WATER TEMPERATURES FOR SELECTED WATERCOURSES AND GROUNDWATER OFF-CHANNEL RESTORATION PROJECTS IN THE THOMPSON AND SHUSWAP RIVER SYSTEMS, BRITISH COLUMBIA 1997-2001

B.D. Rebellato, C.S. Collins, S.M. Nesbit and K.R. Garbutt
(edited by M.B. Flynn)

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Abstract

Rebellato, B.D., Collins, C.S., Nesbit, S.M., and Garbutt, K.R. 2009. Water temperatures for selected watercourses and groundwater off-channel restoration projects in the Thompson and Shuswap River systems, British Columbia 1997-2001. Edited by M.B. Flynn. Can. Data Rep. Fish. Aquat. Sci. 1214: vi + 28p.

This Data Report presents summarized and raw water temperature data recorded in various watercourses within the Thompson and Shuswap River systems through a monitoring study undertaken primarily from 1997 to 2001 by Fisheries & Oceans Canada, B.C. Interior-South.

The monitoring study was undertaken with the primary objective of comparing water temperatures between the mainstem of selected watercourses and associated groundwater-fed off-channel habitats, specifically from the perspective of benefits to endangered Interior Fraser coho salmon. One focus of fish habitat restoration by DFO in the Southern Interior of B.C. has been the development of groundwater-fed off-channels, particularly within watersheds exhibiting flow and temperature impacts. Many watercourses within the Thompson and Shuswap River watersheds have been identified as limiting in available salmonid rearing habitat due to impacts from low flows and high water temperatures during critical summer months. Groundwater can buffer these harmful effects and greatly enhance salmonid rearing productivity.

Secondary, but also important objectives of this study include:

- comparing temperatures between tributaries and mainstem;
- identifying watersheds where extreme temperatures are limiting available summer and winter habitat for juvenile coho;
- providing additional information for regulatory agencies involved in sensitive stream designations;
- increasing the temperature database within the watersheds of the Thompson and Shuswap Rivers for the purposes of assisting agencies and individuals in understanding sensitive habitats and in developing programs to improve stream water quantity and quality; and
- initiating a temperature monitoring study that can be continued over the long-term.

This study was undertaken to compare the water temperatures of primarily groundwater-fed off-channel fish habitat restoration projects with associated mainstem watercourses, to investigate the potential benefits of groundwater temperature and flow characteristics for rearing salmonids. Accordingly, some detailed discussion of restoration projects and associated mainstem watercourses has been included in this report.

Unfortunately in this study, there are a few instances where some water temperature data is incomplete due in part to thermograph loss or damage.

Résumé

Rebellato, B.D., Collins, C.S., Nesbit, S.M., and Garbutt, K.R. 2009. Water temperatures for selected watercourses and groundwater off-channel restoration projects in the Thompson and Shuswap River systems, British Columbia 1997-2001. Edited by M.B. Flynn. Can. Data Rep. Fish. Aquat. Sci. 1214: vi + 28p.

Ce rapport statistique décrit les données de température brutes enregistrées dans divers cours d'eau des bassins de la Thompson et de la Shuswap lors d'une campagne d'étude entreprise entre 1997 et 2001 par Pêches et Océans Canada - Intérieur Sud de la Colombie-Britannique.

Cette campagne d'étude avait pour objet principal de comparer les températures observées dans les artères principales de certains cours d'eau et leurs tributaires phréatiques, en vue de déterminer l'intérêt relatif de ces derniers pour les populations de coho menacées du cours « Intérieur » du Fraser. L'un des principaux axes d'intervention du programme de restauration de l'habitat piscicole mené par le MPO dans l'Intérieur Sud de la Colombie-Britannique a été l'aménagement de tributaires phréatiques, en particulier dans les bassins donnant des signes de perturbation hydraulique et thermique. Plusieurs cours d'eau des bassins de la Thompson et de la Shuswap ont été identifiés comme pauvres en habitat salmonicoles du fait de leur faible écoulement et de leur température relativement élevée durant la critique période estivale. La nappe phréatique peut tempérer ces aléas et contribuer appréciablement à rehausser la productivité des aires de grossissement salmonicoles.

Cette campagne d'étude avait également cinq autres objectifs secondaires :

- comparer les températures entre cours d'eau tributaires et artères principales;
- identifier les bassins où les extrêmes de température ont pour effet de diminuer les zones d'habitat estivales et hivernales disponibles pour les cohos juvéniles;
- augmenter les données dont disposent les agences chargées de la désignation des cours d'eau en situation de vulnérabilité;
- enrichir la base des données de température dont on dispose au sujet des bassins de la Thompson et de la Shuswap afin de mieux connaître les zones d'habitat « sensibles » et de faciliter l'élaboration de programmes d'amélioration quantitative et qualitative des conditions hydriques en présence;
- entreprendre une étude à long terme des températures hydriques observées dans les bassins concernés.

Cette étude avait pour objet de comparer les températures observées dans les artères principales de certains cours d'eau et leurs tributaires phréatiques, en vue de déterminer l'intérêt relatif de ces derniers pour l'équilibre thermique et hydraulique des aires de grossissement salmonicoles. L'étude traite également de certains projets de restauration portant sur les artères principales observées.

À noter toutefois que pour certains sites, les données de température sont incomplètes en raison de la perte ou de l'endommagement du thermographe utilisé.

1.0 Introduction

Water temperature is one of the many habitat factors critical to the survival and productivity of salmonid species. Walthers and Nener (2000) suggest the optimum temperature for rearing juvenile salmon (*Oncorhynchus spp.*) is between 8 °C and 15 °C. Exposure to temperatures exceeding 20 °C to 23 °C and temperatures less than –0.4 °C to –0.7 °C can effect the metabolic processes of pacific salmon and cause mortality (Brett 1970).

Coincident with low water flows, temperatures of several river systems within the watersheds of the Thompson and Shuswap Rivers have exceeded upper lethal levels during summer months. These high temperatures limit the production and distribution of salmonid species, including the endangered Interior Fraser population of coho (*O. kisutch*). This species typically selects areas exhibiting cooler groundwater for summer rearing (Walthers and Nener 1997; Nener and Wernick 1998), as do many other salmonids. Groundwater sources also provide warmer water temperatures during winter months, which can increase egg survival of both sockeye salmon (*O. nerka*) and bull trout (*Salvelinus confluentus*) (Baxter and McPhail 1999). The buffering effect of groundwater on stream temperatures may also increase salmonid survival by protecting rearing juveniles from major temperature fluctuations that can occur over a short period of time within surface water-fed systems (Nener and Wernick 1998). In many watersheds, however, groundwater sources that would be useful for developing off-channel habitat restoration projects may be severely limited or lacking altogether.

In 1997, a study was initiated by the B.C. Interior-South, Fisheries & Oceans Canada (DFO) Resource Restoration Unit to monitor water temperature in several streams and at several fish habitat restoration projects within the watersheds of the Thompson and Shuswap Rivers (Figure 1). The initial purpose of this monitoring study was to investigate differences in water temperature between mainstem and groundwater-fed off-channel habitat restoration projects over time. However, given increasing concern with low flow conditions, additional temperature recording sites were established to increase the seasonal water temperature database for use by fish habitat practitioners.

Since water temperature is one of the critical and essential life cycle requirements for salmonid rearing and spawning and is relatively easy to monitor, it is hoped this program will be continued in the long-term for critical streams. Data presented in this report and in the appended compact disc represent temperature information collected up to 2001 (with a few exceptions up to 2003).

1.1 Objectives

The primary objective of this temperature monitoring study was to compare water temperatures between the mainstem of selected watercourses and associated groundwater-fed off-channel habitats, specifically from the perspective of benefits to rearing coho salmon. One focus of fish habitat restoration by DFO in the Southern Interior of B.C. within salmon-bearing watersheds has been the development of groundwater-fed off-channels. This is considered of particular importance within watersheds exhibiting flow and temperature impacts since groundwater can buffer such harmful fluctuations and greatly enhance rearing and spawning habitats. It is believed this will help to provide the most productive fish habitat for restoring impacted watersheds and salmon stocks.

Secondary, but also important objectives of this study include:

- comparing temperatures between tributaries and mainstem;
- identifying watersheds where extreme temperatures are limiting available summer and winter habitat for juvenile coho;
- providing additional information for regulatory agencies involved in sensitive stream designations;
- increasing the temperature database within the watersheds of the Thompson and Shuswap Rivers for the purposes of assisting agencies and individuals in understanding sensitive habitats and in developing programs to improve stream water quantity and quality; and
- initiating a temperature monitoring study that can be continued over the long-term.

1.2 Temperature Recording Equipment

Temperatures were monitored using Vemco™ Minilog12-T 12-bit temperature data loggers with an accuracy of ±0.1 °C and a temperature range of –5 °C to +35 °C. Temperature loggers (thermographs) were programmed to record water temperatures every two hours. This interval was chosen to ensure daily maximum and minimum temperature extremes were recorded. A RS-232 interface to a personal computer was used for programming and downloading.

1.3 Thermograph Installation

Preferred thermograph installation involved looping braided 3/32 inch stainless steel cable through an anchoring hole provided in the thermograph housing and crimping the loop with copper sleeves (aluminium crimps should not be used due to electrolytic corrosion). The cable is then similarly secured to a stable onshore structure (eg. tree, bridge piling). Although care was taken in the choice of deployment location, problems were experienced with vandalism, burial in bottom sediment and exposure to air during low and flood flows.

Data was usually downloaded on-site after an operational period of one or two years using a lap top computer. Thermographs would be re-initialized and re-deployed for further temperature recording or removed, depending on project objectives and the length of recording. After a period of about 5 years, thermographs were returned to the manufacturer for battery replacement.

1.4 Watershed Selection

Many watercourses within the Thompson and Shuswap River watersheds have been identified as limiting in available salmonid rearing habitat, particularly during critical summer months due to low flows and high water temperatures.

Watersheds, individual tributaries and off-channel restoration sites were chosen for this temperature monitoring study based on known critical flow and temperature conditions limiting rearing habitat (Figure 1). Of particular focus were watersheds within which groundwater-fed off-channel restoration projects had been completed. This provided an opportunity to compare the temperature of groundwater to mainstem (surface) waters. In some cases, it also allowed some inference of the effect of recorded temperatures, as a critical life cycle requirement, to habitat utilization by rearing salmonids. It also provided information on the success of some of DFO's groundwater-fed restoration projects in the Southern Interior of B.C., specifically in creating more productive salmonid rearing conditions.

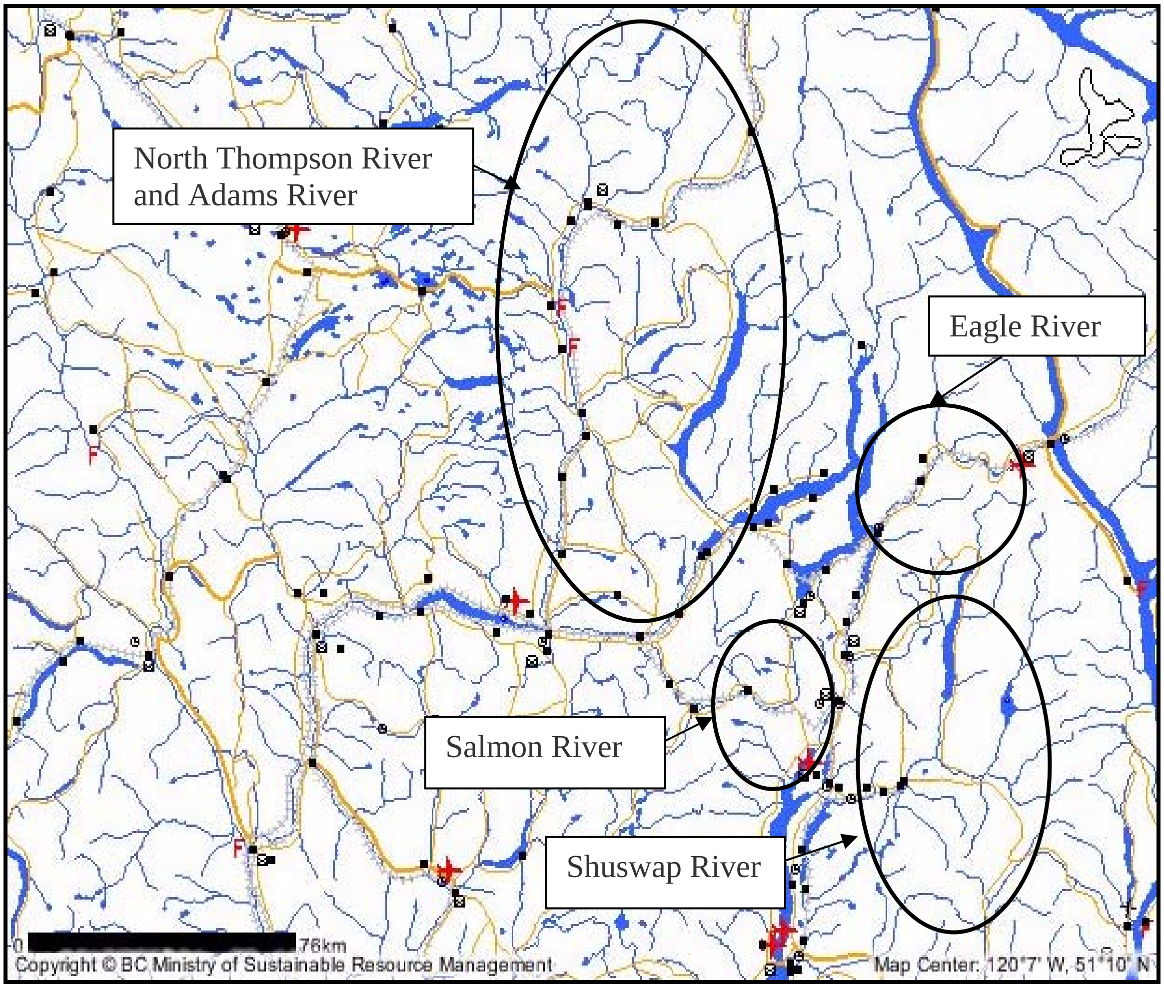

Figure 1. Watersheds of the Thompson and Shuswap Rivers encompassed by this temperature monitoring study (from BC Ministry of Sustainable Resource Management).

