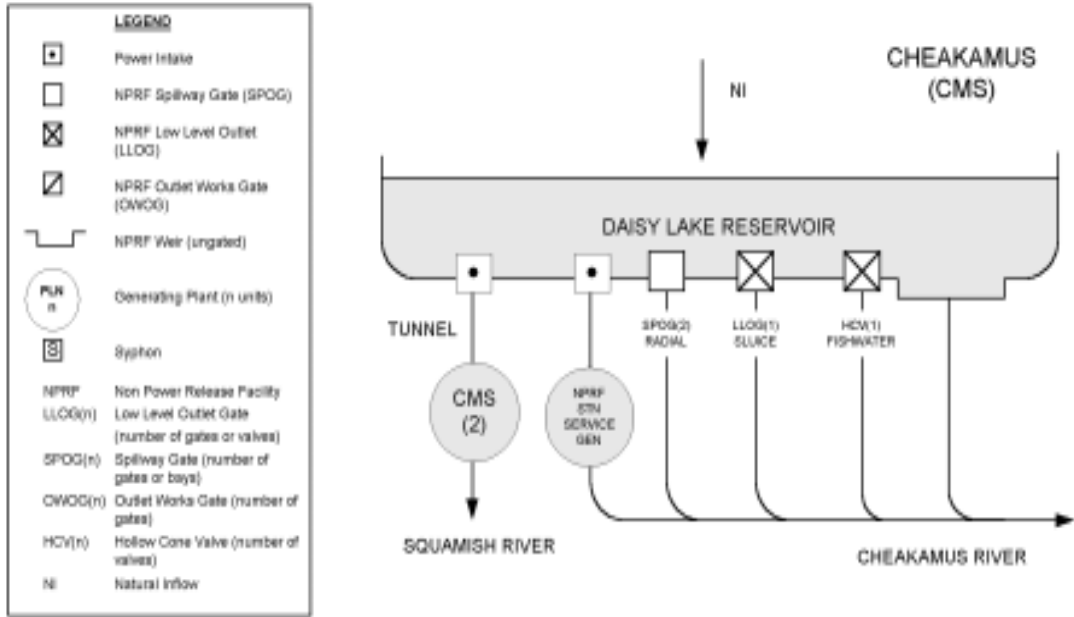
**Figure 10: Hollow Cone Valve Rating Curve for Cheakamus Dam**

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

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

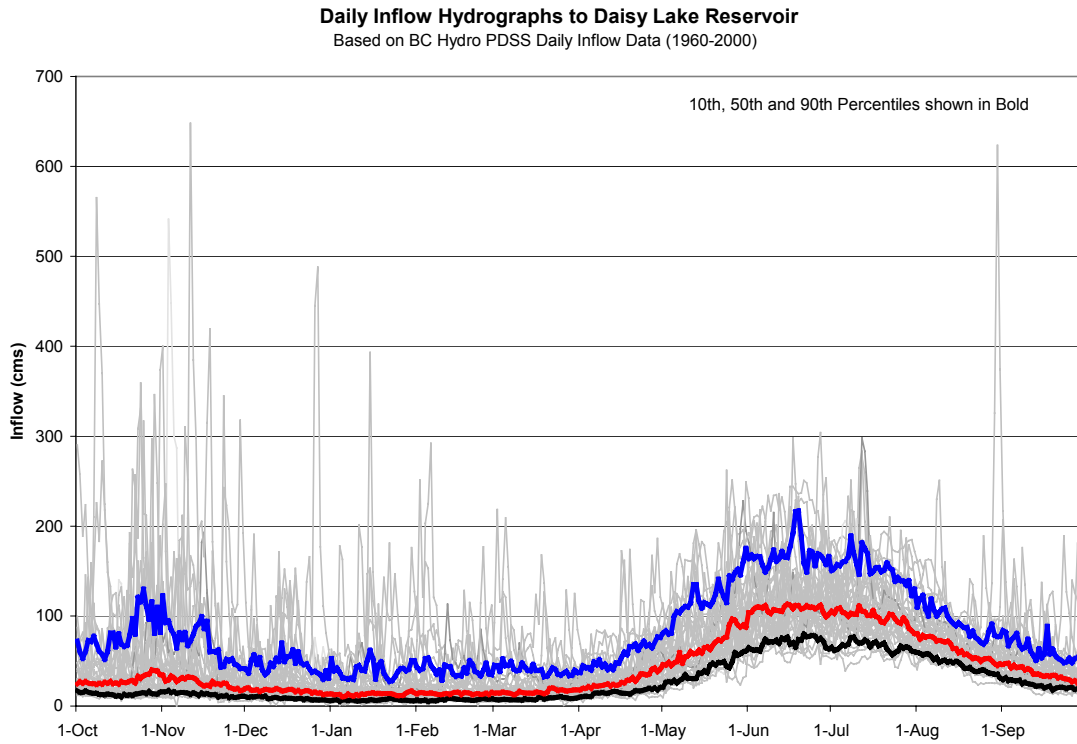
Various information, including gate openings, reservoir and tailwater elevations, energy, spill, turbine flows, and inflows are stored in FLOCAL. A FLOCAL configuration for Cheakamus is shown in Figure 10.

