Bridge River Power Development Water Use Plan

Revised for Acceptance for the Comptroller of Water Rights

March 17, 2011

BChydro

Bridge River Power Development
Water Use Plan
March 17, 2011

Revised for Acceptance for the Comptroller of Water Rights

BC hydro Generation Resource Management March 17, 2011

Bridge River Power Development
Water Use Plan
March 17, 2011

Revised for Acceptance for the Comptroller of Water Rights

Renata Kurschner

Director, Generation Resource Management

Table of Contents

List of Tables

List of Figures

List of Appendices

Preface

The water use planning consultative process for BC Hydro's Bridge River Power Development (La Joie, Bridge River 1, Bridge River 2, and Seton Generating Stations; Downton and Carpenter Lake reservoirs and Seton Lake; and Cayoosh Diversion) was initiated in June 1999. A draft Water use Plan was prepared in September 2003 and submitted to the Comptroller of Water Rights in December 2010.

The conditions in the March 17, 2011 WUP reflect the September 2003 recommendations of the Bridge River Consultative Committee Report, the draft September 2003 WUP and subsequent recommendations by the St'át'imc in 2009 and 2010. The conditions in the March 17, 2011 WUP, once ordered by the Comptroller of Water Rights under British Columbia's *Water Act*, will replace operations previously governed by the Interim Flow Management Strategy previously ordered July 28, 2000 under s39 of the *Water Act.*

The proposed conditions for the operation of BC Hydro's Bridge River Power Development will not come into effect until ordered to be implemented under the *Water Act*.

BC Hydro thanks all those who participated in the process that led to the production of the March 17, 2011 Bridge River Water Use Plan.

1.0 INTRODUCTION

The conditions proposed in this Water Use Plan (WUP), for the operation of BC Hydro's Bridge River Power Development reflect the September 2003 agency and stakeholder recommendations of the Bridge River Water Use Planning Consultative Committee, the associated draft September 2003 WUP, and subsequent recommendations by the St'át'imc in 2009 and 2010.

The terms and conditions, to be authorized under British Columbia's *Water Act*, for the beneficial use of water at the Bridge River Power Development are set out in this document. Future reference to the Bridge River Power Development or Bridge River projects includes La Joie, Bridge River 1, Bridge River 2, and Seton Generating Stations; La Joie, Terzaghi, and Seton Dams; Downton and Carpenter Lake reservoirs and Seton Lake; Cayoosh Diversion and associated works.

The proposed conditions will change operations at the Bridge River projects and are expected to positively affect fisheries and wildlife habitat, shoreline conditions, flood control, and recreation interests. The proposed conditions will decrease power generation and power generation revenues. These conditions will replace operations previously governed by the Interim Flow Management Strategy ordered July 28, 2000 under s39 of the *Water Act*.

Scope for a monitoring program to address key uncertainties is also provided to improve future operating decisions. Details associated with subsequent recommendations by the St'át'imc in 2009 and 2010 are included in this WUP.

The conditions for the operation of BC Hydro's Bridge River Power Development will not come into effect until ordered under the *Water Act* by the Comptroller of Water Rights. A review date, 10 years after implementation of the Water Use Plan as ordered under the *Water Act*, has also been recommended.

2.0 DESCRIPTION OF WORKS

2.1. Overview

The Bridge River Power Development manages water from Bridge River and Seton River watersheds. It also receives water from Cayoosh Creek. These watersheds are located within the territory claimed by St'át'imc.

Bridge River is approximately 120 km long and flows southeast from the snowfields of Monmouth Mountain in the British Columbia coastal mountain range to join Fraser River near Lillooet. The upstream portion of Bridge River is impounded by La Joie Dam and forms Downton Lake reservoir. All releases from La Joie, generation or spill, discharge into Middle Bridge River and flow into Carpenter Lake reservoir.

Carpenter Lake reservoir is impounded by Terzaghi Dam. Water from Carpenter Lake reservoir can be diverted to the Bridge River Generating Stations (BR1 and BR2) via two separate intakes and tunnels through Mission Mountain into Seton Lake. Water is also released from Carpenter Lake reservoir at Terzaghi Dam directly into Lower Bridge River. Releases from Terzaghi Dam are provided to maintain riparian and aquatic habitat in Lower Bridge River prior to joining the Fraser River.

Seton Lake is impounded by Seton Dam. Seton Lake receives water from the natural course of Seton River, discharge from the Bridge River Generating Stations, and diversion from Cayoosh Creek. Water is diverted from Seton Lake at Seton Dam along a 3.7 km power canal to a small forebay which supports Seton Generating Station. Seton Generating Station discharges directly into the Fraser River. Non power releases of water from Seton Lake into Seton River are accommodated through release structures at Seton Dam. Seton River joins the Fraser River upstream of the Seton Generating Station and downstream of the confluence of Lower Bridge River.

BC Hydro also diverts water from Cayoosh Creek made available at the tailrace of an independent power project, Walden North, into Seton Lake. Inflow from Cayoosh Creek in excess of the operating capacity at Walden North is returned back into Cayoosh Creek and joins Seton River approximately 500 m downstream of Seton Dam.

Figure 2-1, Figure 2-2, and Figure 2-3 provide an overview of the Bridge River Power Development. See Figure 2-4 for a schematic on individual projects and water conveyance control points discussed in Section 2.2.

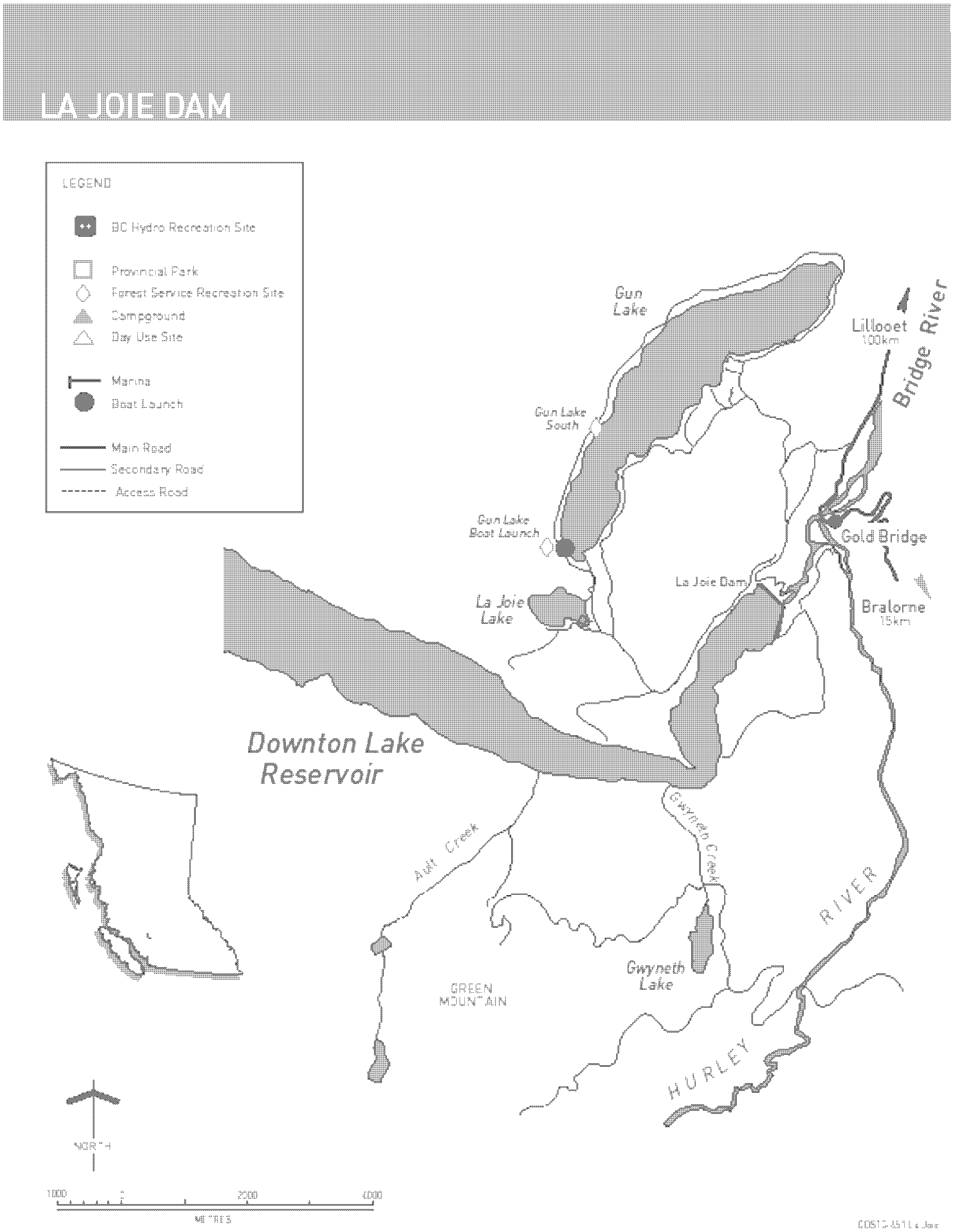

Figure 2-1 La Joie Dam and Downton Lake Reservoir

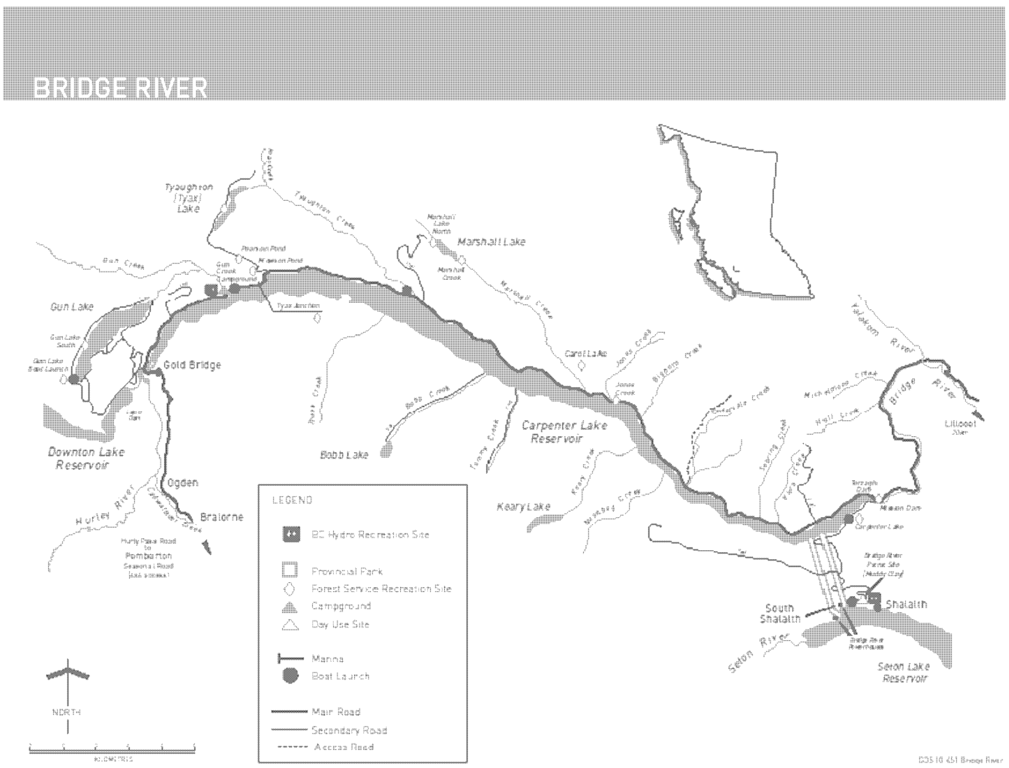

Figure 2-2 Terzaghi Dam and Carpenter Lake Reservoir

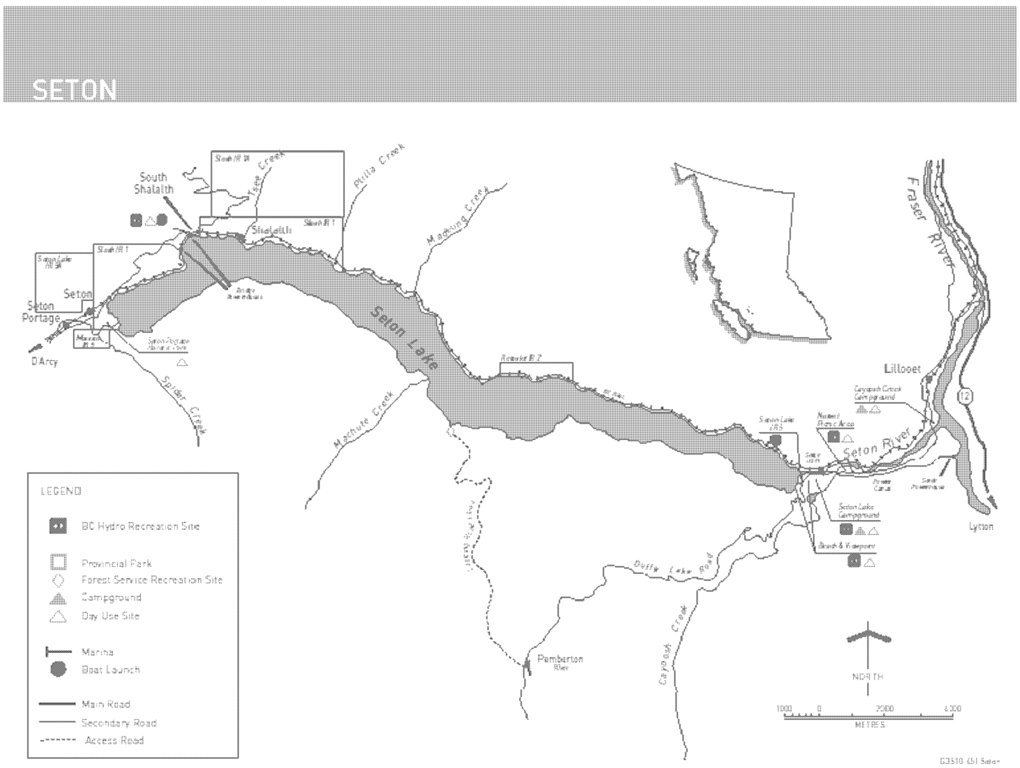

Figure 2-3 Seton Dam and Seton Lake

2.2. Existing Works[1]

2.2.1. La Joie Project

2.2.1.1. Downton Lake Reservoir

The reservoir covers ~23.3 km^2 and has an active storage of 705.6 million m^3 between 707.67 and 749.81 m for the purpose of power. Mean annual inflow into Downton Lake reservoir is approximately 42 m$^{3/}$s.

Subject to appropriate approvals and notification, the reservoir can be drafted to the sill of the hollow cone valves or intakes at 697.38 m for maintenance or dam safety requirements. Water from Downton Lake reservoir is released into Middle Bridge River via two hollow cone valves at the dam or through the La Joie Generating Station through turbine generation or the pressure release valve.

2.2.1.2. La Joie Dam

The dam is located near Gold Bridge, upstream of the confluence of Hurley River and Bridge River. approximately 56 km upstream of Terzaghi Dam. The original La Joie Dam was a low earthfill structure built in 1951. In 1955, the dam was raised to its current height and width (~1064 m long by 87 high). The dam is a rock fill structure with an upstream face of shotcrete over timber.

The crest of the ogee weir is 749.81 m. The normal maximum elevation is exceeded whenever free crest spill occurs. At reservoir elevations below 749.81 m, planned releases from the dam are managed through a low level outlet equipped with two energy dissipating hollow cone valves (HCV) or the pressure release valve (PRV) at the Generating Station. Capacity of the HCV at full pool when fully opened is ~30 m^3/s per HCV. A low level bypass intake gate at 688.54 m is believed to be currently silted in and not operational.

2.2.1.3. La Joie Generating Station (LAJ)

The powerhouse was completed in 1957 along with the changes to La Joie Dam. The generating station has a single vertical Francis unit with an operating range currently between 3 and 25 MW and an estimated maximum discharge of 50.6 m^3/s. La Joie Generating Station discharges into Middle Bridge River.

The power intake for La Joie Generating Station has a sill elevation of 697.38 m. At elevations below 701.00 m, cooling water supply to the turbine may be increasingly affected. The turbine is equipped with a pressure relief valve (PRV). The PRV is used to protect the penstock by maintaining a penstock flow whenever the turbine is forced out of service. The valve is also used to establish flows to start the unit and may be used to maintain fish flows in Middle Bridge River when the unit is out of service. Capacity of the PRV at full pool when fully open is ~67 m^3/s.

---

[1] All elevations, where cited, are measured using the Geodetic Survey of Canada (GSC) datum.

2.2.2. Bridge River Projects

2.2.2.1. Carpenter Lake Reservoir

The reservoir covers 46.2 km^2 and has an active storage of 1,012.5 million m^3 between 606.55 and 651.08 m for the purpose of power. Mean annual inflow into Carpenter Lake reservoir, excluding the contribution from Downton Lake reservoir, is approximately 52 $m^{3/}s$.

Under normal operations, the reservoir can be drafted to 606.55 m. Subject to appropriate approvals and notification, the reservoir can be drafted to the sill of the BR2 intake gate at 599.54 m for maintenance. Water from Carpenter Lake reservoir is released from Terzaghi Dam into Lower Bridge River or into Seton Lake through two intake gates that independently serve BR1 and BR2 generating stations.

2.2.2.2. Terzaghi Dam

The Mission Dam was initially built in 1948. It was raised in 1960 and renamed Terzaghi Dam in 1965. The dam is an earthfill structure, ~60 m high with a crest length of ~366 m.

Water is released from Terzaghi Dam into Lower Bridge River (bypassing generation at Bridge River and Seton Generating Stations) by means of a free crest spillway (sill elevation of 651.08 m), two sluice gates (SPOG sill elevation 641.65 m) and the two low level outlets (LLO sill elevation 599.69 m). Capacity of the SPOGs at full pool when fully opened is ~414 m^3/s per gate. Capacity of the LLOs at full pool when fully opened is ~171.6 m^3/s per gate.

2.2.2.3. Bridge River Generating Station #1 (BR1)

There are two separate buildings for the Bridge generation projects: BR1 (Units 1-4) and BR2 (Units 5-8), located ~1 km apart on the north-east end of the lake, respectively. Generating units 1 to 4 are presently capable of operating between 20 and 52 MW with a total estimated maximum discharge of 65.0 m^3/s. The power intake sill in Carpenter Lake reservoir for BR1 is 600.61 m. BR1 discharges directly into Seton Lake.

2.2.2.4. Bridge River Generating Station #2 (BR2)

Generating units 5 to 8 are located in the BR2. The units are presently capable of operating between 20 and 75 MW with a total estimated maximum discharge of 95.0 m^3/s. The power intake sill in Carpenter Lake reservoir for BR2 is 599.54 m. BR2 discharges directly into Seton Lake.

2.2.3. Seton Project

2.2.3.1. Seton Lake

Seton Lake covers 24.7 km^2 and has an active storage of 14.8 million m^3 between 235.76 and 236.36 m for the purpose of power as measured in the vicinity of BR1. Elevations as measured in Seton Lake near BR1 may be slightly greater than measured downstream of the power canal in the forebay because of head losses in the canal. For water management under the WUP, the level of Seton Lake (not the forebay) is used. Mean annual inflow, excluding Cayoosh and Bridge diversions, into Seton Lake is approximately 17 $m^{3/}$s.

Subject to appropriate approval from the Comptroller of Water Rights and notification to the St'at'imc, Seton Lake can be drafted to the sill of the dam radial gate (230.92 m) for maintenance. Water stored in Seton Lake is released at Seton Dam into Seton River. Water stored in Seton Lake is also released directly into the Fraser downstream of the Seton River confluence via the Seton Generating station.

2.2.3.2. Seton Dam

Seton Dam began to regulate Seton Lake in 1956. The dam is located 23 km downstream from the Bridge River Generating Stations. Seton Dam is a concrete structure, approximately 76.5 m long by 13.7 m high.

Seton Dam may release water into Seton River, bypassing generation at Seton Generating Station, through several conveyance structures. The release facilities are operated in various combinations to manage spills and to provide fish flows.

Table 2.1 Seton Dam Conveyance Structures

Device (No.)	Sill (m)	Discharge m^3/s (236.36 m)
Fish Water Release Gate (1)	231.30	14.1
Siphon (1)	236.03	19.8
Siphons (2-5)	236.10	25.5 per siphon
Fish Ladder (1)	233.89	1.3
Radial Gate (1)	230.92	247.7

2.2.3.3. Seton Power Canal

At Seton Dam, flows diverted to the Seton Generating Station are transferred from Seton Lake through a gated intake structure (sill 232.06 m) into a 3.7 km long concrete lined power canal with a capacity of ~145 m^3/s. The canal traverses over Cayoosh Creek by means of a concrete aqueduct. The canal delivers water to a small intake forebay.

Two siphons are located on the canal and are believed to be capable of delivering up to 1.1 m^3/s. The siphons are used to periodically water adjacent spawning channels which flow into Seton River.

2.2.3.4. Seton Generating Station (SON) and Forebay

The generating station came into service in 1956. Seton Generating Station has a single Francis unit presently capable of generating between 5 and 48 MW with an estimated maximum discharge of 142.76 m^3/s. The intake forebay can be dewatered by closure of a radial gate (sill 226.34 m). Seton Generating Station discharges directly into Fraser River about ~1 km downstream of the confluence of the Seton and Fraser Rivers.

