Slocan River Community Water Monitoring 2019-2020

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Contents

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Introduction

The Slocan River Streamkeepers formed in 2003 with a mission to work with the local community to promote awareness of the aquatic environment and engage in restorative and monitoring activities that benefit the Slocan River. Community-based water quality monitoring in the Columbia River basin plays an important role in preserving watershed function for sustainable communities and ecosystems. It is imperative that current and future water quality and quantity concerns be assessed in the Columbia River basin as environmental change poses substantial risk to ecosystem and societal health (Shaw 2013).

Residents and local groups have long expressed concern about the health of the Slocan River. Issues such as channel infilling, bank erosion, lack of trout habitat and declining stocks, decline in riparian vegetation, and changes in water quality have been cited. As livestock range management, agriculture, and recreation use increases, residents have become increasingly concerned about environmental degradation and pollution from anthropogenic activities.

The monitoring program addresses many threats that face the ecological integrity of the Slocan River watershed. Many of these threats have not changed since the arrival of European settlers but rather have been intensified by the impacts of climate change. In their report Shaw suggests that changes in land use and climate pose the greatest threat to both water quality and water quantity in the Columbia River basin (2013). Outcomes of climate change in this area are expected to result in increased water temperature, higher risk of flooding during freshet with extreme precipitation events in between, increased fire hazard, landslides, water shortages, and ultimately the loss of sensitive habitats and biodiversity (Taylor et al. n.d.).

These factors, coupled with cumulative effects of loss, fragmentation, and degradation of habitat caused by human impacts have serious implications. This reasoning provides the framework for this monitoring program. A complete list of risks and threats was outlined by the Slocan River Streamkeepers (Monnier 2020).

Background

Slocan River Community Water Monitoring 2019-2020 is a community-based monitoring program conducted by the Slocan River Streamkeepers. It is a continuation of a program that has been happening intermittently since the 1990's. The program aims to monitor the effects of climate change and human activities on aquatic and floodplain ecosystems that provide habitat for many species and provide drinking sources and agricultural irrigation to local communities. Additionally, the project involves an environmental education program that aims to connect students to the rich and diverse web of life that contributes to a healthy watershed.

This report documents the ecological assessment and educational outreach program in the Slocan Valley for the 2019-2020 year. Previous assessments occurred between 2008 and 2013. Activities resumed in August 2019 and will continue into 2021. Four important issues threatening the integrity of the Slocan Valley watershed were chosen to be addressed:

1. Effects of turbidity caused by stream bank erosion on water quality and aquatic species downstream of the landslide on Little Slocan River,
2. Changes of water levels on community waters sources,
3. The recovery of aquatic life in Lemon Creek.
4. Rising water temperatures in Slocan River and its effect on aquatic ecosystems.

The need for this type of program was identified by: community members, in regards to drinking water safety and availability; scientists, involved in compensation programs to enhance habitat for declining Rainbow Trout populations; private land-owners, living in the Slocan River corridor; members of Slocan River Streamkeepers; a report on Watershed Governance Initiatives conducted by the Regional District of Central Kootenays (RDCK); and BC Forests, Lands, Natural Resources Operations and Rural Development Senior Fish Biologist, Jeff Burrows.

This project was conducted on various streams within the Slocan River watershed, (RDCK Area H). Water temperature sampling sites are located at strategic and historic sites on the Slocan River (Figure 14). Water flow monitoring took place on McFayden Creek, Rice Creek, Trozzo Creek, and Ravine Creek (Figure 5). The education outreach program with the Whole School was scheduled to take place on Winlaw Creek but until further notice has been delayed due to the Covid-19 pandemic. Monitoring of benthic invertebrates and CABIN protocol was conducted on Lemon Creek at the same site sampled in previous years (Figure 11).

Parameters monitored were water temperature, benthic invertebrates, coliform bacteria, stream flows, and turbidity. These parameters were chosen because they can be easily monitored by community members, have been monitored in the past and baseline data exists to which new data can be compared, or because baseline data was needed in order to assess future changes. The study area boundary is within the Slocan Valley watershed (Figure 1) with sampling sites dispersed throughout.

It should be noted that each of the components covered by this report could be an entire report on their own. Additionally, there are limitations to the level of analysis and data interpretation possible due to the nature of this community-based project and its heavy reliance on citizen scientists. As such, this report acts as a summary of data collected. More time and funding are needed to push the results to their fullest extent.

