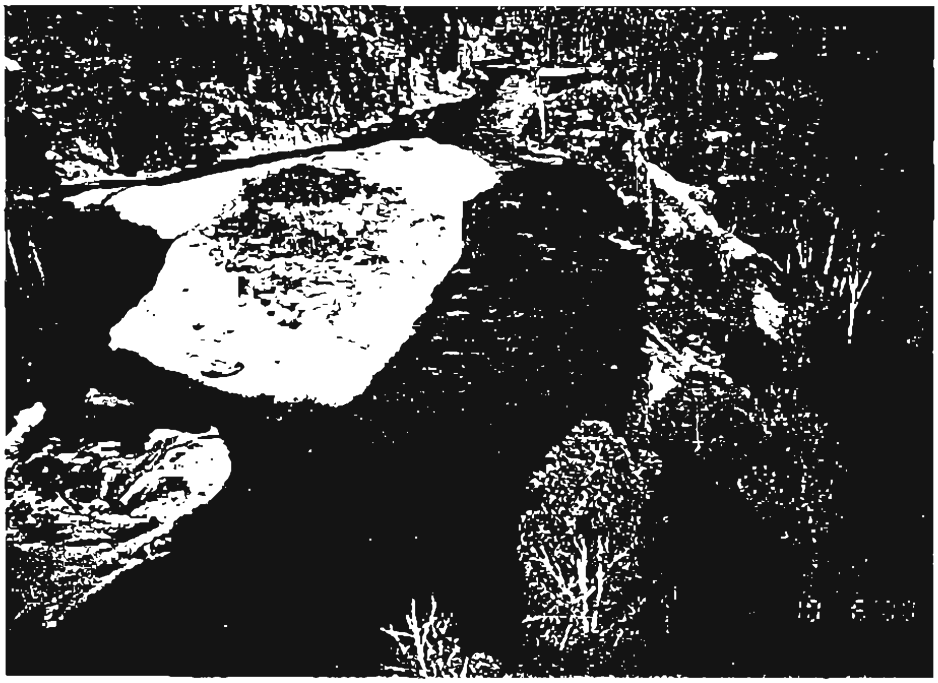
Shuswap River Fish/Aquatic Information Review



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1.0 INTRODUCTION

ARC Environmental Ltd. (ARC) has been contracted by British Columbia Hydro (BCH) to review fish and aquatic information on the Shuswap River as part of the Water Use Plan (WUP) initiated for the Shuswap River system. Following the direction of the terms of reference the project area has been separated into four separate units; Mara Lake to the outlet of Mabel lake, Mabel Lake from its outlet to Wilsey Dam, Wilsey Dam to Sugar lake Dam and upstream of Sugar Lake (Figure 1). This has been done to take into account the varying influences of B.C. Hydro's hydroelectric operations on the different geographical areas throughout the watershed. The report will first provide a general overview that includes study objectives and resource use within the Shuswap system as a whole. Following this general overview, a more detailed discussion for each of the four geographical areas will be presented. Finally, the report will provide a discussion of information gaps relative to the Water Use Planning Process, as well as a list of recommended studies to be undertaken to fill these gaps in information.

Objectives:

The objectives of the Shuswap River Fish/Aquatic Information review were to:

- Conduct a comprehensive and thorough search of all documented literature and file information on fish, fish habitat, water quality and hydro-fish interactions in the Shuswap River watershed above Mara Lake,
- Thoroughly review and summarize the current knowledge searched in "Objective 1" into a succinct useable document, and
- Based on expert interpretation, clearly identify outstanding knowledge gaps and provide well-considered recommendations to close any critical gaps identified which would lead to greater understanding of hydro-fish interactions/impacts. [1]

[1] Note: The interpretations within this report are those of the author. Based on the information presented discussion of gaps and study priorities will be undertaken by the SHU WUP CC. Final priorities for future activities will be identified by this group through this process.

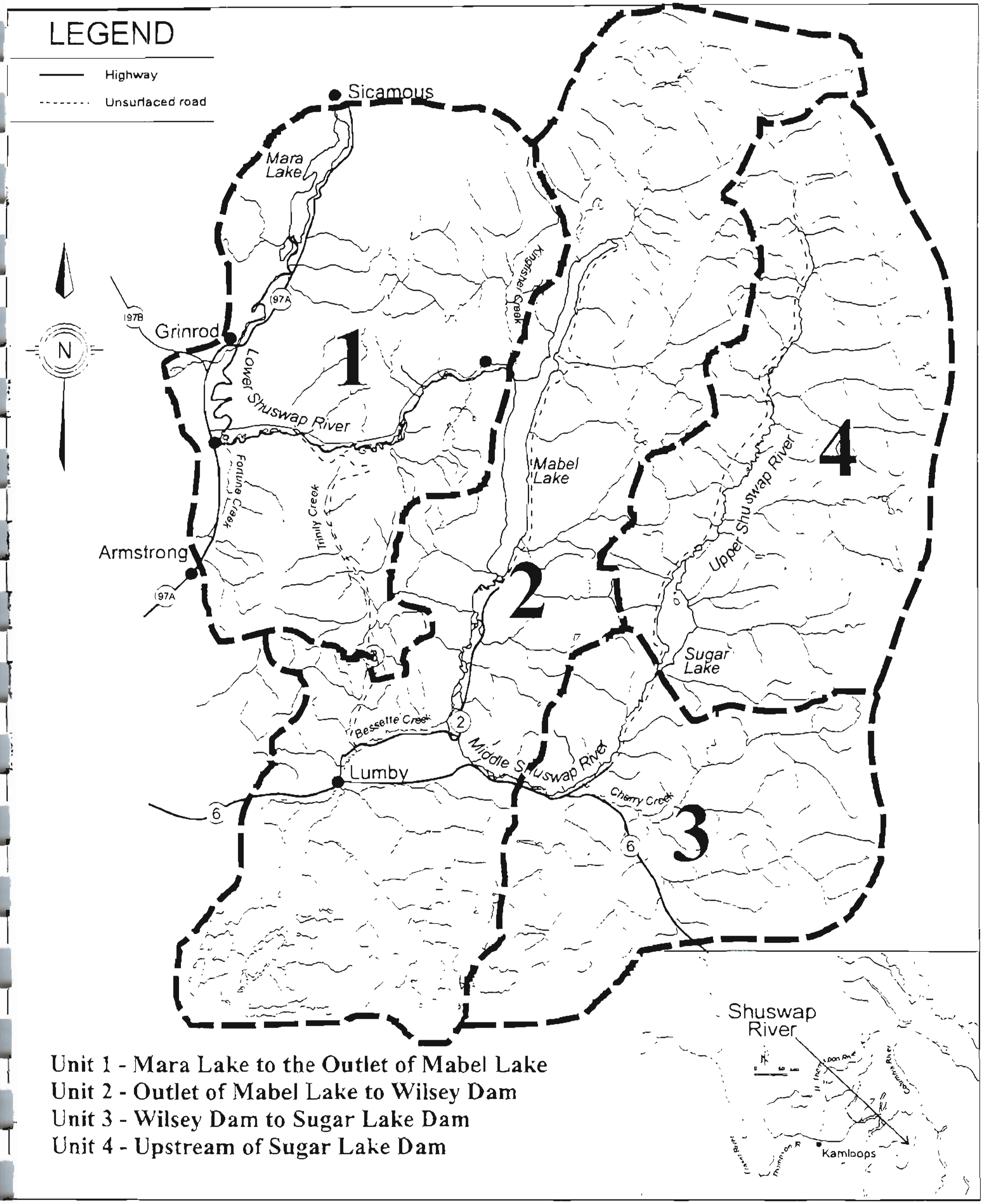


Figure 1. Water Use Planning Units of the Shuswap River Watershed

2.0 BACKGROUND

The Shuswap River, located in south-central British Columbia, flows from it's headwaters in the Monashee mountains through, Sugar Lake, Mabel Lake and Mara Lake before entering into Shuswap Lake at Sicamous, B.C. The Shuswap River has been identified as three separate sections; the Lower Shuswap River from Mabel Lake downstream to Mara Lake, the Middle Shuswap River, from Sugar Lake downstream to Mabel Lake and the Upper Shuswap River from Sugar Lake to the headwaters (Figure 1).

BC Hydro owns and operates two dams and a generating station on the Middle Shuswap River above Mabel Lake. The hydro facilities were constructed by the West Canadian Hydroelectric Corporation in 1929 and acquired by BC Hydro in 1962. The hydroelectric system consists of a small storage reservoir (Sugar Lake) which was created by the Sugar Lake Dam (Peers Dam). The Sugar Lake Dam raised the previous lake level by approximately 8 meters. Control of water releases through the system takes place at the Sugar Lake Dam. Wilsey Dam located 29 km downstream of Sugar Lake creates a small headpond and water is either released through the generating station or over the spillway or a combination thereof.

The Middle Shuswap River then travels approximately 18 km before entering into Mabel Lake. Major contributions to flows upstream of Wilsey Dam come from Cherry, Ferry, Holstein and Reiter Creeks, with smaller contribution from other tributaries. Major tributaries downstream of the Wilsey Dam include Bessette, Ireland and Big Creeks. Other smaller streams contribute some inflow to the system. The Lower Shuswap River has a length of approximately 89 km from its origin at Mabel Lake to its outlet at Mara Lake. Tributary inflows are contributed primarily from Kingfisher, Danforth and Trinity Creeks, with lesser contributions from Ashton, Blurton, Brash, Cooke, Fortune, and Johnson Creeks.

In addition to electric generation, the Shuswap hydroelectric system is operated in order to address environmental and flood control issues. On average, Sugar Lake Reservoir is at its lowest level at the end of April and is filled during spring freshet. The reservoir elevation is maintained throughout the summer recreational periods and then drawn down over winter. Freshet flows, stored in the reservoir, are used to augment downstream flows during the winter months, which are used for incubation of fish embryos and alevins, as well as for power generation.

Anadromous salmon, (chinook, sockeye, and coho) utilize the Shuswap River upstream to Wilsey Dam, as well as variable use in tributary systems (FHIIP 1990). Anecdotal information (French 1995) suggest that chinook salmon were able to access the Middle Shuswap River upstream to Wilsey Dam prior to its construction. Current fish use upstream of the Wilsey Dam includes rainbow trout, bull trout and mountain whitefish. Sugar Lake supports a population of introduced kokanee salmon as well as native rainbow trout and bull trout. In addition to salmonids numerous other fish species utilize the Shuswap River system to varying degrees (Table 1)

Resource use in the Shuswap system includes logging, recreational activities, and agriculture throughout most of the drainage. Forestry is the major resource use in the upper portion of the drainage above Sugar Lake. Agricultural activity is limited upstream of the Sugar Lake Dam, increasing slightly in the Middle Shuswap upstream of the Wilsey Dam, and reaching high levels of activity along the Shuswap River and its tributaries downstream of the Wilsey Dam (DFO 1997). In addition to agricultural activity, other resource use activities increase with distance downstream. Valley flat areas along the mainstem below Wilsey dam, and associated tributary systems, have experienced heavy resource use activity. This has resulted in increasing water withdrawals, decreasing water quality, as well as habitat impacts associated with land clearing (DFO 1997).

Table 1: Fish Species Present in the Shuswap River System.

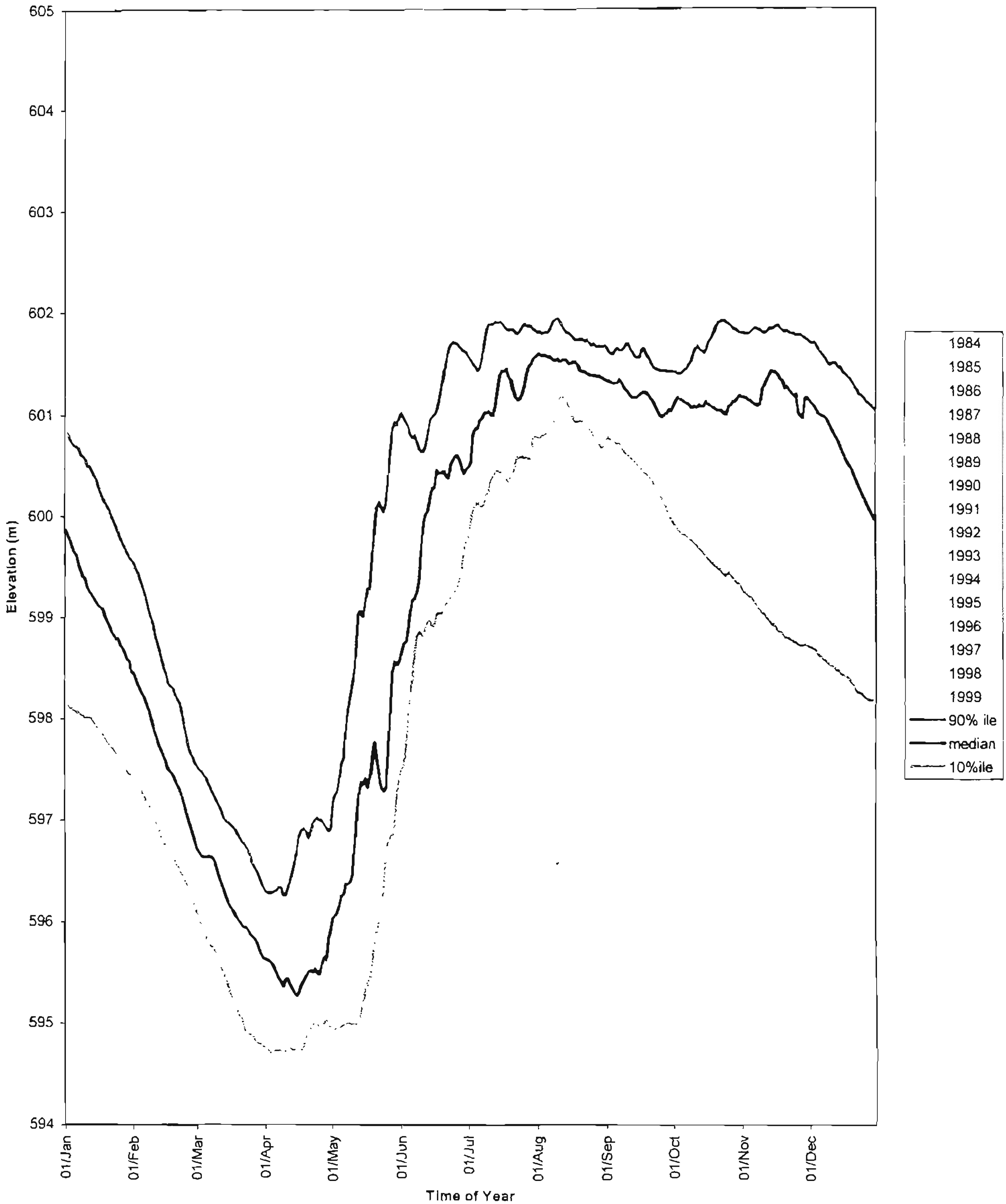
Area	Latin	Common	Reference
Sugar Lake (and tributaries)	*Onchorhynchus mykiss*	Rainbow trout	Lister 1990
	Salvelinus confluentus	Bull trout	Kloho-Coppen, 1998
	Onchorhynchus nerka	Kokanee	ARC, 2000
	Prosopium williamsoni	Mountain whitefish	FISS
	Lota lota	Burbot	
	Onchorhynchus clarki	Cutthroat trout	
	Rhinichthys cataractae	Longnose dace	
	Richardsonius balteatus	Redside shiner	
	Cottus cognatus	Slimy sculpin	
	Cottus asper	Prickly sculpin	
	Catostomus machrocheilus	Largescale sucker	
Middle Shuswap Upstream of Wilsey Dam	*Onchorhynchus mykiss*	Rainbow trout	Griffiths, 1979
	Salvelinus confluentus	Bull trout	Fee and Jong, 1984
	Prosopium williamsoni	Mountain whitefish	Triton 1995
	Rhinichthys cataractae	Longnose dace	FISS
	Richardsonius balteatus	Redside shiner	
	Cottus cognatus	Slimy sculpin	
	Cottus asper	Prickly sculpin	
	Rhinichthys falcatus	Leopard dace (unconfirmed)	
	Catostomus machrocheilus	Largescale sucker	
	Onchorhynchus clarki	Cutthroat trout (historic, no recent captures)	
	Onchorhynchus tshawytscha	Chinook historic/introduced	
Middle Shuswap Downstream of Wilsey Dam	*Onchorhynchus tshawytscha*	Chinook	Fee and Jong, 1984
	Onchorhynchus kisutch	Coho	Envirocon, 1984
	Onchorhynchus nerka	Sockeye	Envirocon, 1989
	Onchorhynchus nerka	Kokanee	FISS
	Onchorhynchus mykiss	Rainbow trout	
	Salvelinus confluentus	Bull trout	
	Ptychocheilus oregonesis	Northern pikeminnow (formerly squawfish)	
	Richardsonius balteatus	Redside shiner	
	Mylocheilus caurinus	Peamouth chub	
	Catostomus macrocheilus	Largescale sucker	
	Cottus asper	Prickly sculpin	
	Rhinichthys cataractae	Longnose dace	
	Prosopium williamsoni	Mountain whitefish	
	Lota lota	Burbot	
Mabel Lake	*Onchorhynchus tshawytscha*	Chinook	FISS
	Onchorhynchus kisutch	Coho	Envirocon, 1989
	Onchorhynchus nerka	Sockeye	Jantz, 1986
	Onchorhynchus nerka	Kokanee	
	Onchorhynchus mykiss	Rainbow trout	
	Salvelinus confluentus	Bull trout	
	Ptychocheilus oregonesis	Northern Pikeminnow (formerly squawfish)	
	Richardsonius balteatus	Redside shiner	
	Mylocheilus caurinus	Peamouth chub	
	Catostomus macrocheilus	Largescale sucker	
	Cottus asper	Prickly sculpins	
	Rhinichthys cataractae	Longnose Dace	
	Prosopium williamsoni	Mountain whitefish	
	Lota lota	Burbot	
	Salvelinus namaycush	Lake trout	
Middle Shuswap Downstream of Mabel Lake	*Onchorhynchus tshawytscha*	Chinook	DFO, 1982
	Onchorhynchus kisutch	Coho	FISS
	Onchorhynchus nerka	Sockeye	Envirocon, 1989
	Onchorhynchus nerka	Kokanee	
	Onchorhynchus mykiss	Rainbow trout	
	Salvelinus confluentus	Bull trout	
	Ptychocheilus oregonesis	Northern Pikeminnow (formerly squawfish)	
	Richardsonius balteatus	Redside shiner	
	Mylocheilus caurinus	Peamouth chub	
	Catostomus macrocheilus	Largescale sucker	
	Cottus sp.	Sculpins	
	Rhinichthys cataractae	Longnose Dace	
	Prosopium williamsoni	Mountain whitefish	
	Cyprinus carpio	Carp	
	Salvelinus namaycush	Lake trout	
	Rhinichthys falcatus	Leopard dace (unconfirmed)	

BC Hydro Operations

The Sugar Lake (Peers) Dam was constructed at the outlet of Sugar Lake on the former site of Brenda Falls. The reservoir provides storage for hydroelectric generation downstream at Wilsey Dam through out the year. Sugar Lake is approximately 11.5 km long and varies in width from 1 – 4 km. The reservoir is typically operated to be at its lowest level in April and full pool in mid summer (Figure 2). Inflows Maximum draft of the reservoir is 7.8 meters. Current operation of the Sugar Lake Dam increases mean fall and winter outflows by approximately 45% (August to March) and decreases spring freshet by approximately 11%, as compared to pre development flows (Figure 3c). The Sugar lake reservoir has the capacity to store only 13.4% of mean annual flow. Once storage is reached the outflows at the Dam equal the inflows to the reservoir through the summer and early fall. During the late fall and winter reservoir inflows are less than outflows. Discharge facilities presently consist of four sluiceways and an overflow spillway with 14 bays. Each bay crest in the overflow spillway can be raised from 600.00 to 601.52 meters with the addition of stop logs. The overflow spillway is used annually to pass spring freshet discharges. After runoff peaks (May – June), the reservoir level follows a recession and typically reaches the level of the stop logs by July. Current Stop Log Operation Guidelines are provided in Table 2. Normally the first stoplogs are put in place from mid April to mid June. The last two (4th and 5th) stoplogs are usually put in place after July 1st. When 5 stoplogs are in place the reservoir alert level is 601.65. Management of levels to 601.65 is accomplished though gate operation. If alert level is exceeded with all gates wide open stoplogs 4&5 must be removed before a reservoir level of 601.80 is reached.

Reservoir storage (releasing less water from the dam than is entering Sugar lake) typically commences in early June and full pool is maintained until late fall. During storage, filling rate is maintained by adjusting the sluice gates. During peak inflows the gates are fully open, however inflows exceed release capacity and rapid filling of the reservoir takes place.

Figure 2. Sugar Lake Reservoir Elevations (1984-1999)



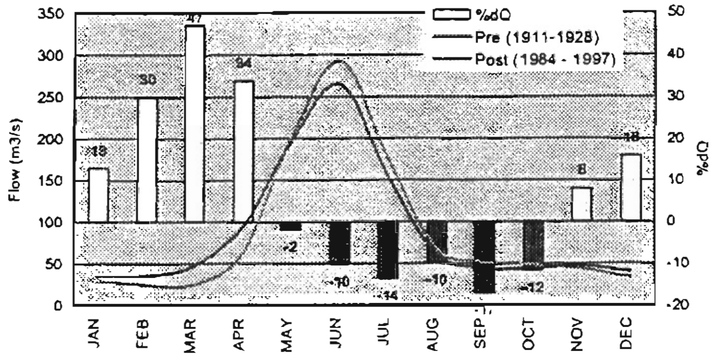


Figure 3a: Shuswap River Downstream Mabel Lake:
Pre and Post regulation mean monthly flows (Sherbot, D. BCH)

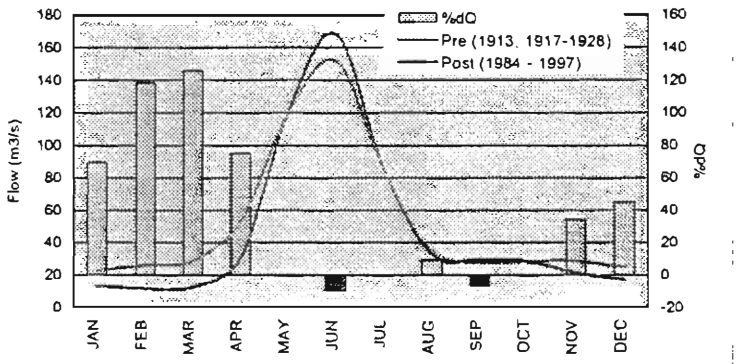


Figure 3b: Shuswap River Downstream Wilsey Dam:
Pre and Post regulation mean monthly flows) (Sherbot, D. BCH)

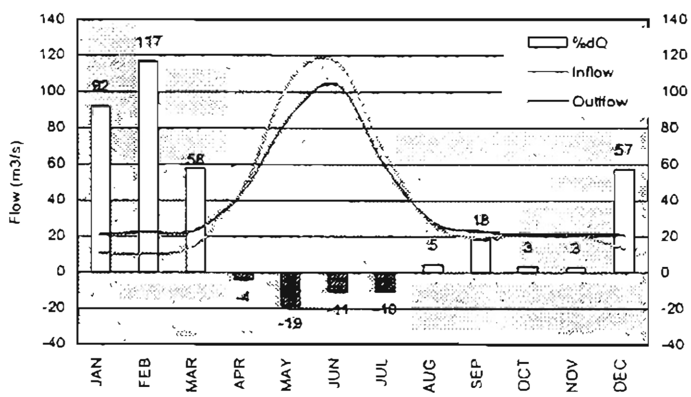


Figure 3c: SGR Mean Monthly Inflows and Outflows (1984-1998)(Sherbot, D. BCH)

Table 2. Current Stop Log Operation Guidelines (prepared by K. Meidal, BCH. 2000).

	MAX	Stop Logs	
15 April - 15 June	0 – 2	Depending on snowpack	El. 600.00 - 600.61 m
15 June - 30 June	3	install after peak of freshet has passed	El. 600.91 m
after 01 July	4	Provided daily inflows are < 85 m^3/s due to snow pack depletion	El. 601.21 m
after 01 July	5	Provided daily inflows are < 50 m^3/s due to snow pack depletion	El. 601.52 m When 5 stop logs are in place, the Reservoir Alert Level is 601.65 m. Crews go to site and operate gates to maintain level below 601.65 m. If 601.70 m is reached with all gates wide open, stop logs 4 & 5 must be removed before 601.80 m is reached.

Power generation in the Middle Shuswap River takes place at the Shuswap Falls Powerhouse immediately below Wilsey Dam. The Wilsey Dam, located 29 km downstream of Sugar Dam was built on the site of Shuswap Falls, a set of extended rapids with maximum head of approximately 21 meters (D.B Lister and Associates 1990). The facility consists of Wilsey Dam, two intake structures and penstocks located at either side of the dam, and an overflow concrete weir (spillway). Spillway crest elevation is 444.52 meters, however this can be increased to 445.43 meters with the addition of flashboards. The headpond at the Wilsey Dam is small with little storage capacity. Assuming full pool (Level = 445.43 m , Volume + 1009 700 m^3), the headpond could be drained in < 37 minutes if all gates are fully opened and inflows are low (ie winter flows.

A total of 78% of the flow downstream of Wilsey Dam originates above Sugar Lake. The remainder of the flows are contributed from the local tributaries. Flows entering from the tributaries, principally Cherry and Ferry Creek, typically start to increase in April and peak in June (Figure 4). Flow recession is moderately steep through July.

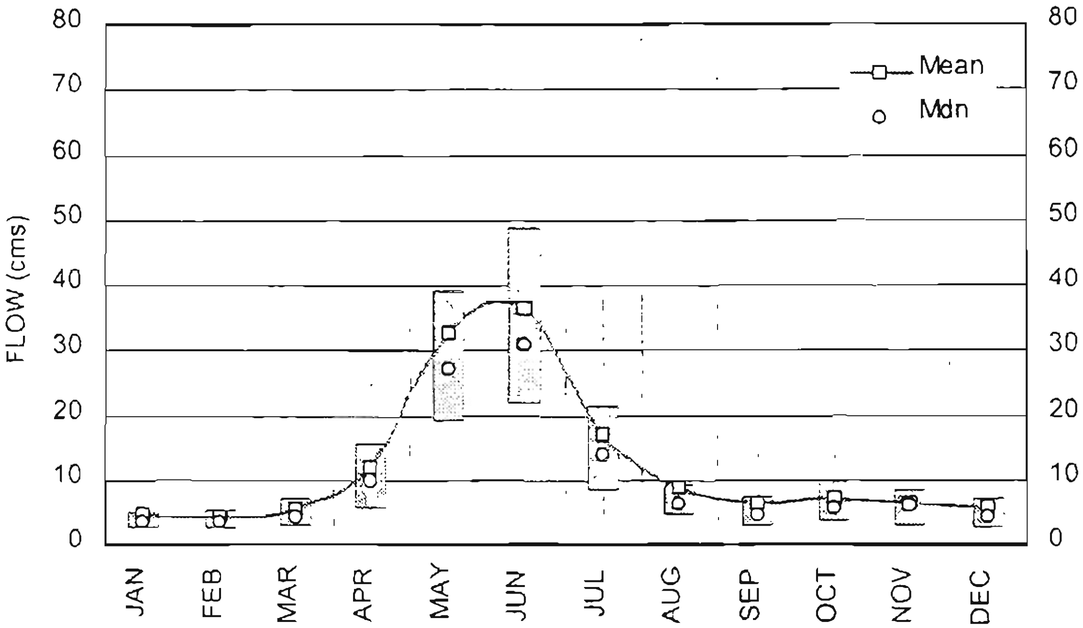


Figure 4: Middle Shuswap Inflows
(1927-35, 70-73, 94-86, 90-97)

Downstream Flows

Wilsey Outflow

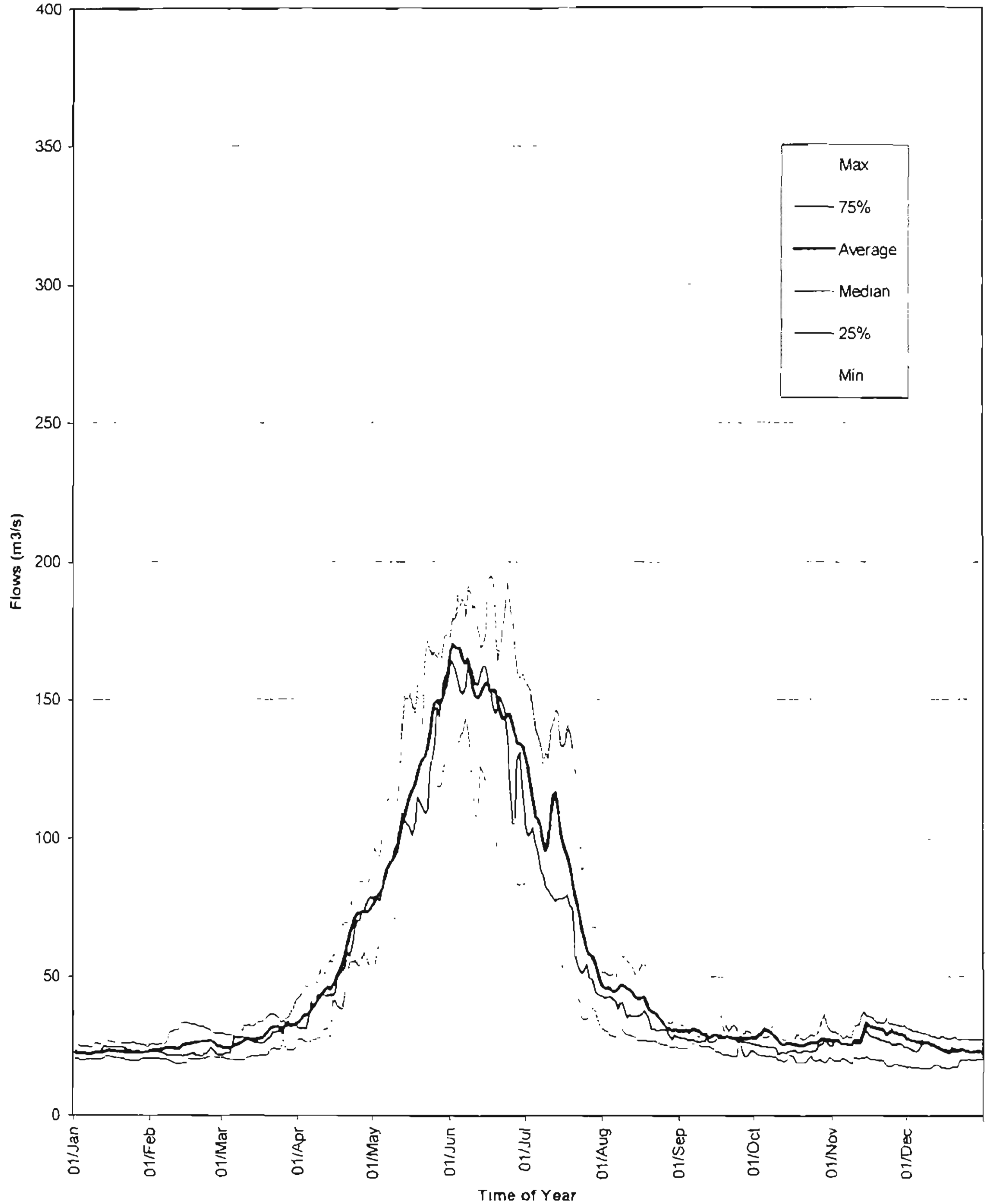
The Wilsey Reservoir is operated to maintain headpond level to allow penstock intakes to be underwater. The Wilsey Reservoir can provide 30 minutes of storage. While there are no formal imposed limits to the rate of filling and/or drawdown of the headpond. Ministry of Environment, Lands and Parks (MoELP), Fisheries and Oceans Canada (FOC), and BCH have agreed to the following releases (BC Hydro 2000):

1) September 15-November 15: Flow >22.7 m^3/sec (802 cfs)
2) All other times: Flow = 15.0 m^3/sec (530 cfs)
3) Flow scenarios, based on forecasting, are presented to MoELP and FOC annually for decision. Inter agency dialogue commences in August to set spawning and overwintering flows. Factors of consideration include inflows to the reservoir, and long term weather forecasts. Dialogue continues through the late summer, fall and winter as information is updated. Both MoELP and FOC must be notified if the flow regime falls or is expected to fall below the annual flow plan.

Flows downstream of Wilsey Dam exhibit the same hydrographic pattern as outflows from Sugar Lake Dam (Figure 5). Current regulated flow patterns demonstrate decreases in peak freshet flows and increases in late fall/winter flows compared to pre-regulated conditions. Natural inflows from tributary systems can produce short term peaks associated with large volume rain events.