2.2.4. Walden Project

2.2.4.1. Walden North Generating Station

Walden North, an independent power producer, is located on Cayoosh Creek approximately 2 km upstream of the confluence with the Seton River. Operation of the Walden North Generating Station is not under BC Hydro's control or direction.

The project has no storage and diverts available inflow, up to the capacity of the Walden North Generating Station, from the natural course of Cayoosh Creek. Walden North Generating Station discharges into works owned and operated by BC Hydro. These works divert the discharge into Seton Lake. Walden North is capable of generation up to 13 MW with an estimated maximum discharge of 43 m^3/s.

Cayoosh Creek inflow that exceeds capacity of Walden North is spilled directly back into Cayoosh Creek and joins Seton River downstream of Seton Lake.

2.2.4.2. Cayoosh Creek Diversion

Discharges from Walden North are diverted by BC Hydro into Seton Lake by means of 500 m long diversion tunnel with an approximate capacity of 42.48 m^3/s. Should the diversion works not be available, the discharge from Walden North is diverted back into Cayoosh Creek downstream of Walden North.

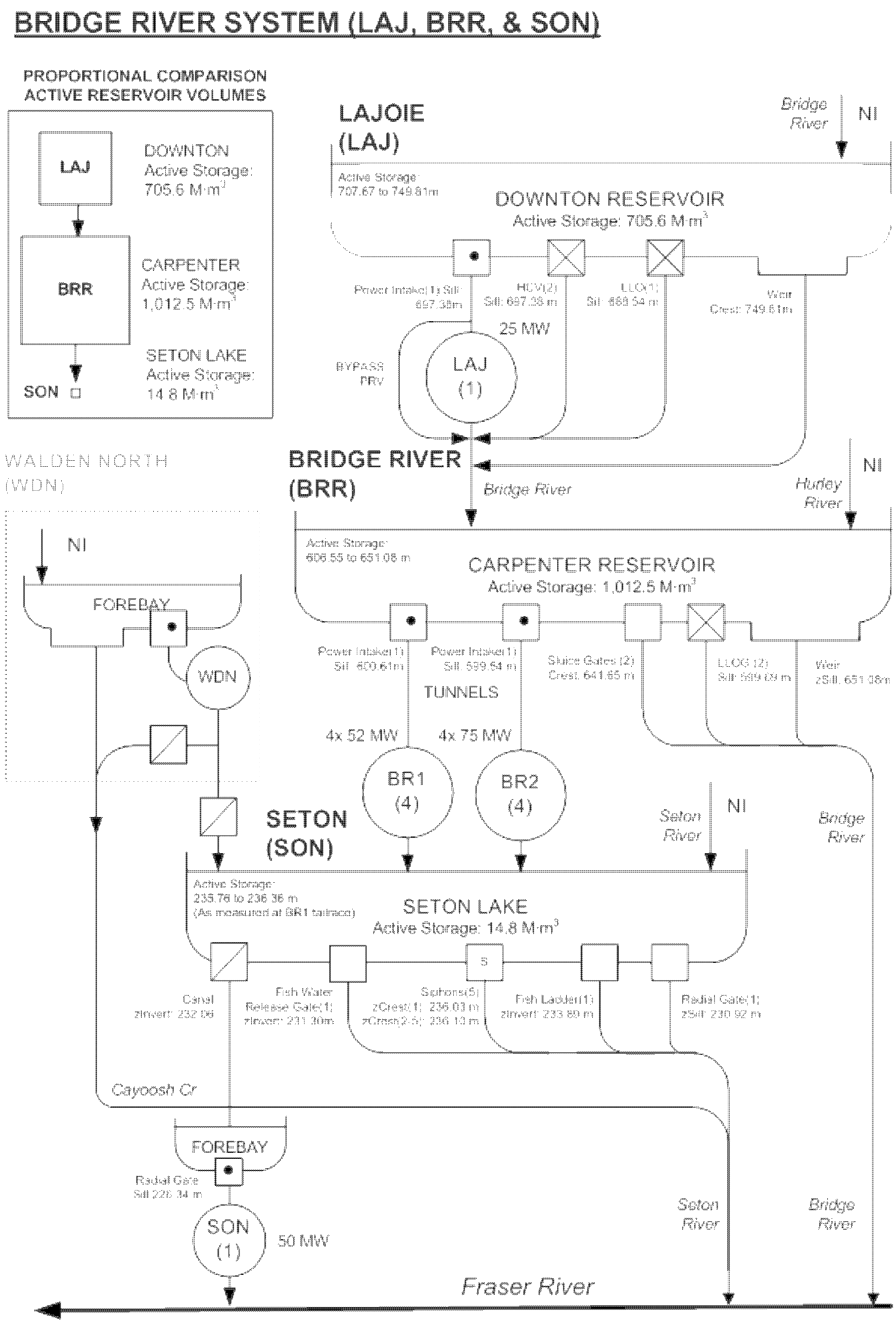

Figure 2-4 Components of the Bridge River System

3.0 HYDROLOGY OF THE BRIDGE RIVER BASIN

3.1. Drainage Basin

The Bridge River system is located in the southern Coastal Range. La Joie Dam has an upstream drainage area of 988 km^2. Between La Joie and Terzaghi Dam, the local upstream drainage area is 2,719 km^2. Seton Dam has an upstream drainage area of 1,017 km^2, excluding the Cayoosh and Bridge diversion basins. The drainage area for Cayoosh Creek is 887 km^2 (Table 3.1).

3.2. Run Off Distribution

The Bridge and Seton Rivers lie in the Cordilleran climatic region and are affected by both continental and modified maritime conditions. Although Pacific disturbances are common, continental airstreams tend to dominate during winter months. The general climatic conditions produce large snowpacks in the winter, warming conditions in April to June and often heavy, short duration rainfall in June and July.

See Appendix 1 for a complete description on daily inflow and seasonal volume forecasting procedures. A description of the supporting network of hydrometeorological stations in the area and a summary of the inflow hydrographs for the system is also provided in the appendix.

Table 3.1 Mean Annual Inflow Summary

PRJ	Location	Mean Annual Inflow (m^3/s)	Drainage Area (km^2)
LAJ	Bridge River upstream La Joie Dam	41.6	998
BRR	Bridge River upstream Carpenter Dam	52.3	2,719
BR1 & BR2	*Bridge River to Seton Lake (Regulated)*	*93.9*	*3,717*
SON	Seton River to Seton Lake	17.4	1,017
WDN	Cayoosh Creek to Seton Lake	18.9	887
	Total (BR1+BR2+SON+WDN)	130.2	5,621

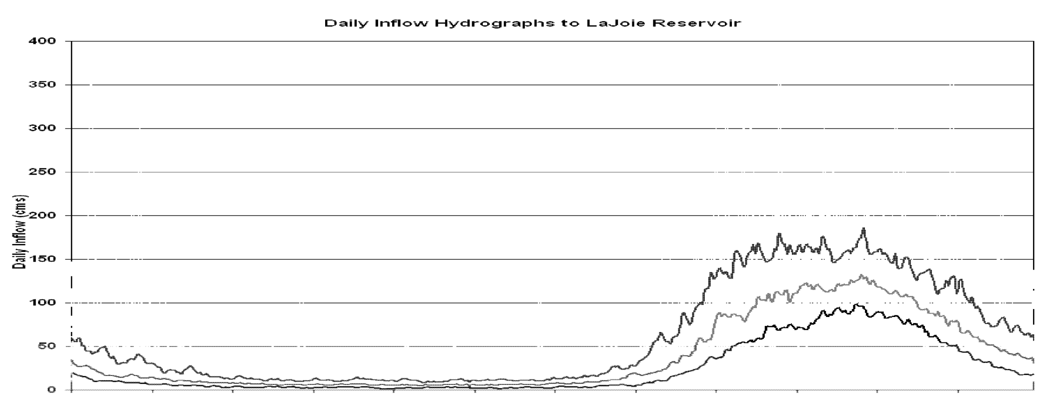

Figure 3-1 Inflow Hydrograph Summary: Downton Lake Reservoir

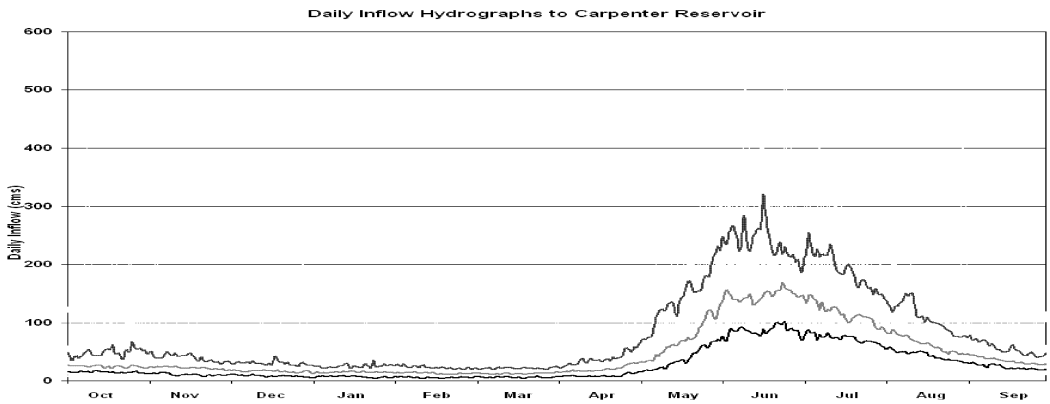

Figure 3-2 Inflow Hydrograph Summary: Carpenter Lake Reservoir

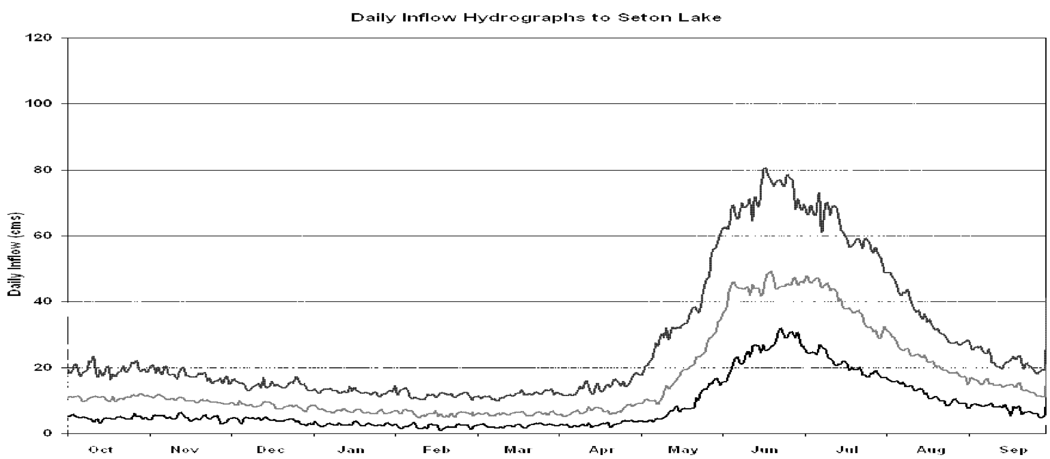

Figure 3-3 Inflow Hydrograph Summary: Seton Lake

4.0 OPERATING CONDITIONS FOR FACILITY

4.1. Role of Facility in BC Hydro's System

The Bridge River Power Development is part of BC Hydro's integrated generation system. For more information on the BC Hydro electric system and how it operates, please refer to BC Hydro's website: www.bchydro.com.

The Bridge River hydroelectric facilities contribute on average approximately 6% of BC Hydro's total hydroelectric generation.

4.2. Water Licence Summary

BC Hydro has the existing and proposed water licences issued to the Bridge River Power Development under the *Water Act*.

Table 4.1 Summary of Existing and Proposed Licences

Project	Licence*	Purpose	Location	Quantity	Notes	Precedence
LAJ	12505	Storage	Downton	707.67 to 749.81 m	Volume 705.55 Mm^3	Feb 05, 1934
LAJ	23552	Diversion	Downton to Carpenter	48.1 m^3/s		Jun 07, 1956
LAJ	*NEW*	*Diversion*	*Downton to Carpenter*	*2.5* m^3/s		*Jan 18, 2011*
BRR	9265	Storage	Carpenter	606.55 to 651.08 m	Volume 20.00 Mm^3	Dec 26, 1912
BRR	19379	Storage	Carpenter	606.55 to 651.08 m	Volume 992.49 Mm^3	Oct 29, 1949
BR1	9264	Diversion	Carpenter to Seton	42.5 m^3/s		Dec 26, 1912
BR1	22129	Diversion	Carpenter to Seton	19.8 m^3/s		Apr 27, 1954
BR1	*NEW*	*Diversion*	*Carpenter to Seton*	*2.7* m^3/s	*Separates BR1 from BR2*	*Jan 18, 2011*
BR2	23626	Diversion	Carpenter to Seton	85.0 m^3/s		Mar 05, 1956
BR2	*NEW*	*Diversion*	*Carpenter to Seton*	*10.0* m^3/s	*Separates BR2 from BR1*	*Jan 18, 2011*
SON	21712	Diversion	Seton Lake to Fraser	3,214.8 Mm^3/yr	Year: 1 October to 30 September	Apr 27, 1953
SON	21712	Diversion	Seton to Fraser	142.8 m^3/s		Apr 27, 1953
SON	21712	Diversion	Cayoosh Creek to Seton	42.5 m^3/s		Apr 27, 1953
SON	21712	Fish Flow	Seton River	5.7 m^3/s	For salmonid eggs	Apr 27, 1953
SON	21712	Fish Flow	Seton River	11.3 m^3/s	For salmonid spawning access	Apr 27, 1953
SON	21712	Storage	Seton Lake	235.76 to 236.36 m	Volume of 14.8 Mm^3	Apr 27, 1953

* Based on original licence numbers prior to clarification. New licence rights requested from the CWR to reconcile actual historical use and capability with current monitoring accuracy. Incremental increases for BR1 and BR2 permits each powerhouse to be run under discrete licence schemes (vs additive between the plants). New licence rights will not increase the existing annual volume transfer between Bridge and Seton watersheds.

4.3. General Power Generation Planning for Bridge River Projects

The majority of inflow into the three Bridge River reservoirs occurs annually during freshet between May and August. The inflow is driven mainly from snowmelt and glacier melt into Downton and snowmelt into Carpenter and Seton. The volume of inflow into the reservoirs during May to August is ~70% of the annual total inflow volume. During this period each year, the two storage reservoirs, Carpenter and Downton, typically refill from their lowest levels pre freshet to their highest levels at the end of freshet. Following completion of freshet, the two storage reservoirs start drafting and continue to draft until the next freshet.

Subject to licence conditions and regulatory obligations for other flow management objectives such as fisheries flows, BC Hydro uses the available storage and inflow for generation within the physical limits of the facilities. Turbine discharge from each project varies seasonally and daily with changing demand for electricity, the availability of water, and timing of maintenance and plant outages. Inflow management during spring runoff and during seasonal storms may require spills when the capacities of Downton, Carpenter, and/or Seton near upper storage limits.

The timing and sequence of planned generator outages at the four plants depends greatly on the number of generators needed to be taken out at the same time, the outage duration and, to some extent, on the snowpack leading into the freshet. The longer duration outages for Seton and Lajoie are usually done in early spring. Long, multiple unit outages at the Bridge River plants are also typically planned over spring. Shorter duration outages or those involving only one or two generators may be scheduled anytime from spring to fall. Outages are not typically planned during the winter. Exceptions to the general timing will occur as part of normal operations or to accommodate system requirements outside of the Bridge Project.

4.4. Emergencies and Dam Safety

Emergencies and dam safety requirements shall take precedence over the operational constraints outlined in this Water Use Plan. Emergencies include, but are not limited to, actual and potential loss of power to customers, mechanical failures and environmental incidents. Dam safety requirements for operations are outlined in the Operation, Maintenance and Surveillance Manuals (OMS) for Dam Safety for La Joie, Terzaghi, and Seton dams.

Operational instructions for surcharging the reservoirs and undertaking special drawdowns for dam safety purposes are also described in the OMS manuals for Dam Safety. Notification procedures, including those that may be agreed to by BC Hydro and the St'at'imc from time to time, will be documented and updated in BC Hydro's Emergency Planning Guides.

4.5. Conditions for the Operation of Works and Water Management

BC Hydro proposes to operate the Bridge River Power Development in accordance with the conditions outlined below. These conditions will replace operations previously governed by the s39 Order under the *Water Act* issued 28th July, 2000.

The constraints identified in this section recognize the complexity and interdependence of the individual projects in the Bridge River Power Development, the social and environmental interests, and the extreme variability of inflows. During normal conditions, the system is managed with the intent to maintain all parameters within the specified licence and order constraints. To meet operational requirements, decisions must be made simultaneously for a number of control points (Figure 2-4) and consider current conditions and the likelihood of meeting future constraints. BC Hydro may not be able to operate within these constraints during unusual short term maintenance or inflow events or extended hydrological conditions.

Conflicts between constraints may arise when managing water during periods of unusual hydrological conditions or resulting from other events such as maintenance or unplanned outages under normal conditions. When conflicts arise the following, from highest priority to lowest, will guide operating decisions:

Highest Priority

- Dam Safety requirements as defined in the Operation Maintenance and Surveillance Manuals;
- Flood routing requirements;
- Terzaghi target flow schedule;
- Generation and spill at Seton in preference to spilling at Terzaghi Dam in excess of the target flow schedule;
- All specified ramping rates;
- Seton Generating Station shut downs for smolt outmigration;
- Carpenter Lake reservoir elevations;
- Seton Lake elevations;
- Seton Dam target flow schedule; and
- Downton Lake reservoir elevations.

Lowest Priority

During operations outside regulatory limits, BC Hydro will continue regular communication with the Comptroller of Water Rights, the provincial and federal fisheries agencies and St'at'imc.

4.5.1. La Joie Project

4.5.1.1. Downton Lake Reservoir

- To manage the reservoir for generation, reservoir fish habitat, and Bridge River fish flows, Downton Lake reservoir will be regulated between the conditional minimum of 710.00 m and the weir crest 749.81 m under normal operating conditions.

- The target minimum elevation of 710.00 m may be relaxed to 697.38 m to maintain minimum flow requirements for Middle Bridge River as specified in Section 4.5.1.3.
- The reservoir may be drafted below 710.00 m to 697.38 m to accommodate planned maintenance.
- The reservoir may exceed 749.81 m to accommodate high inflow events or to help manage other downstream system constraints.
- Surcharging the reservoir above the full supply level of 749.81 m (maximum normal level), drafting the reservoir to the full supply level and drafting the reservoir below the minimum operating level of 707.67 m shall be done in accordance with procedures in the La Joie Dam Operation, Maintenance, and Surveillance Manual.

4.5.1.2. La Joie Generating Station

- Maximum licenced discharge from La Joie Generating Station for the purpose of power is 50.6 m^3/s.

4.5.1.3. La Joie Dam and Generating Station Discharge

- Discharge to Middle Bridge River can be provided by any combination of spill or releases from the dam and flow from the generating station (pressure release valve, hollow cone valves, and turbine).
- To balance between fish habitat in Middle Bridge River and Downton Lake reservoir, the following minimum flow schedule is required:

Downton Lake reservoir Elevation (m)	Middle Bridge River Discharge (m^3/s +/- 10%)
>718.00	> 18.4
718.0 to 715.0	18.4 to 17.0
715.0 to 710.0	17.0 to 11.3
710.0 to 705.0	11.3 to 5.7
705.0 to 697.38	5.7

- Flow changes are expected to be made within two working days of transitioning between elevations.
- If discharge is expected to go below 11.3 m^3/s, the Comptroller of Water Rights, provincial and federal fisheries agencies and the St'at'imc will be informed to determine if monitoring for the Middle Bridge River is required.

4.5.1.4. Middle Bridge River Ramp Rates

- To reduce the likelihood of fish stranding, the combined decrease in flows from La Joie Generating Station and/or La Joie Dam as measured in the vicinity of the Hurley Bridge (~500 m upstream of the Hurley River confluence), shall be limited to:

Middle Bridge River Stage Change Limits
Maximum Hourly Ramp Down Rate < 2.5 cm/hr
Maximum Daily Ramp Down Rate < 15 cm/day

- Operation in excess of ramping rates is permitted if fish salvages are implemented as part of the operational change. Fish salvages will not be required if both the hourly and daily ramp rates are met.
- There are no restrictions on up ramp rates for fisheries reasons.

4.5.2. Bridge River Projects

4.5.2.1. Carpenter Lake reservoir

- Under normal operations, Carpenter Lake reservoir will be regulated between its licenced minimum and maximum levels of 606.55 and 651.08 m by discharge into Lower Bridge River and by diversion into Seton Lake.
- To manage the reservoir for generation, fish habitat, and to minimize spills from Terzaghi Dam into Bridge River, BC Hydro will make reasonable efforts to target a maximum elevation of 648.00 m for the end of snowmelt season in mid August. Extended reservoir excursions above 648.0 m are expected as a result of meeting other constraints with higher priorities.
- If operations are expected to exceed 648.00 m for 8 weeks or more, BC Hydro will inform the Comptroller of Water Rights, provincial and federal fisheries agencies and the St'at'imc.
- The reservoir may exceed 651.08 m to accommodate high inflow events or to help manage other downstream system constraints.
- Surcharging the reservoir above the full supply level of 651.08 m, drafting the reservoir to the full supply level and drafting the reservoir below the minimum operating level of 606.55 m shall be done in accordance with procedures in the Terzaghi Dam Operation, Maintenance, and Surveillance Manual.