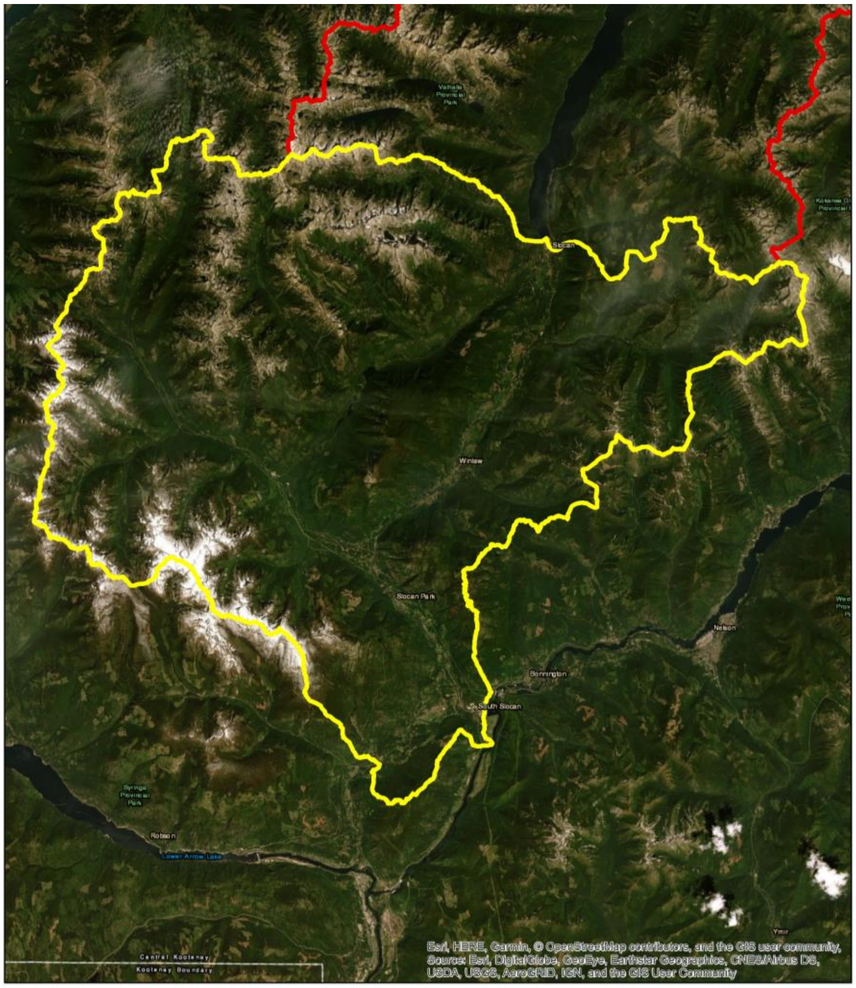

Figure 1. Slocan Valley watershed and study area for 2019-2020 community monitoring program (Google Earth n.d.)

The Effects of Little Slocan River Water Quality Due to a Landslide

The occurrence of a landslide on the Little Slocan River has resulted in a continuous source of stream bank erosion influencing water quality and aquatic species downstream. Landslides can be caused by an unstable landform and/or by development activities. High streamflow and increased precipitation caused by climate change are also predicted to increase the risk of landslides (Taylor et al, n.d.).

This assessment was carried out by the Slocan River Streamkeepers during 2019 and 2020 at the request of residents with support from the RDCK to highlight the health and environmental concerns involved in the matter. Elevated levels of turbidity pose a threat to both drinking water quality and healthy aquatic ecosystems.

Turbidity is a measure of the relative clarity of water due to the presence of suspended sediment. It is caused by colloidal matter such as clay, silt, or finely divided organic and inorganic matter in water, and can be interpreted in a variety of ways. High turbidity values significantly affect water quality, as this may prevent microorganism disinfection by means of particle sheltering. In addition to the presence of solids within drinking waters, high turbidity values have been shown to be correlated with the contamination of water by Giardia and Cryptosporidium and serve to estimate the risk of contamination by these pathogens. Ministry Guidelines state maximum allowable turbidity in drinking water is 1 NTU (WHO 2017).

Elevated levels of sediment and turbidity can reduce the biological productivity of aquatic systems by decreasing quantities of plant material, decreasing abundance of fish food organisms, and decreasing production and abundance of fish. Invertebrate populations also may be adversely affected by elevated levels of sediment due to physical habitat change as a result of the scouring of stream-beds and the dislodgment of individuals, smothering of benthic communities, clogging of the interstices between substrate components which affects microhabitat, and abrasion of respiratory surfaces and interference of food uptake for filter feeders (CCME 2002).

The relationship between landslide-driven bank erosion, increased turbidity levels, and decreased water quality allows turbidity levels to be used as a proxy by which to infer the effects of the landslide on local water quality. For the Little Slocan River landslide, three sampling locations were chosen: Little Slocan sampling site, immediately above the landslide; Vallican Bridge on the Little Slocan , a downstream location (~2 kms), to see the effective travel of the suspended sediments; and Passmore Bridge, a further downstream location (~ 4 kms) immediately after the junction between Little Slocan River and Slocan River, to investigate the effects of river mixing on turbidity (Figure 2). Turbidity assessment at the Vallican Bridge and

Passmore Bridge began in February 2019. Above the slide on Little Slocan River was used as a reference sampling location beginning in April 2020.

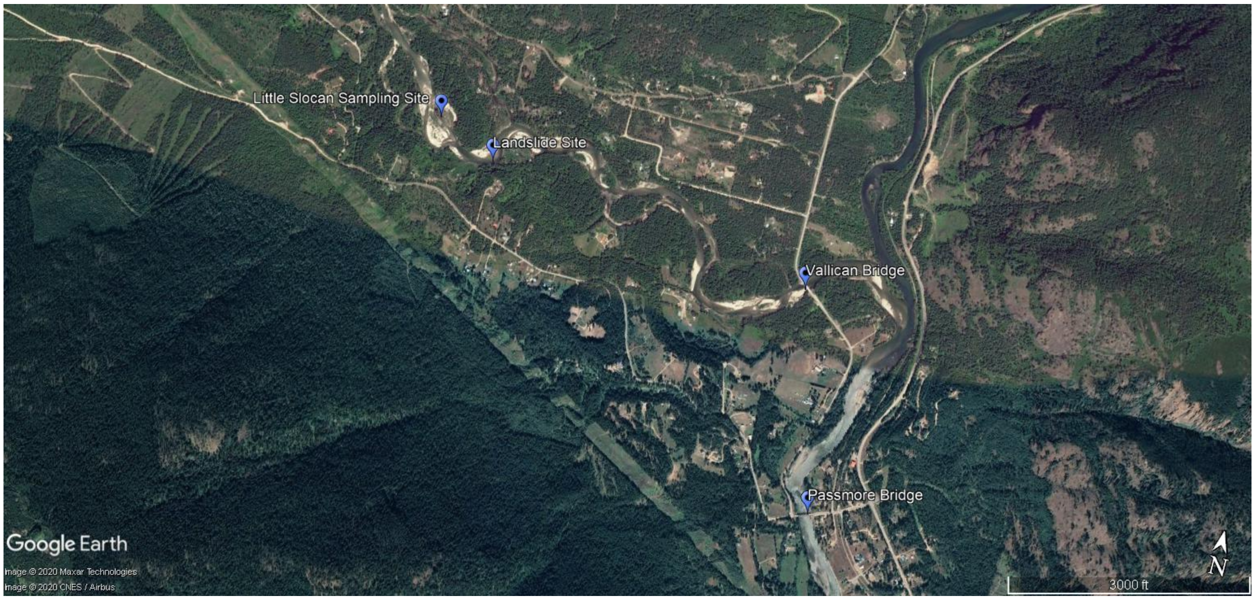

Figure 2: Location of Little Slocan River landslide and surrounding sampling locations (Google Earth n.d.)

