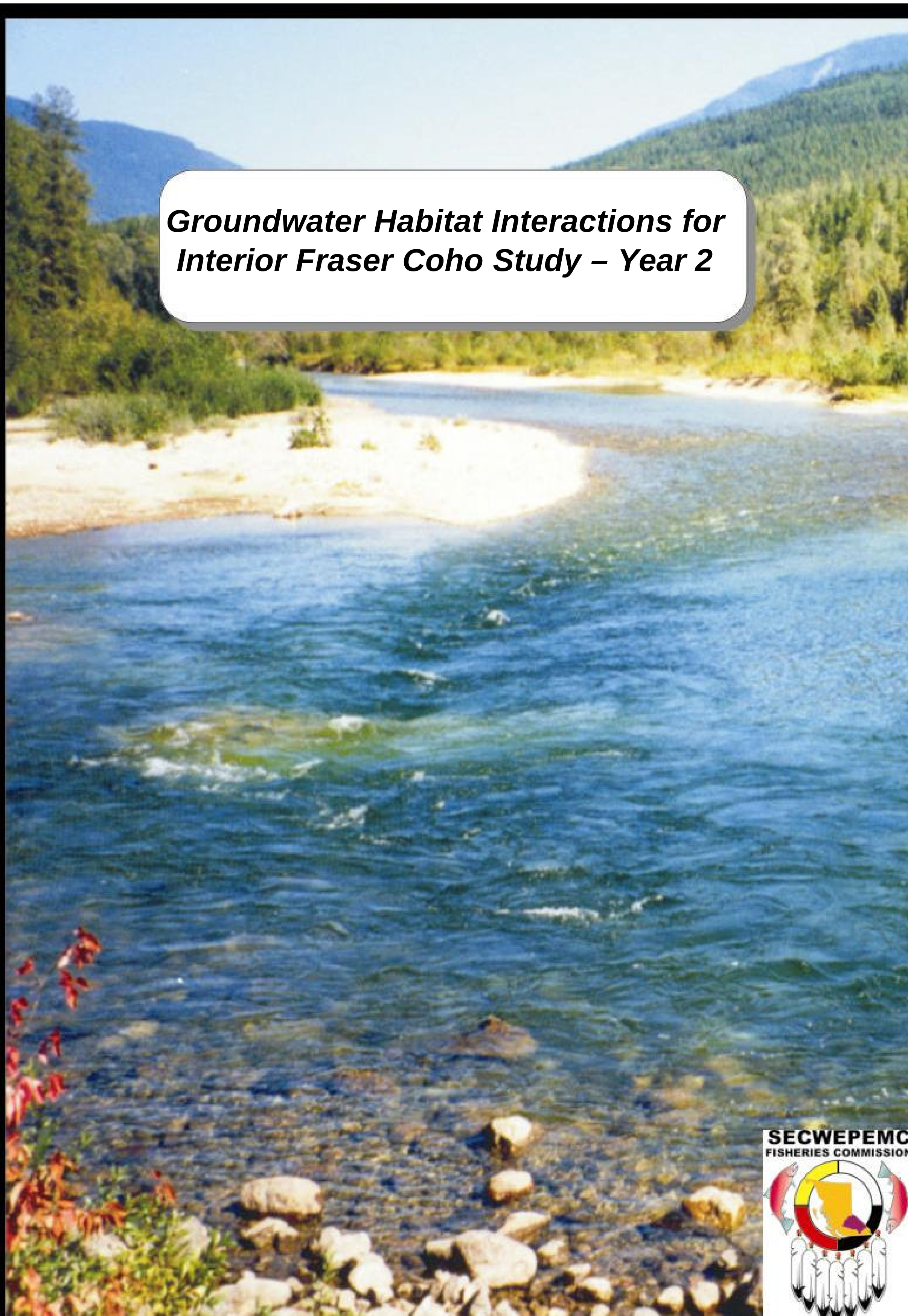
Groundwater Habitat Interactions for Interior Fraser Coho Study – Year 2



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Groundwater Habitat Interactions for Interior Fraser Coho Study – Year 2

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INTRODUCTION

PROJECT BACKGROUND

The Fraser River is the largest river in BC with the portion upstream of the Fraser canyon, known as the interior Fraser, constituting most of the drainage basin (COSEWIC 2002). The Interior Fraser supports significant populations of endangered Coho salmon (*Oncorhynchus kisutch)* as designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and their future continues to be uncertain. These interior Fraser Coho (IFC) are genetically distinct and the 5 major basins constitute 5 local populations: Fraser canyon, upper Fraser, lower Thompson, North Thompson, and South Thompson (Irvine et al., 2001). Most IFC spend their first year in freshwater, live and grow in the coastal marine environment for approximately 1.5 years, and then return to their natal watersheds to spawn and die at 3 years of age (CSAS Science Advisory Report 2005/061). Juvenile IFC often colonize flooded habitats created by spring freshets and their densities are generally higher in pools than riffles, most frequently in streams with gradients less than 3% (CSAS 2005/061). Overall, little is known of the details of juvenile IFC life history and distribution as identified by the Interior Fraser Coho Recovery Team (2004) and thus little is known on what constitutes vital habitat.

Coho and other salmon increasingly face challenges to persist – let alone, thrive – in thermally-sensitive streams including those in the Nicola, Shuswap, [and Okanagan] basins (WWSS et al., 2009). Temperatures in many streams regularly approach and pass “critical temperature thresholds” for salmon. It is not unusual to get summer day time water temperatures in excess of 25°C which is lethal to salmon (SFU 2007). Some systems have extended night time water temperatures remaining as warm as 20°C. Given these extreme conditions groundwater upwellings, which have more stable temperatures compared to mainstem streams, likely serves a critical function by recharging some of these streams and producing cool water thermal refugia from warmer conditions in the surrounding area (Simon Fraser University 2007). This groundwater function may be more important in this area relative to other parts of the province.

Four First Nation groups have partnered with DFO to better understand important juvenile Coho habitat requirements for the Fraser Basin, specifically the importance of groundwater to juvenile IFC. The hypothesis is that in July after freshet, fish are able to make full use of their habitat, but in early August, when daytime water temperatures are on the rise, fish are able to use their habitat fully during the night, but have to rely on thermal refugia during the day. In mid to late August, when water temperatures reach their peak and dissolved oxygen levels drop, fish will have to rely on groundwater upwelling areas in the stream during both day *and* night to avoid lethal water temperatures. It is suspected that some of the study systems may not have effective thermal refugia due to extensive agricultural groundwater extraction. The absence of these thermal refugia could mean that fish in that particular reach are unable to survive high water temperatures in mid to late summer. Salmonids have been documented using coldwater patches elsewhere (Davis and Wright 2007 citing Ebersole, et al., 2001).

But just when we are learning about the critical importance of groundwater for salmon persistence, groundwater itself has never been under more of a threat (WWSS et al., 2009). BC's groundwater protection regulations are archaic and ineffective. Fish enjoy no "right" to water. Unchecked human population growth continues to place huge demand on our surface and groundwater resources-and thus more doubt on the future of salmon. Important groundwater reserves near critical Interior salmon-bearing streams are myopically coveted solely for human use. Furthermore, stream flow and thus water availability is expected to diminish further as the climate becomes more inhospitable (Watershed Watch Salmon Society, et. al. 2009).

PROJECT OBJECTIVES

Objective 1: Confirm the presence of groundwater upwelling sites previously identified in 2007 within tributaries of the Interior Fraser Basin; identify groundwater upwelling sites within the Deadman River.

Objective 2: Determine the presence and/or absence of seasonal and diel spatial distribution patterns of juvenile Coho salmon and its relationship to groundwater flow areas in tributaries of the Interior Fraser Basin.

Objective 3: Provide a coordinated science-based approach between First Nations and government agencies.

METHODS

STUDY AREA

The interior Fraser River system upstream of the Fraser canyon was chosen as the study area, with specific focus on streams that support valuable IFC populations and are suspected to be thermally challenging for IFC that rear during the arid summers. Streams included tributaries within the Thompson River and Quesnel River drainages. Thompson River drainage tributaries included: Bessette Creek (including tributaries: Duteau and Harris creeks), Nicola River (which includes its tributary Coldwater River), Louis Creek, and the Deadman River. The Quesnel River drainage tributary included McKinley Creek.

The Thompson River is the largest tributary of the Fraser River and drains 54 600km^2 of the mountainous southern interior of BC (Bradford and Irvine 2000). This area lies at the northern extent of the Interior Plateau physiographic region (Davis and Wright 2007). The Thompson Basin is an incredibly diverse region that ranges from diverse forest areas to sagebrush grasslands (Davis and Wright 2007 citing Reynoldson et al., 2005). Within the Thompson drainage area Coho salmon spawn in at least 40 streams and rivers.

The Quesnel River system in the mid Fraser River drains 440km^2 into the Horsefly River, a tributary of Quesnel Lake.

Seasonal flows within the study area are snow pack melt driven, with peak flows occurring from mid May to mid June and low flows throughout the summer and even more so in the fall and winter. The mean annual air temperature within the study area is 9.7°C with mean monthly temperature ranging from -2.3°C in January to 21.4°C in July and August (Davis and Wright 2007). In addition to Coho, the region supports many other salmonid species including rainbow trout (*O. mykiss*) and bull trout (*Salvelinus confluentus*), as well as Chinook salmon (*O. tshawytscha*), and sockeye salmon (*O. nerka*).

Within each stream, specific study sites consisted of groundwater upwelling areas accessible to Coho and an associated, or paired, non-groundwater or control site. Control sites were to be located approximately 20-50 m upstream within the mainstem, having a minimum and maximum length of 30 m and 50 m, respectively.

IDENTIFICATION OF GROUNDWATER UPWELLING AREAS

Surface water in streams is connected to groundwater found below ground in the spaces between particles of rock and soil, or in crevices or cracks in rock (The Green Lane, Environment Canada's World Wide Web site 2008). Thus groundwater supplies water to streams and maintains a portion of a stream's flow known as *baseflow*.

Technicians conducting ground-based surveys to identify groundwater upwelling sites in the Deadman River (Left: Avon Isnardy. Right: Bob Hewitt).

Groundwater upwelling areas were previously identified during the pilot project using forward looking thermal infrared (FLIR) imagery combined with ground-based surveys as described in Davis and Wright 2007). Again, in 2008 crews conducted ground-based surveys to confirm the presence of the groundwater sites and also focused on identifying new groundwater upwelling sites. Briefly, groundwater seepage was identified as being at least 2°C colder than the ambient temperature of the stream; new sites were documented using GPS as well as the outer boundaries of the field survey area. The crews documented: the coldest temperature within the groundwater patch, coldwater area of influence, type of groundwater seepage (e.g., lateral seep, tributary, side channel etc) and provided a general site description.

Thermocouple unit (left) and probe (right) used to measure stream temperatures

MONITORING STREAM TEMPERATURES

To document stream temperatures within the paired groundwater and control study sites throughout the study period, temperature loggers (HOBO U22 Water Temp Pro V2, Onset Computer Corporation) were installed within each. Detailed methodology is included in Davis and Wright (2007). Within the Deadman

River, two temperature loggers were installed at each site as opposed to one, but only one logger per site was used in the analysis.

The temperature loggers recorded hourly stream temperature for all study sites except McKinley Creek sites which were at 5 minute intervals and one study site within Louis which was recorded at half-hour intervals.

Temperature data for each study site was plotted over the study period time to depict general temperature trends and variability and are presented in Appendix 1. Trend lines were overlaid to show average daily (24hr) and weekly (168hr) temperature trends and to dampen the variability of the temperature data; 47hr trend lines were used for the site within Louis Creek that was recorded at half-hour intervals and 200hr trend lines were used for sites within McKinley Creek that were recorded at 5-minute intervals.

Technician Steve Jules installs a stake that will secure a temperature logger in Louis Creek.

Additionally, the average daily differences in temperatures between the paired control and groundwater sites were calculated (using control site temperature minus groundwater site temperature) and also plotted over time for each study site in each stream but was also calculated for all sites combined within a stream e.g., for entire Bessette Creek. This calculation allowed for a depiction of the amount of variation between paired sites within a 24 hour period and also for all sites within a stream within a 24 hour period. The standard deviation of these mean daily difference calculations was also plotted over time, to better understand the amount of 'spread' or variation of temperature readings around the mean daily temperature differences. Again, this was calculated for both the paired control and groundwater sites as well as combined for all paired sites within each stream. These temperature data are included in Appendix 2.

MONITORING FISH PRESENCE & ABSENCE

Paired groundwater and control study sites that were conducive to snorkel surveys were snorkelled from July to September to monitor fish presence and absence. Crews intended to focus snorkel surveys to one night per 3 time periods: pre-peak stream temperatures; peak stream temperatures; and post-peak stream temperatures. A selected number of study sites were surveyed per night. Surveys were conducted in the early evenings (i.e. 4pm) and throughout the night (i.e. until midnight) to coincide with both peak afternoon temperatures and cooler night temperatures. Thus each study site (groundwater and control) may have been surveyed 2 – 3 times per evening depending on the number of sites per tributary.

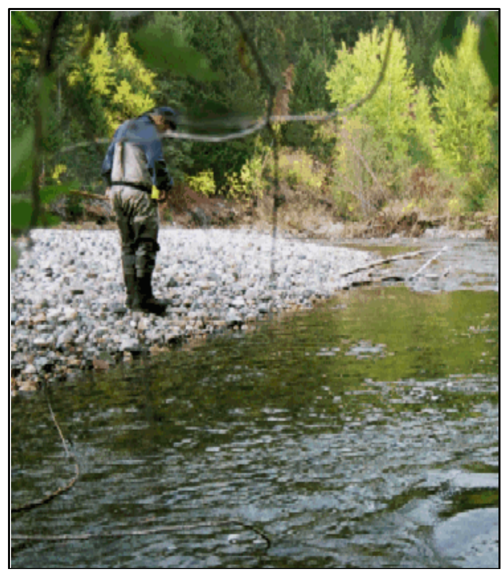
Standard snorkeling methods were used (see O'Neal 2007) and employed high-powered dive lights since the surveys were conducted at night.

Snorkel survey data collection consisted of: number of fish observed per species, general size categories, and behavioural observations where available.

The number of Coho observed per survey and per study site was plotted over time for ease of observing seasonal and diel spatial distribution patterns.

HABITAT DESCRIPTIONS

Baseline habitat descriptions were collected for all study sites surveyed for fish presence and absence to provide an indication that the paired study sites had similar habitats. Thus if more Coho were observed within the groundwater site we might safely say that it was not due to better habitat but rather its temperature influence. Crews recorded: habitat type, substrate, widths, depths, and riparian cover. Photos of each snorkel study site were also taken to document the habitat. Habitat descriptions per system are included in Appendix 4.



Technician collecting habitat characteristic data in the Nicola River.

Habitat descriptions were not collected for the Deadman River. Although habitat descriptions were provided for McKinley Creek they are not reported since snorkel survey data is not available.

RESULTS

IDENTIFICATION OF GROUNDWATER UPWELLING AREAS

In 2008, ground-based surveys were conducted in July to confirm the presence of last year's sites and also focused on identifying new groundwater upwelling sites. New sources were marked with a GPS coordinate in addition to the upper and lower boundaries of the surveyed area.

Approximately 3 to 4 study sites were identified per stream, for a total of 16 sites (Table 1).

Table 1 Summary of study sites per system and location

System	Groundwater Upwelling Site Name*	Paired Control Site Name*	Groundwater Site GPS Coordinate (UTM)	Site Description
Louis Creek	LC13.9juvgw	LC13.97juv	10U 0708552E 5657166N	
	LC16.25juvgw	LC16.25juv	Not Available	
	LC25.5juvgw	LC25.5juv	10U 0710450E 5645052N	
	LC15.6juvgw	LC15.67juv	10U 0707546E 5654051N	Zinc Mtn Road Bridge
Bessette Creek	BC9.65juvgw	BC9.65juv	11U 0361542E 5571381N	Near Vance Creek confluence
	DU4.77juvgw	DU4.77juv	11U 0356071E 5566271N	Duteau Creek, near Dure Meadow Road bridge
	HC1.92juvgw	HC1.92juv	11U 0359705E 5566662N	Harris Creek
Deadman River	DM25.5juvgw	DM25.4juv	10U 644322E 5648709N	Near Bob George property
	DM14.1juvgw	DM14.2juv	10U 643271E 5637151N	Near Dam
McKinley	Site 1	Site 1c	10U 631902E 579495N	

Creek	Site 2	Site 2c	10U 0631881E 5795015N	
	Site 3	Site 3c	10U631875E 5794855N	
Nicola System	NR21.73juvgw	NR21.65juv	10U 0637302E 5562924N	
	NR20.37juvgw	NR20.34bjuv	10U 0638219E 5561635N	Near Jimmy Fountain's creek
	NR18.6juvgw	NR18.54juv	10U 0639092E 5558860N	Near Nuaitch Creek confluence
	CW21.03juvgw	CW21.09juv	10U 0649108E 5534217N	Coldwater River; Eaton Beaton Site

** Site naming methodology is described in Davis and Wright, 2007.*

The majority of the groundwater upwellings are side channels and lateral seeps, with lesser amounts from tributary confluences. Most of the sites had small areas of coldwater influence (<1m^2) however the Deadman and Nicola rivers had relatively large areas of influence (20 – 100m^2). Although more groundwater sites have been identified, they were not conducive to snorkel surveys and thus were excluded from the report.

MONITORING STREAM TEMPERATURES

Temperature loggers were installed during the first week of July in most systems; however high waters and associated crew safety concerns within the Nicola River (including Coldwater River) delayed logger installation into the 3rd week in July. Loggers were removed by the first week in October. On average loggers recorded temperatures for an average period of 85 days, approximately 3 months.

Table 1 Summary of temperature loggers installed per stream system. Shaded boxes indicate that the sites were not included in the analysis.

System	Site Type	Site Name	UTM coordinate	Installed	Removed
Louis Creek	Control	LC0.2log1	10U 701065/5668703	4-Jul-08	8-Oct-08
	Control	LC7.9log6	10U 0706919/5662793	7-Jul-08	8-Oct-08
	Control	LC13.97log	10U 0708502/5657090	8-Jul-08	8-Oct-08

	Groundwater	LCGWLOG13.9	10U 0708552/5657166	7-Jul-08	8-Oct-08
	Control	LC15.67log	10U 0707517/5654024	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG15.6	10U 0707546/5654051	7-Jul-08	8-Oct-08
	Control	LC17.1log	10 U0707396/5653186	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG17.18	10 U0707520/5652963	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG16.92	10 U0707394/5653183	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG16.9	10U 0707394/5653183	8-Jul-08	8-Oct-08
	Control	LC26.67log	10U 0710475/5645002	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG25.6	10U 0710450/5645052	7-Jul-08	8-Oct-08
	Control	LC29.2log	11U 0289525/564598	7-Jul-08	8-Oct-08
	Groundwater	LCGWLOG29.02	11U 0289517/5641728	7-Jul-08	8-Oct-08
Bessette Creek	Control	BC8.16log	11u 0362885/5572471	3-Jul-08	30-Sep-08
	Groundwater	BC9.65juvGW	11u 0361542/5571381	3-Jul-08	30-Sep-08
	Control	BC9.65juv	11u 0361505/5571359	3-Jul-08	30-Sep-08
	Groundwater	DUT4.77GW	11u 0356071/5566271	3-Jul-08	2-Oct-08
	Control	DUT4.77LOG	11u 0356074/5566269	3-Jul-08	2-Oct-08
	Groundwater	HC1.92juvGW	11u 0359705/5566662	18-Jul-08	2-Oct-08
	Control	HC1.96LOG	11u 0359674/5566629	18-Jul-08	2-Oct-08
Deadman	Groundwater	DM 25.5GWjuv	10u 644322E 5648709N	18-Jul-08	1-Dec-08

	Control	DM25.4juv	10u 644 334 5648705	18-Jul-08	1-Dec-08
	Groundwater	DM14.1GWjuv	10u 643271E 5637151N	17-Jul-08	1-Dec-08
	Control	DM14.2	10u 643 287E 5637151N	17-Jul-08	30-Nov-08
	Control	DM14.2b	10u 643 287E 5637151N	17-Jul-08	30-Nov-08
Nicola River	Control	NR21.65log	10u 0637306E ?N	21-Jul-08	2-Oct-08
	Groundwater	NR21.71logGW	10u 0637302E 5562924N	21-Jul-08	2-Oct-08
	Control	NR20.34log	10u 0638228E 5561628N	21-Jul-08	N/A
	Control	NR20.34b log	Not Available	8-Aug-08	2-Oct-08
	Groundwater	NR20.37logGW	10u 0638211E 5561661N	21-Jul-08	2-Oct-08
	Control	NR18.54log	10u 0639120E 5558787N	29-Jul-08	2-Oct-08
	Groundwater	NR18.60logGW	10u 0639092E 5558860N	29-Jul-08	2-Oct-08
	Control	CW21.02log	10u 0649146/5534212	16-Jul-08	3-Oct-08
	Groundwater	CW21.03logGW	10u 0649108/5534217	16-Jul-08	3-Oct-08
McKinley Creek	Control	Site 1c	Not Available	7-Aug-08	21-Sep-08
	Groundwater	Site 1	10U631902/579495	7-Aug-08	21-Sep-08
	Control	Site 2c	Not Available	7-Aug-08	21-Sep-08
	Groundwater	Site 2	10U631881E 5795015N	7-Aug-08	21-Sep-08
	Control	Site 3c	Not Available	7-Aug-08	21-Sep-08
	Groundwater	Site 3	10U631875E 5794855N	7-Aug-08	21-Sep-08

For the purpose of comparing temperatures, loggers were installed within the groundwater source sites and the associated, or paired, non-groundwater (control) sites.

One logger within Nicola River (NR20.34log) was lost due to bank slumping and replaced with a new logger (NR20.34b log). Within the Nicola River tributary, known as the Coldwater River, the control site (CW21.02log) logger was dewatered upon retrieval, thus the data is unusable and comparisons with the groundwater site are also not possible.

Overall, temperature loggers were installed immediately prior to peak stream temperatures and/or during the peak of stream temperatures. Only Site 1 in McKinley Creek saw a typical bell-shaped temperature curve (Appendix 1: Figure 1w). All loggers were removed after the peak of temperatures.

Generally, control site stream temperatures in the Bessette and Deadman stream systems peaked earlier (mid-July to late August) by 2 – 3 weeks compared to the Nicola, Louis, and McKinley system (early August to late August) control sites. After peak stream temperatures, a gradual decline to lower levels was observed as expected.

(All temperature data per system and per groundwater and control sites is included in Appendix 1; Temperature comparison data within study sites is included in Appendix 2.)

Louis Creek:

Within Louis Creek, temperature loggers were installed prior to peak stream temperatures which was observed from August 6th – 20th however peak temperatures were not exaggerated and tended to be near the relatively stable pre-peak temperature values. Temperatures gradually declined after mid August. In contrast to the control sites, most of the associated groundwater site temperatures increased gradually and minimally over the monitoring period (sites LC13.97GWLOG and LC25.6GWLOG) but at one site (site LC15.6GWLOG) the groundwater temperatures mimicked the control site temperatures.

The groundwater sites (sites LC13.97GWLOG and LC25.6GWLOG) showed less variation among the daily maximum and minimum temperatures and were thus more stable, when compared to the control sites, again with the exception of site LC15.6GWLOG which was less stable. These differences are also reflected when plotting the daily mean differences between the control and groundwater site temperatures; in sites LC13.97 and LC25.6, the daily mean temperature differences show a decreasing trend over the study period, meaning that there is a larger difference between these paired control and groundwater temperatures at the beginning of the summer and as time goes on the control and groundwater site temperatures get closer and closer together. And because the temperature differences are always positive, it means that the control sites are always a higher temperature than the groundwater sites. In contrast, study site LC15.6 shows a relatively stable but tiny decreasing trend in the daily mean difference between the control and groundwater site over time, again proving that the temperatures recorded in this paired site almost mimicked each other in temperatures. The greatest difference was observed around August 16th.

Deadman River:

Within Deadman River, temperature loggers were installed within 2 paired sites during peak stream temperatures which were observed from approximately July 17th until August 21st. It is possible that other peak temperatures occurred before logger installation. Temperatures gradually declined after mid-August. Similarly, both of the associated groundwater site (sites DM14.1GWLOG and DM25.4GWLOG) temperatures decreased over the monitoring period and showed similar amounts of variation among the daily maximum and minimum temperatures when compared to the control sites.

When comparing the daily mean differences between the control and groundwater at site DM14.1, we see a decreasing trend over time that eventually reaches zero near the end of the study period, thus initially the control temperatures are warmer than the groundwater but over time these values get closer together until they are near equal. In contrast, the control and groundwater at site DM25.4 are very similar in temperatures throughout the monitoring; initially the differences in their mean daily temperatures are slightly negative with the control site slightly cooler than the groundwater by <1°C and nearing the end of the study period the control gradually gets warmer than the groundwater site by <1°C.

Nicola River:

Temperature loggers were installed in the Nicola River primarily before peak stream temperatures. Peak temperatures were observed from August 3rd to the 20th. Since one of the control temperature loggers was lost, the replacement logger (NR20.34bLOG) was not able to capture pre-peak temperatures. Temperatures gradually declined after the third week in August.

Groundwater site temperature trends were primarily similar to the control sites and also showed similar trends in variation (sites NR18.6 and NR20.3). In contrast, one groundwater site (NR21.7GWLOG) demonstrated immediate temperature declines over time and was less variable in the maximum and minimum daily temperatures (more stable) than its paired control site.

The daily mean temperature differences between the paired sites at NR18.6 and NR21.7 fluctuated over time, but generally increased over time until a 'peak' was observed in August and extended later for the latter site. After the peak, there was a generally decreasing trend in the paired site temperature differences as the paired site temperatures drew closer together. A large fluctuation in temperature differences occurred around September 6th when the paired sites had almost identical temperatures (zero temperature difference) possibly due to rain events, significant water withdrawals, or logger removal. In contrast, paired sites at NR20.3 experienced relatively stable daily temperature differences over the study period, only varying by 0-1°C.

Bessette River:

Within the Bessette system, temperature loggers were installed during elevated stream temperatures near the start of July, but prior to the most peak temperatures from approximately July 18th to August 22nd. Only the Bessette Creek tributary site of Harris Creek was installed too late to capture the elevated temperatures during the start of July.

Groundwater temperatures in Harris and Duteau creeks approximately mimicked the temperature trends observed in the control sites but were generally cooler; however the Bessette River groundwater site (BC9.65GWLOG) temperatures generally declined over time after installation compared to the control sites. These patterns are further confirmed upon analyzing the daily mean average differences between the paired (groundwater and control) study sites, for example, Harris and Duteau creek sites show relatively stable differences over time whereas site BC9.65 shows greater differences at the start of the study which approach near zero by the end, thus getting closer and closer in temperature values.