4.5.2.2. Bridge River 1 (BR1)

- Maximum licenced discharge from BR1 Generating Station, from Carpenter Lake reservoir to Seton Lake, for the purpose of power is 65.0 m^3/s.
- There are no ramp rate restrictions (up or down) required for BR1.

4.5.2.3. Bridge River 2 (BR2)

- Maximum licenced discharge from BR2 Generating Station, from Carpenter Lake reservoir to Seton Lake, for the purpose of power is 95.0 m^3/s.
- There are no ramp rate restrictions (up or down) required for BR2.

4.5.2.4. Terzaghi Dam and Lower Bridge River Target Flow Schedule

- As part of an adaptive management experiment for determining changes to fish habitat, the following target flow schedule will be released from Terzaghi Dam to Lower Bridge River:

Table 4.2 Target Flow Schedule from Terzaghi Dam

	May 2000 to April 2011	May 2011 to April 2015
Mean Annual Discharge	3.0 $m^3/s \pm 5\%$	6.0 $m^3/s \pm 5\%$
	Average Monthly Target Discharge (m^3/s)	
Month	Flow Trial 1	Flow Trial 2
01 January	2.0	1.5
01 February	2.0	2.0
01 March	2.0	3.0
01 April	3.0	5.0
01 May	4.0	10
01 June	5.0	15
01 July	4.0	15
01 August	4.0	12
01 September	3.0	3.0
01 October	3.0	1.5
01 November	2.0	1.5
01 December	2.0	1.5

Transition between monthly flows may occur within +/- 5 days.
Target discharges less than 5.0 m^3/s may vary hourly $\pm$ 0.25 m^3/s.
Target discharges greater than 5.0 m^3/s may vary hourly $\pm$ 5%.
Mean Annual Flow will be determined between May 1st and Apr 30th.

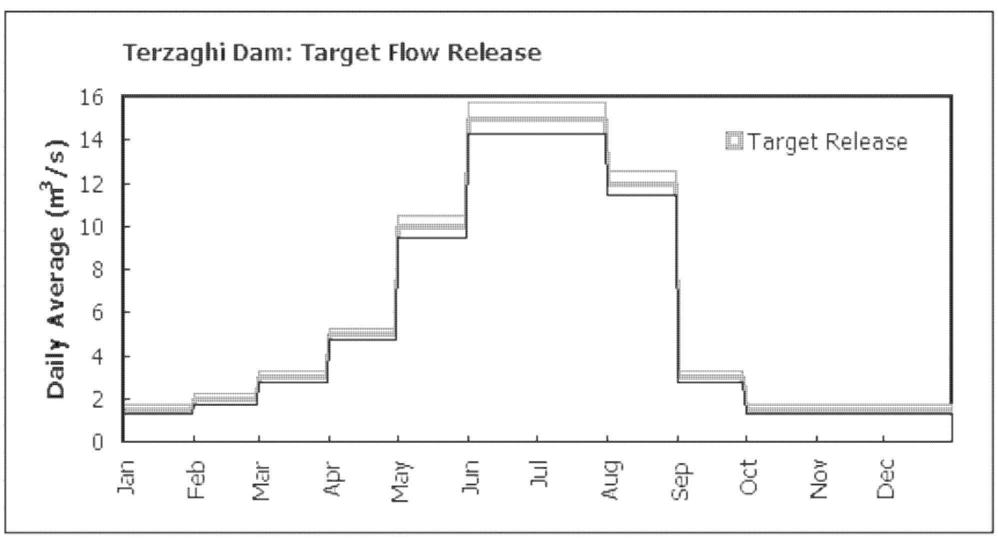

Figure 4-1 Lower Bridge River Target Flow Schedule Trial 2: MAD ~ 6 m^3/s

- After April 2015, BC Hydro will work with the Comptroller of Water Rights, provincial and federal fisheries agencies and the St'at'imc to determine a long term flow release strategy for the Terzaghi Dam based upon existing information and data from the flow trials. A decision on a long term flow release strategy will be completed and implemented by May 1, 2015. The recommended flow release from Terzaghi Dam is intended to simulate a naturalized hydrograph and will not be less than an annual average budget of 3 m^3/s and will not exceed an annual average budget of 6 m^3/s subject to any authorizations or approvals required from the Comptroller of Water Rights.
- To reduce potential impact to fish habitat in Lower Bridge River, spill in excess of the flow schedule, will be released preferentially at Seton Dam and Generating Station instead of Terzaghi Dam when possible.

4.5.2.5. Lower Bridge River Ramp Rates

- To reduce the likelihood of fish stranding, flow decreases from Terzaghi Dam, as measured in the vicinity of km 36.8 (Reach 4) of Lower Bridge River, shall be limited to:

Lower Bridge Stage Change Limits
Maximum Hourly Ramp Down Rate < 2.5 cm/hr
Maximum Daily Ramp Down Rate < 15 cm/d

- Operation in excess of ramping rates is permitted if fish salvages are implemented as part of the operational change. Fish salvages will not be required if both the hourly and daily ramp rates are met.
- There are no restrictions on up ramp rates for fisheries reasons.

4.5.3. Seton Project

4.5.3.1. Seton Lake

- Seton Lake will be regulated between 235.76 and 236.36 m, as measured in the vicinity of BR1 to manage the storage for generation, fish habitat, and to reduce foreshore erosion rates.
- Seton Lake may be operated above 236.36 m to accommodate high inflow events.
- Seton Lake may be operated below 235.76 m to accommodate planned maintenance or implementation of the Seton Lake Erosion Mitigation Plan with appropriate notice to the St'at'imc.
- Surcharging the Seton Lake above the full supply level of 236.36 m, drafting the reservoir to the full supply level and drafting Seton Lake below the minimum operating level of 235.76 m shall be done in accordance with

procedures in the Seton Dam Operation, Maintenance, and Surveillance Manual.

4.5.3.2. Seton Generating Station

- Maximum licenced discharge from Seton Generating Station for the purpose of power is 142.76 m^3/s.
- In an effort to decrease the mortality of sockeye smolts migrating past Seton Dam and Seton Generating Station, the Seton Generating Station will conduct partial (6+ hr) or blanket (24 hr) daily shut downs during smolt out migration between April 20th and May 20th. The frequency and duration of the shutdowns along with the expected benefits in reducing mortality will be reported to the Comptroller of Water Rights annually. The objective of the shut downs is to target an annual smolt mortality of 5% or less or such other target agreed upon by BC Hydro and the St'at'imc.
- There are no ramp rate restrictions (up or down) required for the Seton Generating Station unit for fisheries reasons.
- BC Hydro will make reasonable efforts to coordinate dewatering of the power canal for maintenance purposes with the St’at’imc.

4.5.3.3. Seton Dam to Seton River

- A minimum discharge of 5 m^3/s is required from Seton Dam to Seton River to protect downstream fish habitat at all times.
- Discharge from Seton Dam to Seton River is restricted to a target maximum of 60 m^3/s to reduce potential impacts to downstream habitat and to minimize erosion. Discharge in excess of 60 m^3/s is permitted if required to minimize spill from Terzaghi Dam into Lower Bridge River in excess of the Terzaghi target flow schedule.
- BC Hydro will make reasonable efforts to target the flow release schedule (daily average) from Seton Dam to Seton River (Figure 4-2) to mimic a naturalized hydrograph. Excursions above or below the schedule are expected under normal operations to accommodate maintenance or to manage system constraints. If operations deviate from the schedule by more than +/-25% for more than a week, BC Hydro will inform the St’at’imc and fisheries agencies.

Table 4.3 Seton Dam Target Flow Schedule

	Target (m^3/s)		Target (m^3/s)
01-Jan	11	15-Jun	34
31-Mar	12	30-Jun	30
07-Apr	15	06-Jul	26
15-Apr	25	15-Aug	21
07-May	26	14-Sep	16
15-May	29	14-Oct	14
21-May	32	14-Nov	13
31-May	36	14-Dec	11

Transition between monthly flows may occur within ± 5 days.
Target discharges may vary hourly ± 25%.

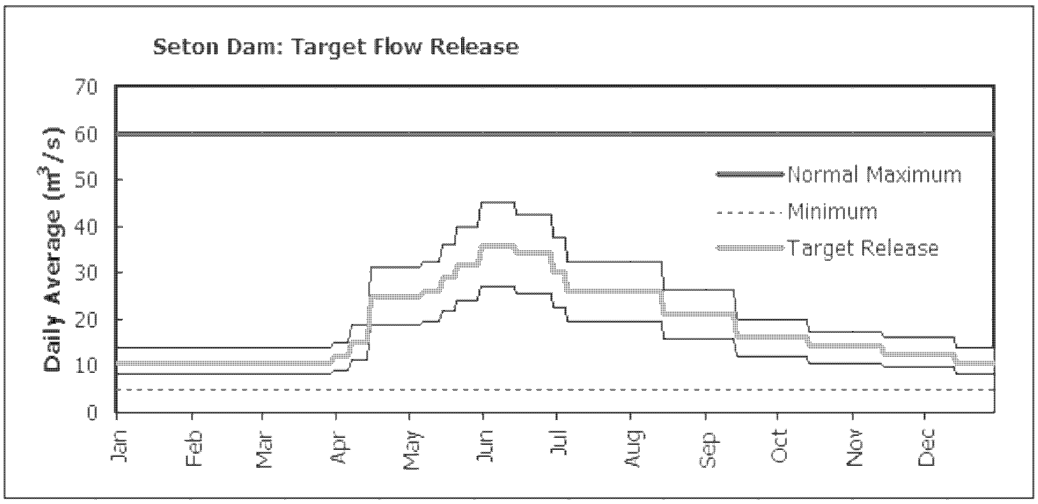

Figure 4-2 Seton Dam Target Flow Schedule to Seton River

- Implementation of the Seton Dam release hydrograph (Figure 4-2) will take second priority relative to management of Carpenter Lake reservoir and La Joie Lake reservoir to minimize spills at Terzaghi Dam in excess of the Lower Bridge River target flow schedule.

4.5.3.4. Seton River Ramp Rates

- To reduce the likelihood of fish stranding, decreases in flow from Seton Dam to Seton River, as measured at the Water Survey Canada gauge (WSC 08ME003) upstream of the confluence with Cayoosh River, shall be limited to:

Seton River Stage Change Limits
Maximum Hourly Ramp Down Rate < 2.5 cm/hr
Maximum Daily Ramp Down Rate < 15 cm/d

- Operation in excess of ramping rates is permitted if fish salvages are implemented as part of the operational change. Fish salvages will not be required if both the hourly and daily ramp rates are met.
- There are no restrictions on up ramp rates for fisheries reasons.

4.5.3.5. Cayoosh Creek Diversion and Seton River Dilution Ratio

- BC Hydro will make reasonable efforts to target the ratio of Cayoosh Creek water to Seton River discharge. The intent of this operation is to encourage migrating Seton River sockeye that may be holding downstream in the Seton Generating Station tailrace to migrate up to the confluence of the Fraser and Seton rivers.
- The ratio is calculated as Cayoosh Creek (as measured in the vicinity of WSC 08ME002) to total Seton River Flow (as measured downstream of the confluence with Cayoosh Creek). Excursions above the target ratio are expected as a result of managing other system constraints, to accommodate facility maintenance under normal operations, or because of factors outside of BC Hydro's control (e.g. Cayoosh inflows):

Date	Target Ratio
20 July to 31 Aug	< 20%
28 Sep to 15 Nov	< 10%

- It is expected that BCH use the flexibility within the Seton target flow requirements to manage the dilution flows. Efforts to maintain the target dilution ratio, however, will remain secondary to meeting the target flow release hydrograph minimum and maximum limits from Seton Dam.
- The target dilution ratios will be re-assessed upon completion of the Adult Fish Passage Monitoring Program.

4.6. Recommended Non-Operating Alternatives

4.6.1. Carpenter Lake Reservoir

4.6.1.1. Riparian Planting

A re-vegetation program is proposed as a means to mitigate the effects of dust storms, increase the aesthetic quality, enhance the quality of riparian habitats, and provide localised improvements in the quality and productivity of aquatic habitats.

It is recommended that the Comptroller direct BC Hydro to implement a re-vegetation program in areas affected by the drafting of Carpenter Lake reservoir.

This would involve planting approximately 500 hectares of grass from Gun Creek Fan to Tyax Junction and, if feasible, localised planting of trees.

4.6.2. Seton Lake

4.6.2.1. Erosion Control Works

The goal of the Seton Lake Erosion Management Program (SLEMP) is to cooperatively develop and implement an effective long term program for addressing moderate and high risk shoreline erosion issues for Seton Lake and along Seton River with particular reference to heritage, cultural and aesthetic resource impacts. These activities will build upon work already initiated by St'at'imc to determine where shoreline erosion impacts are already occurring.

It is recommended that the Comptroller direct BC Hydro to implement the SLEMP through a phased program of work consisting of four main components:

- Completion of a Ranked Inventory of Affected Sites;
- Development of Site Specific Mitigation Plans and Drawdown Requirements;
- Implementation of Site Specific Mitigation Plans; and
- Monitoring Erosion Mitigation Program Effectiveness.

The program of work will be planned and carried out as a cooperative initiative with the St'át'imc. The program will be completed within a maximum of 10 years. The cost of the program is estimated to be less than $1.4 million.

5.0 PROGRAMS FOR ADDITIONAL INFORMATION

Development of the proposed conditions for the Bridge River hydroelectric facilities was complicated by uncertainties and information gaps. The recommendations of the Consultative Committee were contingent on the implementation of physical works and monitoring programs to reduce these uncertainties over time.

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 and physical works recommended; and
- Provide improved information for future operating conditions.

Preliminary details and costs of many proposed monitoring programs and physical works are provided in this document and Bridge River Consultative Committee Report September 2003. Updates to monitoring programs will be collaboratively developed with the Comptroller of Water Rights, fishery agencies, and the St'at'imc.

The monitoring programs are designed to address key questions that affected decision making throughout the consultative process. Table 5.1 to Table 5.4 provide a summary.

Table 5.1 La Joie Project

Component	Objectives
Downton Lake reservoir Riparian Vegetation Monitoring (MON 5)	▪ Does the implementation of the recommended operating conditions for Downton Lake reservoir have negative, neutral or positive impact on the quality and quantity (species composition, biological productivity, spatial area) of the regionally unique riparian area on the upper Bridge River fan and in the immediately adjacent drawdown zone of Downton Lake reservoir? ▪ Has there been a negative impact on riparian vegetation and the overall quality of the habitat for wildlife on the area? What activities could be undertaken to preserve this habitat area?
Downton Lake reservoir Fish Habitat and Population Monitoring (MON 7)	▪ What are the basic biological characteristics of fish populations in Downton Lake reservoir and its tributaries? ▪ Will implementation of the recommended operating conditions have negative, neutral or positive impact on abundance and diversity of fish populations? ▪ Which are the key habitat factors that contribute to reduced or improved productivity of Downton Lake reservoir fish populations? ▪ Is there a relationship between the minimum reservoir elevation and the relative productivity of fish populations? ▪ Do periodic deep drawdowns result in long term impacts on rainbow trout populations? ▪ Can refinements be made to the recommended operating conditions without significant impact to instream flow conditions in Middle Bridge River, improve habitat conditions, or enhance fish populations in Downton Lake reservoir?

Table 5.2 Carpenter Lake Reservoir Projects

Component	Objectives
Carpenter Lake Reservoir Productivity Model Validation and Refinement (MON 10)	▪ What are the seasonal and annual changes in physical inputs of water inflow, nutrients and suspended sediment input into Carpenter Lake reservoir? ▪ How do these physical inputs impact benthic and pelagic productivity? ▪ What is the relative importance of littoral and pelagic food sources for driving aquatic productivity in Carpenter Lake reservoir? ▪ Are there differential impacts of reservoir operations on productivity of pelagic and littoral habitats? ▪ How can we use this additional information to refine current models for predicting these relationships?
Carpenter Reservoir Riparian Vegetation Monitoring (MON 2)	▪ Does the implementation of the recommended operating conditions for Carpenter Reservoir have negative, neutral or positive impact on the quality and quantity (species composition, biological productivity, spatial area) of the riparian area surrounding Carpenter Reservoir? ▪ Does the implementation of a short term (5 yr) intensive reservoir re-vegetation program result in benefits that were equal to or greater than that which were expected from implementation of alternative Carpenter Reservoir operating conditions?

….Continued Table 5.2 Carpenter Lake Reservoir Projects

Component	Objectives
Middle Bridge River and Carpenter Lake Reservoir Fish Habitat and Population Monitoring (MON 4)	▪ What are the basic biological characteristics of fish populations in Carpenter Lake reservoir and Middle Bridge River? ▪ Do the recommended operating conditions for Carpenter Lake reservoir and La Joie Generating Station have a negative, neutral or positive impact on abundance and diversity of fish populations in Carpenter Lake reservoir and Middle Bridge River? ▪ What are the key operating parameters that contribute to reduced or improved productivity of fish populations in Carpenter Lake reservoir and Middle Bridge River? ▪ Is there a relationship between specific characteristics of the instream flow in Middle Bridge River that contribute to reduced or improved productivity of fish populations in Carpenter Lake reservoir and Middle Bridge River? ▪ Can refinements be made to the operation of Carpenter Lake reservoir and management of flow releases from La Joie Generating Station into Middle Bridge River to improve protection or enhance fish populations in both of these areas, or can existing reservoir operating constraints be relaxed? ▪ Do flow restrictions of 24 m^3/s or less from October 15 to December 15 minimize the potential for dewatering mountain whitefish eggs after spawning?

Table 5.3 Bridge River Projects

Component	Objectives
Lower Bridge River Riparian Vegetation Monitoring (MON 11)	▪ What is the influence of the instream flow regime on the spatial extent, species diversity, and relative productivity of the riparian community of Lower Bridge River? ▪ How will the changes in riparian community and instream flow conditions influence the capability of Lower Bridge River corridor to support wildlife populations?
Lower Bridge River Aquatic Monitoring (MON 1)	▪ How will the instream flow regime alter the physical conditions in aquatic and riparian habitats of Lower Bridge River ecosystem? ▪ How do changes in physical conditions in aquatic habitat resulting from the instream flow regime influence community composition and productivity of primary and secondary producers in Lower Bridge River? ▪ How can changes in physical conditions and trophic productivity resulting from flow changes together influence the recruitment of fish populations in Lower Bridge River?
Lower Bridge River Adult Salmon and Steelhead Enumeration (MON 3)	▪ How do different flow regimes impact the quality and quantity of spawning habitat for adult salmon and adult steelhead? ▪ What is the annual abundance of salmon and steelhead spawning in Lower Bridge River and how can it support decision making associated with long term flow requirements at Terzaghi Dam? ▪ How has the implementation of continuous flow releases from Carpenter Lake reservoir altered the life history and productivity of the chinook salmon population that spawn in Lower Bridge River?

….Continued Table 5.3 Bridge River Projects

Bridge-Seton Metals and Contaminant Monitoring Program (MON 12)	▪ Will implementation of the recommended operating conditions result in a change to the concentration/distribution of metals and other contaminants in the water and sediments of reservoirs and rivers in the Bridge River system? ▪ If redistribution of metals and contaminants occurs, will this result in an increased bio-accumulation of metals and contaminants in fish in the Bridge River system?
Lower Bridge River Spiritual and Cultural Value Monitoring (MON 16)	▪ How do alternative levels of flow release from Terzaghi Dam impact the cultural and spiritual attributes of Lower Bridge River for the St'at'imc?

Table 5.4 Seton Project

Component	Purpose/Monitoring Questions
Seton Lake Aquatic Productivity Monitoring (MON 6)	▪ Will the recommended operating conditions for Seton Lake and Bridge River Generating Station have negative, neutral or positive impact on aquatic productivity of Seton Lake? ▪ Is the inter-annual variation in physical conditions in Seton Lake caused by the diversion and is this related to aquatic productivity? ▪ What is the relationship between quality, quantity, and timing of water from Carpenter Lake reservoir and the productivity of Seton Lake resident fish populations? ▪ To what extent does aquatic productivity alone limit the abundance and diversity of fish populations in Seton Lake? ▪ What refinements can be made to the recommended operating conditions to improve habitat conditions or enhance fish populations in Seton Lake?
Seton Lake Resident Fish Habitat and Population Monitoring (MON 8)	▪ What are the basic biological characteristics of resident fish populations in Seton Lake and its tributaries? ▪ Will implementation of the recommended operating conditions have negative, neutral or positive impact on abundance and diversity of fish populations in Seton Lake? ▪ Is there a relationship between the quality, quantity, and timing of water diverted from Carpenter Lake reservoir and the productivity of Seton Lake resident fish populations? ▪ Can refinements be made to the recommended operating conditions to improve habitat conditions or enhance resident fish populations in Seton Lake?