A total of 48 samples were obtained for the three locations surrounding the Little Slocan landslide outlined above between February 2019 and October 2020: 13 samples for Little Slocan, 37 at the Vallican Bridge, and 37 for Passmore Bridge (Figure 3). Turbidity values at the Little Slocan site remained largely below 1 NTU, with only 2 of the 13 samples exceeding this value. Contrastingly, 78% of samples obtained at the Passmore Bridge site and 95% of those obtained at the Vallican Bridge surpassed 1 NTU. Maximum turbidity values observed were 1.85 NTU, 110 NTU, and 95.30 NTU for the Little Slocan, Vallican, and Passmore sites, respectively.

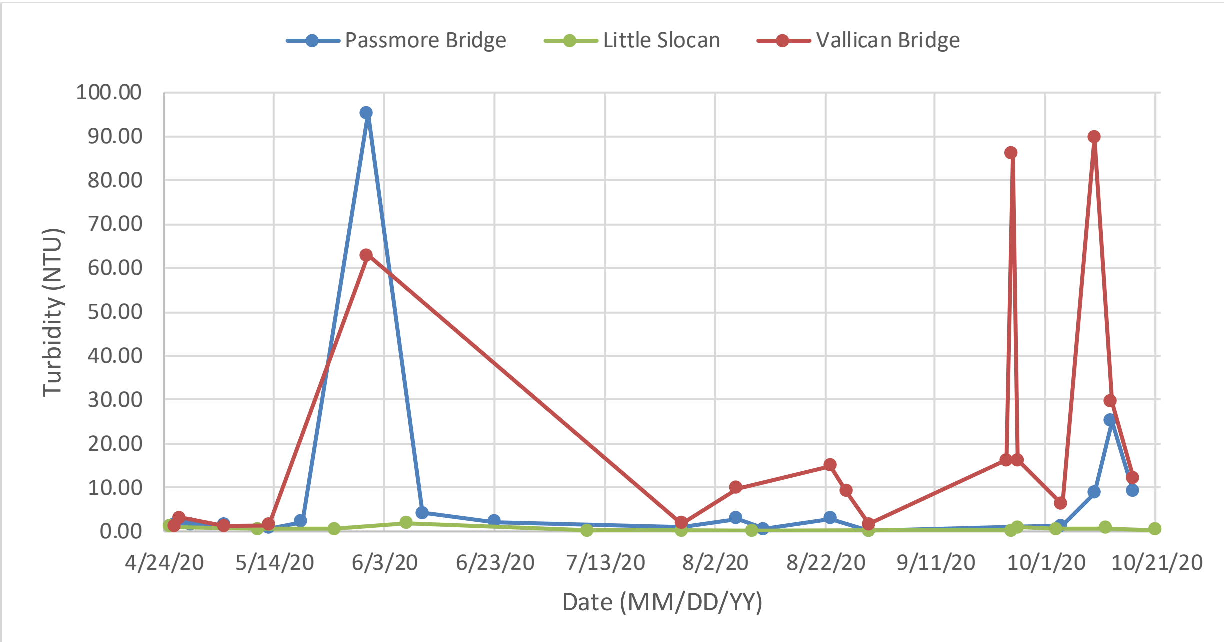

Figure 3: Turbidity values at three sampling locations surrounding the Little Slocan River landslide between April and October 2020.