McKinley Creek:

In the McKinley system, temperature loggers were installed prior to peak stream temperatures which were observed from August 12th until the 21st, however elevated temperatures observed during installation may indicate another peak prior to logger installation.

All three control site temperatures exhibited similar trends in temperatures such that after peak temperatures, a general decline was observed over time. The groundwater temperature at Site 1 was generally cooler than the control but peaked a couple weeks later; only Sites 2 and 3 were generally stable over time, especially Site 3.

The daily mean differences between the control and groundwater temperatures at all sites generally exhibited similar trends with an overall decrease over time followed by a significant increase in differences near the end of the study period likely caused by rain events.

The upper tolerance for Coho is 25.1°C (Scott and Crossman 1973). Only Nicola River (NR21.65LOG) experienced a maximum stream temperature equal to this upper limit. Two other sites within the Nicola reached 24.8°C (NR18.54LOG) and 25°C (20.43b LOG). Bessette Creek (BC9.65JUV) experienced a maximum of 24.9°C. All sites within McKinley Creek reached temperatures around 23.0°C, site 1 particularly reaching up to 23.9°C. Many of the sites had temperatures between 20 - 25°C. If the peak was observed in these systems, they may have exceeded the 25.1°C.

Table 2 The maximum and minimum temperatures recorded during the study period. Shaded boxes were excluded from the analysis.

	Maximum Temperature	Minimum Temperature
LC0.2log1	22.6	6.1

LC7.9log6	21.8	5.7
LC13.97log	21.5	6.4
LCGWLOG13.9	13.0	8.2
LC15.67log	20.1	6.8
LCGWLOG15.6	19.0	8.0
LC17.1log	20.4	5.5
LCGWLOG17.18	13.4	6.6
LCGWLOG16.92	27.3	2.3
LCGWLOG16.9	20.9	6.3
LC26.67log	18.5	5.2
LCGWLOG25.6	7.0	5.0
LC29.2log	N/A	N/A
LCGWLOG29.02	6.9	4.2
BC8.16log	23.3	7.5
BC9.65juvGW	18.3	6.8
BC9.65juv	24.9	8.0
DUT4.77GW	17.6	5.8
DUT4.77LOG	20.2	7.2
HC1.92juvGW	21.8	8.7
HC1.96LOG	22.2	8.8
DM 25.5GWjuv	17.4	4.7
DM25.4juv	16.8	6.0
DM14.1GWjuv	16.3	5.3
DM14.2	20.3	1.9
DM14.2b	20.3	1.9
NR21.65log	25.1	8.5
NR21.71logGW	19.0	7.5
NR20.34b log	25	8.4

NR20.37GWlog	24	8.3
NR18.54log	24.8	8.4
NR18.60logGW	20.2	6.2
CW21.02log	N/A	N/A
CW21.03logGW	18.8	8.4
McKinley Site 1 (GW)	14.6	6.8
McKinley Site 1c (Control)	23.9	11.5
McKinley Site 2 (GW)	17.0	1.1
McKinley Site 2c (Control)	23.4	1.7
McKinley Site 3 (GW)	14.0	0.6
McKinley Site 3c (Control)	23.4	0.8

MONITORING FISH PRESENCE & ABSENCE

Fish presence and absence surveys via snorkel surveys were initiated in early and mid July and the amount of total surveys varied per system, each with a minimum of 3 survey-nights. Surveys were conducted primarily from 17:00hrs until 23:00hrs with slight variations between streams. McKinley Creek was surveyed however the data was lost and thus is not included within the analysis.

Louis Creek:

Snorkel surveys in Louis Creek were conducted from July 9th until August 6th, with a later start in LC15.6juv (July 17th). A total of 5 – 6 survey-nights were conducted per study site. Timing of the snorkel surveys coincided with pre-peak stream temperatures and near-peak stream temperatures; no post-peak survey was conducted. In site LC13.9juv, more Coho were observed using the groundwater site compared to the control, except there was an equal amount in both on July 21st during the earlier survey (Figure 1). This same trend was observed in site LC15.6juv (Fig. 2). In contrast, more Coho were observed in the control site within LC25.5juv during all surveys (Fig. 3). For all Louis Creek sites, more Coho were observed per site during the later hours (20:00-23:00hrs) rather than the earlier survey hours (17:00-18:00hrs).

Deadman River:

Snorkel surveys in the Deadman River were conducted from July 8th until August 21st. A total of 8 survey-nights were completed per study site. All surveys were conducted within the peak stream temperatures recorded; no surveys were completed during pre-peak or post-peak stream temperatures. More Coho were observed in the groundwater sites compared to the control sites, however we observed in site DM25.5juv significantly more Coho within the control site during the earlier surveys on August 6th and 7th possibly explained by the fact that on these dates the control had similar temperatures as the groundwater site (Fig. 5). In site DM14.1juv more Coho were observed within the groundwater site during the late night surveys compared to the earlier afternoon surveys (Fig. 4); in contrast a relatively consistent amount of Coho were observed in the groundwater site DM25.5 during both day and night.

Nicola River:

Snorkel surveys in the Nicola River were conducted from July 21st until September 23rd. In total, 6 survey-nights were completed per study site. Snorkel surveys were timed appropriately to capture pre-peak-, peak-, and post-peak stream temperatures. Site NR18.6juv surveys showed generally more Coho using the groundwater site compared to the control site especially during peak stream temperatures observed in early to mid August (Fig. 6); the most amount of Coho observed within the control site was noted on July 21st during pre-peak stream temperatures. Similar trends of more Coho observed in the groundwater site during peak stream temperatures was also observed in site NR20.37juv (Fig. 8); before and after peak there were few fish in both sites observed. In site NR21.73juv, generally small numbers of Coho were observed in both groundwater and control sites throughout the survey period except or on July 21st when 70+ juvenile Coho were observed within the groundwater site, coinciding with peak stream temperatures (Fig. 7). No strong daily spatial patterns (daytime versus night time snorkel surveys) were observed between the groundwater and control sites.

Technician conducting a snorkel survey in the Nicola River control site (NR18.6LOG) (Dave Tom in photo).

Bessette Creek:

Snorkel surveys in the Bessette Creek system were conducted from July 22nd until August 13th. A total of 3 survey-nights were completed per study site. All 3 surveys were completed during peak stream temperatures; no surveys were completed during pre-peak or post-peak stream temperatures. Overall, few fish were observed however, those that were observed were primarily within the groundwater sites (Fig. 9 & 10). No daily spatial patterns were observable. No Coho were observed in BC9.65juv during all survey occasions.

The most abundant salmon species within the surveyed Louis and Deadman systems were Coho, whereas the most abundant species within the surveyed sites of Bessette and Nicola systems were rainbow trout (Table 3). Caution must be taken when using Table 3 to make comparisons since the number of snorkel surveys per system varied. A detailed summary of salmon species counts per system per survey are included in Appendix 3.

Table 3 Summary of Total Count of Salmon Species per System

System	Total Count of Salmon Species		
	Coho	Chinook	Rainbow Trout
Louis Creek	1495	420	491
Bessette Creek	74	237	794
Deadman River	1101	15	217
Nicola River	343	433	556
McKinley Creek	No data	No data	No data

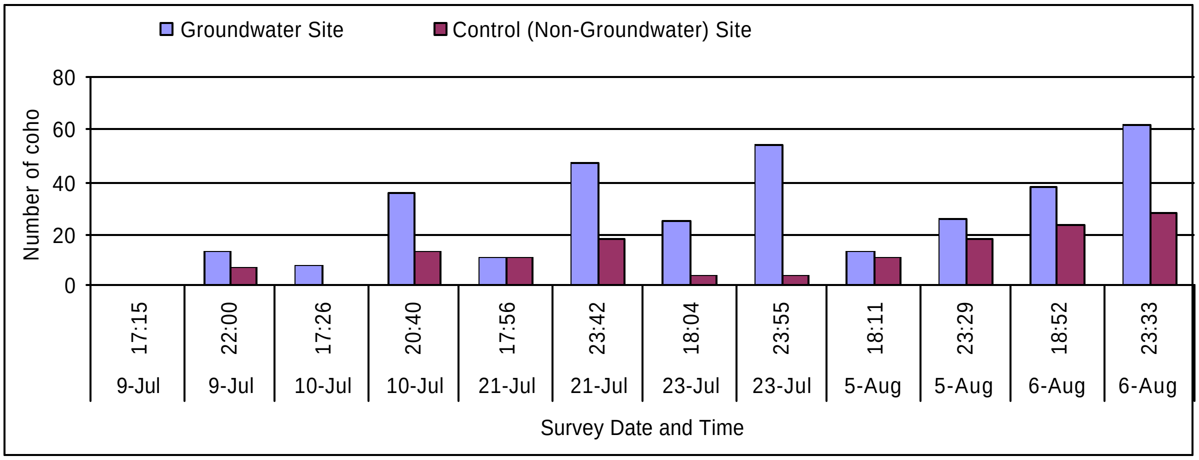


Figure 1 Louis Creek Site LC13.9juv

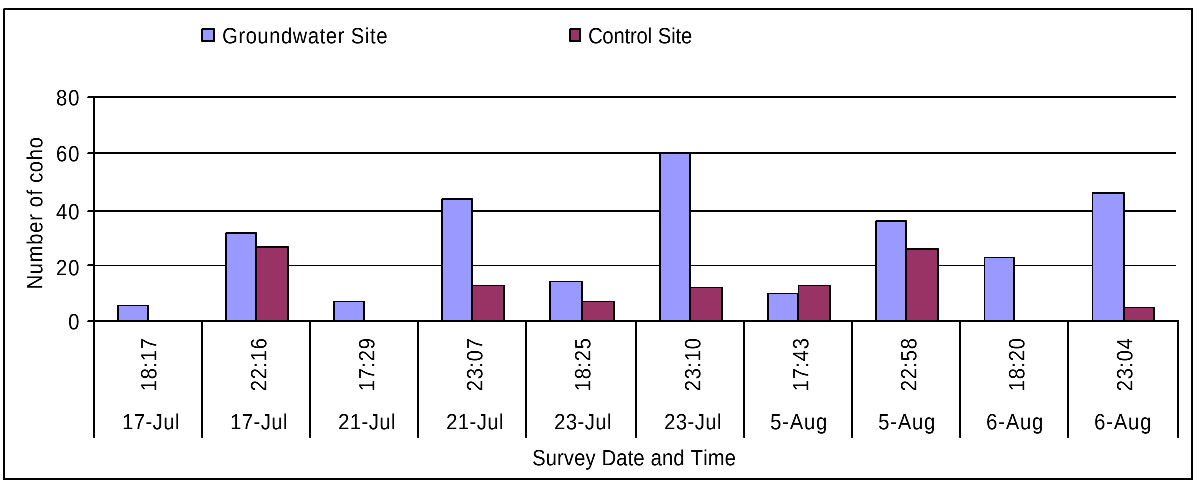


Figure 2Louis Creek Site LC15.6juv

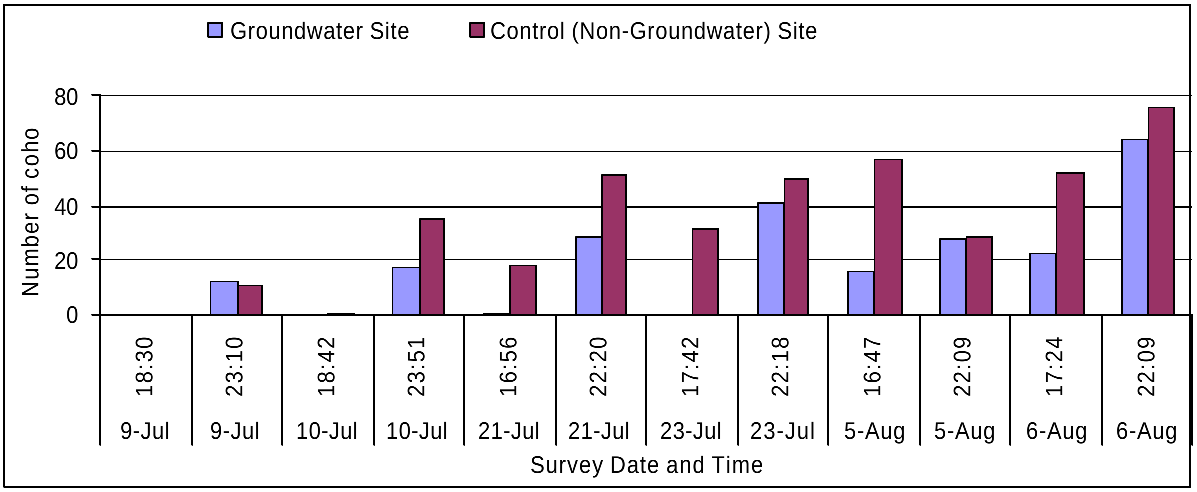


Figure 3Louis Creek Site LC25.5juv

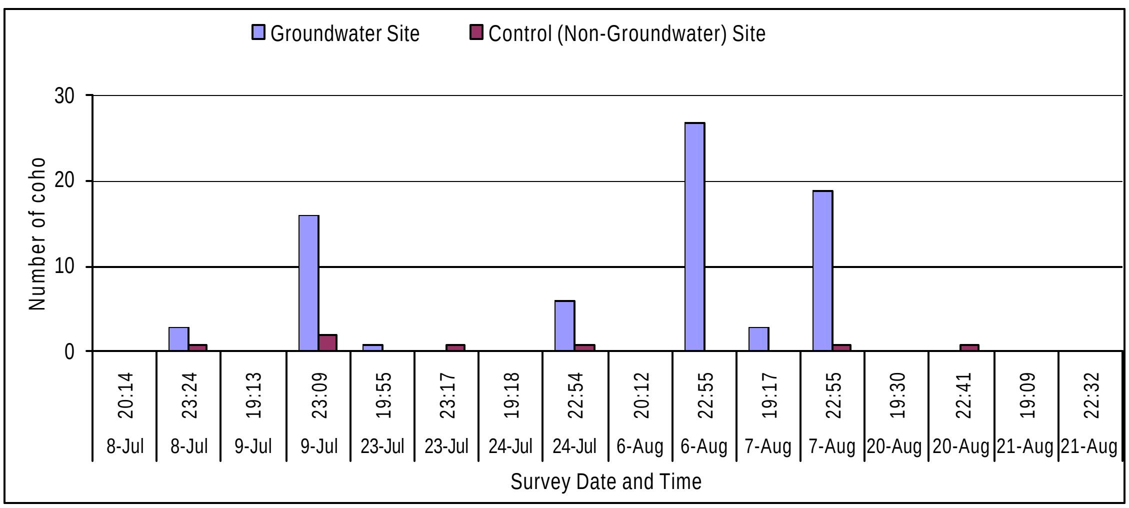


Figure 4Deadman River Site DM14.1juv

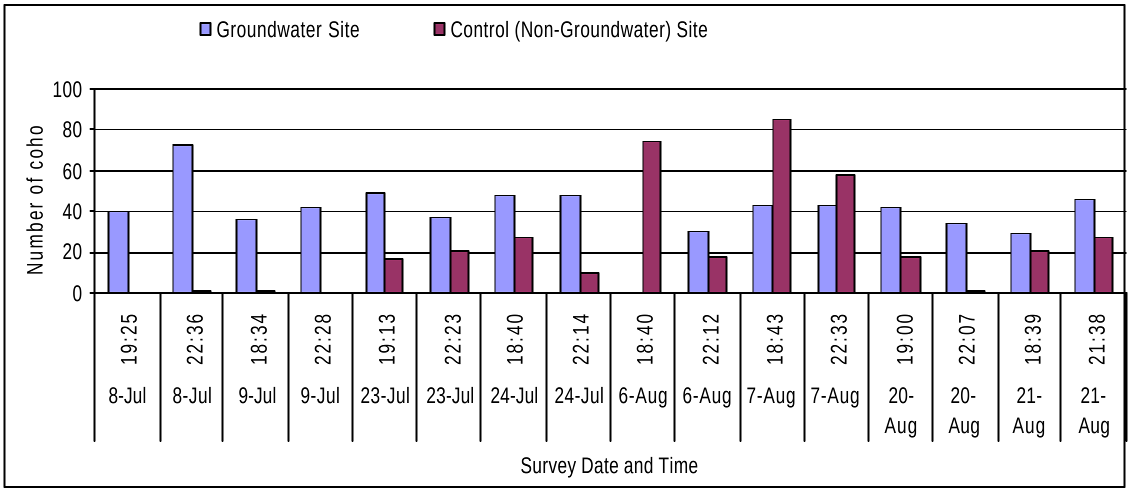


Figure 5Deadman River Site DM25.5juv

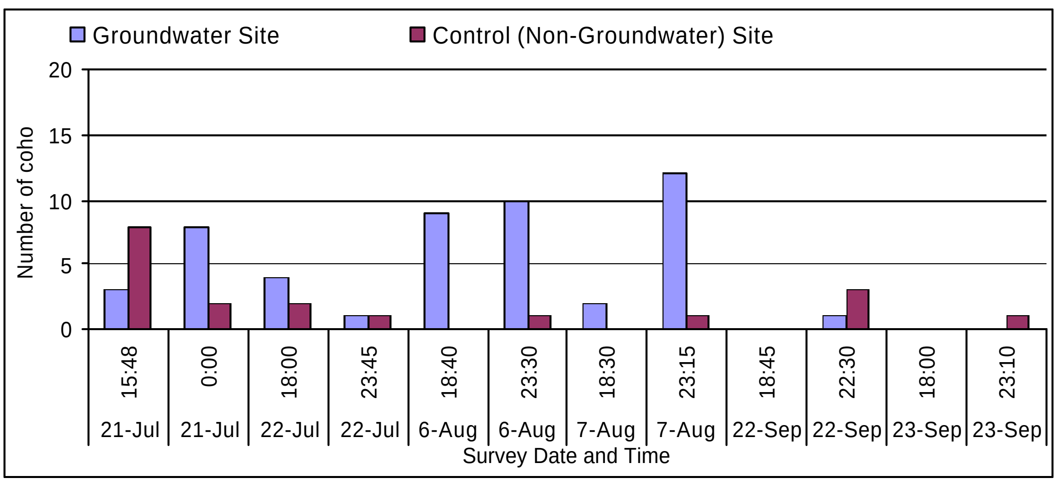


Figure 6Nicola River Site NR18.6juv

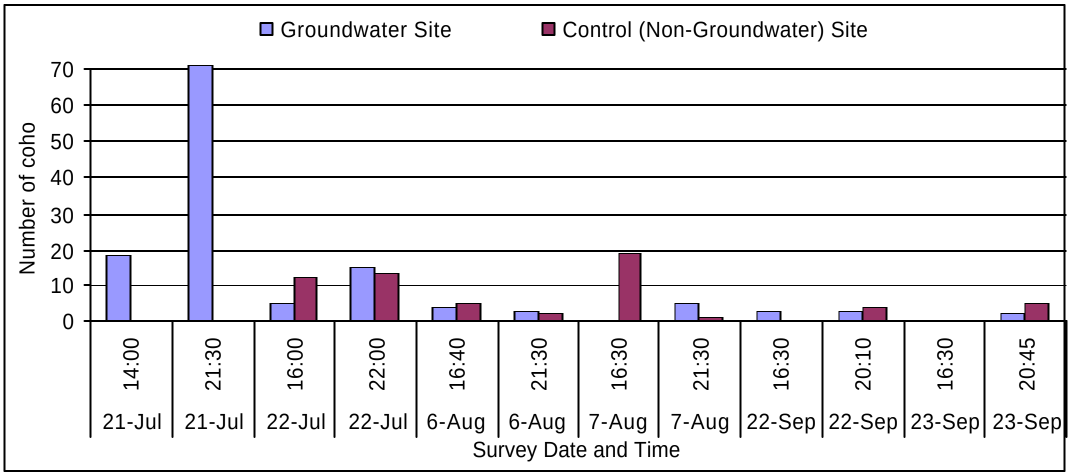


Figure 7Nicola River Site NR21.73juv

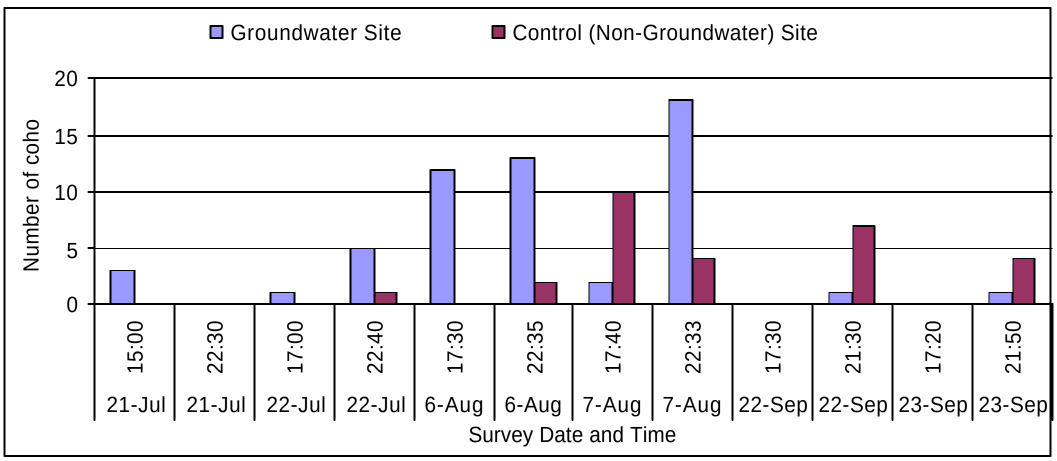


Figure 8 Nicola River Site NR20.37juv

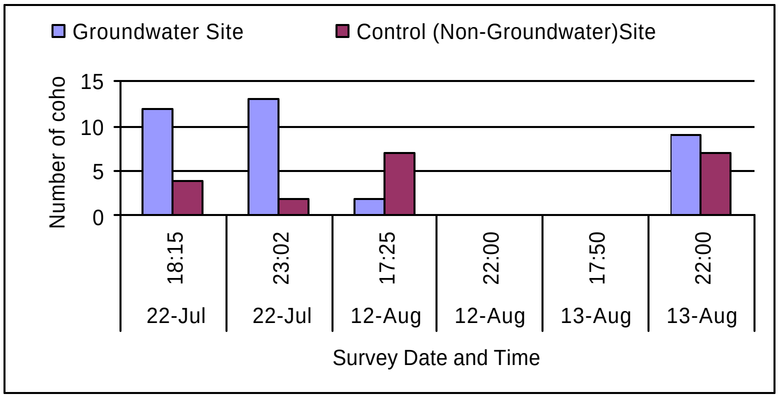


Figure 9 Bessette Creek Site HC1.92juv

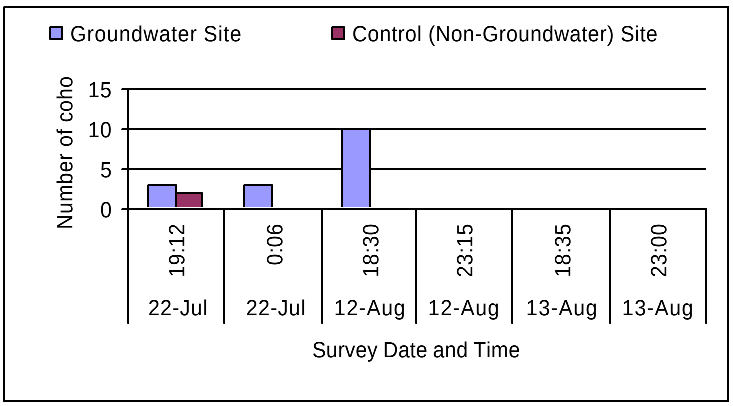


Figure 10 Bessette Creek Site DUT4.77juv

HABITAT DESCRIPTIONS

Habitat descriptions were completed for all sites surveyed for fish presence and absence in all systems excluding the Deadman River and can be found in Appendix 4. McKinley Creek habitat surveys were completed however the data is not included since fish presence and absence results are not available.

DISCUSSION AND RECOMMENDATIONS

Crews successfully achieved objective 1 of the study by confirming the presence of groundwater sites identified in 2007 as well as identifying new groundwater upwelling sites where applicable. Approximately 3 to 4 study sites were identified per stream. However, in general crews detected very few groundwater upwelling sites within the areas surveyed. Many of the groundwater upwelling sites that were detected were in the form of lateral seeps and side channels that had relatively small areas of coldwater influence (<1m^2) to the ambient stream temperature, except for the Deadman and Nicola rivers whose areas of influence ranged from 20 - 100m^2.

The study period extended from the first week of July in most systems until approximately the first week in October, a period of approximately 3 months. Overall, temperature loggers were installed immediately prior to peak stream temperatures and/or during the peak of stream temperatures, which can be improved in future years with earlier installation however freshet conditions may not allow earlier installation as was the case in the Nicola-Coldwater system. We found that control site peak stream temperatures peaked earlier by 2 – 3 weeks in the Bessette and Deadman (mid-July to late August) compared to the Nicola, Louis, and McKinley system (early August to late August) control sites, which may assist the timing of temperature logger installation in future years.

Only Nicola River (NR21.65LOG) experienced a maximum stream temperature equal to the upper tolerance for Coho (25.1°C as noted in Scott and Crossman 1973). Two other sites within the Nicola reached 24.8°C (NR18.54LOG) and 25°C (NR20.43b LOG) and the latter site likely exceeded the upper tolerance limit however the original logger was lost. Bessette Creek (BC9.65JUV) experienced a maximum stream temperature of 24.9°C. All of the McKinley Creek control sites reached temperatures in excess of 23°C. Many of the sites had temperatures between 20°C and 25°C. If the peak was observed in some of these systems, they may have exceeded the critical temperature threshold of 25.1°C.

We did observe groundwater upwellings that were significantly cooler and exhibited less daily variation compared to their paired control sites, for example 2 of the 3 groundwater sites within Louis Creek (LC13.97GWLOG and LC25.6GWLOG) were approximately 5 - 8°C cooler than their paired control sites and showed minimal daily variation in comparison as well. Another example is the McKinley Creek system where all groundwater sites were cooler by approximately 7 - 12°C than the control and Site 3 was especially stable over the study period; sites within the Nicola River (NR21.7GWLOG), Deadman River (DM14.1GWLOG), and Bessette Creek (BC9.65GWLOG) also showed similar results. In contrast, some of the groundwater site temperatures approximately mimicked their paired control site temperatures over the study and thus did not demonstrate the expected stable and smaller temperatures compared to the control as expected. This is likely due to either the groundwater site being too small of an area of influence for the logger to detect or due to seasonal shifts in groundwater patterns, volumes of flow and/or groundwater use (Davis and Wright 2007). These sites included Louis Creek (LC15.6GWLOG), Nicola River (NR18.6GWLOG), Bessette Creek (HC1.92GWLOG and DUT4.77GWLOG) and the Deadman River (DM25.4GWLOG), thus we do not recommend using these groundwater upwelling sites in future comparisons. Overall, some groundwater sites studied in 2008 exhibited cooler temperatures than their paired control sites and their temperatures were also relatively stable in comparison.