….Continued Table 5.4 Seton River Projects

Component	Purpose/Monitoring Questions
Seton River Habitat and Fish Monitoring (MON 9)	▪ What are the basic biological characteristics of the rearing and spawning fish populations in Seton River in terms of relative abundance, distribution, and life history? ▪ How does the proposed Seton River hydrograph influence the hydraulic condition of juvenile fish rearing habitats downstream of Seton Dam? ▪ What is the potential risk for salmon and steelhead redd dewatering due to changes in flow between spawning and incubation periods imposed by Seton River flows? ▪ How will target Seton River flows influence short and long-term availability of gravel suitable for use by anadromous and resident fish for spawning and egg incubation? ▪ Does discharge from Seton Generating Station significantly impact fish habitat in Fraser River above and beyond its natural variation?
Seton River Sockeye Smolt Monitoring (MON 13)	▪ What is the variation in diel and seasonal timing of the annual out migration of sockeye salmon smolts from Seton-Anderson watershed? ▪ How does the operation of Seton Generating Station and Seton Dam affect the relative distribution of fish migrating past the facility in the Seton watershed? ▪ Does the implementation of planned partial or blanket shutdowns of the generating station meet sockeye salmon smolt population protection targets?
Seton Adult Fish Passage Monitoring Program (MON 14)	▪ What are the factors impeding the success of upstream migration of salmon and steelhead? ▪ Is upstream passage of salmon affected due to dilution of Seton River with Cayoosh Cr? ▪ Does the operation of the dam and fish ladder impede fish passage upstream Seton Dam? ▪ What changes to the fishway or operation may mitigate upstream migration issues?
Seton Lake Erosion Mitigation Program (MON 15)	▪ What erosion sites, other than heritage or cultural sites, around Seton Lake are affected by Seton Lake fluctuations resulting from operation of the generating facilities? ▪ What actions are required to protect those sites from further erosion? ▪ What mitigation plans can be developed to address such erosion sites? ▪ Are the actions implemented to mitigate erosion at the sites effective?

6.0 IMPLEMENTATION OF RECOMMENDATIONS

The operating conditions, physical works and monitoring programs proposed in this Water Use Plan will be implemented after BC Hydro receives direction by order under the *Water Act* from the Comptroller of Water Rights.

7.0 EXPECTED WATER MANAGEMENT OUTCOMES

Implications for the provincial interests that were 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 proposed conditions, BC Hydro will be responsible for meeting the operational parameters, but not for achieving the expected outcomes.

7.1. Other Licenced Users of Water

The proposed conditions in this Water Use Plan are not expected to affect other current licensees under the *Water Act* associated with the Bridge River Power Development, associated diversions, or Fraser River downstream of Seton Generating Station.

7.2. Riparian Rights

The proposed conditions in this Water Use Plan are not expected to impact riparian rights associated with Downton and Carpenter Lake reservoirs and Seton Lake or along the rivers downstream from the facilities. The proposed physical works are expected to improve riparian habitat near Downton and Carpenter Lake reservoir.

7.3. Fish Habitat

For Downton Lake reservoir, the proposed conditions in this Water Use Plan are not expected to impact fish or fish habitat.

For Carpenter Lake reservoir, the proposed conditions in this Water Use Plan are not expected to impact fish or fish habitat.

For Lower Bridge River, the proposed conditions in this Water Use Plan are intended to provide an improved flow regime for fish and fish habitat and reduce the frequency and duration of spills past Terzaghi Dam. This is expected to improve the health of juvenile salmonids, a proxy for multiple instream and riparian benefits.

For Seton Lake, the proposed conditions in this Water Use Plan are not expected to result in impacts to fish or fish habitat.

For Seton River, the proposed conditions in this Water Use Plan are intended to improve fish habitat and reduce entrainment mortality in turbines during peak sockeye outmigration. Although residual mortality at the dam is expected to remain, there will be no anticipated change to entrainment of outmigrants outside the peak window. The expected net effect is to produce a positive population response in several fish species.

7.4. Wildlife Habitat

The proposed conditions in this Water Use Plan are expected to result in the preservation of a large wetland on Downton Lake reservoir known as Grizzly Flats.

For Carpenter Lake reservoir, the proposed conditions are expected to result in improvements for wildlife that may benefit from a planting program on Carpenter Lake reservoir from Gun Creek to Tyax and from enhancements to the willow community at the upper end of the reservoir.

For Lower Bridge River, the implementation of Lower Bridge River Adaptive Management program and the system monitoring program will provide key information about the impact of water management on wildlife. This may provide greater certainty for future flow management decisions.

7.5. Flood Management

The proposed conditions in this Water Use Plan are expected to decrease the frequency and duration of local flooding associated with the reservoirs and the river below each facility.

7.6. Recreation and Aesthetics

The proposed conditions in this Water Use Plan will continue providing significantly improved aesthetic and recreation values in the Lower Bridge river due to flow releases from Terzaghi Dam. As well the proposed conditions are expected to result in improvements in aesthetics as a result of the planting program for Carpenter Lake reservoir from Gun Creek to Tyax and enhancements to the riparian community at the upper end of the reservoir.

7.7. Water Quality

The proposed conditions are not expected to affect water quality associated with the reservoirs or the river below the facilities.

7.8. Industrial Use of Water

The proposed conditions are not expected to result in changes to industrial uses of water associated with the Bridge River Power Development.

7.9. St’át’imc Considerations

BC Hydro's Bridge River hydroelectric facilities are located within the territory claimed by the St’át’imc. BC Hydro and St’át’imc have worked together since the initial draft of the Bridge River Water Use Plan was produced in order to incorporate interests of the St’át’imc into the plan. As a result, the Bridge River Water Use plan now includes:

- The recommended flow trial downstream of Terzaghi Dam as outlined in section 4.4.2.4 and related monitoring programs;
- Specific and planned drafts of Seton Lake in order to implement the Seton Lake Erosion Monitoring Plan referenced in section 4.5.3 and Table 5.4;
- The annual shutdowns at the Seton Generating Station during the out migration period of Seton Sockeye smolts, being between April 20 and May 20, in an effort to decrease the mortality of sockeye smolts migrating past Seton Dam and Seton Generating Station as outlined in section 4.5.3 and related monitoring programs; and
- The Seton Adult Fish Passage monitoring program outlined in Table 5.4.

The inclusion of these additional objectives and the further development of a structured decision making process incorporating St’át’imc interests and values has helped facilitate St’át’imc support for the Bridge River Water Use Plan.

7.10. Archaeological Considerations

BC Hydro’s Bridge River Power Development lies within the territory claimed by the St’át’imc. St’at’imc archaeological and heritage interests included:

- Protect cultural sites and resources located in the reservoirs from erosion;
- Protect cultural sites and resources located in the reservoirs from exploitation;
- Provide opportunities for archaeological investigation in the reservoir; and
- Maintain the cultural, aesthetic and ecological context of important cultural resources and spiritual sites.

BC Hydro will work with St'at'imc as required under the BC Heritage Act and other agreements.

7.11. Power Generation

The proposed operations in the Water Use Plan are expected to result in the loss of power benefits (GWh) compared to the pre-Interim Flow Management Strategy and other interim order operating conditions.

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 submission will include records of:

- Downton Lake reservoir elevation;.
- Discharge from La Joie Dam into Middle Bridge River;
- Generation discharge from La Joie Generating Station;
- Carpenter Lake reservoir elevation;
- Discharge into Lower Bridge River from Terzaghi Dam;
- Generation discharge from BR1;
- Generation discharge from BR2;
- Seton Lake elevation;
- Discharge from Seton Dam into Seton River;
- Generation Discharge from Seton Generating Station;
- Flows in Cayoosh Creek upstream of Seton River;
- Flows in Seton River downstream of Cayoosh Cr; and
- Diversion from Cayoosh Creek into Seton Lake.

8.2. Non-compliance Reporting

Non-compliance with operating conditions required by the water licences or associated orders, or anticipation thereof, will be reported to the Comptroller of Water Rights in a timely manner with copy to St'at'imc.

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

An interim review specific only to determining Lower Bridge River flow regime is contemplated 4 years after initiation of the 6 m^3/s flow trial (Figure 4-1).

A comprehensive review is recommended no sooner than 10 years after the associated WUP order is issued. A review of the Water Use Plan could be triggered sooner if significant risks are identified that could result in a recommendation to change operations.

10.0 NOTIFICATION PROCEDURES

Notification procedures for floods and other emergency events are outlined in the Emergency Planning Guides for the La Joie, Terzaghi and Seton Dams . These documents are filed with the Office of the Comptroller of Water Rights.

The Emergency Planning Guide describes hazards associated with BC Hydro dams, and the corresponding notifications that would be issued by BC Hydro to downstream responders in the event of an emergency. These documents are filed and updated with the appropriate agencies and with St'at'imc as required.

Appendix 1
Bridge River Basin Hydrology Memo

BC hydro

HYDROLOGIC OVERVIEW

BC Hydro Bridge River System
La Joie, Carpenter and Seton Basins

February 15, 2011

Scott Weston

Hydrologist, M.Sc.

Hydrology & Technical Services, Runoff Forecasting

Generation Resource Management

hydrology & technical services

Executive Summary

This report summarizes the hydrology of the basins comprising BC Hydro's Bridge River hydroelectric system and updates the Bridge River Water Use Plan report of the Hydrology of the Bridge River Basin (Homenuke 2002). For background, an overview of the hydroelectric system, physiography, stream and lake network, geology, climatology and vegetation of the region are provided. The hydroclimatic station network and inflow forecasting procedures are briefly described.

The BC Hydro Bridge River system consists of three projects: La Joie, Carpenter and Seton. Although not a BC Hydro basin, the Cayoosh Creek basin also affects BC Hydro operations as it is partially diverted into Seton Lake. The projects are located in the Coast Mountains of southern British Columbia, northwest of an imaginary line drawn between the towns of Pemberton and Lillooet to the west and east, respectively. The basins are drained by the Bridge and Seton Rivers and belong to the Fraser River drainage.

Table 1 and the following are a summary of the key characteristics of the basins and its water resources:

- Carpenter basin is the largest of BC Hydro's basins in the Bridge River region, followed by the Seton and La Joie basins.
- Mean annual inflows into Carpenter Reservoir are higher than Downton Reservoir (La Joie basin) inflows, which in turn are higher than Seton Lake inflows.
- When normalized by drainage area, La Joie basin produces the largest runoff due to its location on the relatively wetter western side of the Bridge River region, a negative glacier mass balance for the period analyzed and relatively low evapotranspiration losses.
- Glacier coverage in the La Joie basin, and consequently glaciermelt-runoff, is high. As of 2005 glacier coverage was 19% of the total drainage area.
- A spring and summer snowmelt freshet and a winter low flow period are common to inflows into all three reservoirs. Late summer flows in the La Joie basin are augmented by ice melt from glaciers. La Joie inflows are, therefore, characterized by a nivo-glacial runoff regime, while Carpenter and Seton inflows are characterized by nival runoff regimes.
- The natural stream network in the Bridge River region has been altered through the construction of the Carpenter-Seton and Cayoosh-Seton diversion tunnels.
- The Bridge and Seton Rivers lie in the Cordilleran climatic region, which is affected by both modified maritime air masses and continental conditions. Although Pacific disturbances are common in the Bridge River region, continental air masses tend to dominate. These climatic conditions produce cold winters, a large snowpack, hot summers and convective rainfall throughout the summer.

- Indicative of the zonal precipitation gradient across the Bridge River region is a change from coastal, temperate vegetation (i.e., dense mountain forests) to the west of La Joie Dam to interior, boreal vegetation (i.e., open forests with little underbrush) in the east near the Town of Lillooet.
- Global Climate Model predictions indicate that the 2050s will be warmer across all seasons and possibly wetter overall. Specifically, winters will likely be wetter, while summers will be drier. Studies to date suggest that the effect on flow timing will likely be larger than the effect on the magnitude of total annual inflow, although currently highly glacierized basins may be an important exception. It is expected that winter flows will increase, the snowmelt freshet will start and end earlier, the duration of the summer low flow period will last longer and the magnitude of late summer flows will be lower.

Table 1 Bridge River basin summary

Basin	La Joie	Carpenter	Seton	Cayoosh
Drainage area (km^2)	988	2719	1017	887
Glaciated area (% of drainage area)	19	2	<1	<1
Mean annual precipitation (mm)	1495	975	919	1179
Mean annual inflow (mm)	1331	598	534	680
Mean annual inflow (m^3/s)	42	52	17	19
Reservoir storage (Mm^3)	706	1012	15	N/A

Table of Contents

Table of Figures

Table of Tables

1 Location

BC Hydro's Bridge River hydroelectric system is located in southern British Columbia, northwest of an imaginary line drawn between the towns of Pemberton and Lillooet to the west and east, respectively. The largest towns within the watersheds are Gold Bridge and Seton. Figure 1 shows the general location of the Bridge River basins in BC.

Figure 1 Location of the Bridge River system in British Columbia.

2 Physiography and Stream/Lake Network

The La Joie, Carpenter and Seton basins are located in the Pacific Ranges of the southern Coast Mountains. As part of the Fraser River drainage basin, the Bridge and Seton Rivers drain the eastern slopes of the Coast Mountains. BC Hydro's La Joie, Carpenter and Seton basins have local drainage areas of 988 km^2, 2719 km^2 and 1017 km^2, respectively. The Cayoosh basin above the diversion has a drainage area of 887 km^2. Figure 2 shows the location of the basins, hydroelectric facilities and hydroclimatic stations within the Bridge River system.

Bridge Glacier is the source of the Bridge River, which starts as two branches that extend eastward before joining in lower-lying areas. The Bridge River passes through Downton and Carpenter Reservoirs, before being partially diverted through Mission Mountain into Seton Lake. This causes a portion of the Bridge River to eventually discharge into the Fraser River downstream of the town of Lillooet. The remaining portion of the Bridge River, which is not diverted into Seton Lake, is discharged at Terzaghi Dam, from where it follows its natural streambed. It is augmented by the Yalakom River some distance downstream of the dam and flows into the Fraser River upstream of the town of Lillooet.

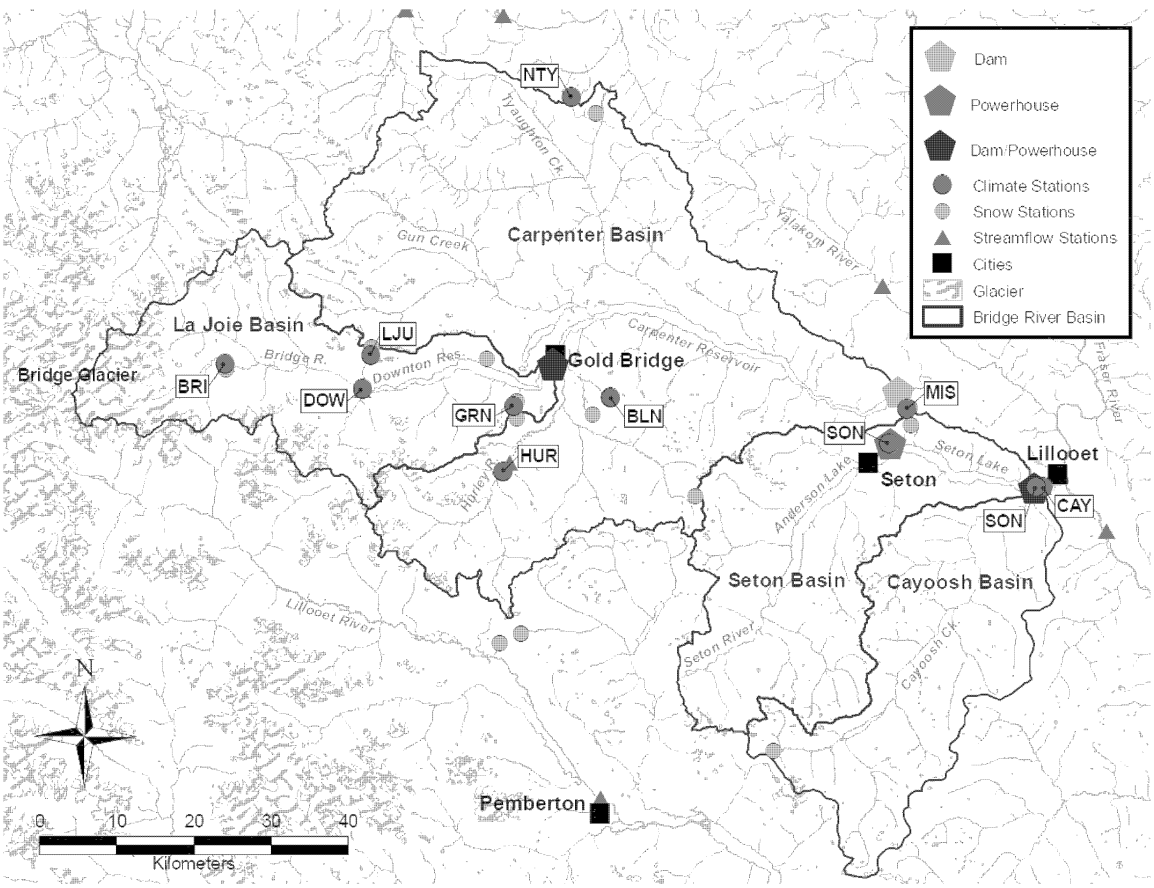

Figure 2 BC Hydro watersheds, facilities and hydroclimatic stations in the Bridge River system.

The source of the Seton River is Gates Lake located in the valley opening between the Lillooet and Seton River basins. The Seton River passes through Anderson Lake before discharging into Seton Lake. From there, non-power releases follow the natural Seton River streambed to their confluence with Cayoosh Creek and the Fraser River, while power releases are diverted straight into the Fraser River. Regulated diversion flows enter Seton Lake from the Bridge River (daily average of 87 m^3/s from 2000-2008) and Cayoosh Creek (daily average of 12 m^3/s from 2000-2008) basins via the Bridge River and Walden North generating stations, respectively.

2.1 La Joie Basin

The Dickson and Hurley Ranges separate the La Joie basin from the Carpenter basin to the south and east, respectively. The elevation of the La Joie basin ranges from 717 m to 2933 m. The median elevation of the basin is 1926 m. The hypsometric curves[1] for all three basins are shown in Figure 3. The La Joie basin is characterized by a relatively large vertical elevation range, high median basin elevation, rugged topography, glacial landforms, such as arêtes, horns, nunataks, cirques, U-shaped and hanging valleys and large glacier coverage. A photo of the upper section of the basin and Bridge Glacier is provided in Figure 4.

The La Joie basin is the most heavily glaciated of all of BC Hydro's watersheds. As of 2005, the total glacier extent is 19% of the drainage area. Of that, the Lillooet Icecap and Bridge Glacier, located at the western edge of the basin, make up the largest portion. Together, they cover 11% of the watershed.

La Joie Dam, which forms Downton Reservoir, is located near the Town of Gold Bridge at the eastern end of the reservoir. Downton Reservoir is approximately 20 km long. The Bridge River is the major tributary to Downton Reservoir.

2.2 Carpenter Basin

The Carpenter basin is bound to the northeast by the Shulaps Range and to the southeast by Mission Ridge, the Bendor Range and the Cadwallader Range. The elevation of the basin ranges from 649 m to 2902 m, with a median elevation of 1809 m. The basin is characterized by a relatively large vertical elevation range, high median basin elevation, a moderately rugged topography and glacial landforms. The basin lacks the extensive glacier coverage of the La Joie basin; the glacier extent is approximately 2% of the drainage area. A photo of the basin and reservoir is provided in Figure 5.

[1] A ***hypsometric curve*** is a graph that shows the fraction of a watershed's land area that lies at or above a given elevation.

Four major streams discharge into the approximately 50 km long Carpenter Reservoir: the Bridge River, which at this point is the regulated discharge from Downton Reservoir, Hurley River, Gun Creek and Tyaughton Creek.

2.3 Seton Basin

The Seton basin is separated from the Carpenter basin to the north by Mission Ridge and the Bendor Range and from the Cayoosh Creek watershed to the south by the Cayoosh Range. The elevation of the Seton basin ranges from 219 m to 2914 m with a median elevation of 1533 m. As shown in Figure 3, the highest peaks in the Seton basin reach elevations close to those in the La Joie and Carpenter basins, but the minimum and median elevations are lower than those of the other two basins. The topography in the basin is very rugged. Glacial landforms are present. The glacier extent in the basin is relatively small; it is less than 1% of the total drainage area. A photo of Seton Lake is provided in Figure 6.

Anderson and Seton Lakes are each approximately 20 km in length. Lake storage in Anderson Lake is large and, as a result, provides effective attenuation of peak flows into Seton Lake. Approximately 70% of the Seton basin drainage area is upstream of Anderson Lake. As stated above, regulated diversion flows also enter Seton Lake from the Bridge River and Cayoosh Creek basins via the Bridge River and Walden North generating stations, respectively.

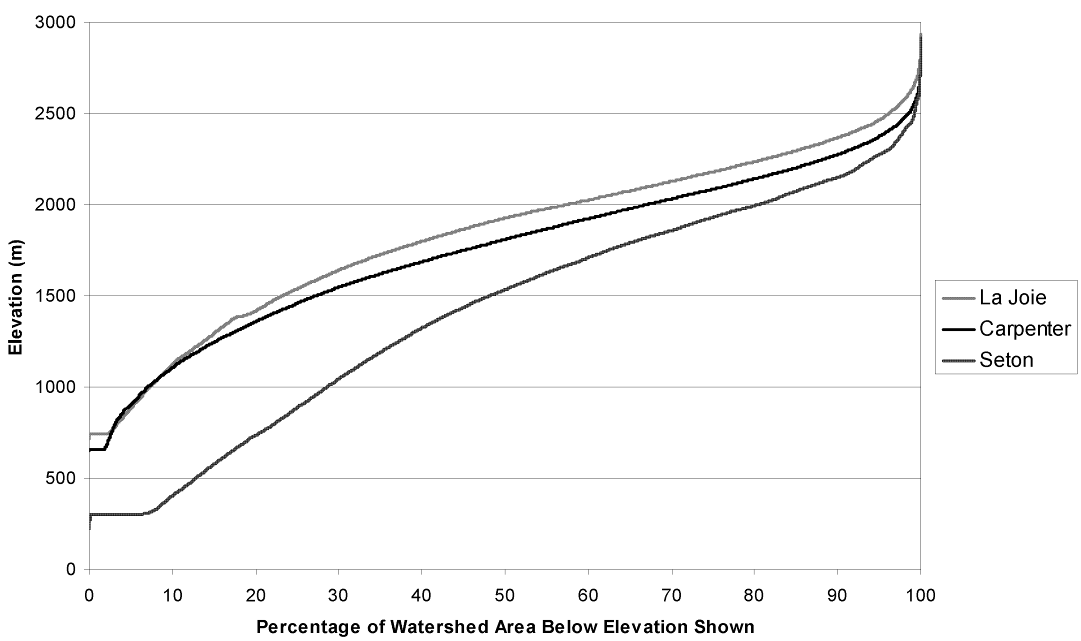

Figure 3 Hypsometric curves for the Bridge River basins.