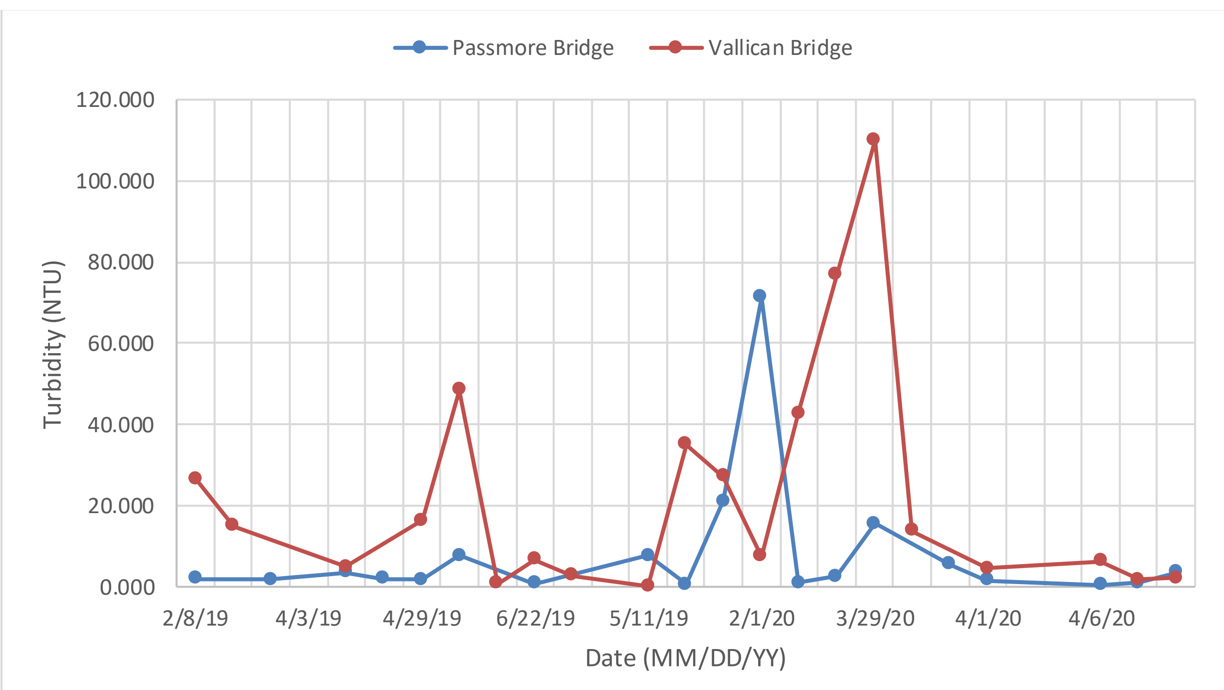

Figure 4: Turbidity values at two sampling locations surrounding the Little Slocan River landslide between February 2019 and April 2020.

Table 1: Notable turbidity of Little Slocan River landslide study locations from February 2019 to October 2020.

Sampling Site	Highest Turbidity Reading (NTU)	% Samples above 1 NTU	Number of Samples (n)
Little Slocan	1.85	15%	13
Vallican Bridge	110	95%	37
Passmore Bridge	95.30	78%	37

The lower turbidity average at Passmore Bridge compared to Vallican can be explained by the mixing of turbid waters from the Little Slocan with water from the larger Slocan River, which takes place between the Vallican Bridge and Passmore Bridge. This suggests the landslide's effects decrease with distance from the site, although not substantially or quickly enough to be safe for water users located in Passmore. Maximum turbidity values seen at both sites below the landslide are over 50 times more than values obtained above. This points to irrefutable evidence that turbidity is higher downstream of the landslide, and therefore is an important consideration from the human health perspective.

As expected, spikes in turbidity values coincide with large-scale rain events for samples both above and below the landslide. This pattern is likely due to increased rates of bank erosion brought on by rain events. Minor fluctuations in turbidity above the landslide site have a significantly larger influence on locations downstream; 100% of samples obtained at Vallican Bridge showed turbidity values above the allowable maximum of 1 NTU as indicated by the World Health Organization (Figure 4) (WHO 2017). If it remains uncontrolled, the increased turbidity of Little Slocan could be detrimental to the overall quality of local water users which directly or indirectly draw water from the Little Slocan River and surrounding area.

Residents downstream of the Little Slocan landslide have been experiencing high turbidity levels as a result of the landslide and noticed the water level in their wells have dropped due to restricted groundwater flows. This ongoing degradation of drinking water quality poses a humanitarian concern which is beyond the scope of local institutions, and as such should be treated and restored by the government.

Low Flow Stream Gauging on Community Water Sources

There are several potential outcomes for the effect of climate change on smaller mountain streams in the Slocan Valley. Current and future reductions in snow accumulation and glacial ice have been shown to result in reduced water supply in the Columbia basin, particularly for the low flow summer periods (Barnett et al. 2008; Burger et al. 2011; Jost et al. 2012). Lower streamflow can lead to a reduced ability for streams to dilute pollution which may result in substantial water quality issues. This is of concern in the Slocan Valley because residents and farmers rely on these water sources for drinking and irrigation purposes. Connectivity of small tributaries to the main stem of the Slocan River is also crucial for fish and aquatic ecosystems as it provides cold water refuges and inputs.

For the purposes of this study, four small tributary creeks were selected for monitoring of discharge (Figure 5). Study sites were selected based on the availability of historic data and their ability to represent creeks used for the same purposes throughout the Slocan Valley. The tributaries investigated are McFayden Creek, Trozzo Creek, Rice Creek, and Ravine Creek. Measurements were taken above water boxes with a Pygmy Current Meter in 2019 and a Swoffer Current Meter 2100 in 2020.