This is the first year of standardized fish presence and absence surveys conducted for the study streams as 2007 was a training exercise. In Louis Creek, snorkels were only conducted during pre-peak stream temperatures when we expected to see Coho making full use of habitat both day and night. We did observe that for the 'true' paired sites (e.g., having differences between the groundwater and control temperatures such as sites LC25.5 and LC13.9), Coho were using both the groundwater and control sites both day and night. Upon further examination, more Coho were almost always observed in either the groundwater site (LC13.9) or in the control site (LC25.5) only - habitats within both of these paired sites were very similar and the differences in Coho presence may be explained by temperatures - the groundwater temperatures in the former site (LC13.9) were around 8-11°C likely preferred by the Coho over the control which was 5-6°C warmer; in contrast the latter site (LC25.5) groundwater was very cold at around 5-6°C likely too cool for the juvenile Coho whereas the control site offered temperatures 7°C warmer. Furthermore, a definite diel spatial migration behaviour was occurring where many more Coho were observed during the night surveys (20:00hrs-23:00hrs) as opposed to the earlier daytime surveys (17:00-18:00hrs).

In the Deadman River, snorkels were concentrated during peak stream temperatures that reached up to 20.3°C and we expected Coho to be using the groundwater upwelling areas more than the paired control sites. This was observed within site DM14.1 where overall most Coho were counted within the groundwater site which was approximately 2 - 4°C cooler and had more stable temperatures then the control site which reached up to 20.3°C during the daytime. Since habitat comparisons between the groundwater and control at this site are not available we cannot say for sure that the differences in groundwater use by Coho are solely temperature related. Thus next year we recommend that habitat characteristics within the Deadman River be completed. Daily spatial distribution patterns were observed within this site with more Coho observed within the groundwater site during the late night surveys compared to the daytime surveys. Although groundwater site DM25.4GWLOG is not recommended for future study due to its similar temperatures as the control, its habitat seems to be preferable to Coho since they were observed in this site consistently throughout the peak-temperature surveys, both afternoon and night.

Within the Bessette Creek system, snorkel surveys were only conducted during peak stream temperatures where we would expect more Coho to be using the cooler groundwater source rather than the control site. Since most of our paired groundwater and control sites recorded similar temperatures they are not good for making comparisons of fish presence/abundance relative to temperature, however most Coho observed in Harris Creek (HC1.92) were within the groundwater sites which was a few degrees cooler than the control site and had similar habitat as the control. Had fish been observed in site BC9.65 it would have been useful to see the difference in Coho presence/absence since this groundwater site was much cooler than the control and their habitats were similar. We did not observe any daily spatial patterns, likely due to the low sample size (Coho counts).

The Nicola River Coho surveys seemed to be timed appropriately to coincide with pre-, during-, and post-peak stream temperatures however logger installation was a little late to verify the pre-peak temperatures and thus make comparisons. At pre-peak stream temperatures we expected to see more Coho within the groundwater site compared to the paired control sites which we did observe (NR21.7LOG) during the first survey, in fact, a significant amount of Coho (70^{+}) were observed in the groundwater site and none in the control at this time. Temperatures here were elevated in the control at approximately 22°C but the groundwater was cooler by 4 - 5°C likely offering some cooler water refuge. Part of the difference in Coho abundance between the groundwater and control site may be explained by the slight differences in habitat – the groundwater site having a bit more cover and a small area of riffle habitat. Although temperatures and the habitats between the groundwater and control at site NR20.34 were very similar, we did consistently observe more Coho within the groundwater area during what was expected to be peak stream temperatures (based on other loggers within the stream - recall that the original logger was lost) and relatively few Coho in both sites before and after the assumed peak. No strong daily spatial patterns were observed during the study.

Conclusions on the daily and seasonal spatial migration patterns related to temperature are not possible for the McKinley Creek study area since snorkel survey and habitat descriptions are not available. Results would have been interesting considering that the system did experience temperatures over the critical temperature threshold for salmon (23.1°C) and the groundwater sites was much cooler than the control sites by approximately 7°C.

After a second year of fish presence and absence surveys are conducted (2009-10), we may be able to draw more solid conclusions about the seasonal and diel spatial distribution patterns of Coho. We also recommend that fish monitoring surveys be conducted during pre-, during, and post-peak stream temperatures so that comparisons on spatial patterns of Coho can be made.

Furthermore, in year three a more detailed statistical analysis of the relationship between habitat characteristics and seasonal and diel spatial distribution patterns can be conducted to encompass all study years. We would also recommend that the study design be improved by employing the help of a statistician prior to the field season to ensure that scientifically rigorous comparisons will be possible.

Preliminary analysis has shown that groundwater upwelling areas are cooler than mainstem stream temperatures and relatively more stable as well. We also observed that in some sites Coho juveniles were within the groundwater upwelling areas more often than their paired control sites and that daily spatial distribution patterns were observable in some streams. Although not all study sites reached near lethal levels for juvenile Coho, some systems such as Bessette, Nicola, and McKinley streams did and other systems experienced elevated and thus stressful levels of temperatures for juvenile Coho which can result in increase mortality due to increase in metabolic demands especially when the high temperatures can continue for several days (Davis and Wright 2007). More emphasis for investigations of groundwater as thermal refuge should be placed on the streams that do consistently reach lethal levels of stream temperatures for juvenile Coho.

Overall, the project was a success in that multiple partners including First Nations and government were able to effectively collaborate to conduct this study, the final objective for this study.

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APPENDIX 1 – TEMPERATURE LOGGER DATA

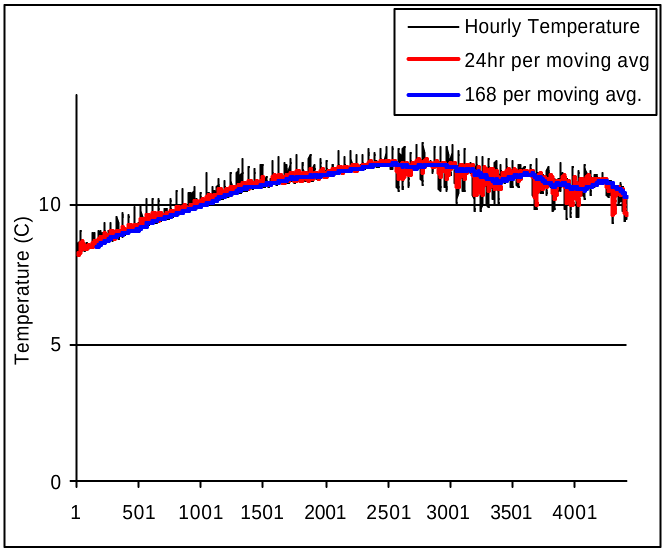

Figure 1a Louis Creek logger at Groundwater site (LC13.97GWLOG) with half-hour readings.

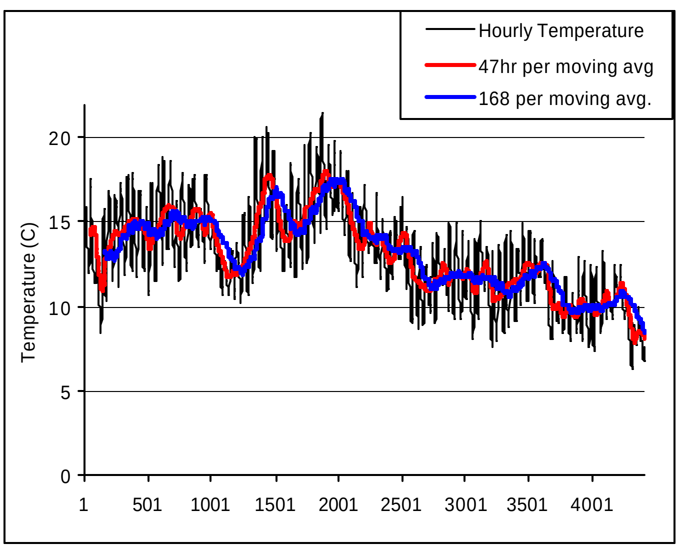

Figure 1b Louis Creek logger at Control site (LC13.97LOG) with half-hour readings.

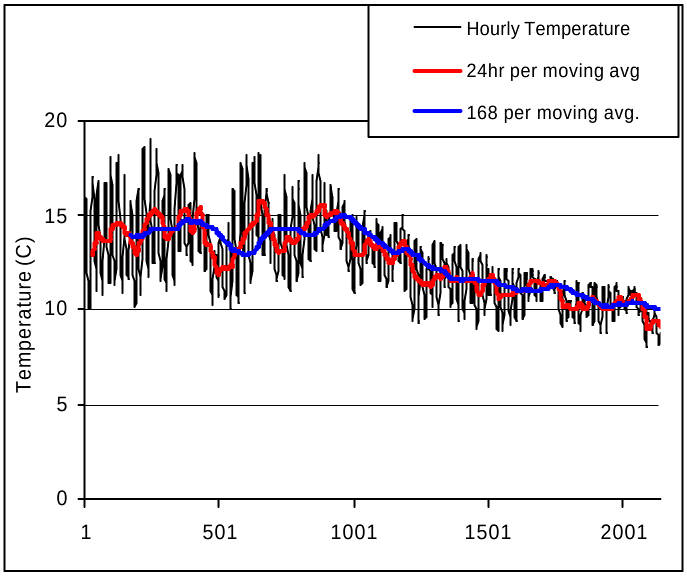

Figure 1c Louis Creek logger at Groundwater site (LC15.6GWLOG) with hourly readings.

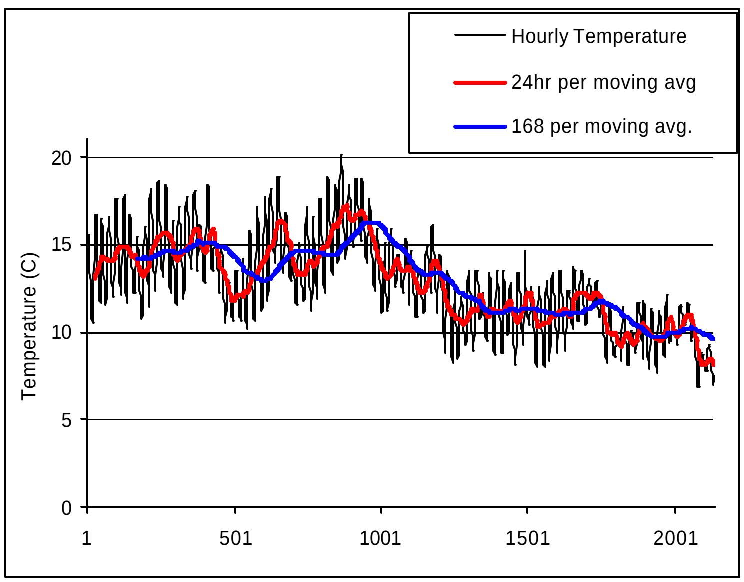

Figure 1d Louis Creek logger at Control site (LC15.67LOG) with hourly readings.

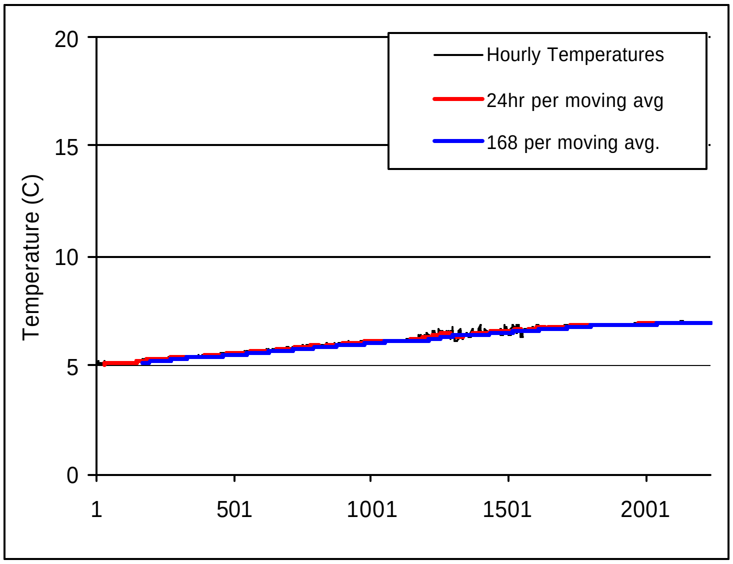

Figure 1e Louis Creek logger at Groundwater site (LC25.6GWLOG) with hourly readings.

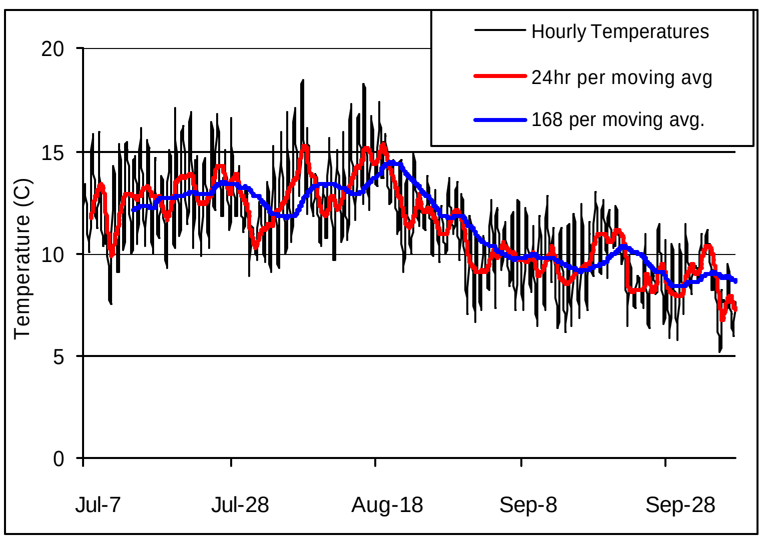

Figure 1f Louis Creek logger at Control site (LC26.67LOG) with hourly readings.

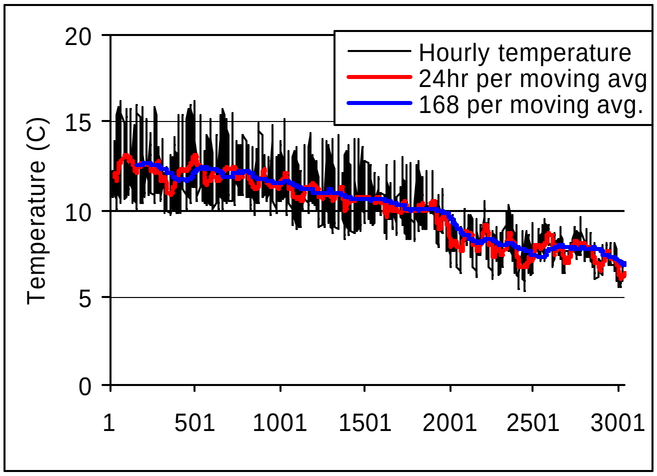

Figure 1g Deadman River logger at Groundwater (DM14.1GWLOG) with hourly readings.

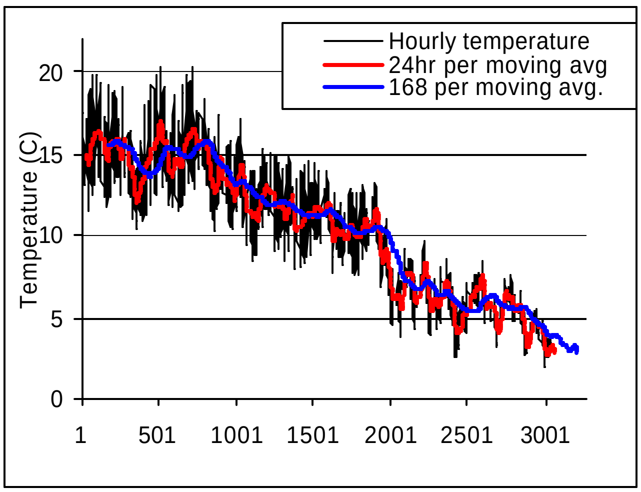

Figure 1h Deadman River logger at Control site (DM14.2LOG) with hourly readings.

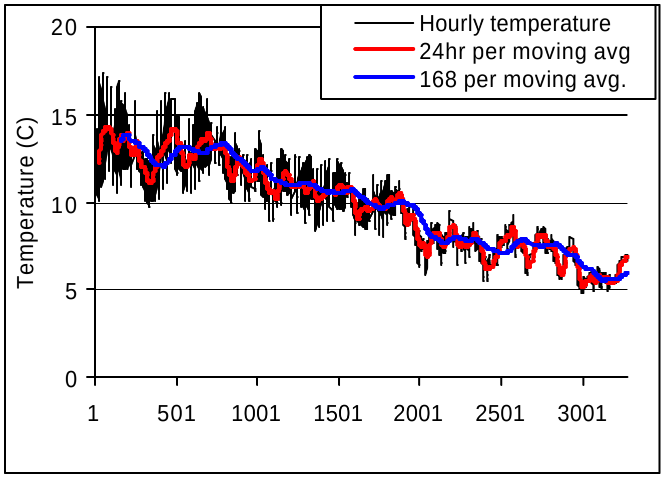

Figure 1i Deadman River logger at Groundwater site (DM25.5GWLOG) with hourly readings.

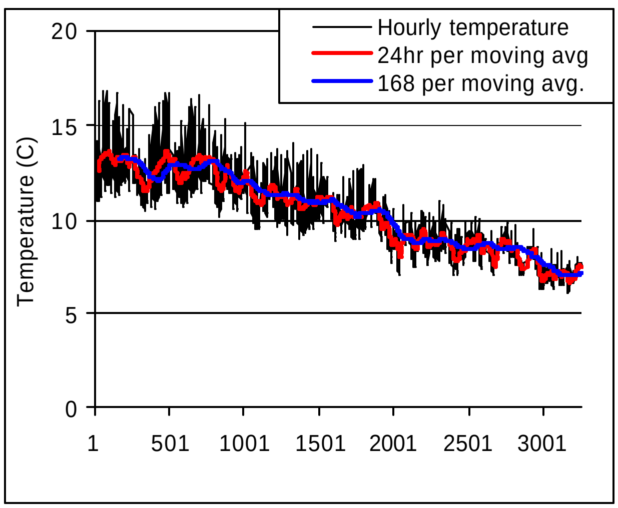

Figure 1j Deadman River logger at Control site (DM25.4LOG) with hourly readings.

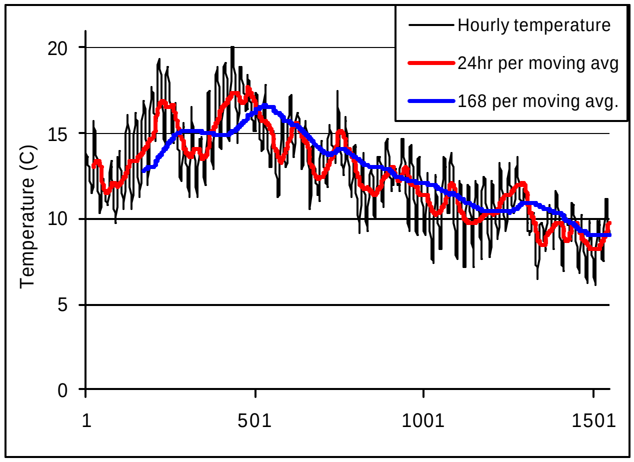

Figure 1k Nicola River logger in Groundwater (NR18.6GWLOG) with hourly readings.

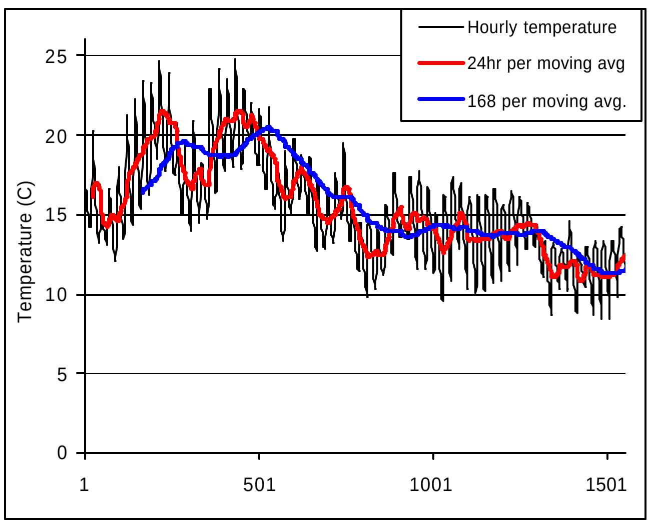

Figure 1l Nicola River logger at Control (NR18.54LOG)with hourly readings.

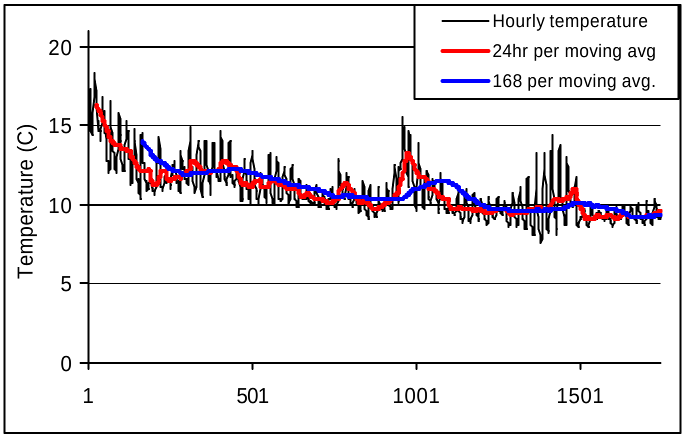

Figure 1m Nicola River logger in Groundwater (NR21.7GWLOG) with hourly readings.

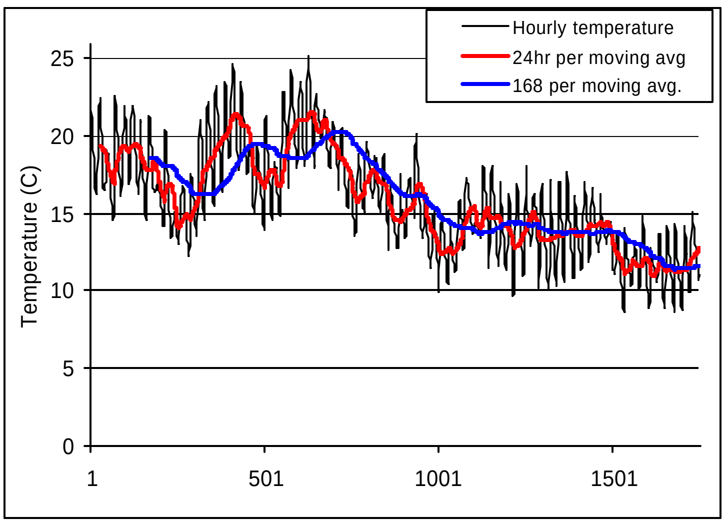

Figure 1n Nicola River logger at Control (NR21.65LOG) with hourly readings

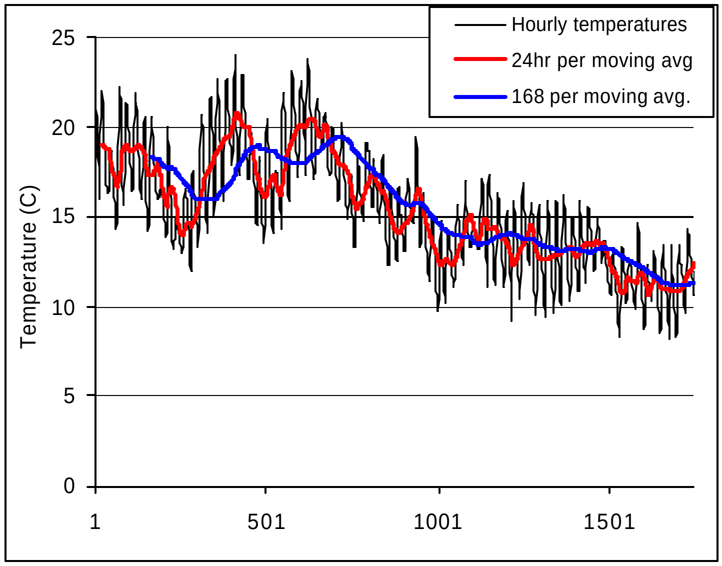

Figure 1o Nicola River logger in Groundwater (NR20.37GWLOG) with hourly readings.

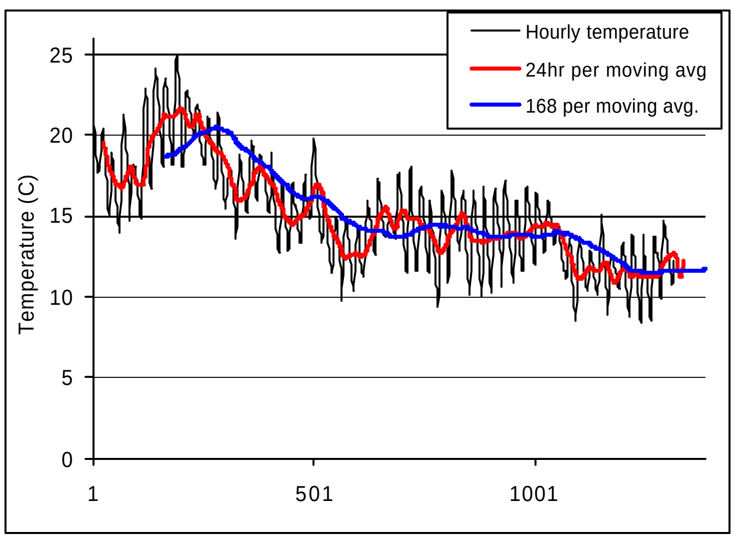

Figure 1p Nicola River logger at Control (NR20.34bLOG) with hourly readings.