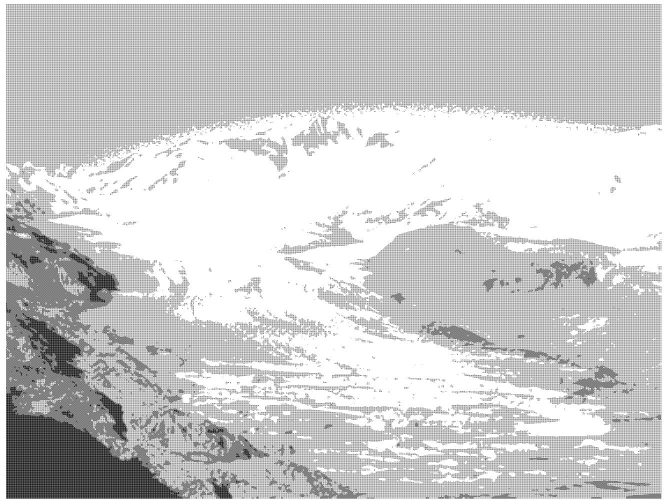

Figure 4 Upper La Joie basin and Bridge Glacier (photo: Shea 2006).

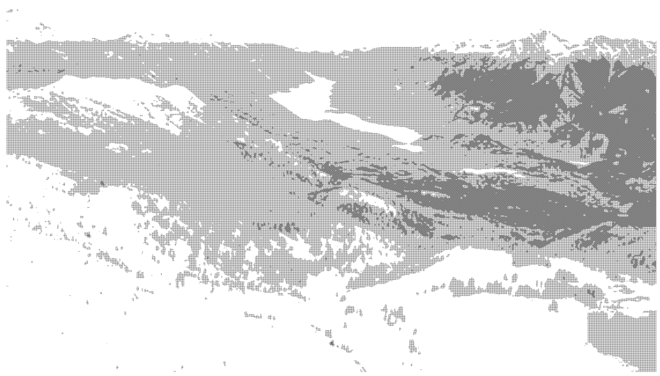

Figure 5 Carpenter Reservoir (photo: Weber 2005).

Figure 6 Seton Lake.

3 BC Hydro Project Infrastructure

3.1 BC Hydro Project Characteristics

The Bridge River system encompasses three hydroelectric projects. A schematic of the system is shown in Figure 7. Key features of the projects are listed below[2].

3.1.1 La Joie Project

- La Joie Dam impounds Downton Reservoir.
- Power and non-power releases from La Joie Dam flow into the Bridge River near Gold Bridge and eventually into Carpenter Reservoir.
- The La Joie generating station contains a single unit (25 MW).

3.1.2 Carpenter Project

- Terzaghi Dam impounds Carpenter Reservoir.
- Power releases from Carpenter Reservoir are diverted via two tunnels to Bridge River generating stations one (208 MW) and two (300 MW), each housing four units, and eventually flow into Seton Lake.
- Non-power releases from Terzaghi Dam discharge into the Bridge River.

3.1.3 Seton Project

- Seton Dam impounds Seton Lake.
- Power releases from West Kootenay Power's Walden North Project on Cayoosh Creek are partially diverted into Seton Lake. On average, about two thirds of Cayoosh natural inflow is diverted.
- Power releases from Seton Dam are diverted via a 3.7 km canal to the Seton generating station (one unit, 48 MW) and eventually flow into the Fraser River.
- Non-power releases from Seton Dam discharge into the Seton River above its confluence with Cayoosh Creek.

[2] Generation station outputs are from the December 17th, 2010 Bridge River Water Use Plan.

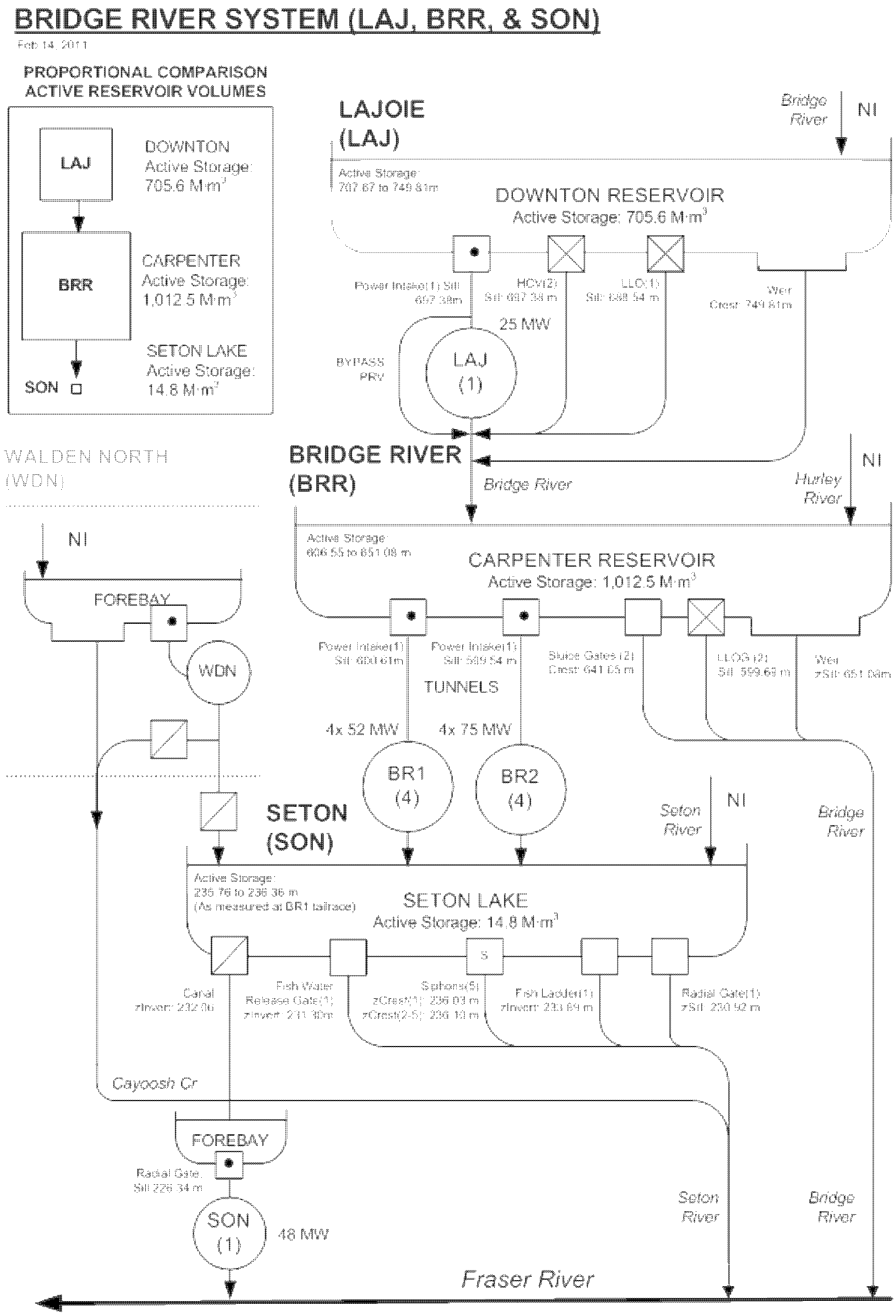

Figure 7 Schematic of the BC Hydro Bridge River hydroelectric system.

3.2 Hydroclimatic Data Collection

3.2.1 Hydroclimatic Data

A network of weather, snow and streamflow stations was established to collect hydroclimatic data in support of planning, monitoring, and operating the BC Hydro Bridge River system facilities. The variables collected include precipitation, air temperature, snow water equivalent, snow depth and streamflow. Weather and snow stations in the region of interest are funded and operated by BC Hydro. Weather stations are automated for both data collection and transmission. Snow data are collected using two types of stations: manual snow surveys[3] and automated snow pillows[4]. Automated hydrometric stations in the Bridge River watersheds are operated by the Water Survey of Canada and funded by BC Hydro. Key hydroclimatic stations in the Bridge River region are summarized in Table 2. Locations of hydroclimatic stations are shown in Figure 2.

Table 2 Key hydroclimatic stations in the Bridge River region.

Station Name	ID	Elev (m)	Lat. (º)	Long. (º)	Station Type
Bralorne Upper DCP[5]	BLN	1920	50.77	122.73	Climate
Bridge R. blw Glacier DCP	BRI	1350	50.85	123.45	Climate/Hydrometric
Cayoosh Cr. nr Lillooet DCP	CAY	266	50.67	122.97	Hydrometric
Bridge R. above Down. DCP	DOW	708	50.82	123.20	Climate/Hydrometric
Green Mountain DCP	GRN	1780	50.80	122.92	Climate/Snow Pillow
Hurley R. above Lone DCP	HUR	990	50.72	122.95	Climate/Hydrometric
La Joie Upper DCP	LJU	1829	50.87	123.18	Climate
Mission Ridge DCP	MIS	1850	50.75	122.23	Climate/Snow Pillow
N. Tyaughton Ck. DCP	NTY	1969	51.13	122.75	Climate
Seton Dam Forebay DCP	SON	284	50.67	121.98	Hydrometric
Shalalth DCP	SON	320	50.73	122.24	Climate
McGillivray Pass	1C05	1800	50.68	122.60	Snow Course
Nahaltlatch River	1D10	1520	49.83	122.05	Snow Course
Tenquille Lake	1D06P	1680	50.53	122.93	Snow Pillow

Climate data are quality controlled in several stages using outlier, plausibility and consistency checks and various automated and manual estimation techniques. A similar procedure is employed for monthly snow water equivalent data. Streamflow data in the

[3] ***Manual snow surveys*** are conducted at predetermined times of the year (up to a maximum of eight times per year) using the Federal Snow Sampler (a specific type of snow corer).

[4] ***Automated snow pillows*** measure the displacement of antifreeze solution from a bladder in response to the weight of the snow exerted on it. Snow pillows transmit snow water equivalent data in real-time.

[5] ***Data Collection Platform*** (DCP): Automated weather stations operated by BC Hydro.

Bridge region are not quality controlled in real-time. Instead they are quality controlled several months after they have been collected by the Water Survey of Canada.

3.2.2 Reservoir Inflow Data

Reservoir inflows are not directly measured by BC Hydro, but are instead calculated from measured changes in reservoir storage and discharge, specifically power and non-power releases, using the principle of conservation of mass as applied to flow volumes:

- The change in reservoir storage from the beginning to the end of the computational time step (typically, hour) is derived from measured reservoir elevation(s) and reservoir-specific stage-storage relationships. The reservoirs' stage-storage relationships and licensed operating ranges are shown in Figures 8-10. Between their minimum and maximum licensed elevations Downton and Carpenter Reservoirs and Seton Lake have licensed storage capacities of approximately 8167 cms-days[6], 11719 cms-days and 171 cms-days (706 Mm^3, 1012 Mm^3 and 15 Mm^3) , respectively.

- Power releases (i.e., reservoir discharge through turbines or, also called, turbine discharge) at the La Joie, Bridge and Seton power houses, are computed based on measurements of generation (i.e., megawatt output) and hydraulic head[7].

- Non-power releases (e.g., reservoir discharge through spill gates, weirs or valves) are computed from reservoir (or, forebay) elevation and rating curves for each structure. These rating curves are numeric representations of the relationship between discharge, gate opening, and reservoir elevation for a given release device. For illustration, rating curves for fully opened spill facilities at La Joie, Terzaghi and Seton Dams are shown in Figures 11-13.

BC Hydro computes inflow using a computer program called FLOCAL. Typically, the FLOCAL program calculates inflows as unregulated flows from the local drainage area only. However, for operational purposes, in some cases, controlled discharge from upstream reservoirs is included in the data. This is the case for FLOCAL's Seton inflow data, which include Cayoosh Diversion flows. Diversions from Cayoosh Creek to Seton Lake have

---

[6] ***cms-days***: volume of water in units of flow rate (m^3/s) over a specified period (day).

[7] ***Hydraulic head*** is a measure of the vertical distance between the reservoir (or, forebay) elevation and the water level immediately below the turbine outlet adjusted for friction losses.

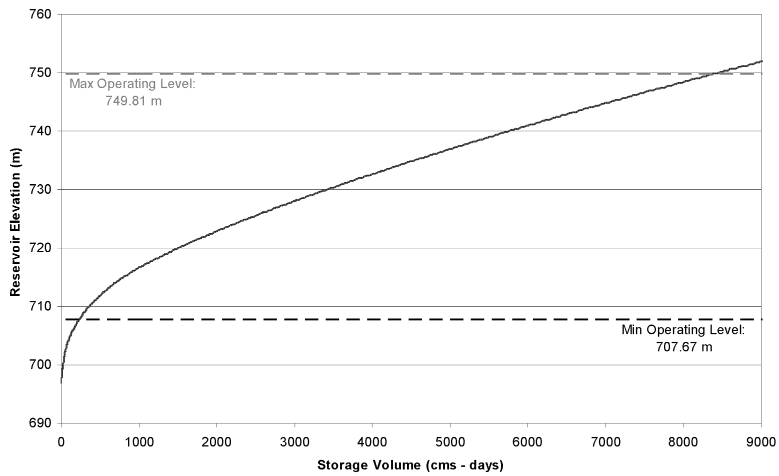

Figure 8 Stage-storage relationship for Downton Reservoir.

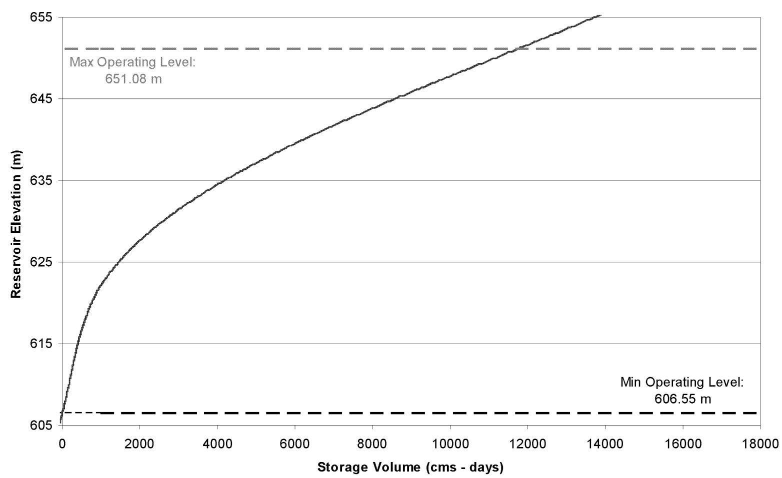

Figure 9 Stage-storage relationship for Carpenter Reservoir.

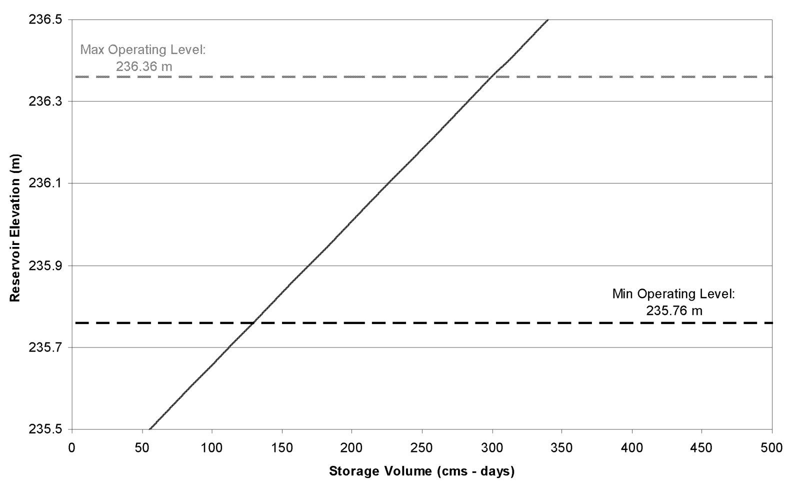

Figure 10 Stage-storage relationship for Seton Lake.

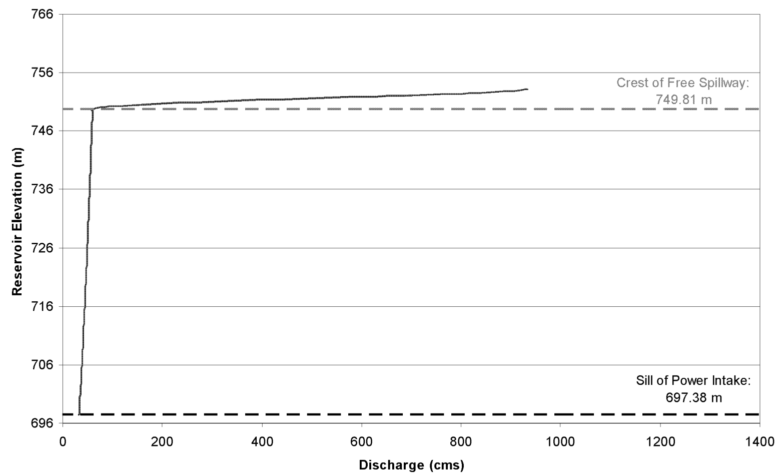

Figure 11 Stage-discharge relationship for Downton Reservoir with all discharge facilities open.

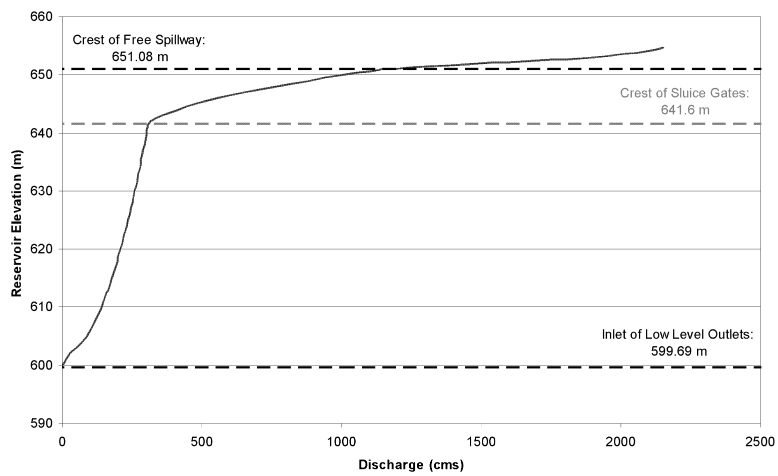

Figure 12 Stage-discharge relationship for Carpenter Reservoir with all discharge facilities open.

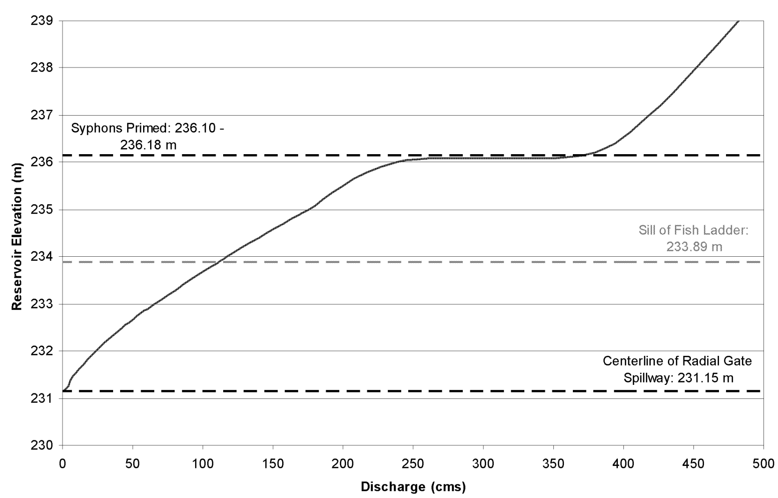

Figure 13 Stage-discharge relationship for Seton Lake with all discharge facilities open.

functioned as part of the Walden North power project (WDN) operated by BC Enertech Ltd.'s for FortisBC since 1993. Diversion flow data are acquired from BC Enertech Ltd. Missing data (primarily on weekends and holidays) are infilled by BC Hydro using the linear regression technique. Seton Lake unregulated inflow is then calculated for the historical period by removing Cayoosh Diversion flows.

Unregulated, local inflows are very close to, but not identical to natural, local flows (i.e., streamflows that would have occurred if the reservoirs had not been built). The differences are caused by losses from the system through reservoir evaporation and seepage through dams and into the groundwater that exceed natural evapotranspiration and natural influent river conditions. These differences are not taken into account in BC Hydro calculations. For that reason, calculated inflow is also referred to as 'inflow available for outflow'.