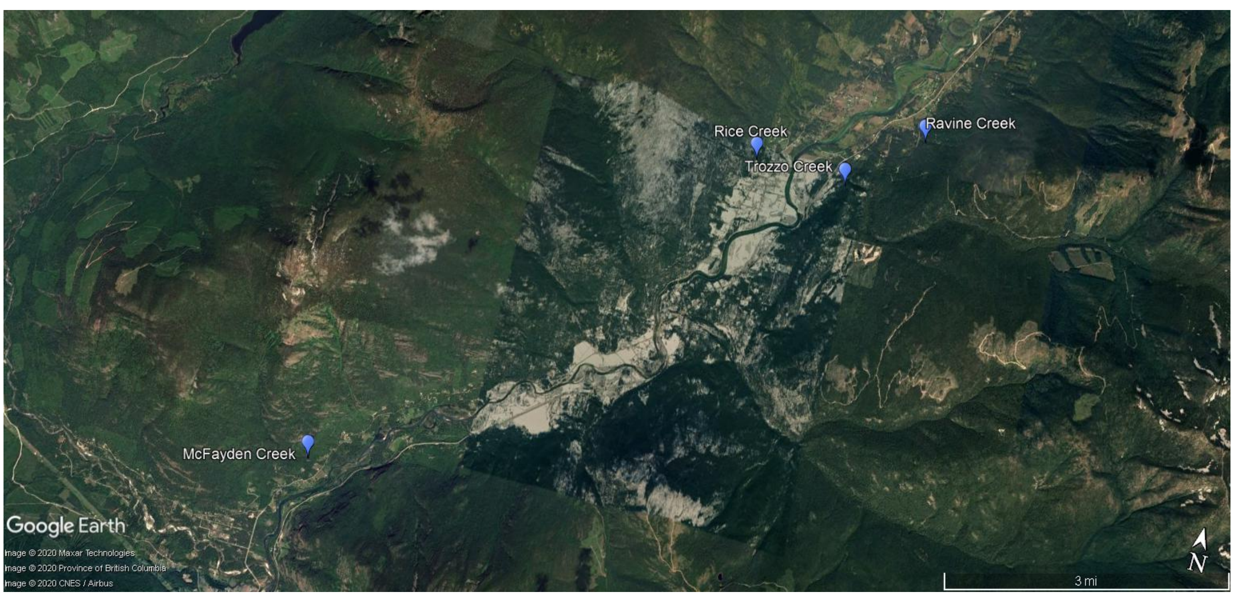

Figure 5. Location of tributary creeks selected for low flow monitoring (Google Earth n.d.)

Discharge measurements were collected at low flows in September 2019 and 2020. Between 2019 and 2020, Trozzo and Rice Creeks showed increased water levels while McFayden and Ravine Creeks showed decreased water levels (Figure 6).

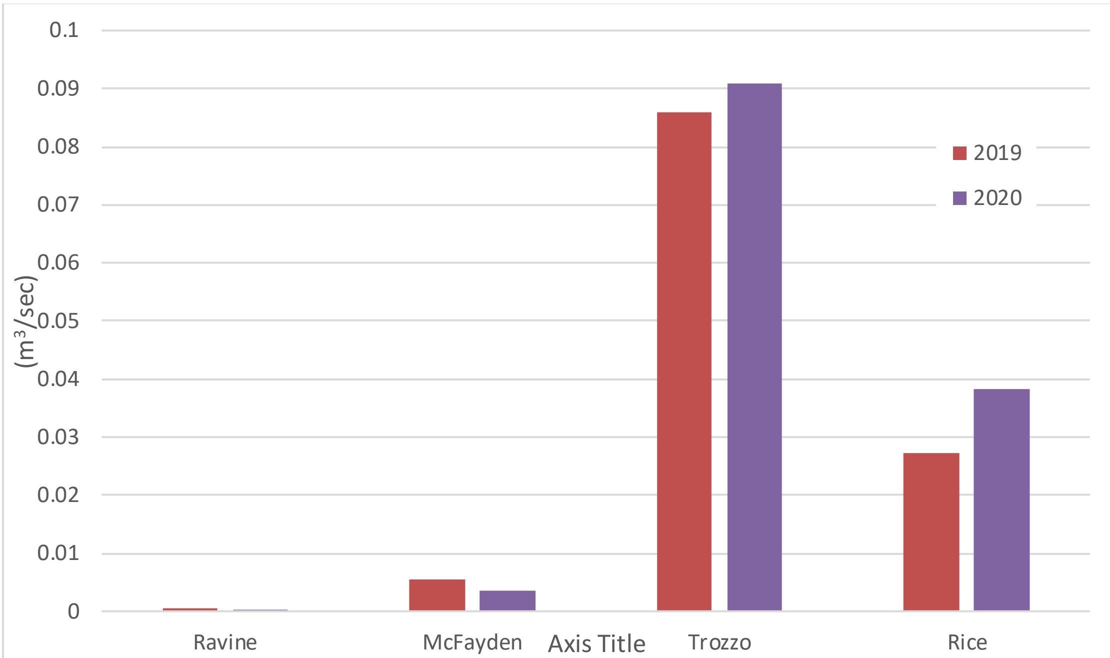

Figure 6. Comparison of September 2019 and 2020 discharge (m^3/sec) of four source water tributaries of the Slocan River.

There are many factors that could influence the flow regimes of these creeks including the amount of annual precipitation, the elevation and aspect of headwaters, and the number of contributing tributaries. On average, 2020 had more precipitation and was warmer than 2019 (Table 2). Total annual precipitation in 2020 was 706 mm compared to 601.7 mm in 2019 and 7 months out of 11 were warmer in 2020.

Table 2: Comparison of monthly total precipitation, mean and max temperature averages for Nelson, BC 2019 and 2020 (Environment Canada, n.d)

	2019 Total Precip (mm)	2020 Total Precip (mm)	Max Temp 2019	Max Temp 2020	Mean Temp 2019	Mean Temp 2020
January	65	179	3.3	1.8	0.7	0.3
February	74	38	0.2	4.7	-3.4	1.2
March	24	66.8	9.7	8.8	3.8	3.8
April	77.6	44.2	14.6	14.6	8.6	8
May	18.8	94.6	22.1	19.5	14.6	13.3
June	44.8	69.8	23.4	22	16.6	15.8
July	78.5	24.6	25.7	27.3	18.7	19.4

August	29.4	25.4	27	28.4	19.5	20.4
September	42.6	46.8	19.8	22.5	14.7	16.2
October	96.2	108	10.7	12.3	6.2	8.3
November	50.8	68.8	3.3	7	6.6	3.9

Historical data is available for McFayden, Trozzo and Rice Creek. Values for average September discharge rates for each of these creeks were compared. Although the data is not consistent between creeks, interesting patterns were identified. Ravine Creek does not have historical data, and as shown in Figure 6, was flowing at a very low rate (0.000503m^3/sec) above water user intakes. This has the potential of completely drying up and should continue to be monitored closely.

McFayden Creek has seen several spikes in discharge rates since data collection started in 1944; continuous data collection ended in 1987. Discharge shows a steady decrease since 1982 (Figure 7).