2.0 Monitoring Sites

2.1 Eagle River

The Eagle River watershed covers an area of 1,246 km² (Nener and Werwick 1998). Eagle River is 68 km in length and supports sockeye, coho and chinook salmon, kokanee and rainbow, cutthroat and bull trout (including early reports of dolly varden). Rocky mountain whitefish (*Prosopium williamsoni*) and numerous cyprinid spp. are also present (DFO 1986).

Forestry and agricultural activities, urban and industrial development, and linear corridors have impacted fish and fish habitat in the Eagle River through river siltation and reduction of riparian vegetation (Nener and Wernick 1998). Loss of riparian vegetation has accelerated the instability and erosion of streambanks. Glacier-fed Perry River delivers a high sediment load to the lower portion of Eagle River which impacts available spawning habitat (DFO 1986). Restoration and enhancement projects have focused on re-establishing habitat for rearing and spawning salmonids, including the development of groundwater-fed off-channels.

In summer 2000, DFO and the Eagle River Watershed Roundtable (ERWR) established a temperature monitoring study in the watershed. The main objective of this study was to monitor and compare temperatures between off-channel restoration sites and the mainstem, in addition to assessing tributaries and groundwater sources for potential restoration. Five sites were identified as having enhancement opportunities, as noted in Figure 2:

1. Craigellachie Creek
2. Senn Creek and Oxbow (including a mainstem thermograph site)
3. Teto Beaver Pond
4. Campbell Oxbow
5. Ylisto Oxbow

One thermograph was placed in mainstem Eagle River in July 2000 about 50 m downstream of the confluence of Senn Oxbow. Unfortunately, temperature recordings strongly suggest this mainstem thermograph became entangled in the shoreline anchor and was exposed to air temperatures except during high water levels. Accordingly, no temperatures are presented for Eagle mainstem in this report.

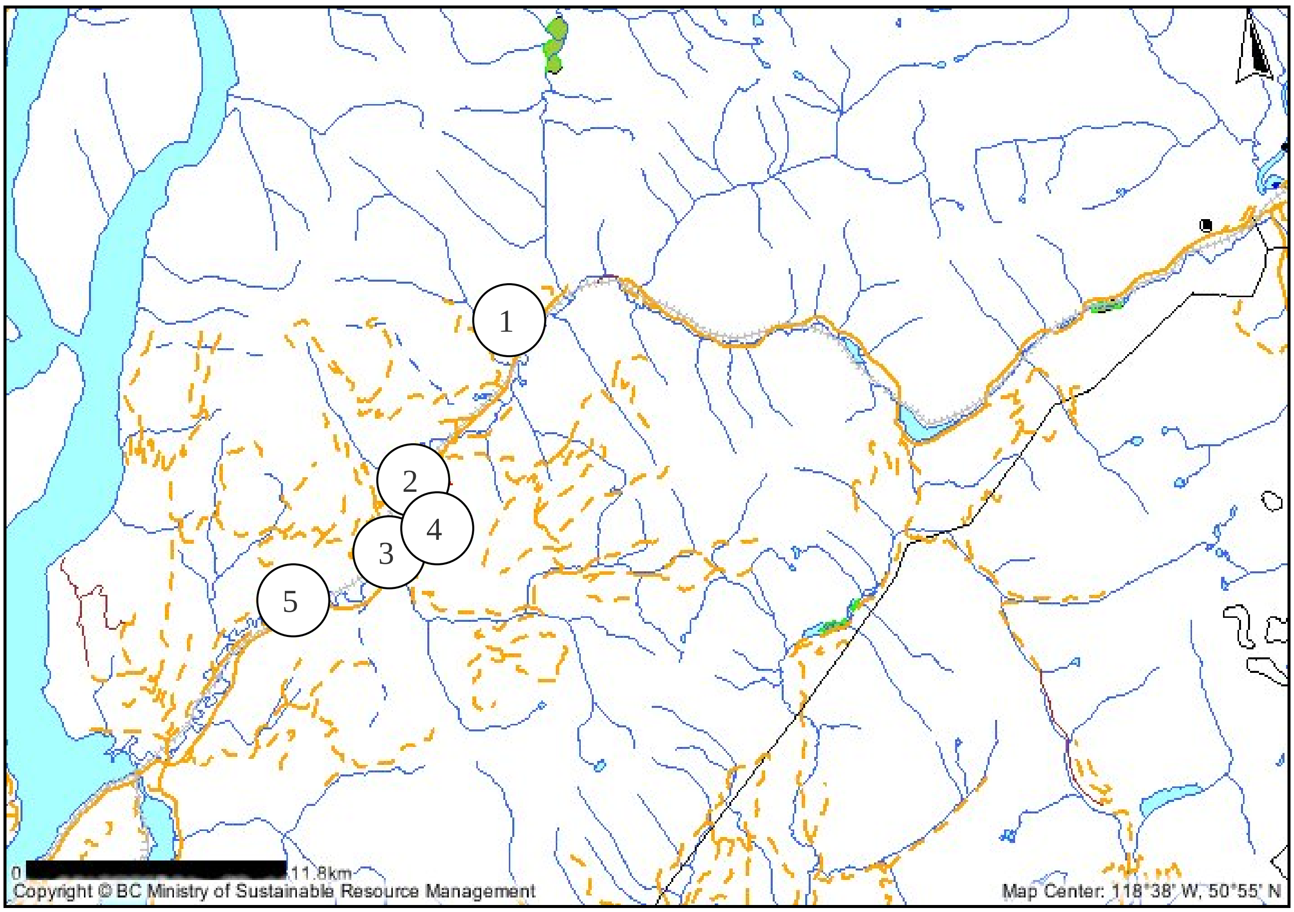

Figure 2. Map of Eagle River watershed showing habitat restoration and thermograph monitoring sites (from BC Ministry of Sustainable Resource Management).

2.1.1 Craigellachie Creek

Craigellachie Creek enters Eagle River at Craigellachie (Last Spike Monument site), approximately 19 km northeast of Sicamous on the Trans-Canada Highway. Craigellachie Creek widens into a wetland area on both sides of the highway before entering Eagle River. Prior to installing thermographs, the wetland areas and Creek were GEE trapped to determine fish presence. Trapping revealed a large number of juvenile coho salmon in the wetland area, with smaller numbers in mainstem Craigellachie Creek. On July 5, 2000, one thermograph was placed at the mouth of Craigellachie Creek and one in the wetland. The ERWR also installed staff gauges to measure Creek flow.

Subsequent evaluation of the flow data indicated that Craigellachie Creek and the wetland had unfavourable flow characteristics, causing the wetland to dry during certain times of the year. Figure 3 shows the average daily temperatures for Craigellachie Creek and wetland.

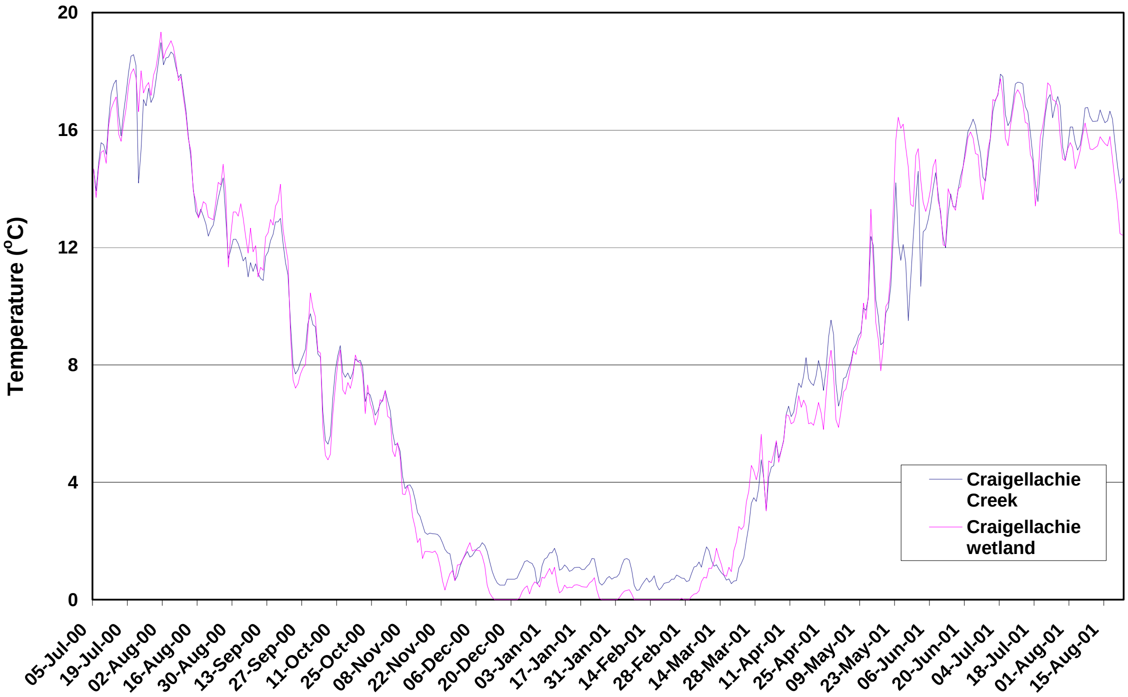

Figure 3. Comparison of daily averaged temperatures of Craigellachie Creek and wetland from July 5, 2000 to July 22, 2001.

Although Creek and associated wetland temperatures appear very similar, the wetland seems to be somewhat warmer in summer and cooler in winter. This suggests the wetland receives a minimal amount of stabilizing groundwater infiltration and is poorly flushed. No habitat restoration was subsequently undertaken.

2.1.2 Senn Creek

Senn Creek flows into a large oxbow (historic remnant of Eagle River), which in turn confluences with Eagle River. Past channel alteration and straightening impacted the Creek and limited spawning and rearing habitat, due in part to lack of riparian cover. In 2001, a habitat restoration project was implemented in Senn Creek to improve coho rearing and spawning habitat. This involved the creation of three off-channel pools, stabilizing 300 m of bank using tree revetments and placing large woody debris instream. Fencing was installed to limit cattle access and promote riparian stability and vegetation growth. Cattle access was restricted to one open vehicle crossing.

In July 2000, one thermograph was placed in Senn Creek, one in the pond at the outlet of a groundwater tributary and one at the downstream end of the Oxbow (Figures 4 and 5). [Editor's note: no temperature data was found for the downstream end of the Oxbow]

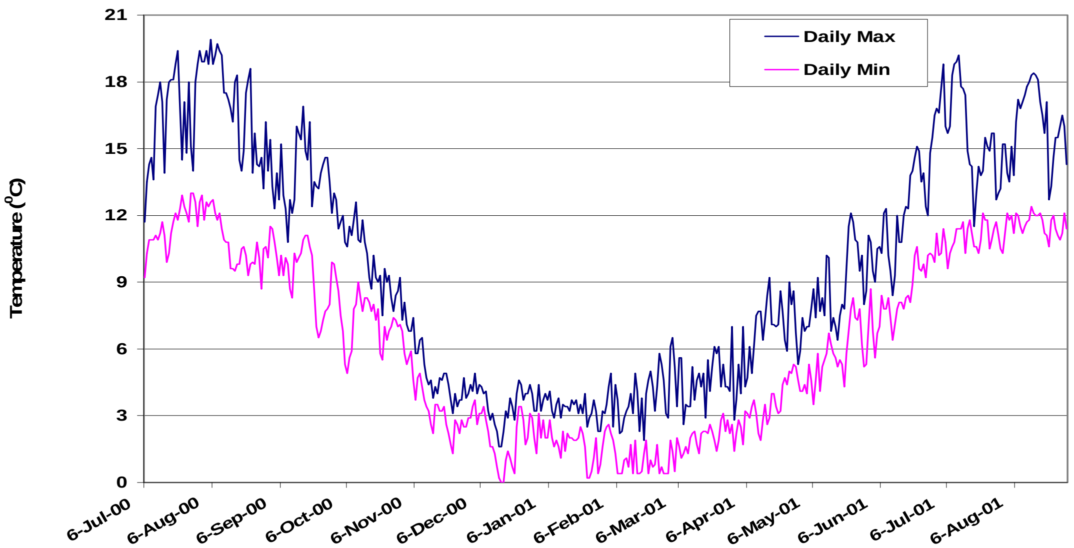

Figure 4. Daily maximum and minimum water temperatures for Senn Creek.

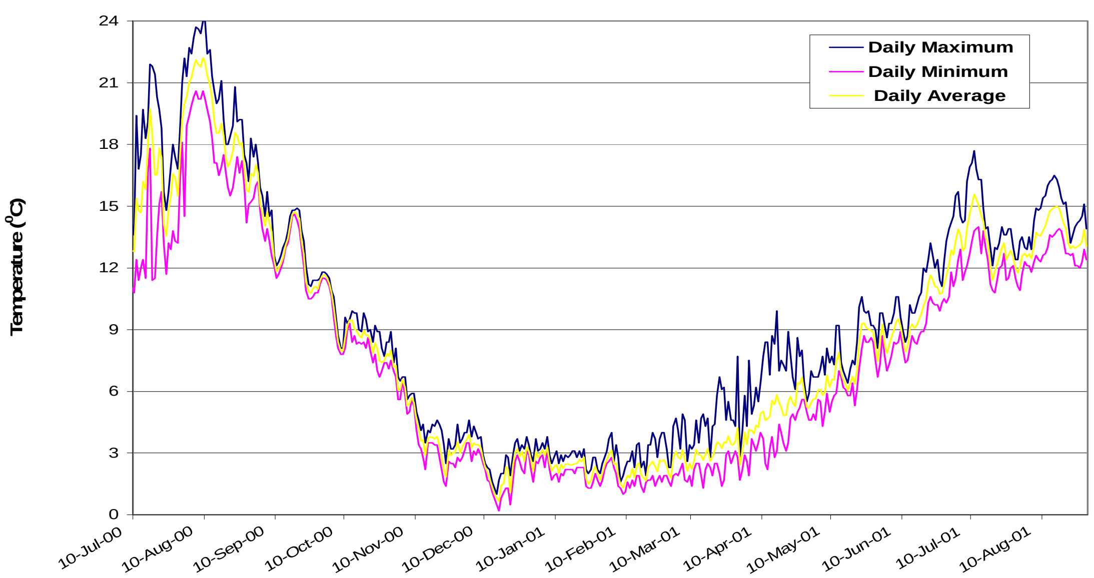

Figure 5. Daily maximum, minimum and averaged water temperatures for Senn Creek Pond.