Inflow data of hourly and daily resolution can exhibit a large degree of random errors or noise. Random errors become more obvious at times of low inflows, which is when the signal-to-noise ratio is low. Random errors are predominantly caused by the difficulty of determining the precise and representative reservoir volume:

- Measurements of reservoir elevations are affected by temporary wind set up on reservoirs (so-called 'seiches') and by the limited resolution of the instruments measuring reservoir elevations. The latter effect is particularly pronounced in large reservoirs, where a small change in stage is associated with a large change in volume. As a result, small errors in stage measurements can cause significant errors in the storage volume and, thus, reservoir inflows. Furthermore, temperatures below freezing can negatively affect the operation of gauges.

- An inaccurate stage-storage curve can contribute to errors. In some cases, the curve is the composite of a number of curve segments. These curve segments may not fit together smoothly and therefore may not yield good continuous estimates of reservoir storage.

Other error sources are faulty measurements of releases due to inaccurate measurements and (or) rating curves. Additionally, human errors in entering and transcribing data can occur.

Random errors in daily, local, unregulated inflows were estimated to currently be of a typical magnitude of about 3 m^3/s at Downton Reservoir (i.e., 6% of mean annual inflow), 8 m^3/s at

Carpenter Reservoir (i.e., 15% of mean annual inflow) and 5 m^3/s at Seton Lake (i.e., 29% of mean annual inflow)[8].

BC Hydro regularly performs quality control of historical daily inflows. This process involves the comparison of inflow data with data from nearby Water Survey of Canada streamflow gauges in hydrologically similar watersheds to check for outliers, plausibility and consistency. Data are corrected for errors, while conserving the overall (i.e., annual) inflow volume to the maximum extent possible.

3.2.3 Glacier Data

Only few and short-lived efforts have been made to collect glaciological data in the area of interest. Glacier mass balance surveys were carried out on the Bridge Glacier from 1977 to 1984 (Mokievsky-Zubok et al. 1985). These data were not analyzed for this report and more recent mass balance data are not available. A province-wide survey of aerial photography and satellite imagery determined the glacier coverage for 1985 and 2005 (Bolch et al. 2010). Allen and Smith (2007) used geobotanical (i.e., dendroglaciology and lichenometry) dating techniques to reconstruct the late Holocene history of the spatial extent of the Bridge Glacier terminus.

4 Geology

The Bridge River region belongs to the coastal belt[9]. This belt includes the Coast Mountains and consists of terranes[10] accreted to the North American continent including island and continental arcs (Mathews and Monger 2005).

The La Joie basin and the western and southern portions of the Carpenter and Seton basins are composed of Mesozoic dioritic and granodioritic intrusive rocks that make up the eastern flank of the Coast Mountains (Massey et al. 2005 and Holland 1976). Stream channels commonly follow elements of the bedrock structure, such as fracture zones and major joint patterns, but also follow traces of soft strata. In this region, the resistance of the granitic

[8] The ***typical magnitude of the random error in raw inflow data*** was calculated as RMSE as derived from the difference between daily raw and quality controlled (i.e., ‘true’) data for the 2001-2008 period.

[9] The division of BC into geological ***belts*** is based on the distinctive nature of bedrock. From west to east BC consists of the Insular, Coastal, Intermontane, Omineca and Foreland belts.

[10] ***Terranes*** are regions of similar geologic record bound by faults. They are fragments of former island arcs, accretionary complexes and back-arc basins and were added to the old continental margin millions of years ago.

bedrock to erosion and the steep topography resulted in a moderately dense channel network. The drainage pattern in this region is reminiscent of the trellis pattern[11]. Towards the eastern parts of the Carpenter and Seton basins (i.e., towards the Fraser Plateau), granitic rock begins to give way to sandstone and siltstone that make up the Cayoosh assemblage and marine sedimentary and volcanic rock that form the Bridge River complex. Mesozoic and Paleozoic sedimentary deposits are interspersed by small granitic stocks in various locations. Between the granitic and sedimentary-dominated portions of the region is a small transitional zone of serpentinite metamorphic rock. The density of the drainage network is higher than in the western parts of the basins, possibly due to a relatively lower infiltration capacity of the ground. The drainage pattern has elements of the trellis, dendritic[12] and parallel[13] patterns.

The Tyaughton Creek sub-basin, located in the northeastern part of the Carpenter basin, is dominated by sedimentary deposits of sandstone, siltstone, conglomerate and shale and, consequently, exhibits a particularly high density drainage network relative to other parts of the basins. Here, the drainage pattern is predominantly dendritic.

5 Climatology

In BC, the dominant weather pattern during the summer stems from a strong area of high pressure, the Pacific High, which keeps the area warm and dry. This pattern is periodically broken by surges of moisture from the Pacific. During the winter a semi-stationary low-pressure center, the Aleutian Low, sets up in the Gulf of Alaska and shifts the storm track towards the BC coast. By winter, BC can therefore regularly experience intense storms (St. Clair 2009).

---

[11] ***Trellis drainage patterns*** look similar to their namesake, the common garden trellis. Trellis drainage develops in folded topography. Short tributary streams enter the main channel at sharp, nearly right angles as they run down sides of parallel ridges called anticlines (Ritter 2006).

[12] ***Dendritic drainage patterns*** look like the branching pattern of tree roots. They develop in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take. Tributaries join larger streams at acute angle (Ritter 2006).

[13] ***Parallel drainage patterns*** form where there is a pronounced slope to the surface. A parallel pattern also develops in regions of parallel, elongate landforms like outcropping resistant rock bands. Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface (Ritter 2006).

The Bridge and Seton Rivers lie in the Cordilleran climatic region, which is affected by both modified maritime air masses and continental conditions. Although Pacific disturbances are common in the Bridge River region, the Coast Mountains serve as a barrier that keeps mild Pacific air from entering the BC interior. Continental air masses, therefore, tend to dominate. These climatic conditions produce cold winters, a large snowpack, hot summers and convective rainfall throughout the summer.

Low-pressure weather systems typically reach the area of interest from a westerly direction (i.e., northwestly to southwesterly) and cross the Coast Mountains in a perpendicular direction. This produces a strong precipitation gradient in the area of interest: precipitation amounts are high in the west - due to the orographic lifting of air masses – and low in the east – due to the rain shadow effect.

Figure 14 shows mean annual precipitation throughout the Bridge River region as derived from ClimateBC's PRISM-based data (Wang et al. 2006 and Daly et al. 2002). The sharp precipitation gradient is evident in the spatial dataset: annual precipitation ranges from a maximum of just over 2700 mm on the Bridge Glacier on the western edge of the La Joie basin to a minimum of about 400 mm near Seton Lake. Mean annual basin precipitation in the La Joie, Carpenter and Seton basins is 1495 mm, 975 mm and 919 mm, respectively.

Figure 15 shows average monthly precipitation at three high-elevation stations on a zonal transect across the basin: La Joie Upper (elevation 1829 m) in the west, Bralorne Upper (elevation 1920 m) in the central part of the region and Mission Ridge (elevation 1850 m) in the east. The plot shows that the zonal precipitation gradient is especially strong in the winter months, when particularly the western parts of the basin are influenced by Pacific storms. Summer precipitation is higher in the eastern parts of the basin due to higher temperatures, which create favourable conditions for convective rainfall.

Figure 16 shows minimum, mean and maximum monthly precipitation at the Mission Ridge station. Most of the precipitation falls throughout the winter months when the climate is dominated by Pacific storms. A secondary precipitation maximum occurs in summer due to convective rainfall.

Figure 17 shows the average snow water equivalent (SWE) at the regionally representative McGillivray Pass snow course (1C05, elevation 1800 m). Maximum snow accumulation is equally likely to occur on the April 1 or May 1 measurement dates. Peak accumulation averages about 600 mm, but can range from less than 300 mm in a dry year to over 1100 mm in a wet year.

Figure 18 shows the average monthly minimum, mean and maximum temperatures at the Mission Ridge station. Average monthly temperatures at this high elevation station range from a minimum of about -7°C in December and January to a maximum of 11°C in July and August. Temperatures drop to record lows during Arctic Outflows, when a large high-pressure center moves south from the Arctic and gets sandwiched between the Pacific Coast and the Rocky Mountains (St. Clair 2009).

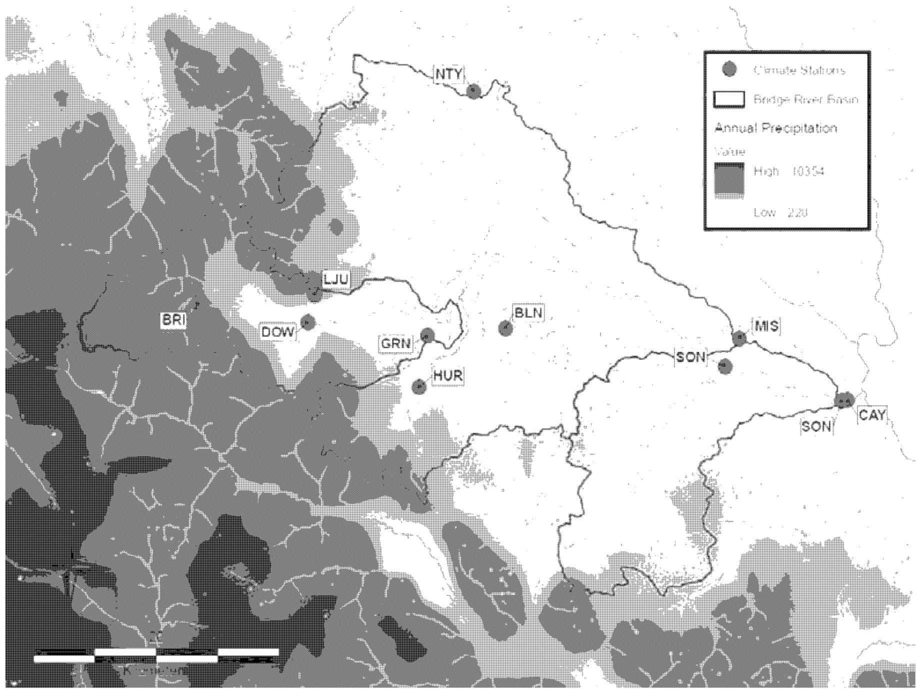

Figure 14 Mean annual precipitation as derived from ClimateBC PRISM data.

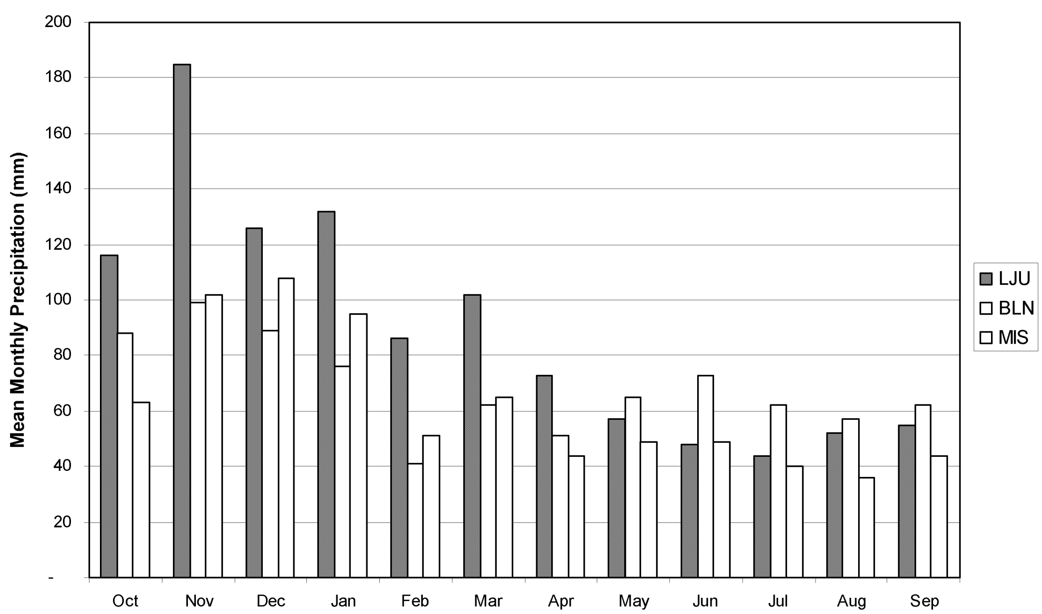

Figure 15 Mean monthly precipitation at the La Joie Upper (LJU; 1829 m), Bralorne Upper (BLN; 1920 m) and Mission Ridge (MIS; 1850 m) weather stations (1995-2008).

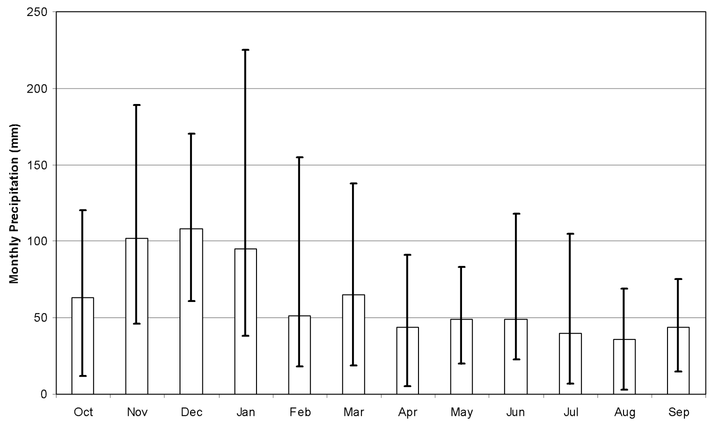

Figure 16 Minimum, mean and maximum monthly precipitation at the Mission Ridge weather station (MIS; 1850 m, 1995-2008).

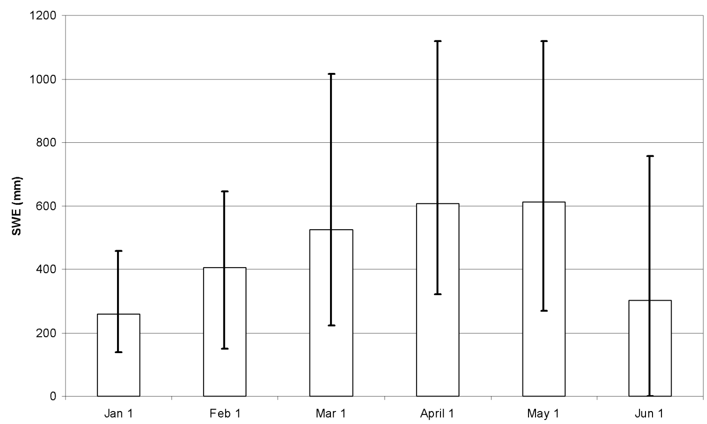

Figure 17 Minimum, mean and maximum snow water equivalent at the McGillivray Pass snow course (1C05; 1800 m, 1952-2009).

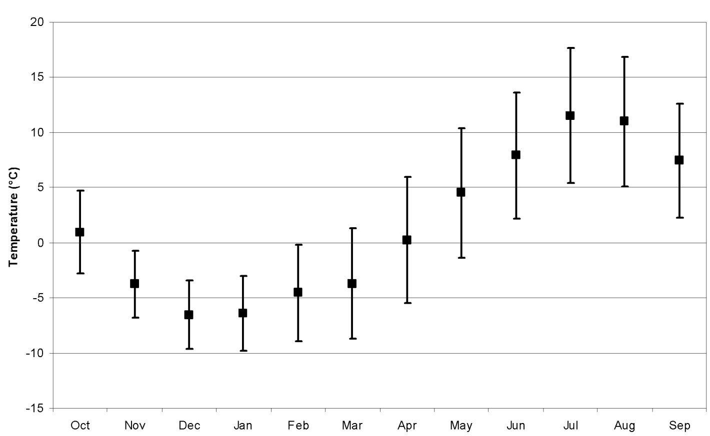

Figure 18 Minimum, mean and maximum monthly temperatures at the Mission Ridge weather station (MIS; 1850 m, 1995-2008).

6 Flora

Vegetation is the product of interactions between geology, topography, climate, glaciation, flora colonization and the competition among species for space (Cannings and Cannings 1996). Indicative of the zonal precipitation gradient across the Bridge River region is a gradient from coastal, temperate vegetation (i.e., dense mountain forests) to the west of La Joie Dam to interior, boreal vegetation (i.e., open forests with little underbrush) in the east near the Town of Lillooet.

The lower elevations of the Seton and Carpenter basins are dominated by mixed forests of Douglas Fir and Ponderosa Pine. Higher elevation forests are made up of Douglas Fir, Subalpine Fir and Engelman Spruce. Although the region is mostly covered by coniferous forest, Aspen meadows are also common in low to mid elevations, providing ideal habitat for abundant growth of wildflowers. Above the treeline (i.e., above approximately 2000 meters), the region is covered in vast alpine meadows which are snow-covered for more than half the year (Trail Ventures BC 2009).

Since so many factors influence a region's dominant vegetation cover, it is commonly used as a surrogate for categorizing the physical environment as a whole. The ecoprovinces system uses climatology and physiography to categorize ecosystems in BC. Based on this classification, the La Joie, Carpenter and Seton basins belong to the Southern Interior Ecoprovince (Cannings and Cannings 1996).

The system of biogeoclimatic zones is an alternative ecosystem classification system. It is based on climatic factors and defined by the dominant tree species. According to this system, the three basins are encompassed by the Interior Douglas Fir, Montane Spruce, Engelman Spruce – Subalpine Fir and Alpine Tundra zones (Cannings and Cannings 1996).

7 Water Resources

7.1 Hydrologic Regime

Historical inflows to Downton Reservoir are shown in Figure 19. Downton Reservoir inflows follow a nivo-glacial regime[14]. Low flows occur throughout the winter period as snowpack accumulates. The snowmelt freshet starts in late April and, on average, reaches its peak in July. Flows begin to recede thereafter, but remain relatively high in August and September

[14] A ***hydrologic regime*** categorizes a river or stream by its dominant flow-producing processes. In BC the following regimes can be observed: pluvial (rainfall-dominated), pluvio-nival hybrid (a combination of rainfall- and snowmelt-dominated), nival (snowmelt-dominated) and nivo-glacial (a combination of snowmelt- and glaciermelt-dominated).

due to glaciermelt: throughout the late summer period, after the snow has melted from the lower sections of the glacier (i.e., the ablation zone), glacier ice becomes exposed to the atmosphere, melts, and contributes to streamflow. Glacier mass balance is particularly negative, and, consequently, glaciermelt-runoff is particularly large, in years with low winter snowpacks and/or warm, dry summers. Hence, glaciers in the La Joie basin are able to reduce the year-to-year variability of Downtown Reservoir inflows. Annual maximum peak flows occur during the spring freshet period as a result of intense snowmelt or rainfall-runoff superimposed on snowmelt. Extreme flows can also be caused by intense rainstorms in fall and summer and by glaciermelt in response to extreme heat in late summer.

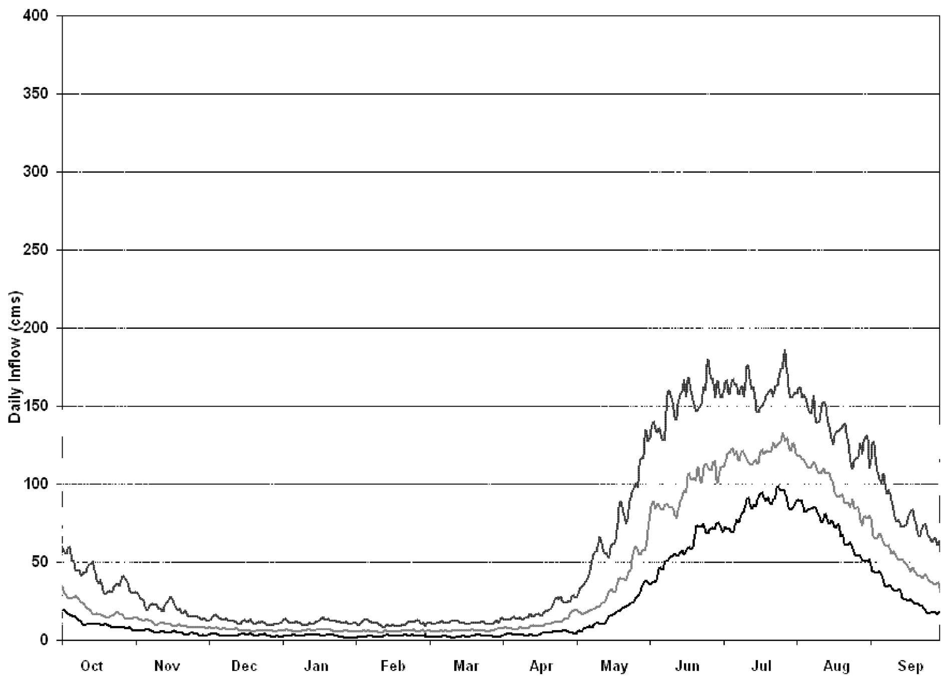

Figure 19 Historical daily local, unregulated inflows to Downton Reservoir (1964-2008). The 10th, 50th and 90th percentile non-exceedance inflows are shown in bold black, red, and blue lines, respectively.

Figures 20, 21 and 22 show historical inflows to Carpenter Reservoir, Seton Lake and Cayoosh Creek. Carpenter Reservoir, Seton Lake and Cayoosh Creek inflows follow a nival regime. Low flows occur throughout the winter period as snowpack accumulates. The snowmelt freshet begins in late April and, on average, reaches its peak in June, followed by gradually decreasing flows throughout the summer. Annual maximum peak flows are primarily generated during the spring freshet period as a result of intense snowmelt or rainfall-runoff superimposed on snowmelt, but also occasionally by intense rainstorms in fall and summer.