Flows in the Lower Shuswap River downstream of Mabel Lake are significantly less influenced by flow management at Sugar Lake. Although 53% of the flow volume in the Lower Shuswap River is contributed from Sugar Lake inflows (1990 – 1998 data) (Webber 2000) only a small fraction can be retained. The pattern of annual discharge is similar to the Middle Shuswap River in that there is a reduction in average peak flows and augmentation of late fall winter flows. During the 1999 – 1998 period peak flows

Figure 5. Wilsey Dam Discharge Summary (1984-1999)



were attenuated by and average of 15% (Range 3-21%) (Webber 2000). Winter flows (February, March and April) can be in excess of 30% greater than pre-regulated flows (Figure 3a).

Fish/Flow Impacts

River systems experience natural variability in flows. In the interior of BC, which includes the Shuswap drainage, snow melt provides the primary source of inflow to the system. Once the snowmelt ends, the river stage follows a natural recession whereby water flows and associated water levels decline through the summer and fall period. Inflows are further decreased through the winter as water is stored as snow.

Fish assemblages develop spawner timing and rearing patterns linked to seasonal habitat availabilities. In the interior of BC, fish have adapted their life history patterns around typical flow/habitat relationships. Maintenance of natural flow patterns is generally believed to be a risk averse approach in regards to flow management. Currently flow pattern, peak flows, and flow recession, in the Shuswap follows the pre-regulation pattern with the exception that augmented fall and winter flows increase the frequency of higher river levels (Figures 3 a, b and c). It should be noted that the data presented on the graphs represent the average of several years of data, which tends to smooth out annual variability Annual variability for reservoir filling and river flows downstream of Wilsey Dam can be seen in Figures 2 and 5. On a year to year basis short term high flows will still occur. Often these short term flow fluctuations are largely contributed to by inflows from unregulated tributaries.

Although flow management in the Shuswap system has resulted in only small changes in annual flow patterns, and increases in winter flows are thought to have potentially benefited downstream fish resources, short term disruption of flows associated with BC Hydro operation can put fish and aquatic resources at risk. Changes in flows at Sugar Lake Dam (Controlled Events) are subjected to ramping rates put in place to manage the risks of downstream stranding of fish. These ramping rates, as discussed later, take into consideration time of year and life history information for fish species within the river.

Short term disruptions can occur due to abrupt gate changes or as a result of unscheduled outages and cessation of power generation (Uncontrolled or Unit Tripping Events). These short term disruptions in flow have the potential to significantly affect water levels in the river which, in turn, can result in stranding fish on gravel bars, isolating them in pools or side channels. Isolated fish may be more susceptible to increased predation and/or changes in water quality. In addition, flow reduction can potentially dewater eggs and ova that have been deposited in the gravel. These operational issues are areas of concern within the Shuswap River system. The effect of these short term flow fluctuations is dependent on the magnitude and the duration of the flow changes, as well as, the time of year. Good management of operational components of the system and a thorough knowledge of fish species and life history (greatest periods of risk) will help reduce risks of impacts due to flow fluctuations.

3.0 METHODS

3.1 Collection of Information

The collection of information can be divided into two categories including: interviews with individuals, and references from libraries, agency memos, world wide web databases, consultant reports, and community group reports.

Personal interviews were collected from individuals from various disciplines including;

- Fisheries and Oceans Canada,
- Ministry of Environment, Lands and Parks,
- BC Hydro,
- First Nations, and
- Community Groups.

Initially a letter and an accompanying response sheet (Appendix A) was sent (e-mailed) to individuals in the above organizations, outlining various objectives of the Water Use Plan (WUP) information review. The *response sheet* consists of several headings including:

1) Contact Information	title and address of the individual;
2) Relevant Information	i) Fish and Fish Habitat Assessments, ii) Water Quality, iii) Hydro-Fish Interactions, and iv) Other;
3) References	references the individual considers useful; and
4) Other Contacts	other people that may have relevant information relating to the WUP Process.

For cases where the response sheet could not be used, or further follow-up was required a telephone or personal interview was conducted. A list of individuals contacted is provided in Appendix B.

A thorough search for information and references relating to the WUP was conducted. Information was collected from libraries and office files including:

- BC Hydro (Burnaby/Vernon);
- Triton Environmental Consultants Ltd;
- Fisheries and Oceans Canada (Kamloops and Salmon Arm);
- Ministry of Environment, Lands and Parks (Penticton and Kamloops); and
- ARC Environmental Ltd.

In addition, several search databases were used including; WAVES, BC Conservation Data Centre, ASFA (American Fisheries Society Database), and the FOC and MoELP maintained Fisheries Information Summary System (FISS). The Ministry of Environment, Lands and Parks web site was also used to search for lake survey information, release records, watershed codes, and water licenses, and the Environment Canada database was used to query for hydrometric stations.

3.2 Documentation and Review of Information

The author, title, year and location of all references identified were entered into an excel spreadsheet (Appendix C), and unique numbers were assigned to each. The excel spreadsheet allowed for all references to be *sorted* and for *filters* to be applied, thus assisting in tracking the references and avoiding duplication. The reference information was reviewed and categorically identified as relevant or not relevant. Relevant references were further reviewed and notes were made identifying information useful to WUP. The review of reports included the identification of study objectives, appropriateness of study plans, as well as an assessment of results relative to the original objectives. This was done to ascertain whether information was incomplete, and consequently to provide a direction for additional work that might be required. Relevant information was entered into a *data summary sheet* for each of the 4 units (Appendix D). The data *summary sheet* assisted in forming the basis for the report and the *data gap* and *matrix* spreadsheets (Appendix E and F respectively).

4.0 RESULTS

4.1 Mara Lake to the outlet of Mabel Lake

4.1.1 Aquatic Resources

4.1.1.1. Water Quality and Quantity

A comparison of water quality among, Sugar, Mabel and Mara Lakes indicates that overall water quality is good (Bryan and Jensen 1999). All three lakes are relatively clear and quite low in nutrients, phytoplankton, and zooplankton. No measurable effects to water quality deterioration in Mara Lake have been reported from 1971 – 1998, but affects from non-point sources and treated waste have been noted (Bryan and Jensen 1999). Other than concerns related to high stream temperatures, water quality has not, to this point, been identified as a major problem in the Shuswap River between Mabel and Mara Lake Unit as it applies to the fisheries resources. There are however concerns regarding water quality associated with water potability and human health (Nordin 1978). Impacts to water quality in the Lower Shuswap are noted mainly from municipal waste discharges, degradation of riparian habitat, and streambank erosion by ranching and logging. Several tributary systems including Blurton, Fortune, Johnson, Kingfisher and Trinity Creeks are impacted by ranching and logging (Nener and Wernick No Date). Kingfisher Creek is also a major natural source of suspended sediment, and bacterial levels in Fortune Creek are a high level of concern (Nordin 1978). Water temperatures have been measured up to 25 °C near Mabel Lake (Nener and Wernick No Date). These high temperatures during the fall have the potential to impact spawning salmon, and in some years prespawn mortality has been noted in years of elevated temperatures (Wolski, S. 2000. pers comm.).

There are a total of 131 water licenses that draw water from the major tributary systems of the Lower Shuswap River (downstream of Mabel Lake) for domestic, irrigation, enterprise, waterworks, power, conservation and stockwatering (MoELP 2000d).

4.1.1.2 Discharge

One active hydrometric station (station no. 08LC002) lies on the Lower Shuswap River near Enderby. Hydrometric data exists from 1911 to 1936 and 1960 to present (Environment Canada 2000). The mean annual discharge at Enderby is 88.6 m^3/sec with maximum flows occurring in June and minimum flows occurring in late winter (February and March) (Figure 3c).

4.1.2 Fish and Fish Habitat

4.1.2.1 Fish Distribution

Anadromous salmon species in this unit include sockeye, coho, pink, and chinook. Sportfish species within the Lower Shuswap include kokanee, lake trout , mountain whitefish, rainbow trout and bull trout [Fish Habitat Inventory and Information Program (FHIIP)1990; DFO 1997; Jantz 1986] Brook trout, cutthroat trout, and lake trout have also been released into lakes in the Lower Shuswap (MoELP 2000c). Chiselmouth were observed in 1964 within Mara lake, however no other records of threatened or endangered species have been identified within the study area (BC Conservation Data Centre 2000). Species distribution and comparison to other areas of the Shuswap Drainage can be found in Table 1.

In general, salmonids are concentrated in the upper half of the Lower Shuswap River above the village of Enderby. The upper section of the river has a steeper gradient and gravel/cobble/boulder substrate, preferred by salmonids. Downstream of Enderby, the Lower Shuswap is a slower more meandering river with fine substrates, providing habitat conditions more suitable to non-salmonid species.

Overall there is a good knowledge of spawning distribution of chinook and sockeye salmon. Spawner distribution of kokanee and coho salmon is not as well documented.

4.1.2.2. Life History

In general, the Lower Shuswap River is used as a migration, spawning, incubation and early rearing system for salmon. Chinook salmon enter the Lower Shuswap as early as July and hold in deeper water sections of the river, with some fish moving upstream into Mabel Lake. Spawning commences in late September and persists through October. Chinook spawning is concentrated in the Shuswap River upstream of the Village of Enderby (DFO 1997). Eggs incubate through the winter and emerge in the spring (late March through to early May) (Figure 6). Margin habitats along the Lower Shuswap River are used for early rearing [Federenko and Pearce 1982; Envirocon Pacific Ltd. (Envirocon) 1989]. The majority of fry leave the system to rear downstream in Mara Lake (Envirocon 1989; FHIIP 1990). Lower Shuswap River chinook are mainly ocean type (95%) (Envirocon 1989). Ocean type chinook migrate to the ocean during their first year, alternately stream type chinook spend a complete year in fresh water before migrating to the ocean. The majority of the adults return as 4 year olds, with fewer 3 and 5 year olds.

Sockeye and kokanee spawning takes place in October, with spawning concentrated in the upper area of the Lower Shuswap River, above the Village of Enderby. Sockeye and kokanee fry migrate downstream to Mara Lake upon emergence. Sockeye adults return primarily as 4 year olds with a small percentage of 3 year old males. Kokanee salmon return to spawn as 3 year olds.

Coho spawning and rearing takes place in the mainstem and tributaries (FHIIP 1990). Spawning occurs in November and coho fry rear in tributary and/or mainstem habitats for a minimum of one year prior to migrating downstream to the ocean.

Rainbow trout use tributaries to spawn, since there is apparently limited rearing in the mainstem (Jantz 1986). Life history information of Lower Shuswap rainbow is limited, particularly fry/juvenile distribution. The elevated summer water temperatures in the Lower Shuswap likely contribute to low usage by salmonids. Bull trout have only been

Figure 6. Lower Shuswap River Lifestage Periodicity Chart (prepared by Sherbot, D. BCH, 2000).
Note: chinook, sockeye and coho information is specific to the Lower Shuswap River, while the Kokanee, rainbow trout, bull trout and whitefish life history timing information follows the known Middle Shuswap River Periodicity Summary.

Chinook	Start	End	Peak
Adult Migration	Jul 01	Sep 30	Aug 15
Spawn	Oct 06	Nov 16	Nov 07
Incubate	Oct 06	Apr 30	
Rear	May 01	Aug 01	
Parr Migration			

Sockeye			
Adult Migration			
Spawn	Sep 21	Nov 07	Oct 15
Incubate	Oct 01	Apr 01	
Rear			
Parr Migration			

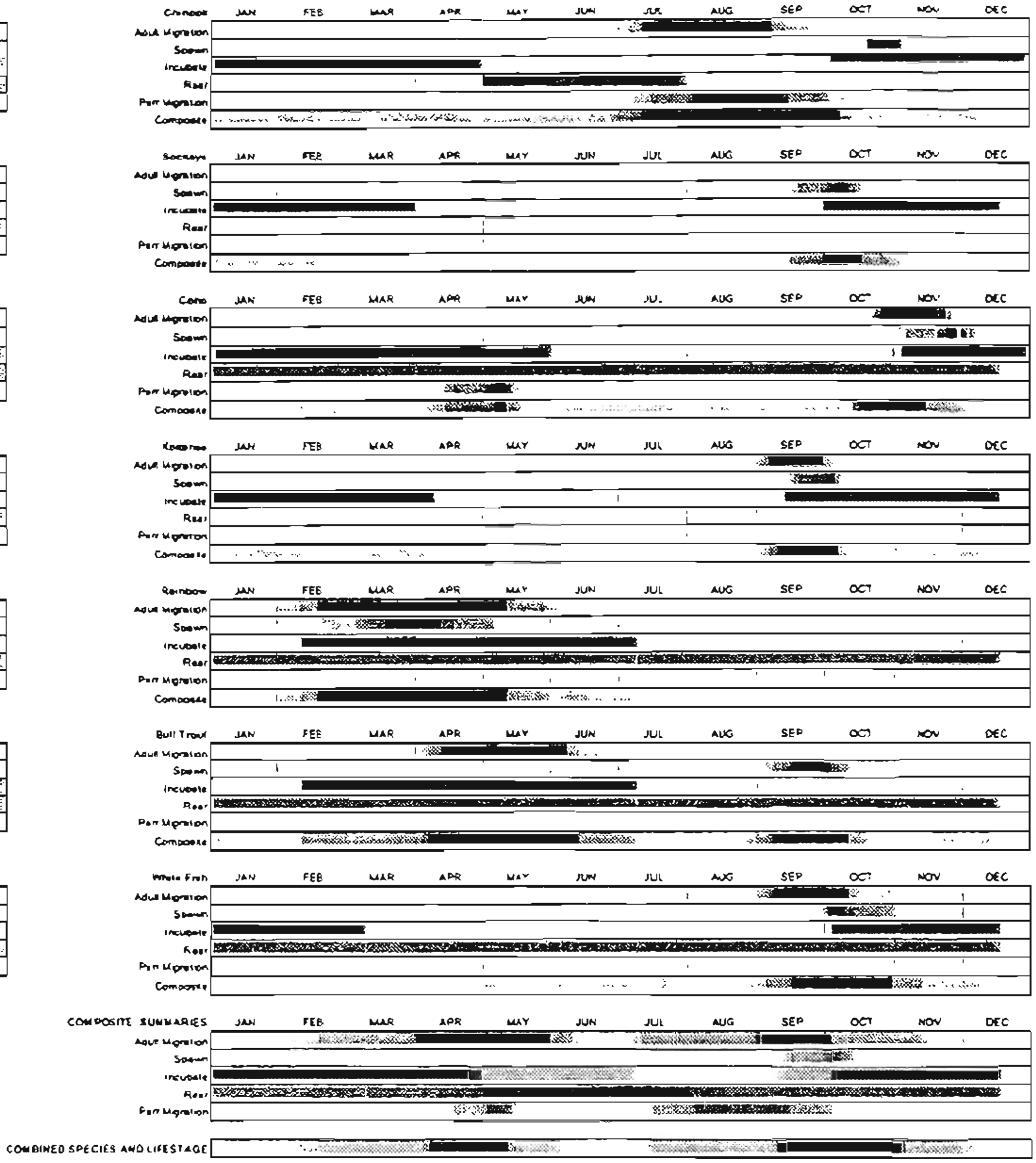
Coho			
Adult Migration	Oct 15	Nov 30	Nov 06
Spawn	Nov 21	Dec 30	Nov 30
Incubate	Nov 21	May 31	
Rear	Apr 01	Mar 31	
Parr Migration	Apr 15	Jun 01	May 15

Kokanee	Start	End	Peak
Adult Migration	Sep 01	Oct 10	Sep 22
Spawn	Sep 21	Oct 20	Oct 07
Incubate	Sep 21	Apr 15	
Rear			
Parr Migration			

Rainbow			
Adult Migration	Feb 01	Jun 15	Apr 06
Spawn	Feb 15	May 30	Apr 06
Incubate	Feb 15	Jul 15	
Rear	Jul 16	Jul 14	
Parr Migration			

Bull Trout	Start	End	Peak
Adult Migration	Apr 01	Jun 30	May 16
Spawn	Sep 01	Oct 30	Oct 01
Incubate	Feb 15	Jul 15	
Rear	Jul 15	Jul 14	
Parr Migration			

White Fish	Start	End	Peak
Adult Migration	Sep 01	Oct 31	Oct 01
Spawn	Oct 01	Nov 21	Oct 07
Incubate	Oct 07	Mar 15	
Rear	Mar 15	Mar 14	
Parr Migration			



found in limited numbers in the Lower Shuswap River. The mainstem is considered to have higher temperatures than preferred by bull trout for rearing. Numerous non-salmonids use the system for rearing and probable spawning (Envirocon 1989) (Table 1).

4.1.2.3 Habitat Productivity

Both Mabel Lake, draining into, and Mara Lake at the outlet of, the Lower Shuswap River, are considered oligotrophic, although Mara Lake is nearing mesotrophic status. (Bryan and Jensen 1999). Although tributary systems are noted as having elevated nutrient levels (Nordin 1978), the nutrient levels in the Lower Shuswap River are not high. The system is likely limited for salmonids due to elevated water temperatures during the summer that exceed the preferred range for stream dwelling salmonids. Elevated water temperatures during the spawning period have the potential to put chinook spawners at risk (Wolski, S. 2000. pers comm). There is no current information suggesting where any limits to production are occurring.

4.1.2.4 Escapement

Chinook escapements have shown a recent trend of increasing numbers, with 1999 having the highest escapement number for the period of record 1951-1999 (24,698) (Table 3)(Figure 7). Current chinook escapements to the Lower Shuswap River have exceeded the interim escapement target of 11,000 spawners established as a result of the Canada-US Pacific Salmon Treaty of 1985 (DFO 1997).

Lower Shuswap River sockeye demonstrate a four year cyclic dominance, with the recent cycle returns, 1994 and 1998, showing a decline from the cycle high in 1990. Returns in 1994 and 1998 (367,661 and 291,631 respectively), were less than the 1990 returns of 983,554, which are the highest in the current data record. (Table 3) (Figure 7). Current

Table 3. Escapements of Salmonids for the Lower and Middle Shuswap River

DATE	CHINOOK		COHO		SOCKEYE		KOKANEE	
	LS	MS	LS	MS	LS	MS	LS	MS
1951	750	750	n/r	n/r	0	0		
1952	3.500	1.500	n/r	n/r	0	0		
1953	7,500	750	3,500	1.500	140	0		
1954	1.500	n/r	n/r	750	17.462	61		
1955	3,500	1,500	3.500	3.500	23	0		
1956	3,500	1,500	1,500	750	5	0		
1957	3,500	1,500	750	400	490	0		
1958	7.500	750	3.500	1.500	9,387	499		
1959	1,500	750	1,500	750	281	0		
1960	3.500	750	1.500	3.500	0	0		
1961	3,500	1.500	750	3.500	342	0		
1962	3,500	750	750	1,500	31,205	457		
1963	3,500	750	750	1,500	2,014	0		
1964	3,500	750	3,500	750	0	0		
1965	1.500	400	200	400	583	0		
1966	3,500	400	400	400	24.629	1.872		
1967	15,000	1.500	200	200	5,951	58		
1968	7.500	400	400	400	0	0		
1969	7,500	500	750	750	1,703	0		
1970	7,500	750	400	400	29,074	4.559		
1971	7,500	750	75	400	6.117	284		
1972	4.500	300	300	400	290	0		
1973	9.000	400	250	500	7,452	0		
1974	10.000	600	100	500	86,396	3,064		
1975	17,500	600	100	250	11,652	227		
1976	2,500	400	40	60	400	0		
1977	9,500	550	100	594	14,695	0		
1978	10,400	350	300	350	187.167	10.890		
1979	10.000	500	300	500	10,092	578		
1980	4.000	500	350	550	81	0		
1981	5,500	500	250	250	7,358	0		
1982	2.200	500	300	350	513.925	40,302		
1983	5,800	300	200	250	7,308	27		
1984	7,892	700	300	250	79	-		
1985	11.125	900	500	1.200	3,123	180		
1986	12.000	1,000	250	350	600,495	80,529		
1987	10.000	1,700	350	500	10,343	787	8.500[D]	
1988	14,000	1.600	450	1.200	194	0		
1989	11.000	1,500	250	500	3,017	0		
1990	13.000	4.000	200	200	983,554	96.451		
1991	10.000	5.000	200	300	15.678	581		37.000[D]
1992	13.300	5.000	350	800	355	180		
1993	6.000	2.500	20	20	2.736	47		58.500[D]
1994	16,150	4.000	100	300	368.385	31.806		33,900[D]
1994					367661[(C)]			
1995	10.000	3.000	25	50	12,330	155		
1996	19000[(B)]	5000[(A)]			652[(C)]	58[(C)]		
1997	13100[(B)]	3800[(A)]			162[(C)]	0[(C)]		
1998	16704[(B)]	4474[(A)]			291631[(C)]	15262[(C)]		
1999	24698[(B)]	2441[(A)]			6788[(C)]	293[(C)]		108.000[D]

n/r - no numerical estimate available

Information Sources:

(A) - Chinook escapement 1991-1999

(B) - Chinook escapements to the South Thompson River System

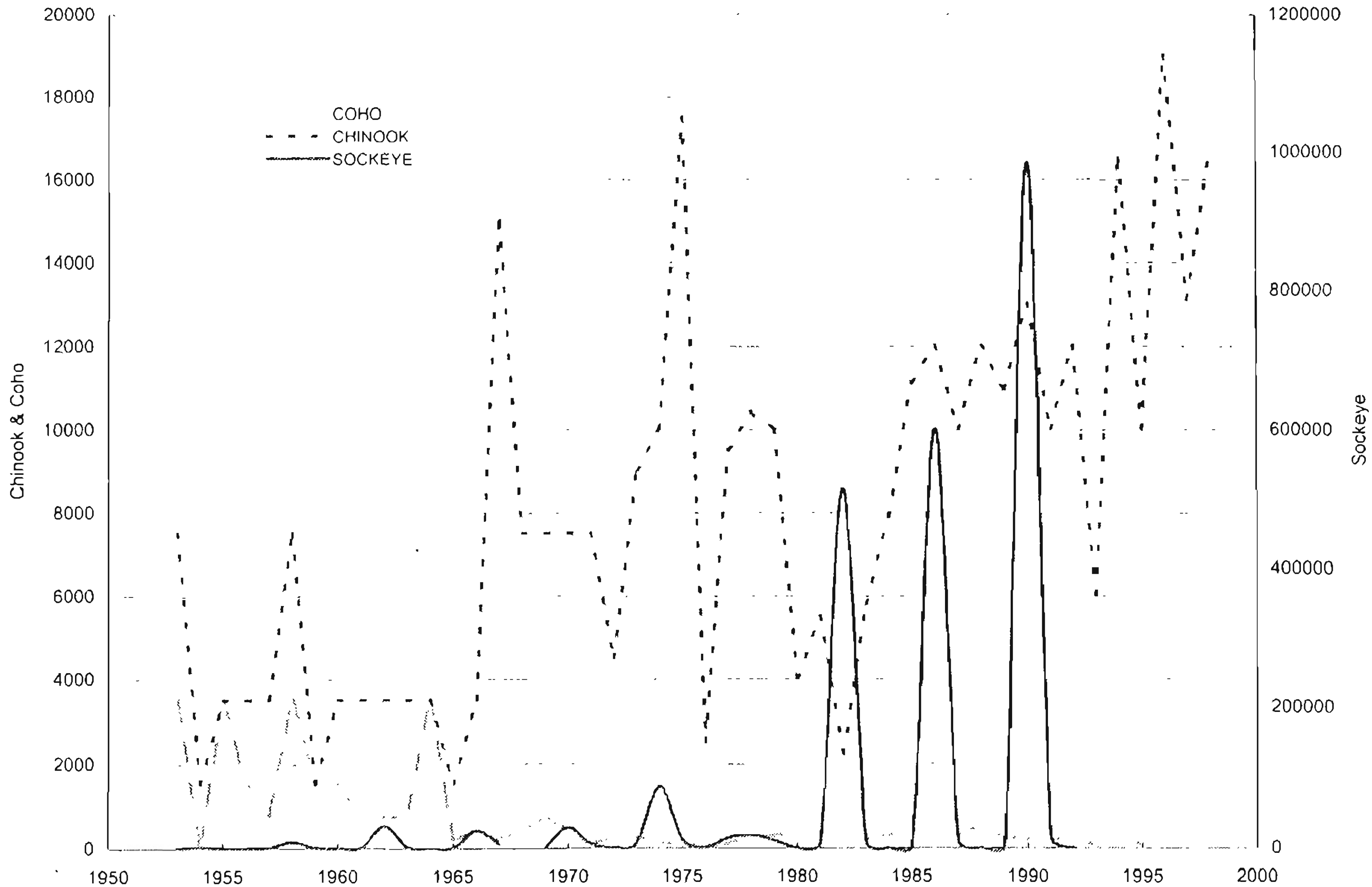
(C) - Lower and middle Shuswap sockeye escapement table

(D) - Ministry of Environment Penticton

Remaining Data Extracted from:

Strategic Review of Fisheries Resources for the South Thompson-Shuswap Habitat Management Area

Figure 7. Spawner Returns for the Lower Shuswap River (Sherbot, D. BCH).



sockeye escapements are still below the interim escapement target of 1,200,000 established by Fisheries and Oceans (DFO 1997).

Coho salmon escapements have declined from the 1950's and early 1960 and are currently at the lowest values from the period of record (Table 3)(Figure 7). The decline in coho escapements has been seen throughout the Thompson-Shuswap system, and are currently believed to be as a result of a decline in ocean productivity combined with excessive harvest. Loss of freshwater habitats is also a concern related to coho salmon production.

Pink salmon have been enumerated in the Lower Shuswap River, however numbers have been low with the greatest number of pinks recorded in 1987 (15) (FHIIP 1990). The Lower Shuswap River would be considered at the extreme of the range for pink salmon. Given that pink salmon fry demonstrate passive downstream migration directly post emergence, relying on river currents to take them to the estuary, it is unlikely that fry from the Lower Shuswap River can successfully survive a migration through the Shuswap Lake system.

4.1.2.5 Stock Monitoring/Assessment

Annual spawner counts for chinook and sockeye are conducted in the Lower Shuswap River. Kokanee counts have been done however, they are not done annually (Caverly, A. 2000. pers comm; Jantz, B. 2000. pers comm). Trapping and coded wire tagging of chinook juveniles was conducted in the Lower Shuswap River in 1976, 1979 and 1980, in order to document ocean migration and timing, as well as, fishery contribution of the stock prior to enhancement activities. No records of re-captures of the tagged fish have been found. In 1985 and 1986, Envirocon conducted an assessment in order to determine the interaction of hatchery and wild salmon (Envirocon 1989). No evidence was found that hatchery releases were negatively impacting wild salmon fry.

4.1.2.6 Enhancement

Releases of rainbow trout, cutthroat trout, brook trout, and lake trout by MoELP within the Lower Shuswap River system have occurred between the years 1909 and 2000 (MoELP 2000c). MoELP's stocking strategy is to stock smaller high elevation lakes to provide sport fish opportunities. No river stocking is being done since stocks are managed by means of regulation (Jantz, B. 2000. pers comm). Brood stock collection and chinook salmon fry releases within the Lower Shuswap River are conducted by the Shuswap River Hatchery [Triton Environmental Consultants (Triton) 1995c]. Fry releases to the Lower Shuswap from the Shuswap Hatchery have been conducted every year since 1984. During this period the releases have ranged in size from a low of 72,136 in 1989, to a high of 1,113,900 in 1986 (Table 4). In addition to the releases from the Shuswap Hatchery, the Kingfisher Community Hatchery has been in operation since 1981, and releases up to 237,000 fry annually (Table 5).

Fisheries enhancement potential was identified for Kingfisher/Danforth Creeks in 1984 (Griffith 1984)

4.1.2.7 Angler Use

A sport fishery for chinook salmon re-opened in 1986 on the Lower Shuswap with an average of 475 adults harvested from 1986 to 1994 (Schubert 1995). Generally 70-300 chinook are taken per year by sport fishers, and 200-300 are taken for the Indian Food Fishery throughout Shuswap River (Ball, J. 2000. pers comm). There is a small recreational fishery for rainbow trout and mountain whitefish which mostly appears to be from locals.

Table 4. Lower Shuswap River chinook Releases from Shuswap Hatchery.

Stock	Br Yr	Start Date	End Date	Total Rel.	Totals
Shuswap R Low	1984	/ /	1985/05/25	67011	
Shuswap R Low	1984	/ /	1985/04/26	51869	118880
Shuswap R Low	1985	1986/05/27	1986/05/29	27161	
Shuswap R Low	1985	1986/04/28	1986/04/30	25725	
Shuswap R Low	1985	1986/04/28	1986/04/30	25672	
Shuswap R Low	1985	1986/05/27	1986/05/29	27124	105682
Shuswap R Low	1986	1987/04/27	1987/04/29	561900	
Shuswap R Low	1986	1987/05/21	1987/05/23	552000	1113900
Shuswap R Low	1987	1988/05/10	1988/05/11	447100	
Shuswap R Low	1987	1988/05/04	1988/05/05	441200	888300
Shuswap R Low	1988	1989/05/17	1989/05/18	443640	
Shuswap R Low	1988	1989/04/06	1989/04/07	400000	843640
Shuswap R Low	1989	1990/05/15	1990/05/15	36052	
Shuswap R Low	1989	1990/05/15	1990/05/15	36084	72136
Shuswap R Low	1990	1991/05/14	1991/05/15	82005	82005
Shuswap R Low	1991	1992/04/15	1992/04/16	241120	241120
Shuswap R Low	1992	/ /	1992/11/25	28730	
Shuswap R Low	1992	1993/05/03	1993/05/06	403000	431730
Shuswap R Low	1993	/ /	1993/11/29	45140	
Shuswap R Low	1993	1994/05/03	1994/05/07	625570	670710
Shuswap R Low	1994	1995/05/15	1995/05/21	702500	702500
Shuswap R Low	1995	1996/05/14	1996/05/19	667380	
Shuswap R Low	1995	/ /	1995/11/29	16380	683760
Shuswap R Low	1996	1997/05/16	1997/05/19	892820	
Shuswap R Low	1996	1996/11/21	1996/11/26	89240	982060
Shuswap R Low	1997	1998/05/19	1998/05/22	656700	656700
Shuswap R Low	1998	1999/05/08	1999/05/12	59882	
Shuswap R Low	1998	1999/05/08	1999/05/12	384288	
Shuswap R Low	1998	1999/05/08	1999/05/12	382108	
Shuswap R Low	1998	1999/05/08	1999/05/12	41222	867500
Shuswap R Low	1999	2000/05/15	2000/05/19	26072	
Shuswap R Low	1999	2000/05/15	2000/05/19	28041	
Shuswap R Low	1999	2000/05/15	2000/05/19	28085	
Shuswap R Low	1999	2000/05/15	2000/05/19	311902	
Shuswap R Low	1999	2000/05/15	2000/05/19	18291	
Shuswap R Low	1999	2000/05/15	2000/05/19	385650	798041

Table 5. Lower Shuswap River chinook Releases from Kingfisher Hatchery.

Stock	Br Yr	Start Date	End Date	Total Rel	Totals
Shuswap R Low	1981	/ /	1982/06/01	4275	4275
Shuswap R Low	1982	/ /	1983/04/01	27000	27000
Shuswap R Low	1983	/ /	1984/06/20	27000	27000
Shuswap R Low	1984	/ /	1985/06/09	83500	83500
Shuswap R Low	1985	/ /	1986/06/27	20000	
Shuswap R Low	1985	/ /	1986/07/31	180000	200000
Shuswap R Low	1986	/ /	1987/04/15	100000	
Shuswap R Low	1986	/ /	1987/06/30	135000	235000
Shuswap R Low	1987	1988/07/04	1988/07/05	99500	99500
Shuswap R Low	1988	1989/04/02	1989/05/18	172000	172000
Shuswap R Low	1989	1990/04/27	1990/04/27	138000	138000
Shuswap R Low	1990	1991/04/14	1991/04/14	160000	160000
Shuswap R Low	1991	1992/03/29	1992/03/29	45000	45000
Shuswap R Low	1992	1993/04/	1993/04/	160000	160000
Shuswap R Low	1993	1994/04/	1994/04/	75000	
Shuswap R Low	1993	1994/07/	1994/07/	20000	95000
Shuswap R Low	1994	1995/04/05	1995/04/10	237000	237000
Shuswap R Low	1995	1996/05/01	1996/05/02	110000	110000
Shuswap R Low	1996	1997/04/01	1997/04/30	86000	86000
Shuswap R Low	1997	1998/06/27	1998/06/27	31000	31000
Shuswap R Low	1998	1999/05/09	1999/05/30	110138	110138
Shuswap R Low	1999	2000/04/22	2000/05/19	222465	222465

4.1.3 Effect on Aquatic Resources

4.1.3.1 Flow Fluctuations

The resulting effects of flow fluctuations at the Wilsey Dam on the Lower Shuswap are buffered by Mabel Lake. Although the shape of releases from Sugar Lake maintains its fidelity, the impacts of operational outages at the Wilsey Dam are not likely transferred downstream of Mabel Lake.