2.1.3 Teto Creek

Teto Creek confluences with Eagle River on the right bank adjacent to Yard Creek (south of Malakwa) and has been impacted by significant flooding with consequent bedload deposition in some areas, streambed erosion and re-alignment. The Creek exhibits limited spawning and rearing habitat and supports a small coho escapement. A velocity barrier restricts fish passage to upper reaches. An adjacent beaver pond fed by groundwater had been isolated due to bedload deposition, although it did support some rearing coho.

One thermograph was placed in mainstem Teto Creek at the Baxter Road crossing and one in the isolated, off-channel beaver pond. The temperature study was initiated in July 5, 2000 (Figure 6). Temperature data for the beaver pond is appended.

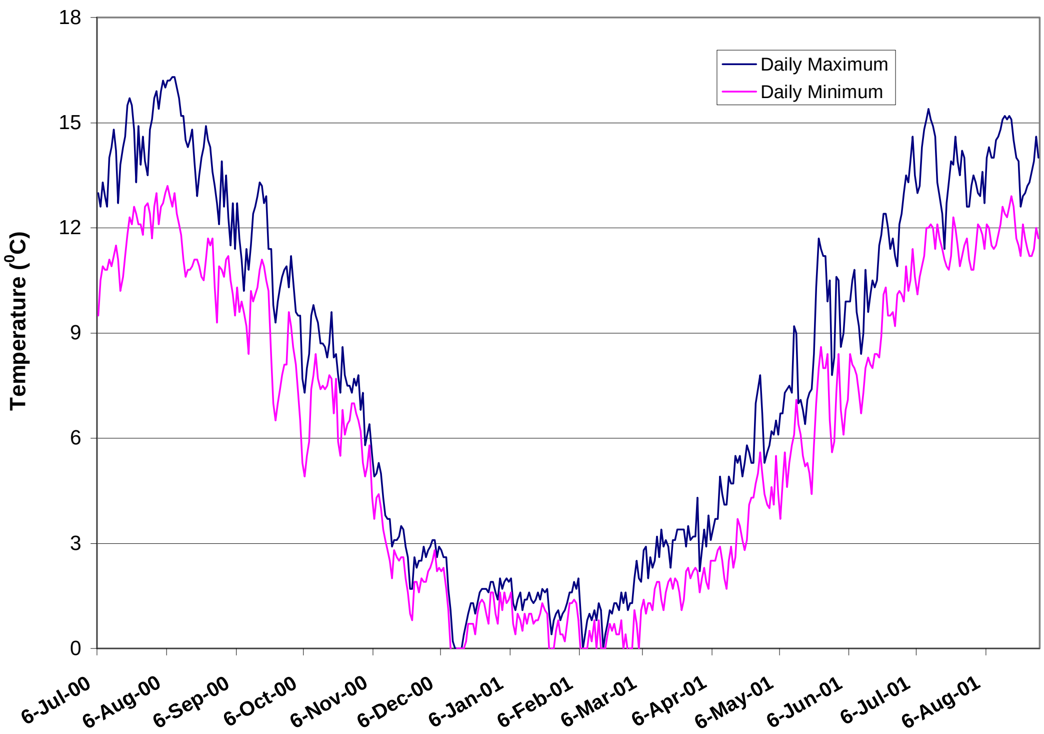

Figure 6. Daily maximum and minimum water temperatures for Teto Creek.

Subsequent fish habitat restoration consisted of expanding the existing beaver pond, constructing an impervious dike to ensure stability and permanency and establishing permanent inlet and outlet channels connecting to Teto Creek. The channels were designed to also provide spawning and rearing habitat.

2.1.4 Ylisto Oxbow

The Ylisto Oxbow is located adjacent to but isolated from the mainstem Eagle River, 6 km Northeast of Sicamous. One thermograph was placed in the Ylisto Oxbow on July 5, 2000. Since that time, water quality monitoring of the Oxbow has indicated that dissolved oxygen levels are relatively low and that the dominant resident fish species is redside shiner (*Richardsonius balteatus*), with no known salmonid species present. Survey data indicates that a direct connection to Eagle River is not reasonably feasible. Consequently, there would appear limited opportunity for habitat restoration of Ylisto Oxbow. The thermograph was downloaded and removed September 2000.

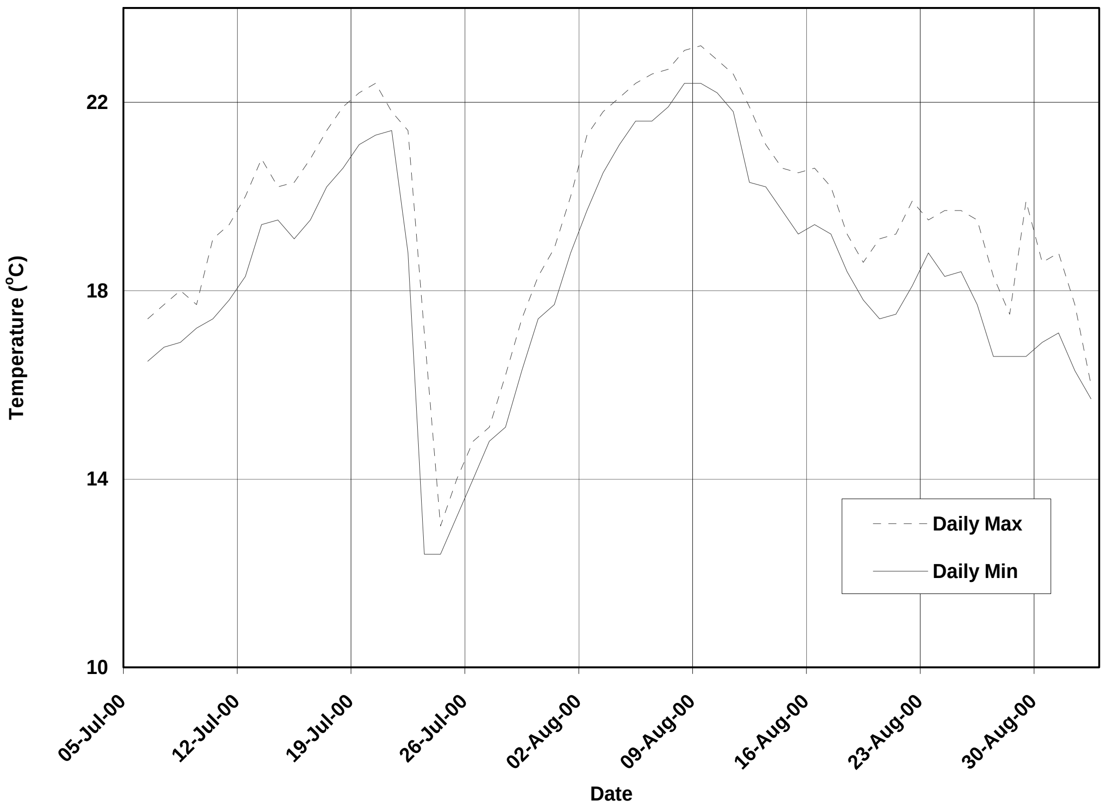

Figure 7. Daily maximum and minimum temperatures in Ylisto Oxbow.

2.1.5 Eagle River Oxbow

A number of remnant oxbows exist adjacent to the Eagle River. This particular oxbow is located approximately one kilometer upstream of the Teto Creek project and was monitored to determine its potential for possible off-channel groundwater restoration. Due to existing program commitments at the time, no restoration work was pursued. Temperature data for the oxbow pond and outlets are included in the attached appendix (compact disc).

2.2 Adams River

Adams River is renowned for its production of sockeye salmon, but it is also an important river for endangered Interior Fraser coho. In addition, the Adams watershed supports pink and chinook salmon, kokanee, rainbow and bull trout (including early reports of dolly varden), rocky mountain whitefish, sculpins, and various species of cyprinids (DFO 1986). The mainstem of the Lower Adams is 11 km long and this lower watershed covers an area of 3,323 km², 18 percent of which has been logged with a small percentage used for agriculture.

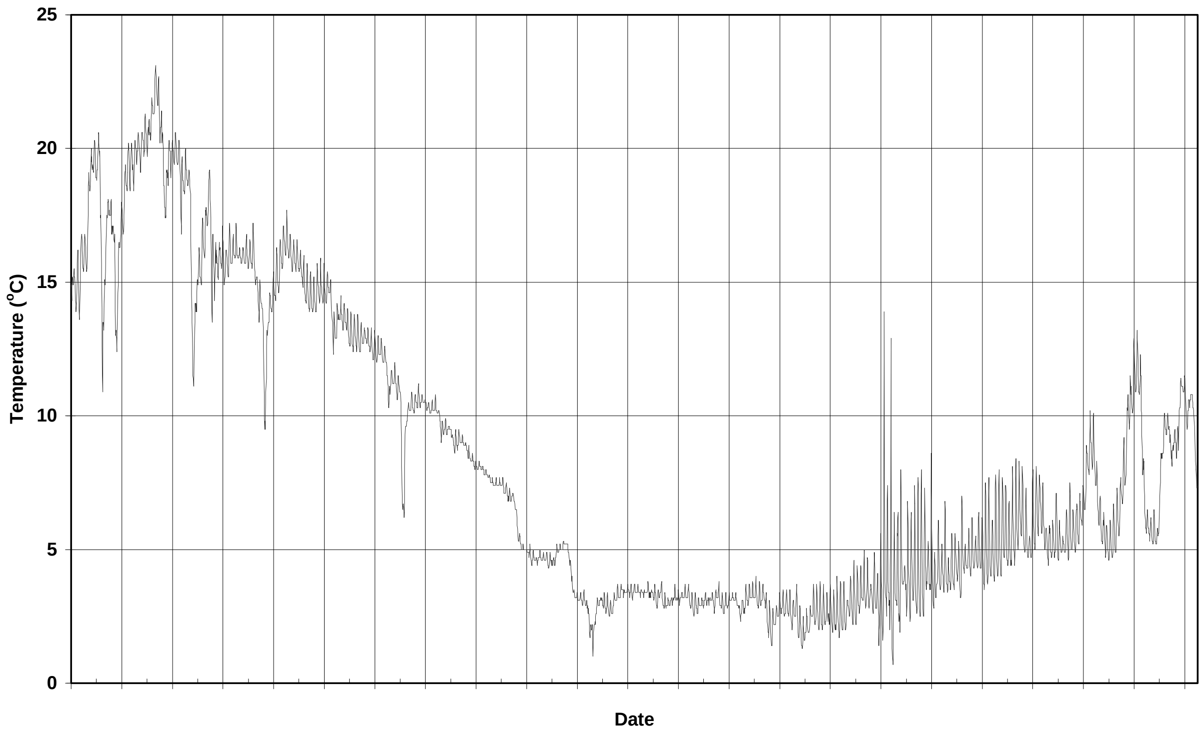

Figure 8. Recorded temperatures for Adams River from July14, 2000 to June 13, 2001 (in 6 month gridline increments).

2.2.1 Cottonwood Channel

In 1990, the 980 m Cottonwood Channel was constructed in an old flood channel adjacent to Adams River within the Roderick Haig-Brown Park. This channel is entirely fed by a good source of groundwater and confluences with a branch of the Adams River into Shuswap Lake. Little in-channel habitat complexing was incorporated during initial construction. To increase salmonid rearing habitat quality and productivity and groundwater infiltration, a number of in-channel improvements were undertaken during 1996, including the creation of side-pools, planting, installation of undercut banks and placement of woody material. Natural channel erosion and movement of the Adams River subsequently necessitated the excavation of a new outlet for the Cottonwood Channel into Shuswap Lake in 2001. This outlet included side-pools and complexing with whole trees, stumps and large rocks. The channel has supported exceedingly large numbers of rearing and spawning salmonids, including coho salmon, and exhibits exceptional productivity due, in part, to nutrient-rich groundwater buffered from high flows and temperatures.

In 1997, three thermographs were installed in the channel (upper head pond, mid-channel and end-channel) and one in mainstem Adams River. However, all but the pond thermograph were lost due to flood and vandalism. Data for the pond thermograph are shown in Figure 9. During summer 2000, two more thermographs were installed, one in mainstem Adams River and one mid-channel (also destroyed by vandalism). Data for mainstem Adams River is shown in Figure 8 above.

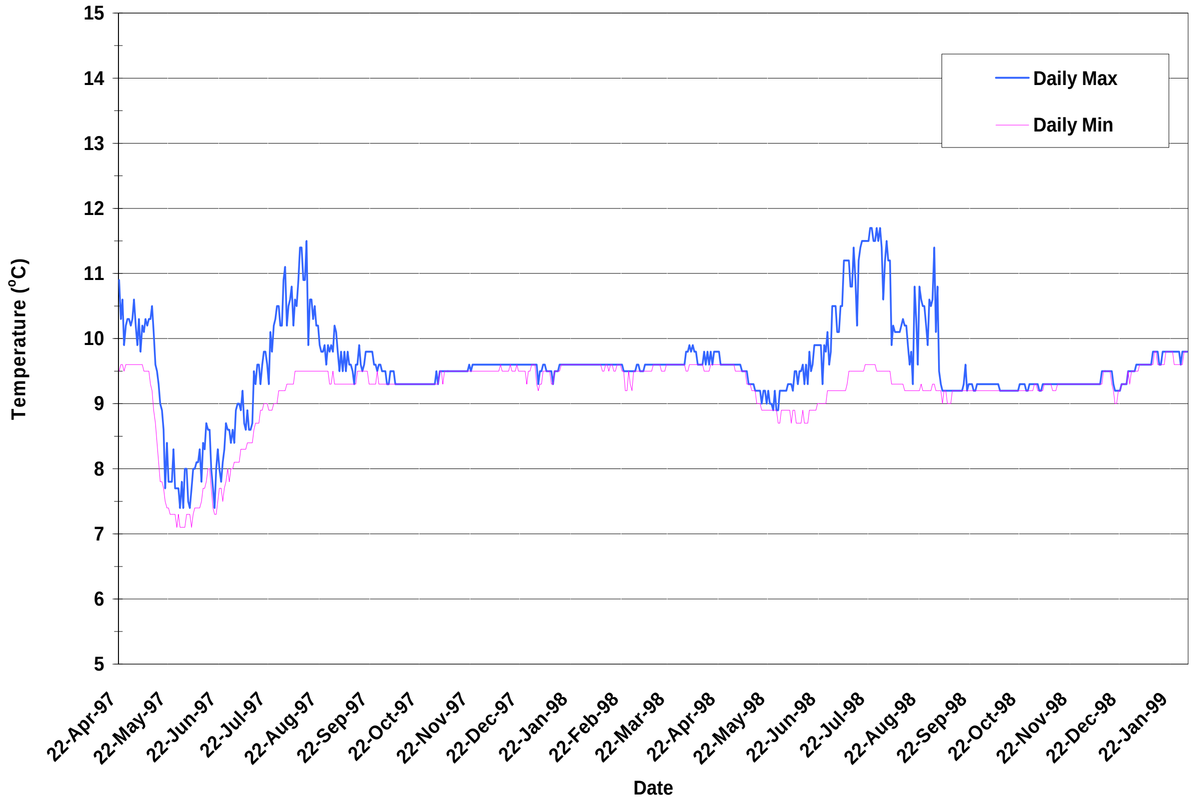

Figure 9. Daily maximum and minimum temperatures of Cottonwood Groundwater Channel Pond from April 22, 1997 to February 22, 1999

The Cottonwood Channel is totally groundwater-fed, which is reflected by the relative stability of seasonal temperatures and small daily variability compared to mainstem Adams River (Figure 8). Unfortunately, direct comparison of temperatures between mainstem and Channel cannot be made due to thermograph loss and consequent non-overlapping periods of temperature recording.