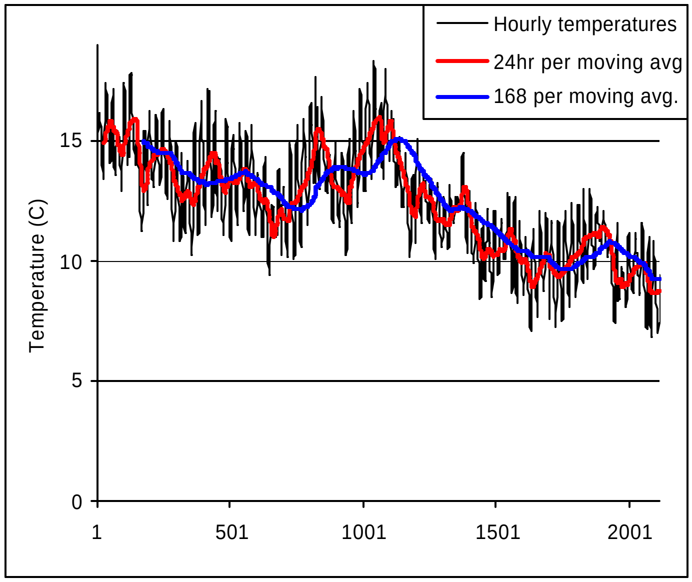

Figure 1q Bessette Creek logger at Groundwater (BC9.65GWLOG) with hourly readings.

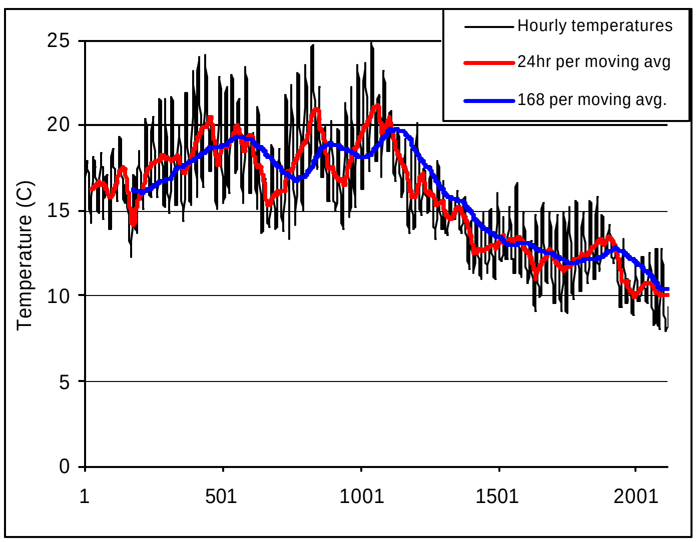

Figure 1r Bessette Creek logger at Control (BC9.65LOG) with hourly readings.

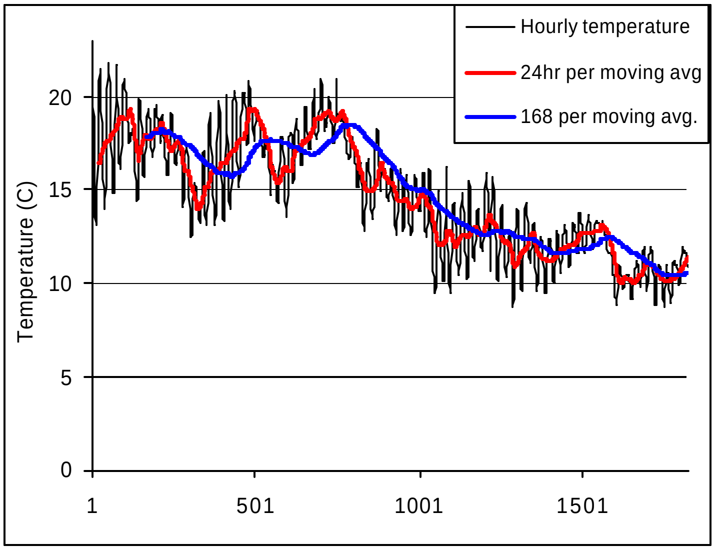

Figure 1s Bessette Creek Tributary (Harris Creek) logger at Groundwater (HC1.92GWLOG) with hourly readings.

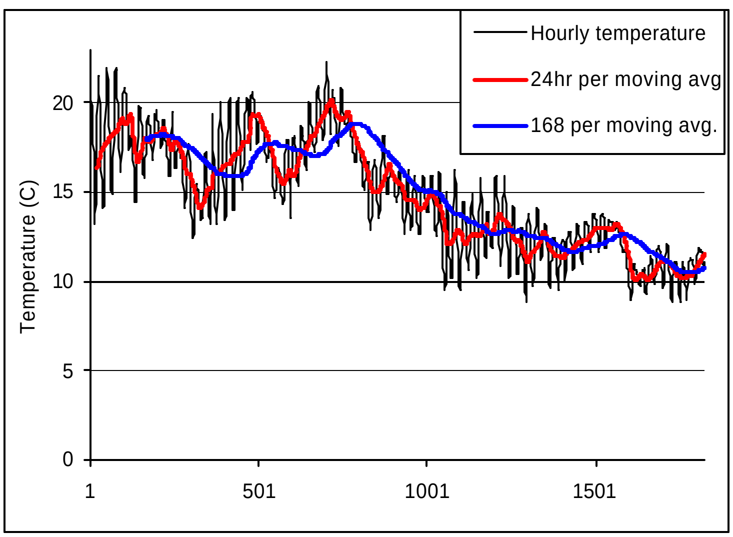

Figure 1t Bessette Creek Tributary (Harris Creek) logger at Control (HC1.96LOG) with hourly readings.

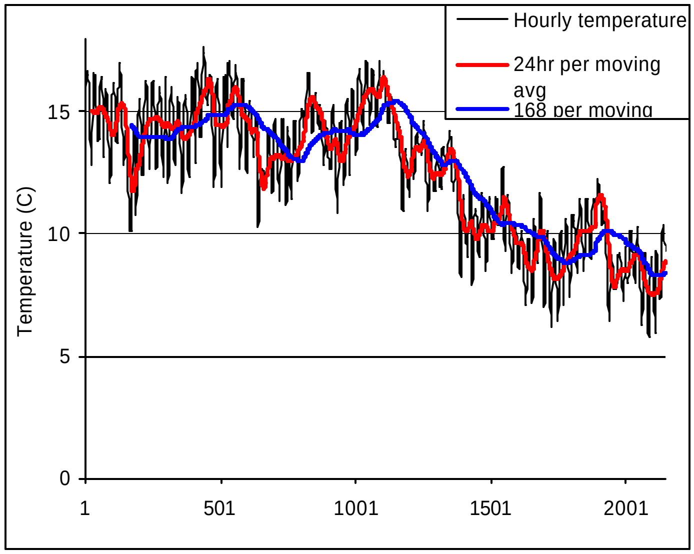

Figure 1u Bessette Creek Tributary (Duteau Creek) logger at Groundwater (DUT4.77GWLOG) with hourly readings.

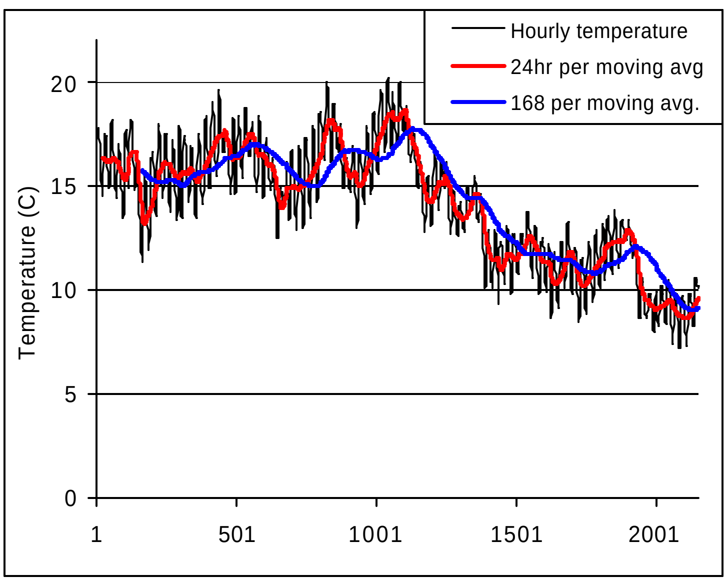

Figure 1v Bessette Creek Tributary (Duteau Creek) logger at Groundwater (DUT4.77LOG) with hourly readings.

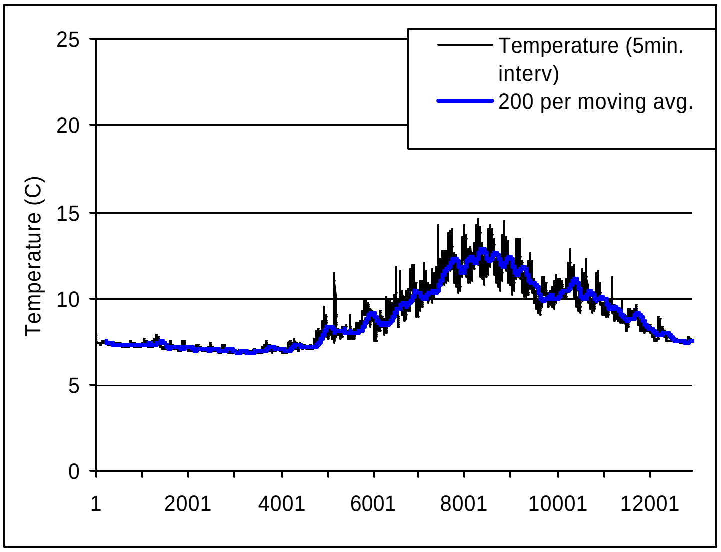

Figure 1w McKinley Creek logger at Groundwater site 1 with 5-minute readings.

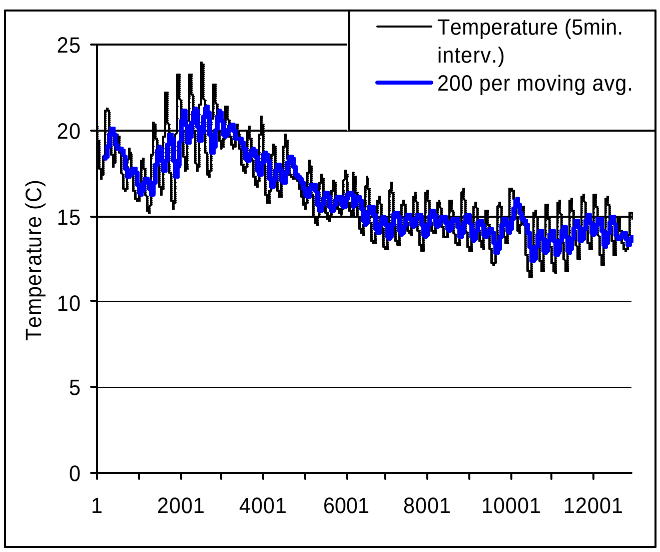

Figure 1x McKinley Creek logger at Control site 1 with 5-minute readings.

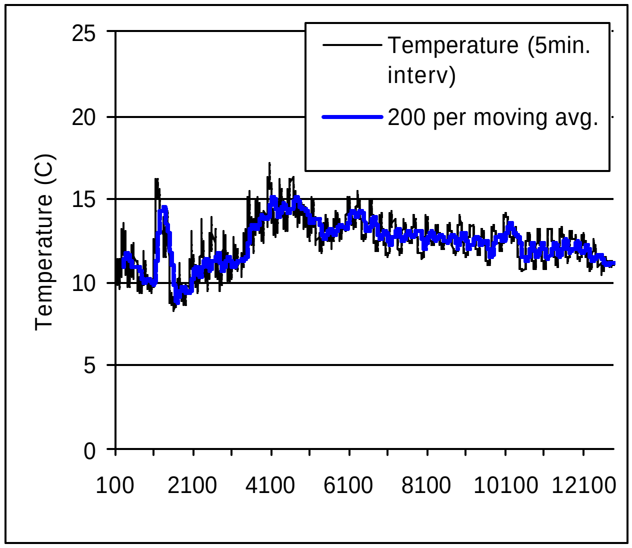

Figure 1y McKinley Creek logger at Groundwater site 2 with 5-minute readings.

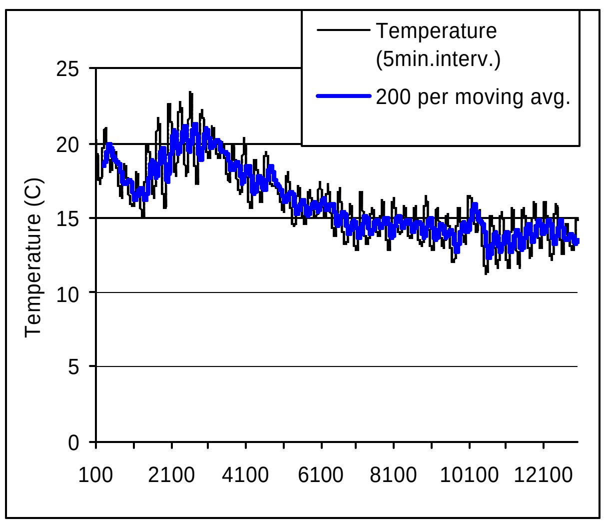

Figure 1z McKinley Creek logger at Control site 2 with 5-minute readings.

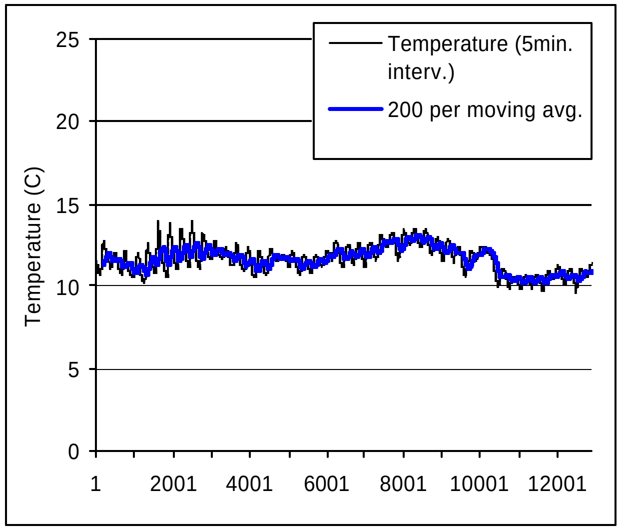

Figure 1z-a McKinley Creek logger at Groundwater site 3 with 5-minute readings.

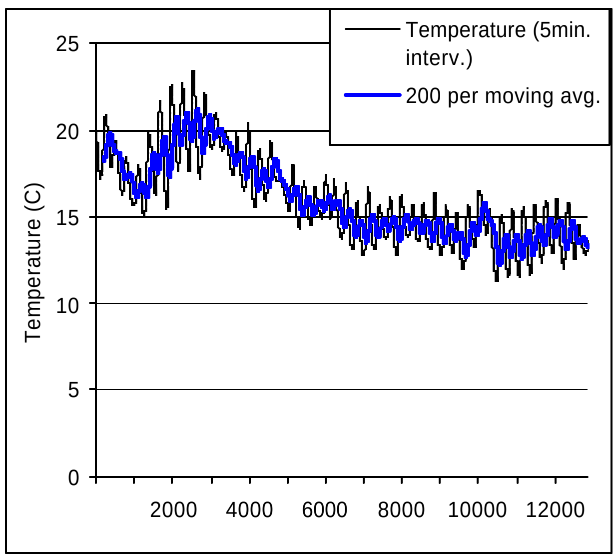

Figure 1z-b McKinley Creek logger at Control site 3 with 5-minute readings.

APPENDIX 2 – TEMPERATURE DIFFERENCE CALCULATION DATA

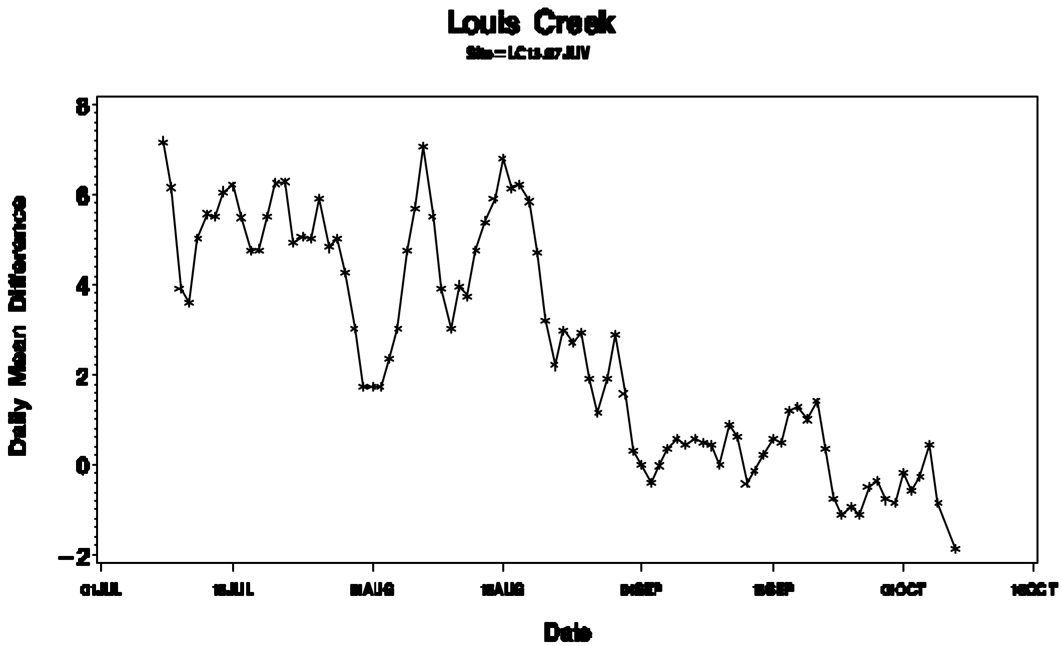

Figure 2a Daily mean difference between control (non-groundwater) and groundwater at site LC13.97JUV in Louis Creek.

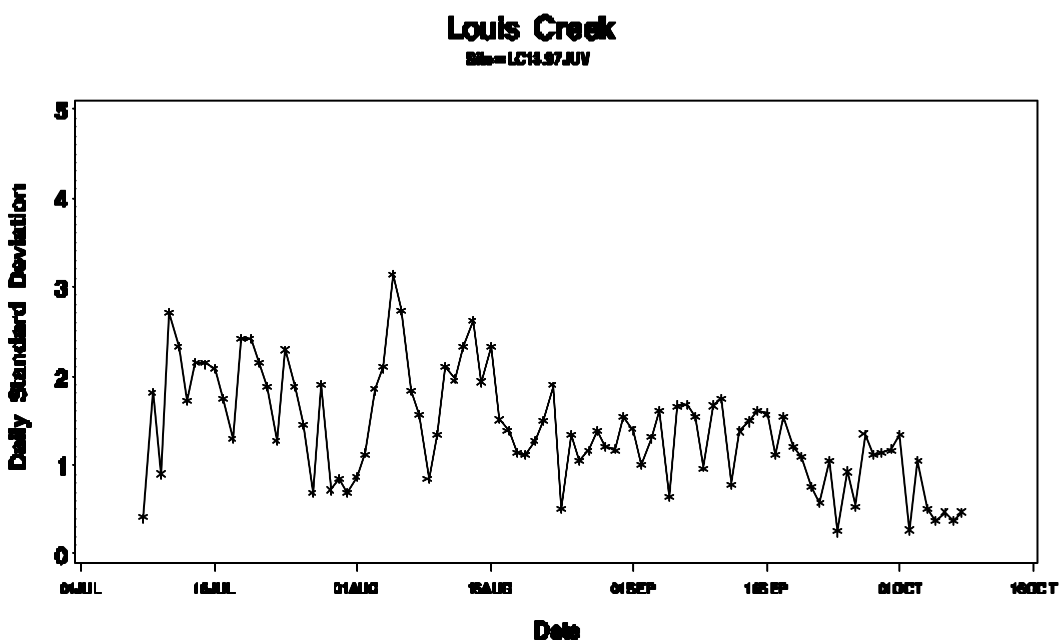

Figure 2b Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site LC13.97JUV in Louis Creek.

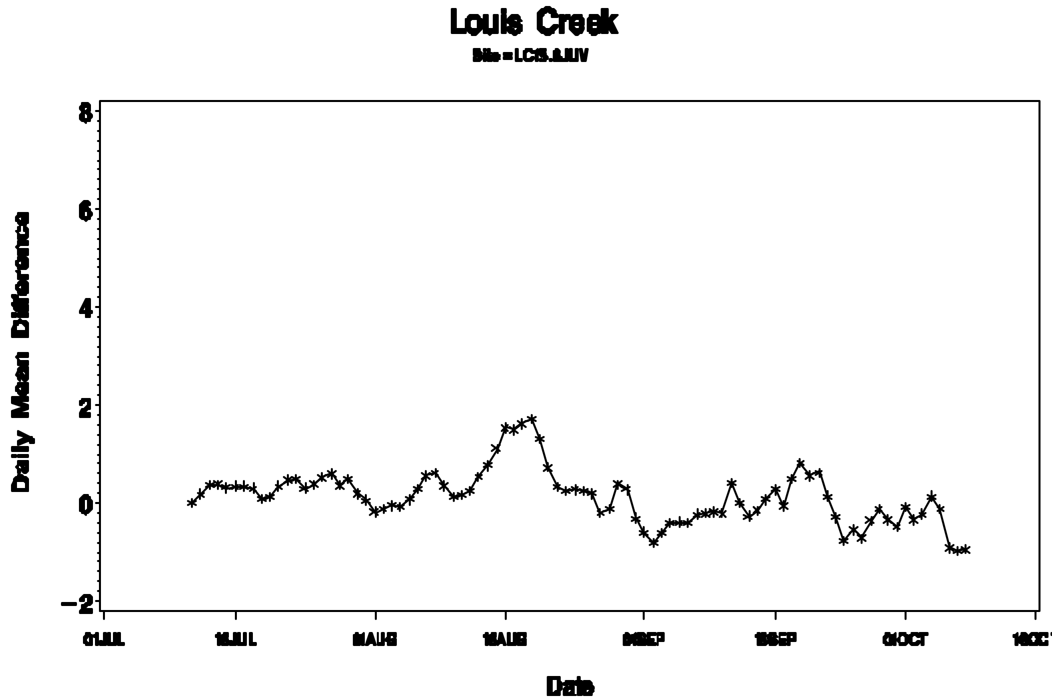

Figure 2c Daily mean difference between control (non-groundwater) and groundwater at site LC15.6JUV in Louis Creek.

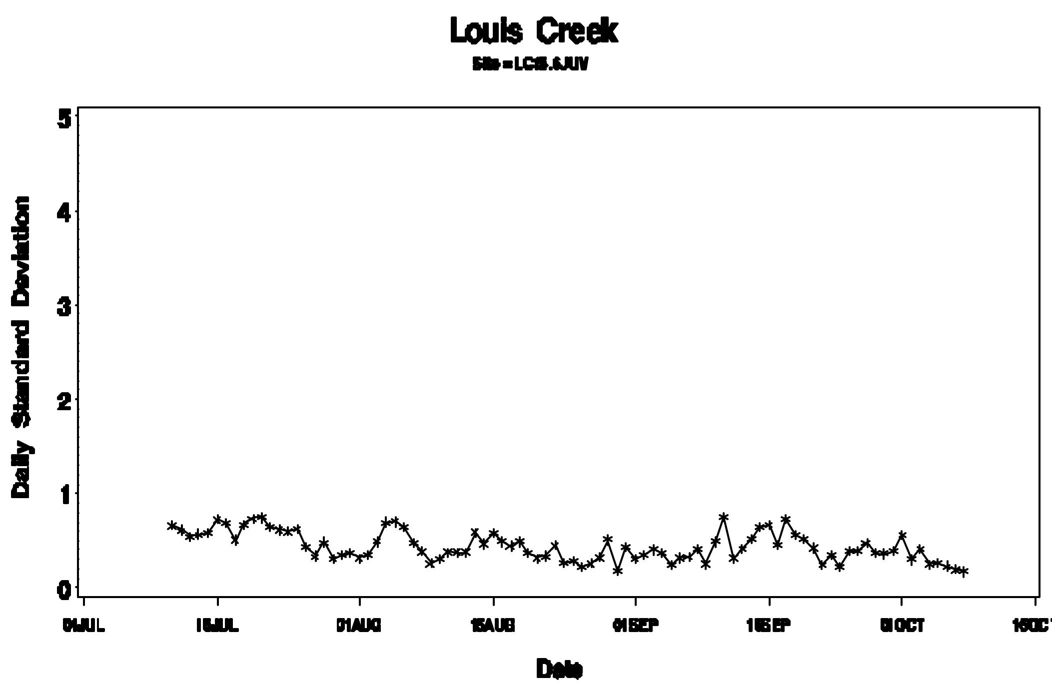

Figure 2d Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site LC15.6JUV in Louis Creek.

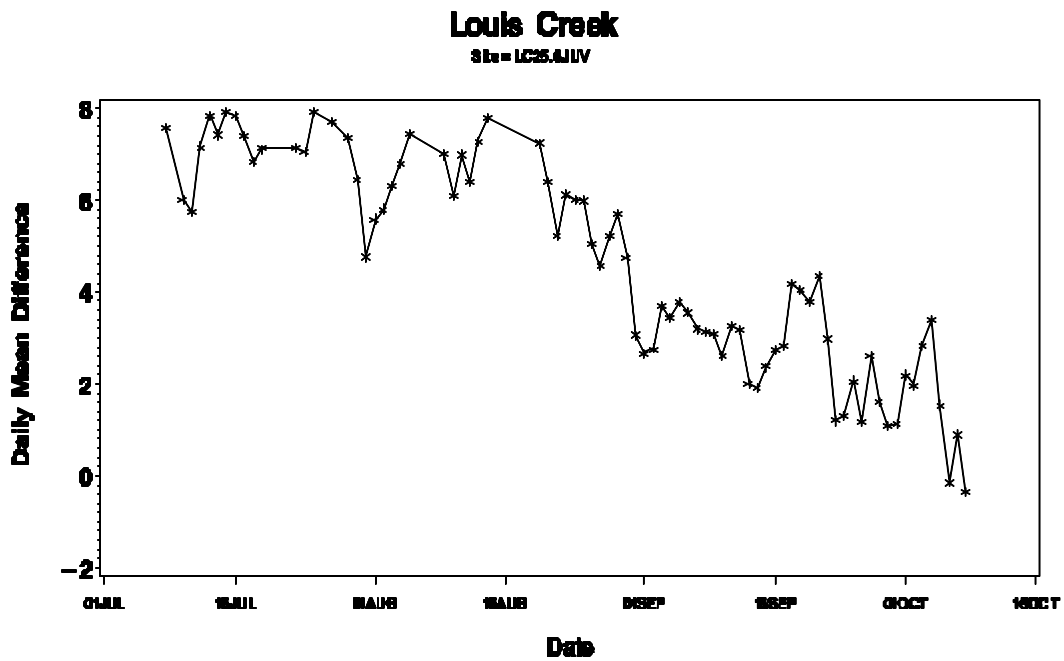

Figure 2e Daily mean difference between control (non-groundwater) and groundwater at site LC25.6JUV in Louis Creek.