4.1.3.2 Flow Management Strategies

Flow management strategies developed for the Middle Shuswap River could potentially have some effect on the flow conditions in the Lower Shuswap. Inflows from upstream of the Sugar Lake Dam, contribute approximately 53% of the mean annual flow to the Lower Shuswap River (Webber, 2000). As Sugar Lake has the capacity to store only 13% of the mean annual inflow, the operations at Sugar Lake can only actively influence approximately 7% (13% of 53%) of the annual flows below Mabel Lake, and are subject to timing constraints associated with the filling and drafting of the reservoir. At a monthly resolution, the regulation at Sugar Lake reduces flows by approximately 10% for peak flows, and increases and stabilizes winter flows by approximately 16% (BC Hydro 2000). In addition, it should be expected that flow management for the benefit of fish in the Middle Shuswap River, would also benefit fish in the Lower Shuswap River due to similar species composition and life histories.

4.1.3.3 Habitat Productivity

Current flows in place in the Middle Shuswap River have not had any apparent negative effect on returns of chinook and sockeye salmon since returns have been increasing recently. Unless large changes in flows are experienced in the Lower Shuswap River it seems reasonable to assume that current habitat productivity will be maintained. Large changes in flows are unlikely due to limited storage and fish flow requirements upstream in the Middle Shuswap River. The assumption is that current storage and river management in the Middle Shuswap River has provided a positive effect associated with late fall winter flow augmentation. Future river management will be developed by the WUP.

4.1.4 Identified Interests and Concerns

The following section briefly documents the current state of knowledge regarding interests/issues or concerns from various stakeholder groups.

Shuswap Nation Fisheries Commission (SNFC)

- The SNFC is currently maintaining a fish fence on Danforth Creek in cooperation with FOC, to monitor coho stocks [Shuswap Falls and Sugar Lake Water Use Plan Consultative Meeting (WUPCM) 2000].

Spallumcheen Indian Band

- The Spallumcheen Indian Band currently harvests chinook salmon in the Lower Shuswap River. There is a desire to increase the capability of the Spallumcheen Band to harvest chinook near the Village of Enderby.

Kingfisher Environmental Society

- The Kingfisher Environmental Society is a local society made up of residents. This society continues to be active in conducting fisheries projects and promoting environmental awareness. They have been active in fish culture for chinook salmon and restoring habitat values within the watershed.

Fisheries and Oceans Canada (FOC)

- FOC is committed to continuing stock rebuilding efforts for chinook, sockeye and coho salmon in the Lower Shuswap River. FOC concerns related to resource use, include the degradation of fish and fish habitat due to poorly managed land use practices.

4.1.5 Discussion

4.1.5.1 Aquatic Resource

Water Quality

The major current concern associated with water quality is that of high water temperatures, particularly during the chinook spawning period. Water temperatures in excess of 20 °C increase risks to spawning salmon due to increases in the potential for disease, as well as increases in metabolic demand that have the potential to affect spawning success. Elevated water temperature appears to be a result of warm summer and fall temperatures causing the warming of Mabel Lake, and the fact that the shallow outlet shelf effectively skims warmer surface water. The only potential concern relative to the WUP process could be related to changes in water management that could exacerbate temperature problems in the Lower Shuswap River. Given the current objectives for fish flow releases in the Middle Shuswap River large reductions in late summer/fall flows are not expected.

A possible benefit of reduction in peak flows as a result of water management at Sugar Lake is possibly a reduction in bank erosion along the Lower Shuswap mainstem. Although bank erosion is a naturally occurring process agriculture, urbanization, and linear development have resulted in the loss of riparian values along the Lower Shuswap River and the associated increase in risk of erosion (DFO 1997).

Flow studies

Although the Middle Shuswap River inflows above Sugar Lake contribute approximately 53% to the total Mabel Lake inflows, the small storage capacity (13% of inflows) limits any effects that upstream flow management might have on the fisheries and aquatic resources in the Lower Shuswap River. Confirmation of contribution on a monthly basis should be undertaken with any flow scenario developed for the Middle Shuswap River, however it is difficult to see how any change from current operation would be of sufficient magnitude to warrant flow studies in the Lower Shuswap River.

4.1.5.2 Fish and Fish Habitat

Current knowledge of fish distribution and life history for salmon in the Lower Shuswap River is generally good for chinook and sockeye salmon. Information on kokanee stocks is incomplete because kokanee enumeration, which has occurred in the past, is not being done at present . Knowledge of coho salmon is not as complete as for the other salmon species, although, additional effort is being directed at increasing knowledge of coho spawner numbers particularly in tributary streams. The knowledge of resident fish in the area is somewhat limited. While information is lacking to maximize fisheries management options in the Lower Shuswap, particularly as it relates to sport fish concerns, no information gaps have been identified relating to the Water Use Planning process.

4.1.5.3 Hydro-Fish Interactions

No significant effects from hydroelectric operations in the Middle Shuswap River are apparent for fish and aquatic resources in the Lower Shuswap River, unless there are significant changes in flow management, particularly in the fall/winter period (which is unlikely). Flow changes associated with tripping events are buffered by Mabel Lake.

4.1.6 Summary and Recommendations

Based on the information collected on the section of the Shuswap River from Mabel Lake to Mara Lake, there are resource related concerns from anthropogenic activities.

However given the current stream flow patterns and the limited capacity to significantly alter flows within the Lower Shuswap River, no study needs have been identified relative to the Water Use Planning Process. In general fisheries is relatively complete for life history and distribution of anadromous stocks, with the exception of coho in the drainage. Information on non-anadromous stocks is less complete and fisheries management could benefit from the collection of additional data, however this is viewed as outside the mandate of WUP. Large flow fluctuations form the Sugar Lake Dam could in theory impact fisheries resources in the Lower Shuswap, but as there is limited storage, the ability to greatly modify flows is also limited. In addition, the objective of maximizing fish production in the Middle Shuswap will logically have a beneficial affect on downstream resources due to the similarity in fish assemblages and life history. If new information, suggesting that large flow fluctuations could occur in the Middle Shuswap River then risks to fisheries impacts on the Lower Shuswap River should be revisited

4.2 Mabel Lake from its outlet to Wilsey Dam

4.2.1. Aquatic Resources

4.2.1.1 Water Quality and Quantity

Current water quality in the mainstem of the Middle Shuswap River has not been identified as degraded as far as fish habitat values are concerned. There are, however, concerns relating to public health and potability of water. Current resource use activities along the Middle Shuswap River, and in its tributaries, have the potential to put water quality at risk.

Intensive farming, with the removal of riparian vegetation, channelization, stream bank trampling, and non-point source pollution, has the potential to affect water quality in the Middle Shuswap River. Water quality issues and excessive water withdrawal are most severe within tributary systems. A total of 28% of the watershed has been logged, 14% recently (Nener and Wernick No Date). Logging in the tributary systems is contributing to erosion and sedimentation (Nener and Wernick No Date). Water quality in Mabel

Lake is considered good with no deterioration in water quality from 1971 – 1998, although there is potential for water quality to be affected by non-point source pollution and treated waste (Bryan and Jensen 1999).

A total of 359 water licenses exist on the entire Shuswap River mainstem, however, their location along the mainstem is indiscernible. A total of 180 water licenses extract water from the tributary systems within the drainage from Mabel Lake to Wilsey Dam for the purpose of domestic, irrigation, stock watering, waterworks, power, conservation, storage, camps, and processing (MoELP 2000d).

There are concerns with potential August water demand, and low summer and winter flows in tributary systems. For instance, water is diverted out of Duteau Creek to the Vernon Irrigation District. Concerns also exist with municipal and rural discharges, stormwater runoff, and chlorinated effluents (Nener and Wernick No Date), again mostly concentrated in tributary systems.

4.2.1.2 Discharge

One active hydrometric station (station no. 08LC003) exists in the Middle Shuswap River downstream of Wilsey Dam with data available from 1913 to present (Environment Canada 2000).Streamflows typically increase from April reaching a peak in early to mid June, after which time they follow a relatively steep recession through July and into August. Lowest streamflows typically occur in later winter (March). Flow regulation at Sugar Lake has resulted in a reduction in peak flows and an augmentation in winter flows over unregulated values (Figure3b and Figure 5).

4.2.2 Fish and Fish Habitat

4.2.2.1 Fish Distribution

Fish distribution is referenced by reach delineation that is taken from Fee and Jong 1984, Figure 8. The mainstem of the Middle Shuswap River is known to contain chinook, coho, and sockeye salmon, as well as kokanee, bull trout, rainbow trout, and mountain whitefish. Non-salmonids include sculpins, longnose dace, redside shiner, peamouth chub, largescale sucker, northern pikeminnow and burbot (Table 1) (FHIIP 1990; Fee and Jong 1984; Envirocon 1989; Envirocon 1984). Tributary systems contain rainbow trout, coho and chinook salmon, and mountain whitefish, as well as suckers, shiners, dace, and sculpin (Fee and Jong 1984). The Bessette system provides the majority of the tributary habitat. Habitat values in other Middle Shuswap River tributaries are generally restricted to the lowermost reaches. Inventory work identified rainbow trout as the dominant species in tributary drainages with some use by salmon in lower reaches of tributary streams [ARC Environmental Ltd. (ARC) 1998]. Bull trout use of Middle Shuswap River tributaries is unknown.

Mabel Lake fisheries resources include: rainbow trout, bull trout, kokanee, mountain whitefish, burbot, cutthroat trout, longnose dace, redside shiners, slimy sculpin, prickly sculpin and largescale sucker, as well as early rearing for chinook and sockeye salmon.

Although, there are no records of threatened or endangered species identified within area (BC Conservation and Data Centre 2000), bull trout have been listed as threatened provincially (Caverly, A. 2000. pers comm). Given the lack of information in the Shuswap system in regards to stock status, related to historic habitat impacts and harvest pressure, there is concern regarding this species.

In addition, Middle Shuswap coho stocks are at extremely low numbers, and have recently been the focus of attention by FOC. Current efforts include hatchery supplementation of Middle Shuswap River coho and development of groundwater side channels, preferred habitat for coho juveniles.

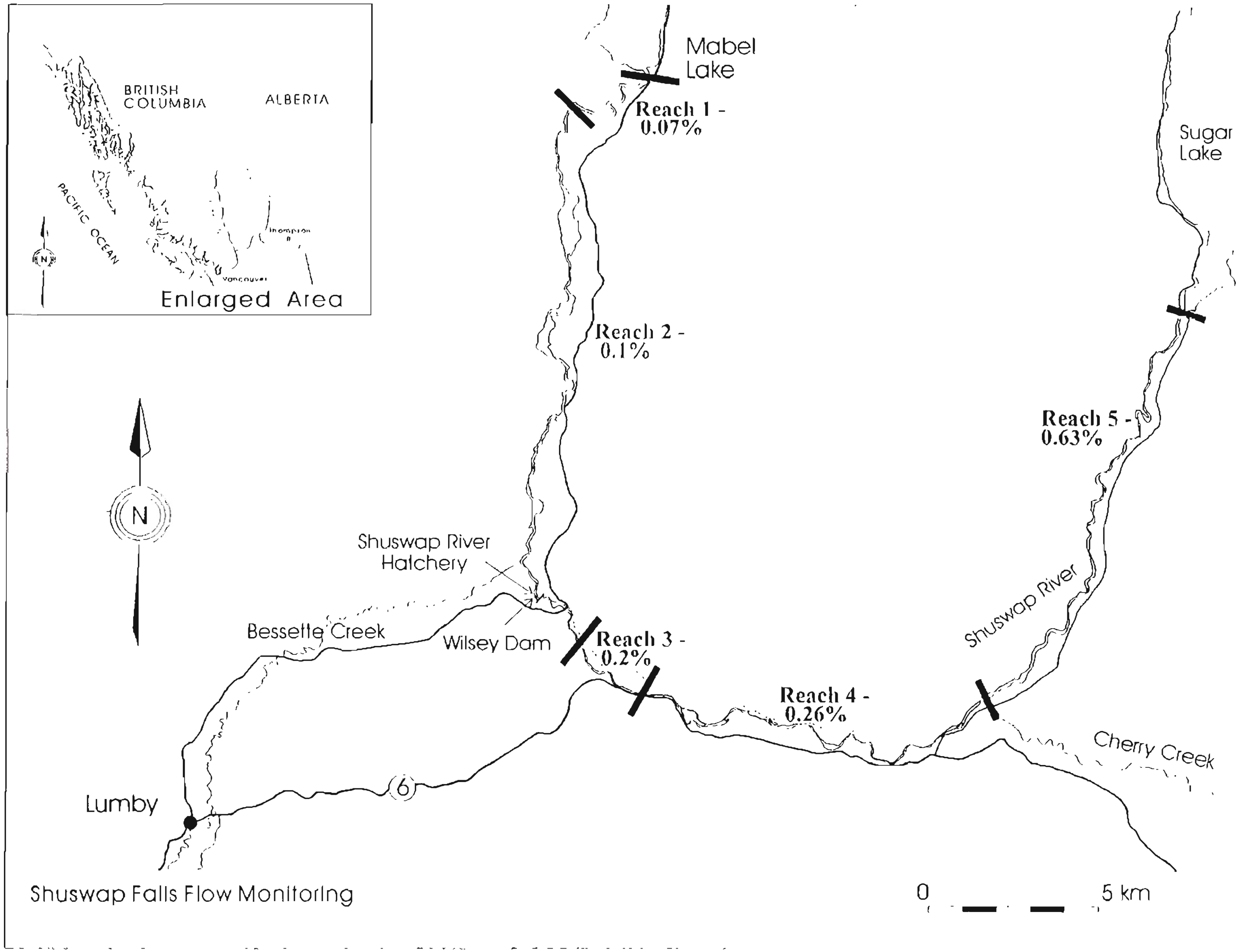


Figure 8. Reach Delineation for the Middle Shuswap River (Fee and Jong 1984)

4.2.2.2 Life History

Life Histories for chinook, sockeye, coho, kokanee, rainbow, bull trout, and whitefish are outlined in Figure 9. Sockeye and kokanee spawn below Wilsey Dam and migrate directly to Mabel Lake in April and May (Jantz 1992). Sockeye enter the Middle Shuswap River in late September and early October with peak spawning occurring typically between the 10th and 20th of October. Sockeye spend 1 year rearing in freshwater lakes prior to migrating downstream to the ocean. Fraser River sockeye return to spawn as 4 year olds, with a small percentage of 3 year old males (jacks). Middle Shuswap kokanee rear in Mabel Lake, and return to spawn as 3 year olds. As spawners they are generally small, averaging approximately 20 cm. Kokanee spawners distribute themselves throughout the river making extensive use of side channels (Figure 10). Due to their size, kokanee spawning preference is for shallow, lower velocity water and small substrate. This habitat preference puts them at risk to reductions of flows from the spawning to incubation period, although current flow regulation has reduced the risk over pre regulated flows (Figure 3b). A small number of kokanee (hundreds) spawn in lower Bessette Creek. Historically this population numbered in the thousands and spawned upstream as far as Lumby according to archival information in Lumby (Caverly, A. 2000. pers comm).

Coho spawn in Middle Shuswap and tributaries arriving in mid October with spawning starting October 21st peaking November 13th and ending December 7th (Triton 1994). Some emergent coho migrate directly downstream, however most rear for a year in the Middle Shuswap and tributaries (Envirocon 1984). Preferred rearing is in off channel habitats and in areas of low velocity, generally, in association with woody debris, and in tributary systems.

Figure 9. Middle Shuswap River, downstream of Wilsey Dam, Lifestage Periodicity Summary (prepared by Sherbot, D. BCH, 2000).

Chinook	Start	End	Peak
Adult Migration	Jul 01	Sep 30	Aug 15
Spawn	Sep 16	Oct 21	Oct 02
Incubate	Sep 15	Apr 30	
Rear	May 01	Aug 01	
Fry Migration	Jul 01	Oct 31	Aug 31

Sockeye	Start	End	Peak
Adult Migration			
Spawn	Sep 21	Nov 07	Oct 15
Incubate	Oct 01	Apr 01	
Rear			
Fry Migration			

Coho	Start	End	Peak
Adult Migration	Oct 15	Nov 30	Nov 06
Spawn	Oct 21	Dec 07	Nov 13
Incubate	Oct 21	May 31	
Rear	Apr 01	Mar 31	
Parr Migration	Apr 15	Jun 01	May 15

Kokanee	Start	End	Peak
Adult Migration	Sep 01	Oct 10	Sep 22
Spawn	Sep 21	Oct 20	Oct 07
Incubate	Sep 21	Apr 15	
Rear			
Parr Migration			

Rainbow	Start	End	Peak
Adult Migration	Feb 01	Jun 15	Apr 08
Spawn	Feb 15	May 30	Apr 08
Incubate	Feb 15	Jul 15	
Rear	Jul 15	Jul 14	
Parr Migration			

Bull Trout	Start	End	Peak
Adult Migration	Apr 01	Jun 30	May 16
Spawn	Sep 01	Oct 30	Oct 01
Incubate	Feb 15	Jul 15	
Rear	Jul 15	Jul 14	
Parr Migration			

White Fish	Start	End	Peak
Adult Migration	Sep 01	Oct 31	Oct 01
Spawn	Oct 01	Nov 21	Oct 07
Incubate	Oct 07	Mar 15	
Rear	Mar 15	Mar 14	
Parr Migration			

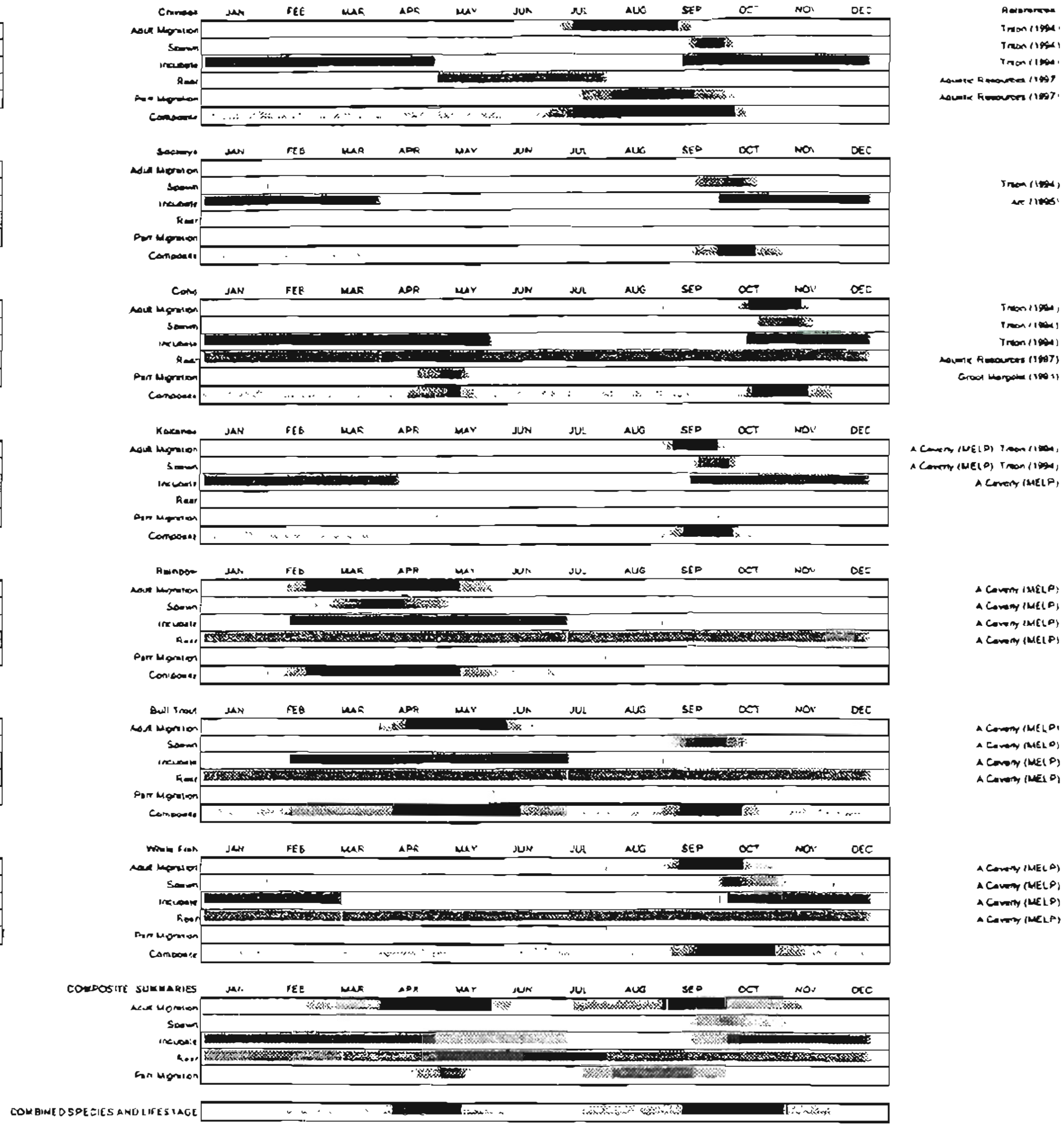
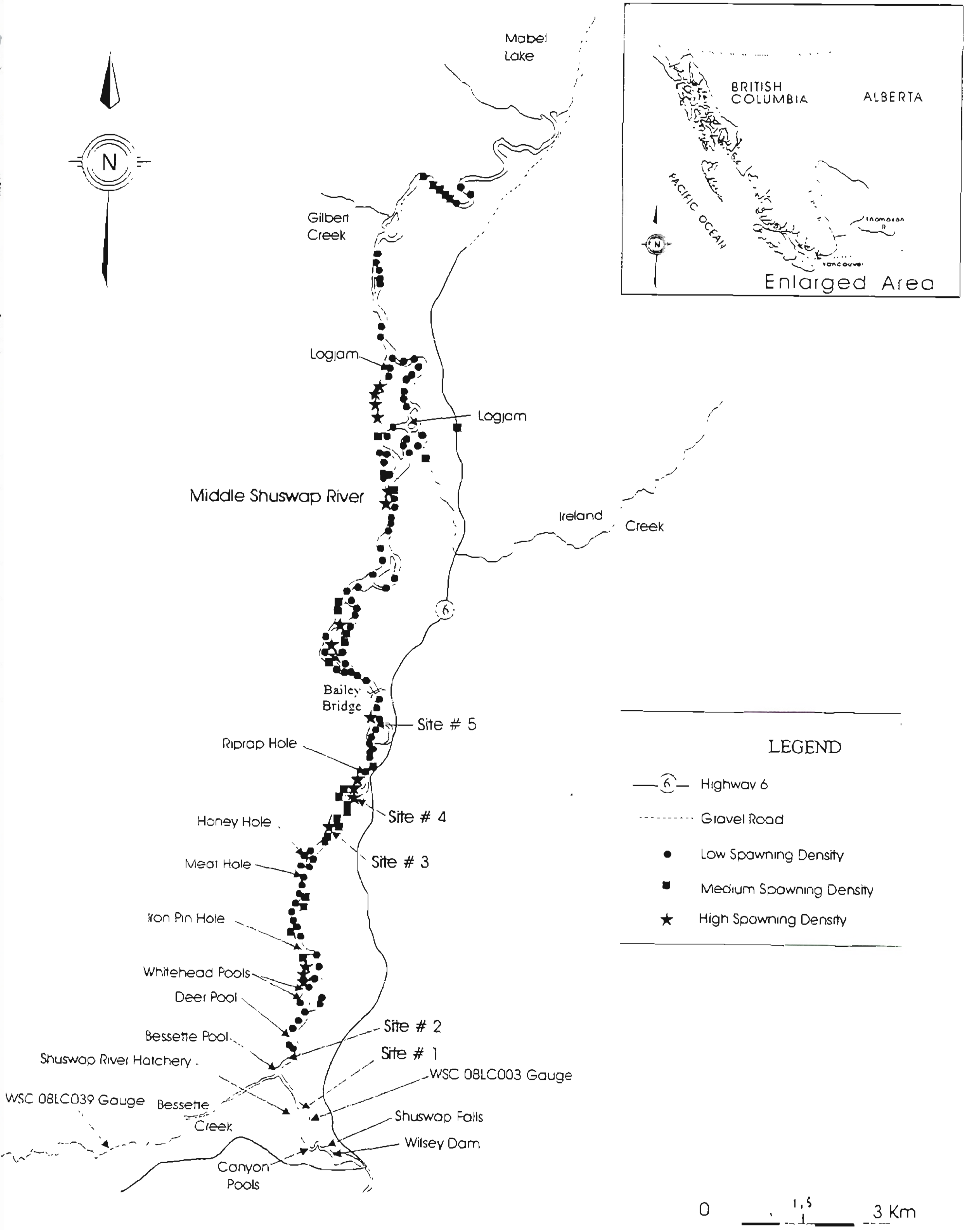


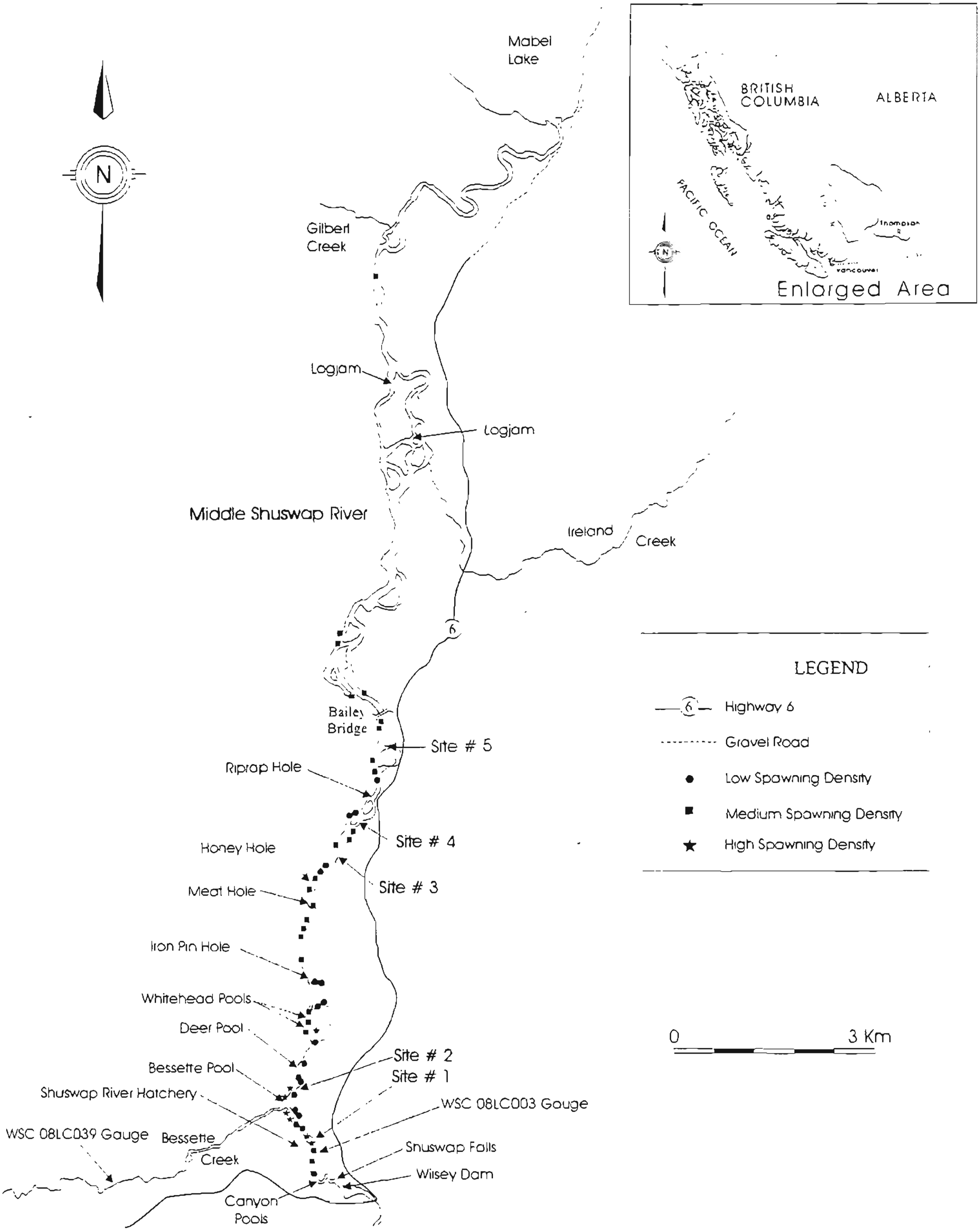
Figure 10. Kokanee: 1993 Spawning Distribution and Densities in the Middle Shuswap River.



Chinook enter the Middle Shuswap River starting in July with spawning commencing in mid September peaking on October 2 and finishing on October 21 (Triton 1994). Spawning takes place within the upper 8 km of the Shuswap River downstream of Wilsey Dam, Reach 2, although approximately 80-90 % of chinook spawning takes place in the upper 3.5 km. (Figure 11). Water depths, velocities, and substrate within the lower 15 km of the Middle Shuswap River are generally not within the preference for spawning chinook. Fry emerge in the spring beginning in April and show variable life histories. Some fry continue downstream migration to Mabel Lake immediately post emergence (Envirocon 1984), while most reside in low velocity margins and off/side channel habitats for several weeks. After residing in off/side channel habitats, they begin to show a preference for increased velocities. The majority of chinook migrate out of the system to Mabel Lake within 60-90 days, and to the ocean 90-150 days post emergence (Stalberg, H. 2000. pers comm). Rearing densities of chinook fry are high along the shoreline of Mabel Lake through June and July (Envirocon 1989). A small number of fry remain in the river for a full year. The majority of adults return as 4 year old fish with smaller numbers of 3 and 5 year olds. The Middle Shuswap stock is classified as *Ocean Type*, as most juveniles migrate to the ocean in their first year. Analysis from scales collected during the 1980's has shown Middle Shuswap Chinook were 60% *Ocean Type* (DFO 1997). Recent scale data collected during the 1990's indicates that currently over 95% of the fish returning are exhibiting an Ocean Type life history. Freshwater age information from both the Lower and the Middle Shuswap Rivers have shown similar freshwater age during the 1990's. As the hatchery contribution to returns is significantly different, the anomaly seen in the Middle Shuswap between the 1980's and the 1990 may be purely an artifact of the scale reading itself rather than any change in life history.

The limited number of chinook juveniles that stay in the Middle Shuswap River appear to select deep, back eddy areas in the mainstem or are associated with log debris and abundant cover in main sites with suitable water velocities (>30 cm/sec) (Fee and Jong 1984; Envirocon 1989).

FIGURE 11. Chinook salmon: 1993 Spawning Distribution and Densities in the Middle Shuswap River.



There appears to be a small population of chinook that spawn and rear in the Bessette Creek drainage and demonstrate a *Stream Type* life history (Bailey, R. 2000. pers comm). There are records in the archives in Lumby that tell of locals pitch forking chinook salmon from the stream (Caverly, A. 2000. pers comm).

Rainbow trout primarily use tributary systems (mainly the Bessette system) to spawn and rear for 1-2 years (Jantz 1986). These tributaries serve as recruitment systems for Mabel Lake as there are very low numbers of mature rainbow in the mainstem (Jantz 1992). Migration occurs from February to June with spawning taking place anywhere from February through to the end of May. Incubation takes place up to the middle of July (Caverly, A. 2000. pers comm). Rainbow trout fry rear in side channels of the Middle Shuswap River and some parr rearing is found in habitats with suitable velocities and complexity within the mainstem (Caverly, A. 2000. pers comm).

Whitefish spawn in the fall (September and October) over cobble substrate in flowing water and are not nest builders, but rather eggs are dispersed over the substrate. Distribution of Middle Shuswap spawners is currently unknown. Incubation occurs from October through to mid March. Immediately after emergence, whitefish seek out quiet water habitats with dense cover, such as inundated vegetation or weedy growth. After several weeks in quiet habitats, whitefish move into faster water habitats with gravel substrates. Whitefish have been found rearing in some tributary systems (Fee and Jong 1984; Griffiths 1986). No habitat preference data for Middle Shuswap whitefish is currently available therefore risks to flow values has not been defined, however, current whitefish populations appear to be healthy (S. Wolski pers comm).

Bull trout are limited in the Middle Shuswap and tributary use is unknown, although they are part of the Mabel Lake sport fishery. Water temperatures in this area are generally higher than preferred for bull trout systems during summer and early fall.

The Middle Shuswap River is heavily utilized by non-salmonid species. Some migration from lakes takes place by adults moving into the river to spawn. Rearing occurs in the mainstem primarily in lower velocity water and side/off channel habitats, particularly for juveniles (Wolski, S. 2000. pers comm).