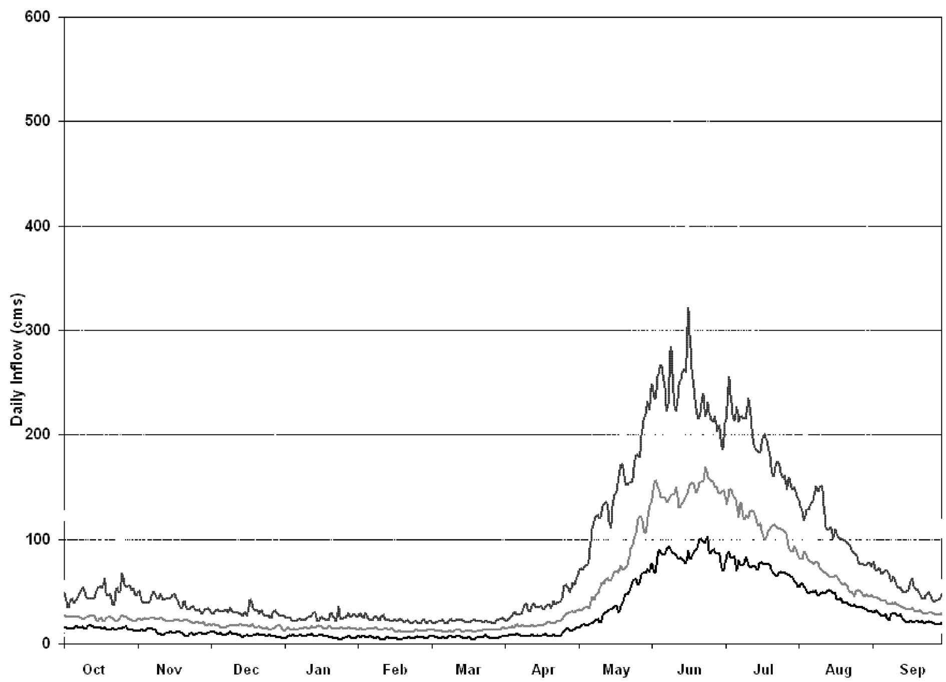

Figure 20 Historical daily local, unregulated inflows to Carpenter Reservoir (1964-2008). The 10th, 50th and 90th percentile non-exceedance inflows are shown in bold black, red, and blue lines, respectively.

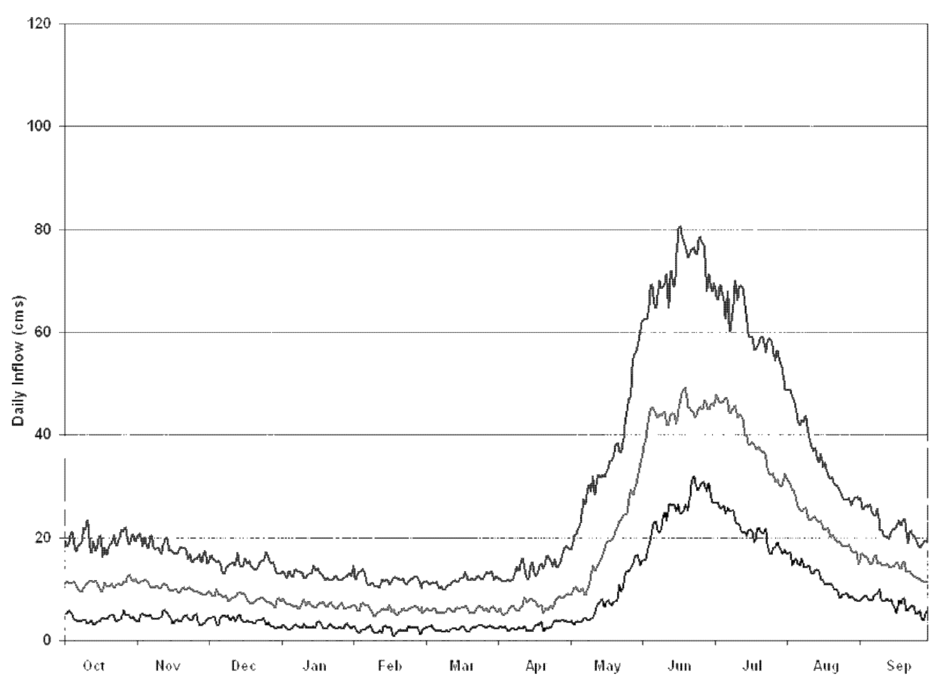

Figure 21 Historical daily local, unregulated inflows to Seton Lake (1964-2008). The 10th, 50th and 90th percentile non-exceedance inflows are shown in bold black, red, and blue lines, respectively.

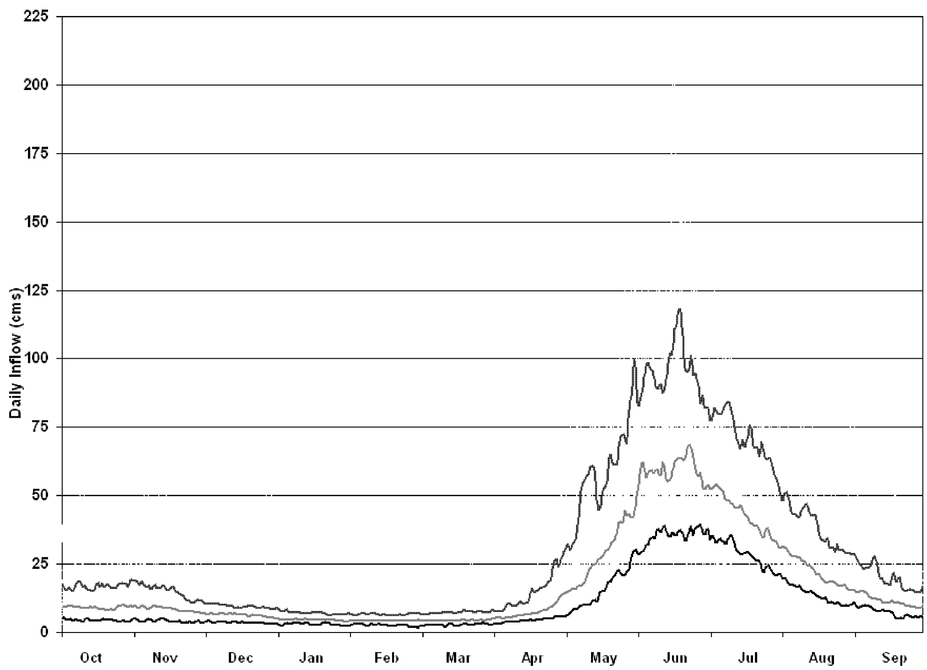

Figure 22 Historical daily local, unregulated inflows to Cayoosh Creek (1964-2001). The 10th, 50th and 90th percentile non-exceedance inflows are shown in bold black, red, and blue lines, respectively.

7.2 Hydrologic Characteristics

Mean annual inflows into Downton and Carpenter Reservoirs, Seton Lake and Cayoosh Creek are 42 m^3/s, 52 m^3/s, 17 m^3/s and 19 m^3/s, respectively, thereby reflecting the size, and hydroclimatic, physiographic and geologic characteristics of the basins. Carpenter Reservoir receives the highest inflows, followed by Downton Reservoir.

When normalized by drainage area, mean annual runoff in the La Joie, Carpenter, Seton and Cayoosh basins is 1331 mm, 598 mm, 534 mm and 680 mm, respectively. Those numbers reflect the hydroclimatic, physiographic and geologic characteristics of the basins only. La Joie basin produces the largest runoff per unit area due to its location on the relatively wetter western side of the Bridge River region, a negative net glacier mass balance for the period analyzed, which is associated with a surplus of water that was released from glacier storage (also see Section 7.3 below) and lower evapotranspiration losses than the basins further to the east.

Figure 23 illustrates the monthly distribution of inflows and the variability of daily inflows within each month of the year for the three Bridge River projects and Cayoosh Creek. Tables 3, 4, 5 and 6 show the data in greater detail. Due to its large drainage area, Carpenter Reservoir typically receives the highest monthly inflow, with the notable exceptions of August and September, in which La Joie inflows are higher. In those months, glaciermelt keeps flows higher in the La Joie basin than in the Carpenter basin. The variability of daily flows is particularly large during the summer months (June, July and August) and in October.

Table 7 shows the distribution and variability of daily flow through the Cayoosh Diversion. During the winter and at other periods of low flow almost all of Cayoosh Creek's inflow is diverted, whereas a considerably lower percentage is diverted when flow are high during the freshet and heavy rainfall events. On average, about two-thirds of Cayoosh Creek's inflow is diverted into Seton Lake.

Figure 24 shows a flow duration curve[15] of daily inflows. The figure illustrates the large range of daily inflows into Downton and Carpenter Reservoirs compared to that of inflows into Seton Lake and Cayoosh Creek. Figure 25 shows the duration curves for annual flows. The flow duration curve for La Joie flows is flatter than that for Carpenter flows indicating smaller year-to-year inflow variability due to the buffering effect of glaciers (see Section 7.1).

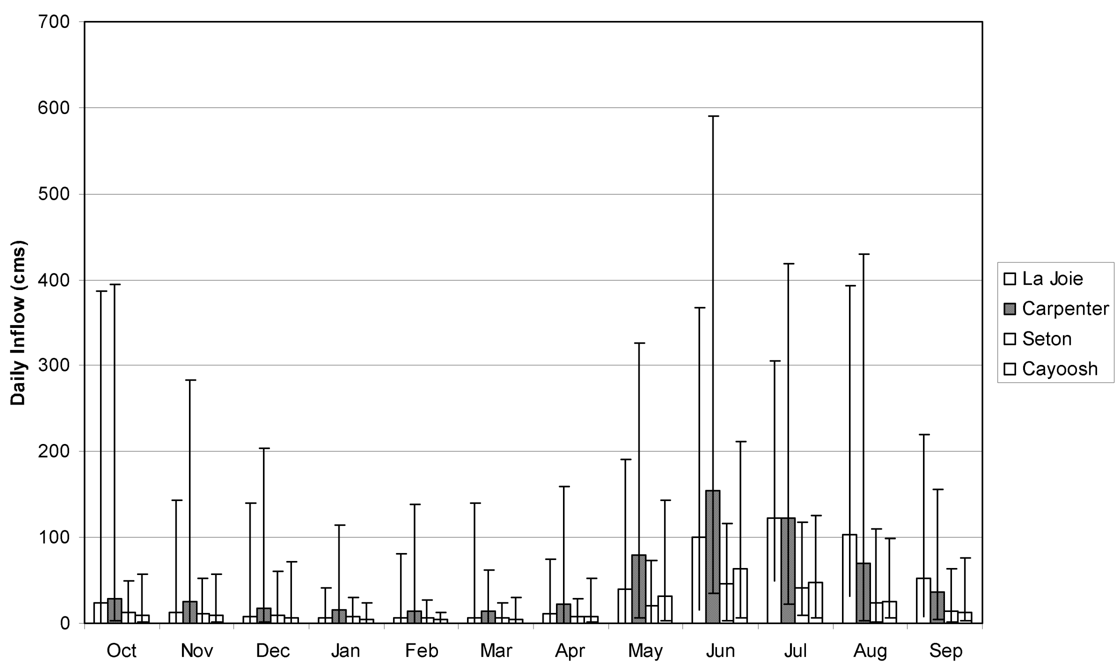

Figure 23 Minimum, mean and maximum daily local, unregulated inflows to Bridge River reservoirs for each month of the year (1964-2008, except 1964-2001 for Cayoosh).

[15] ***Flow duration curves*** show the fraction of time that flows of a certain magnitude are exceeded.

Table 3 Monthly distribution of daily local, unregulated La Joie inflows in m^3/s (1964-2008).

Month	Min	5%	30%	50%	Mean	70%	95%	Max
October	2	8	14	20	26	28	58	386
November	<1	3	7	10	12	13	26	143
December	<1	2	5	7	7	9	15	141
January	<1	1	5	6	7	8	14	42
February	<1	2	4	6	7	8	13	81
March	<1	2	5	6	7	8	14	140
April	<1	2	7	9	11	12	23	75
May	<1	7	20	31	39	46	96	191
June	16	43	76	96	101	117	175	367
July	50	75	103	120	123	137	181	305
August	32	58	85	102	104	118	162	393
September	9	20	39	52	55	66	102	220
Annual	<1	3	8	16	42	55	139	393

Table 4 Monthly distribution of daily local, unregulated Carpenter inflows in m^3/s (1964-2008).

Month	Min	5%	30%	50%	Mean	70%	95%	Max
October	4	12	20	25	31	32	67	394
November	<1	8	17	22	25	27	50	283
December	1	7	13	17	19	21	39	204
January	<1	5	11	15	16	18	33	115
February	<1	4	9	13	14	17	29	139
March	<1	5	9	13	14	16	25	62
April	<1	6	14	19	21	24	46	158
May	7	18	44	65	78	94	182	326
June	35	70	120	147	159	182	300	591
July	23	63	95	116	128	146	230	419
August	3	36	52	64	73	80	144	429
September	6	18	29	35	38	42	72	156
Annual	<1	7	17	27	52	54	174	591

Table 5 Monthly distribution of daily local, unregulated Seton inflows in m^3/s (1964-2008).

Month	Min	5%	30%	50%	Mean	70%	95%	Max
October	<1	3	8	11	12	14	24	49
November	<1	3	7	10	11	13	21	53
December	<1	3	6	8	9	11	18	60
January	<1	2	5	7	8	10	15	30
February	<1	1	4	6	7	8	14	27
March	<1	2	4	6	7	9	13	25
April	<1	2	5	7	8	10	17	29
May	<1	4	11	17	20	24	45	74
June	4	18	37	44	47	55	80	117
July	9	16	30	40	41	49	74	118
August	2	9	18	22	24	28	46	109
September	1	5	11	14	15	17	26	63
Annual	<1	3	7	11	17	18	53	118

Table 6 Monthly distribution of daily local, unregulated Cayoosh inflows in m^3/s (1964-2001).

Month	Min	5%	30%	50%	Mean	70%	95%	Max
October	2	4	7	9	10	11	21	57
November	1	4	6	8	10	10	21	57
December	0	3	5	6	7	7	11	72
January	0	2	4	5	5	5	10	24
February	0	2	4	4	4	5	8	13
March	0	1	4	4	5	5	8	30
April	2	4	5	6	8	8	19	53
May	4	8	18	27	32	39	73	143
June	6	30	47	59	63	72	109	211
July	7	25	35	43	47	52	84	125
August	6	11	17	22	25	29	49	99
September	3	5	9	12	13	14	27	76
Annual	<1	3	6	9	19	19	68	211

Table 7 Monthly distribution of daily Cayoosh Diversion flows in m³/s (2000-2008).

Month	Min	5%	30%	50%	Mean	70%	95%	Max
October	2	4	6	9	10	12	25	33
November	0	4	6	8	8	10	14	27
December	1	2	4	5	6	7	10	16
January	1	2	3	4	5	5	11	23
February	0	1	3	3	4	4	7	15
March	0	0	3	3	4	5	10	14
April	2	3	5	7	9	10	17	35
May	1	5	13	18	18	23	33	41
June	1	10	23	25	25	30	34	46
July	2	12	22	25	25	28	36	39
August	6	9	13	15	16	18	27	38
September	2	5	8	9	10	11	15	19
Annual	<1	2	5	9	12	14	32	100

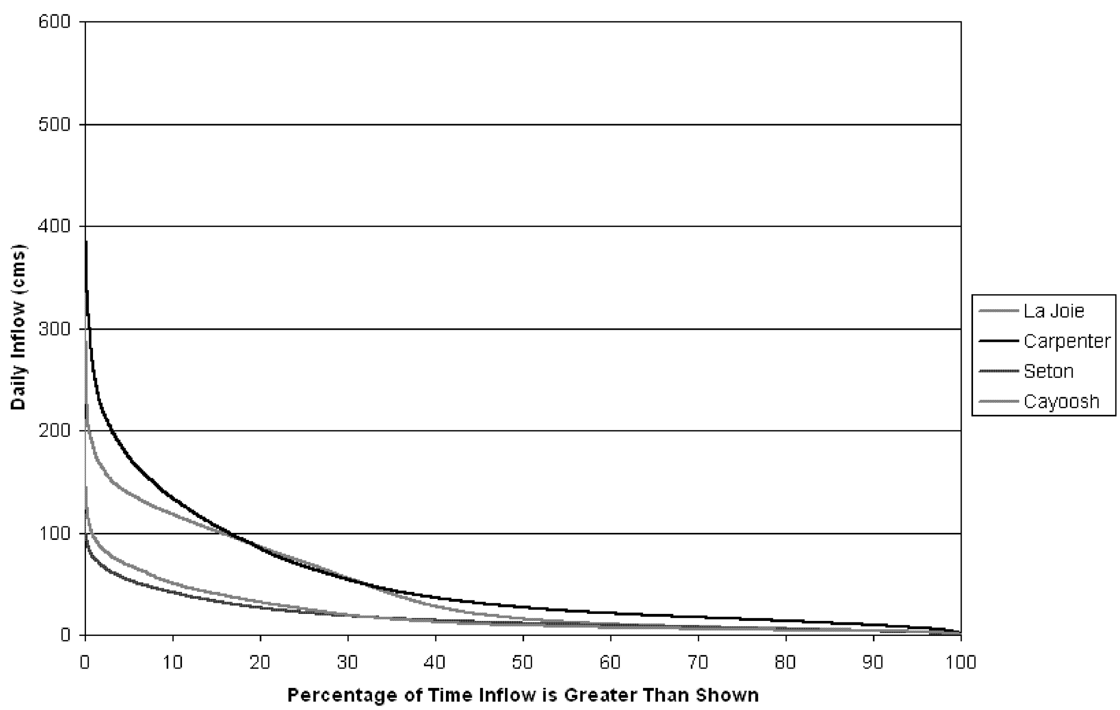

Figure 24 Duration curves of daily local, unregulated inflows to the Bridge River reservoirs (1964-2008).

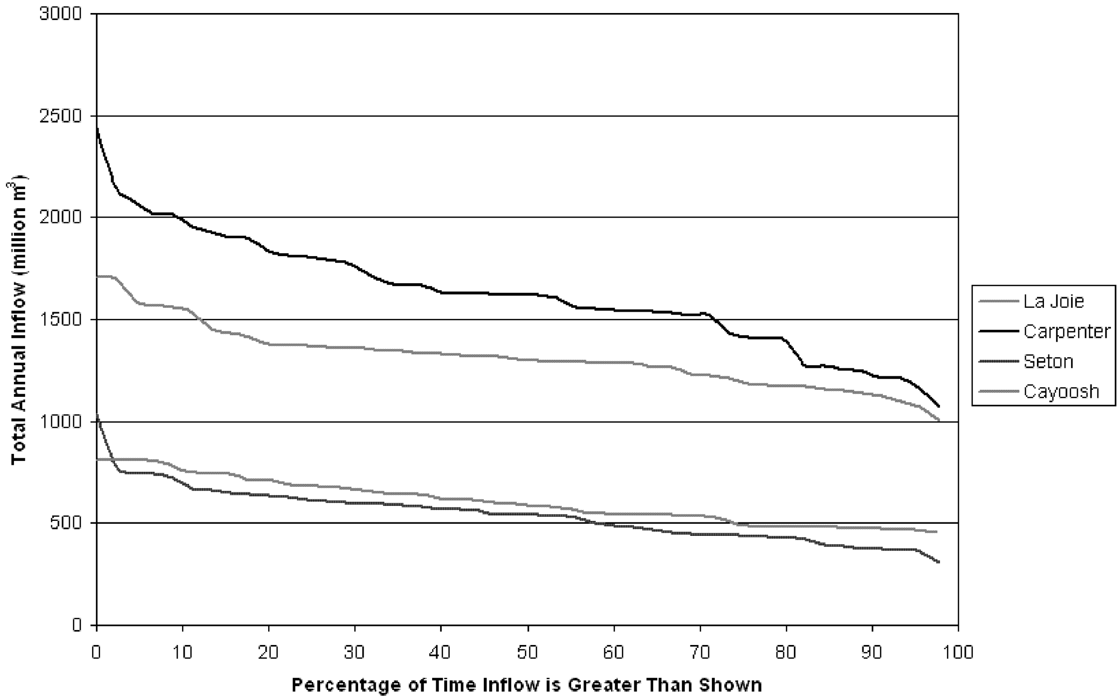

Figure 25 Duration curve of annual local, unregulated inflows to the Bridge River reservoirs (1964-2008).

7.3 Inflow Design Floods

The Inflow Design Flood (IDF) for La Joie Dam is the Probable Maximum Flood (PMF) and has a peak 6-hour inflow of 2165 m^3/s (Stewart, 2008).

The IDF for Terzaghi Dam is the PMF. The PMF has a peak 6-hour inflow of 5583 m^3/s (Stewart, 2004).

The IDF for the Seton power canal is the PMF and has a peak 6-hour inflow of 1070 m^3/s (Oswell, 2008). The IDF for Seton Dam is 50% of the PMF, corresponding to 535 m^3/s. Similarly, fully opened spillway radial gates and siphons are designed to pass 50% of the PMF.