2.3 Little River

Little River, near Squilax, is 3 km long and connects main Shuswap and Little Shuswap Lakes. Little River was chosen as a study location to assess the potential for off-channel fish habitat restoration opportunities within a backwater floodplain on First Nation land. On August 20, 1999, one thermograph was placed in mainstem Little River and one each in eastern and western portions of the floodplain. All thermographs were removed on March 22, 2000. Extreme temperature fluctuations in the eastern portion of the floodplain indicate the thermograph was most likely out of water and recording air temperatures during certain times (Figure 10).

The floodplain exhibited widely fluctuating temperatures which at times were within the ranges considered lethal to salmonids. Even mainstem Little River exhibited high temperatures, but only periodically (total of 10 hours) compared to a much longer period for the floodplain. These potentially lethal temperatures and the possibility of stranding, in part, resulted in abandonment of plans for any salmonid habitat restoration in this area.

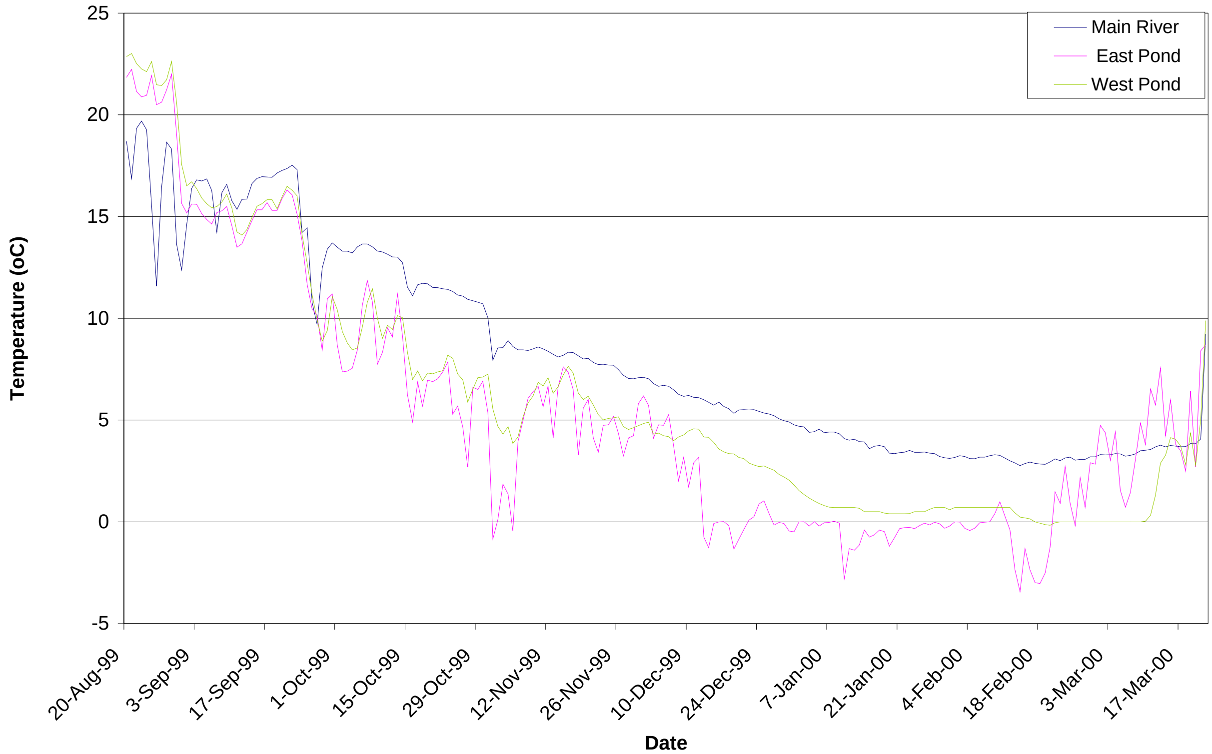

Figure 10. Daily averaged temperatures in Little River and adjacent floodplain ponds.

2.4 Lower Shuswap River

Lower Shuswap River extends for 64 km between Mabel and Mara Lakes and exhibits impacts from forestry practices, agricultural activities and urban development (eg. channelization, loss of riparian vegetation and increased bank erosion). Lower Shuswap River has been known to reach temperatures as high as 25 °C (Nener and Wernick 1998). Riparian impacts instigated fish habitat restoration efforts.

2.4.1 Dale Channel

Dale Channel is 1100 m in length and located on private property approximately 22 km east of Enderby. Dale Channel is a combined surface-groundwater channel consisting of both new excavation and old floodplain channel, which originally lacked continuous flow and had restricted fish access. Habitat restoration work within the channel complex in 2001 was directed primarily at improving salmonid rearing conditions and provides stable year-round flow, complexed habitat and created wetland/marsh. Habitat complexing consists of woody debris, rock, undercut banks, pool and riffle habitats. The adjacent riparian area was fenced to exclude livestock and planted with native species. The main species of focus was coho salmon, but other species of salmonids such as chinook, sockeye, kokanee and rainbow trout will likely also benefit. Sampling prior to channel development indicated the presence of juvenile sockeye, as well as numerous juvenile rainbow trout.

In January 2000, one thermograph was placed in a side channel of mainstem Lower Shuswap River and, on August 12, 2000, two thermographs were placed at two locations in the lower portions of Dale Channel. Thermographs were removed during construction in 2001.

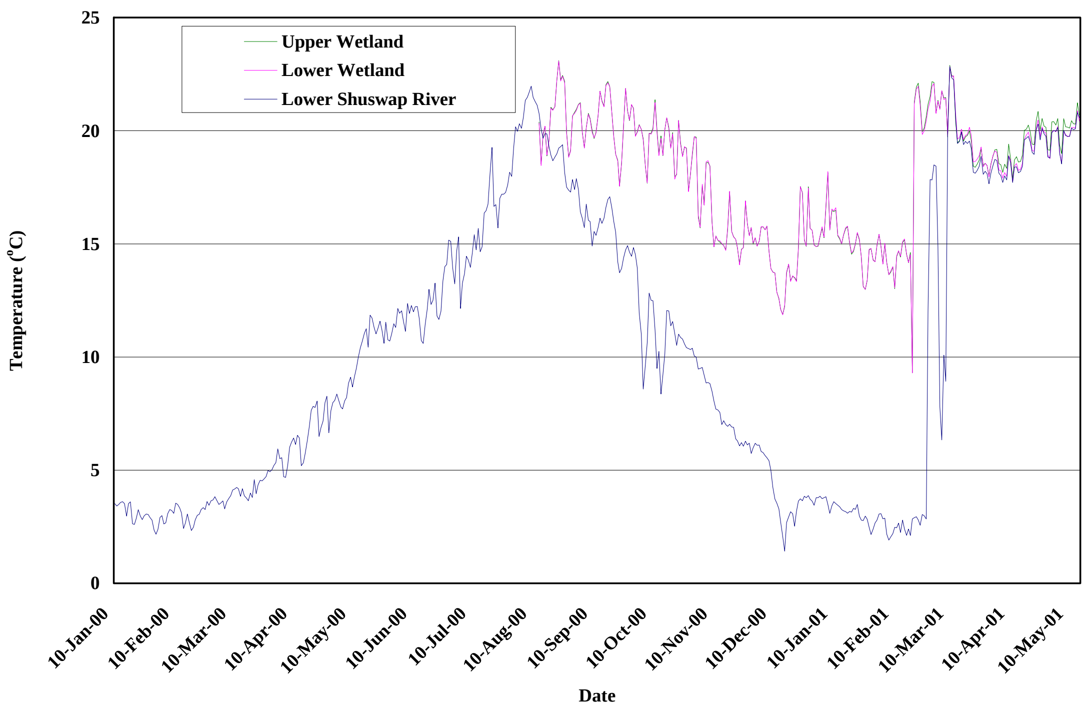

Figure 11. Daily averaged temperatures of Dale Channel wetlands and Lower Shuswap River from January 10, 2000 to May 10, 2001 (pre-restoration).

The temperatures for the two wetlands are virtually identical for most of the period of record (Aug. 13/00 to May 10/01) and, therefore, appear as one colour (pink). The warmer temperatures recorded for the wetlands up to early March/01 strongly suggests a buffering effect by groundwater. The highly variable recordings in early March/01 appear to be affected by air temperatures likely caused by reduced water levels.

2.5 Middle Shuswap River

Mainstem Middle Shuswap River between Mabel and Sugar Lakes is 76.1 km in length. Two dams are located within the Middle Shuswap River system; Wilsey Dam generation facility at Shuswap Falls about 30 km upstream of Mabel Lake and Peers Dam, a water impoundment structure at the outlet of Sugar Dam at Brenda Falls. Chinook, coho and sockeye (historically also pink) salmon, as well as bull trout, kokanee, adfluvial Mabel Lake rainbow trout, whitefish and numerous cyprinids presently spawn and rear in the system. Both dams are presently impassable to fish. However, there is some historic information suggesting chinook, and possibly also sockeye, may have successfully negotiated Shuswap Falls before dam construction in 1929 and spawned in upstream reaches.

Considerable habitat restoration has been undertaken on the mainstem below Shuswap Falls with a focus on coho salmon, although chinook, kokanee and rainbow also extensively utilize these restored habitats. Restoration has consisted of the development of four significant off-channel surface and groundwater-fed spawning and rearing channels and numerous riparian stabilization projects. In addition, the strategic enhancement program at Shuswap Falls hatchery releases coho and chinook to the mainstem and tributaries.

Mainstem river temperatures were recorded coincident with monitoring the Lang and Maltman off-channels. In the summer of 1998 and 2000, temperatures in the Middle Shuswap River reached levels considered critical for juvenile salmon. These data reiterate the importance of groundwater-fed off-channels for rearing habitat, particularly during hot summer months. The mainstem thermograph was moved about one kilometre upstream in the summer of 2000.

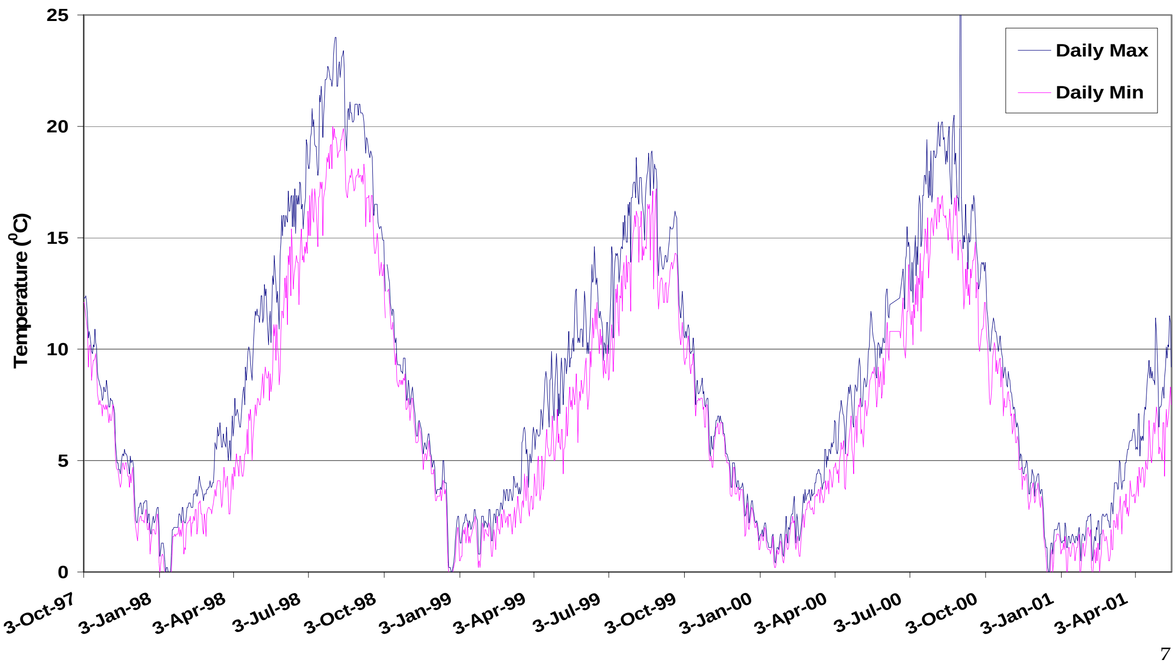

Figure 12. Middle Shuswap River daily maximum and minimum temperatures for the period 1997-2001.

2.5.1 Bessette Creek

Gradient obstructions, flood and low flow issues, temperature fluctuations and degradation of water quality, riparian vegetation and streambank stability have impacted the quality and quantity of fish habitat available in the Bessette system. The literature indicates that the overall loss of freshwater habitat has contributed to declines in salmon stocks (Smith and Gilden 2000, Bradford and Irvine 2000). In response, fish habitat restoration efforts have focused on the development of off-channel habitats to mitigate impacts of land use on the decline of salmon habitat and stocks. Evidence indicates side-channels can be more productive for rearing juvenile salmon than mainstem habitats (Nickelson et al. 1992). Off-channel areas have also been recognised specifically as valuable for juvenile over-wintering habitat (Bustard and Narver 1975, Nickelson et al. 1992).