4.2.2.3 Habitat Productivity

Sugar and Mabel Lakes are considered oligotrophic (Bryan and Jensen 1999). Although nutrient inputs from the tributaries enter into the Middle Shuswap River, water quality data indicates that the nutrient status of the mainstem is low. The Middle Shuswap River appears to be Nitrogen limited (Fee and Jong 1984). Sugar and Mabel Lakes have Nitrogen:Phosphorus (N:P) ratios of > 14:1 suggesting that both of these waterbodies are P limiting (Bryan and Jensen1999).

Coho, chinook and sockeye primarily use the 8km of river below the Wilsey Dam for spawning (D.B Lister and Associates 1990), although the majority of chinook spawning takes place in the 3.5 km downstream of the Wilsey Dam. The remaining 15 km of river while providing limited suitable spawning conditions for salmon is well utilized by kokanee. Superimposition of redds during chinook spawning at several sites may indicate that spawning substrates could be limiting (Wolski, S. 2000. pers comm). Mainstem habitats are used for rearing chinook and coho (Fee and Jong 1984), with low velocity margin habitats and side/back channel habitats providing post emergence nursery habitat for chinook, coho and rainbow trout. Coho rearing takes place in off channel habitats throughout the year including newly constructed groundwater channels (Flynn, M. 2000. pers comm). Warmer off-channel habitats and groundwater channels are heavily utilized for rearing of non-salmonid species.

Bessette Creek. near the confluence with the Shuswap River has spawning populations of chinook and coho, and provides rearing opportunities for chinook juveniles and preferred rearing for and coho fry and smolts (Envirocon 1984). Water quality problems including sediment inputs, elevated temperatures, high nutrient inputs and mill leachates (DFO 1997) within the tributary systems may be affecting tributary production.

High water temperatures in the mainstem during summer months, combined with low food, reduces productivity however, an increase in productivity may be expected with the increase in spawner numbers and carcasses to the Middle Shuswap downstream of Wilsey Dam (Slaney, 2000. pers comm). The low productivity within the system appears to be related to low natural production.

The average wetted width, under current flow management, exceeds the pre- regulated wetted width (due to winter flow augmentation). Therefore, it is possible that current productive capacity the Middle Shuswap could be somewhat greater than historic values.

Low numbers of rainbow trout utilize the mainstem (Fee and Jong 1984; and Envirocon 1989). Rainbow trout production from tributary systems appears to recruit to Mabel Lake.

Mabel Lake kokanee are small averaging 22 cm, possibly an indicator of the low productivity within Mabel Lake. In Wood Lake, a eutrophic lake, kokannee grow up to 45+ cm. In Okanagan Lake, a mesotropkhic lake, they reach 30-35 cm in length.

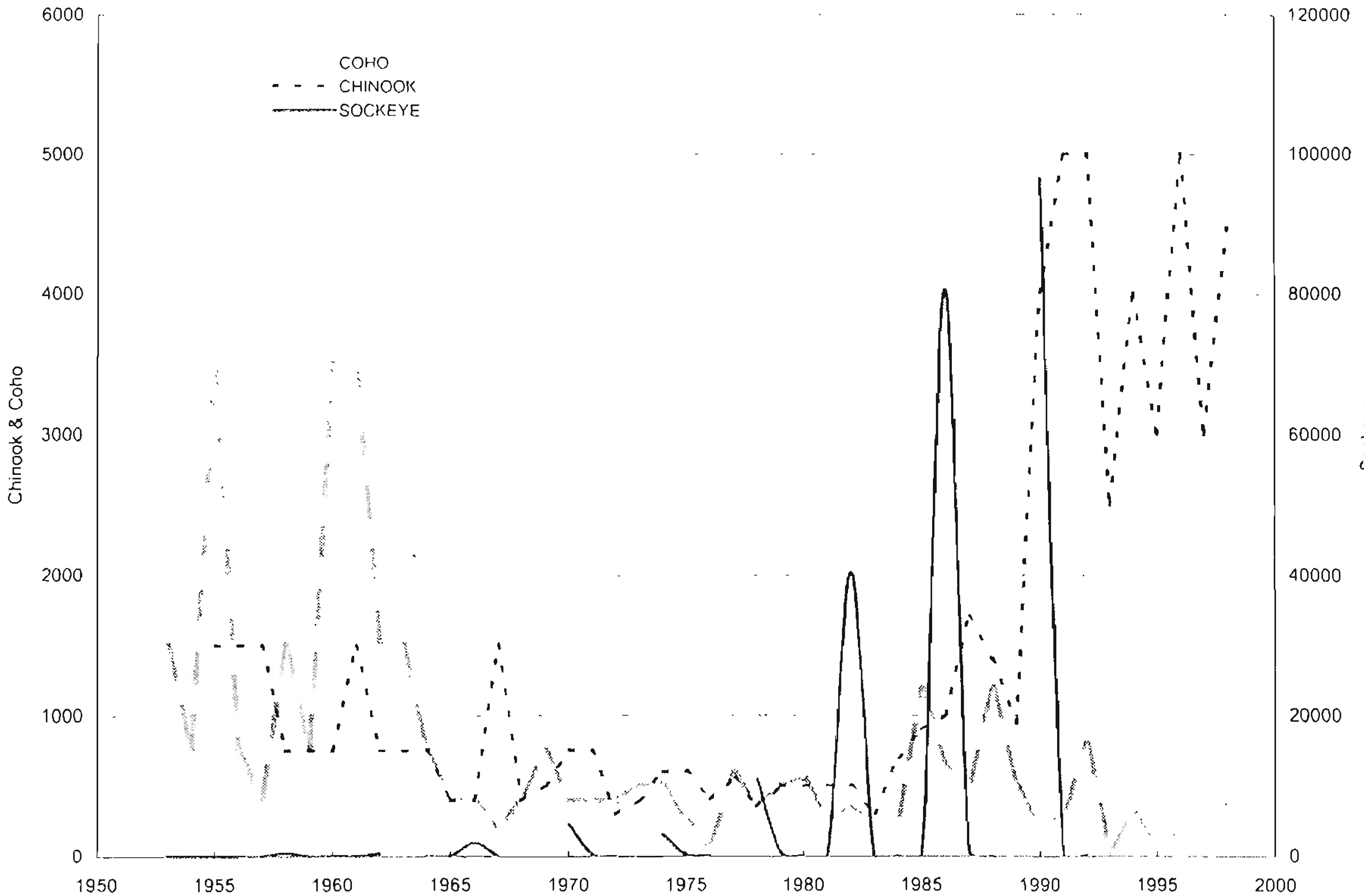
4.2.2.4 Escapement

Escapements to the Middle Shuswap River are summarized in (Table 2). Middle Shuswap chinook escapements, which were relatively stable from 1951 to 1986, showed an increase in numbers from 1987 to 1990 after which time they have remained relatively stable again. Average escapement over the past 10 years is 3,922 (Figure 12). Early increases in returns are, possibly due to hatchery contribution to the system. Fry stocking of the Middle Shuswap River was initiated in 1985, and continues to date. Stocking numbers and release dates can be found in Table 6. Although both the Middle and Lower

Table 6. Middle Shuswap Chinook Releases from Shuswap Hatchery (Cook, R. DFO)

Stock	Br Yr	Start Date	End Date	Total Rel.	
Shuswap R Mid	1985	/ /	1986/04/28	35244	
Shuswap R Mid	1985	1986/05/28	1986/05/29	37102	
Shuswap R Mid	1985	/ /	1986/04/28	35193	
Shuswap R Mid	1985	1986/05/28	1986/05/29	37448	144987
Shuswap R Mid	1986	1987/05/20	1987/05/22	313300	
Shuswap R Mid	1986	/ /	1987/04/09	297600	610900
Shuswap R Mid	1987	/ /	1988/05/16	257059	
Shuswap R Mid	1987	/ /	1988/05/16	261941	
Shuswap R Mid	1987	/ /	1988/04/13	257703	
Shuswap R Mid	1987	/ /	1988/04/13	260797	1037500
Shuswap R Mid	1988	/ /	1989/05/15	219010	
Shuswap R Mid	1988	/ /	1989/05/15	219010	
Shuswap R Mid	1988	/ /	1989/04/10	235000	
Shuswap R Mid	1988	/ /	1989/04/10	235000	908020
Shuswap R Mid	1989	1990/05/16	1990/05/16	261957	
Shuswap R Mid	1989	1990/04/04	1990/04/04	259836	
Shuswap R Mid	1989	1990/05/16	1990/05/16	261577	
Shuswap R Mid	1989	1990/05/16	1990/05/16	23180	
Shuswap R Mid	1989	1990/04/04	1990/04/04	258919	1065469
Shuswap R Mid	1990	/ /	1991/04/19	439381	
Shuswap R Mid	1990	/ /	1991/05/15	440502	879883
Shuswap R Mid	1991	/ /	1992/05/13	410875	
Shuswap R Mid	1991	/ /	1992/04/27	409406	820281
Shuswap R Mid	1992	1992/11/10	1992/11/16	97630	
Shuswap R Mid	1992	/ /	1993/05/27	518100	615730
Shuswap R Mid	1993	1994/05/24	1994/05/27	442340	
Shuswap R Mid	1993	1993/11/13	1993/11/18	21740	464080
Shuswap R Mid	1994	1994/11/08	1994/11/15	102900	
Shuswap R Mid	1994	1995/05/30	1995/05/31	413220	516120
Shuswap R Mid	1995	1995/11/07	1995/11/21	58030	
Shuswap R Mid	1995	1996/05/28	1996/05/30	417150	475180
Shuswap R Mid	1996	/ /	1996/11/14	62630	
Shuswap R Mid	1996	1997/05/28	1997/05/29	262200	324830
Shuswap R Mid	1997	1998/05/29	1998/05/30	327580	
Shuswap R Mid	1997	/ /	1997/11/18	11050	338630
Shuswap R Mid	1998	0/ 0/	1999/05/18	101909	
Shuswap R Mid	1998	0/ 0/	1999/05/18	103378	
Shuswap R Mid	1998	0/ 0/	1999/05/18	77613	282900
Shuswap R Mid	1999	2000/05/26	2000/05/26	96596	
Shuswap R Mid	1999	2000/05/26	2000/05/26	93406	
Shuswap R Mid	1999	2000/05/26	2000/05/26	93798	283800

Figure 12. **Spawner Returns for the Middle Shuswap River (Sherbot, D. BCH).**



Shuswap chinook stocks increased through the late 1980's and early 1990's the Lower Shuswap stocks have continued to increase through the later 1990's while the Middle Shuswap stock has not. One possible explanation for this could be that the Middle Shuswap system is at capacity for chinook production.

Sockeye salmon in the Middle Shuswap River return to spawn every four years. The Middle Shuswap stock demonstrates cyclic dominance with the dominant cycle occurring (most recently) in 1994 and 1998 with escapements of 31,806 and 15,262 respectively. The Middle Shuswap dominant year return is coincidental with the dominant cycle of the Lower Shuswap River. A significantly smaller return cycle occurs the year after the dominant cycle. Escapement data indicate that in some years sockeye show up in the Middle Shuswap River during the other cycle years (Table 3).

Coho salmon have declined in numbers in the Middle Shuswap over time and are currently at their lowest point over the period of record (Table 3). Other Thompson and Shuswap River coho stocks have shown a similar decline in numbers during the 1990's (Galesloot, M. 2000. pers comm.)

Kokanee spawner counts have not been conducted an annual basis but are available for 1991, 1993, 1994, and 1999. A recent increasing trend in Kokanee spawners could be a result of flow management relative to spawning/incubation flow ratios (Jantz, B. 2000. pers comm), or perhaps due to increase productivity in Mabel Lake due to nutrient inputs from salmon carcasses.

4.2.2.5 Stock Monitoring/Assessment

An assessment conducted in 1984 determined that there was additional capacity for chinook outplants in the Middle Shuswap (Fee and Jong 1984). However, the study may have overestimated the amount of useable area because of the use of unsuitable habitat preference curves, as well as, an untested assumption that juveniles would utilize the entire cross section of the channels for rearing. Studies of juvenile rearing in larger river systems have indicated that rearing is heavily weighted to use along the margins (Anonymous 1987).

An additional assessment was done in (1984) by Envirocon. This assessment determined that the majority of chinook fry leave the Middle Shuswap River after a short period of time, as very few overwintered smolts were captured. This study focussed on the collection of overwintered smolts which may have resulted in less than optimum trapping methods and/or location to monitor outmigration of fry. Beach seining in Mabel Lake documented chinook fry rearing from May to the end of July. Catches peaked at the end of July (Envirocon 1989).

A 1985/86 assessment assessed the impact of hatchery verses wild chinook. This report found no obvious impact from outplanting (Envirocon 1989).

Adult chinook, sockeye, and coho are monitored annually. Kokanee escapement information is limited to four years of data. Monitoring of juvenile use of man made side channels is currently being done through the use of fences at channel outlets (Flynn, M. 2000. pers comm; Wolski, S. 2000. pers comm).

4.2.2.6 Enhancement

MoELP has had releases of rainbow trout. cutthroat trout, and brook trout from 1928 to 1999 w· n tributary systems of this section of the Middle Shuswap River (MoELP 2000c). Stocking occurs in higher elevation lakes to provide recreational fisheries. No stocking is done in river systems. River stocks are managed through regulations.

The Shuswap hatchery has been in operation since 1985, during this period releases of chinook have ranged from 144, 987 in 1985 to 1,065,469 in 1989 (Table 6). Hatchery contribution to returns has been high in the Middle Shuswap River varying from a high of

73% in 1994, to 36% in 1998. Releases in the past two years have been reduced to just over 280.000 . (Cooke, R. 2000. pers comm). These reductions are an attempt to assess the relationship between numbers of fish released and contribution to returns (Wolski, 2000. pers comm). In addition, it was believed that the Middle Shuswap River was at its escapement target (D. Lofthouse, 2000. pers comm). Recent enhancement of coho has taken place from 1998-2000. Egg targets from the Middle Shuswap and Duteau stocks while set at 100,000 have not been reached due to the low numbers of returning adults to the system.

Man made groundwater fed side channels have been constructed to increase off channel rearing habitat for Middle Shuswap River salmonids (Flynn, M. 2000. pers comm). The man made portion of the Maltman channel is approximately .8 km in length while the Engineered portion of the Lang channel is 3.8 km long. The channels are currently being monitored and are used by early rearing chinook and coho fry and juveniles, rainbow trout, as well as, numerous course fish species.

4.2.2.7 Angler Use

As a result of increases in chinook returns to the Middle Shuswap River a summer fishery for chinook salmon has been in operation since 1986 (Kristamanson 1999), restoring a traditional fishery in the Middle Shuswap River (Caverly, A. 2000. pers comm). This recreational activity is monitored through an annual creel survey.

Current angler use for resident species on the Middle Shuswap is unquantified. There is a fishery for whitefish and occasionally rainbow trout. Bull trout are sometimes captured when cooler water temperatures and salmon abundance provide suitable conditions (Caverly, A. 2000. pers comm.).

Mabel Lake received the highest angler use of 101 Okanagan regional lakes (D.B Lister and Associates 1990). A 1984 creel study in Mabel Lake indicated that 53% of the catch was rainbow trout and 36% was comprised of kokanee (Jantz 1986).

4.2.3 *Effects on Aquatic Resources*

4.2.3.1 Short Term Flow Changes

Short term fluctuations can occur at the Wilsey Dam. These can be attributed to:

1. Placement or removal of flashboards at Wilsey Dam. This requires a temporary flow increase through the powerhouse to reduce headpond level and subsequent flow reduction to refill the headpond for normal operations.
2. Planned shutdown of generating unit(s) for maintenance work or to facilitate dredging.
3. Temporary shut-off of the generating unit(s) due to tripping events.

BC Hydro has operational protocols in place to minimize flow disruption associated with the first two events. To mitigate sudden reductions in flow below Wilsey Dam during unplanned tripping events, BC Hydro normally operates the headpond +/- 2cm of the spillway sill. In the event of tripping either or both units, the headpond would begin to spill within 4-6 minutes at an initial discharge of 15 m^3/sec increasing until outflow equals inflow (D.B Lister and Associates 1990). It was noted that under different monitoring programs, that downstream flow minimums were reached within 30-50 minutes and water levels are fully recovered in 1-2 hours (D.B Lister and Associates 1990; Aquatic Resources 1997). Water reductions ranged from 0.09 m to 0.42 m associated with an average discharge reduction of approximately 43%. Prior to 1990, it was observed that 82% of the reductions occurred between November and March (D.B Lister and Associates 1990). There have been 30 tripping events since 1989 or approximately 3 per year. Risk from tripping occurs when maximum turbine discharge exceeds median releases, which generally occurs over the seven month period from September to March.

The Howell Bunger Valve installed in 1993 on *Penstock No. 2* mitigates some flow fluctuations by providing immediate bypass flow until the Wilsey Dam forebay fills and spills are resumed however, some change in stage is experienced with the Howell Bunger valve in operation. The Howell Bunger Valve bypass is not always able to function due to the type of outage. In the past operational constraints including cross tripping, trash rack debris have prevented the bypass valve from operating during some tripping events. When the system fails there is a cessation of flows until the forebay of the Wilsey Dam fills and water flows over the spillway. This negative stage change can result in the stranding of fish on gravel bars, isolating of fish in lateral pools and dewatering of eggs and ova, depending on the timing and severity of the event.

4.2.3.2 Reservoir Drawdown

Reservoir drawdown does not affect the fish and aquatic resources below the Wilsey Dam. However, during dredging operations at the forebay of the Wilsey Dam, the forebay is drawn down which increases the risk to downstream fish values in the event of an outage. During an outage at this time it will take a greater amount of time to refill the forebay to a level that spills will occur.

4.2.3.2 Flow Management Strategies

While there is limited reservoir capacity at Wilsey Dam to regulate discharges, flows are managed during installation and removal of flashboard, cleaning of trashracks, during gate/penstock/turbine maintenance, and bringing units on line to reduce impacts of flow ramping downstream of Wilsey Dam. There is no flow management undertaken at the Wilsey Dam operation. Flows are managed by operation of the Sugar Lake Dam. Wilsey Dam facility operation is linked to the flow releases from Sugar Lake. For background purposes the general flow operation is presented.

Typically, the Sugar Lake reservoir is managed to be at low pool in the last week in April prior to freshet. The reservoir fills with the natural inflows and reaches full pool in July. Peak freshet flows are stored and re-distributed to the post spawning period, October on, with the main net benefit accruing to the January to March period. This redistribution provides winter flows in excess of historical levels. Interactive management with decisions on flow release are made by BC Hydro, FOC and MoELP on an ongoing basis from August (Lewynsky, V. 2000. pers comm). In general, the flow management strategy appears to benefit the fisheries resources downstream of the Wilsey Dam by augmenting winter flow levels. This provides improved protection for incubating eggs and ova and increases wetted habitat values for winter use.

4.2.4 *Identified Interests and Concerns*

Ministry of Environment, Lands and Parks-

- Kokanee- specifically flow reductions after spawning and through winter. Spawner counts have shown an increase in returns over the last few years (Jantz, B. 2000. pers comm).
- Maximize rainbow trout production, although it appears that the tributaries are the of primary importance there may be some mainstem areas important for production (ie side channels).
- Although there is not a significant bull trout population, due to the warmth of the system, there may be seasonal use. Prior to the construction of the Wilsey Dam it may have been possible for bull trout to move to more favourable habitats upstream .
- There do not appear to be concerns relating to Middle Shuswap mountain whitefish, at present however knowledge of this species life history in the Middle Shuswap is incomplete.

Fisheries and Oceans Canada-

- Maximizing chinook, coho and sockeye production. Reduction of impacts due to flow fluctuations. Establishment of incubation flows that are no less than 2/3 of spawning flows.
- Water quality related to dredging the Wilsey Headpond, as well as the increased risks associated with drafting the forebay for dredging.

Landowners-Flood Issues. Mabel Lake Preservation Society.

- Recreational Users-Paddlers low water hazards make the river impassable at times. Is there potential for better whitewater if the river returned to its natural flows?

Anglers

- Anglers would like to have better fishing in the Middle Shuswap River.

Spallumcheen Indian Band-

- Indian Food Fishery, information needs including traditional use areas, and trading route between Sugar and the Kootenays.

Okanagan Nation Fisheries Commission-

- Indian Food Fishery.

Others

- Fish ladder around Shuswap Falls (Dam prevents salmon from accessing historical spawning/rearing habitat)
- Flooding problems, spring freshet problems for farms and ranches when all four gates opened at once.
- Maintaining integrity of river, balanced use of water.
- Erosion at high levels, heavy silt choking spawning grounds, erosion along banks with heavy flows.
- Use bio-degradable hydraulic fluid at generating station to minimize risks of impacts associated with spills.

4.2.5 Discussion

4.2.5.1 Aquatic Resources

Water Quality

Water quality can be affected by sediment inputs from tributary systems. At the current time FRBC studies have indicated that sediment sources are occurring in the tributaries, some of which are natural and some logging related. No major sources of sediment have been identified from FRBC studies and no cumulative sediment contribution has been determined. FRBC activity and adherence to Forest Practices Code (FPC) should reduce sediment inputs from the tributaries. Restoration activities have been initiated at some sites. Dredging of the forebay of the Wilsey Dam will continue to be a maintenance activity. Although suction dredging has been use in the past the current operation involves lowering of the forebay and the mechanical removal of accummulated sediments. The operation will require continued protection of downstream values including risks of sediment discharge as well as protection from flow changes when the forebay is lowered for the dredging. Total Gas Pressure (TGP) may be an issue. This has been identified by BCHydro which is currently undertaking a study to assess the risks associated with TGP. Sediment discharges have the potential to affect spawning grounds in the Middle Shuswap. Flow volumes should be competent enough to provide flushing flows to mobilize materials. Water quality from tributary inflows (Bessette) has the potential to impact downstream fisheries values. Sediment inputs from the Bessette system, while not a hydro impact, has the potential to put downstream fish habitat values in the Middle Shuswap mainstem at risk.

4.2.5.2 Fish and Fish Habitat

There is a need to know more about temporal use of off channel habitat. Off channel habitat is used by chinook fry post emergence, until they acquire competent swimming capability. Knowledge of the timing of use for post emergent habitat, along with adequate knowledge about the river stage to access to nursery habitats will provide the information required to ensure that these habitats are available. Fish distribution information is based on studies conducted in the early to mid 1980's. There may be some value in re-visiting these studies to determine if 15 years of hatchery production has resulted in any change in the system, due to changes in life history or increases of nutrients due to increases of carcasses. For an appropriate comparison of values, *methods* should follow as closely as possible the *methods* used for the original studies. The methods in the original studies appear to be adequate to describe the relative abundance and distribution of fish in the system.

The 1997 high water event resulted in channel changes that potentially affected the amount of available spawning habitat, as well as, the distribution of spawners throughout the upper portion of the river. Previous studies have provided good information on distribution of spawners to identify those areas of high importance. Spawner distribution should be re-mapped to determine current use and to compare with previous values and to aid in an assessment of spawner capacity. As approximately 90% of chinook spawners appear to use the upper portion of the Middle Shuswap River, mapping of spawning habitat within 3.5 km of the Middle Shuswap River downstream of the Wilsey Dam might provide a good approximation of available chinook spawning habitat in the Middle Shuswap River. There is a suggestion that increased sediment from Bessette in 1997 may have affected spawning gravel quality downstream and the distribution of spawners (Stalberg, H. 2000. pers comm).

The development of optimum fish flows requires knowledge of spawner capacity at different flows. The approach needed included an assessment of risk that weighs the amount of available spawning habitat at different flows verses the risk associated with flow decline from spawning to incubation flows. Flow decline is dictated not only by the selection of the spawning flow but also the amount of available storage, which as previously mentioned is limited at Sugar Lake Reservoir. Assessing available spawning area at achievable flows (from 1000cfs-500cfs) will help determine the flow habitat relationships to help in the decision making process. Spawner survey data collected by DFO in 1991 indicated that at the spawning area near the hatchery flow reduction from 1000cfs–900 cfs resulted in a reduction of available spawning habitat of 12%. Reduction increased to 25% when flows were reduced to 800 cfs. Spawning habitat reduction was greater at the spawning site downstream of Bessette with reduction in habitat availability of 33% and 57% respectively when flows were reduced from 1000-900-800 cfs (Stalberg 1992). Similarly a study by MoELP on kokanee in 1991/92 observed that approximately 10% of kokanee redds were dewatered by flow reductions form 1000 –650 cfs, however a further reduction in flows to 500 cfs resulted in approximately 50% of redds being affected (Jantz, 1992)

It will be necessary to conduct model runs similar to ones conducted by Sigma in 1993 to determine flow scenarios associated with selection of spawning flows less than 1000 cfs. The objective of determining the optimal spawning flow is to ensure that adequate water remains to guard against flow reduction over the winter incubation period, even in dry years (FOC's objective is to provide incubation flows that are maintained at no less than 2/3 of spawning flows). Kokanee may be the species most at risk due to negative stage change post spawning as indicated in Kjantz 1992. MoELP has mapped specific flow thresholds where spawning areas dewater (Caverly, A. 2000. pers comm). These flow/spawner area relationships should be determined for chinook and kokanee. Useable spawning area for kokanee needs to take into account the need to access side channel spawning habitats. Coho also benefit form the access to side channel spawning habitats. The objective of the exercise will be to gather the data to develop a risk assessment matrix that can be used on an annual basis to set fall/winter flow values. This selection of flows, done on an annual basis, will take into consideration, not only the habitat information, but also the reservoir data and forecast information.

There is also some concern due to the lack of gravel recruitment to the system and there is a risk that either the quality of the gravel or the amount of suitable gravel could decline over time. Baseline information, specifically upstream of Bessette Creek, can be collected which documents the current quality and aerial extent of the gravels. This information regarding be used comparatively in future years for similar assessments. Alternately, airphoto analysis of historic verses current airphotos could provide information on changes over time. As sediment discharges from the Bessette system have the potential to impact downstream spawning areas, it may be desirable to assess gravel quality downstream of Bessette to either compare with upstream values (spatial comparison) or to values in later years (temporal comparisons). This is not a WUP issue but it may affect Performance Measures selected for the WUP process.

Groundwater/riverwater side-channels are currently being built by FOC to provide side channel refuge habitats. Spawner escapement into the channels is being monitored, however there is presently no biological monitoring of natural versus man made habitats or juvenile use. This comparison can assist in better understanding the function and importance of the natural off channel habitats.

4.2.5.3 Impacts of Flow Management

Flow changes in the Middle Shuswap, including downstream of Wilsey Dam, result from flow changes at the Sugar Lake Dam. Flow changes at Sugar Lake are governed by established ramping criteria. Effects of stage change at the Sugar Dam attenuate with distance downstream and would be even more conservative below Wilsey than in the Middle Shuswap above Wilsey Dam. It is unknown how the rates of stage change downstream of Wilsey Dam associated with Sugar Dam flow management may compare to natural rates of stage change in the system from rainfall events.

Rates of stage change below the Wilsey Dam, associated with outages (Tripping Events), do not follow ramping rate guidelines and present a risk to fisheries values. Impacts of flow perturbations can include stranding, pocket isolation, side channel isolation as well as dewatering of sidechannels and redds. The severity of these impacts will vary depending on timing of the event, relative to critical life history, as well as duration of the event. Flow changes resulting in isolation events due to natural flow recession should be separated to those related to flow management. Timing of isolation of habitats will be required to assist with this assessment.

There are no applicable interactions relating to reservoir drawdown, therefore no information gaps are identified relating to the Water Use Planning process. The one operational risk is that of operational outages during the period of Wilsey Dam forebay drawdown which could increase lag in flow restoration.

4.2.6 Summary and Recommendations

In general, information on fish distribution and life history provides the ability to understand the fish habitat use in the Middle Shuswap downstream of the Wilsey Dam. However, the most recent assessment was conducted in 1984 and since that time 15 years of hatchery production and changes in habitat may have affected fish rearing patterns and densities in the river. Revisiting the 1984 study will provide the ability to compare current distribution/abundance to pre-enhancement values. In addition, the knowledge of amount of total available spawning habitat, at different spawning flows is not of sufficient detail to assess capacity for species that use the system, particularly for chinook salmon. Also, channel changes that occurred in 1997 may have resulted in a change in spawning habitat and a change in spawner distribution. Data that was reasonably complete prior to the event should be updated to provide a good understanding of the current spawning habitat distribution and use.

The Middle Shuswap River, in addition to being heavily utilized for spawning, is also important for early rearing, particularly for chinook. These fish use low velocity habitat along the margins, as well as side and back channel habitats. A good understanding of the period of use and the river conditions that provide access to these nursery habitats will help in understanding fish/flow requirements during this period.

The major effect of flow regulation has been the reduction of the peak flows and augmentation of overwinter flows to benefit incubating eggs and overwintering fish. This increase of winter flows has also resulted in wetted widths that are greater than unregulated flows which would presumably be of some benefit to benthic rearing organisms. Although studies conducted to date have indicated that productivity of the system is low (typical of many interior BC streams), this appears to be more related to the natural condition of the system rather than any impacts associated with flow regulation. Anadromous returns for chinook to the Middle Shuswap have increased and are currently at the high end of the range for the period of record. Sockeye returns have been strong through the 1980's and 1990's. The exception is the decline of coho returns, however coho declines are common throughout the Thompson Shuswap System and are more a result of over harvesting than conditions in natal streams.

Flow management strategies can include developing flow options to maximize production. There is a requirement to survey the maximum available spawning habitat for chinook, kokanee, coho and sockeye at different flows 500, 600, 700, 800, 900, 1000 cfs, to accurately assess at what level protection will be guaranteed for incubation, for all species. The objective is to develop spawning flows that can provide the most spawning for all species, and yet will allow for incubation flows to be maintained at a level that will provide the lowest risk to eggs and alevin. The data collected will allow for a decision protocol to be established that weighs the risks associated with the amount of available habitat verses risks associated with winter flow recession. Part of this exercise will be to assess access to side channel or off channel spawning habitats. Once flow habitat relationships are better understood annual fall/winter flow schedules can be decided each year using this information and information on annual snowpack, precipitation, inflow and storage.

There is general agreement that short term changes in flows have the capacity to affect production through short term changes in stage, which can result in impacts such as stranding or isolation of fish or dewatering of eggs and alevin. It is unlikely that the affect on incubating eggs or alevin is significant (D. B. Lister and Associates 1990). There is a recognized need to reduce or manage short term flow fluctuations to the greatest extent possible and to quantify the affects of these changes to assess what the implication of these operational impacts might be.

As the quantity and quality of the spawning habitat in the Middle Shuswap River is important there is a need to monitor the condition of the spawning habitat over time. This includes an assessment of gravel recruitment/scour upstream of Bessette Creek as well as overall gravel quality (% fines) downstream of Bessette Creek, since it contributes fine sediments to the system.

To fill the gaps in knowledge the following studies are suggested (taken from the Mabel to Wilsey Matrix Table – Appendix F).

- Reassess spawner distribution in the Middle Shuswap River. A 1997 flow event resulted in changes in channel morphology and potentially impacted spawning habitats available to the fish stocks in the River. In some cases side channels that were previously used for kokanee spawning, have become the main river channel with conditions unsuitable for kokanee spawning. In addition, substrate/flow conditions for chinook have been altered due to the channel changes (Wolski. S. 2000. pers comm). Sediment inputs from Bessette Creek may have affected downstream spawning quality and resulted in chinook spawners redistributing to upriver sites, where superimposition of redds has been observed (Stalberg, H. 2000. pers comm). Current spawner distribution should be documented and compared to previous information to assess what, if any, changes in spawner distribution have occurred. Flow monitoring sites used in 1994 (Triton 1995b) should be revisited to assess whether they can still be used as index sites. This information in spawner distribution will be necessary to assess current spawner capacity in the system. (Priority – High)

- Assess spawning capacity for chinook. Amounts of suitable spawning gravel at different achievable spawning flows (1000, 900, 800 and 700 cfs, as well as under extreme low flows, 550 cfs). Conduct model runs at these different spawning flows to develop fall winter flow recession. Using these recessions develop flow release based on results of the spawning capacity assessment and the risks associated with various levels of flow reduction from spawning flows. This information will be input into a matrix to assess the relative risks associated with amount of spawning habitat verses potential negative impact due to winter flow recession. As a first cut FOC has identified a 2/3 reduction from spawning to incubation flows as a maximum flow reduction for chinook. The value can be refined through a risk assessment framework. (Update of Sigma Study). (Priority – High)

- Quantify risks to short term flow fluctuation through stranding/isolation studies. by staging event with on-site monitoring of index sites. (Priority – High)

- Survey side channel inverts - assess emergent fry rearing habitats (assess risks to rainbow trout young of the year to flow recession). Side and off channel habitats are used by salmon at various times of the year. Chinook, coho and rainbow trout use these low velocity areas as early rearing (nursery) habitat. Information on the timing of use of these areas, as well as information on the flow levels that will make these habitats available, is important in maximizing off channel habitat in the Middle Shuswap River downstream of the Wilsey Dam. In addition, information on habitat use and channel outlet elevations will help in identifying when these habitats become isolated during flow recession. These channels are often selected for spawning by kokanee. (Priority – Moderate to High)

- Compare fish use of off channel habitats verses man made habitats. (Priority – Moderate to High)

- Update Middle Shuswap stock status, from 1980's) by using similar methodologies to earlier work that will allow for comparison of current condition to the earlier stock status. (Priority – Moderate to High)

- Assess spawning gravel recruitment, specifically in the spawning area above Bessette Creek (Priority moderate to high). Collect baseline gravel quality downstream of Bessette Creek, however this may be monitoring non-Hydro impacts. (Priority – Low to Moderate)

- Assess whitefish spawning distribution and potential susceptibility to flow fluctuation (Priority – Moderate)

4.3 Wilsey Dam to Sugar Lake Dam

4.3.1. Aquatic Resources

4.3.1.1 Water Quality and Quantity

Water quality may be affected by increases in sediment inputs to the Middle Shuswap River area from tributary systems as a result of logging and other resource activities. The amount of contribution to the mainstem has not been quantified, however, remedial actions within tributary systems, Cherry and Ferry Creeks, have been identified [Summit Environmental Consultants (Summit) 1996]. Land use activities along the mainstem have resulted in bank instability and loss of riparian values (Summit 1996).