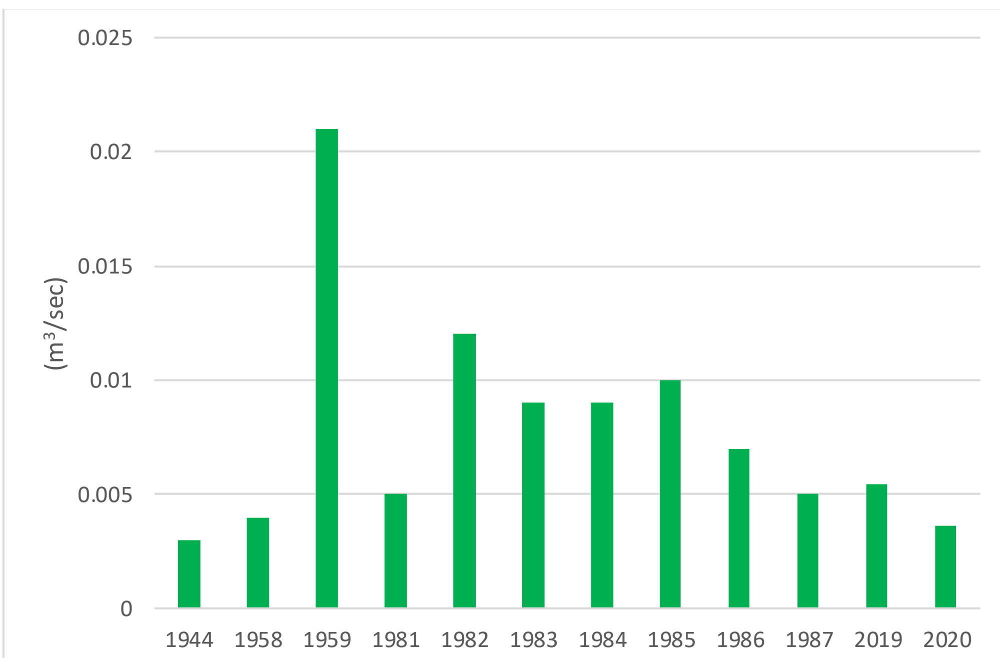

Figure 7. Average discharge (m^3/sec) of McFayden Creek in September

Trozzo Creek discharge values have increased and stayed within 0.05 m^3/sec since 1931, apart from an anomalous spike in 1965 (Figure 8).

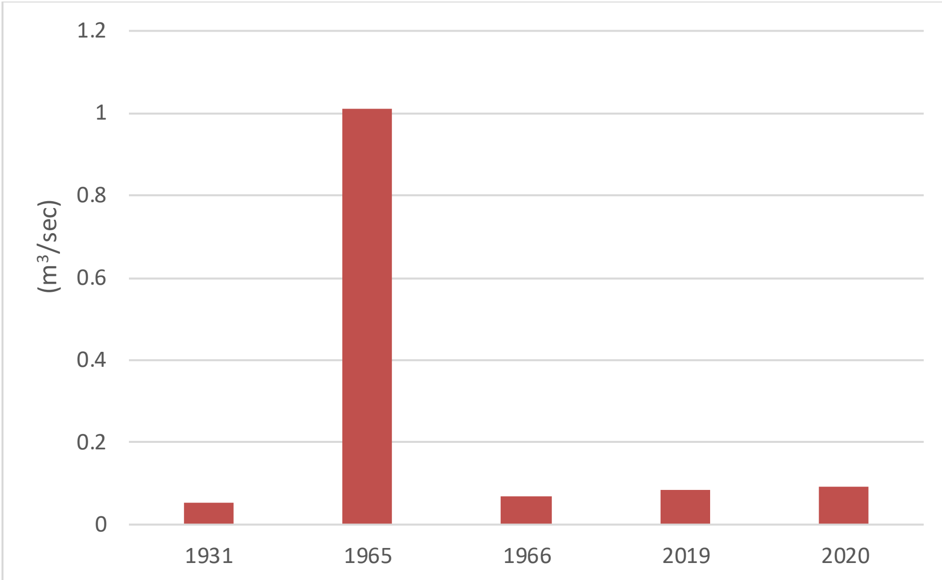

Figure 8. Average discharge (m^3/sec) of Trozzo Creek in September

Rice Creek shows a steady increase in flow from an absolute minimum in 1921 to an absolute maximum in 1964, followed by a local minimum in 1965 and a steady increase until 2020 (Figure 9).