Bessette Creek begins in Lumby with the confluence of its two major tributaries, Duteau and Harris Creeks. From Lumby, Bessette flows approximately 38 km northeast and confluences with the Middle Shuswap River approx. 2 km downstream of Wilsey Dam. Chinook, coho, rainbow trout and occasionally sockeye use Bessette Creek and tributaries for both rearing and spawning habitat. The majority of chinook, coho and rainbow spawning is located upstream of Lumby in Duteau Creek. Numerous riparian stabilization, planting, fencing and habitat restoration projects have been undertaken on mainstem Bessette Creek. No thermographs were deployed in Bessette Creek.

2.5.2 Duteau Creek

The portion of Duteau Creek accessible to migratory salmonids extends for about 10 km upstream of Lumby to Whitevale Road bridge. Lawson Creek, the largest tributary to Duteau Creek, has a portion of its flow diverted into Ruechel Channel, which is a very productive, restored groundwater-fed off-channel. The lower reaches of Duteau Creek is low gradient and meandering with several beaver dams. Duteau Creek is flow regulated, with storage within Grizzly Swamp (DFO presently holds water storage rights for minimum flow augmentation). Regulated flow fluctuations and minimum releases have impacted fish stocks severely. Coho, chinook and adfluvial Mabel Lake rainbow trout spawn above Lumby to Whitevale Road bridge.

Temperature recordings were initiated for Duteau Creek in 1997. The thermograph was located downstream of the CN Railway Bridge. There is a gap in data from March 1999 to June 2000 because thermograph memory was exceeded before downloading. Temperatures in Duteau Creek during the hot summer months of July and August reached critical levels for juvenile salmon. This data reiterates the importance of cool refuge habitat for juvenile salmonids.

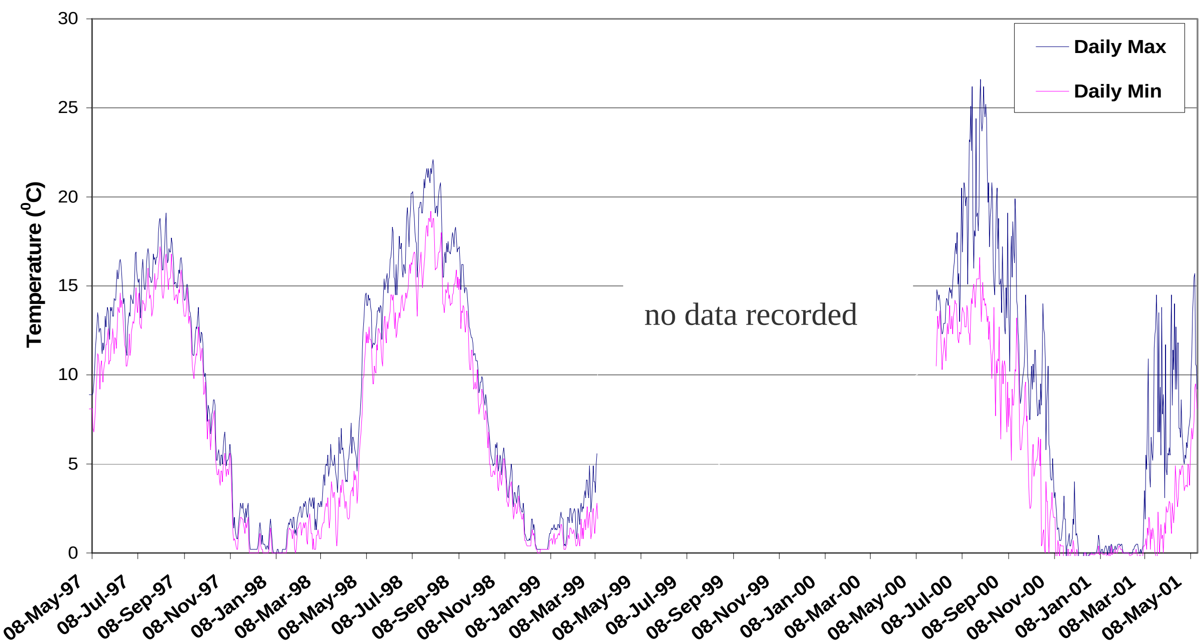

Figure 13. Daily maximum and minimum temperatures for Duteau Creek.

2.5.2.1 Ruechel Channel

Ruechel Channel was constructed in the mid-1990s with the primary goal of providing stable, off-channel spawning and rearing habitat for coho. A portion of Lawson Creek flow, controlled by a weir, was diverted into an excavated channel along the CN right-of-way and into Duteau Creek. Ruechel Channel was complexed using a variety of boulders, anchored woody debris, concrete undercut banks and excavated pools. Set-back fencing and two designated livestock watering sites provide protection and allow riparian growth. All disturbed areas along Ruechel Channel were seeded and planted with native tree and shrub species. Based on juvenile coho sampling data, Reuchel channel is exceptionally productive.

In May 1997, one thermograph was placed at the upstream end of the excavated Ruechel Channel and one near the artesian upwelling in the upper reach of Lawson Creek (some subsequent data from the Channel was lost when a beaver dam was removed). Temperature recordings provide an indication of the beneficial buffering effect of groundwater, compared to mainstem Duteau Creek. Comparison of thermograph data and Figures 13 and 14 show temperatures during summer months in Ruechel Channel to be consistently lower than mainstem Duteau Creek. During winter months, temperatures are generally higher in Ruechel Channel than in Duteau Creek, suggesting comparatively better rearing conditions for juvenile salmon. Walthers and Nener (2000) indicate an optimum temperature range for juvenile salmon rearing between 8 °C and 15 °C.

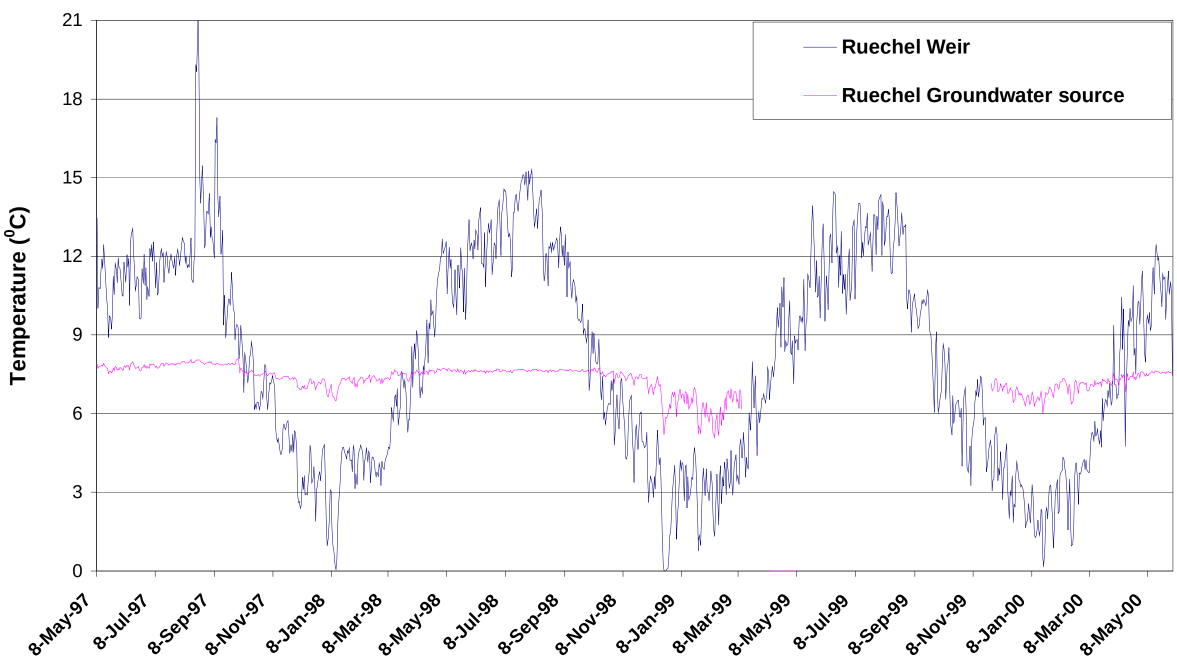

Figure 14. Daily averaged temperatures for Ruechel Channel (lower-end of channel at diversion weir) and upper groundwater source.

The above figures provide excellent examples of the difference in temperatures that can be exhibited by groundwater-fed sources compared to mainstem surface waters. The groundwater source for Reuchel Channel (pink line) is very consistent (between 5-8 °C) compared to mainstem Duteau Creek. Even at the lower reaches of Reuchel Channel approx. 4 km downstream of the groundwater source, temperatures are buffered (ie. cooler in the summer and warmer in the winter) compared to mainstem Duteau. This temperature buffering effect is one of the major benefits of groundwater-fed off-channels that contribute to their inherent biological productivity, particularly in temperature sensitive watersheds. Some of the largest coho smolts within the watershed were sampled in this off-channel.

2.5.3 Harris Creek

Harris Creek (also referred to as Bessette Creek upstream of Lumby) is the second main tributary which confluences to form Bessette Creek in Lumby and has a mainstem length of 31.8 km. It is unregulated and has the following tributaries: Creighton, Blue Springs, Beetle, McCauly, West Harris, Home, and Fish Creeks. Harris Creek has a moderate to high gradient above Lumby and a cascade (gradient barrier) obstructs fish migration at 18.1 km. The stream has also been reported to flow subsurface at 5 km. Salmonid utilization is generally limited, compared to Duteau. Logging, urban development, siltation, high bedload movement and loss of riparian vegetation and stability has contributed to reduced productivity.

One thermograph was installed in Harris Creek upstream of the Whitevale Road bridge in June 1997. There is a gap in data from April 1999 to June 2000 because thermograph memory was exceeded before downloading. Temperatures in Harris Creek reached critical levels in July and August.

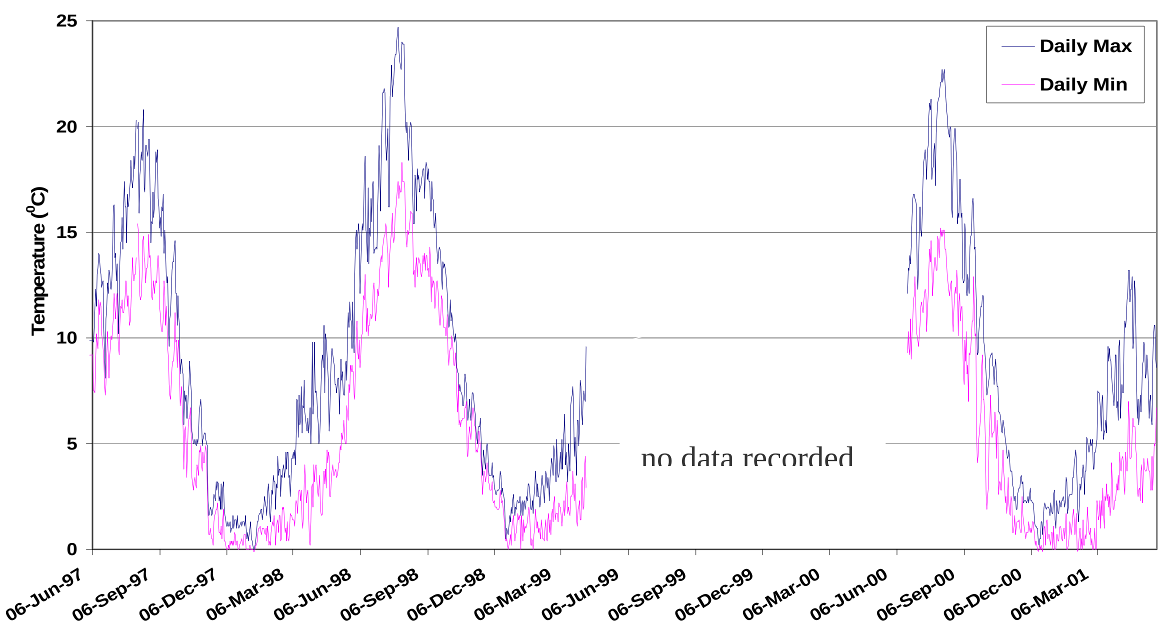

Figure 15. Harris Creek daily maximum and minimum temperatures for June 1997-May 2001 (no records for April 1999 to June 20, 2000).

2.5.3.1 Creighton Creek

Creighton Creek (tributary to Harris Creek) is 30.7 km long and has a low to moderate gradient. Two historically impassable irrigation weirs are located 0.8 km upstream (opened in 1984 to allow fish passage) and 4.1 km upstream (remains impassable at the time of writing). Low summer flows limit spawning and rearing potential. One enhancement project on tributary Teal Creek (see below) was designed to improve summer and winter rearing habitat and groundwater supply.

The temperature study on Creighton Creek started in September 1998. One thermograph was placed in the lower reaches of Creighton Creek. Daily maximum temperatures in July, August and September are approaching levels critical to juvenile salmon.

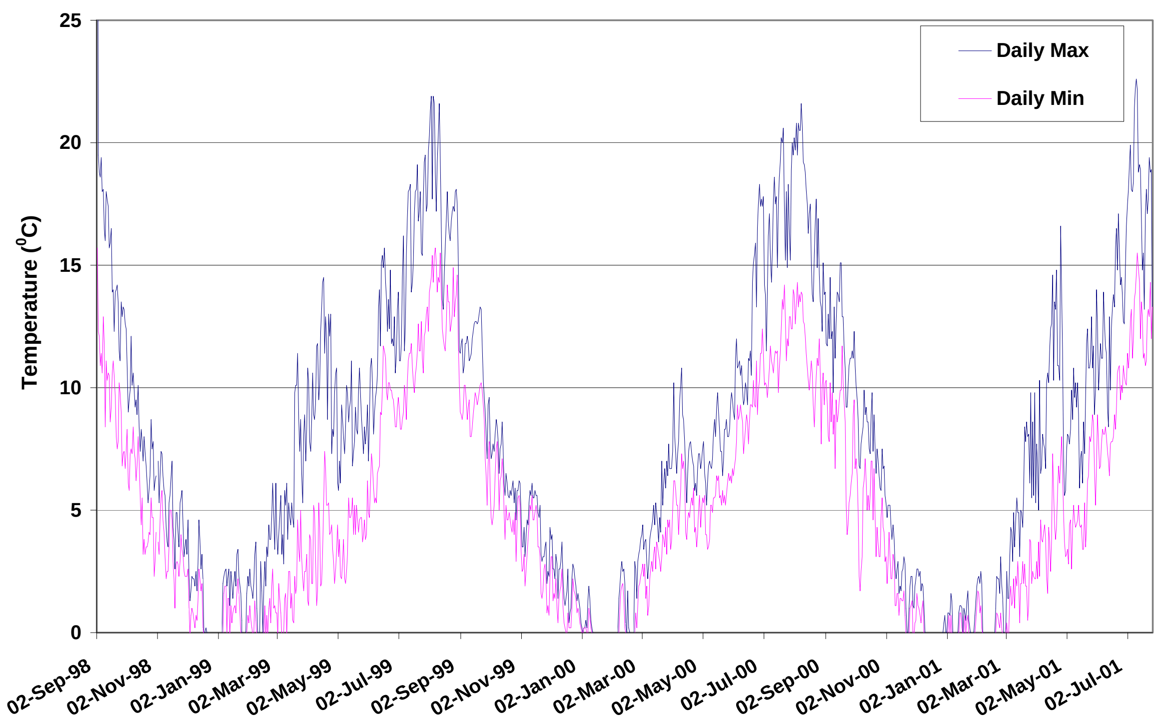

Figure 16. Daily maximum and minimum temperatures for Creighton Creek from September 1998 to July 2001.