7.4 Hydrologic Impacts of Land Cover and Climate Change

Bridge Glacier is located at the headwaters of the Bridge River in the La Joie basin. Figure 26 shows that the Bridge Glacier terminus retreated by approximately 1300 m since 1964, or approximately 32 m/year (Allen and Smith 2007). Bridge Glacier's response is in line with the regional response of southern British Columbia glaciers. The general findings of widespread glacier retreat are confirmed by Bolch at al. (2010), who determined a loss in BC's glacier coverage of 12% from 1985 to 2005.

Stahl and Moore (2006) analyzed the hydrologic impacts of glacier retreat on streamflow in BC for the historical period. After eliminating the effects of interannual climatic variations, negative trends in August discharge for most glacier-fed rivers in BC, particularly from 1976 to 1996 and for southern basins, were found. These are consistent with the effects of glacier mass and area loss.

For the future, Stahl et al. (2008) show that, due to the lagged glacier response time to changes in the climate, the Bridge Glacier will, even if the climate remained unchanged from recent years, decrease in area by a further 20% over the next 50 to 100 years and will result in a corresponding further decrease in late-summer streamflow. When warming scenarios were considered, the glacier retreated even more rapidly and did not reach equilibrium with the climate within the 100 year study period, but continued to shrink.

At the time of writing, quantitative predictions of the combined hydrologic impacts of climate and land cover changes for the Bridge River BC Hydro basins were not available. Much of the hydrologic long-range predictions for the Bridge River basins remain of a qualitative nature. General Circulation Model predictions indicate that the 2050s will be warmer across all seasons and possibly somewhat wetter overall. Specifically, winters will likely be wetter, while summers will be drier. It should be noted, however, that the confidence in temperature predictions is greater than the confidence in precipitation predictions.

Studies to date suggest that – in general - the effect on flow timing will likely be larger than the effect on the magnitude of total annual inflow, although currently highly glacierized basins may be an important exception. It is expected that with warmer winter temperatures a larger fraction of winter precipitation will fall as rain, which would consequently lead to increased winter flows. The snowmelt freshet will start and end earlier. The duration of the summer low flow period will, therefore, last longer. Additionally, higher summer temperatures will likely increase summer evapotranspiration and thereby further lower late summer flows. In glacierized basins, such as La Joie, late summer flows are expected to decrease as glaciers continue to shrink or disappear.

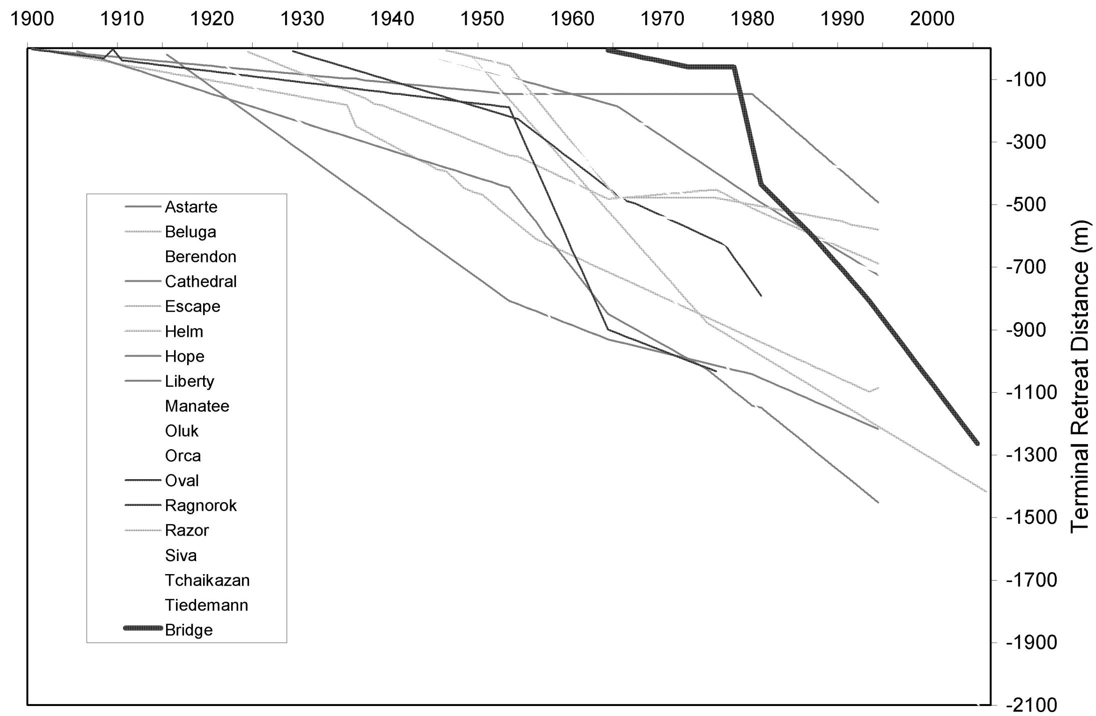

Figure 26 Terminal glacier retreat in southern British Columbia, including Bridge Glacier data (acquired from Dan J. Smith 2010).

7.5 Hydraulic Characteristics of BC Hydro Reservoirs

The licensed storage capacity[16] of BC Hydro's major storage reservoirs is plotted in Figure 27. Amongst those, the storage capacities of Downton and Carpenter Reservoirs rank in the middle. In Figures 28 and 29, mean annual local, unregulated inflow is compared with the licensed storage capacity for BC Hydro's major storage reservoirs. Downton and Carpenter Reservoirs can both store approximately 60% of their local, annual inflow within their licensed storage limits. Seton Lake has very little storage. Its storage capacity is equivalent to about 2% of its local, annual inflow.

[16] **Licensed storage** is the amount of storage capacity in a reservoir between the minimum and maximum water license elevations. Normal operating elevations will often differ from these values and can vary throughout the year resulting in different associated storage values.

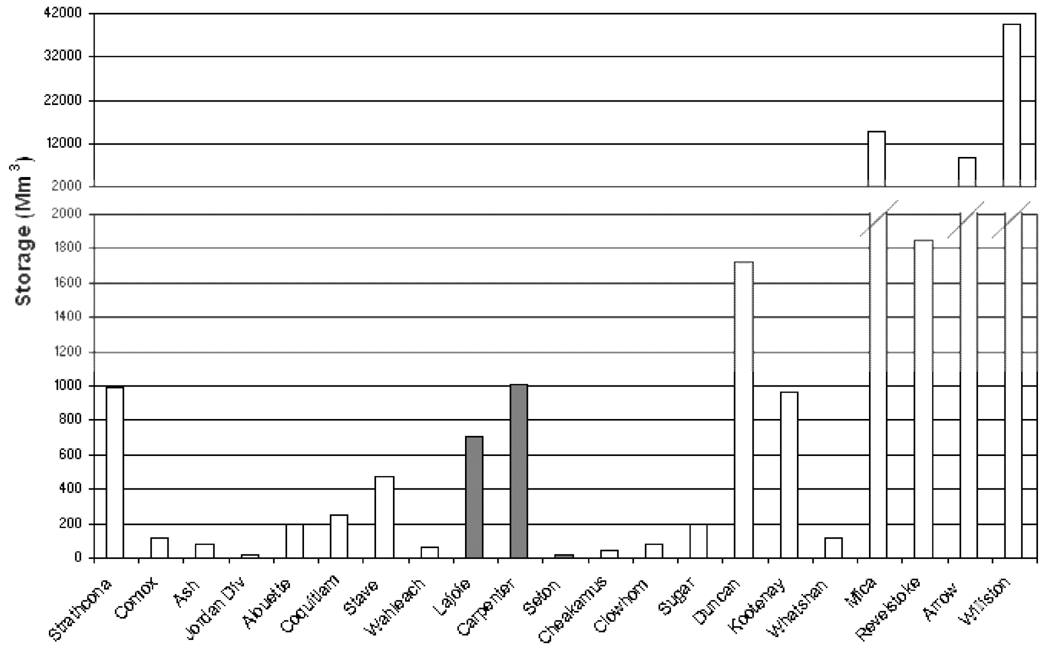

Figure 27 Comparison of reservoir storage throughout BC Hydro's system. Storage is based on licensed water storage volume.

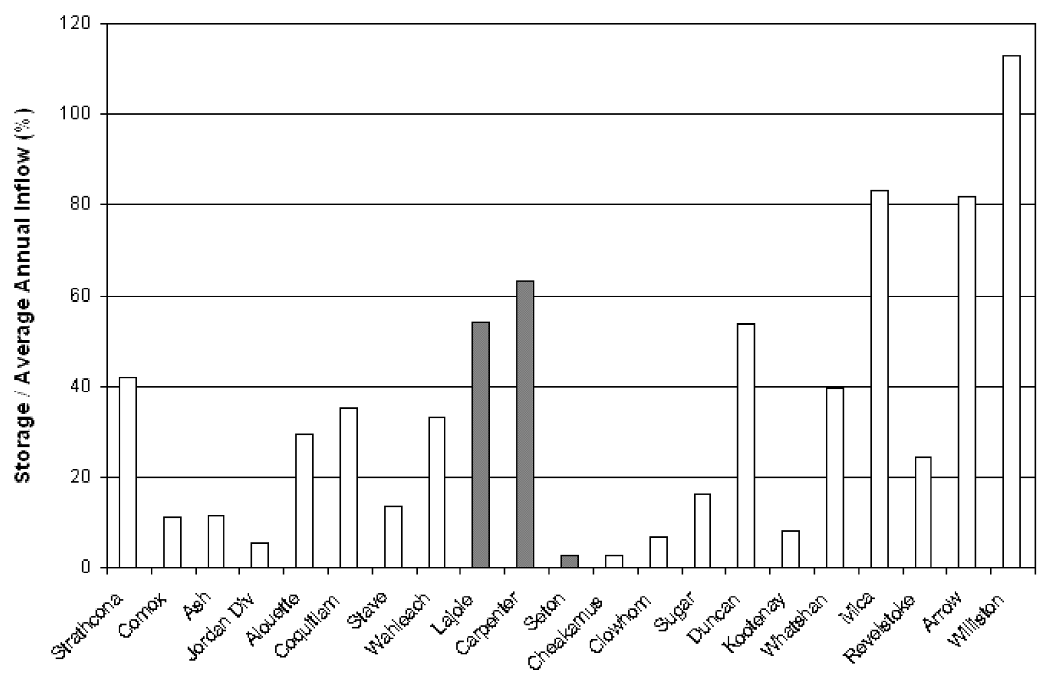

Figure 28 Comparison of the capacity of BC Hydro reservoirs to store a year of local, unregulated inflow. Storage is based on licensed water storage volume.

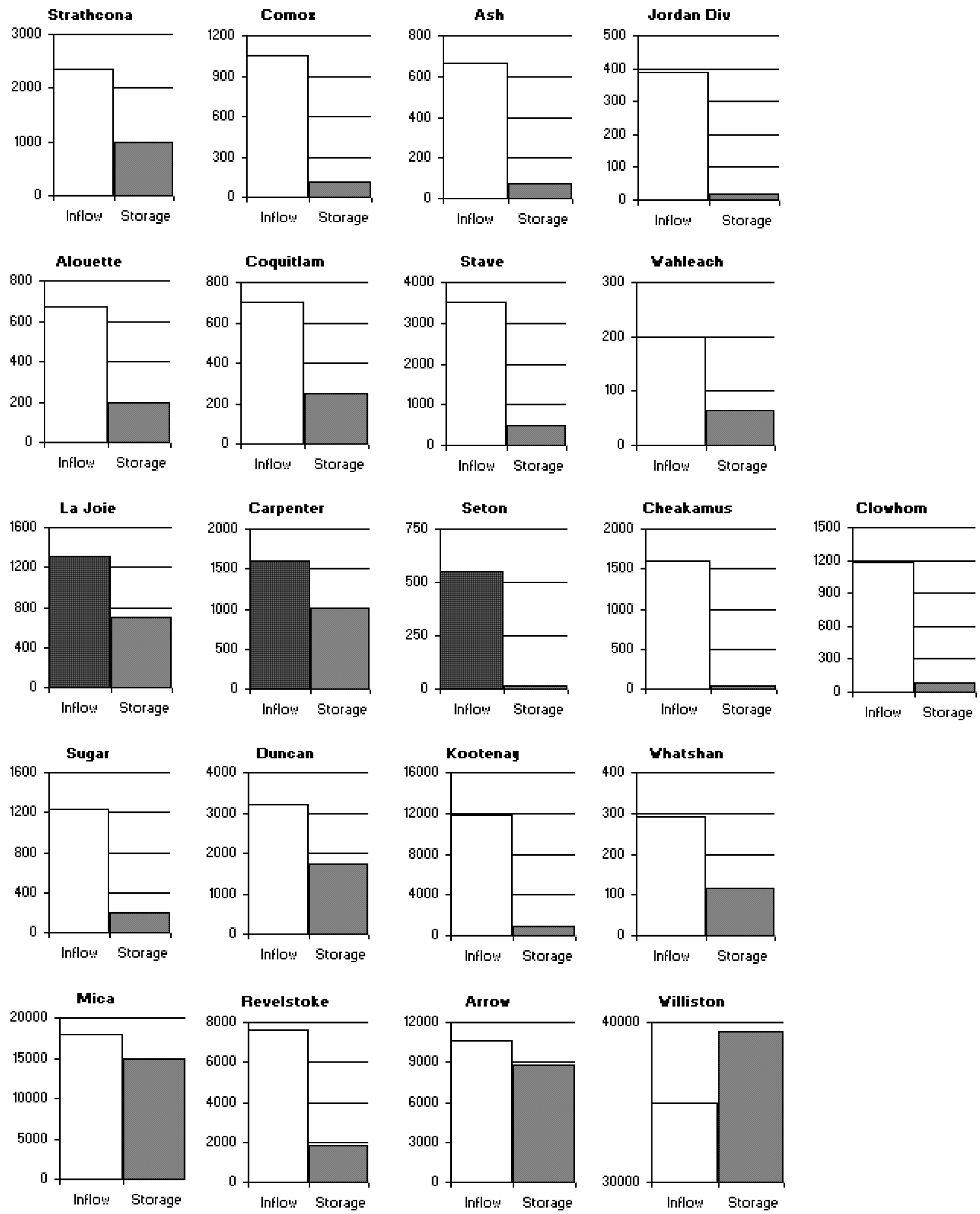

Figure 29 Mean annual local, unregulated inflow volume (1971-2000) into and licensed reservoir storage volume of major BC Hydro's reservoirs in millions of cubic meters.

8 Inflow Forecasting

BC Hydro Generation Resource Management's Runoff Forecasting group produces operational hydrologic short-range and long-range seasonal inflow forecasts for the Bridge River projects.

8.1 Short-range Inflow Forecasts

Forecasts of daily (midnight-to-midnight) inflows for up to seven days into the future are produced using the process-based, semi-distributed UBC Watershed Model. The model requires observed and forecast daily precipitation and daily minimum and maximum temperature data to simulate inflows. Forecast skill is derived primarily from skillful weather forecasts (e.g., forecasts from the Canadian Meteorological Center's Global Environmental Model), but also from knowing the hydrologic conditions in the basin at the time the forecast is issued. These hydrologic conditions include variables such as mountain snowpack, soil moisture and baseflow. The current short-range forecast system only issues deterministic forecasts, but is in the process of being expanded into a probabilistic forecast system. Forecasts are typically issued before 12 pm of each working day for the La Joie and Carpenter projects. Short-range inflow forecasts for the Seton project are planned to be available by the end of 2011.

8.2 Long-range Seasonal Inflow Forecasts

Water supply (also 'long-range' or 'seasonal') forecasts are made at the beginning of every month, from November to August, for all BC Hydro Bridge River projects and for Cayoosh Creek. Forecasts issued in November, December, and August are labelled 'outlooks', whereas those issued in other months are labelled 'forecasts', with the latter term denoting a higher level of confidence in the forecasts. The overall emphasis is on predicting total inflow volumes over the upcoming February-September period.

Two techniques are used and yield probabilistic forecasts: one technique is based on statistical hydrologic models (specifically, principal components regression) and the other is based on the process-based UBC Watershed Model, run in an Ensemble Streamflow Prediction (ESP) framework. Water supply forecasts mainly reflect the hydrologic conditions in the basin as of the forecast date, including mountain snowpack, and proxies thereof, such as soil moisture and antecedent flows. In some cases, statistical forecasts also incorporate climate information from the El Niño Southern Oscillation as a predictor.

9 References

Allen, S.M. and D.J. Smith (2007), Late Holocene glacial activity of Bridge Glacier, British Columbia Coast Mountains. *Canadian Journal of Earth Sciences.*, 44, 1753-1773.

Bolch, T., B. Menounos and R. Wheate (2010), Landsat-based inventory of glaciers in western Canada, 1985 - 2005. *Remote Sensing of Environment*, 114, 127-137.

Cannings, R. and S. Cannings (1996), British Columbia – A Natural History. Greystone, Vancouver, BC.

Daly, C., W.P. Gibson, G.H. Taylor, G.L. Johnson and P. Pasteris (2002), A knowledge-based approach to the statistical mapping of climate. *Climate Research*, 22, 99-113.

Holland, S.S. (1976), Landforms of British Columbia – A Physiographic Outline. Province of British Columbia, Victoria, B.C.

Homenuke, M. (2002), Bridge River WUP - Hydrology of Bridge River Basin. Internal BC Hydro report from January 3, 2002, PSE 151.0.

Massey, N.W.D., D.G. MacIntyre, P.J. Desjardins, R.T. Cooney (2005), Digital Geology Map of British Columbia: Whole Province. Province of British Columbia, Victoria, BC. http://www.em.gov.bc.ca/mining/Geolsurv/Publications/catalog/bcgeolmap.htm

Mathews, B. and J. Monger (2005), Roadside Geology of Southern British Columbia. Mountian Press Publishing Company, Missoula, Montana.

Mokievsky-Zubok, O., C.S.L. Ommanney, J. Power (1985), NHRI glacier mass balance 1964-1984 (Cordillera and Arctic). Glacier Section, Surface Water Division, National Hydrology Research Institute Internal Report.

Oswell, M.T. (2008), Seton Dam – Operation, Maintenance and Surveillance Manual for Dam Safety. Internal BC Hydro report from May 2008, Report No. OMSSON.

Ritter, M.E. (2006), The Physical Environment: an Introduction to Physical Geography. http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/title_page.html, accessed February 2010.

St. Clair, C. (2009), Canada's Weather. Firefly, New York, N.Y.

Stahl, K. and R.D. Moore (2006), Influence of watershed glacier coverage on summer streamflow in British Columbia, Canada. *Water Resources Research*, 42, W06201.

Stahl, K., R.D. Moore, J.M. Shea, D. Hutchinson and A.J. Cannon (2008), Coupled modelling of glacier and streamflow response to future climate scenarios. *Water Resources Research*, 44, W02422.

Stewart, R.A. (2008), La Joie Dam – Operation, Maintenance and Surveillance Manual for Dam Safety. Internal BC Hydro report from April 2008, Report No. OMSLAJ.

Stewart, R.A. (2004), Terzaghi Dam – Operation, Maintenance and Surveillance Manual for Dam Safety. Internal BC Hydro report from March 2004, Report No. OMSTRZ.

Trail Ventures BC (2009), Southern Chilcotin Mountains – Flora. http://www.trailventuresbc.com/scm/fl/fl.html, accessed December 2009.

Wang, T., A. Hamann, D. Spittlehouse and S.N. Aitken (2006), Development of scale-free climate data for western Canada for use in resource management. *International Journal of Climatology*, 26 (3), 383-397

Prepared by: Scott Weston

S. Weston, M.Sc.

Reviewed by: Frank Weber

F. Weber, M.Sc., P.Geo.

Appendix 2
Summary of WUP Monitoring and Physical Works

Summary of Estimated Program Costs for the Bridge River WUP Program

DECEMBER 2010 BRIDGE WUP
Preliminary Estimate 10 Year Monitoring and Works Program

Program ID	Program Name	Total ($Nominal)
MON 1	Lower Bridge River Aquatic Monitoring	$ 1,810,745
MON 2	Carpenter Reservoir Riparian Vegetation Monitoring	$ 293,372
MON 3	Lower Bridge River Adult Salmon and Steelhead Enumeration	$ 1,781,764
MON 4	Middle Bridge River and Carpenter Fish Habitat and Population Monitoring	$ 1,321,123
MON 5	Downton Reservoir Riparian Vegetation Monitoring	$ 114,694
MON 6	Seton Lake Productivity Monitoring	$ 514,850
MON 7	Downton Reservoir Fish Habitat and Population Monitoring	$ 853,037
MON 8	Seton Lake Fish and Fish Habitat Monitoring	$ 900,847
MON 9	Seton River Habitat and Fish Monitoring	$ 821,477
MON 10	Carpenter Reservoir Productivity Model Validation and Refinement	$ 412,412
MON 11	Lower Bridge River Riparian Vegetation Monitoring	$ 191,842
MON 12	Bridge-Seton Metals and Contaminant Monitoring	$ 377,327
MON 13	Seton River Sockeye Smolt Enumeration Program	$ 1,880,643
MON 14	Seton Adult Fish Passage Monitoring Program	$ 2,106,850
MON 15	Seton Lake Erosion Mitigation Program	$ 402,774
MON 16	Lower Bridge River Spiritual and Cultural Value Monitoring	$ 435,395
WORKS 1	Carpenter Reservoir Drawdown Zone Re-Vegetation Program	$ 667,663
WORKS 2	Seton Lake Erosion Control	$ 1,430,646
	Total	$ 16,317,463