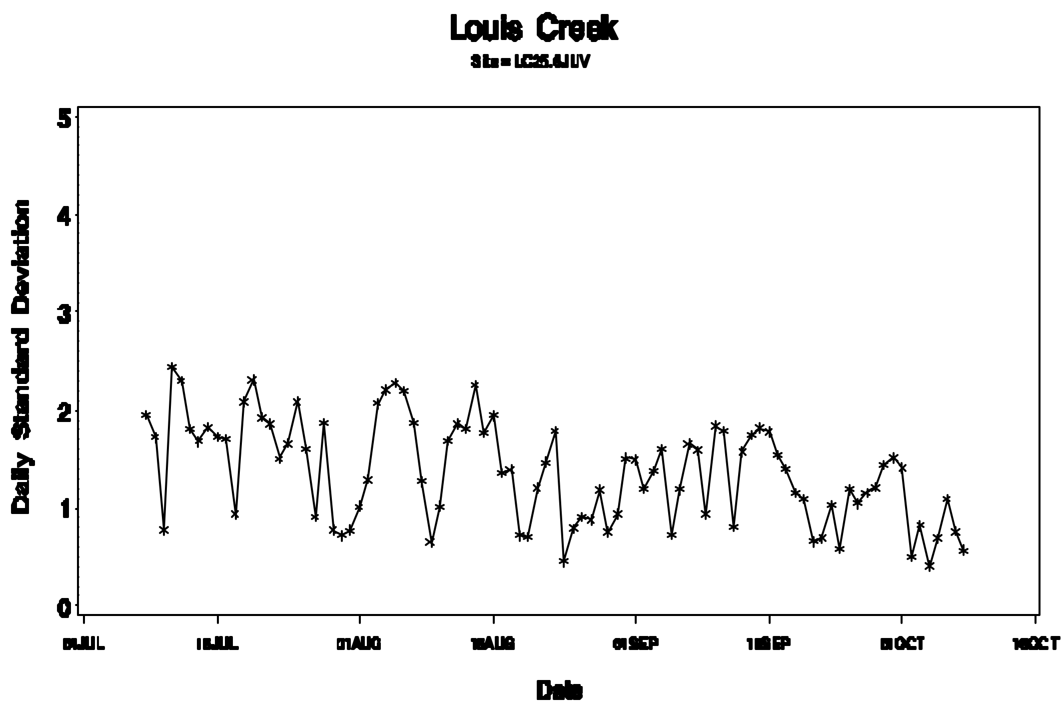

Figure 2f Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site LC25.6JUV in Louis Creek.

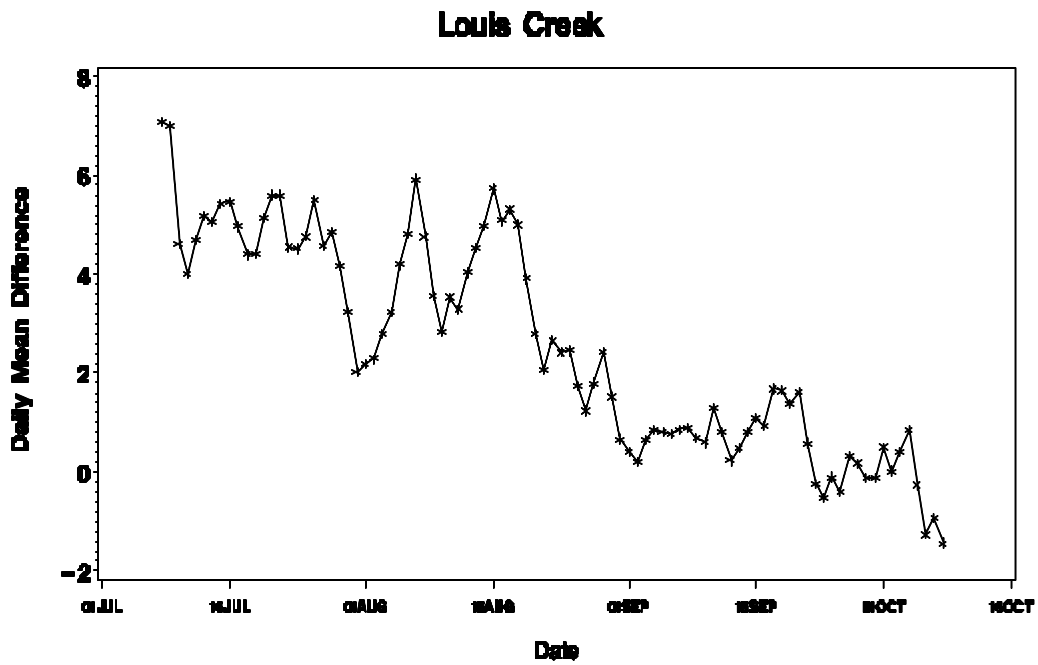

Figure 2g Daily mean difference between ALL combined control (non-groundwater) and groundwater sites within Louis Creek.

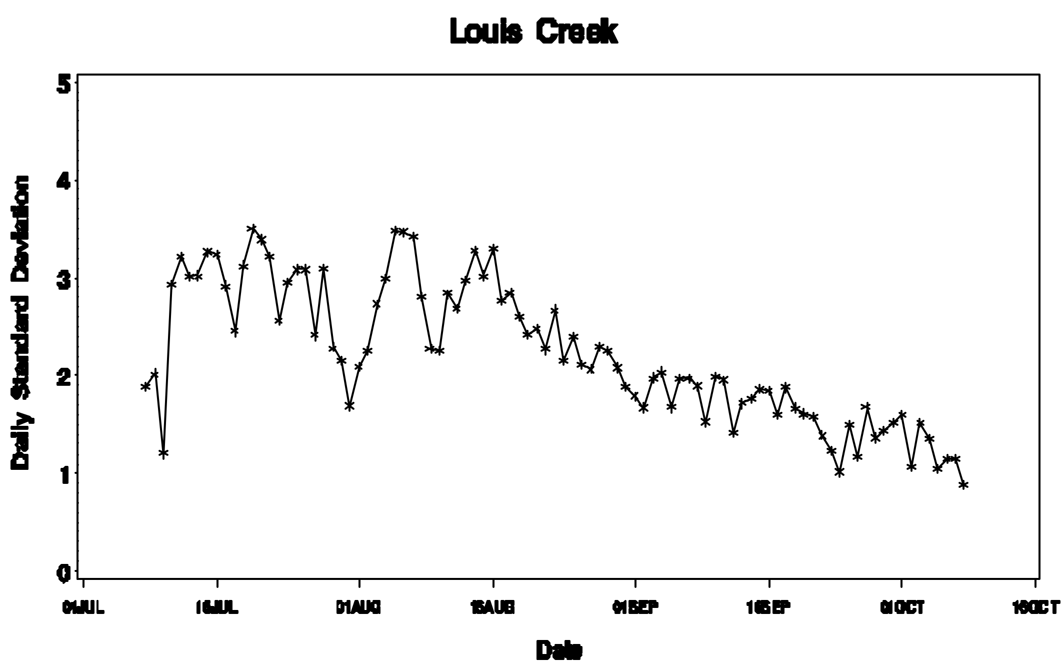

Figure 2h Daily standard deviation of the mean difference between ALL control (non-groundwater) and groundwater sites within Louis Creek

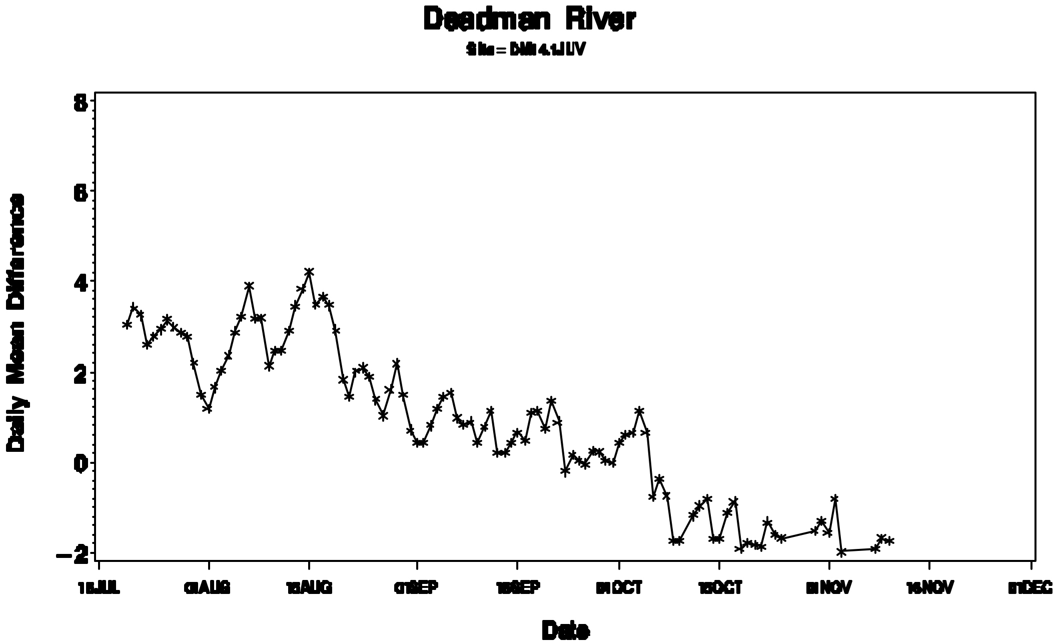

Figure 2i Daily mean difference between control (non-groundwater) and groundwater at site DM14.1JUV in Deadman River.

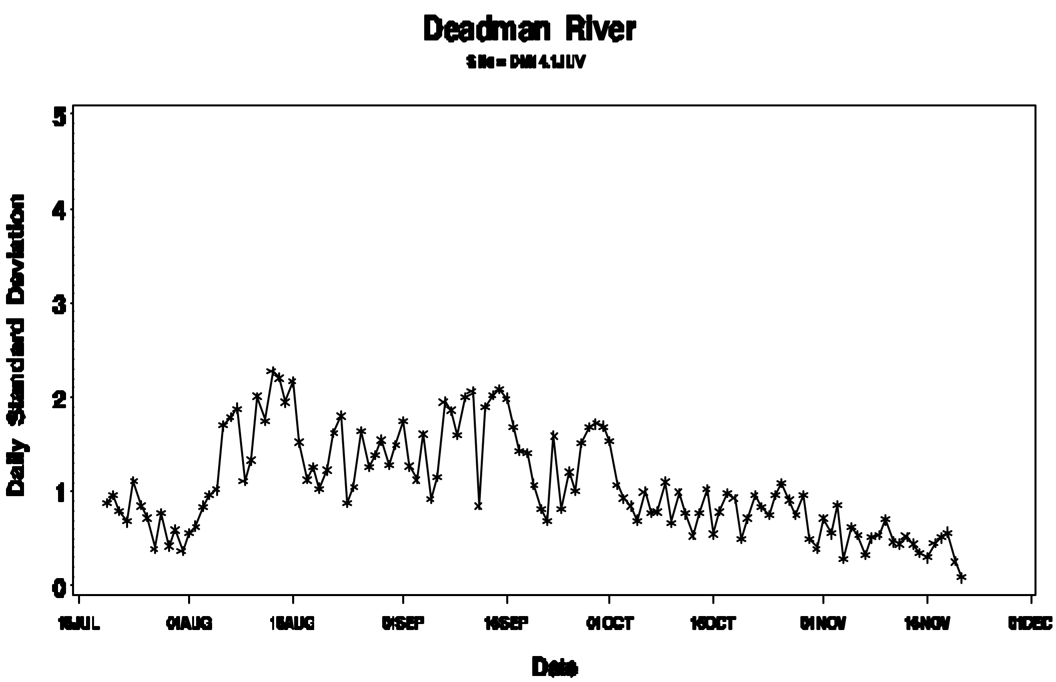

Figure 2j Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site DM14.1JUV in Deadman River.

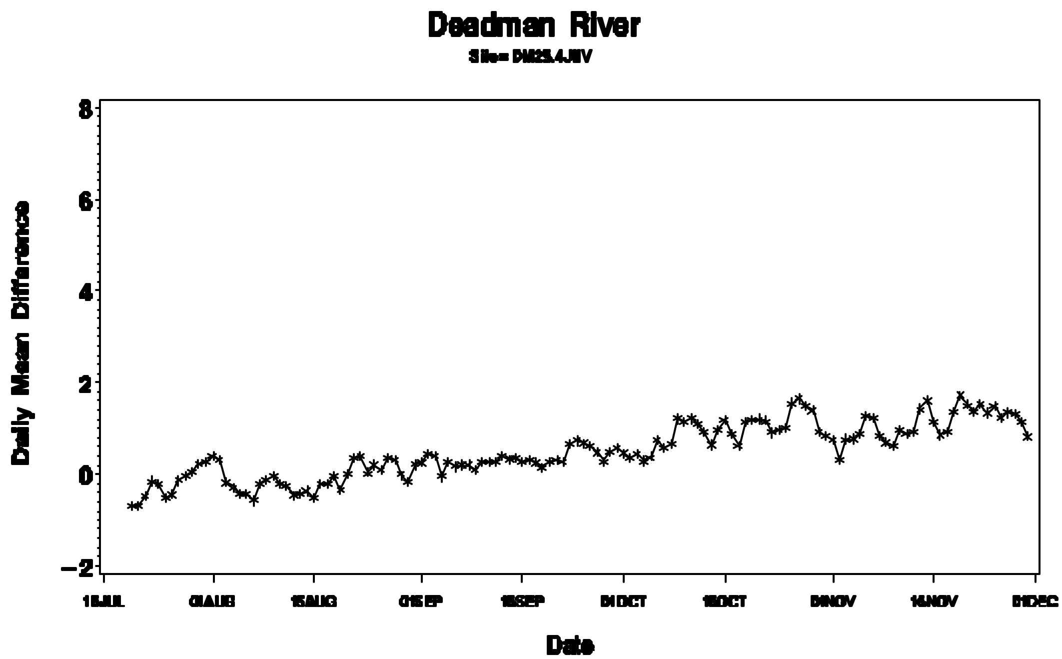

Figure 2k Daily mean difference between control (non-groundwater) and groundwater at site DM25.4JUV in Deadman River.

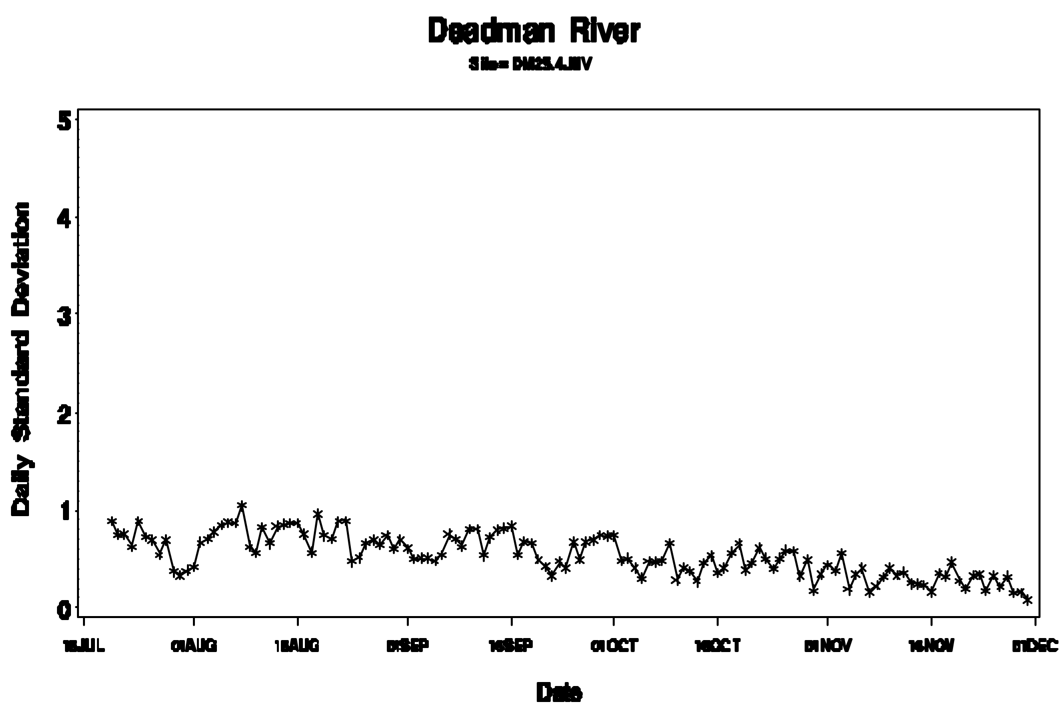

Figure 2l Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site DM25.4JUV in Deadman River.

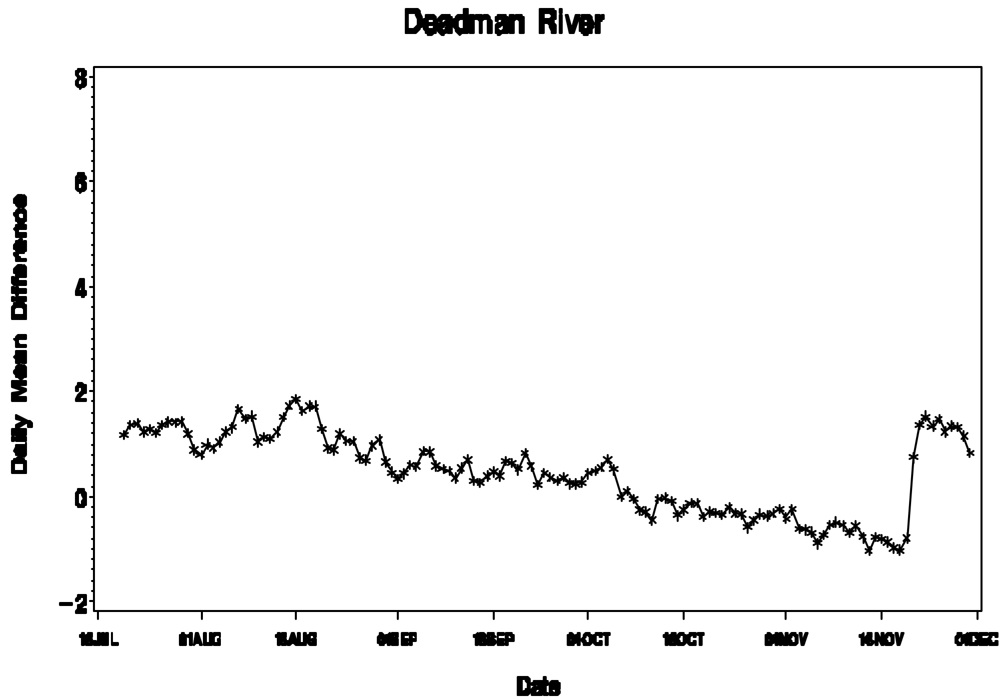

Figure 2m Daily mean difference between ALL control (non-groundwater) and groundwater sites in Deadman River.

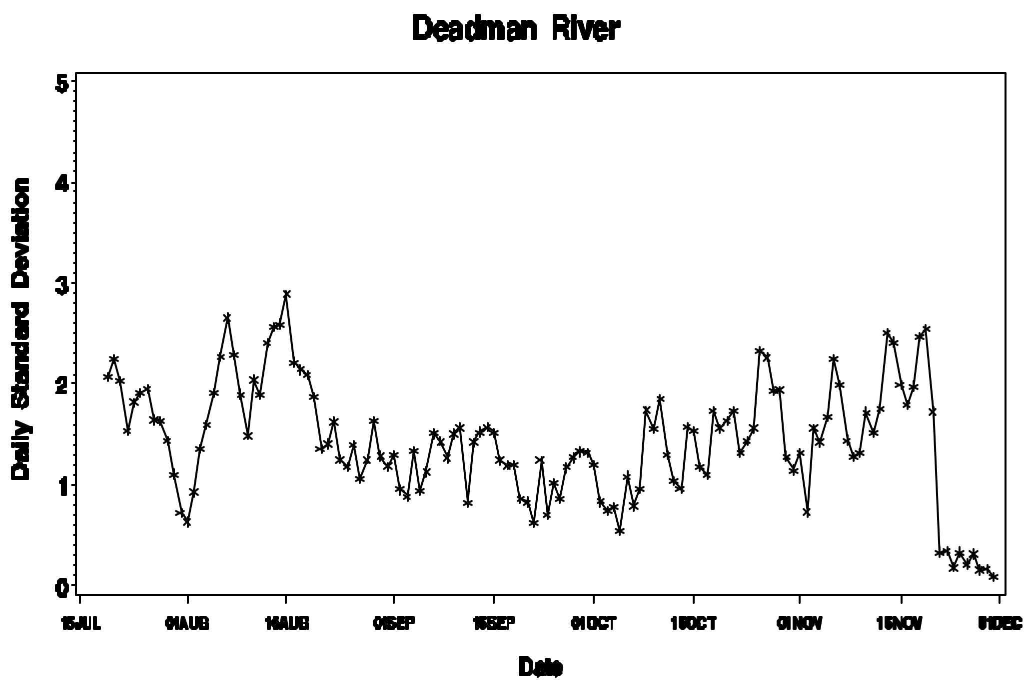

Figure 2n Daily standard deviation of the mean difference between ALL control (non-groundwater) and groundwater sites in Deadman River.

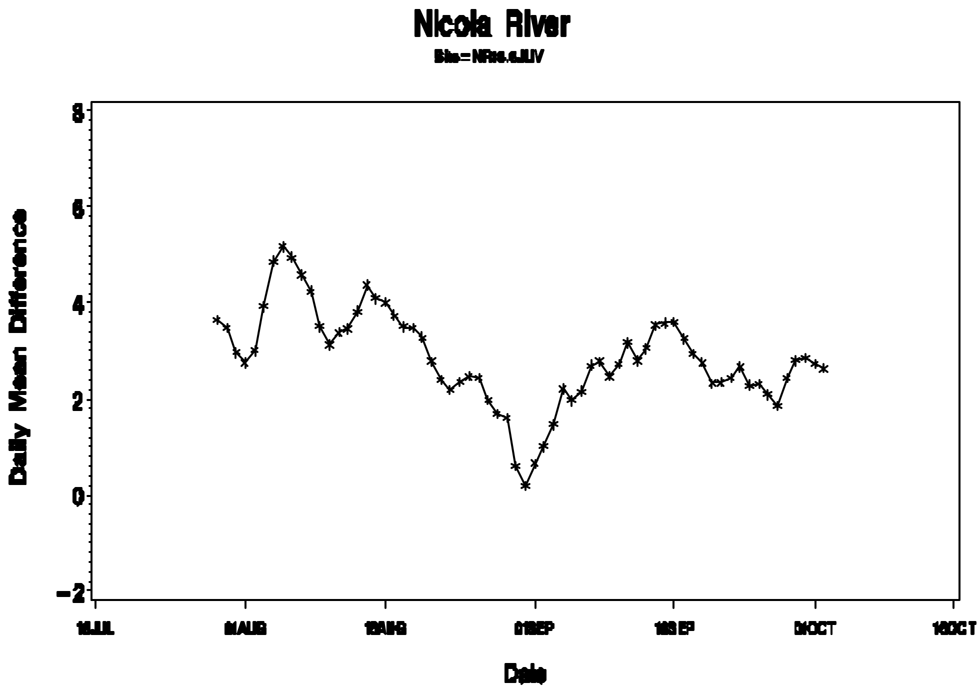

Figure 2o Daily mean difference between control (non-groundwater) and groundwater at site NR18.6JUV in Nicola River.

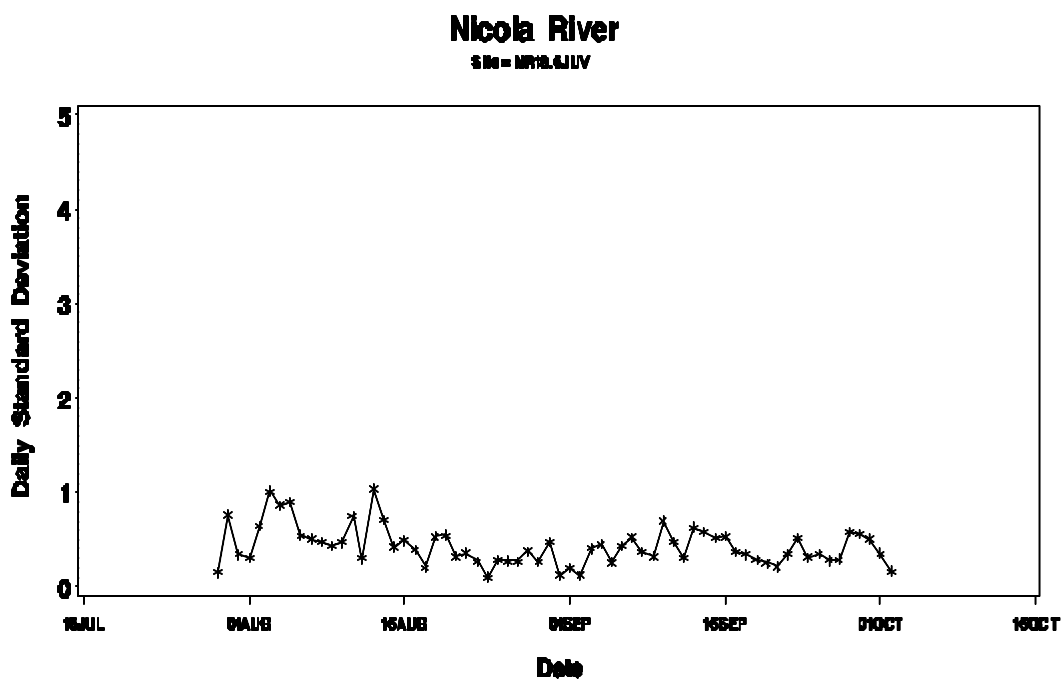

Figure 2p Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site NR18.6JUV in Nicola River.