2.5.3.2 Teal Creek

Teal Creek (local name) is a small groundwater-fed watercourse (actually an excavated ditch draining a marshy area) which flows into the lower reaches of Creighton Creek. Teal Creek is 2.1 km long and includes approximately 5.9 ha of wetlands and ponds. Assessment of Teal Creek indicated that coho juveniles were utilizing the system for rearing and over-wintering habitat. Temperature data was collected to identify the potential of this significant groundwater source for increased juvenile salmonid rearing.

One thermograph was placed in the lower section of Teal Creek in July 1998 prior to enhancement work. A second was installed in the upper portion in June 2000. Extreme daily fluctuations were initially recorded, however, burial of the thermograph in bottom sediment likely resulted in the reduced fluctuations in daily maximum and minimum temperatures recorded from 1998 to 2000.

In fall 2000 and spring 2001, 1.3 km on both sides of Teal Creek were fenced and planted with rooted stock and cottonwood whips. Possible future work to modify water temperatures, improve water quality and extend the use of the channel by juvenile salmonids would include the addition of a culvert allowing fish passage, excavation to provide more groundwater flow and addition of woody debris.

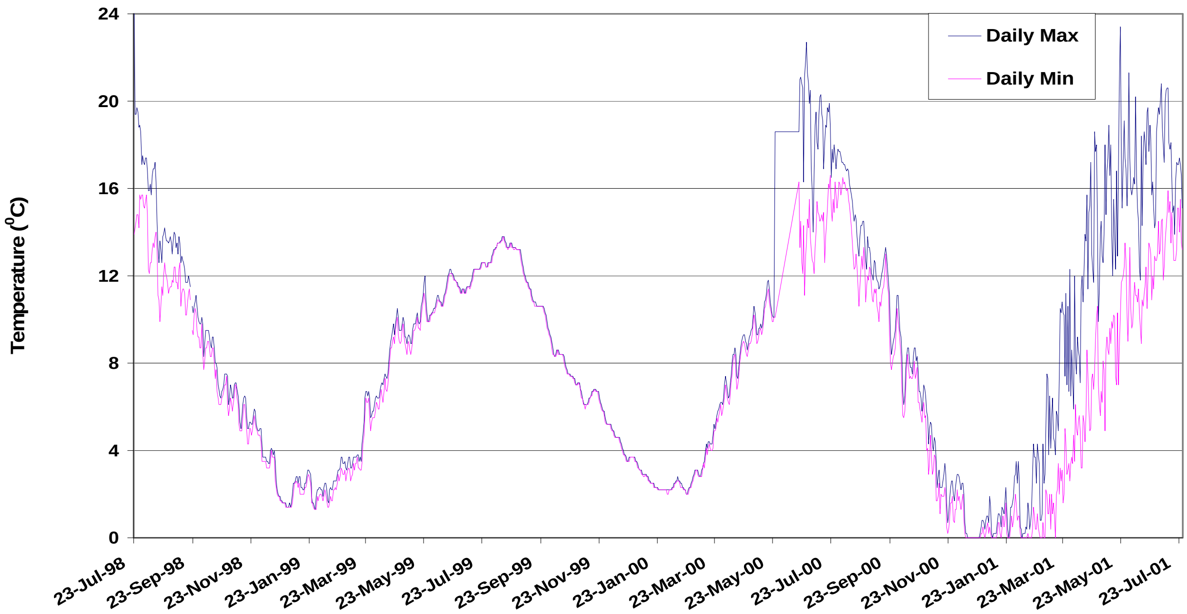

Figure 17. Daily maximum and minimum temperatures for lower Teal Creek from July 1998 to July 2001. Thermograph burial in sediment likely caused the much reduced temperature fluctuations between late 1998 and early 2000.

It was hoped that Teal Creek may provide critical cooling water flows to Creighton and Harris Creeks, particularly during hot summer months. However, it would appear a beneficial buffering influence on temperatures by groundwater is minimal.

2.5.3.3 Brett Creek

Brett Creek is a 4 km long ephemeral, groundwater-fed tributary which originates above Whitevale Road and flows into Harris Creek opposite the Bell Pole property. Low dissolved oxygen levels due to nutrient loading and low, intermittent flows are the major problems associated with Brett Creek. Channel complexing, excavation of rearing ponds, re-grading, re-alignment, riparian fencing and planting were undertaken in an attempt to improve the quantity and quality of flows into Harris Creek and, possible also to enhance fish habitat. Although there was significant attraction of juvenile salmonids observed at the outlet of Brett Creek into Harris Creek, continued poor water quantity and quality severely limit the salmonid rearing potential and utilization in this Creek.

In June 1997, three thermographs were placed at fairly equal distances (upstream to downstream) along Brett Creek and one in a groundwater (test) pit adjacent to Harris Creek. Data is limited due to loss of two thermographs post-1998. Upstream sites exhibited lower average daily temperatures but daily maxima for the middle site (and test pit) reached temperatures lethal to juvenile salmon.

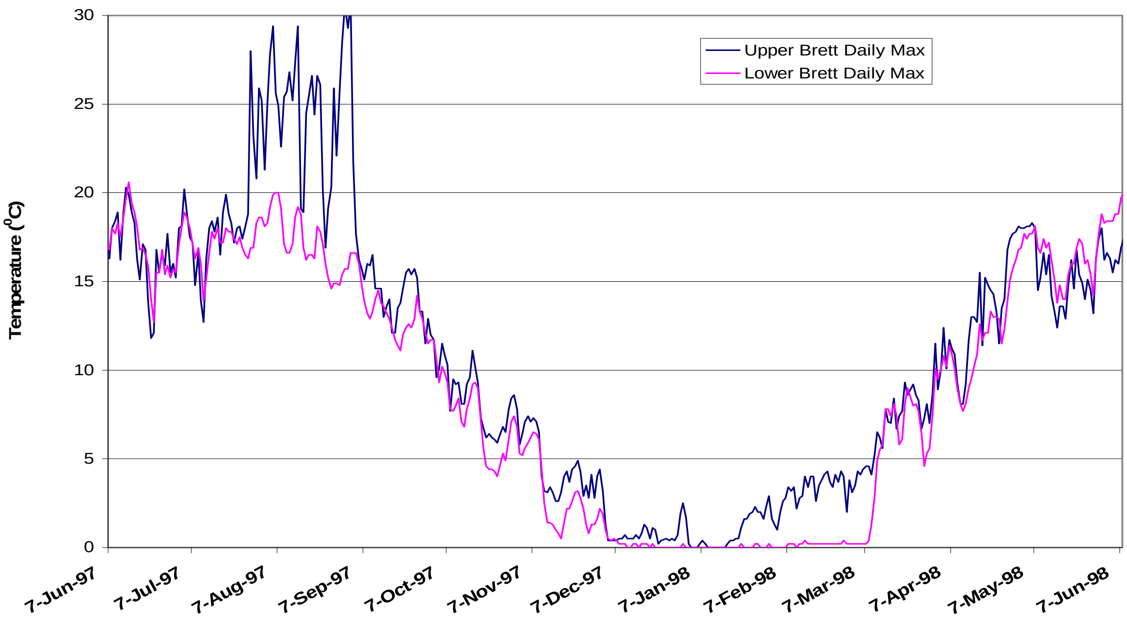

Figure 18. Comparison of the daily maximum temperatures for Brett Creek.

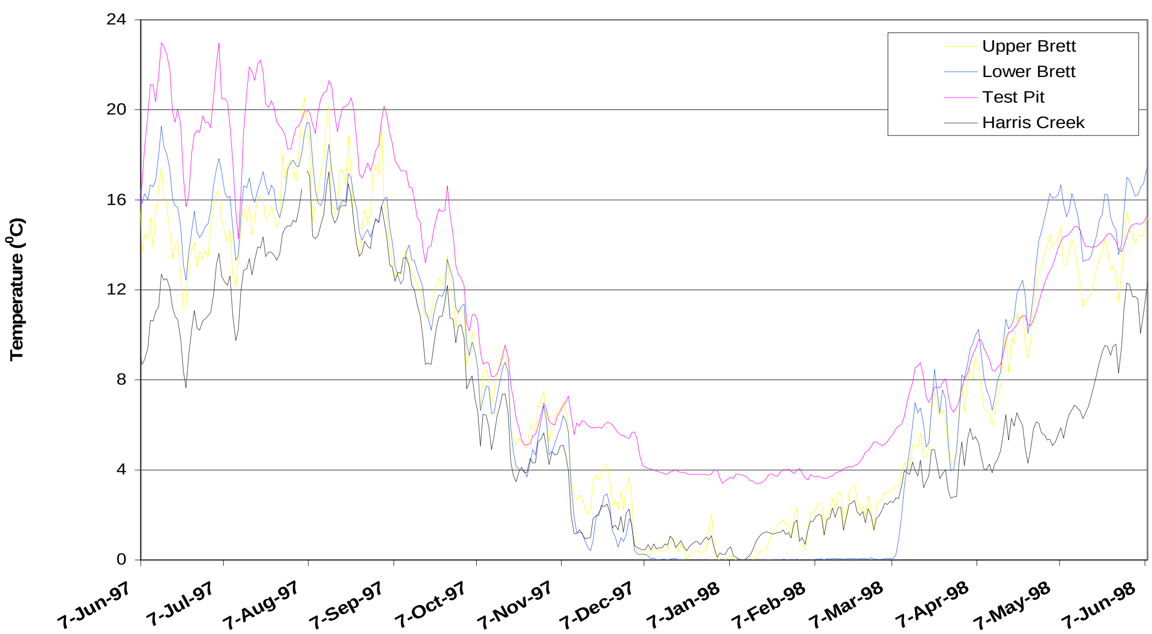

Figure 19. Comparison of the averaged daily temperatures for upper and lower Brett Creek, groundwater test pit and mainstem Harris Creek.

2.5.4 Lang Channel

Lang Channel was built in 1996 along a series of disconnected flood channels adjacent to the Middle Shuswap River. The channel is located approx. 4 km downstream of Wilsey Dam, is surface and groundwater-fed and has a total length of 3.8 km. Channel improvements include additions of woody material and rocks, deep pools, riparian planting and fencing. In 1997, Lang Channel was damaged by major flooding of the Middle Shuswap River.

Temperatures in Lang Channel have been monitored for different periods of time at upper, middle and lower sites from April 1997 to February 1999. A thermograph was placed in mainstem Middle Shuswap River in May 1997 adjacent to Lang Channel for comparison purposes (see Figure 12).

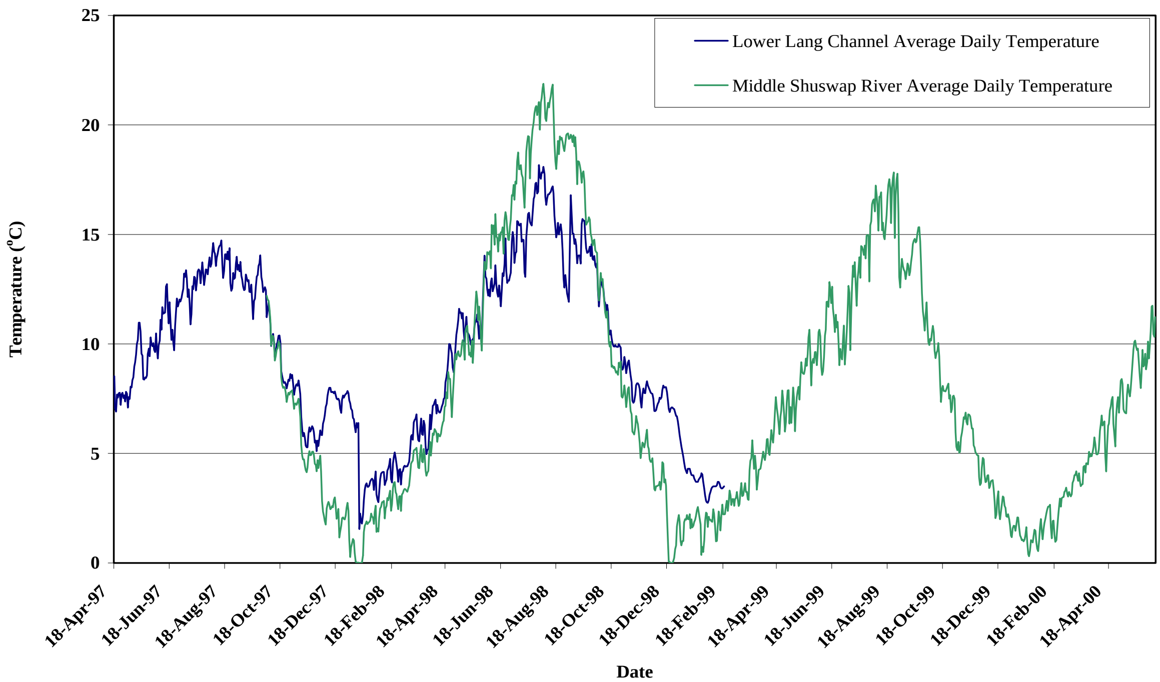

Figure 20. Daily averaged temperatures for Lang Channel (lower reach) and Middle Shuswap River from April 18, 1997 to June 8, 2000.

The influence of the partial groundwater infiltration in Lang Channel can be seen to some degree in the above figure (ie. somewhat cooler channel temperatures in summer and warmer temperatures in winter).