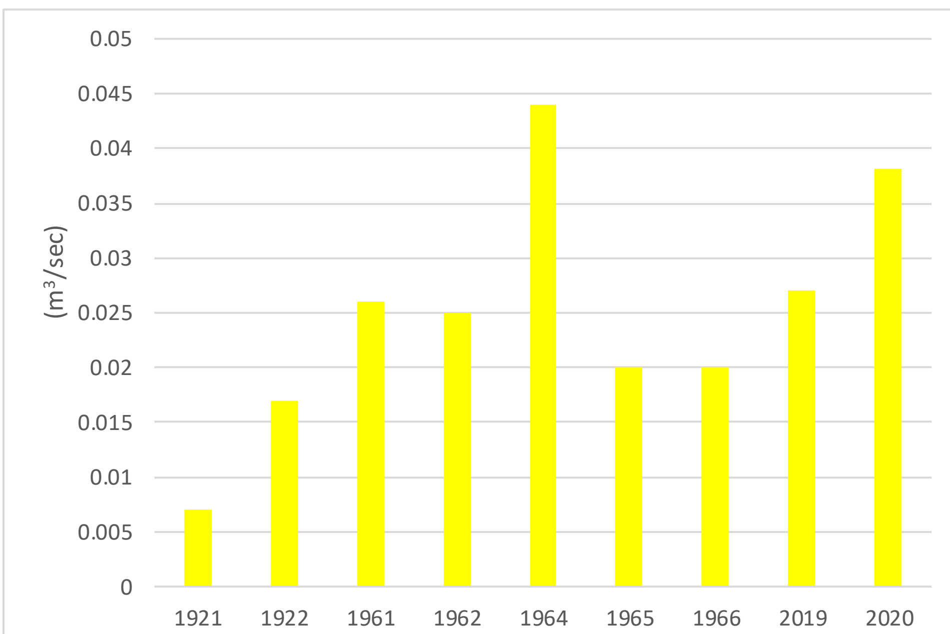

Figure 9. Average discharge (m^3/sec) of Rice Creek September

Comparisons of current and historic flow regimes on small tributaries show that streamflows are not predictable, with some creeks showing increasing flows and others showing decreasing flows. It is important to continue to collect this data to see how these patterns change over time. The installation of continuous gauges or the collection of multiple data points is recommended to obtain a better overall picture of current discharge rates.

Winlaw Creek Education Program, Turbidity Sampling and Water Quality

The Slocan River Streamkeepers Society offers an interactive, experiential, fun, exploratory, and hands-on opportunity for outreach with different local schools. Students make invaluable connections with their local stream and river watershed by watching a water channelization display, collecting aquatic insects, exploring with a microscope, collecting water samples, and learning fundamental river science. The idea of this component is to simultaneously collect important water quality data for the community drinking water source and provide educational opportunities for local youth.

Unfortunately, this year's program was cut short due to the Covid-19 pandemic. The program was supposed to consist of turbidity and total coliform sampling conducted by the students in addition to an education program delivered by the Streamkeepers. Ultimately, students were able to collect water quality samples on Winlaw Creek, but the education program has yet to take place.

Students at Winlaw Whole School collected a total of 8 turbidity samples from Winlaw Creek between April 1st, 2019 and December 29th, 2019. Samples were collected at random and did not follow large rain events. Turbidity values on Winlaw Creek remained largely below 1 NTU, with only 2 of the 8 samples exceeding this value. Maximum turbidity value observed was 1.9 NTU (Table 3).

Table 3: Notable turbidity of Winlaw Creek from April to December 2019

Sampling Site	Highest Turbidity Reading (NTU)	% Samples above 1 NTU	Number of Samples (n)
Winlaw Creek	1.9	25	8

Turbidity sampling on Winlaw creek has been taking place since 1996. Compared to historic data, maximum turbidity values in 2019 were below average, however, the percentage of samples above 1 NTU was higher (Figure 10). More consistent sampling is needed to further clarify the state of Winlaw Creek turbidity.

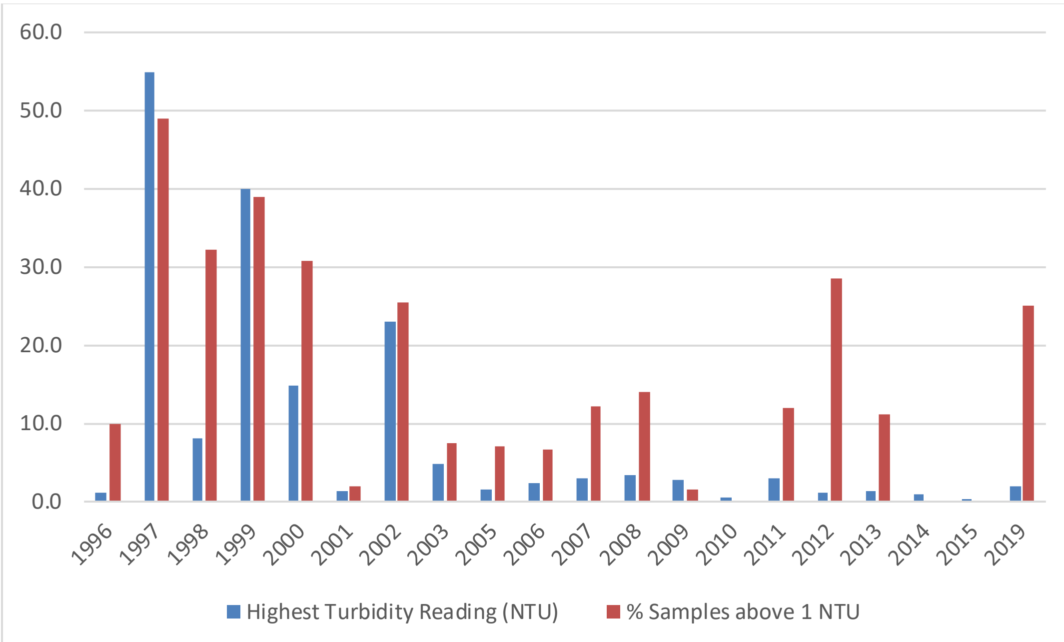

Figure 10. Comparison of highest of turbidity readings and % of samples above 1 NTU from 1996 to 2019

Total coliforms refer to a group of bacteria that are used as indicators of water potability. Total coliforms are monitored because they can indicate changes in water quality (Health Canada 2017) Their occurrence indicates that pathogenic organisms of fecal origin may be present. These may include other bacteria, viruses, protozoa (giardia, cryptosporidium) and multicellular parasites. Provincial guidelines for drinking water state that no total, fecal coliforms, or E. coli should be present, which is normally achieved by chlorinating the water. Total coliforms can be associated with plants only and are not implicated in human infection.

Results from the coliform sample collected on Winlaw Creek were 56 total coliforms, with less than 1 fecal, and less than 1 E. coli. Although the counts were not especially high, elevated fecal and E. coli counts are a reminder that Winlaw and other valley creeks, are at risk for contamination especially during fall after rain events.