Figure 10: Schematic of the FLOCAL configuration for the Cheakamus system



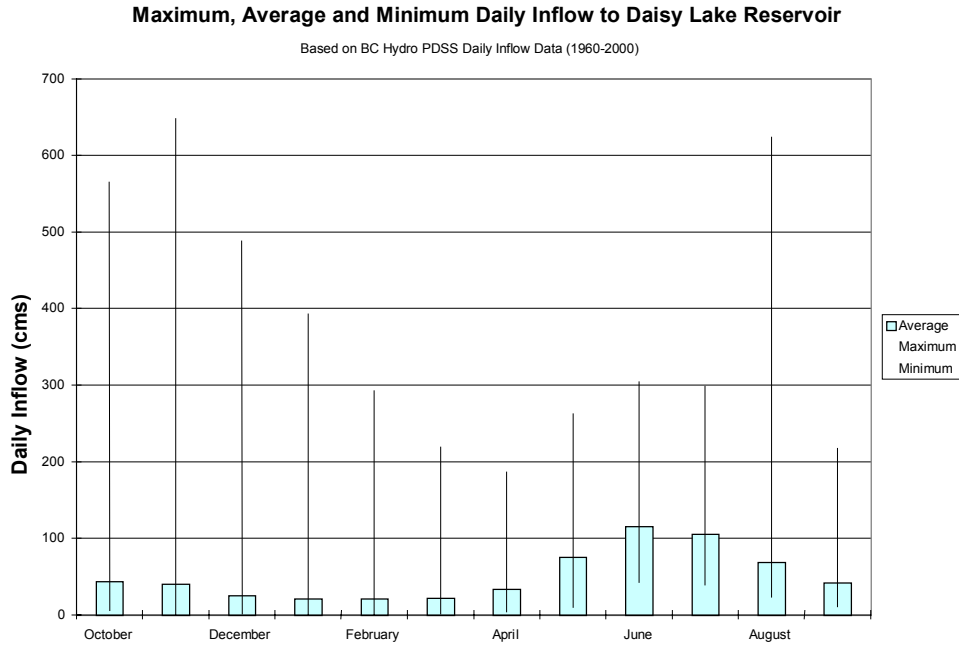
### 3.2 Reservoir inflow characteristics

Figure 11 shows a “spaghetti plot” of historical inflows to the Daisy Reservoir. The 10<sup>th</sup>, 50<sup>th</sup> and 90<sup>th</sup> percentile inflows are also shown.



*Figure 11: Historical Daily Inflows for Daisy Lake Reservoir*

Figure 12 and Table 1 summarize the daily inflows by month.



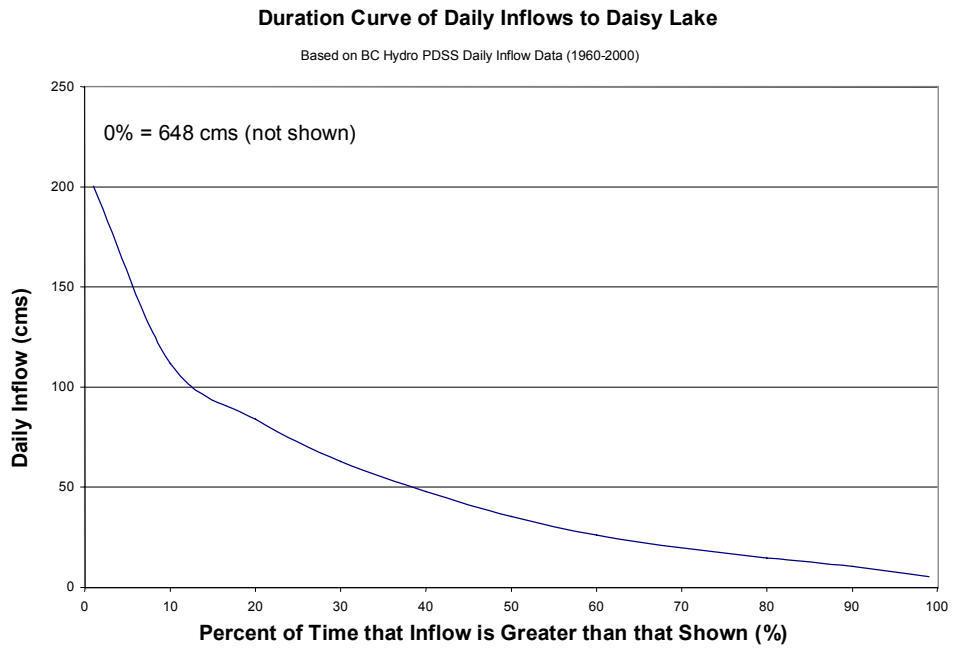
**Figure 12: Variability in Daisy Lake Reservoir daily inflows**