2.5.5 Maltman Channel

Maltman Channel was constructed in two phases; Phase I during November and December 1998 and Phase II during March and April 2001. The Channel was constructed with the primary goal of providing stable rearing and spawning habitat for coho salmon, with coincident use by chinook, kokanee and rainbow trout. Maltman (originally Whitehead) Channel was a historic side-channel of the Middle Shuswap River used for spawning and rearing but, due to mainstem bedload movement, the channel became isolated during all but flood flows.

Surface water input to Maltman Channel is controlled primarily by a regulated intake at the top end of Phase II, although groundwater infiltrates to varying degrees throughout and some surface water enters at the top end of Phase I. Phase I was constructed with a variety of different habitat complexing structures including deep refuge pools with woody material (root wads and large logs), straight gravel bottom runs and concrete undercut structures. Phase II extended the original off-channel to a total length of 1.3 km and involved the provision of a controlled, stable flow to an existing mud bottom side-channel. This phase was complexed by creating deep, rearing side pools and spawning habitat and by placing woody material. The different materials and techniques used to complex Maltman Channel created a diversity of habitats, water depths and flows important for the life cycle needs of salmonids. A dike was constructed to protect the channel from river flooding and erosion and the channel riparian area was seeded and re-planted.

Two thermographs were placed in the Phase I portion of Maltman Channel in June 1999, one in the groundwater pond and one at the road culvert near the downstream end. Figure 21 compares the temperature differences in the groundwater-fed section of Maltman Channel (pond thermograph) with the surface-fed section (culvert thermograph) and mainstem Middle Shuswap River. At least in 2000, there appears to be a clear groundwater influence. Temperatures in the groundwater-fed pond are generally higher in winter and lower in summer than those in the mainstem and in the mostly surface-fed portion of the channel. It would also appear that groundwater infiltration in Maltman Channel acts to buffer daily temperature fluctuations, since groundwater-fed pond temperature variations (and possibly also main channel temperatures) are visibly reduced. Accordingly, temperatures in Maltman Channel are likely more conducive to rearing salmonids than the mainstem Middle Shuswap River.

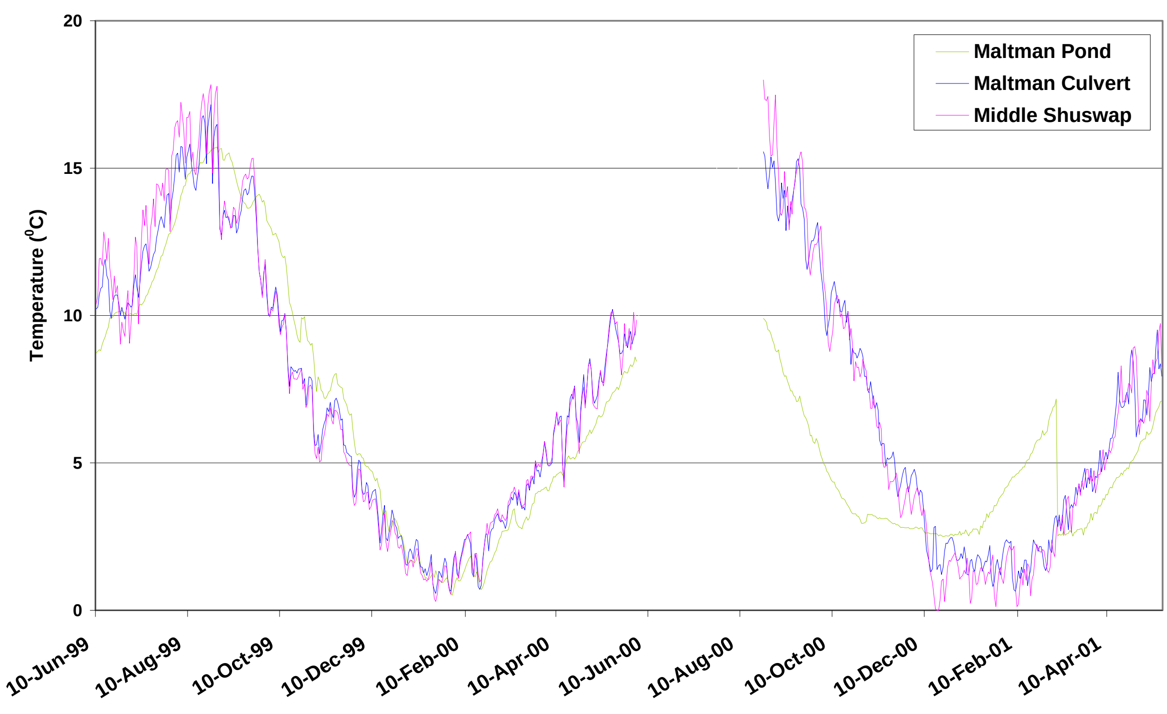

Figure 21. Comparison of daily averaged temperatures of the Middle Shuswap River, Maltman Pond (groundwater-fed) and lower Maltman culvert (lower portion of Channel with a combination of surface and groundwater) June 1999-April 2001

However, the buffering effects of groundwater infiltration in this channel appear varied and less pronounced, compared to the more evident influences in some other groundwater-fed channels. This may be due to the proximity of the groundwater-fed pond in the channel to the mainstem Middle Shuswap River.

2.6 North Thompson River

The North Thompson River is a large system which confluences with the South Thompson River at Kamloops. There is a fish migration impediment located about half-way between Avola and Blue River at Porte d'Enfor (aka. Little Hells Gate). Unstable canyon walls contribute large rock to the river which creates velocity barriers to upstream migrating coho salmon. A blasting project by DFO in the late 1990s was successful and increased passage through this site, depending upon river flows. Several fish species are distributed in the North Thompson River including coho, chinook, sockeye and pink salmon. Other fish species include whitefish, rainbow trout and bull trout, as well as dace, suckers, sculpin, chub, northern pike minnow and redside shiners. Thermographs were not located in the North Thompson River mainstem, but were placed in Albreda River, Dunn and Joseph Creeks and an off-channel pond located a few kilometres north of Avola within the TransMountain pipeline right-of-way.

2.6.1 Albreda River

Albreda River is 30.8 km long and flows into the North Thompson River at Gosnell. Dominion, Allan and Clemina Creeks are tributaries. The major spawning area for coho in Albreda River is downstream of Clemina Creek. Two unnamed streams North of Dominion Creek have been identified as important overwintering habitats. There are also groundwater-fed spawning channels on Clemina and Dora Creeks.

One thermograph was placed in Albreda River March 1998 and removed June 2000.

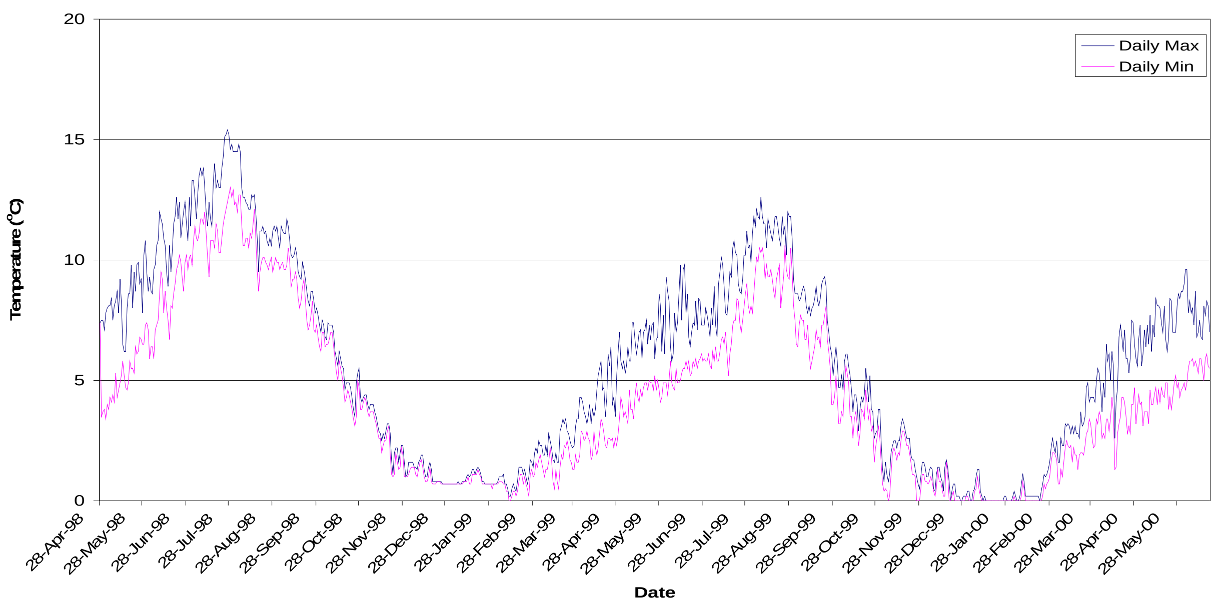

Figure 22. Daily maximum and minimum temperature recordings for Albreda River.

The reach of Albreda River in which thermographs were placed had observable groundwater upwelling. The relatively low maximum recorded temperatures shown in Figure 22 (ie. approx. 12-15 ºC) may in part be due to the buffering influence of groundwater.

2.6.2 Dunn Creek and Hatchery

The Dunn Creek hatchery is located at the confluence of Dunn and Joseph Creeks (aka. Boulder Creek) about 1 km downstream of Dunn Lake. Despite construction delays due to water supply problems, the hatchery became functional in the late 1990s as a brood stock collection and rearing facility for coho salmon from Dunn, Louis and Lemieux Creeks. Water supply is primarily from Dunn Creek, with cooling water from Joseph Creek, as required.

Figure 23. Daily maximum and minimum temperature recordings for Dunn Creek (hatchery intake temperatures).

2.6.3 Avola Creek and Pond

Avola Creek supports a surprisingly large escapement of coho salmon, given approximately 1.5 km available spawning and rearing habitat and historic impacts from riparian vegetation removal, channelization and pollution. The Creek flows into Avola Pond, which is located adjacent to the confluence with the North Thompson River and historically was used as a log sort and booming area for a local forest company. With mill closure and demolition in the 1970s, a portion of the vacant property was used to enhance the rearing and spawning habitat of the system. Restoration work in Avola Pond included the creation of artificial islands, undercut banks, large woody material and spawning gravel. An outlet channel which flows around a pond elevation control dike was also constructed. The pond measures 480m long and 30m wide. The area was planted with native species.

A thermograph was placed in Avola Pond from January 25, 1999 to June 20, 2000. Over the 17-month study period, temperatures fluctuated over twenty two degrees, reaching a maximum of 22.1 °C on February 2, 1999 and a minimum of -0.3 °C during most of February. Over a single 24-hour period, temperatures fluctuated over 15 degrees on February 4, 1999. Temperatures remained steady, with no variation within a single 24-hour period occurring for one day in October 1999, four dates in November 1999, and for much of December 1999 and January to March 2000. [Editor's note: temperature data and related figures for Avola Creek and Pond could not be located]

2.6.4 TransMountain Pipeline Right-of-Way Pond

A relatively large groundwater-fed pond complex which drains under Highway 5 into the North Thompson River several kilometres north of Avola was monitored to determine if water temperatures were suitable for juvenile salmonids. The overall objective was to assess whether the pond could potentially be developed to support rearing juvenile salmonids, particularly coho, from the North Thompson.

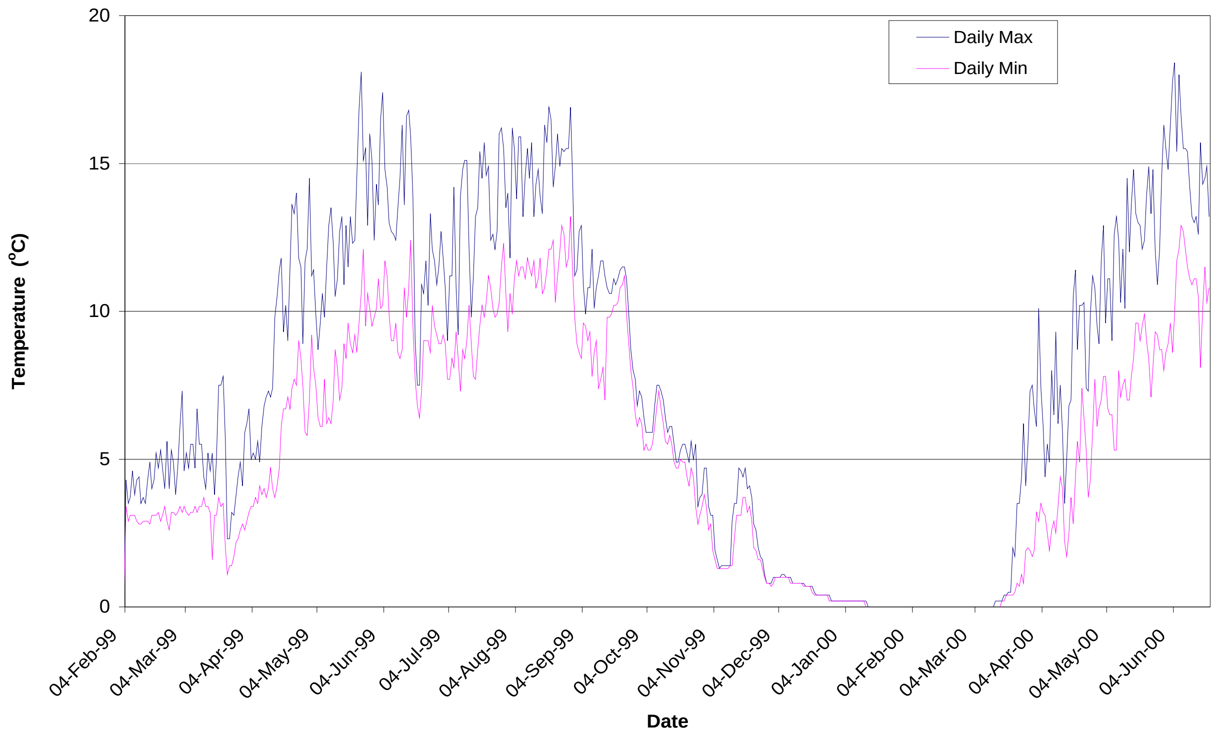

Figure 24. Daily maximum and minimum temperatures for a groundwater-fed pond within the TransMountain Pipeline Right-of-Way.

Although water temperatures shown in the above figure appear encouraging, the pond outlet posed a significant passage impediment to juvenile salmonids from the North Thompson and, accordingly, no habitat restoration activity was considered for this pond system.