Forty-seven water licenses allocated for domestic, irrigation, ponds, institutions, enterprise and storage use draw water from tributary systems between the Wilsey and Sugar Lake Dams. There are no community watersheds in the Wilsey Dam to Sugar Lake area (MoELP 2000a)

4.3.1.2 Discharge

There is one active hydrometric station (station no. 08LC018) at the outlet of Sugar Lake with data available from 1926 to present (Environment Canada 2000). Typical streamflows, pre and post regulation can be found in Figure 3c.

4.3.2 Fish and Fish Habitat

4.3.2.1 Fish Distribution

Fish species in the Shuswap River between Wilsey Dam and Sugar Lake include rainbow trout, bull trout, kokanee, cutthroat, mountain whitefish, northern pikeminnow, longnose dace, redside shiner, slimy sculpin, prickly sculpin, leopard dace, bridgelip, sucker, and largescale sucker. A list of species present in the Middle Shuswap between Sugar Lake and the Wilsey Dam, as well as, species present in the remainder of the Shuswap drainage can be found in Table 1. All species are present in the mainstem, rainbow trout and sculpins are the most widely distributed in the tributaries. Fisheries inventory work determined that rainbow trout are the dominant species in the Middle Shuswap River tributary streams and Cherry Creek was identified to have rainbow trout throughout, with bull trout concentrated in the upper reaches (ARC 1999). Bull trout are found in limited numbers in the mainstem. Anecdotal information suggests that bull trout densities are below historic levels. Whitefish are the most abundant species in the Middle Shuswap River above Wilsey Dam (Griffith 1979; Fee and Jong 1984).

There are anecdotal reports of high cutthroat trout numbers in the Middle Shuswap River. No cutthroat have been captured in recent sampling of the mainstem or tributaries (Griffiths 1979; Fee and Jong 1984; Triton 1995d; ARC 2000). MoELP stocking records indicate that cutthroat trout were stocked in Valerian Lake and Valerian Creek located in the headwaters of the Upper Shuswap River (MoELP 2000).

Chinook salmon were transplanted above the Wilsey Dam and are documented in association with the 1993 (August 10-20th -144 females/144 males/5 jacks) and 1995 (August 21 to September 7th- 153 females/140 males/ 7 jacks) transplants (Triton 1995a). The objective of the transplant was to detrennone if chinook could effectively spawn, incubate and rear in the Middle Shuswap River upstream of the Wilsey Dam.

4.3.2.2 Life History

Multiple age classes of rainbow trout are found in the mainstem including young of the year, although there is no documented mainstem spawning. Typically in larger systems rainbow trout spawning and early rearing, up to two or three years occurs in tributary systems. Cherry and Ferry Creeks have multiple age classes of rainbow trout suggesting that some portion of the population are resident (Triton 1995d). Ferry Creek is currently inaccessible to rainbow trout upstream of an impassible culvert at Highway 6. Some recruitment may also come from the lower reaches of Holstein and Reiter Creeks (Griffiths 1979).

Good adult rearing values for rainbow trout are found in the uppermost reach, Reach 5, of the Middle Shuswap River, although potential for spawning in this section is limited (Griffith 1979). Good early rearing habitat for rainbow trout can be found in the middle reach in the vicinity of Cherryville, Reach 4.

Whitefish are distributed in high numbers throughout the Middle Shuswap, and have been found in high concentrations in the upper section of the river in the fall where they may be aggregating to spawn (Triton 1995d).

Bull trout numbers are low in the mainstem but, resident bull trout are found in the upper reaches of Cherry Creek (ARC 1999). Recruitment systems for Middle Shuswap bull trout are unknown.

4.2.2.3 Habitat Productivity

Fish biomass in the upper reach of the Shuswap River, Reach 5 is dominated by whitefish (Griffith 1979). The low number/biomass of resident rainbow trout may result from lack of suitable spawning substrate (Griffith 1979), or possibly from lack of recruitment from tributary systems. Standing stocks are below theoretical capacity using both (Ptolemy alkalinity model, and Binns and Eiserman HQ index) (Triton 1995d). Low standing stocks could be a function of under recruitment to the mainstem, environmental conditions including flow variables or exploitation (Slaney, P. 2000. pers comm). Alkalinity. a measure of productivity, is low (36 mg/l), and Sugar Lake upstream is known to have low nutrient values.

4.3.2.4 Escapement

There are no anadromous escapement records above Wilsey Dam (FHIIP1990). However, there are historical accounts of chinook salmon above Shuswap Falls (French 1995). Shuswap falls were described as a series of extended rapids with head of approximately 21 meters (D.B. Lister and Associates 1990). The results of a historic review provided anecdotal information of chinook being captured in the Middle Shuswap River above Shuswap Falls. There is no indication of the numbers of fish that might have spawned, in that section of river. If returns to the Shuswap River were significant it might be possible to look for marine nitrogen from cores of trees that were growing in the late 1800's.

4.3.2.5 Stock Monitoring/Assessment

Fish and fish habitat, including standing stock assessments, have been carried out in 1979, 1984 and 1995 . Although there were differences in standing stock estimates among the studies, all three studies indicated that the system was performing below theoretical capacity (Fee and Jong 1984; Griffith 1979; Triton 1995d). Triton (1995d) reported an anomaly in rainbow trout age class within Reach 4 of the study area. This lack of 1993 recruitment in Reach 4 was not observed in Reaches 3 and 5 or in Cherry or Ferry Creek. The cause for this was not determined (Triton 1995d).

4.3.2.6 Enhancement

Adult chinook transplant pilot studies were conducted in 1977, 1993, and 1995. (Triton 1995a). Chinook salmon transported above Wilsey Dam spawned successfully and fry were documented rearing in the river (Triton 1994; Triton 1995d). Releases by MoELP within this section of the Middle Shuswap River system have included rainbow trout (MoELP 2000c). MoELP stocks high altitude lakes to provide recreational opportunities for anglers. Fish resources in rivers are managed through regulations (Jantz. B. 2000. pers comm).

4.3.2.7 Angler Use

Angler use is presently low, likely due to current low stocks. However, rivers in this region are easily overfished. As of 1994 there were no special angling regulations in the Shuswap River above Shuswap Falls. This section of river is exempt from the region wide angling closure from April 1-June 30 (Triton 1995d). Middle Shuswap experiences relatively little sport fishing due to the small size of resident rainbow trout in the area (Fee and Jong 1984). However, residents report reasonable size of rainbow trout and bull trout in the past (Caverly, A. 2000. pers comm).

4.3.3 Effects on Aquatic Resources

4.3.3.1 Flow Fluctuations

Flows are regulated from Peers Dam and flow fluctuations are the result of placement and removal of stop logs, as well as, the operation of the spillway. Flow changes are managed to minimize changes in stage and to comply with ramping rate guidelines. These guidelines are outlined in Table 7.

Table 7. Ramping Rate Guidelines (flow changes at the WSC gauge (Station No. 08LC018).

Duration	Life History Stage	Day Ramp Rate	Night Ramp Rate
Apr 1 – July 31	Fry Emergence	0 – 2.5 cm/hour	2.5 – 5.0 cm/hour
August 1 – October 31	Rearing until temp. <5° C.	0 – 2.5 cm/hour	5.0 – 10.0 cm/hour
November 1 – May 31	Winter Rearing	O cm/hour	<5 cm/hour

Rates of stage change are measured at the WSC gauging station on the Shuswap immediately below Sugar Dam. Fry emergence period is extended to include rainbow trout. Minor increases in flows can occur during daylight hours to a maximum of 1.4 m^3/s (50 cfs) at stage changes less than 2.5 cm/hour. (BC Hydro 2000).

4.3.3.2 Reservoir Drawdown

The Wilsey Dam headpond experiences fluctuations with maintenance including dredging of the forebay.

4.3.3.3 Flow Management Strategies

In general, the reservoir is managed to be at low pool in late April. The reservoir fills with increasing natural inflows and typically reaches full pool in July. Peak freshet flows are stored and re-distributed to the fall/winter period with the main benefit accruing to the January to March period providing flows in excess of historical levels. Interactive management decisions on flow release are made on an ongoing basis from August onward (Lewynsky, V. 2000. pers comm). Additional information on Flow Management can be found in Section 4.2.3.3.

4.3.4 Identified Interests and Concerns

Ministry of Environment, Lands and Parks -

- Maintenance of the sport fishery, while maximizing production (WUPCM 2000).
- Re-establish migratory bull trout and rainbow trout stocks (Caverly, A. 2000. pers comm).
- Ensuring that, if chinook are introduced into the Middle Shuswap above Wilsey Dam, they will not impact on resident species (WUPCM 2000).
- Assess if current flow regime for anadromous fish/kokanee downstream of Wilsey Dam is beneficial to resident fish above.

Fisheries and Oceans Canada -

- Opportunity to re-establish chinook (Stalberg, H. 2000. pers comm.).

Local stakeholders -

- Maintain/improve fishing opportunities.
- Maintain/improve recreational opportunities including canoeing and kayaking. establish better access to the river.
- Maintain/improve aesthetic values.
- Reduce flooding and erosion.

4.3.5 Discussion

4.3.5.1 Aquatic Resources

Water Quality

Water quality is currently good, however nutrients and productivity are low. Sediment contribution from the tributary systems is a concern as it can impact on the water quality within the Middle Shuswap River. Although FRBC assessments of the tributaries have identified some sediment sources, the contribution to the Middle Shuswap River is unquantified. There is no data to assess current sediment contribution to historic values. In addition, eroding banks along the mainstem are providing sediment inputs into the system. Removal of riparian vegetation along the stream channels has increased the potential for streambank erosion (DFO 1997).

The effects of short term flow regulation due to operation needs to be assessed. Although conservative ramping guidelines have been put in place, braided channel habitats in Reach 4 are susceptible to flow changes, particularly when young of the year rainbow trout are in the system. Better information on both temporal and spatial use of these habitats will provide information to confirm the efficacy of established ramping rates. Risks to stranding and isolation need to be quantified. In addition, assessment of river stage at tributary mouths during periods of upstream migration will identify whether there are any risks associated with upstream access.

4.3.5.2 Fish and Fish Habitat

Although previous studies have identified fish distribution in the Middle Shuswap River, little data is available to document early life history distribution and habitat use of young-of-the-year rainbow trout. This information is required to assess risks associated with flow changes.

There is a lack of general understanding regarding rainbow trout recruitment to the Middle Shuswap. It is unknown if there is mainstem spawning, or if all recruitment is from tributary systems. Little is known of timing and the distribution of young of the year rainbow. In addition, there is little knowledge of bull trout life history and no explanation for low population numbers other than historical harvest rates.

Habitat productivity in the Middle Shuswap is low and current standing stock information suggest that the system is under capacity. It is not clear if this is due to a lack of recruitment to the system, lack of nutrients, high summer temperature, overexploitation, flow effects or a combination of several of these factors. Of importance to the WUP process, is to provide adequate information to insure that no direct losses of production are taking place due to flow management or flow fluctuations, such as stranding or isolation of important habitats. Water quality/nutrient status is likely similar to unregulated values (Bryan and Jensen 1999), unless salmon runs were large and contributing nutrients to the system. In addition, flow management has resulted in increased fall winter flows and consequently wetted widths, which would be expected to be of some benefit to benthic production.

In the event that chinook and other migratory fish are provided access to the Middle Shuswap above Wilsey Dam, it may be prudent to confirm that habitat capacity is available without compromising resident stocks. One benefit of the introduction of chinook is the supply of nutrients from the carcasses (Slaney, P. 2000. pers comm). This benefit could potentially offset any risks to resident stocks. It should be noted that fish access past Wilsey Dam is not a WUP Management issue.

Fisheries regulations in the Middle Shuswap should take into account the apparent low productivity of the system.

4.3.5.3 Hydro-fish Interactions

There may be opportunities to minimize flow fluctuations and identify sensitive periods in critical mainstem habitat areas. In addition, ensuring that the reduction of forebay at the Wilsey Dam does not negatively impact fish in the headpond.

By better understanding life history requirements, strategies can be developed to improve conditions downstream of Wilsey Dam, and not impact stocks above the dam. Flow management should ensure that important life history requirements of rainbow trout fry are identified and taken into consideration.

4.3.6 Summary and Recommendations

The data gaps and suggested studies are based on the current physical conformation of the Middle Shuswap River with the Wilsey Dam in place, and without addressing the option of decommissioning or developing fish passage around the dam. This activity, although brought forward by a number of parties, is understood to be beyond the terms of reference of this review. However, if anadromous fish were allowed access to the Middle Shuswap River above the Dam, there would be a need to revisit the question of impacts on resident fish. One of the outstanding data gaps is an understanding of historic use of this section of river. Although anecdotal information strongly suggests anadromous fish use (French 1995), there is no indication of the number of fish that might have accessed this habitat. If anadromous fish use was high then the issue of displacing resident fish would be viewed in a different light. It may be feasible to assess for the presence of marine nitrogen in cores of 100 year old and older trees and compare the data to similar data collected below the dam. This research might provide the opportunity to assess historic usage. In addition if fish were allowed access upstream of the Wilsey Dam consideration for downstream fish passage would need to be addressed.

The major data gap identified relative to WUP is a lack of understanding of recruitment of rainbow trout from the tributary systems and life history of Middle Shuswap River bull trout stocks. Rainbow trout young of the year are present in the mainstem and these fish may be susceptible to flow changes in the less channelized section of the river near the village of Cherryville, as well as at several other locations. Better understanding of habitat use by young rainbow trout will help quantify risks associated with flow changes.

While productivity in the Middle Shuswap is low, this probably reflects the inherent low productivity of the system.

To fill the gaps in knowledge the following studies are suggested (taken from the Wilsey to Sugar Lake Matrix Table – Appendix F):

- Assess rainbow trout early rearing in Reach 4 of the Middle Shuswap River. Assessment should include both temporal and spatial use of fry habitats. (Priority - Moderate to High)
- Based on the assessment of rainbow early rearing habitats, assess risks associated with flow change in important habitat areas. The study should identify when important habitats become isolated and risks, if any, of stranding of rainbow trout. (Priority – Moderate to High)
- Assess Middle Shuswap water levels during spring to ensure that access of spawners to tributary systems is not impaired by flow management (Priority- Low)

- Undertake a bull trout study to understand life history requirements and constraints to production. May be more of a management rather than flow issue. (Priority-Moderate)
- Update species composition and ageclasses in the Middle Shuswap between Wilsey Dam and Sugar Lake Dam (Priority-Low to Moderate)
- Assess spawner utilization in the mainstem (may require telemetry) (Priority – Low to Moderate.

4.4 Upstream of Sugar Lake Dam

4.4.1. Aquatic Resources

4.4.1.1 Water Quality and Quantity

Water quality in Sugar Lake from 1971 to 1998 is reported as being good, with no deterioration in water quality, although there is nonpoint source pollution (Bryan and Jensen 1999). Sediment inputs have been increased because of a lack of riparian buffers and forest activities in tributaries (Summit 1996). Five water licenses draw water from tributary systems upstream of Sugar Lake, as well as, Sugar Lake itself. These water withdrawls are used for domestic and power storage uses. A total of 359 water licenses exist on the entire Shuswap mainstem, however their location is indiscernible (MoELP 2000d).

No community watersheds were identified for this area (MoELP 2000a).

4.4.1.2 Discharge

There are no active hydrometric stations on the Shuswap River upstream of Sugar Lake (Environment Canada 2000). Discharges and inflows from the Sugar Lake Dam are monitored by BC Hydro (Figure 2c).

4.4.2 Fish and Fish Habitat

4.4.2.1 Fish Distribution

Sugar Lake is known to support populations of kokanee, rainbow trout (including stocked Gerrard rainbow), cutthroat trout, bull trout, mountain whitefish and burbot (Klohn-Crippen 1998; Crowley 1974; MoELP 2000b). Tributary areas, upstream of Sugar Lake Dam, show records of rainbow trout, cutthroat trout, bull trout, prickly sculpin, slimy sculpin, longnose dace, largescale sucker and redside shiner(Klohn-Crippen 1998; Van Drimmelen 1978; ARC 2000). MoELP stocking records indicate that cutthroat trout were stocked in Valerian Lake and Valerian Creek located in the headwaters of the Upper Shuswap River (MoELP 2000c). Table 1 provides a list of fish species present in Sugar Lake and upstream, as well as comparative information for the rest of the Shuswap drainage.

FRBC fish inventory information conducted on tributary streams to the Upper Shuswap River have identified rainbow trout and bull trout within the system. Rainbow trout are the dominant species, however this drainage has been identified as an important bull trout area (Klohn-Krippen 1998; ARC 2000). Bull trout in the system appear to be limited to tributaries on the east side of the watershed (Klohn-Krippen 1998).

The Upper Shuswap River is 50km in length and serves as a spawning and juvenile rearing area for Sugar Lake salmonid stocks (D.B Lister and Associates 1990). There are no records of anadromous salmon above Sugar Lake, although anecdotal information has suggested that chinook salmon may have reached Sugar Lake (French 1995). The Sugar Lake Dam is located at the historic site of Brenda Falls. Fish passage at this location would likely have been affected by these falls.

Review of the BC Conservation Database failed to discover records of threatened or endangered fish species within area (BC Conservation Centre 2000). Species considered to be vulnerable include burbot and bull trout (Caverly, A. 2000. pers comm).

4.4.2.2 Life History

Kokanee, originally stocked in 1950, 1951 and 1952 are now self supporting, spawning in tributary systems, primarily the Upper Shuswap River and recruiting to Sugar Lake (Einarson 1985). It is currently unknown whether there are shore spawning kokanee in Sugar Lake.

Rainbow trout, bull trout and cutthroat trout may exhibit resident, fluvial and adfluvial life histories (Klohn-Krippen 1998). Specific knowledge of recruitment systems and strategies for Sugar Lake salmonids is generally lacking, however, there is anecdotal information of kokanee and bull trout spawning in Sitkum Creek.

4.4.2.3 Habitat Productivity

The Upper Shuswap River is described as moderately productive for rainbow trout and bull trout upstream of Sugar Lake. Fish usage is primarily found within Rainbow, Star, Curwen, Vigue, and Gates Creeks. The remaining tributaries are characterized by steep gradients and low discharge (Van Drimmelan 1978).

Bryan and Jensen (1999) report that Sugar Lake is an oligotrophic lake, which was likely the case prior to construction of the Sugar Lake Dam. Kokanee introduced into Sugar Lake between 1959 and 1964 weighed as much as 3.3 kg. The average size in 1985 was approximately 120g (Einarson 1985). Reservoir operation results in an annual drawdown of 6-8 meters which has likely affected littoral production (Einarson 1985). Bathymetric mapping of Sugar Lake was undertaken in 1969 (MoELP 2000b), and is available for assessment of littoral habitats.

Productivity of Sugar Lake is limited by a high flushing rate (6 months), low nutrient levels, and a fluctuation in lake levels from use as storage (D.B Lister and Associates 1990). Winter drawdown inhibits, the establishment of aquatic vegetation and bottom dwelling fish food organisms in shallow areas (D.B Lister and Associates 1990).

There are suggestions that kokanee may be a competitor with resident species, contributing to a decline in their populations (Einarson 1985). Recent information from resort owners on Sugar Lake suggest that kokanee catches have declined (although size has not changed). This could be in part due to success of introduced Gerrard rainbow to successfully predate kokanee, however the current status of the Gerrards is unknown.

4.4.2.4 Escapement

There are no anadromous escapement records (FHIIP 1990). There have been two kokanee counts. One was done in 1987 above Sugar Lake (Jantz, B. 2000. pers comm), and a second done in 1999 when an estimated 17,000 kokanee were enumerated near the Vique Creek confluence.

4.4.2.5 Stock Monitoring/Assessment

An unsanctioned creel survey done in 1985, suggested that kokanee have become smaller over time and that the bull trout population has been reduced, perhaps due to over exploitation (Einarson 1985). The status of rainbow trout and bull trout populations is uncertain (Caverly, A. 2000. pers comm). The status of burbot is unknown, but winter exploitation by ice fishermen has been reported.

4.4.2.6 Enhancement

Releases by MoELP within the area upstream of the Sugar Lake Dam are recorded from 1931 to 1994 and have included Gerrard rainbow trout (Fee and Jong 1984), kokanee, lake trout, lake whitefish and rainbow trout (MoELP 2000c). Additional stocking of kokanee occurred from 1950 to 1952 (MoELP 2000c), and 1959 to 1964 (Einarson 1985) into Sugar Lake. MoELP stocking records indicate that cutthroat trout were stocked in Valerian Lake and Valerian Creek located in the headwaters of the Upper Shuswap River (MoELP 2000c). MoELP's current stocking stategy is to stock small lakes to provide angling opportunity. Large lakes and rivers are managed by regulation (Jantz, B. 2000. pers comm).

4.4.2.7 Angler Use

An unsanctioned creel survey, done in 1985, documented a total of 6289 rod hours of fishing activity, the biweekly range in fish per hour was between 0.08 in the last two weeks in May, to a high of 0.89 fish/hour in the first two weeks of August (Einarson 1985). Kokanee provided the majority of the catch. There is a lodge/resort on Sugar Lake catering to anglers. An annual derby held in October promotes catch and release.

4.4.3 Effects on Aquatic Resources

4.4.3.1 Flow Fluctuations

Flow fluctuations in tributaries upstream of the Sugar Lake dam are a result of unregulated run-off. A discussion of flow management can be found in Section 4.2.3.3.

4.4.3.2 Reservoir Drawdown

The reservoir is managed to full pool in July, and stays at or near this level until September. Reservoir drawdown occurs through the fall and winter period with maximum drawdown in March or April (Lewynsky, V. 2000. pers comm). The annual drawdown is between 6-8 meters. Drawdown can affect littoral production as well as access to tributaries for fish.

4.4.3.3 Flow Management Strategies

Flow management from Sugar Lake dam applies to the Middle Shuswap River downstream of Sugar Lake. Additional information on Flow Management can be found in Section 4.2.3.3.

4.4.4 Identified Interests and Concerns

The following section briefly documents the current state of knowledge regarding interests/issues or concerns from various stakeholder groups

Ministry of Environment, Lands and Parks -

- Sport fishery and recreational opportunities in Sugar Lake.

Local landowners and Fishing Resort owners -

- Continued and improved fishery.
- Maintenance of recreational values associated with reservoir management. Currently during highest recreational use, reservoir is at or near full pool.
- Exposed stumps (aesthetics Sugar Lake).

Mabel Lake Preservation Society -

- Filling Sugar Lake and pulling gates during high flood times dramatically increasing the flow of the river in a very short time causing major flooding into valley bottom.
- Siltation of the north end of Sugar Lake.
- Issuing of 'new' water licenses.

Cherry Ridge Management (VP)-

- Keep water levels at Sugar Lake high for summer.

4.4.5 Discussion

4.4.5.1 Aquatic Resources

Water quality in Sugar Lake is considered good and has shown no signs of a downward trend.

Reservoir management has the potential to reduce littoral production, to affect upstream fish access into tributary streams that flow directly into the lake when reservoir levels are low, and to inundate lower reaches of tributaries in early summer. There is limited information to assess pelagic or littoral production as well as limits to tributary access.

4.4.5.2 Fish and Fish Habitat

There is general knowledge of fish distribution in Sugar Lake and in the Upper Shuswap River from inventory work conducted through FRBC. However, there is incomplete knowledge of life history of fish in this area, specifically Sugar Lake bull trout and burbot. Additional information on spawning and recruitment systems would help to better manage the stocks. In addition, the productive capacity of the reservoir and the constraints to production caused by reservoir drawdown, is not well understood. This information is required to determine how to best establish exploitation rates in order to manage reservoir populations. There is some concern that reservoir populations are easily exploited. Burbot are known to spawn in shallow water (and sometimes streams in winter), and may be susceptible to drawdown.

4.4.5.3 Hydro-Fish Interactions

BC Hydro operation impacts in the Sugar Lake Reservoir relate to reservoir drawdown and the associated decrease in Sugar Lake productivity from a reduction in pelagic and littoral productivity, as well as, potentially restricting tributary access. The resource use consideration regarding reservoir management is the downstream benefits associated with current flow management strategies. There may be a need to assess overall benefit to fisheries resources by comparing Sugar Lake productivity to downstream fisheries values in the Shuswap River. This can potentially be done by modeling trade offs. No attempt has been made to date to undertake this analysis. It is unlikely that there is currently sufficient data to undertake that analysis.

4.4.6 Summary and Recommendations

Although there are data gaps relating to an understanding of reservoir productivity and drawdown, effects such as loss of littoral production and tributary access, there appears to be agreement that current BCHydro operations have benefited downstream fish stocks. Augmentation of winter flows has resulted in protection of incubation habitat for chinook, coho, sockeye and kokanee downstream of the Wilsey Dam. In addition, the fact that the reservoir has the capacity to store only 13% of the inflows limits what can be done. The need for information to better describe reservoir production may be needed to help in the discussion of trade-offs relating to resident fish production in Sugar Lake and production of anadromous and resident fish downstream.

To fill the gaps in knowledge the following studies are suggested (taken from the Wilsey to Sugar Lake Matrix Table – Appendix F):

- Assess reservoir productivity, effects of loss of littoral production and contribution of littoral versus pelagic production (update bathymetry) (Priority – Moderate to High)

- Determine whether spawning activity is taking place in the drawdown zone of the reservoir. (Priority – Low to Moderate , Moderate to High for Burbot)

- Assess changes in tributary access associated with reservoir operation, d etermine which, if any, are spawning/recruitment systems. For those that are, assess how reservoir fluctuation may affect tributary access. May need to do habitat assessment as a surrogate, if upstream access is not possible during the spawning period. (Priority – Low to Moderate)

- Assess inundation of tributaries and effects on spawning. (Priority - Low to Moderate)

5.0 OVERALL SUMMARY AND DISCUSSION. OF DATA GAPS

This section summaries the information on the data gaps that currently have been identified relative to BC Hydro Operation within the Shuswap River systems. The *Gap Summaries* and the *Matrices* in Appendices E and F provide summarized information on data gaps and suggested studies. The summary below brings forward the suggested studies from the individual sections and presents them with a suggested priority. It has been put together using the data gathered to date and responses from several reviewers. As noted in the introduction the priorities are those of the author. Final prioritization and decisions on further work needed will be done by the SHU WUP CC.

High Priority

- **Shuswap River Mabel Lake to Wilsey Dam** - Reassess spawner distribution. A 1997 flow event resulted in changes in channel morphology and potentially impacted on spawning habitats available to the fish stocks in the river. In some cases side channels that were previously used for kokanee spawning have become the main river channel with conditions unsuitable for kokanee spawning. In addition, substrate/flow conditions for chinook have been changed due to the channel changes (Wolski, S. 2000. pers comm). Sediment inputs from Bessette Creek may have affected downstream spawning quality and resulted in chinook spawners redistributing to upriver sites where superimposition of redds has been observed (Stalberg, H. 2000. pers comm). Current spawner distribution should be documented and compared to previous information to assess what, if any, changes in spawner distribution has occurred. Flow monitoring sites from 1994 should be revisited to assess whether these sites are still appropriate to use as index sites for flow monitoring. This information in spawner distribution will be necessary to assess current spawner capacity in the system.

- Assess spawning capacity for chinook. Amounts of suitable spawning gravel at different achievable spawning flows (1000, 900, 800 and 700 cfs, as well as under extreme low flows, 550 cfs). Conduct model runs at these different spawning flows to develop fall winter flow recession. Using these recessions develop flow release based on results of the spawning capacity assessment and the risks associated with various levels of flow reduction from spawning flows. This information will be input into a matrix to assess the relative risks associated with amount of spawning habitat verses potential negative impact due to winter flow recession. As a first cut FOC has identified a 2/3 reduction from spawning to incubation flows as a maximum flow reduction for chinook. The value can be refined through a risk assessment framework. (Update of Sigma Study). (Priority – High)

- **Shuswap River Mabel Lake to Wilsey Dam** - Quantify risks to short term flow fluctuation through stranding/isolation studies, by staging a typical flow reduction event with on-site monitoring of index sites (Assess applicability of 1994 monitoring sites).

Moderate to High Priority

- **Shuswap River Mabel Lake to Wilsey Dam** -Survey side channel inverts - assess emergent fry rearing habitats (assess risks to rainbow trout young of the year to flow recession). Side and off channel habitats are used by salmon at various times of the year. Chinook as well as rainbow trout use these low velocity areas as early rearing (nursery) habitat. Information on timing of use of these areas as well as flow levels that will make these habitats available is important in maximizing off channel habitat use in the Middle Shuswap River downstream of the Wilsey Dam. This survey will provide information to identify a critical flow value at which extra habitat may become available. In addition, information on habitat use and channel outlet elevations will help in identifying when these habitats become isolated, during flow recession.

- **Shuswap River Mabel Lake to Wilsey Dam** - Compare fish use of off channel habitats verses man made habitats.

- **Shuswap River Mabel Lake to Wilsey Dam** - Update Middle Shuswap stock status (from 1980's) using similar methodologies to earlier work that allow for comparison of current condition to earlier status.

- **Mabel Lake to Wilsey Dam** - Assess spawning gravel recruitment, specifically in the spawning area above Bessette Creek (Priority moderate to high). Collect baseline gravel quality downstream of Bessette Creek, however this may be monitoring non-Hydro impacts.

- **Shuswap River Wilsey Dam to Sugar Lake** - Assess rainbow trout early rearing in Reach 4 of the Middle Shuswap River. Assessment should include both temporal and spatial use of fry habitats.

- **Shuswap River Wilsey Dam to Sugar Lake** - Based on the previous identification and assessment of rainbow early rearing habitats, assess risks associated with flow change in important habitat areas. The study should identify when important habitats become isolated and risks, if any, of stranding of rainbow trout juveniles.

- **Sugar Lake** – Identify risks to spawning Burbot associated with reservoir drawdown.

- **Sugar Lake** - Assess reservoir productivity, effects of loss of littoral production and effect on pelagic production (update bathymetry).

Moderate Priority

- **Shuswap River Wilsey Dam to Sugar Lake** - Undertake a bull trout study to understand life history requirements and constraints to production. (May be more of a management rather than flow issue).

- **Mabel Lake to Wilsey Dam** - Assess whitefish spawning distribution and potential susceptibility to flow fluctuation.

Low to Moderate Priority

- **Shuswap River Wilsey Dam to Sugar Lake**- Assess Middle Shuswap River water levels during spring to ensure that access of spawners to tributaries is not impaired by flow management.

- **Shuswap River Wilsey Dam to Sugar Lake**- Assess spawner utilization in mainstem (may require telemetry studies).

- **Shuswap River Wilsey Dam to Sugar Lake**- Update species composition and ageclass in the Middle Shuswap between Wilsey Dam and the Sugar Lake Dam.

- **Above Sugar Lake Dam** - Assess changes in tributary access associated with reservoir operation. Determine which are spawning/recruitment systems. For those that are, assess how reservoir fluctuation may affect tributary access or whether spawning areas are inundated at high reservoir levels. (May have to do habitat assessment as surrogate, if upstream access is not possible during the spawning period).

- **Above Sugar Lake Dam** - Determine whether spawning activity is taking place in the drawdown zone of the reservoir.

Low Priority

- **Shuswap River Wilsey Dam to Sugar Lake** - Assess Middle Shuswap water levels during spring to ensure that access of spawners to tributary systems is not impaired by flow management.