**Table 1: Daisy Lake Reservoir daily inflows (1960-2000)**

	Minimum Daily Inflow (cms)	Maximum Daily Inflow (cms)	Mean Daily Inflow (cms)
<b>October</b>	6	565	43
<b>November</b>	<1	648	40
<b>December</b>	1	488	25
<b>January</b>	<1	393	20
<b>February</b>	<1	292	21
<b>March</b>	<1	218	22
<b>April</b>	4	186	33
<b>May</b>	9	262	75
<b>June</b>	42	304	115
<b>July</b>	39	298	105
<b>August</b>	23	623	68
<b>September</b>	10	217	41

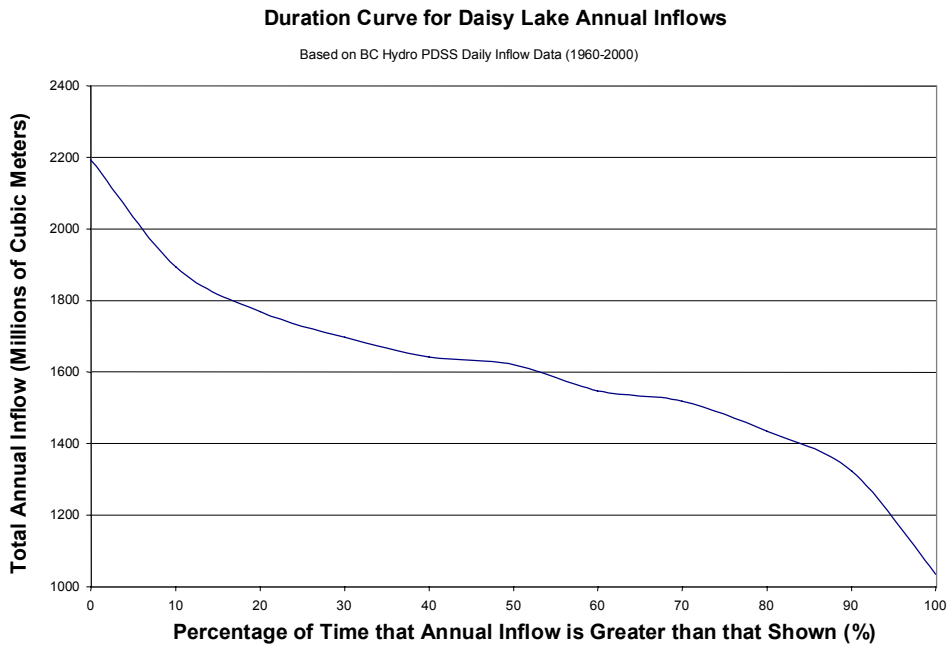


A “flow duration curve” indicates the percent of time that a flow is greater than a given discharge. Figure 13 shows a flow duration curve of daily inflows for the years 1960-2000. This figure again illustrates the large range and variability of inflows.