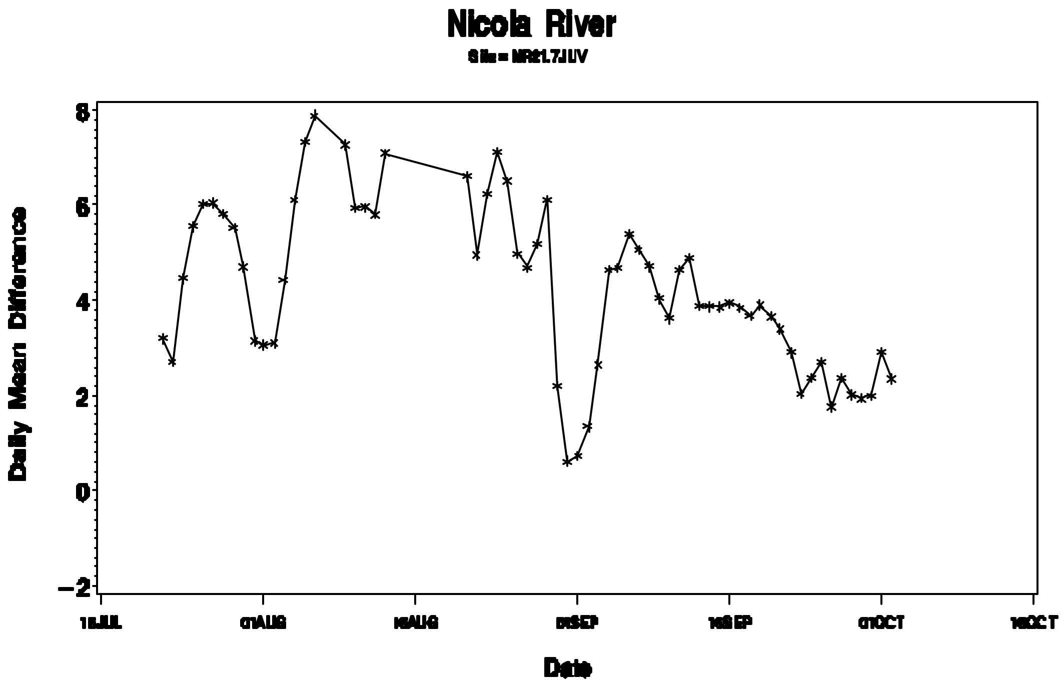

Figure 2q Daily mean difference between control (non-groundwater) and groundwater at site NR21.7JUV in Nicola River.

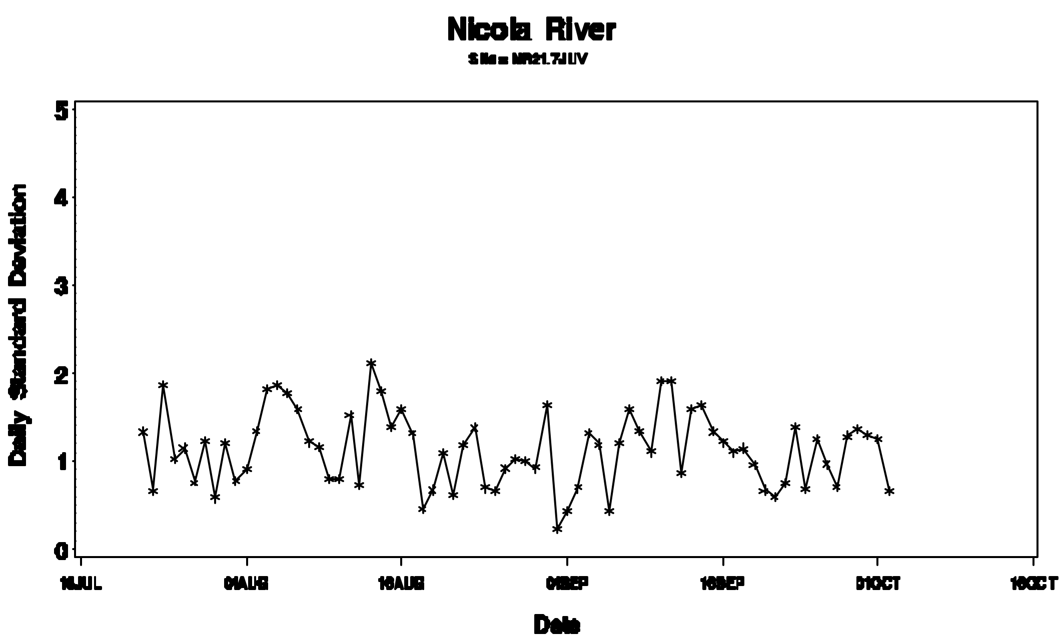

Figure 2r Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site NR21.7JUV in Nicola River.

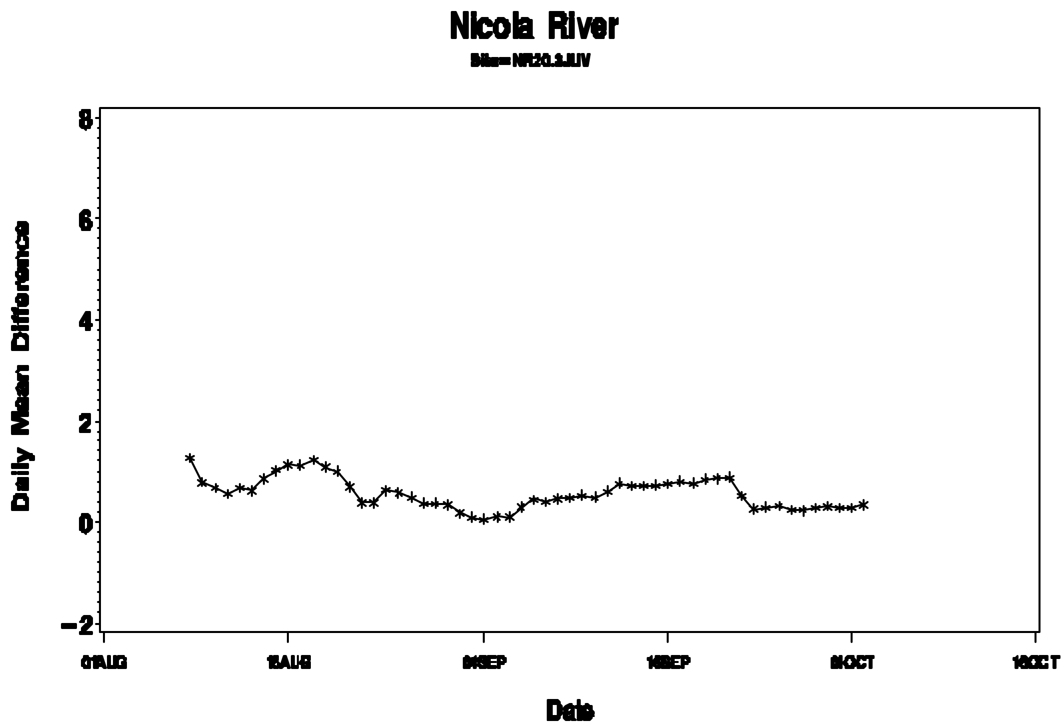

Figure 2s Daily mean difference between control (non-groundwater) and groundwater at site NR20.3JUV in Nicola River.

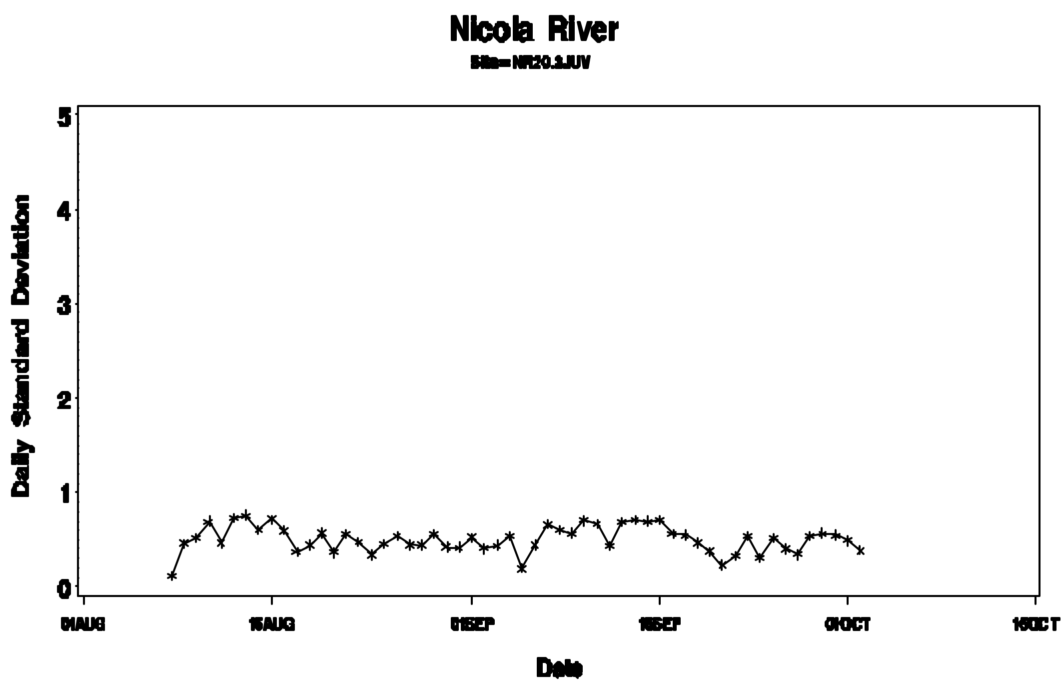

Figure 2t Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at NR20.3JUV in Nicola River.

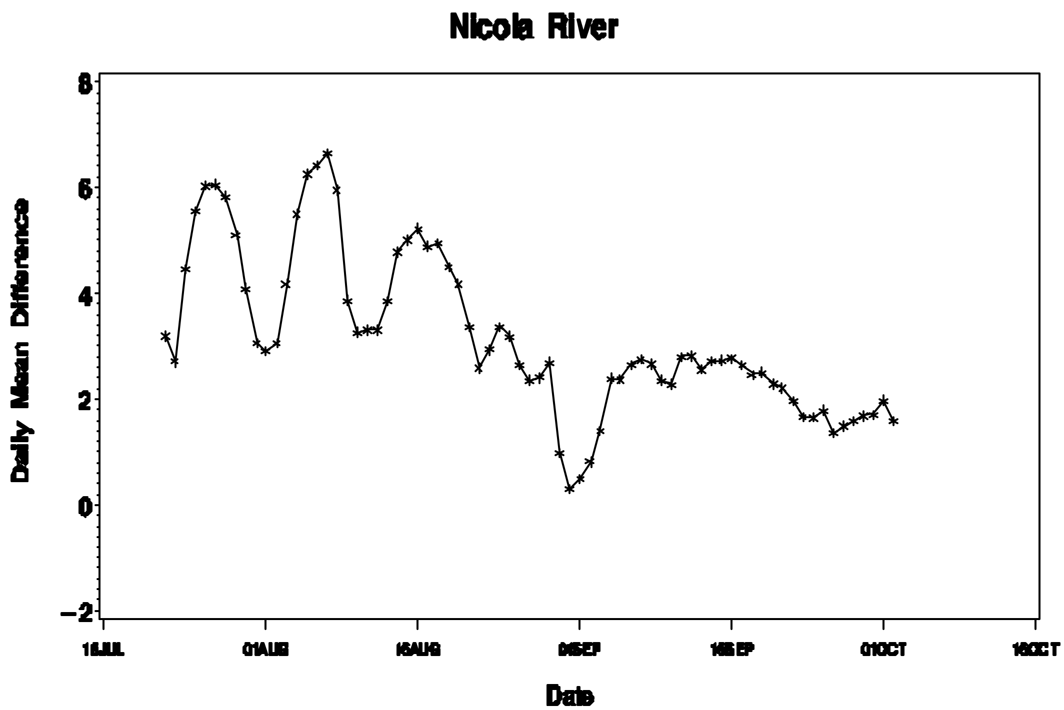

Figure 2u Daily mean difference between ALL control (non-groundwater) and groundwater sites in Nicola River.

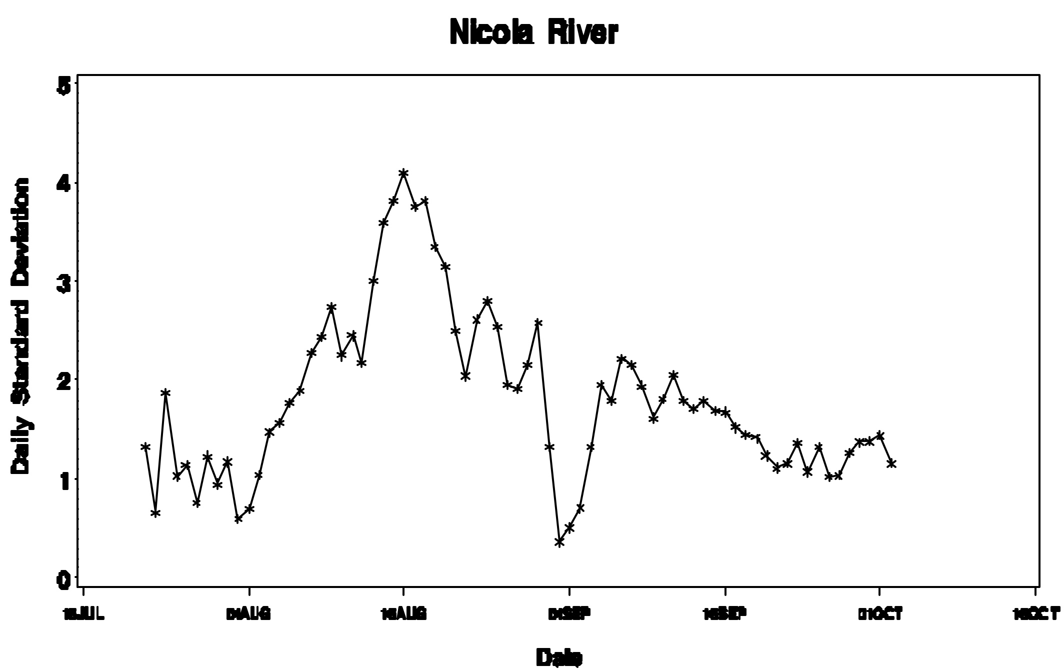

Figure 2v Daily standard deviation of the mean difference between ALL control (non-groundwater) and groundwater sites in Nicola River.

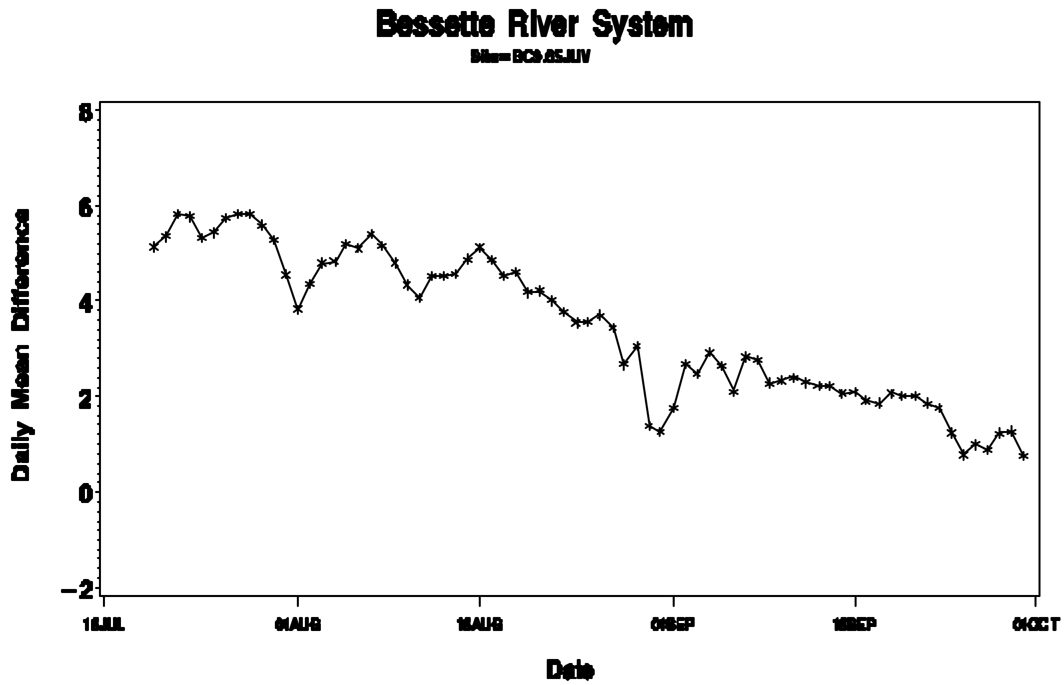

Figure 2w Daily mean difference between control (non-groundwater) and groundwater at site BC9.65JUV in Bessette Creek.

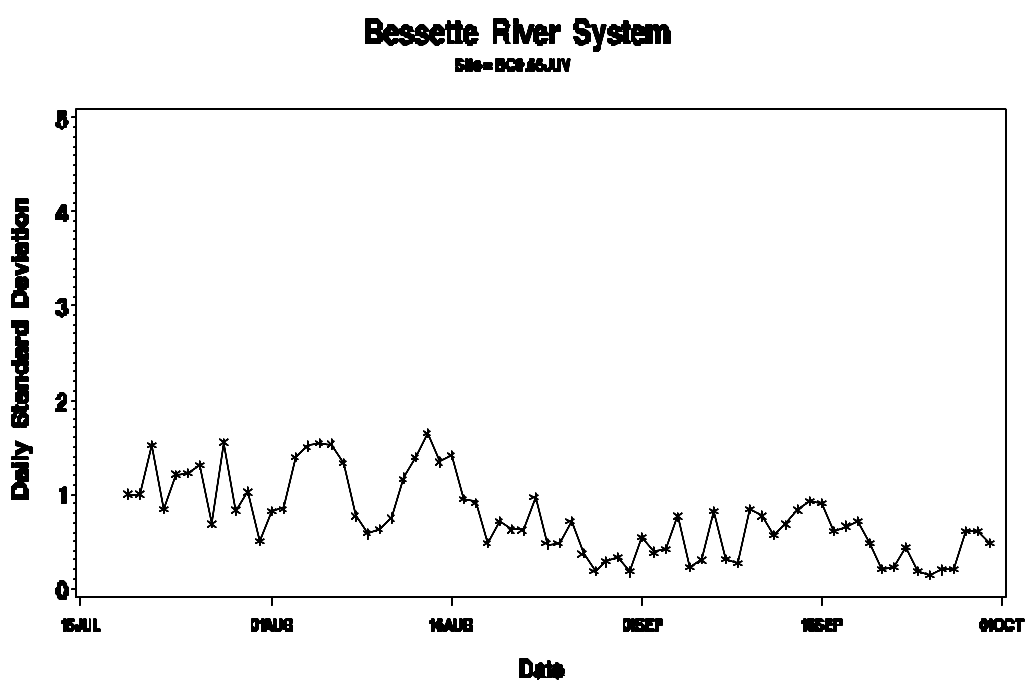

Figure 2x Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site BC9.65JUV in Bessette Creek.

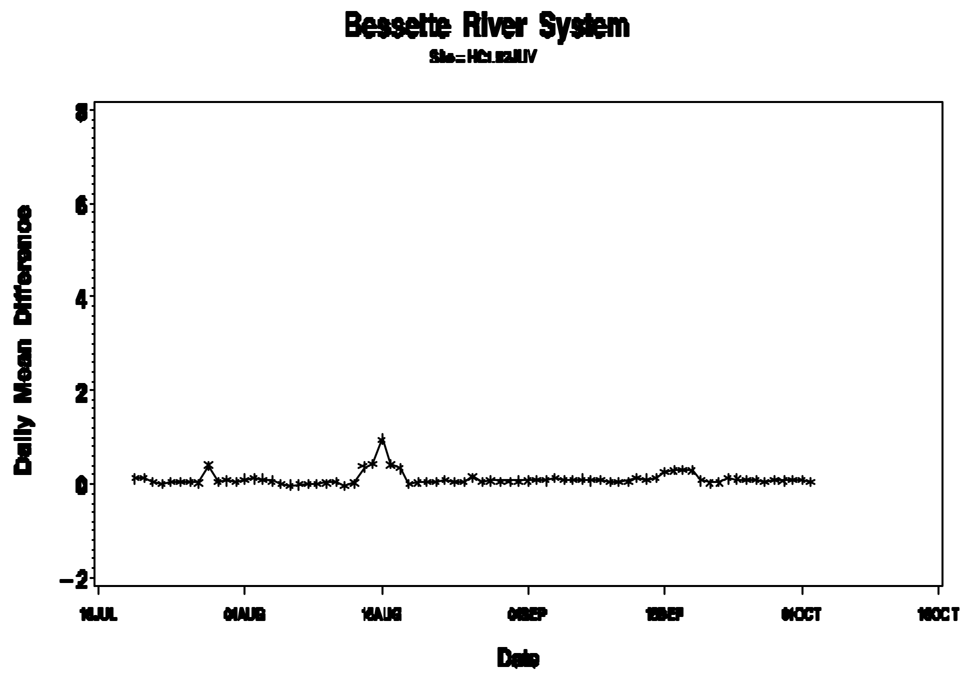

Figure 2y Daily mean difference between control (non-groundwater) and groundwater at site HC1.92JUV in Bessette Creek.

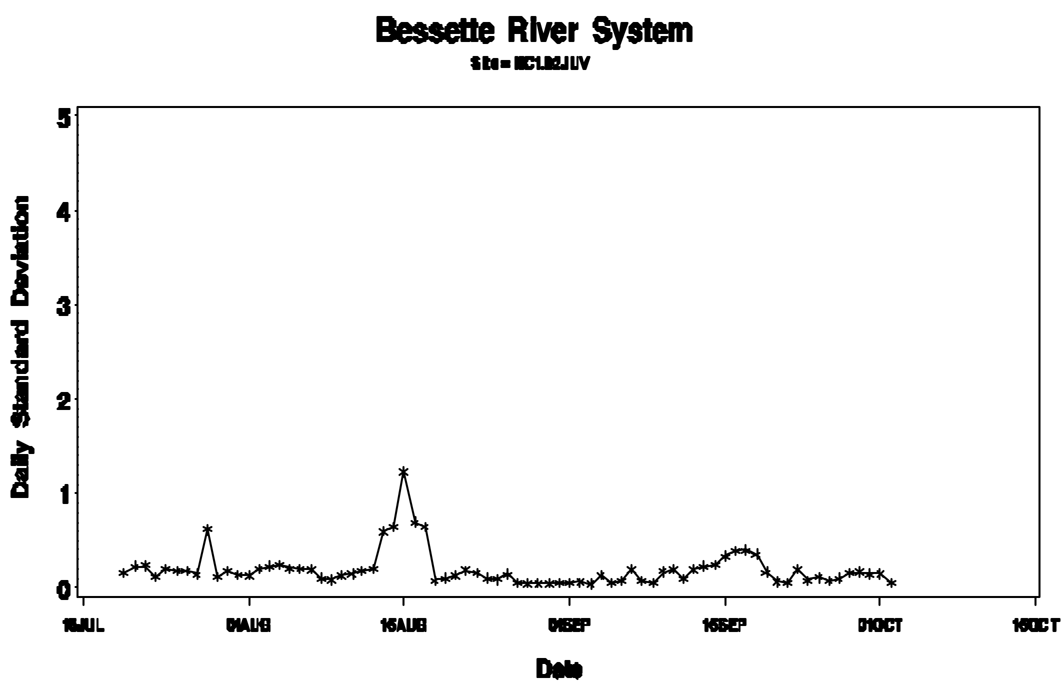

Figure 2z Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site HC1.92JUV in Bessette Creek.

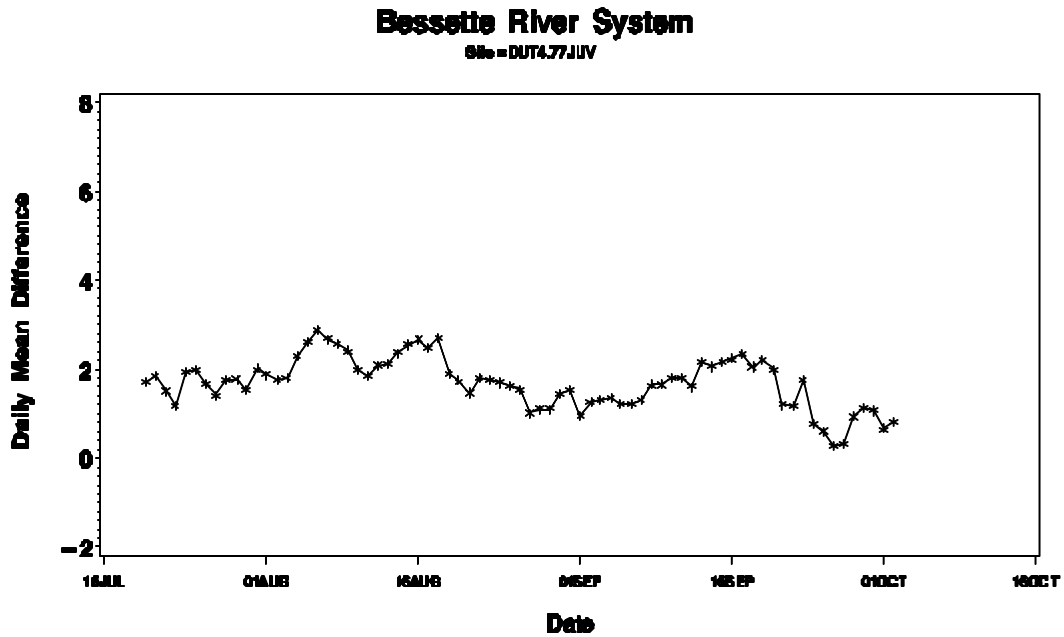

Figure 2za Daily mean difference between control (non-groundwater) and groundwater at site DUT4.77JUV in Bessette Creek.

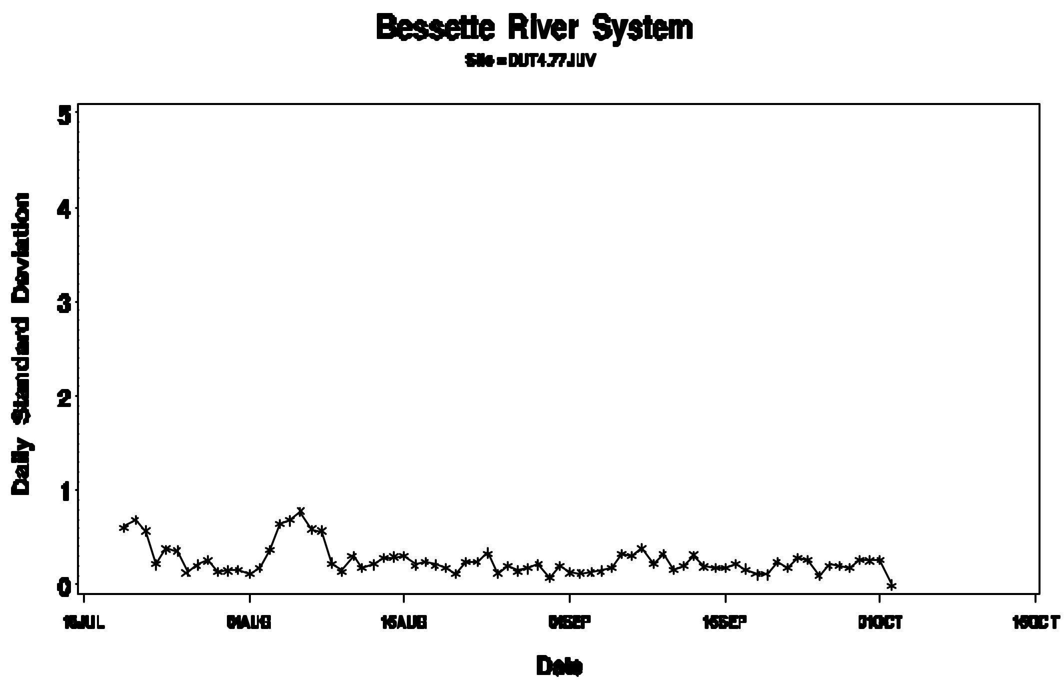

Figure 2zb Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at site DUT4.77JUV in Bessette Creek.