2.7 South Thompson River

In summer 2000, a preliminary assessment study was undertaken on one of the very few remaining back-channels of the South Thompson River floodplain in the Dallas area east of Kamloops. Lower portions of this back-channel are presently watered for at most three months starting around mid-May during spring freshet. The objective of this study was to undertake a preliminary evaluation of temperature, dissolved oxygen, physical parameters, invertebrates and utilization by rearing salmonid juveniles. This preliminary information would be used to evaluate the potential for developing this off-channel so it could be utilized by rearing and downstream migrating salmonids for a longer period of time.

The following three figures show some temperature profiles obtained during this study.

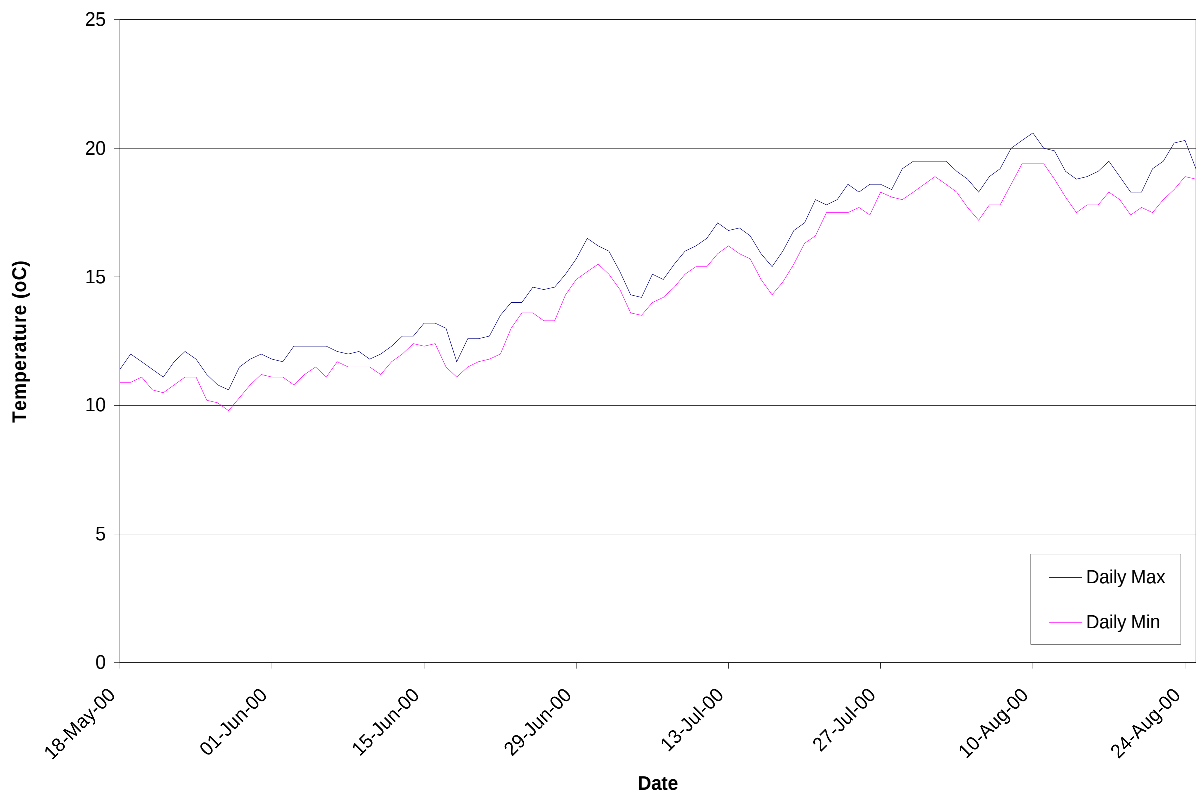

Figure 25. Daily maximum and minimum temperatures for the South Thompson River at Dallas (thermograph placed at a depth of about 1 metre).

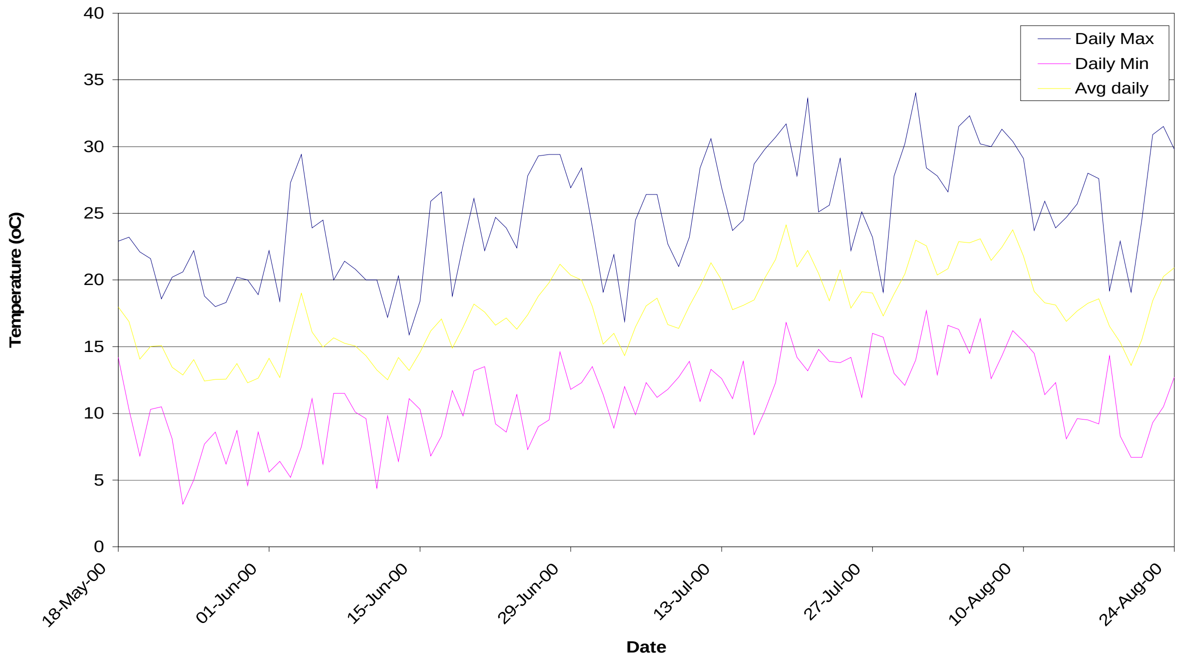

Figure 26. Daily maximum, minimum and averaged water temperatures for the middle portion of the back-channel.

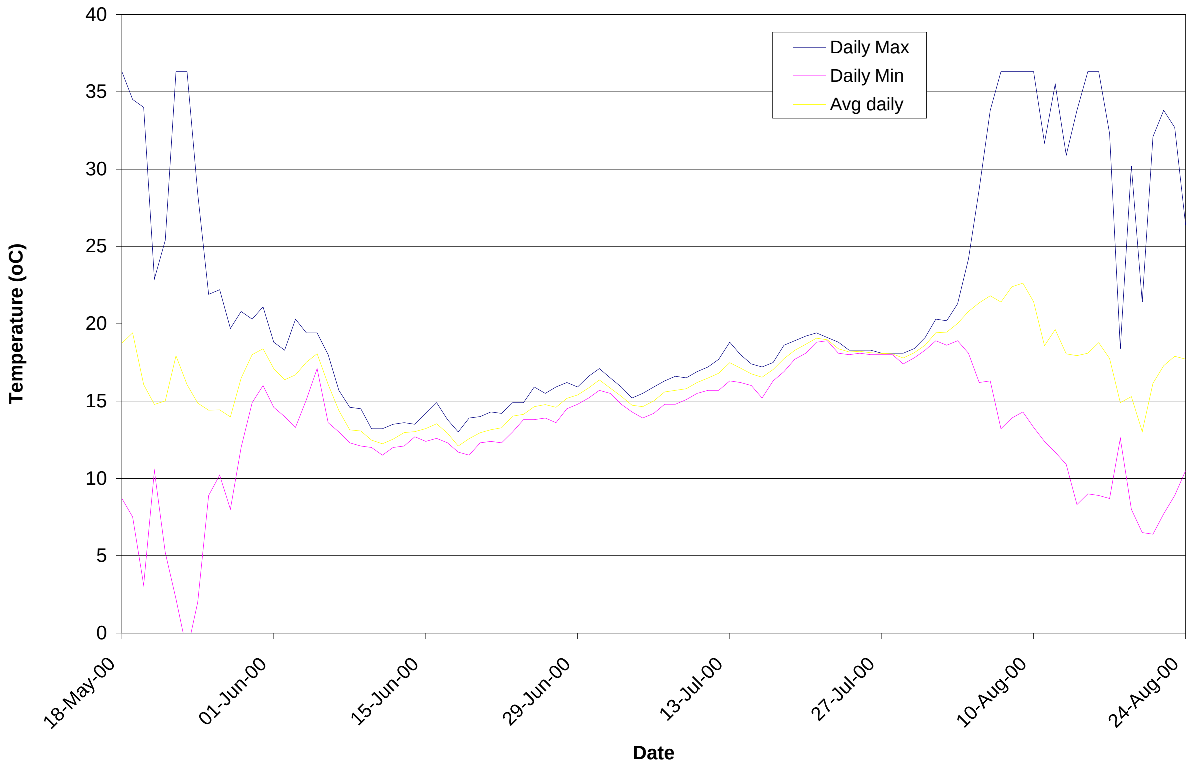

Figure 27. Daily maximum, minimum and averaged water temperatures for the upper portion of the back-channel (initial and end recordings represent no water or minimal water depths (ie. virtually air temperatures) since this upper portion of the back-channel was not significantly flooded until the beginning of June and dewatered in early August).

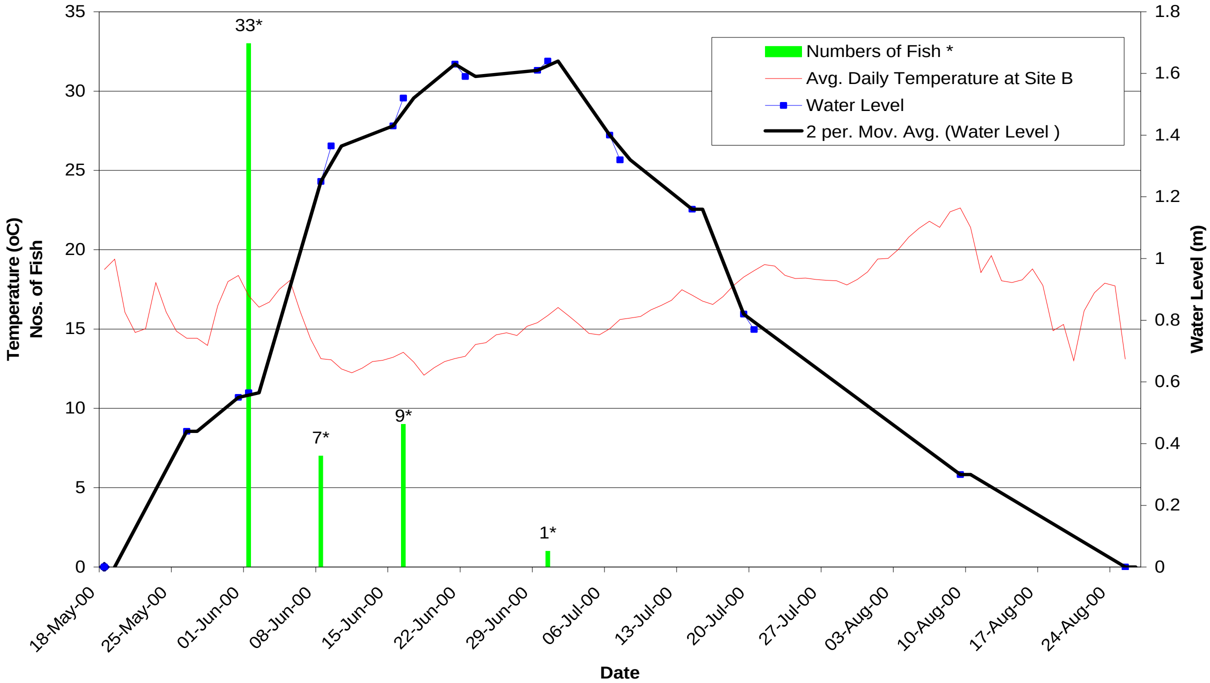

Figure 28. Daily averaged temperatures, fish numbers and water levels (averaged) for a site in the upper portion of the back-channel.

* it can be assumed that "fish numbers" represent composite salmonids. Fish trapping was undertaken through the use of baited GEE traps over a 24 hr. period and represent relative presence only (no attempt was make to estimate total numbers of salmonids utilizing the back-channel (ie. no mark-recapture techniques were used)).

In consideration of the results of this preliminary study and the importance of this habitat to waterfowl and other wildlife in its present state, it was concluded that development of this back-channel to enhance juvenile salmonid rearing habitat adjacent to the mainstem South Thompson River was not a realistic or beneficial option.

3.0 Summary

The primary purpose of this data report is to make available to habitat practitioners summary and detailed temperature data collected on several watercourses and associated habitat restoration projects in the Southern B.C. Interior. A number of systems were chosen for this study based on the presence of important coho salmon stocks and of impacts on habitat components, including low flow conditions, which can severely limit productive capacity. Of particular interest in this temperature monitoring study was the comparison of water temperatures between mainstem and groundwater-fed off-channel habitats.

Groundwater-fed habitats have been constructed within a number of watersheds (eg. Middle Shuswap River) which have been subjected to mainstem habitat impacts, such as riparian vegetation loss, streambank and benthic instability, low flows, sudden water level changes, instream habitat loss and high water temperatures. Groundwater-fed off-channels can provide stable water temperatures and flow and protected habitat for salmonids and, consequently, can be highly productive, particularly for rearing coho.

The magnitude of this temperature buffering effect is clearly demonstrated in Figure 14 for the Reuchel Channel, which is totally groundwater-fed. The groundwater at source is very constant but, at the lower end of the channel (weir site), although still buffered, water temperatures begin to resemble the daily and seasonal fluctuations characteristic of the mainstem of Duteau Creek. This buffering effect varies with site, as can be seen in the totally groundwater-fed Teal Creek (Figure 16). This is a tributary to Creighton (and Harris) Creek and exhibits daily and seasonal fluctuations similar to larger mainstem systems.

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