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APPENDIX A:

Information Letter

June 15, 2000

Reference: ARC Project 1180

RE: BC Hydro Water Use Planning: Shuswap River Fish/Aquatic Information Review

ARC Environmental Ltd., at the request of BC Hydro, is currently conducting an information review of the Shuswap River basin to identify the current status of the fisheries/aquatic resource and those factors that may be affecting the resource. The study area includes the Shuswap River upstream of Mara Lake to its headwaters above Sugar Lake.

The objective of the review is to develop a comprehensive list of references (journal, consultant reports, etc) and personal communications and with this information at hand, identify gaps in information that need to be filled to aid in the Water Use Planning initiative that is currently underway. The intent is to access all the information that exists on the system and therefore your input is requested.

Please take the time to fill out the attached individual contact sheet and return it by mail. The information we are requesting is as follows;

- Section I – Contact Information
- Section II – Relevant Information: subjects may include *Fish and Fish Habitat Assessments* (i.e. stock management issues, restoration initiatives, standing stock, etc.), *Water Quality*, *Hydro-Fish Interactions* (i.e. minimum flow issues, entrainment, operational issues, etc.) *Other* (i.e. land-use issues, Forest Renewal BC relevant projects, etc.)
- Section III - References (references you suggest that should be reviewed)
- Section IV - Other Contacts (other individuals, organizations, and/or stakeholders you suggest we should contact)

In addition to the above, any historic (pre-impoundment) information related to the above sections would also be of value.

We will follow up with you your responses to the enclosed contact sheet. Please respond to either Bill Rublee or Harry Goldberg at:

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Phone (250) 851-0023
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e-mail: brublee@arc-env.com
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Yours truly,
ARC Environmental Ltd.

Bill Rublee, R.P. Bio.

APPENDIX B:

Individuals Contacted

Appendix B

Individuals Contacted

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Brian Symonds	MoELP, Water Management	Penticton	250-490-8255		Brian.Symonds@gems9.gov.bc.ca
Lee Hesketh	Cattlemens Association, Stewardship Coordinator		250-547-6586	250-547-6586	
Brian Nuttal	MoELP, Forest Renewal Officer	Kamloops	250-371-6200		Brian.Nuttal@gems2.gov.bc.ca
Kathy Groves	BC Hydro				Kathy.Groves@bchydro.ca
Phil Epp	MoELP,Watershed Restoration / Geomorph	Penticton	250-490-8274	250-492-1314	Phil.Epp@gems5.gov.bc.ca

Appendix B
Individuals Contacted

Name	Title/Organization	Address	Phone	Fax	E-mail
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Gordon Haas	MoFish, Biologist	Vancouver	604-222-6769	604-660-1849	Gordon.Haas@gems4.gov.bc.ca
Szczepan Wolski	Shuswap Hatchery, Manager		W:250-547-6673, H:250-545-5634	250-547-6673	lswolski@telus.net
Neil Schubert	FOC	New Westminster			SchubertN@pac.dfo-mpo.gc.ca
Steve MacFarlane	FOC				MacFarlaneS@pac.dfo-mpo.gc.ca
Elmer Fast	FOC	Kamloops	250-851-4950		
Angelo Facchin	MoFish, Data Management Unit Head	Victoria	250-953-4982	250-356-1202	Angelo.Facchin@gems6.gov.bc.ca
Diana French	Okanagan University College		250-762-5445 (local 7363)		
Loretta Eustache	Spallumcheen Indian Band	Enderby	250-838-6496		
Bob Reid	Riverside Forest Products	Lumby	250-545-3168		
Howie Wright	Okanagan Nation Fisheries Commission	Westbank	250-707-0095 250-707-0166		

APPENDIX C:

References for Entire Project

Appendix C
References for Entire Project

Reference Number	FISS Reference Number	Author(s)	Year	Reference Title	Location (in the world)	Source List
1		Triton Environmental Consultants Ltd.	1995	Shuswap River Flow Monitoring Program, 1994, Draft	ARC Office	C
2		Triton Environmental Consultants Ltd.	1994	Shuswap River Flow Monitoring Program.	ARC Office	C
3		Triton Environmental Consultants Ltd.	1994	Howell-Bunger Bypass Valve Testing and Commissioning, Nov. 16, 1994. Result of Water Quality and Water Level Monitoring	ARC Office	B/C
4			1997	Power Facilities Upper Columbia Generation Local Operating Order No. 3P03-76C Shu-Shuswap Falls Generating Station Unit Operation	ARC Office	B/C
5			1998	Power Facilities Upper Columbia Generation Local Operating Order No. 4P03-80A Shu-Middle Shuswap River, Sugar Lake and Wilsey Reservoir	ARC Office	B/C
6			1998	Power Facilities Upper Columbia Generation Local Operating Order No. 4P03-80C Shu-Middle Shuswap River	ARC Office	C
7			1997	Power Facilities Upper Columbia Generation Local Operating Order No. 4P03-80B Shu-Sugar Lake Dam Discharge	ARC Office	B/C
8			1998	Power Facilities Upper Columbia Generation Local Operating Order No. 3P03-73B Shu-Shuswap Falls Generating	ARC Office	C
9			1998	Power Facilities Upper Columbia Generation Local Operating Order No. 1P03-75 Shu-Power System Safety	ARC Office	C
10		BC Hydro	2000	BC Hydro Shuswap Falls Field Facility Guide 2000/06/09 DRAFT	ARC Office	C
11		BC Hydro	2000	Shuswap Falls and Sugar Lake Water Use Plan Project: Project Team Meeting No. 6:ED09-NI: April 10, 2000	ARC Office	C
12		BC Hydro	2000	Shu: Bypass Valve Briefing Note: DRAFT: 00-05-17	ARC Office	C
13		BC Hydro	2000	Environmental Incident Reporting	ARC Office	C
14		Triton Environmental Consultants Ltd.	1994	Shuswap Falls Penstock #2 Replacement: Environmental Monitoring During Construction	ARC Office	B/C
15		Triton Environmental Consultants Ltd.	1994	NO TITLE: DRAFT	ARC Office	C
16		Fielden, R.J. and T.L. Slaney	1994	Preliminary Implications of Summer Flow Ramping in the Middle Shuswap River	ARC Office	B/C
17		BC Hydro	1983	Shuswap Falls Project: Probable Maximum Flood	ARC Office	B/C
19		Aquatic Resources Ltd.	1997	Middle Shuswap River: Flow Ramping and Fish Production: DRAFT	ARC Office	B/C
20		D.B. Lister and Associates Ltd.	1990	An Assessment of Fisheries Enhancement Potential of BC Hydro Operations at Shuswap River	ARC Office	B/C
21		BC Hydro	1991	Wilsey Dam: Comprehensive Inspection and Review 1989	ARC Office	C
22		Envirocon Limited	1985	Shuswap River Enhancment Site Reconnaissance 1982 to 1984	ARC Office	G
23	HQ1164	Klohn-Crippen	1998	Upper Shuswap River Fish and Fish Habitat Inventory	ARC Office	A/B/D
24		Triton Environmental Consultants Ltd.	1995	Shuswap River Hatchery Operation 1994-1995	ARC Office	G

Reference Number	FISS Reference Number	Author(s)	Year	Reference Title	Location (in the world)	Source List
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26		Triton Environmental Consultants Ltd.	1994	Evaluation of the Effectiveness of Water Release as Mitigation to Protect Fish	ARC Office	G
27		Province of British Columbia	1999	Okanagan Shuswap Land and Resource Management Plan. Draft #7	ARC Office	G
28		USL Urban Systems Ltd.	1986	Shuswap Lake 1986 Secchi Disk Program Water Quality Review	ARC Office	G
29		Dobson Engineering Ltd.	1996	Interior Watershed Assessment for the Duteau Creek Watershed: Watershed Restoration Program: Summary Report	ARC Office	G
30		WRP MoELP	1998	Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program 1997-1998	ARC Office	G
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32		ARC Environmental Ltd.	1999	Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of the Cherry Creek Watershed.	ARC Office	G
33		Summit Environmental Consultants Ltd.	1996	Watershed Restoration Program: Middle Shuswap River Watershed Stream Assessment	ARC Office	C/D/G
34		Summit Environmental Consultants Ltd.	1996	Watershed Restoration Program: Upper Shuswap River Stream Assessment	ARC Office	C/D/G
35		DFO	1997	Strategic Review of Fisheries Resources for the South Thompson-Shuswap Habitat Management Area	ARC Office	D/G
36		Hartman. F. and Miles. M	1995	Evaluation of Fish Habitat Improvement Projects in BC and Recommendations on the Development of Guidelines for Future	ARC Office	G
37		Shuswap Nation Fisheries Commission	1999	Results from Juvenile Fish Surveys of Thompson and South Thompson Basin Streams During the Fall of 1998	ARC Office	G
38	8046/8078	Griffith. R.P.	1986	Rainbow Trout Production and Implications of Coho Salmon Enhancement in the Bessette Creek Drainage, Tributary to the Middle	ARC Office	A/B/C/D
39		ARC Environmental Ltd.	1997	The Kamloops Forest Region Stream Classification Project	ARC Office	D/G
40		Shuswap Nation Fisheries Commission	1998	Results from Monitoring Adult Coho Escapements into Thompson Basin Streams During the Fall of 1997.	ARC Office	G
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43	29K-25	Sebastion D.C.	1983	Outplanting Opportunities for Chinook, Coho (and steelhead) in Six Selected Tributaries of the South Thompson Drainage 1982	ARC Office	A/E
44		MoELP	No Date	Shuswap Lake Environmental Management Plan	ARC Office	G
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48		Dobson Engineering Ltd.	1996	Duteau Creek Watershed: Results of the Watershed Restoration Project	ARC Office	G
49		Dobson Engineering Ltd.	1996	Interior Watershed Assessment for the Harris Creek Watershed: Watershed Restoration Program: Summary Report	ARC Office	G
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51		Jantz, B.	1986	Creel Survey and Life History Characteristics of Rainbow Trout and Kokanee in Mabel Lake, 1984	ARC Office	B/C
52	8186	Griffith, R.P.	1979	Enhancement Opportunities for Resident Rainbow Trout in the Middle Shuswap River Above Shuswap Falls and Potential Impact of Chinook Salmon Re-	ARC Office	A/B
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61		Jantz, B.	1998	Lang/Tulley Channel Complexing	ARC Office	B/C
62	29K-27	Nordin, R.N	1978	Water Quality in the Shuswap River Between Mabel and Mara Lakes, 1977	ARC Office	A/B/C
63		Sigma Engineering Ltd.	1993	Shuswap Flow Capability Study	ARC Office	B/C/D/G
64		Federenko, A.Y and B.C. Pearce	1982	Trapping and Coded Wire Tagging of Wild Juvenile Chinook Salmon in the South Thompson/ Shuswap River System, 1976, 1979 and 1980	ARC Office	E/G
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71		Columbia Shuswap Regional District	1988	Shuswap Lake System Management Strategy	ARC Office	G
72		FOC	1994	Interior and Fraser River Above Hope: Master List of Habitat Improvement Projects.	ARC Office	D,G
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76	HQ0107	Spallucheen Band	1994	Fortune Creek Fisheries Project, March 1993-October 1993	ARC Office	A/D
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80		Hirst, S.M.	1991	Impacts of the Operation of existing Hydroelectric Developments on Fishery Resources in BC. Volume 2	Triton Office	D/H
81		Lewis, A.F., Triton Environmental Consultants, G.J Naito, Sigma Engineering Ltd., S.E Redden	1996	Fish flow Overview Report	Triton Office	H
82		Schubert, N.D. and N.J Vivian	1994	Estimation of the Shuswap River System Sockeye Salmon (Oncorhynchus nerka) escapement.	Triton Office	E/H
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191	EW237	Rosenberger, R. B.	1994	Personal communication with fishery officer	DFO - DISTRICT 1 - KAMLOOPS	A
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198	EW270	Ross, M.	1994	Untitled	Shuswap Nation Fisheries Commission, Kamloops, BC	A
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209	SUM-1	AG_SUMMARY	No Date	Angling Guides Database		A
210	SUM-10	SL_SUMMARY	No Date	SLIM (Small Lake Database)		A
211	SUM-11	RH_SUMMARY	No Date	Rehabilitation (poison and re-stock of		A
212	SUM-12	RG_SUMMARY	No Date	Regulations dbase		A
213	SUM-14	LSF SUMMARY	1999	SUMMARY FISH DISTRIBUTION DATA EXTRACTED FROM THE BC LAKES DATABASE	MINISTRY OF FISHERIES, VICTORIA, B.C.	A
214	SUM-2	RL_SUMMARY	No Date	Stocking dbase		A
215	SUM-3	EC_SUMMARY	1997	Summary from FSHWHSE	FSHWHSE	A

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218	SUM-8	LSA_SUMMARY	No Date	BC Lakes - angler access dbase		A
219	SUM-9	LST_SUMMARY	No Date	BC Lakes - facilities dbase		A
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222		BC Hydro	No Date	Shuswap Falls Hydroelectric Development Information Pamphlet.	BC Hydro	B
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225		BC Hydro	1984	Dam Safety Deficiency Investigation: Sugar Lake Dam Rehabilitation Studies	BC Hydro	B
226		BC Hydro	1984	Wilsey Dam	BC Hydro	B
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230		BC Hydro	1986	Wilsey Dam Emergency Preparedness Plan	BC Hydro	B
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233		BC Hydro	1988	Shuswap Generating Station: Headpond Sedimentation	BC Hydro	B/C
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238		BC Hydro	1991	Dam Safety investigations: Wilsey Dam Comprehensive Inspection and Review	BC Hydro	B/C
239		BC Hydro	1991	Shuswap Falls Forebay Dredge Monitoring 1990	BC Hydro	B
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241		BC Hydro	1992	Dam Safety investigations: Wilsey Dam Deficiency Investigation	BC Hydro	B
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244		BC Hydro	1992	Wilsey Dam Intermediate Civil Inspection Report	BC Hydro	B
245		BC Hydro	1993	Wilsey Dam Intermediate Civil Inspection Report	BC Hydro	B
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249		BC Hydro	1994	Report on the Electrical System Operations Review.	BC Hydro	B
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258		BC Hydro	1996	Lake Revelstoke Reservoir Integrated Recreation Plan	not known	B/C
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261		BC Hydro	1998	Power Facilities Upper Columbia Generation Local Operating Order No. 3P03-76C Shu-Shuswap Falls Generating Station Unit Operation	BC Hydro	B
262		BC Hydro	1998	Shuswap Powerplant Seismic Evaluation and Upgrade Program: Phase I Survey	BC Hydro	B
263		BC Hydro	1998	Wilsey Dam: 1997 Comprehensive Inspection and Review.	BC Hydro	B
264		BC Hydro	1998	Wilsey Dam: Intermediate Civil Inspection Report.	BC Hydro	B
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267		BC Hydro	1999	System Operating Order 4P-19 (Revision to SOO 4P-19 1997) Sugar Lake/ Shuswap Project	BC Hydro	B
268		BC Hydro	No Date	Dam Safety Investigations: Sugar lake dam - Dam Breach	BC Hydro	B
269		BC Hydro	No Date	Dam Safety Investigations: Sugar lake Dam Comprehensive	BC Hydro	B
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271		BC Hydro	1974	Memorandom on Rehabilitation of Sugar Lake Dam	BC Hydro	B/C
272		BC Hydro	No Date	Report on Sugar Lake Debris	BC Hydro	B/C
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Reference Number	FISS Reference Number	Author(s)	Year	Reference Title	Location (in the world)	Source List
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277		BC Hydro	No Date	Sugar Lake Dam Emmergency Preparedness Plan	BC Hydro	B
278		BC Hydro	No Date	Sugar Lake Dam Intermediate Civil Inspection Report	BC Hydro	B
279		BC Hydro	No Date	Sugar Lake Dam Intermediate Civil Inspection Report	BC Hydro	B
280		BC Hydro	No Date	Sugar Lake Dam Left Abutement Peizometer and Weir Ins.	BC Hydro	B
281		BC Hydro	No Date	Sugar Lake Dam Preliminary Report of Geological Mapping	BC Hydro	B/C
282		BC Hydro	No Date	Sugar lake Project: 1985 Rehabilitation Memorandom	BC Hydro	B
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284		BC Hydro	No Date	Wilsey Dam Penstock #2 Replacement	BC Hydro	B
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288		BC Power Commission	1958	Shuswap Falls Hydro Electric Generating Stations Civil Plant Inspection	BC Hydro	B
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290		BC Power Commission	1961	Annual Report on the Shuswap Generating Station	BC Hydro	B
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Appendix C
References for Entire Project

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309		BC Hydro	2000	DRAFT Tripping Event Summary	BC Hydro	C
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333		Maclellan SG, Mueller CW, Enzenhofer HJ and Hume JMB	1995	Trawl Catch Statistics on Shuswap Lake from 1987-1993	Can. Data. Rep. Fish. Aquat. Sci.	E
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336		MoELP.FsRBC. FOC, Riverside	1999	Bessette Creek Riparian Restoration/ Rehabilitation	not known	F
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338		Okanagan Nation Fisheries Commission , FsRBC	1998	Bessette Creek Waterhshed Coho Spawning Survey	not known	F
339		Okanagan Nation Fisheries Commission , FsRBC	1999	Bessette/Ireland/Bolean Creek/Salmon River-Coho Enumeration	not known	F
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341		Riverside Forest Products, FRBC	1998	Kingfisher Creek Watershed 1:20000 Fish and Fish Habitat Inventory	not known	F
342		FsRBC, FOC, Kingfisher Environmental Ltd	1998	Kingfisher Environmental Interpretive Centre	not known	F
343		FOC, Kingfisher Environmental Ltd	1981	Kingfisher Environmental Interpretive Centre	not known	F
344		Tolko Industries Limited Lavington Division	1998	Lumby 1:20000 Reconnaissance Fish and Fish habitat Inventory	not known	F
345		MoELP	1998	Okanagan TSA Small Lakes Inventory	not known	F
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347		Riverside Forest Products, FsRBC	1998	Riverside Multi-Year Plan-Inventory 1:20000 Reconnaissance.	not known	F
348		Weyerhaeuser Canada Ltd.-Okanagan Falls FRBC, ARC Environmental	1998	Upper Kettle/Upper Shuswap Watersheds 1:20000	not known	F
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363		Levings, CD; Scrivner JC; Andersen, B; Shirvell; Lauzier, R.	1985	Results of Reconnaissance Sampling for Juvenlile Salmonids in the Upper Fraser and Selected Tributaries, August and October 1984	Can. Data. Rep. Fish. Aquat. Sci. No.549	E

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365		Morton, KF; Shortreed, KS	1996	Results from a Seven-Year Limnological Study of Shuswap Lake. Part 2	Can. Data. Rep. Fish. Aquat. Sci.	E
366		Quinn, TP; Graynoth, E; Wood, CC; Foote CJ	1998	Genotypic and Phenotypic Divergence of Sockeye Salmon in New Zealand from Their Ancestral BC Populations	Transactions of the American Fisheries Society. Vol. 127, no 4.can	E
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368		Schubert, N.D.	1995	Angler Effort and Catch in four Fraser River Chinook salmon Sport Fisheries, 1994, and a Retrospective on Nine years of Upper Fraser River Sport Fishery management and Assessment	ARC Office	E
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373		Triton Environmental Consultants Ltd.	1995	Chinook Salmon Adult Transplant on Middle Shuswap River - 1995	ARC Office	
374		Triton Environmental Consultants Ltd.	1994	The Assessment of Chinook Salmon Fry Migration Timing in Middle Shuswap River Upstream of Wilsey Dam 1994 and	ARC Office	
375		Triton Environmental Consultants Ltd.	1993	Chinook Salmon Adult Transplant on Middle Shuswap River - 1993	ARC Office	
376		DFO	1990	Stream Summary Catalogue. Subdistrict 29K, Salmon Arm.	ARC Office	
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380		BC Hydro	1998	Rare element occurrence: Field Guide to the rare and endangered species found within the watershed boundaries of each	not known	I
381		Bryan, J. and EV Jensen.	1999	Water Quality Trends in Mara, mabel and Sugar Lakes 1971-1998		I/K
382		DFO	1982	Salmon Enhancement program at Shuswap Falls. Notes meeting DFO-SEP-BC	not known	I
383		International Pacific Salmon	1977	Middle Shuswap River and Sugar Lake	not known	I
384		Northwest Hydraulic Consultants	1987	Shuswap Generating Station. Headpond Silting Hydraulic Model Studies	not known	I
385		Starr, P	1978	A short Revies of Fisheries related information pertinent to the BC Hydro dam and Generating plant at Shuswap Falls	not known	I
386		Silvatech Consulting Ltd.	1999	Reconnaissance (1:20000) Fish and Fish Habitat Inventory of the Cooke, Kingfisher and Noisy Creek Watersheds	ARC Office	

Reference Number	FISS Reference Number	Author(s)	Year	Reference Title	Location (in the world)	Source List
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388		BC Conservation Data Centre	2000	Faxed Report of Rare Eelement Occurrences: Shuswap River Watershed	ARC Office	
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390		Shuswap Falls and Sugar Lake Water Use Plan Consultative Committee	2000	Shuswap Falls and Sugar lake Water use Plan Consultative Meeting: Meeting Notes - White Valley Hall, Lumby	ARC Office	
391		Crowley, D.	1974	Technical Report - Creel Census Mabel and Sugar Lakes 1974	ARC Office	
392		Silvatech Consulting Ltd.	1998	Interior Watershed Assessment Procedure for the Kingfisher, Cooke and Noisy Creek Watersheds.	not known	
393		Silvatech Consulting Ltd.	1999	Overview Fish and Fish Habitat Asssessment Procedure for Cooke, Kingfisher and Noisy Creek Waterhsheds	not known	
394		Silvatech Consulting Ltd.	1999	Channel Assessment Procedure for the Kingfisher, Noisy and Cooke Creek Watersheds	not known	
395		Ball, J.	2000	Personal Communication regarding angler use and escapement numbers within Shuswap River watershed	ARC Office	
396		MoELP	2000	http://www.env.gov.bc.ca/sir/wrp/iwap/phase1/admin.html	web	
397		Wolski, S.	2000	Personal communication, regarding fisheries resources in the Middle and Lower Shuswap Rivers.	ARC Office	
398		Jantz, B.	2000	Personal communication regarding kokanee and bull trout populations, angler use and fish-hydro interactions in the Shuswap River watershed	ARC Office	
399		Griffith, R.	1984	Biophysical Reconnaissance of Kingfisher/Danforth Creeks: Program Options	ARC Office	
400		ARC Environmental Ltd.	1999	Reconnaissance (1:20000) Fish and Fish Habitat Inventory Program of the East Sugar Lake and Upper Kettle: Phase I to III Pre-Field Project Planning Report	ARC Office	
401		Kristmanson, J.	1999	Angler Effort and Catch in the Shuswap River Chinook Salmon Sport Fisheries, 1996.	ARC Office	
402		Slaney, P.	2000	Personal communication, regarding fish and fish habitat in the Middle Shuswap River, as well as management flows	ARC Office	
403		Lewynsky, V	2000	Personal communication, regarding fish and fish habitat in the Middle Shuswap River, as well as management flows	ARC Office	
404		Stalberg, H., FOC Habitat Biologist	2000	Personal communcation, regarding fisheries resources in the Middle and Lower Shuswap Rivers.	ARC Office	
405		Flynn, Mike, FOC Restoration Biologist	2000	Personal communcation, regarding fisheries resources in the Middle and Lower Shuswap Rivers, specifically restoration activities, groundwater	ARC Office	

Appendix C
References for Entire Project

Reference Number	FISS Reference Number	Author(s)	Year	Reference Title	Location (in the world)	Source List
406		Cooke, Roberta, DFO Vancouver	2000	Data files, hatchery releases, hatchery returns, age class data	ARC Office	
407		Caverly, Al. MoELP Kamloops	2000	Data files and personnal communication	ARC Office	
408		Bailey, R. DFO Kamloops	2000	Personnal Communication	ARC Office	
409		Rublee W.O, H Goldberg, D.B. Gamble	1997	Winter Habitat Use and Related Constraints to Production of Interior B.C.	ARC Office	
410		Anonymous	1987	Department of Fisheries and Oceans Studies of juvenile chinook salmon in the Nechako River, 1985 and 1986. Dept. Fish. Ocean. Pac. Yuk. Region, Vancouver		
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			B	BC Hydro RFP		
			C	Darren Sherbot's List		
			D	ARC Proposal		
			E	Triton/FOC - Louise Archibald		
			F	Fisheries Project Registry		
			G	ARC Environmental Library		
			H	Triton Environmental Library		
			I	List from Bill Bengeyfield		
			J	Bob Westcott June 1/2000		
			K	From Bryam Jantz		

APPENDIX D:

<u>Data Summaries</u>

AREA DESCRIPTION

Drainage Area (ha):

NTS Maps:
82L/6, 82L/7
82L/10, 82L/11
82L/14, 82L/15

Major Waterbody Systems:

Ashton Creek
Blurton Creek
Brash Creek
Cooke Creek
Danforth Creek
Fortune Creek
Johnson Creek
Kingfisher Creek
Mara Lake
Trinity Creek

AQUATIC RESOURCES

Keyword	Summary of Current Knowledge	References
Water Quality/Quantity	• Water quality in Mara Lake is good with no deterioration in water quality from 1971-1998, although affected by nonpoint source pollution and treated waste[381]. • Impacts to water quality in Lower Shuswap River noted as a result of municipal discharges, degradation of riparian habitat and streambank erosion by ranching, and logging to, stream banks, tributary valleys and upslope areas by forestry[389]. Impact risks greater in regard to human risk (potable water) than risk to fisheries resources. • Water temperatures measured up to 25°C near Mabel Lake[389]. • Agriculture and logging impacts identified in tributary systems such as Blurton, Fortune, Johnson, Kingfisher, and Trinity Creeks as well as concerns with summer and winter low	62 – Nordin (1978) 351 – MoELP (2000) 360 – MoELP (2000) 381 – Bryan and Jensen (1999) 389 – FOC (No Date) 397 – Wolski (2000)

	flows[389]. • A total of 131 water licenses draw water from the major tributary systems of the Lower Shuswap River for the purposes of domestic, irrigation, enterprise, waterworks, power, conservation, stockwatering, watering and fire protection. In addition a total of 359 water licenses exist on the entire Shuswap River mainstem, however, their location along the mainstem is indiscernible[360]. • Brash Creek and Fortune Creek have been designated as community watersheds[351]. • Kingfisher Creek watershed has been identified as a major natural source of suspended sediments into the Lower Shuswap. Fortune Creek (primarily through agriculture) and the Enderby sewage treatment plant also contribute nutrients into the mainstem. In addition bacterial levels in Fortune Creek were at a high level of concern[62]. • High temperatures a concern in fall due to risk to chinook spawning. Prespawn mortality has been noted in some years[397].	
Discharge	• One active hydrometric station (station no. 08LC002) lies on the Lower Shuswap River near Enderby. Hydrometric data exists from 1911 to 1936 and 1960 to present[359].	359 – Environment Canada (2000)
Tributary System Watershed Works	**Kingfisher Creek** • Interior Watershed Assessment Procedure [392] • Overview Fish Habitat Assessment Procedure[393] • Channel Assessment Procedure[394] • Sediment Source Survey[392] • Access Management Plan[392] • Watershed Restoration Program Middle Shuswap Stream Assessment[303] • Reconnaissance Fish and Fish Habitat Inventory [386] • Kingfisher Creek Instream and Off-Channel Fish Habitat Restoration Project[31] • Tributary of Kingfisher Creek-Hunter's Creek-Cougar Groundwater Channel[30] **Noisy Creek** • Interior Watershed Assessment Procedure[392] • Overview Fish Habitat Assessment	30 – WRP (1998) 31 – WRP (1999) 303 – Summit (1996) 392 – Silvatech (1998) 393 – Silvatech (1999) 394 – Silvatech (1999) 386 – Silvatech (1999)

	Procedure[393] • Channel Assessment Procedure[394] • Sediment Source Survey[392] • Access management Plan[392] • Reconnaissance Fish and Fish Habitat Inventory [386] **Cooke Creek** • Interior Watershed Assessment Procedure[392] • Overview Fish Habitat Assessment Procedure[393] • Channel Assessment Procedure[394] • Sediment Source Survey[392] • Access management Plan[392] • Reconnaissance Fish and Fish Habitat Inventory [386] • Watershed Restoration Program Middle Shuswap Stream Assessment[303]	

FISH AND FISH HABITAT

Keyword	Summary of Current Knowledge	References
Fish Distribution	• Records of sockeye, coho, pink (presence noted), and chinook salmon, kokanee, lake trout, mountain whitefish and bull trout are known within the Lower Shuswap River system[376]. Rainbow trout are also documented within the system[35, 51]. • Releases of brook trout, cutthroat trout, and lake trout have occurred within the system[357]. • Chiselmouth were observed in 1964 within Mara lake, no other records of threatened or endangered species identified within area[388].	35 – DFO (1997) 51 – Jantz (1986) 357 – MoELP (2000) 376 – DFO (1990) 388 – BC CDC (2000)
Life History	• Lower Shuswap River chinook primarily follow ocean type life history(95%).[25] • Chinook spawning and early rearing in the Lower Shuswap River. Majority of fry leave the system to rear downstream in the lakes[25, 376]. • Sockeye and kokanee spawn in Lower Shuswap River and migrate downstream to Mara Lake upon emergence. • Coho spawning and rearing in mainstem and tributaries.[376] • Rainbow trout use tributaries to spawn, limited rearing in mainstem[51].	25 – Envirocon (1989) 51 – Jantz (1986) 376 – DFO (1990)

	• Numerous non-salmonids use the system for rearing and probable spawning.[25]	
Habitat Productivity	• Mara Lake is considered oligotrophic, although it is approaching mesotrophic status.[381]. • No barriers or obstructions to mainstem migration, access to Mabel Lake[376]. • System likely limited for salmonids due to high summer water temperatures. Risk to adult spawners due to elevated temperatures in fall[397].	376 – DFO (1990) 381 – Bryan and Jensen (1999) 397 – Wolski (2000)
Escapement	• Escapement summary available for sockeye, coho, pink and chinook salmon (see escapement Table in the text)[376]. • Large producer of chinook and sockeye salmon, with fewer coho and pink salmon[35].	35 – DFO (1997) 376 – DFO (1990)
Stock Monitoring / Assessment	• Juvenile fish surveys conducted in 1997 and 1998 within tributary systems[37, 41]. • Juvenile tagging was conducted in 1976, 79, 80. No information available on recaptures.[64] • Assessment of hatchery vs. wild chinook and coho done in 1985 and 1986, no impacts identified[25]. • Fisheries enhancement potential identified for Kingfisher/Danforth Creeks in 1984[169].	25 – Envirocon (1989) 37 – SNFC (1999) 41 – SNFC (1998) 169 – Griffith (1985) 64 – Federenko and Pearce 1982
Enhancement	• Releases of rainbow trout, cutthroat trout, brook trout, and lake trout by MoELP within the Lower Shuswap River system have occurred between the years 1909 and 2000[357]. • Brood stock collection and chinook salmon fry releases within the Lower Shuswap River by the Shuswap River Hatchery[24]. Fry releases have occurred annually form the Shuswap Hatchery since 1984 Releases have ranged from a 72,136 to 1,113,900. Kingfisher community hatchery has been releasing up to 237,000 chinook fry annually since 1981. Hatchery contribution to returns form 1987 to 1996 has ranged from less than 1 % to a high of 17.3%[406].	24 – Triton (1995) 357 – MoELP (2000), 406 DFO 2000
Angler Use	• Chinook salmon sport fishery reopened in 1986 on the Lower Shuswap with an average of 475 adults harvested from 1986 to 1994[368]. Generally 70-300 chinook taken per year[395] throughout Shuswap River. • Indian Food Fishery of 200-300 chinook	368 – Schubert (1995) 395 – Ball (2000)

	salmon yearly[395]. • Small recreational fishery for rainbow trout, mostly locals.	

HYDRO-FISH INTERACTIONS

Keyword	Summary of Current Knowledge	References
Flow Fluctuation	• The resulting effects of flow fluctuations on the Lower Shuswap by the Wilsey Dam, are buffered by Mabel Lake.	
Reservoir Drawdown	• No applicable interactions.	
Flow Management Strategies	• None developed for the Lower Shuswap River[63].	63 – Sigma (1993)

IDENTIFIED INTERESTS AND CONCERNS

Stakeholder / Interest Group	Issue / Concern	Reference
Shuswap Nation Fisheries Commission	• Currently maintaining a fish fence on Danforth Creek in cooperation with FOC[390].	390 – WUP (2000)
Spallumcheen Indian Band	• Establish an aboriginal fishery in the Lower Shuswap River to harvest chinook salmon.	
Kingfisher Environmental Society	• Stewardship group wants to restore and enhance fisheries values, Kingfisher hatchery. Active in promoting environmental stewardship.	390 –WUP (2000)

IDENTIFIED GAPS

Keyword	Recommendations
Aquatic Resource	
Water Quality	• If autumn flows greatly reduced from middle Shuswap then water Quality may be a concern as well as possibly available spawning habitat. If flows reduced within Lower Shuswap the increased water temperature issue as wll as spawning habitat should be re-visited. • Continue monitoring. • No information gaps identified relating to the Water Use Planning process.