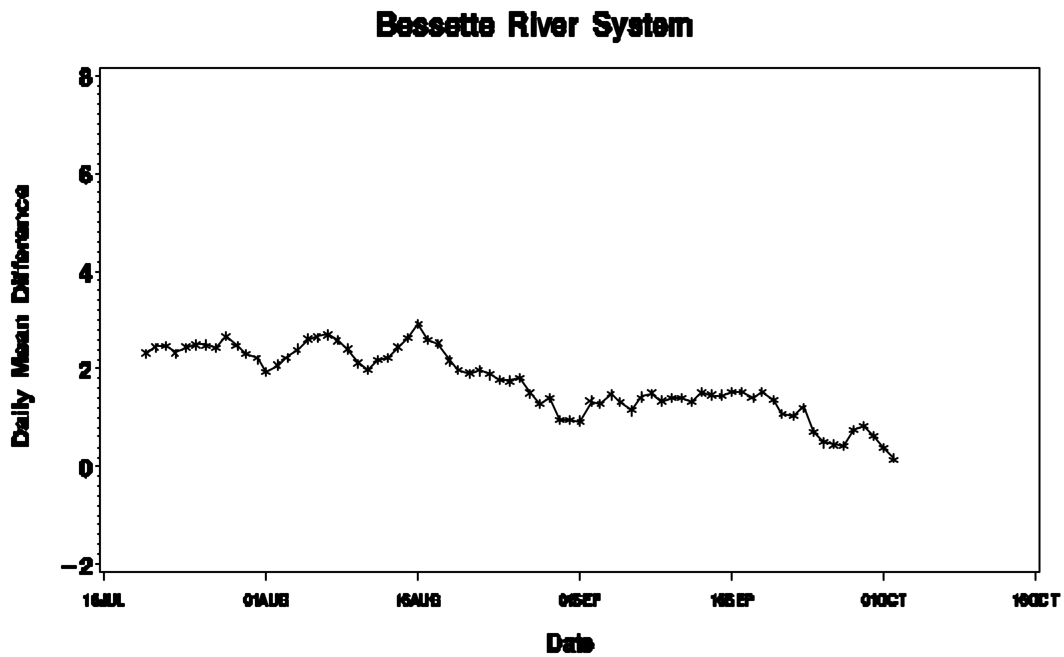

Figure 2zc Daily mean difference between ALL control (non-groundwater) and groundwater sites in Bessette Creek.

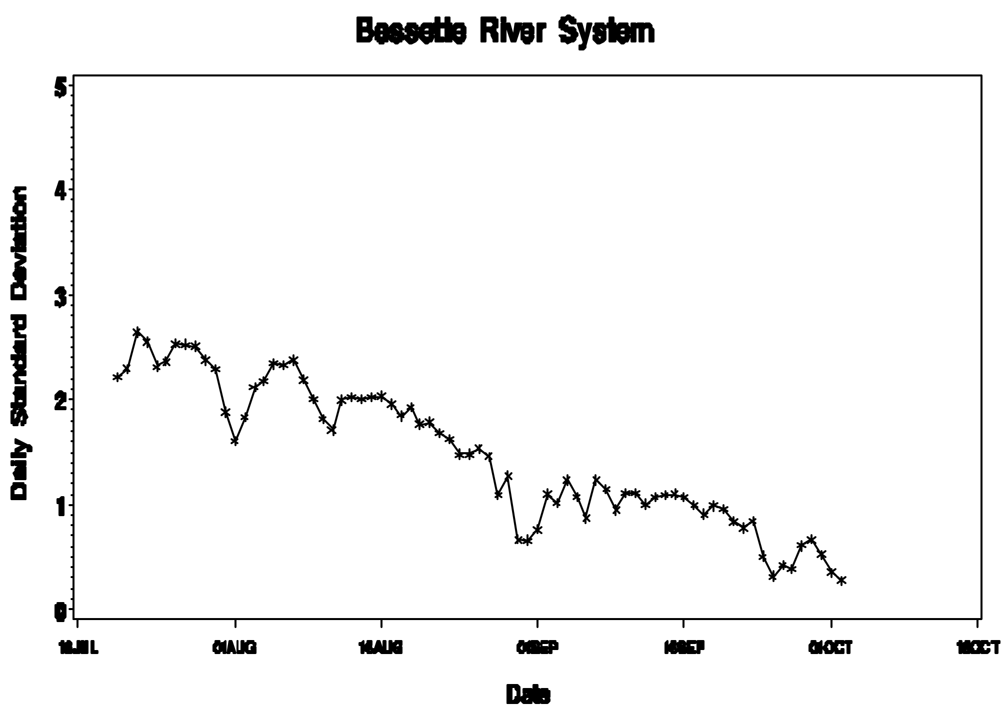

Figure 2zd Daily standard deviation of the mean difference between ALL control (non-groundwater) and groundwater sites in Bessette Creek.

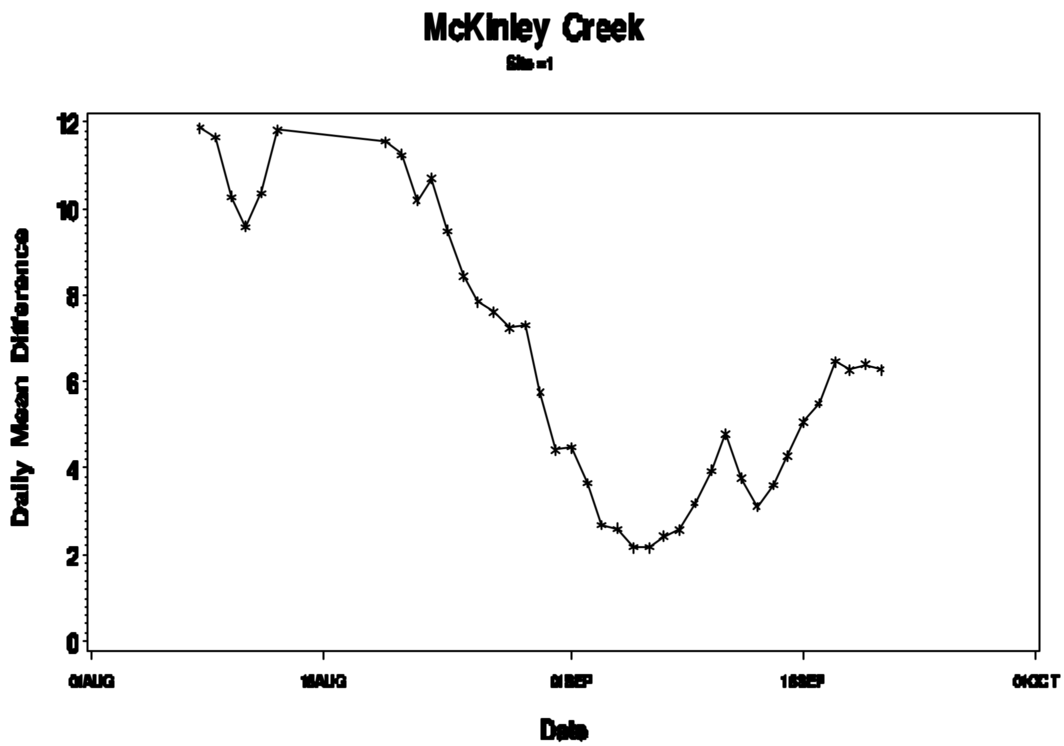

Figure 2ze Daily mean difference between control (non-groundwater) and groundwater at Site 1 in McKinley Creek

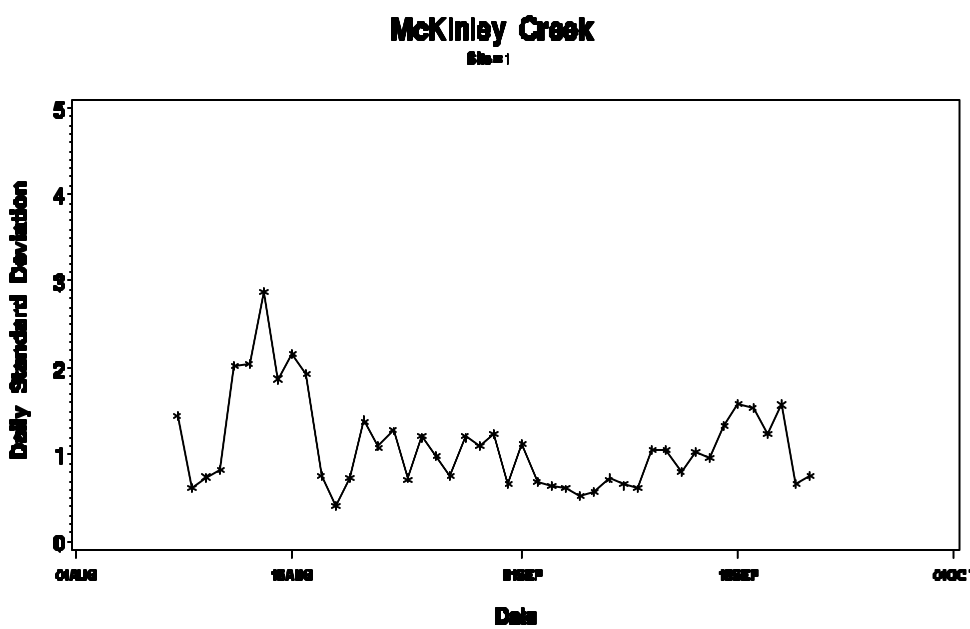

Figure 2zf Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at Site 1 in McKinley Creek

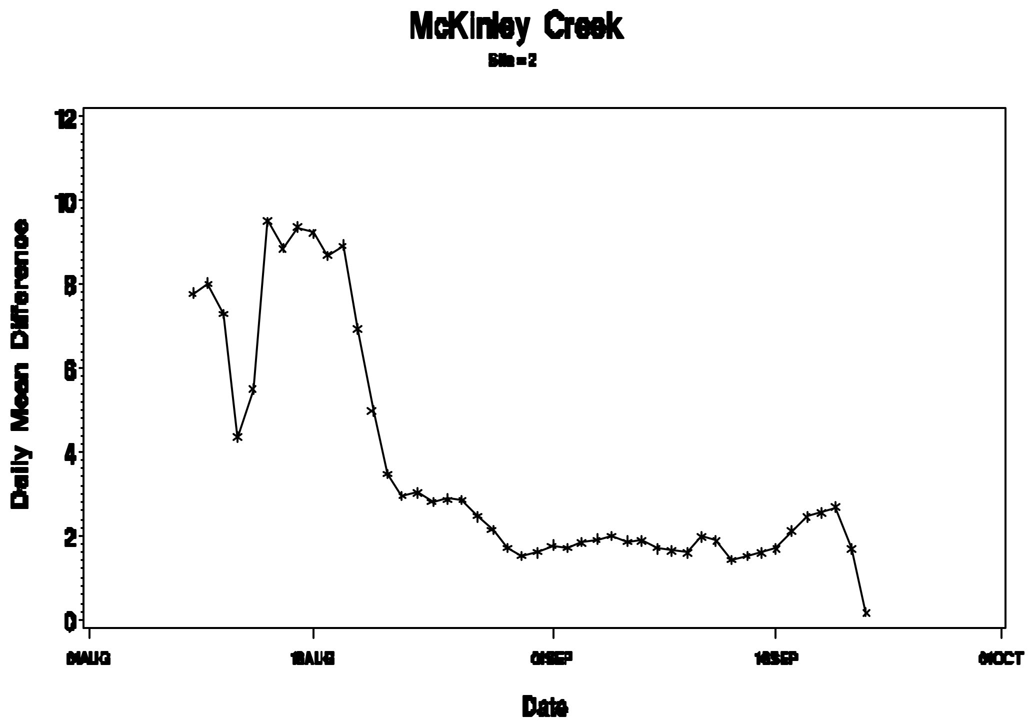

Figure 2zg Daily mean difference between control (non-groundwater) and groundwater at Site 2 in McKinley Creek.

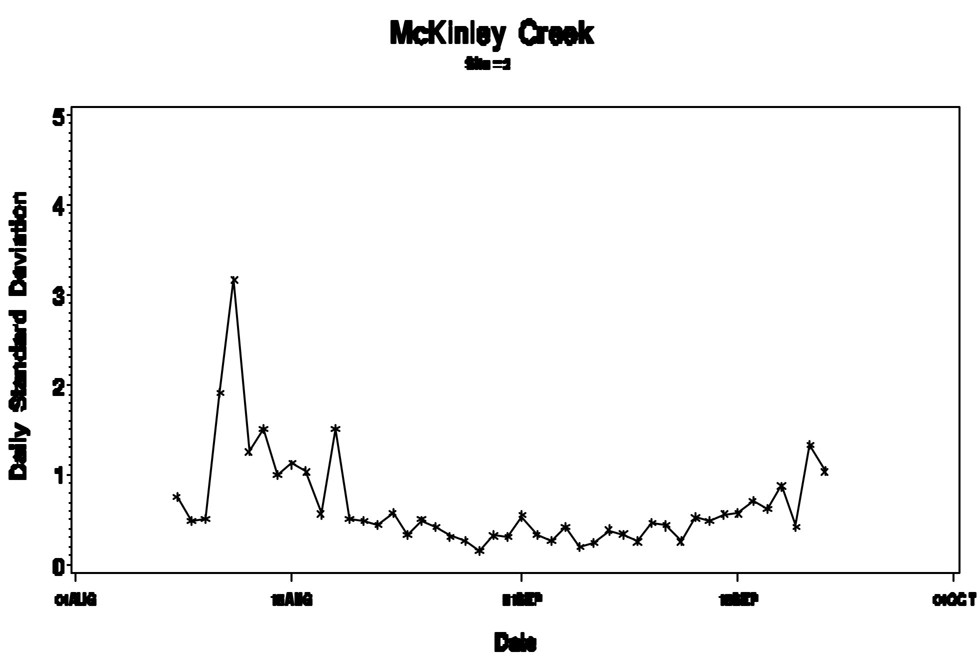

Figure 2zh Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at Site 2 in McKinley Creek

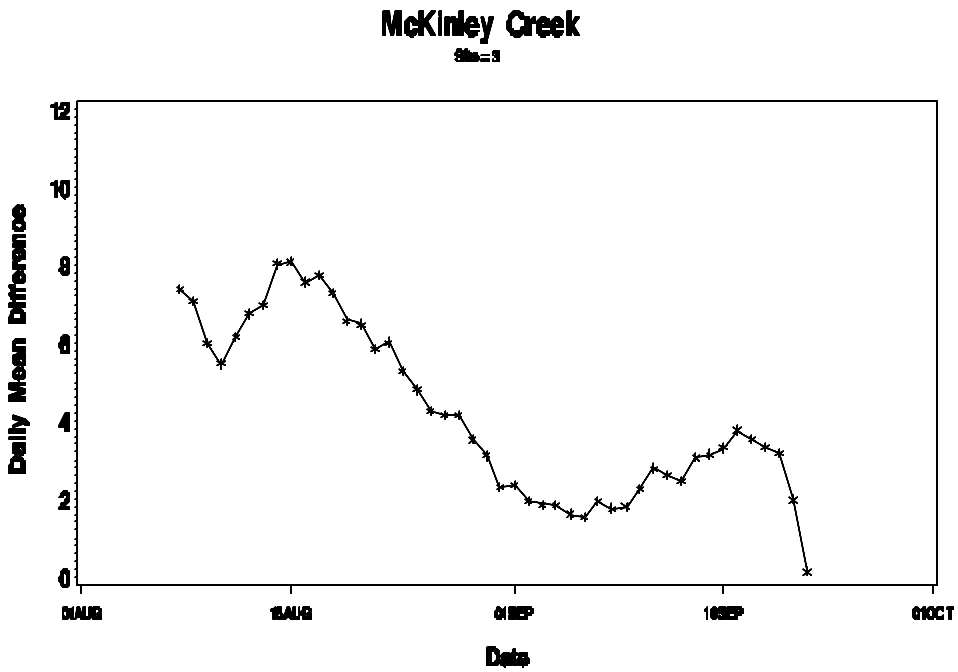

Figure 2zi Daily mean difference between control (non-groundwater) and groundwater at Site 3 in McKinley Creek.

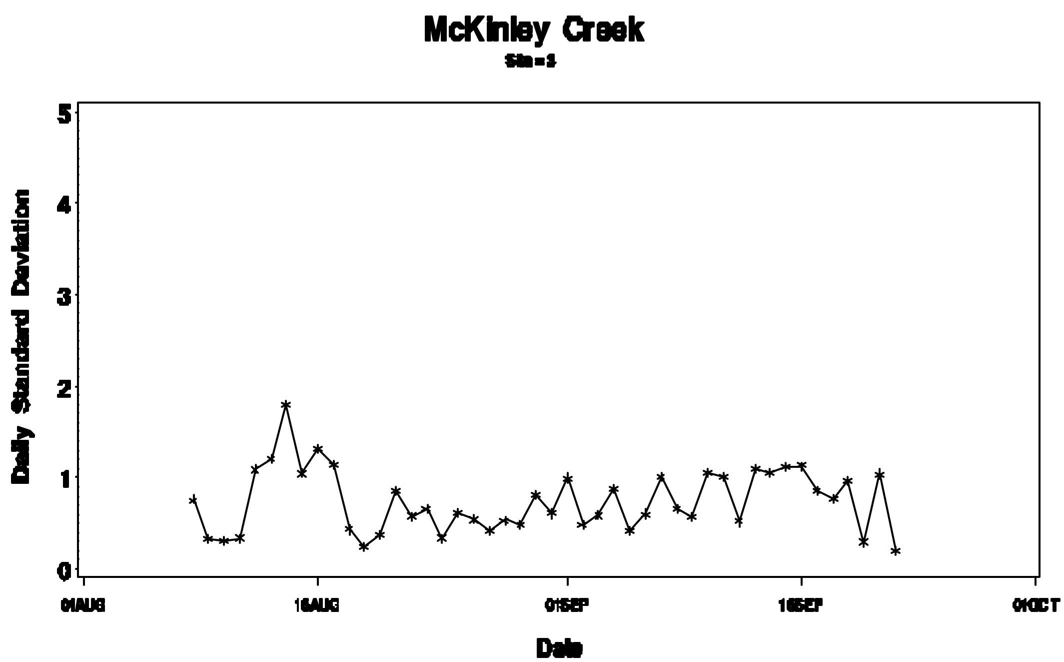

Figure 2zj Daily standard deviation of the mean difference between control (non-groundwater) and groundwater at Site 3 in McKinley Creek

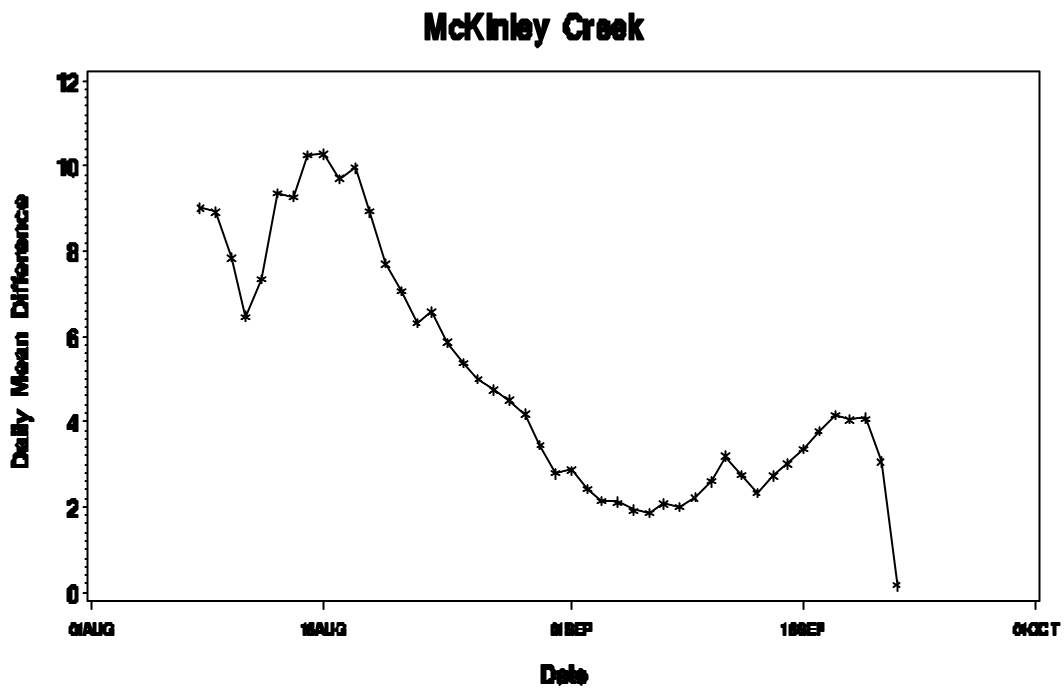

Figure 2zk Daily mean difference between ALL combined control (non-groundwater) and groundwater sites within McKinley Creek.

Figure 2zl Daily standard deviation of the mean difference between ALL control (non-groundwater) and groundwater sites within McKinley Creek.

APPENDIX 3 - SNORKEL COUNTS BY SPECIES

Table C-1 Coho counts for the Thompson tributaries

Site	Date	Time	Total Coho Count	
			Groundwater Site	Control Site
LC13.9juv	9-Jul	17:15	0	0
LC13.9juv	9-Jul	22:00	13	7
LC13.9juv	10-Jul	17:26	8	0
LC13.9juv	10-Jul	20:40	36	13
LC13.9juv	21-Jul	17:56	11	11
LC13.9juv	21-Jul	23:42	47	18
LC13.9juv	23-Jul	18:04	25	4
LC13.9juv	23-Jul	23:55	54	4
LC13.9juv	5-Aug	18:11	13	11
LC13.9juv	5-Aug	23:29	26	18
LC13.9juv	6-Aug	18:52	38	24
LC13.9juv	6-Aug	23:33	62	28
LC15.6juv	17-Jul	18:17	6	0
LC15.6juv	17-Jul	22:16	32	27
LC15.6juv	21-Jul	17:29	7	0
LC15.6juv	21-Jul	23:07	44	13
LC15.6juv	23-Jul	18:25	14	7
LC15.6juv	23-Jul	23:10	60	12
LC15.6juv	5-Aug	17:43	10	13
LC15.6juv	5-Aug	22:58	36	26
LC15.6juv	6-Aug	18:20	23	0
LC15.6juv	6-Aug	23:04	46	5
LC25.5juv	9-Jul	18:30	0	0
LC25.5juv	9-Jul	23:10	12	11
LC25.5juv	10-Jul	18:42	0	1
LC25.5juv	10-Jul	23:51	17	35
LC25.5juv	21-Jul	16:56	1	18
LC25.5juv	21-Jul	22:20	29	51
LC25.5juv	23-Jul	17:42	0	32
LC25.5juv	23-Jul	22:18	41	50
LC25.5juv	5-Aug	16:47	16	57
LC25.5juv	5-Aug	22:09	28	29
LC25.5juv	6-Aug	17:24	22	52
LC25.5juv	6-Aug	22:09	64	76
HC1.92juv	22-Jul	18:15	12	4
HC1.92juv	22-Jul	23:02	13	2
HC1.92juv	12-Aug	17:25	2	7

HC1.92juv	12-Aug	22:00	0	0
HC1.92juv	13-Aug	17:50	0	0
HC1.92juv	13-Aug	22:00	9	7
DUT4.77juv	22-Jul	19:12	3	2
DUT4.77juv	22-Jul	0:06	3	0
DUT4.77juv	12-Aug	18:30	10	0
DUT4.77juv	12-Aug	23:15	0	0
DUT4.77juv	13-Aug	18:35	0	0
DUT4.77juv	13-Aug	23:00	0	0
DM14.1juv	8-Jul	20:14	0	0
DM14.1juv	8-Jul	23:24	3	1
DM14.1juv	9-Jul	19:13	0	0
DM14.1juv	9-Jul	23:09	16	2
DM14.1juv	23-Jul	19:55	1	0
DM14.1juv	23-Jul	23:17	0	1
DM14.1juv	24-Jul	19:18	0	0
DM14.1juv	24-Jul	22:54	6	1
DM14.1juv	6-Aug	20:12	0	0
DM14.1juv	6-Aug	22:55	27	0
DM14.1juv	7-Aug	19:17	3	0
DM14.1juv	7-Aug	22:55	19	1
DM14.1juv	20-Aug	19:30	0	0
DM14.1juv	20-Aug	22:41	0	1
DM14.1juv	21-Aug	19:09	0	0
DM14.1juv	21-Aug	22:32	0	0
DM25.4juv	8-Jul	19:25	40	0
DM25.4juv	8-Jul	22:36	73	1
DM25.4juv	9-Jul	18:34	36	1
DM25.4juv	9-Jul	22:28	42	0
DM25.4juv	23-Jul	19:13	49	17
DM25.4juv	23-Jul	22:23	37	21
DM25.4juv	24-Jul	18:40	48	27
DM25.4juv	24-Jul	22:14	48	10
DM25.4juv	6-Aug	not available	0	74
DM25.4juv	6-Aug	22:12	30	18
DM25.4juv	7-Aug	18:43	43	85
DM25.4juv	7-Aug	22:33	43	58
DM25.4juv	20-Aug	19:00	42	18
DM25.4juv	20-Aug	22:07	34	1
DM25.4juv	21-Aug	18:39	29	21
DM25.4juv	21-Aug	21:38	46	27
NR18.6juv	21-Jul	15:48	3	8
NR18.6juv	21-Jul	0:00	8	2