*Figure 13: Duration curve of daily inflows to Daisy Lake Reservoir*

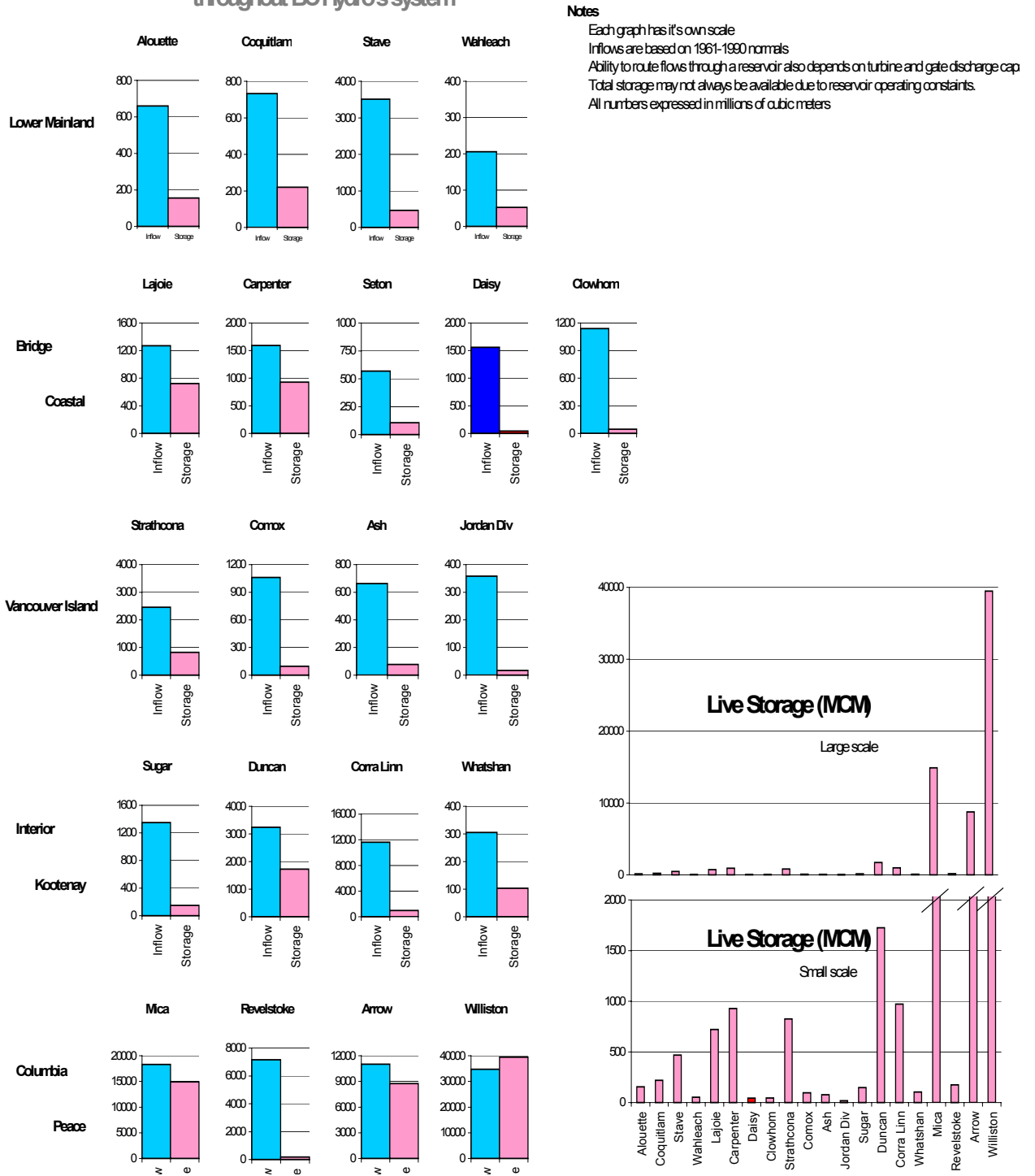
Figure 14 shows the duration curve of annual inflows to the project.