Discharge	• No information gaps identified relating to the Water Use Planning process.
Flow studies	• Middle Shuswap contributes approximately 40% of flow to the Lower Shuswap River. If large changes in flows are done in the fall may have to assess the % change in the Lower Shuswap • No information gaps identified relating to the Water Use Planning process.
Fish and Fish Habitat	
Fish Distribution	• Good knowledge of spawning chinook salmon, sockeye salmon, less for kokanee, limited knowledge of coho salmon. • No information gaps identified relating to the Water Use Planning process.
Life History	• Good knowledge for salmon, less information regarding resident species. • No information gaps identified relating to the Water Use Planning process.
Habitat Productivity	• Information gaps in knowledge of resident species, although no requirements for purposes of Water Use Planning. • No information gaps identified relating to the Water Use Planning process.
Escapement	• No information gaps identified relating to the Water Use Planning process.
Stock Monitoring / Assessment	• No information gaps identified relating to the Water Use Planning process.
Enhancement	• No definable impact from BC Hydro, no measurable differences to enhancement activities, unrelated to Water Use Planning. • No information gaps identified relating to the Water Use Planning process.
Angler Use	• No information gaps identified relating to the Water Use Planning process.
Hydro-Fish Interactions	
Flow Fluctuation	• The resulting effects of flow fluctuations on the Lower Shuswap by the Wilsey Dam, are buffered by Mabel Lake. • No applicable interactions, therefore no information gaps identified relating to the Water Use Planning process.
Reservoir Drawdown	• No applicable interactions, therefore no information gaps identified relating to the Water Use Planning process.
Flow Management Strategies	• Flow management has a minimal impact on Lower Shuswap. Fish flows designed for Middle Shuswap will have a positive effect (or at least seen as not having a negative effect) on Lower Shuswap as fish assemblages and general life history strategies are similar. Large changes in fall flows could affect water temperatures in the Lower

Shuswap River Watershed Unit: Mabel Lake from its outlet to Wilsey Dam

AREA DESCRIPTION

Drainage Area (ha):

NTS Maps:

82L/2, 82L/3
82L/6, 82L/7
82L/9, 82L/10
82L/15, 82L/16

Major Waterbody Systems:

Bessette Creek
Bigg Creek
Creighton Creek
Duteau Creek
Harris Creek
Ireland Creek
Mabel Lake
Tsuius Creek
Wap Creek

AQUATIC RESOURCES

Keyword	Summary of Current Knowledge	References
Water Quality/Quantity	• Intensive farming with removal of riparian vegetation, channelization, stream bank trampling and non-point source pollution affecting the river. Water quality is worst in tributaries.[389] • Watershed has been logged, mostly in tributaries, contributing to erosion and sedimentation[389]. • Concerns with potential August water demand, and low summer and winter flows in tributary systems[389]. • Concerns with municipal and rural discharges, stormwater runoff and chlorinated effluents[389]. • Water quality in Mabel Lake is good with no deterioration in water quality from 1971-1998, although affected by nonpoint source pollution and treated waste[381]. Nutrient levels in the mainstem are low. • 180 water licenses extract water from the	360 – MoELP (2000) 381 – Bryan and Jensen (1999) 389 – FOC (No Date)

	tributary systems within the drainage from Mabel Lake to Wilsey Dam. These are for the purposes of domestic, irrigation, stockwatering, waterworks, power, conservation, storage, camps, and processing. In addition a total of 359 water licenses exist on the entire Shuswap River mainstem, however, their location along the mainstem is indiscernible[360].	
Discharge	• One active hydrometric station (station no. 08LC003) near Lumby. Hydrometric data available from 1913 to 1986[359]. • Historic flow data from gauging station at Couteau falls from 1912-1916[293].	293 – French (1995) 359 – Environment Canada (2000)
Tributary System Watershed Works	**Bessette Creek** • Rehabilitation Project[31] **Duteau Creek** • Interior Watershed Assessment for the Duteau Creek Watershed[29] Diversion of Duteau Creek to the Vernon Irrigation District. **Harris Creek** • Interior Watershed Assessment for the Harris Creek Watershed[49] • Rehabilitation Project-Stabilization of a large slide[31] **Tsuis Creek** • Middle Shuswap River Watershed Stream Assessment[303] **Wap Creek** • Middle Shuswap River Watershed Stream Assessment[303] **Creighton Creek** • Creighton Creek Riparian Restoration[31]. • Interior Watershed Assessment Procedure[377]. **Other** • Middle Shuswap River and Mabel Lake Tributaries. Fish and Fish Habitat Inventory[68] • Middle Shuswap River Watershed Stream Assessment[303] • IWAP Mabel Lake Northeast and Southeast[396]	29-Dobson (1996) 31-WRP (1999) 49-Dobson (1996) 68-ARC (1998) 303-Summit(1996) 396-MoELP (2000) 377 – EBA (1999)

FISH AND FISH HABITAT

Keyword	Summary of Current Knowledge	References
Fish Distribution	• Mainstem known to contain chinook, coho, and	51-Jantz (1986)

	sockeye salmon. kokanee, bull trout, rainbow trout. and mountain whitefish. Non salmonids include sculpins, longnose dace, redside shiner, peamouth chub, largescale sucker, northern pikeminnow and burbot[376]. • Tributary systems contain rainbow trout, coho and chinook salmon, and mountain whitefish, as well as suckers, shiners, dace, and sculpin[50] Bull trout distribution in the tributaries is unknown[407]. • Inventory work identified rainbow trout as the dominant species in tributary drainages. Some use by salmon in lower reaches of tributary streams[68]. • No records of threatened or endangered species identified within area[388].	68 – ARC (1998) 376 – DFO (1990) 388 – BC CDC (2000) 50 – Fee and Jong (1984) 407 A Caverly pers com.2000
Life History	• Sockeye spawn late s September to early November peak is around the 15th of October. Spawning is in the 8 km of river downstream of the Wilsey Dam. • Kokanee spawn from early September to mid October peaking in the third week of September. Spawning is concentrated several km downstream of the Wilsey Dam. Spawning occurs in shallow lower velocity water and small substrate, side channels are heavily utilized. Kokanee fry immigrate to Mabel Lake directly after emergence.[55]. • Coho spawn in Middle Shuswap and tributaries arriving in mid October and spawning from late October through to early December[163]. Spawning starts November 15th peaks November 30th and ends December 15th [404]. • Some migrate directly downstream (most rear a year in the Middle Shuswap and tribs).[163] Preferred rearing in off channel habitats and in areas of low velocity including tributary system. • Chinook enter the Middle Shuswap River between early July and late September and hold in the upper canyon and deep pools until ready to spawn. During periods of high water temperatures chinook will stay in Mabel Lake[397] Spawning takes place in the 8 km section of river downstream of the Wilsey Dam (Reach 2). Most (approximately 90%) of the	55-Jantz (1992) 51- Jantz (1986) 163 – Envirocon (1984) 397 – Wolski pers comm. (2000) 404 Stalberg pers. com.(2000) 408 R. Bailey pers com, (2000) 409 Rublee et al (1997) 407 Caverly pers com. (2000)

spawning occurs in the upper 3.5 km below the Wilsey Dam. Spawning starts in mid September peaks in late September and ends in mid October[55] Fry emerge in spring (April into May) and show variable life history. Some downstream migration to Mabel Lake occurs immediately post emergence[163]. Most reside in low velocity margin and off/side channel habitats for several weeks after which time they begin to show a preference for increased velocities. Most of the chinook migrate out of the system within 60-90 days and continue on to the ocean to arrive 90-150 days after emergence[404]. Chinook fry are found rearing along the margins of Mabel Lake in June and July 25. A portion of the population remains in the river for a full year. The majority of the stock is ocean type (95%)[25]. There is a second stock that spawns in Besette and Duteau Creeks that are stream type (rearing a full year in fresh water). These fish are smaller than the mainstem stock.[408]

- Chinook rearing in the mainstem appear to select deep, back eddy areas in middle Shuswap as well as mainstem habitats with moderate water velocities with log debris and abundant cover. Some downstream migration likely occurs throughout the warm water rearing period May to October/November. Overwintering likely occurs within substrate and dense cover.[409]
- Rainbow trout primarily use tributary systems to spawn and rear for 1-2 years[51]. Middle Shuswap tributaries primary contributors as recruitment systems for Mabel Lake. Rainbow trout fry are found in side channel habitats in the mainstem[407]. Very low numbers of mature rainbow in the mainstem.[55]
- Whitefish are fall spawners (September and October). Whitefish spawn in flowing water over cobble substrates. Fry emerge in the spring, rear in quite water habitats along the margin for several weeks then take up position in riffle/gravel habitats. Whitefish rear in the Middle Shuswap throughout all life history phases and also may use some tributaries[407,397].

	• Non-salmonid species some migration from lake by adults to spawn. Rearing in mainstem in lower velocity water and side/off channel habitats[397].	
Habitat Productivity	• Sugar and Mabel Lake is considered oligotrophic[381]. • Productivity low although studies conducted in the Middle Shuswap River suggest that the system is nitrogen limiting [50]. N:P ratios in Sugar and Mabel Lake of > 14:1 suggest that those water bodies are P limiting[381]. • Coho, chinook and sockeye primarily use 8km below dam for spawning.[20] Coho (and some chinook) also spawn in the Besette system). • Bessette R. near confluence with Shuswap R. preferred rearing for chinook salmon fry and coho smolts[163] The origin of the fish rearing in this area is unknown. • An elevated temperature in summer, combined with low food, reduces productivity in the Middle Shuswap River. Temperatures in the Middle Shuswap River have exceeded 20°C.during the summer [397,54]Should be an increase in productivity with the increase in spawner numbers and carcasses to the system.[402] • A limiting factor to the number rainbow trout in the Middle Shuswap River is suspected to be the shortage of spawning and rearing habitat as well as the elevated summer temperatures. • Mable Lake is used for rearing chinook and coho.[50] Rearing densities in Mabel Lake increase from June through July [25]	50-Fee and Jong (1984) 20-d.b. Lister and associates (1990) 163- Envirocon (1984) 402 –Slaney pers.com. (2000) 381 Bryan and Jensen 54 Tredger (1977) 397 Wolski (2000) 25 Envirocon Pacific Ltd. (1989)
Escapement	• Escapement summary available for sockeye, coho, and chinook salmon (see Table in text)[376]. • Kokanee spawner counts available for 1986, 1987, 1991, 1993, 1994, and 1999 [398].	376 – DFO (1999) 398 – Jantz (2000)
Stock Monitoring / Assessment	• Assessment done pre and post hatchery operation. [163, 50, 25] Pre assessment indicated that there was capacity for outplants. Post assessment did not detect negative impact of hatchery releases on wild population.	163 Envirocon (1984) 50 – Fee and Jong (1984) 25 – Envirocon (1989)
Enhancement	• MoELP has had releases of rainbow trout, cutthroat trout, and brook trout from 1928 to	357 – MoELP (2000)

	1999 within tributary systems of this section of the Middle Shuswap River[357]. • The Shuswap River has been in operation since 1984, during this period the releases have ranged from 144,987 in 1995 to 1,065,469 in 1989. (Summary table in text)Hatchery contribution to returns has been high in the Middle Shuswap River varying from a high of 73% in 1994 to 36% in 1998. Releases in the last two years have been reduced to just over 280,000.[406] Coho stocks (Duteau, Mainstem Middle Shuswap (from channels) have been enhanced since 1998. Egg targets have been set at 100,000 although targets have not been met due to low returns. • FOC has constructed groundwater channels to provide off-channel rearing habitat with threatened interior coho being the target species for this activity.	406 R. Cooke pers com. (2000)
Angler Use	• Summer fishery for chinook salmon. • Fishery for whitefish and the occasional rainbow trout in the river[407] • Limited access points • Mabel Lake received highest angler use of 101 Okanagan regional lakes.[20] Angling in August is directed at chinook.	(Check with Szczepan) 55-Jantz (1992) 20-DB Lister and Associates (1990) 407 Caverly (2000)

HYDRO-FISH INTERACTIONS

Keyword	Summary of Current Knowledge	References
Flow Fluctuation	• Short term fluctuation from Wilsey Dam, caused by outages, can result in downstream impacts. When generation ceases flow drops dramatically and only resumes when the Wilsey Dam forebay fills and begins to spill. This can result in short term changes of stage up to 50 cm[20]. Depending on time of year this can result in stranding of fish, isolating fish in shallow lateral pools and potential dewatering of eggs in the gravel. Operational impacts have been mitigated by the use of a Howell Bunger valve in Unit 2 penstock. With this running flow reductions are reduced. The Howell Bunger bypass has had reliability problems which are	20-DB Lister and Associates (1990)

	being addressed. It cannot fully restore river flows if both units trip because the valve is only on one of the two penstocks.	
Reservoir Drawdown (No reservoir on this reach)	• Dredging forebay of Wilsey Dam increases downstream risks to fish in the event of a concurrent power outage.	
Flow Management Strategies	• In general the reservoir is managed to be at low pool in March. The reservoir fills with the natural inflows and reaches full pool in July. Peak freshet flows are stored and redistributed to the post spawning period, October on the main net benefit accruing to the Jan to March period providing flows in excess of historical levels. Flows benefit both fish and power production. Interactive management with decisions on flow release made on an ongoing basis from August.[403]	403-Lewynsky pers.com.(2000)

IDENTIFIED INTERESTS AND CONCERNS

Stakeholder / Interest Group	Issue / Concern	References
Ministry of Environment, Lands and Parks	• Kokanee- specifically flow reductions after spawning and through winter, spawner counts have shown an increase in returns over the last few years[398]. • Mountain whitefish probably no concerns at present.[407] • Rainbow trout production, main focus in the tributaries. Bull trout not a significant population, system is too warm.	398 – Jantz (2000)
Fisheries and Oceans Canada	• Maximizing chinook, coho and sockeye production. Reduction of impacts due to flow fluctuations. • Water quality dredging.	
Landowners	• Flood issues, Mabel Lake Preservation Society.	
Recreational users	• Paddlers - low water hazards make the river impassable at times. Is there potential for better whitewater if the river returned to its natural flows.	390-WUPCC (2000)

Anglers	• Recreational fishing, including chinook salmon.	
Spallumcheen Indian Band	• Indian Food Fishery, information including traditional use areas and trading route between Sugar and the Kootenays.	
Okanagan Nation Fisheries Commission	• Indian Food Fishery.	
Mabel Lake Preservation Society		11-Project Team Meeting (2000)
Others	• Fish ladder around Shuswap Falls • Dam prevents salmon from accessing traditional spawning channel • Flooding problems, spring freshet problems for farms and ranches when all four gates opened at once. • Maintaining integrity of River-balance use of water • Erosion at high levels, heavy silt choking spawning grounds, erosion along banks heavy flows. • Use bio-degradable hydraulic fluid.	11-Project Team Meeting (2000)

IDENTIFIED GAPS

Keyword	Recommendations
Aquatic Resource	
Water Quality	• Monitor sediment from tributaries and dredging of forebay. Assess Total Gas Pressure (TGP) downstream of the facility.
Discharge	• Establishment of optimum flow regime.
Fish and Fish Habitat	
Fish Distribution	• Need to know more about fish species and temporal use of off channel/side channel habitat. • Need to reassess spawning areas following 1997 high water event. • Identify available spawning areas for different species at different flows.
Life History	• Better understand off-channel use, post emergence habitat requirements. • Trapping program inconclusive not designed for fry [163]. • Fish distribution an abundance based on mid 1980's data, should be

	updated using similar methodologies to assess current status.
Habitat Productivity	• Identify capacity related to spawning habitat. • Assessment of changes in gravel quality percent fines, gravel recruitment near Wilsey.
Escapement	Continue escapement estimates (salmon and kokanee)
Stock Monitoring / Assessment	• Continue spawner counts, assess for changes in spawner distribution. Continue monitoring of man made off channel habitats compare densities to natural off channel habitats.
Enhancement	• Continue enhancement for chinook , assess hatchery contribution. Rebuild coho stocks.
Angler Use	
Hydro-Fish Interactions	
Flow Fluctuation	• Assess how to achieve flow changes with minimal ramping rates to avoid salvage (i.e. electronic gate operation). • Assess impacts of flow perturbations, stranding pockets isolation of side channels, dewatering of sidechannels, or redds
Forebay Drawdown	• Reduce risk of outage, operational failure when forebay is drawn down for dredging.
Flow Management Strategies	• Assess ability to achieve an incubation flow which is 2/3 of the spawning flow. • Develop flow option to maximize production need to know maximum available spawning habitat for chinook, kokanee and coho, sockeye. Stage change spawning to incubation factoring in needs of kokanee, Maximum groundwater channel access for coho assess if happened historically • Revisit Sigma report to see if there can be more surety in developing seasonal hydrographs • Estimate (quantify) risks associated with flow fluctuation (Establish indexing sites, monitor during flow fluctuation).

Shuswap River Watershed Unit: Wilsey Dam to Sugar Lake Dam

AREA DESCRIPTION

Drainage Area (ha):

NTS Maps:

82L/1, 82L/2
82L/7, 82L/8

Major Waterbody Systems:

Cherry Creek
Ferry Creek
Holstein Creek
Reiter Creek
Woodward Creek

AQUATIC RESOURCES

Keyword	Summary of Current Knowledge	References
Water Quality/Quantity	• Suggestion of increases in sediment inputs to the Middle Shuswap River area from tributary sources as a result of logging and other resource activity. Amount of contribution to mainstem is unquantified, however, remedial actions were identified. Land use activities along the mainstem have resulted in bank instability and loss of riparian values[34]. Low nutrient values[52, 50, 57] • No community watersheds identified[351]. • 47 water licenses draw water from tributary systems between the Wilsey and Sugar Lake Dams. These are for the purposes of domestic, irrigation, ponds, institutions, enterprise and power uses. In addition a total of 359 water licenses exist on the entire Shuswap River mainstem, however, their location along the mainstem is indiscernible[360].	34 – Summit (1996 351 – MoELP (2000) 360 – MoELP (2000) 50 – Fee and Jong (1984) 52 – Griffith (1979) 57 – Triton (1995)
Discharge	• One active hydrometric station (station no. 08LC018) at outlet of Sugar Lake. Hydrometric data available from 1926 to present[359].	359 – Environment Canada (2000)
Tributary System Watershed Works	**Holstien Creek** • Middle Shuswap River and Mabel Lake Tributaries: Fish and Fish Habitat Inventory[68].	32 – ARC (1999) 68 – ARC (1998)

Cherry Creek	• Reconnaissance 1:20000 Fish and Fish Habitat Inventory[32].

FISH AND FISH HABITAT

Keyword	Summary of Current Knowledge	References
Fish Distribution	• System known to include rainbow trout, bull trout, kokanee, northern pike minnow, cutthroat, mountain whitefish, longnose dace, redside shiner, slimy sculpin, prickly sculpin, leopard dace, bridgelip sucker, largescale sucker. All species are present in the mainstem, rainbow trout and sculpins are the most widely distributed in the tributaries. [52, 50, 57]. There are anecdotal repors of high cutthroat numbers in the Middle Shuswap Rievr. No cutthroat have been captured in recent sampling of the mainstem or tributaries[52, 50, 57]. MoELP stocking records indicate that cutthroat trout were stocked in Valerian Lake and Valerian Creek located in the headwaters of the upper Shuswap River in the early 1980s[352] • Chinook salmon are documented in association transplants conducted in 1979, 1993 (144 females, 144 males and 5 jacks(, 1995 153 females, 140 males and 7 jacks. [373]. Chinook from transplants were found rearing throughout the year in the Middle Shuswap. Anecdotal reports of chinook above Shuswap falls prior to the construction of the Wilsey Dam. [293] • Inventory work determined that rainbow trout is the dominant species in Middle Shuswap River tributary streams. Access to lower reaches by Middle Shuswap River rainbow trout[32]. • Cherry Creek identified to have rainbow trout throughout with bull trout concentrated in the upper reaches[32]. • Whitefish comprise the largest percentage of fish biomass • There are anecdotal reports of abundant cutthroat.	32 – ARC (1999) 50 – Fee and Jong (1984) 52 – Griffith (1979) 57 – Triton (1995) 373 – Triton (1995) 375 – Triton (1993), 293 French 1995 352 MoELP 2000

Life History	• 0+ rainbow trout are present in the mainstem. There is no knowledge of rainbow trout spawning in the mainstem, although mainstem spawning is generally not noted for systems of this size. Recruitment from the mainstem is likely from tributary systems. • Cherry and Ferry Creek have multiple age classes of rainbow trout suggesting that some portion of the population is resident[57]. • Bull trout numbers are low, resident bull trout are found in upper Cherry Creek. Recruitment systems for Middle Shuswap bull trout are unknown[32]. • Good habitat values exist for adult rainbow trout in Reach 5. Rearing habitat for juvenile rainbow trout and chinook are highest in reach 4.[52,50,57]	57 – Triton (1995) 32 – ARC (1999) 52 – Griffith (1979) 50 – Fee and Jong (1984)
Habitat Productivity	The upper reach (Reach 5) is confined and whitefish dominate the population, limited spawning gravels in this reach.[52] • Low number/biomass of resident rainbow trout may result from lack of suitable spawning substrate.[52] Habitat productivity in the Middle Shuswap is low (36 mg/l). Standing stocks are below theoretical capacity using both (Ptlomy alkalinity model and Binns and Eiserman HQ index).[57] Low standing stocks could be a function of under recruitment to the mainstem, environmental conditions (including flow variables) or exploitation[402].	52-Griffith – (1979) 57-Triton (1995) 402-Slaney,pers. comm. (2000)
Escapement	• No anadromous escapement records[376]. • Historical accounts of chinook salmon above Shuswap Falls[293].	376 – DFO 1990 293 – French (1995)
Stock Monitoring / Assessment	• Fish and fish habitat (including standing stock assessments) have been carried out in 1979, 1984 and 1995. Although differences in standing stocks, all three studies indicated that that system was performing below theoretical capacity[50, 52, 57]. • Triton (1995) reported an anomaly in rainbow trout age class within reach 4 of the study site. This lack of the 1993 recruitment was not observed in reaches 3 and 5 or in Cherry or Ferry Creek. The cause for this was not	50 – Fee and Jong (1984) 52 – Griffith (1979) 57 – Triton (1995)

	determined[57].	
Enhancement	• Three adult chinook transplant pilot studies were conducted one in 1977, one in 1993 and one in 1995[373]. • Releases by MoELP within this section of the Middle Shuswap River system have included rainbow trout[357].	357 – MoELP (2000) 373 – Triton (1995)
Angler Use	• Angler use presently low, likely due to current low stocks. However rivers in this region are easily overfished. As of 1994 there were no special angling regulations in the Shuswap River above Shuswap Falls. This section of river is exempt from the region wide angling closure from April 1-June 30.[57] • Middle Shuswap experiences relatively little sport fishing due to small size of resident rainbow trout in area.[50]	50 – DB Lister and associates (1990) 57 – Triton (1995)

HYDRO-FISH INTERACTIONS

Keyword	Summary of Current Knowledge	References
Flow Fluctuation	• Flows are regulated from Peers Dam.	
Reservoir Drawdown	• No applicable interactions, other than risks associated with Wilsey Dam headpond fluctuations.	
Flow Management Strategies	• In general the reservoir is managed to be at low pool in March. The reservoir fills with the natural inflows and reaches full pool in July. Peak freshet flows are stored and redistributed to the post spawning period, October on the main net benefit accruing to the Jan to March period providing flows in excess of historical levels. Interactive management with decisions on flow release made on an ongoing basis from August.[403]	403-Lewnsky, pers.comm. (2000)

IDENTIFIED INTERESTS AND CONCERNS

Stakeholder / Interest Group	Issue / Concern	References
Ministry of Environment, Lands and Parks	• Maintenance of the sport fishery, while maximizing production.[390] • Ensuring that if chinook are re-introduced into the Middle	390-WUPCC (2000)

		Shuswap above Wilsey Dam that they will not impact on resident species.[390]	
Fisheries and Oceans Canada	•	Opportunity to re-establish anadromous fish if operations limit habitat downstream of Wilsey.[404]	404-Stalberg pers.comm. (2000)
Local stakeholders	•	Maintain/Improve fishing opportunities, recreational opportunities, aesthetic values, etc.	11-Project Team Meeting (2000)

IDENTIFIED GAPS

Keyword	Recommendations
Aquatic Resource	
Water Quality	• Water quality is currently good, while nutrients and productivity are low. • Assess the impacts of sediment contribution to the system and their impacts on fish habitat.
Discharge	• The effects of short term flow regulation due to operation needs to be addressed. • Braided channel habitats in Reach 4 are susceptible to flow changes, particularly in June and July with short term changes and potentially in winter if these side channel habitats are important. • Risks to stranding and isolation need to be quantified. • Tributary access needs to be assessed to ensue access is possible during possible periods of upstream migration. .
Fish and Fish Habitat	
Fish Distribution	• Require a better understanding of fish habitat use over time in Reach 4 (i.e. temporal and spatial uses, habitat preference etc.)
Life History	• Require a better understanding of rainbow trout recruitment (i.e. is there mainstem spawning, where, when does early rearing take place). • Have no knowledge of bull trout life history and as a result no idea why the numbers are low.
Habitat Productivity	• Understand the limits to production and determine whether they are flow related or non flow related (i.e. habitat).
Escapement	• No information gaps identified relating to Water Use Planning.
Stock Monitoring / Assessment	• Assess bull trout population. Possibly assess current rainbow trout status vs. capacity.
Enhancement	• Identify if the current habitat capacity for chinook is underutilized and therefore have a minimal impact associated with introduction of chinook through transplants.

	• Determine if there may be a benefit due to the introduction of carcasses., or other nutrient sources.
Angler Use	• Develop appropriate regulations.
Hydro-Fish Interactions	
Flow Fluctuation	• Minimize flow fluctuations and identify sensitive periods in critical mainstem habitat areas. Ramping rates have been established for flow changes at the Peers Dam. No assessments have been done to assess efficacy of ramping rates.
Reservoir Drawdown	• Monitor drawdown of the forebay at Wilsey dam to ensure that drawdown is not negatively affecting fish in the headpond. There is an increased risk to downstream fish resources in the event of an outage when the forebay is drawn down.
Flow Management Strategies	• Understand life history requirements so that strategies to improve conditions downstream of Wilsey Dam do not impact on stocks above the dam. Assess flows for late summer/fall rearing.

Shuswap River Watershed Unit: Upstream of Sugar Lake Dam

AREA DESCRIPTION

Drainage Area (ha):

NTS Maps:
82L/7, 82L/8
82L/9, 82L/10

Major Waterbody Systems:
Kate Creek
Outlet Creek
Sitkum Creek
Sugar Creek
Sugar Lake

Biogeoclimatic Zones:

AQUATIC RESOURCES

Keyword	Summary of Current Knowledge	References
Water Quality	• Water quality in Sugar Lake is good with no deterioration in water quality from 1971-1998, although affected by nonpoint source pollution[381]. • No community watersheds identified[351]. • 5 water licenses draw water from tributary systems upstream of Sugar Lake, as well as Sugar Lake itself. These are for the purposes of domestic and storage-power uses. In addition a total of 359 water licenses exist on the entire Shuswap River mainstem, however, their location along the mainstem is indiscernible[360]. • Lack of riparian buffer and sediment inputs resulting from forestry activities within upper Shuswap River area[34]. • Bathymetric mapping of Sugar Lake in 1969[356].	34 – Summit (1996) 351 – MoELP (2000) 356 – MoELP (2000) 360 – MoELP (2000) 381 Bryan and Jensen 1999
Discharge	• No active hydrometric stations on the Shuswap River upstream of Sugar Lake[359]. • Available inflow information into Sugar Lake, as well as release information from Peers Dam.	359 – Environment Canada (2000) BC Hydro Records
Tributary System Watershed Works	**Sitkum Creek** • Reconnaissance 1:20,000 Fish and Fish Habitat Inventory of East Sugar Lake[310]	310 – ARC (2000)

	Kate Creek • Reconnaissance 1:20,000 Fish and Fish Habitat Inventory of East Sugar Lake[310].

FISH AND FISH HABITAT

Keyword	Summary of Current Knowledge	References
Fish Distribution	• Sugar Lake known to support populations of kokanee, rainbow trout (including stocked Gerrard trout), cutthroat trout bull trout, mountain whitefish and burbot[23, 391, 353]. • Records of rainbow trout, cutthroat trout, bull trout, prickly sculpin, slimy sculpin, longnose dace, largescale sucker and redside shiner are also known within the tributary areas upstream of Sugar Lake Dam[23, 114, 310]. • Inventory studies have identified fish use by rainbow trout and bull trout. Rainbow trout is the dominant species, however this drainage has been identified as an important bull trout area[23, 310]. • MoELP stocking records indicate the stocking of cutthroat trout in Valerian Lake and Valerian Creek located in the headwaters of the Upper Shuswap River[352] • Bull trout in the system appear to be limited to tributaries on the east side of the watershed [23]. • Upper Shuswap R. (50km mainstem) serves as a spawning and juvenile rearing area for Sugar Lake salmonid stocks.[20] • No records of anadromous salmon above Sugar Lake, although suggestions that chinook salmon may have reached Sugar Lake[293]. • No records of threatened or endangered species identified within area[388].Burbot and mountain whitefish are considered to be vulnerable species in this area of the drainage[407].	23 – Klohn-Crippen (1998) 114 – van Drimmelen (1978) 293 – French (1995) 310 – ARC (2000) 353 – MoELP (2000) 388 – BC CDC (2000) 391 – Crowley (1974) 352 – MoELP 2000 407 Al Caverly Pers. com.
Life History	• Kokanee, once stocked, are now self supporting, spawning in Upper Shuswap tributary systems and recruiting in the lake (naturalized stock)[320]. • Rainbow trout, bull trout and cutthroat trout may exhibit resident, fluvial and adfluvial life	23 – Khlohn Crippen (1998) 320 – Einarson (1985)

	histories[?].	
Habitat Productivity	• Moderately productive for rainbow trout and bull trout upstream of Sugar Lake, primarily within Rainbow, Star, Curwen, Vigue, and Gates Creeks. Remaining tributaries are characterized by steep gradients and low discharge[114]. • Sugar Lake is oligotrophic[381]. • Annual drawdown of 6-8 meters has greatly reduced any littoral production[320]. • Kokanee introduced between 1959 and 1964 and reached 3.3 kg. Average size in 1985 was approximately 120 g[320]. • Indications that kokanee may be a competitor with resident species contributing to a decline in their populations[320]. • Productivity of lake limited by high flushing rate, low nutrient levels fluctuation in lake levels from use as storage.[20] • Winter drawdown inhibits establishment of aquatic vegetation and bottom dwelling fish food organisms in shallow areas.[20]	114 – van Drimmelen (1978) 320 – Einarson (1985) 381 – Bryan and Jensen (1999) 20-d.b Lister and Associates (1990)
Escapement	• No anadromous escapement records[376].	376 – DFO (1990)
Stock Monitoring / Assessment	• Unsanctioned creel survey done in 1985, suggested that kokanee have become smaller over time and that the bull trout population has been reduced, perhaps due to over exploitation[320]. Status of rainbow trout uncertain.	320 – Einarson (1985)
Enhancement	• Releases by MoELP within the area upstream of the Sugar Lake Dam are recorded from 1931 to 1994 and have included Gerrard rainbow trout[50], kokanee, lake trout, lake whitefish and rainbow trout[357]. • Sugar Lake has had extensive stocking of rainbow from 1931 to 1994[357]. • Additional stocking of kokanee from 1950 to 1952[357] and 1959 to 1964[320] into Sugar Lake.	320 – Einarson (1985) 357 – MoELP (2000)
Angler Use	• Unsanctioned creel survey done in 1985. Total of 6289 rod hours, range in monthly fish per hour of 0.05 in May to 9.2 in August[320].	320 – Einarson (1985)

HYDRO-FISH INTERACTIONS

Keyword	Summary of Current Knowledge	References
Flow Fluctuation	• No applicable interactions.	
Reservoir Drawdown	• Annual drawdown of 6-8 meters. • Reservoir managed to full pool in July, maximum drawdown in March.[403] • Reservoir has low nutrient status and likely did before impoundment[381].	320 – Einarson (1985) 403-Lewynsky pers. comm. (2000) 881 Bryan and Jensen (1999)
Flow Management Strategies	• No applicable interactions.	