NR18.6juv	22-Jul	18:00	4	2
NR18.6juv	22-Jul	23:45	1	1
NR18.6juv	6-Aug	18:40	9	0
NR18.6juv	6-Aug	23:30	10	1
NR18.6juv	7-Aug	18:30	2	0
NR18.6juv	7-Aug	23:15	12	1
NR18.6juv	22-Sep	18:45	0	0
NR18.6juv	22-Sep	22:30	1	3
NR18.6juv	23-Sep	18:00	0	0
NR18.6juv	23-Sep	23:10	0	1
NR21.73juv	21-Jul	14:00	18	0
NR21.73juv	21-Jul	21:30	71	0
NR21.73juv	22-Jul	16:00	5	12
NR21.73juv	22-Jul	22:00	15	13
NR21.73juv	6-Aug	16:40	4	5
NR21.73juv	6-Aug	21:30	3	2
NR21.73juv	7-Aug	16:30	0	19
NR21.73juv	7-Aug	21:30	5	1
NR21.73juv	22-Sep	16:30	3	0
NR21.73juv	22-Sep	20:10	3	4
NR21.73juv	23-Sep	16:30	0	0
NR21.73juv	23-Sep	20:45	2	5
NR20.37juv	21-Jul	15:00	3	0
NR20.37juv	21-Jul	22:30	0	0
NR20.37juv	22-Jul	17:00	1	0
NR20.37juv	22-Jul	22:40	5	1
NR20.37juv	6-Aug	17:30	12	0
NR20.37juv	6-Aug	22:35	13	2
NR20.37juv	7-Aug	17:40	2	10
NR20.37juv	7-Aug	22:33	18	4
NR20.37juv	22-Sep	17:30	0	0
NR20.37juv	22-Sep	21:30	1	7
NR20.37juv	23-Sep	17:20	0	0
NR20.37juv	23-Sep	21:50	1	4

Table C-2 Juvenile chinook counts for the Thompson tributaries

Site	Date	Time	Total Chinook Count	
			Groundwater Site	Control Site
LC13.9juv	9-Jul	17:15	0	0
LC13.9juv	9-Jul	22:00	0	3
LC13.9juv	10-Jul	17:26	0	0
LC13.9juv	10-Jul	17:53	0	0
LC13.9juv	10-Jul	20:40	1	3
LC13.9juv	21-Jul	17:56	0	0
LC13.9juv	21-Jul	23:42	0	2
LC13.9juv	23-Jul	18:04	0	2
LC13.9juv	23-Jul	23:55	0	7
LC13.9juv	5-Aug	18:11	16	4
LC13.9juv	5-Aug	23:29	28	5
LC13.9juv	6-Aug	18:52	13	15
LC13.9juv	6-Aug	23:33	14	12
LC15.6juv	17-Jul	18:17	6	0
LC15.6juv	17-Jul	22:16	1	3
LC15.6juv	21-Jul	17:29	1	0
LC15.6juv	21-Jul	23:07	0	8
LC15.6juv	23-Jul	18:25	5	7
LC15.6juv	23-Jul	23:10	0	46
LC15.6juv	5-Aug	17:43	19	0
LC15.6juv	5-Aug	22:58	15	32
LC15.6juv	6-Aug	18:20	16	28
LC15.6juv	6-Aug	23:04	5	16
LC25.5juv	9-Jul	18:30	0	0
LC25.5juv	9-Jul	23:10	1	0
LC25.5juv	10-Jul	18:42	0	0
LC25.5juv	10-Jul	23:51	5	3
LC25.5juv	21-Jul	16:56	0	0
LC25.5juv	21-Jul	22:20	0	0
LC25.5juv	23-Jul	17:42	1	2
LC25.5juv	23-Jul	22:18	5	4
LC25.5juv	5-Aug	16:47	6	5
LC25.5juv	5-Aug	22:09	11	16
LC25.5juv	6-Aug	17:24	14	2
LC25.5juv	6-Aug	22:09	11	1
HC1.92juv	22-Jul	18:15	2	13
HC1.92juv	22-Jul	23:02	0	0
HC1.92juv	12-Aug	17:25	26	25
HC1.92juv	12-Aug	22:00	25	27
HC1.92juv	13-Aug	17:50	22	15

HC1.92juv	13-Aug	22:00	3	49
DUT4.77juv	22-Jul	19:12	5	2
DUT4.77juv	22-Jul	0:06	0	0
DUT4.77juv	12-Aug	18:30	0	12
DUT4.77juv	12-Aug	23:15	0	0
DUT4.77juv	13-Aug	18:35	6	5
DUT4.77juv	13-Aug	23:00	0	0
DM14.1juv	8-Jul	20:14	0	0
DM14.1juv	8-Jul	23:24	0	0
DM14.1juv	9-Jul	19:13	0	0
DM14.1juv	9-Jul	23:09	1	0
DM14.1juv	23-Jul	19:55	0	0
DM14.1juv	23-Jul	23:17	2	0
DM14.1juv	24-Jul	19:18	0	0
DM14.1juv	24-Jul	22:54	1	0
DM14.1juv	6-Aug	20:12	0	0
DM14.1juv	6-Aug	22:55	0	0
DM14.1juv	7-Aug	19:17	0	0
DM14.1juv	7-Aug	22:55	8	0
DM14.1juv	20-Aug	19:30	0	0
DM14.1juv	20-Aug	22:41	0	0
DM14.1juv	21-Aug	19:09	0	0
DM14.1juv	21-Aug	22:32	0	0
DM25.4juv	8-Jul	19:25	0	0
DM25.4juv	8-Jul	22:36	0	0
DM25.4juv	9-Jul	18:34	0	0
DM25.4juv	9-Jul	22:28	1	0
DM25.4juv	23-Jul	19:13	0	0
DM25.4juv	23-Jul	22:23	0	0
DM25.4juv	24-Jul	18:40	0	0
DM25.4juv	24-Jul	22:14	0	0
DM25.4juv	6-Aug	na	0	0
DM25.4juv	6-Aug	22:12	0	0
DM25.4juv	7-Aug	18:43	0	0
DM25.4juv	7-Aug	22:33	0	0
DM25.4juv	20-Aug	19:00	0	0
DM25.4juv	20-Aug	22:07	1	0
DM25.4juv	21-Aug	18:39	0	0
DM25.4juv	21-Aug	21:38	1	0
NR18.6juv	21-Jul	15:48	6	2
NR18.6juv	21-Jul	0:00	12	6
NR18.6juv	22-Jul	18:00	3	1
NR18.6juv	22-Jul	23:45	5	2
NR18.6juv	6-Aug	18:40	7	0

NR18.6juv	6-Aug	23:30	6	3
NR18.6juv	7-Aug	18:30	5	0
NR18.6juv	7-Aug	23:15	10	3
NR18.6juv	22-Sep	18:45	0	0
NR18.6juv	22-Sep	22:30	7	4
NR18.6juv	23-Sep	18:00	0	0
NR18.6juv	23-Sep	23:10	2	1
NR21.73juv	21-Jul	14:00	26	0
NR21.73juv	21-Jul	21:30	71	0
NR21.73juv	22-Jul	16:00	10	13
NR21.73juv	22-Jul	22:00	13	23
NR21.73juv	6-Aug	16:40	2	4
NR21.73juv	6-Aug	21:30	4	0
NR21.73juv	7-Aug	16:30	0	17
NR21.73juv	7-Aug	21:30	4	2
NR21.73juv	22-Sep	16:30	0	0
NR21.73juv	22-Sep	20:10	8	6
NR21.73juv	23-Sep	16:30	1	0
NR21.73juv	23-Sep	20:45	14	5
NR20.37juv	21-Jul	15:00	2	0
NR20.37juv	21-Jul	22:30	0	22
NR20.37juv	22-Jul	17:00	3	9
NR20.37juv	22-Jul	22:40	5	16
NR20.37juv	6-Aug	17:30	8	0
NR20.37juv	6-Aug	22:35	6	1
NR20.37juv	7-Aug	17:40	4	7
NR20.37juv	7-Aug	22:33	14	3
NR20.37juv	22-Sep	17:30	0	0
NR20.37juv	22-Sep	21:30	3	2
NR20.37juv	23-Sep	17:20	0	0
NR20.37juv	23-Sep	21:50	12	8

Table C-3 Rainbow trout counts for the Thompson tributaries

Site	Date	Time	Total Rainbow Trout Count	
			Groundwater Site	Control Site
LC13.9juv	9-Jul	17:15	0	0
LC13.9juv	9-Jul	22:00	8	5
LC13.9juv	10-Jul	17:26	0	0
LC13.9juv	10-Jul	17:53	0	0
LC13.9juv	10-Jul	20:40	7	2
LC13.9juv	21-Jul	17:56	2	0
LC13.9juv	21-Jul	23:42	17	2
LC13.9juv	23-Jul	18:04	14	0
LC13.9juv	23-Jul	23:55	14	0
LC13.9juv	5-Aug	18:11	2	3
LC13.9juv	5-Aug	23:29	9	0
LC13.9juv	6-Aug	18:52	7	0
LC13.9juv	6-Aug	23:33	18	0
LC15.6juv	17-Jul	18:17	0	0
LC15.6juv	17-Jul	22:16	5	1
LC15.6juv	21-Jul	17:29	2	0
LC15.6juv	21-Jul	23:07	12	7
LC15.6juv	23-Jul	18:25	7	5
LC15.6juv	23-Jul	23:10	16	7
LC15.6juv	5-Aug	17:43	4	11
LC15.6juv	5-Aug	22:58	9	17
LC15.6juv	6-Aug	18:20	12	1
LC15.6juv	6-Aug	23:04	17	9
LC25.5juv	9-Jul	18:30	0	0
LC25.5juv	9-Jul	23:10	8	11
LC25.5juv	10-Jul	18:42	0	0
LC25.5juv	10-Jul	23:51	16	18
LC25.5juv	21-Jul	16:56	2	2
LC25.5juv	21-Jul	22:20	17	9
LC25.5juv	23-Jul	17:42	3	3
LC25.5juv	23-Jul	22:18	19	20
LC25.5juv	5-Aug	16:47	3	8
LC25.5juv	5-Aug	22:09	21	11
LC25.5juv	6-Aug	17:24	6	11
LC25.5juv	6-Aug	22:09	28	23
HC1.92juv	22-Jul	18:15	21	49
HC1.92juv	22-Jul	23:02	70	18
HC1.92juv	12-Aug	17:25	50	93
HC1.92juv	12-Aug	22:00	87	69
HC1.92juv	13-Aug	17:50	45	75

HC1.92juv	13-Aug	22:00	69	36
DUT4.77juv	22-Jul	19:12	2	10
DUT4.77juv	22-Jul	0:06	8	3
DUT4.77juv	12-Aug	18:30	19	21
DUT4.77juv	12-Aug	23:15	5	12
DUT4.77juv	13-Aug	18:35	8	13
DUT4.77juv	13-Aug	23:00	4	7
DM14.1juv	8-Jul	20:14	9	0
DM14.1juv	8-Jul	23:24	7	4
DM14.1juv	9-Jul	19:13	0	0
DM14.1juv	9-Jul	23:09	5	11
DM14.1juv	23-Jul	19:55	0	0
DM14.1juv	23-Jul	23:17	12	2
DM14.1juv	24-Jul	19:18	0	0
DM14.1juv	24-Jul	22:54	1	2
DM14.1juv	6-Aug	20:12	0	1
DM14.1juv	6-Aug	22:55	3	3
DM14.1juv	7-Aug	19:17	0	0
DM14.1juv	7-Aug	22:55	3	3
DM14.1juv	20-Aug	19:30	1	0
DM14.1juv	20-Aug	22:41	8	1
DM14.1juv	21-Aug	19:09	2	1
DM14.1juv	21-Aug	22:32	1	2
DM25.4juv	8-Jul	19:25	0	19
DM25.4juv	8-Jul	22:36	2	10
DM25.4juv	9-Jul	18:34	0	25
DM25.4juv	9-Jul	22:28	2	19
DM25.4juv	23-Jul	19:13	0	7
DM25.4juv	23-Jul	22:23	2	6
DM25.4juv	24-Jul	18:40	1	7
DM25.4juv	24-Jul	22:14	2	1
DM25.4juv	6-Aug	na	0	0
DM25.4juv	6-Aug	22:12	3	1
DM25.4juv	7-Aug	18:43	0	0
DM25.4juv	7-Aug	22:33	1	6
DM25.4juv	20-Aug	19:00	4	7
DM25.4juv	20-Aug	22:07	1	1
DM25.4juv	21-Aug	18:39	0	3
DM25.4juv	21-Aug	21:38	0	5
NR18.6juv	21-Jul	15:48	8	1
NR18.6juv	21-Jul	0:00	12	5
NR18.6juv	22-Jul	18:00	10	11
NR18.6juv	22-Jul	23:45	12	6
NR18.6juv	6-Aug	18:40	10	3

NR18.6juv	6-Aug	23:30	15	5
NR18.6juv	7-Aug	18:30	5	3
NR18.6juv	7-Aug	23:15	15	2
NR18.6juv	22-Sep	18:45	0	0
NR18.6juv	22-Sep	22:30	2	6
NR18.6juv	23-Sep	18:00	0	0
NR18.6juv	23-Sep	23:10	1	5
NR21.73juv	21-Jul	14:00	15	3
NR21.73juv	21-Jul	21:30	57	8
NR21.73juv	22-Jul	16:00	14	12
NR21.73juv	22-Jul	22:00	17	22
NR21.73juv	6-Aug	16:40	6	3
NR21.73juv	6-Aug	21:30	8	1
NR21.73juv	7-Aug	16:30	1	3
NR21.73juv	7-Aug	21:30	17	5
NR21.73juv	22-Sep	16:30	0	0
NR21.73juv	22-Sep	20:10	8	11
NR21.73juv	23-Sep	16:30	0	0
NR21.73juv	23-Sep	20:45	10	26
NR20.37juv	21-Jul	15:00	6	6
NR20.37juv	21-Jul	22:30	5	13
NR20.37juv	22-Jul	17:00	5	6
NR20.37juv	22-Jul	22:40	7	10
NR20.37juv	6-Aug	17:30	12	20
NR20.37juv	6-Aug	22:35	18	3
NR20.37juv	7-Aug	17:40	3	5
NR20.37juv	7-Aug	22:33	19	3
NR20.37juv	22-Sep	17:30	0	0
NR20.37juv	22-Sep	21:30	5	8
NR20.37juv	23-Sep	17:20	0	0
NR20.37juv	23-Sep	21:50	8	10

APPENDIX 4 – HABITAT CHARACTERISTIC OF SNORKELLED SITES

Table D-1 Louis Creek Habitat Characteristics

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover	Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC13.9GW	GW	60m	6m		0	0	2	0	20	0	1-20%	Ever-green

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	41	13.7	19.8	1.6	G	0	n	4	12	7	16	41	SA	100
2	37				G	0	n	4	18	15	26	37	SA	100
3	40				G	0	n	15	15.5	18	19	5	SA	100
4	48.5				G	0	n	2	23	25	41.5	7	SA	100
5	40				G	0	n	1.5	19	38	30	4	SCB	40
6	30				G	0	n	2	30	31	21	3	SCB	30
7	50	9.6	15.9	1.7	G	0	n	3	45	55	36	2	SCB	30

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover	Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC13.9	Control	44m	4m		0	0	2	0	20	0	1-20%	Mixed

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	38.5	12.5			G	0	n	2	18	9	24	9	SA	100
2	48				G	0	n	6	15	18	38	12	SA	100
3	39				G	0	n	6	25	33	39	6	SCB	5
4	44				G	1.8	n	4	18	34	35	4	SCB	5
5	38	8	16.6	1.4	G	0	n	4	38	32	21	3.5	SCB	50

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover	Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC25.5GW	GW	50m	5m		0	5	5	0	40	0	1-20%	Mixed

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	69	6.2	9.5	1.23	G	0	n	3.5	46	68	43	7	SCB	10
2	47				LCR	0	n	5.5	32	47	36	3.5	SCB	80
3	41				LCR	0	n	8	31	41	29	22	SCB	80
4	44.5				G	0	n	6	44.5	27	17	2	SA	95
5	64				G	0	n	2	64	53	41.5	4	SA	90
6	26	6.45	11.6	0.96	SCR	0	n	5	26	21	16	2	GF	80

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover	Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC25.5GW	Control	50m	5m		0	5	5	0	40	0	1-20%	Mixed

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	69	6.2	9.5	1.23	G	0	n	3.5	46	68	43	7	SCB	10
2	47				LCR	0	n	5.5	32	47	36	3.5	SCB	80
3	41				LCR	0	n	8	31	41	29	22	SCB	80
4	44.5				G	0	n	6	44.5	27	17	2	SA	95
5	64				G	0	n	2	64	53	41.5	4	SA	90
6	26	6.45	11.6	0.96	SCR	0	n	5	26	21	16	2	GF	80

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC16.6GW	GW	30m	3m			1	3	1	0	10	0	1-20%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	108	11.25	18.42	1.7	P	0	n	2	64	108	72	14	SCB	5
2	69				P	0	n	1.5	25	69	47	22	SCB	5
3	69.5				P	0	n	2.5	35	69.5	34	22	SA	90
4	100	9.3	21.6	1.71	P	0	n	3	20	99	91	5	SA	100

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Louis Cr.	LC16.6GW	Control	40m	4m			0	1	0	0	5	0	1-20%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	34	11.1	17.7	90	G	0	n	3	4.5	34	25	3	SCR	90
2	44				G	2.5	n	5	24	0	44	3	SA	100
3	69				P	1.2	n	5	8	69	46	4	SA	100
4	124				P	0	n	13	119	124	94	4	SA	100
5	67	8.6	11.1	1.24	P	0	n	19	67	35	14	3	GC	20

Table D-2 Bessette Creek Habitat Characteristics

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Bessette Cr	BC9.65LOG	GW	12m	1.2m			50	0	10	1	50	0	41-70%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	90	8.9	13.4	0.75	PT	0	n	3	58	79	59	6.5	LCB	15
2	86				PT	0	n	4	43	71	76	21	LCB	10
3	85				PT	0	n	6	46	85	66	5	LCB	10
4	100				P	0	n	13	63	91	71	6	LCB	10
5	98				P	0	n	1	58	98	66	11	LCB	10
6	97	8	16.4	1.04	P	0	n	7	46	95	51	3	LCB	20
7	93				P	0	n	3	60	93	55	4	LCB	20
8	88				P	0	n	2	52	88	56	5	SCB	10
9	109				P	0	n	4	13	90	49	10	LCB	10
10	105	7.3	19.2	1.05	P	0	n	6	28	81	83	8	LCB	10

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Bessette Cr	BC9.65LOG	Control	17m				70	10	0	15	45	0	21-40%	Decid.
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1														
2														
3				NOT COMPLETED										
4														
5														
6														
7														
8														
9														
10														

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Duteau Cr	DUT4.77LOG	GW	8m	0.8m			75	0	0	0	0	0	71-90%	Evergreen
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	42	5.5	8.4	1.2	PT	0	N	8	38	42	14	0	GC	10
2	50				P	0	N	6	39	50	20	4	GC	10
3	58				P	0	Y	1	37	56	30	8	GC	15
4	62				P	0	Y	1	45	58	34	12	GC	15
5	63				P	0	Y	1	44	58	40	9	GC	20
6	61	4.8	8.3	1	P	0	Y	1	31	55	40	0	GC	20
7	58				P	0	N	1	42	58	39	5	GC	15
8	43				LCR	0	N	2	2	38	30	7	LCB	5
9	37				LCR	0	N	5	2	21	23	3	LCB	0
10	25	6.6	9	0.9	LCR	0	N	1	5	8	22	0	SA	10

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Duteau Cr	DUT4.77LOG	Control	9m	0.1m			50	20	0	10	20	5	41-70%	Ever-green
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	62	3.9	7.2	0.9	P	0	n	20	46	61	8	8	GC	15
2	63				P	0	n	22	47	64	8	8	GC	15
3	65				P	0	n	21	46	65	4	4	GC	15
4	60				P	0	n	22	43	60	8	8	GC	10
5	47				P	0	n	25	41	47	42	42	SCB	10
6	52	4.6	5.8	1.2	P	0	n	29	48	40	40	40	SCB	10
7	59				P	0	n	36	59	31	25	25	SCB	10
8	52				P	0	n	39	50	33	6	6	SCB	10
9	50				P	0	n	36	50	35	5	5	SCB	10
10	49	5.6	9.8	0.8	P	0	n	40	42	43	42	42	SCB	10

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Harris Cr	HC1.92LOG	GW	35m	3.5m			40	10	5	10	40	5	41-70%	Decid.

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	46	0.9	1.6	1.6	P	1.5	n	0	42	10	0	17	GC	5
2	82				P	0	n	7	82	53	4	6	GC	5
3	121				P	0	n	2	115	101	56	2	SCB	0
4	65				G	0	n	15	55	44	6	1	GC	0
5	105				P	0	n	1	50	103	51	1	GC	5
6	100	0.6	1.1	1.8	P	0	n	2	75	97	57	2	GC	0
7	60				P	0	n	9	45	40	10	2	GC	0
8	35				G	0	n	1	20	31	12	1	LCB	0
9	35				G	2	n	3	35	0	0	2	SCB	0
10	41	0.6	1.1	1.9	G	1.2	n	5	39	20	0	2	SCB	0

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Harris Cr	HC1.92LOG	Control												

Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1														
2														
3														
4				NOT COMPLETED										
5														
6														
7														
8														
9														
10														

Table D-3 Nicola River Habitat Characteristics

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR21.73LOG	Control	46m	4.6m			5	0	20	10	2	0	0%	Decid.
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	70	26.8	47.5	1.3	G	0	n	0	0	45	63	0	LCB	8
2	78				G	0	n	0	0	43	55	0	LCB	10
3	78				G	0	n	0	30	63	56	0	LCB	10
4	90				G	0	n	0	30	62	58	0	LCB	10
5	73				G	0	n	0	0	46	59	0	LCB	10
6	84	23.1	50.1	2.4	G	0	n	0	0	30	66	0	LCB	15
7	90				G	0	n	0	0	12	78	0	LCB	20
8	92				LCR	0	n	0	0	36	88	0	LCB	15
9	70				LCR	0	n	0	0	34	61	0	LCB	10
10	71	29.3	46.2	3.2	LCR	0	n	0	4	13	60	0	LCB	5

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR21.73LOG	Control	30m	3.3m			0	10	0	0	5	5	0%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	60	32.3	61.2	1.2	G	0	n	0	38	48	28	0	LCB	25
2	67				G	0	n	0	43	44	18	0	LCB	25
3	71				G	0	n	0	42	41	17	0	LCB	25
4	88				G	0	n	0	70	52	30	0	LCB	25
5	93				G	0	n	0	79	46	33	0	LCB	25
6	89	30.6	54.2	1	G	0	n	0	69	38	22	0	LCB	30
7	88				G	0	n	0	64	39	13	0	LCB	30
8	67				G	0	n	0	71	47	17	0	LCB	25
9	69				G	0	n	0	60	48	19	0	LCB	20
10	64	31.5	70.3	1.8	G	0	n	0	52	51	12	0	LCB	20

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR20.36LOG	GW	42	4.5			0	0	2	0	2	0	1-20%	Decid.
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	52	43.9	47.1	1.5	LCR	10.1	N	0	9	0	41	0	LCB	5
2	44				LCR	10.5	N	0	19	0	40	0	LCB	5
3	50				LCR	10.1	N	0	21	0	37	0	LCB	5
4	50				LCR	11.5	N	0	9	0	39	0	LCB	10
5	60				LCR	13.4	N	0	10	0	40	0	LCB	10
6	62	50.6	51.6	1.35	LCR	15.6	N	0	10	0	38	0	LCB	10
7	58				LCR	14.8	N	0	22	0	35	0	LCB	5
8	55				LCR	16.7	N	0	23	0	36	0	LCB	5
9	64				LCR	17.9	N	0	20	0	33	0	LCB	5
10	70	54.9	58.7	1.62	LCR	18.7	N	0	17	0	42	0	LCB	5

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR20.36LOG	Control	50m	5m			0	0	2	2	3	0	0%	Decid.
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	70	54.9	58.7	1.6	LCR	18.7	n	0	17	0	42	0	LCB	15
2	69				LCR	19.4	n	0	0	13	50	0	LCB	15
3	59				LCR	19.1	n	0	0	11	50	0	LCB	15
4	53				LCR	18.6	n	0	0	10	52	0	LCB	20
5	58				LCR	17.3	n	0	0	19	56	0	LCB	15
6	52	67.5	70.2	1.5	LCR	47.1	n	0	0	9	48	0	LCB	20
7	50				LCR	18.6	n	0	0	22	30	0	LCB	20
8	58				LCR	20.8	n	0	0	27	55	0	LCB	20
9	70				LCR	24.6	n	0	0	9	66	0	LCB	25
10	71	77	80.4	1.8	LCR	33	n	0	0	21	58	0	LCB	25

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR18.6LOG	GW	50m	5m			0	0	1	2	5	0	1-20%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	58	36.6	45.3	1.5	G	0	n	0	40	32	27	0	LCB	40
2	58				G	0	n	0	56	30	22	0	LCB	40
3	42				G	0	n	0	38	36	30	0	LCB	40
4	57				G	0	n	0	44	39	31	0	LCB	30
5	50				G	0	n	0	46	35	32	0	LCB	30
6	48	33.7	45.2	1.3	G	0	n	0	29	36	35	0	LCB	40
7	46				G	0	n	0	41	37	38	0	LCB	30
8	55				G	0	n	0	40	37	33	0	LCB	45
9	41				LCR	0	n	0	32	37	34	0	LCB	40
10	48	32.9	45.2	1.4	LCR	0	n	0	32	38	35	0	LCB	40

System	Site Name	Site Type	Site Length	Transect Length	Total Summary of % Cover		Deep Pool	LWD	Boulder	In-stream Veg.	Over-head Veg.	Cut Bank	Crown Closure	Primary Veg.
Nicola R	NR18.6LOG	Control	50m	5m			0	0	1	5	5	0	1-20%	Mixed
Transect #	Thalweg Depth	Wetted Width	Bankfull Width	Bankfull Height	Hab. Type	Bar Width	Back-water	Depths(cm)					Dominant Substrate	
								LB 1	2	Mid 3	4	RB 5	Size Class Code	% Embed.
1	44	31.8	46.3	1.4	LCR	0	n	0	17	40	36	0	LCB	30
2	47				LCR	0	n	0	21	38	40	0	LCB	25
3	49				LCR	0	n	0	27	34	42	0	LCB	25
4	47				G	0	n	0	19	33	46	0	LCB	25
5	49				G	0	n	0	31	32	44	0	LCB	20
6	49	34.2	44.3	1.5	G	0	n	0	33	28	38	0	LCB	20
7	44				G	0	n	0	32	33	36	0	LCB	30
8	52				G	0	n	0	32	29	31	0	LCB	30
9	46				G	0	n	0	30	32	35	0	LCB	25
10	47	34.6	45.1	1.4	G	0	n	0	29	33	42	0	LCB	25