*Figure 14: Duration curve of annual inflows to Daisy Lake Reservoir*

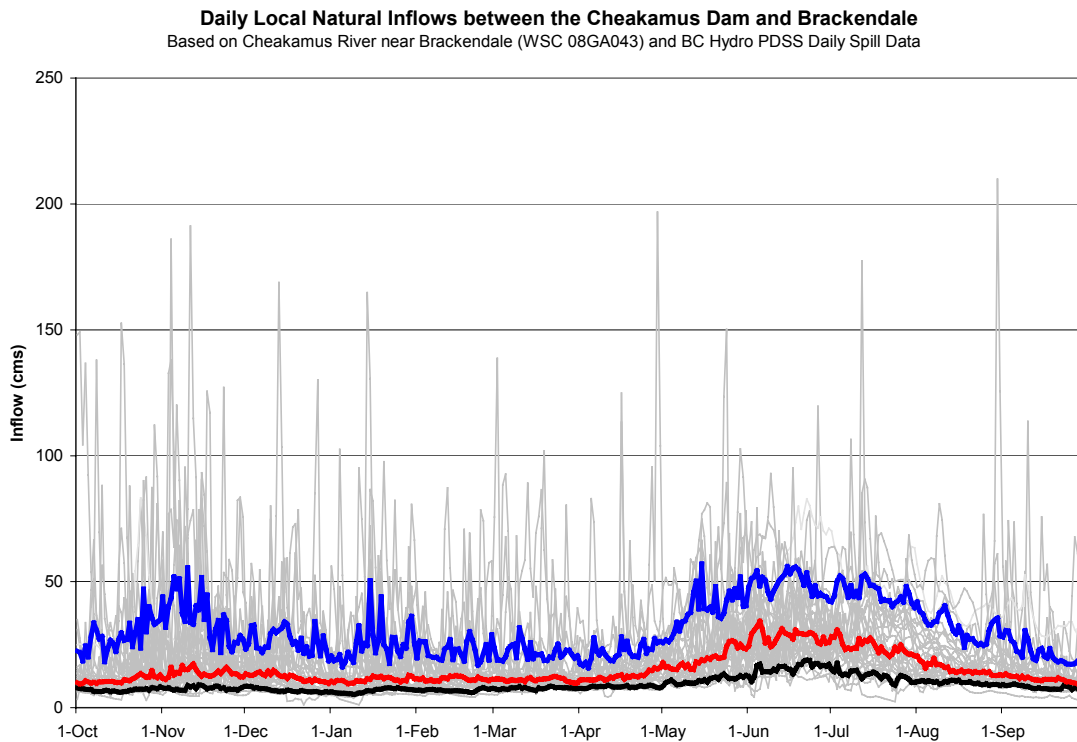
For reference, figure 15 shows a comparison between the mean annual local inflow and total live storage available at a number of project reservoirs including the Cheakamus/ Daisy Lake project.

**Comparison of project  
annual local inflow to reservoir storage  
throughout BC Hydro's system**



**Figure 15: Comparison of project annual inflows to reservoir storage throughout BC Hydro's system**

For the purpose of the Water Use Plan, the natural inflows to the Cheakamus River downstream of Daisy Dam were also required. These inflows were calculated for the reach between the dam and the WSC Cheakamus River near Brackendale gauge (08GA043) by subtracting the recorded Daisy Dam spill from the historic WSC record. The local drainage area for this reach is 233 km<sup>2</sup>. Additional corrections to the calculated hydrograph were required to compensate for possible sources of error in both the WSC flow record and BCH spill record. The resulting natural inflow hydrograph used in the WUP is shown in Figure 16.



*Figure 16: Cheakamus River natural inflows below Cheakamus Dam*

#### **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 Cheakamus Project.

*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 Cheakamus project during a given period. BC Hydro typically produces forecasts for the period of February through September. Volume inflow forecasts are issued beginning January 1 of each year. The forecasts are updated on the first of each month until August 1. 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.

## 5 Hydrometeorologic network

Hydrometeorological data is required to plan, monitor, and operate facilities in the Cheakamus Project watersheds. Characteristics of the hydrometeorological data collection stations used for inflow forecasting in Table 2. Locations of hydrometeorological stations are shown in figure 1.

*Table 2: Active hydrometeorological stations used for inflow forecasting*

Station	Type	ID	Elev (m)	Latitude	Longitude	Start Year	Characteristics
Callaghan Creek	MELP	3A20	1040	50 08	123 06	1976	Snow Course
Cheakamus above Millar Cr.	DCP	CHK	640	50 04 48	123 02 02	1982	Climate
Clowhom	DCP	CLO	10	49 42 30	123 31 20	1986	Climate
Daisy Lake Dam	DCP	CMS	390	49 58 30	123 08 05	1985	Climate
Elaho River	DCP	ELA	206	50 13 25	123 34 40	1981	Climate
Nahatlatch	MELP	1D10	1520	49 50	122 03	1968	Snow Course
Powell River	MELP	3A05	910	50 16	124 19	1939	Snow Course
Shalalth	AES	SON	244	50 44	122 13	1963	Climate
Squamish	DCP	WSK	52	49 47	123 10	1982	Climate
Stave	MELP	1D08	1210	49 35	122 19	1967	Snow Course
Tenquille Lake	MELP	1D06	1680	50 32	122 56	1953	Snow Course
Upper Cheakamus	DCP	CMU	880	50 07	123 08	1986	Climate
Whistler Alta Lake	AES	WAE	658	50 08	122 57	1976	Climate

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