IDENTIFIED INTERESTS AND CONCERNS

Stakeholder / Interest Group	Issue / Concern	References
Ministry of Environment, Lands and Parks	• Sport fishery and recreational opportunities in Sugar Lake.	
Local landowners and Fishing Resort owners.	• Continued and improved fishery. • Maintenance of recreational values associated with reservoir management. Currently during highest recreational use, reservoir is at or near full pool.	
	• Exposed stumps (aesthetics Sugar Lake).	11-Project Team Meeting
Mabel Lake Preservation Society	• Filling Sugar lake and pulling gates during high flood times dramatically increasing the flow of the river in a very short time causing major flooding into valley bottom. • Siltation of the north end of Sugar Lake. • Issuing of 'new' water licenses.	11-Project Team Meeting
Cherry Ridge Management (VP)	• Keep water levels at Sugar Lake high for summer.	11-Project Team Meeting

IDENTIFIED GAPS

Keyword	Recommendations
Aquatic Resource	
Water Quality	• Water quality in Sugar Lake is considered good and has shown no signs of downward trend, also low nutrients (Sugar Lake may act as

	nutrient sink). • No information gaps identified relating to the Water Use Planning process.
Discharge	• No information gaps identified relating to the Water Use Planning process.
Fish and Fish Habitat	
Fish Distribution	• Basic knowledge of fish distribution determined by means of inventory work. • No information gaps identified relating to the Water Use Planning process.
Life History	• Incomplete knowledge of life history, specifically Sugar Lake bull trout, additional information required to better manage the stock.
Habitat Productivity	• Unknown productive capacity of reservoir and the constraints to production caused by reservoir drawdown • Determine how to best establish exploitation rates in order to manage reservoir populations.
Escapement	• No information gaps identified relating to the Water Use Planning process.
Stock Monitoring / Assessment	• Limited knowledge of recruitment to Sugar Lake especially for bull trout. • Unknown effects of reservoir drawdown and reduction in littoral production.
Enhancement	• No information gaps identified relating to the Water Use Planning process.
Angler Use	• Increase knowledge of exploitation in order to maintain populations. Relates to Water Use Planning such that changes in production due to reservoir management can be isolated from changes in production due to exploitation.
Hydro-Fish Interactions	
Flow Fluctuation	• No applicable interactions, therefore no information gaps identified relating to the Water Use Planning process.
Reservoir Drawdown	• Reduction in Sugar Lake productivity related to reservoir drawdown (littoral productivity, tributary access). May need to assess overall benefit to fisheries resources by comparing Sugar Lake productivity to downstream fisheries values in the Shuswap River. Insufficient data to currently undertake that analysis.
Flow Management Strategies	• No applicable interactions, therefore no information gaps identified relating to the Water Use Planning process.

APPENDIX E:

Data Gap Summaries

Gap Summary Mara Lake to the Outlet of Mabel Lake

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Aquatic Resource				
Water Quality	J.E. Bryan and F.V. Jensen (381), Nordin, R.N (62), Nemer, J.C.and Wernick (389), B.G. FRBC Reports	Good Review of water quality in Mabel and Mara Lakes. No decline in water quality over course of the study. Sediment contribution from Kingfisher Creek, Fortune Creek, nutrient inputs. Surface water temperatures near Mabel lake measures at 25°C. Potential water quality impacts from forestry and agriculture. Sediment inputs from tributaries.	Increases in sediment inputs and increased bank erosion in mainstem, over historic values unquantified. No references found suggesting decline in spawning habitat values. Large spawning population likely keeps gravels clean, major sediment events occur after emergence.	No new study needs identified. Continue monitoring. Issue of fall water temperature likely only a concern if fall flows are greatly reduced from the Middle Shuswap. If flows are reduced in the Middle Shuswap then temperature may be an issue in the Lower Shuswap and should be re-visited.
Discharge	WSC review of contribution of flows from middle Shuswap			N/A
Flow studies	No Flow study references found			Need to identify contribution of MSR and % of flows relative to LSR changes in MSR likely to have limited effect on Lower Shuswap.
Fish and Fish Habitat				
Fish Distribution	Stewart et al 1989 (25), DFO 1982 (64), Hutton 1986 (53), Jantz (51), DFO spawner records, MoELP Files FRBC Reports for tributaries	Good description of spawner distributions of chinook, sockeye and kokanee.		Good information for spawning salmon and kokanee, with the exception of coho. No gaps re: WUP identified.
Life History	Stewart et al 1989 (25), DFO 1982 (64), Hutton 1986 (53), Jantz (51)	Adequate to describe life history for chinook, sockeye and kokanee.	Incomplete information on rainbow trout life history. Suggestion there is low use of Lower Shuswap because of high summer water temperatures. There is limited information for fall rainbow trout fry	No additional studies pertinent to Water use planning.

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Habitat Productivity	No studies reviewed directly related to assessment of habitat productivity.			Gaps in knowledge for capacity of anadromous fish and for resident species, however there will not be any requirement to augment knowledge for the purpose of Water Use Planning, unless large changes in flows are proposed in the Middle Shuswap that will
Escapement	DFO Spawner records, MoELP Data files.	Adequate for monitoring chinook and sockeye stocks		No
Stock Monitoring / Assessment	DFO Spawner records, MoELP Data files.	DFO enumeration is more rigorous than MoELPs activity.		N/A
Enhancement	DFO Reports, Stewart, 1989 (25)	Release records, no indication of impacts of Hatchery releases on wild population. Do not have current information on percent composition of Hatchery returns. Enhancement work carried out by the Kingfisher Environmental Society.		
Angler Use	DFO reports - chinook sport fishery, MoELP files	DFO creel adequate to monitor catch Sportfish catch monitoring generally lacking		Not a WUP issue, unless changes in flow result in impacts to fish entry habitat. Unlikely given constraints to storage and management of flows for fish in Middle Shuswap River.
Hydro-Fish Interactions	No studies directed at hydro fish interactions in the Lower Shuswap	General streamflow information from WSC adequate to assess contribution of flows from Middle Shuswap and to identify buffering effects of Mabel Lake.		
Flow Fluctuation				No operational fluctuations from Wilsey Dam, flow changes buffered byMabel Lake
Reservoir Drawdown				

Gap Summary Mara Lake to the Outlet of Mabel Lake

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Flow Management Strategies	BC Hydro Operation reports			Flow management in the Middle Shuswap can affect flows in the Lower Shuswap River. Flow contribution from upstream of Sugar Lake is approximately 53% of flows. at Mabel Lake. Sugar Lake has minimum storage (13% of inflows). Regulated flows have resulted in shaving the peak hydrograph and augmenting winter floows. Salmon stocks have increased and chinook stocks are at highest levels for the period of record. Fish flows designed for Middle Shuswap will have a positive effect (or at least seen as not having a negative effect) on Lower Shuswap as fish assemblages and general life history similar.

Gap Summary Mabel Lake from its outlet to Wilsey Dam

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Aquatic Resource				
Water Quality	BC Hydro Operation Reports (Forebay Dredging)	Monitoring of activities provides data on sediment discharge downstream associated with the activity.	A consideration relative to the WUP process is the increases in sediments from other non BCHydro related sediment inputs into the system. No information on TGP - is presently being addressed by BCH	Sediment inputs from tributary systems may need to be explored if there is some concern that risks associated with other resource impacts will limit the effectiveness of water release strategies. Review results of TGP study to assess risk.
Discharge	BCHydro Operation Reports (Sugar Lake Discharges, Wilsey Dam operation), WSC Gauge information, Aquatic Resources 1997 (19), Triton 1994 (1), Triton 1994 (2) Sigma (18), Lewinsky (398)	Stream flow information and water release data adequate to monitor flows. Flow study has indicated constraints to different flow scenarios due to limits to storage. Flows are intensively managed from August on taking into account reservoir volume and fo	Confirmation on available spawning habitats at different flow for salmon and kokanee. Information required to set optimum spawning/incubation flows given storage constraints. Data used to generate Sigma Report needs revisiting?	Establishment of optimum flow regime. Survey of available spawning area for chinook at different i.e. 1000cfs, 800 cfs and 900 cfs (above this level may be incompatible with available water to avoid unsuitable decreases in incubation flows). Similar exer
Fish and Fish Habitat				
Fish Distribution	BCHydro Operation Reports (Sugar Lake Discharges, Wilsey Dam operation), WSC Gauge information, Aquatic Resources 1997 (19), Triton 1994 (1), Triton 1994 (2) Sigma (18), Lewinsky (398), Bowman and Stewart 1984 (163)	Adequate information on distribution of spawners, change in river morphology in 1997 may have affected distribution to some extent. Distribution and abundance of rearing populations should be updated. Don't know peak outmigration timing.	Good general knowledge, based on mid 1980's studies. Should be updated to provide current status. Need to know more about temporal use of off channel use, need to reassess spawning areas post 1997 high water event and sediment inputs from Bessette Creek	Assess off channel use and compare use to man made side channels. Assess current fish distribution and abundance employing methodologies that provide data that can be compared to results from earlier studies.

Gap Summary Mabel Lake from its outlet to Wilsey Dam

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Life History	Stewart 1989 (25), Fee and Jong, 1984 (50), Aquatic Resources 1997 (19), Triton 1994 (1), Triton 1994, Bowman and Stewart 1984 (163)	Chinook primarily ocean type, except for Duteau/Harris fish which have a stream type life history. Extensive use of Mabel Lake for early rearing of chinook. Some overwintering in Middle Shuswap. Coho use Middle Shuswap and tributary systems for 1 year.	Knowledge of spawning needs and early rearing needs adequate for development of flows. No obvious need for additional studies to describe life history identified however, timing of peak outmigration is not clear. Incomplete knowledge of use of side channe	Conduct assessments post emergence to assess early life history use in nursery habitats (side and off channel).
Habitat Productivity	Stewart 1989 (25), Fee and Jong, 1984 (50), Aquatic Resources 1997 (19), Triton 1994 (1), Triton 1994,Bowman and Stewart 1984 (163), Slaney, P	Standing stock estimates may not be the best assessment of capacity due to recruitment issues (RBT) and food/temperature issues. For chinook availability of spawning habitats and nursery habitats may be important. Gravel quality data available suggests	Estimate of available spawning habitat plus area required per pair. Assess superimposition of redds at main spawning sites . System specific habitat preference data required. Inventory of nursery habitats (side channel and off channel) used in first mo	Map available spawning habitats at different achievable flows, 1000cfs, 900cfs, 800cfs. Assess changes in spawning area factoring in appropriate habitat parameters (Depth velocity substrate size).Also assess superimposition of redds at major spawning site
Escapement	DFO Records, MoELP Data Files		Continue collection during WUP	
Stock Monitoring / Assessment	Chinook Enumeration DFO Records, Stewart 1989 (25), Fee and Jong, 1984 (50), Aquatic Resources 1997, Bowman and Stewart 1984 (163)	Annual monitoring of salmon adults, monitoring of off channel habitats constructed. Previous assessments to identify potential for enhancement		
Enhancement	DFO Hatchery Outplanting records, Chinook Enumeration, Stewart 1989 (25), Fee and Jong, 1984 (50), Aquatic Resources 1997, Bowman and Stewart 1984 (163)	Assessing hatchery returns, production from constructed off-channel habitats, built to provide preferred habitat for threatened interior coho.		Assess contribution from Man made vs. natural channel habitats.

Gap Summary Mabel Lake from its outlet to Wilsey Dam

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Angler Use	MoELP Data files, DFO Chinook Sport Fishing Reports	Some local use for RBT, the major activity is the annual sportfishery for chinook. There is a desire for a better fishery. There is a mountain whitefish fishery	Creel information to assess use and success.	
Hydro-Fish Interactions				
Flow Fluctuation	BCHydro Operation Reports (Sugar Lake Discharges, Wilsey Dam operation), WSC Gauge information, Aquatic Resources 1994,1997 (19, 16), Triton 1994 (1), Triton 1994 (2) Sigma (18),	Information on changes in flows are recorded, information on the impacts of the flows (ramping/stranding) are incomplete. Risks to coho due to flow reductions not done. Guidelines for flow ramping are conservative and based on the best information curre	Knowledge of impacts of short term flow changes regarding stranding and lateral pool isolation specifically in Reach 2) is insufficient. Knowledge of channel invert elevations will aid in determining flow levels at which channels become isolated. Seri	Conduct flow stranding (gravel bar stranding and lateral pool isolation) study that quantifies potential risk associated with short term flow fluctuations. Survey information on channel invert elevations will help determine when side channel habitats be
Reservoir Drawdown	NA			NA

Gap Summary Mabel Lake from its outlet to Wilsey Dam

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Flow Management Strategies	BCHydro Operation Reports (Sugar Lake Discharges, Wilsey Dam operation), WSC Gauge information, (19), Triton 1994 (1), Triton 1994 (2) Sigma (18),	In the past flow management generally follows rule curve No 12. Management now more adaptive. Inter agency group (FOC, BCH, MoELP) actively manage, starting in August, to achieve the most beneficial flows for salmon and kokanee spawning as well as for	Have not developed the relationship of available spawning habitat at possible flows (1000,900, 800, 700, 600) Channel changes may require revisiting 1993,94 survey sites. Need invert elevations of side channel spawning sites and off channel sites to asse	Develop flow option to maximize production. Need to know maximum available spawning habitat for chinook, kokanee and coho, sockeye, given flow constraints and the need to access side channel spawning for kokanee, and coho as well as the limits to reducti

Gap Summary Wilsey Dam to Sugar Lake

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Aquatic Resource				
Water Quality	BC Hydro Operation Reports, FRBC Reports, Bryan, 1999 (381),Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Information on reservoir water quality, some baseline water quality nutrients from biological studies. Adequate to describe basic water quality parameters. Some information on sediment inputs from tributary systems.	Sediment inputs from tributaries, not quantified. Potential to affect BCH operation.	Tracking of WRP initiatives to address sediment issues in the tributaries.
Discharge	BCHydro Operation Reports (Sugar Lake Discharges Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Stream flow information and water release data adequate to monitor flows. Flow related information from biological studies. Risks to fish productions relate to rate of stage change as well as magnitude of change for higher risk habitats. Insufficient data	Habitat use in Reach 4 where early rearing habitat is present for rainbow trout is not sufficient to assess risk due to flow related events. Data on temporal and spatial use of habitats used by rainbow fry needs to be collected (specifically during rainbo	Survey Reach 4, assess use for early rearing and risks to stranding and isolation due to changes in flows. (Rate and magnitude)
Fish and Fish Habitat				
Fish Distribution	Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Information on species abundance and distribution adequate, with the exception of use of Reach 4 as early rearing for rainbow trout.	Young of the year present in this area, no record of mainstem spawning. Braided area susceptible to flow changes 1995 Triton report identified missing ageclass in this reach.	Early rearing fish survey in Reach 4. (assessment of potential chinook spawning habitat in Reach 4 - is this on??)

Gap Summary Wilsey Dam to Sugar Lake

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Life History	Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Adequate for most life history for rainbow and white fish. Mainstem rearing bull trout - early life history unknown.	Early life history information for rainbow trout incomplete. O+ fish are present but it is unknown whether there is mainstem spawning or recruitment is exclusively from tributary system. Bull trout recruitment patterns unknown.	Mainstem spawning surveys, or as a surrogate post emergence trapping. Bull trout surveys (likely radio tagging), sufficient sample size may be a problem.
Habitat Productivity	Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Standing stock estimates may not be the best assessment of capacity due to recruitment issues such as rainbow from the tributaries and food/temperature issues. Whitefish populations comprise the majority of the biomass. Habitat for rainbow trout curre	Lack of RBT production may be due to either lack of recruitment, food/temperature issues, losses due to flow regulation or over-exploitation. Low productivity of systems increases the risks to exploitation.	If chinook accessis to be restored to the Middle Shuswap above Wilsey Dam there may be a requirement to asses available food resources (nutrients, primary and secondary production) to determine if the presence of chinook juveniles will further reduce rai
Escapement		No escapement records for system.		
Stock Monitoring / Assessment	Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979	Adequate as baseline	Rainbow trout stocks not monitored Bul trout stocks not monitored.	

Gap Summary Wilsey Dam to Sugar Lake

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Enhancement	Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52), Triton 1995 (373)	Standing stock studies provides baseline information. Chinook can spawn and rear above Wilsey Dam. No final determination whether restoring access for chinook will affect sportfish production.	Not related to water use planning?	Stocks currently appear to be under-utilizing habitat, if no change should be room for adadromous salmon.
Angler Use	MoELP Data files, Jantz, 2000 (pers. com), Triton 1995 (57)	Some local use for RBT, information scarce, no fishery closures.	No WUP Gap Fisheries management issue.	
Hydro-Fish Interactions				
Flow Fluctuation	BC Hydro Operation Reports (Sugar Lake Discharges) Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Data on record	Ramping needs for middle Shuswap above Wilsey Dam	Assess fish use and susceptibility to flow reductions in Reach 4. Conduct stranding study (bar stranding and isolation in lateral pools and side/back channels)
Reservoir Drawdown	NA			NA
Flow Management Strategies	BC Hydro Operation Reports (Sugar Lake Discharges) Aquatic Resources 1994 (16), Fee and Jong, 1984 (50), Triton 1995 (57), Griffiths 1979 (52)	Flow management generally follows rule curve No. 12 and are managed actively starting in August to achieve the most beneficial flows for salmon and kokanee spawning below Wilsey Dam.	Critical instream flow needs for Middle Shuswap above Wilsey dam not addressed. Apart for risks to young of the year rainbow (if there are any) generally flow regimes for downstream areas should benefit upper Shuswap	Assess flow needs for rainbow trout young of the year - specifically in Reach 4. Habitat survey, early life history sampling.

Gap Summary Sugar Lake Upstream

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Aquatic Resource				
Water Quality	Bryan 1999 (381), FRBC Reports, MoELP files	Water quality data indicate Sugar is an Oligotrophic Lake, water quality has shown no significant change from 1971 to 1998.	Pelagic productivity	Assessment of current pelagic productivity. Assess opportunity to increase production.
Discharge	BCHydro Operation Reports (Sugar Lake Reservoir operation), MoELP data files	Data provided to assess temporal aspects of drawdown. Lake bathymetric profile is available to assess changes in littoral area associated with drawdown.	Lake tributary access, changes in littoral productivity	Assess changes in lake tributary access relative to reservoir operation. Assess loss of production due to reservoir drawdown.
Fish and Fish Habitat				
Fish Distribution	FRBC Reports, MoELP Data files, Einarson, 1985 (320)	Provides baseline on species composition and distribution.	Recruitment systems for lake rearing stocks not described.	Identify recruitment systems for lake populations
Life History	FRBC Reports, MoELP Data files, Einarson, 1985 (320)	General life history understood. Timing and spawning locations of adfluvial stocks not well known. Burbot life history inadequate, especially spawning locations.	Specific information on early rearing stategies lacking Spawner location and risks to reservoir drawndown is needed.	Determine burbot spawning and early life history requirements and quantify risks to producution from reservoir operation.
Habitat Productivity	FRBC Reports, MoELP Data files, Einarson, 1985 (320)	Productivity not addressed in the tributary systems. Lake productivity low, size of kokanee has decreased. Low productivity may make bull trout and rainbow susceptible to overexploitation.	Reservoir productivity might be reduced due to drawdown effects.	Assess change in productivity associated with reservoir operation.
Escapement		No escapement records for system. Some MoELP Kokanee counts.		
Stock Monitoring / Assessment	Einarson 1985 (320)	Inadequate		

Gap Summary Sugar Lake Upstream

Keyword	Relevant Reports Reviewed (Reference Number)	Adequacy of Information	Gaps in Information - Relative to needs of Water Use Planning	Recommendations for studies relative to Water use planning
Enhancement	MoELP Data files.	Historic stocking of kokanee, stocking of headwater lakes with Rainbow trout and cutthroat trout.	NA	
Angler Use	Einarson 1985 (320), MoELP Data files	1985 Creel Census no other documented information found.	No WUP Gap - Fisheries management issue. Creel would provide a rough indicator of stock status.	
Hydro-Fish Interactions				
Flow Fluctuation	NA			
Reservoir Drawdown	BC Hydro Operation Reports, MoELP Files	Data provided to assess temporal aspects of drawdown. Lake bathymetric profile is available to assess changes in littoral area associated with drawdown	Lake tributary access, littoral habitat, tributary inundation after spawning, presence of shore spawning kokanee.	Assess changes in lake tributary access relative to reservoir operation also tributary inundation after spawning. Assess changes in productivity relating to loss of littoral production. Determine whether shore spawning kokanee are present. Assess ris
Flow Management Strategies	NA			

APPENDIX F:

Data Matrices

Mara Lake to the Outlet of Mabel Lake Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap (relating to WUP)	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
Mabel Lake to Mara Lake	Lower Shuswap River	Sockeye	Adult, emergent fry	Spawning, migration, incubation	Indirect effect buffered by Mabel Lake and additional tributary inflows.	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		Kokanee	Adult, emergent fry	Spawning, migration, incubation	Indirect effect buffered by Mabel Lake and additional tributary inflows	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		Chinook	Adults fry, juveniles	Spawning, migration, incubation, rearing	Indirect effect buffered by Mabel Lake and additional tributary inflows	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		Coho	Adults fry, juveniles	Spawning, migration, incubation, rearing	Indirect effect buffered by Mabel Lake and additional tributary inflows.	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	102 - 104
		Rainbow trout	fry, juveniles, adults	rearing, migration	Indirect effect buffered by Mabel Lake and additional tributary inflows.	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality.	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	102 - 105
		Whitefish	fry, juveniles, adults	Spawning, rearing, incubation	Indirect effect buffered by Mabel Lake and additional tributary inflows	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality.	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	102 - 107
		Bull Trout	Adult	Migration staging/feeding	Indirect effect buffered by Mabel Lake and additional tributary inflows.	Forestry/Recreation/agriculture/Linear Development/Urban Development	Only possible effect due to large changes in flow regulation	Riparian Impacts, habitat degradation, water quality	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	

Mara Lake to the Outlet of Mabel Lake Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap (relating to WUP)	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
	Tributaries to Lower Shuswap	Chinook	Juvenile	Rearing (	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	Habitat degradation/ water quality problems	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		Coho	Juveniles/ adults	Rearing/spawning	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	Habitat degradation/ water quality problems	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		rainbow	Juveniles/ adults	Rearing/spawning	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	Habitat degradation/ water quality problems	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
	Mara Lake	chinook/coho/sockeye	Juveniles	Rearing	Not significant	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	habitat degradation	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	
		Rainbow, bull trout, burbot.	Juveniles adults	Rearing	Not significant	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	habitat degradation	None identified, unless large departure from current flow management considered	None identified, unless large departure from current flow management considered	Currently Low	

Summary of Recommendations - Flow releases from Middle Shuswap are buffered by Mabel Lake. Flows developed to maximize fish production in the Middle Shuswap will be of benefit to fish production in the Lower Shuswap, due to similar fish assemblages and life histories.

Mabel Lake from its outlet to Wilsey Dam Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
Wilsey Dam to Mabel Lake	Middle Shuswap	Sockeye	Adult, emergent fry	Spawning, incubation	Yes	Forestry/Recreation/agriculture	Wilsey and Peers Dam - Flow Fluctuations	Riparian Impacts, habitat degradation, water quality	Effects of flow fluctuations on incubating sockeye. Channel changes since 1997 have occurred, study sites should be revisited.	Assess effects of short term flow fluctuation on incubating sockeye. Collect survey information to assess risks of flow changes from spawning to rearing flows.	H	
		Kokanee	Adult, emergent fry	Spawning, incubation	Yes	Forestry/Recreation/agriculture	Wilsey and Peers Dam - Flow Fluctuations	Riparian Impacts, habitat degradation, water quality.	Effects of flow fluctuations on incubating kokanee. Channel changes since 1997 have occurred, study sites should be revisited.	Assess effects of short term flow fluctuation on incubating kokanee. Collect survey information to assess risks of flow changes from spawning to rearing flows. Conduct surveys to assess need for side channel access (update pre 1997 data after channel ch	H	
		Chinook	Adults, fry, juveniles	Spawning, incubation and rearing	Yes	Forestry/Recreation/agriculture	Wilsey and Peers Dam - Flow Fluctuations	Riparian Impacts, habitat degradation, water quality.	Effect of flow regulation on incubation and on rearing fish Capacity of spawning area at different flows. Early rearing use of nursery /off channel habitats. Mid 1980's abundance and distribution of fish in the Middle Shuswap should be updated to prov	Survey spawning areas to determine spawning ground capacity at different flows (100/900/800). Assess impacts of short term flow fluctuations. (stranding studies, including gravel bar stranding and isolation in lateral pools) Stranding studies could be co	H	
		Coho	Adults, fry, juveniles	Spawning, incubation and rearing	Yes	Forestry/Recreation/agriculture	Wilsey and Peers Dam - Flow Fluctuations	Riparian Impacts, habitat degradation, water quality.	Effect of flow regulation on incubation and on rearing fish. Access to off channel habitats. Comparison of Natural verses man made channels. Mid 1980's abundance and distribution of fish in the Middle Shuswap should be updated to provide current inform	Collect data to indicate flow levels required for off channel access to spawners (need to update data because of stream channel changes that occurred in 1997). Assess impacts of flow fluctuation on incubating coho eggs. Assess impacts of short term flo	H	102 - 104

Mabel Lake from its outlet to Wilsey Dam Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
		Rainbow trout,	fry, juveniles, adults	rearing	Yes	Forestry/Recreation/agriculture	Wilsey and Peers Dam - Flow Fluctuations	Riparian Impacts, water quality.	Early rearing life history. Mid 1980's abundance and distribution of fish in the Middle Shuswap should be updated to provide current information.	Assess effects of flow regulation on isolation of rainbow trout fry in lateral pools and in cut off side channels. Requires surveys of channel inlets and stranding/isolation surveys during flow recession. Conduct stranding surveys to assess risk associat	H - as the work will be combined with studies for other fish.	102 - 105
		Whitefish	fry, juveniles, adults	Spawning, incubation and rearing	Wilsey and Peers Dam - Flow Fluctuations	Forestry/Recreation	negligible	Recreation-encroachment on riparion and foreshore	Complete life history information of Middle Shuswap whitefish. Population currently appears to be healthy? Mid 1980's abundance and distribution of fish in the Middle Shuswap should be updated to provide current information. Identification of spawning ar	Conduct studies, using comparative methodologies to the 1980's studies, that provide current status of Middle Shuswap populations	M	102 - 107
		Bull Trout	Adult	Rearing (temporal)	Wilsey and Peers Dam - Flow Fluctuations	Forestry/RecreationAgriculture	negligible	Recreation-encroachment on riparian and foreshore	Bull Trout life history uncertain. The middle Shuswap below Wilsey dam is likely too warm to be a good bull trout system. Use would be limited.	None		
	Tributaries to Middle Shuswap	Chinook,	Juvenile (some adults in Besette)	Rearing (some spawning in Bessette)	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	habitat degradation/ water quality problems	Impact on recruitment to Middle Shuswap	Monitor tributary conditions through Agencies		
		Coho	Juveniles adults	Rearing/spawning	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	habitat degradation/ water quality problems	Impact on recruitment to Middle Shuswap	Monitor tributary conditions through Agencies		
		Rainbow	Juveniles adults,. Bessette/Duteau	Rearing/spawning	None	Forestry/RecreationAgriculture/linear development/urban use/industrial development	none	habitat degradation/ water quality problems	Impact on recruitment to Middle Shuswap	Monitor tributary conditions through Agencies		

Mabel Lake from its outlet to Wilsey Dam Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
	Mabel Lake	Chinook/coho/sockeye	Juveniles	Rearing	Not significant	Forestry/Recreation/Agriculture/linear development/urban use/industrial development	none	habitat degradation	Rearing capacity	Monitor conditions through Agencies		
		Rainbow, bull trout, burbot.	Juveniles adults	Rearing	Not significant	Forestry/Recreation/Agriculture/linear development/urban use/industrial development	none	habitat degradation	Rearing capacity. Resident fish status	Monitor conditions through Agencies. Creel Survey CPUE.		

Summary of Recommendations -

Assess spawning capacity for chinook. Amounts of suitable spawning habitat at different achievable spawning flows (1000, 900, 800, 700, 600) Priority High
Revisit flow monitoring study sites, reassess river conditions and risks to flows post 1997 flows which produced channel modification and under extreme low flows (550 cfs) Priority High
Quantify risks to short term flow fluctuation through stranding/isolation studies, by staging event with on-site monitoring of index sites. Priority High
Assess spawning gravel recruitment and scour - specifically in the spawning area above Bessette Creek. Priority Moderate to High
Survey side channel inverts - assess emergent fry rearing habitats (assess risks to rainbow trout young of the year to flow recession Priority Moderate to High
Update Middle Shuswap stock status (from 1980's) using similar methodologies to earlier work that allow for comparison of current condition to earlier status. Priority Moderate to High
Assess superimposition of Redds at high density sites Priority Moderate
Compare fish use of off channel habitats verses man made habitats Priority Moderate to High
Assess Whitefish spawning/incubating/early rearing habitat needs and any risks to flow fluctuations Priority Moderate
Mabel Lake Creel - RB CPUE Priority Low to Moderate

Wilsey Dam to Sugar Lake Dam Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap (Relative to WUP)	Recommended Action	Priority	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use				
Sugar Lake Outlet to Wilsey Dam	Middle Shuswap River	Rainbow trout	Adult, juvenile, fry	Rearing, spawning and incubation?	Yes	Forestry/Recreation/ Rural Urban, Linear Development	Yes	Yes	Impacts of flow regulation on rainbow trout, specifically in Reach 4	Early life history rearing assessment in Reach 4. Study to assess the impacts of flow regulation on flow regulation in Reach 4. Study to include stranding assessment including gravel bar stranding, isolation in lateral pools, isolation in side/offchannel	M - H	
		Bull Trout	Adult	Rearing	Yes	Yes	Yes	Yes	Life history of adfluvial bull trout unknown (Bull trout numbers are low)	Undertake bull trout study to understand life history requirements.	M - H	
		Mountain Whitefish	Adult, Juvenile, Fry	Rearing, spawning and incubation	Yes	Yes	Yes	Yes	Last assessment of whitefish population in 1995. Comparison to 84 study, numbers greater but biomass lower, may be a result of differences in flows and expansion of observed numbers	None		
		Chinook ??	Adult fry juvenile	Spawning and rearing	Yes	Yes	Yes	Yes	Restoring chinook (and other fish) access to the Middle Shuswap upstream of Wilsey Dam may affect resident populations	Assess productivity of the Middle Shuswap - nutrients, primary and secondary production to review potential impact on resident stocks.	?	

Summary of Recommendations

Assessment rainbow trout early rearing in Reach 4 of the Middle Shuswap River. Assessment should include both temporal and spatial use of fry habitats (Priority - Moderate to High).
Based on the assessment of rainbow early rearing habitats assess risks associated with flow changes to important habitat areas. The study should identify when important habitat becomes isolated and risks, if any of stranding of rainbow trout. (Priority
Assess Middle Shuswap water levels during spring to ensure that access of spawners to tributary systems is not affected by flow management. (Priority Moderate)
Undertake bull trout study to understand life history requirements and constraints to production. Priority Moderate to High
Update species composition and age class in the Middle Shuswap (Wilsey Dam to Sugar Lake) Priority Low to Moderate.

Optional
Relating to restoration of fish access (chinook and others) to the Middle Shuswap above Wilsey Dam (non-WUP related)

Assess productivity of the Middle Shuswap - nutrients, primary and secondary production to review potential impact on resident stocks.

Upstream of Sugar Lake Dam Tributaries Matrix Analysis

Geographical Area	Water body	Aquatic Resource			Resource Use		Potential Impact		Knowledge Gap	Recommended Action (Relative to WUP)	*Reference No.
		Species	Life History Stage	Primary Habitat Use	BC Hydro Operation	Other Resource Use	BC Hydro Operation	Other Resource Use			
Sugar Lake Upstream	Sugar Lake	Rainbow, kokanee, bull trout, burbot	Adult, juvenile?	Rearing	Yes	Forestry/Recreation	Yes	Yes	Reservoir production, exploitation, tributary access, inundation. Burbot life history - specifically spawning locations	Assess reservoir productivity, effects of loss of littoral production, assess tributary access. Spawning activity in drawdown zone. Burbot spawning locations in reservoir and risks to drawdown.	
	Sugar Lake tributaries	Rainbow, kokanee, bull trout	Fry, juveniles adult	Spawning, incubation and rearing	No	Forestry/Recreation	Yes relating to tributary access	Yes	Changes to tributary access for tributaries flowing directly into Sugar Lake	Assess tributary access.	

While impacts to production of reservoir fish stocks have resulted as a result of reservoir operation, it is generally agreed that the downstream benefits to current reservoir operation have been positive.
Since it is likely that reservoir management to i
be required to be able to assess values for trade offs.

Possible Actions
- Updating Sugar Lake Bathymetry to provide information on drawdown effects to the littoral zone. Priority Moderate to High
- Identifying burbot spawning locations to assess risk associated with reservoir operation - Priority Moderate to High
- Determine whether spawning is taking place within the drawdown zone of the reservoir. Priority Low to Moderate
- Assess changes in tributary access associated with reservoir operation Priority Low to Moderate.