The Recovery of Aquatic Life in Lemon Creek

On July 26, 2013, approximately 35,000 liters of Jet A-1 fuel spilled into Lemon Creek. The event resulted in the evacuation of over 2,500 people from the Slocan Valley, as the fuel was carried downstream through the Slocan River to Brilliant Reservoir. The event occurred at a time when water levels were moderately high. For this reason, the fuel went into side channels and into prime fish habitat in the Slocan River downstream of Lemon Creek. It settled into the stream substrate, woody debris, and riverbanks.

Benthic macro-invertebrates are an indicator of stream health and and an important source of food for fish. Slocan River Streamkeepers collected invertebrate data above and below the spill site in 2013, and again at the downstream site in the fall of 2016, 2017, and 2019 (Figure 11). CABIN techniques were used to collect data on benthic macro-invertebrates, habitat, and water quality. Invertebrate samples were analyzed by Biologica, following CABIN laboratory methods. All data was entered into the online CABIN database which was used to analyze findings and provide site reports.

Figure 11. Lemon Creek invertebrate sampling site (Google Earth, n.d.)

Results from 2019 findings fall in line with the other post-spill sampling of 2016 and 2017. Total abundance and *Ephemeroptera*, *Plecoptera* and *Trichoptera* (EPT) individuals are up from 2013 upstream and downstream of spill and 2016 and 2017 downstream of spill sampling (Figure 12). Most notably, 2013 showed a depressed population of invertebrates relative to upstream and post spill sampling; 2019 results indicate the population exceeds that of previous post spill sampling years. It is possible that this is a recovery curve but additional comparisons to reference sites over time are needed. Additional inferences may be drawn by sampling upstream of the spill, as was done in 2012; this approach may be taken at any other location that has been sampled in the past.

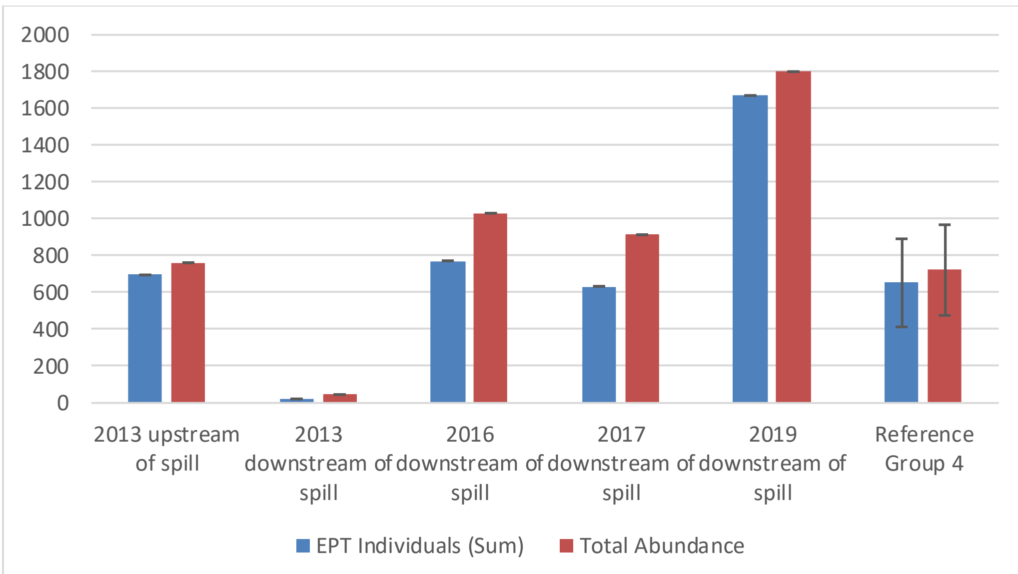

Figure 12. Benthic macro-invertebrate results using CABIN methods from before and after the 2013 gas spill into Lemon Creek.

Although Lemon Creek has seemingly recovered from the jet fuel spill, there are still logging and mining developments occurring in the watershed that could affect ecosystem health. Logging has altered the natural pattern of forest succession in many portions of the Lemon Creek watershed. Mining in the watershed dates to the 1800's and while most claims are now inactive, the possibility remains for exploration and further mining development in the future.

Rising Water Temperatures in Slocan River

Rising water temperatures in the Slocan river watershed threaten fish populations and water quality. Water temperature has been collected intermittently at several sites in the watershed since 1997 to determine the correlation between temperature and the low abundance of trout in the drainage (Arndt 1999). Daily mean temperatures in 1998 were found to be higher than 24° C for extended periods of time, a temperature above optimum values for rearing juvenile trout (Arndt 1999). Irvine and Baxter determined that it is likely a significant issue for the decline in Bull trout populations in the Slocan river watershed. Higher temperatures also encourage the growth of unfavorable algae and bacteria (Taylor et al., n.d.), resulting in decreased water quality.

Factors contributing to rising water temperatures include the ongoing loss of wetland and riparian areas in the floodplain for agriculture and residential development, logging of old growth in headwaters and riparian areas of tributaries, residential water use reducing overall volume of cold water inputs, and climate change.

Rising water temperatures are likely to be the most imminent threat associated with climate change in the Slocan river watershed, as indicated by a gap analysis conducted on the Slocan River watershed (Monnier 2019).

Flow Summary

Outcomes of climate change in this area are expected to result in increased water temperature, higher risk of flooding during freshet with extreme precipitation events in between, increased fire hazard, landslides, water shortages, and ultimately the loss of sensitive habitats and biodiversity (Taylor et al. n.d.). During 2020 spring freshet, Slocan River reached much higher flow rates than in 2019 followed by lower flow rates in the hot and dry months of summer and fall (Figure 13). A relationship also exists between river water temperatures and river flow rate; high water temperatures are associated with low river flow rate. As such, water flow in Slocan River is expected to decrease after spring freshet with rising temperatures.

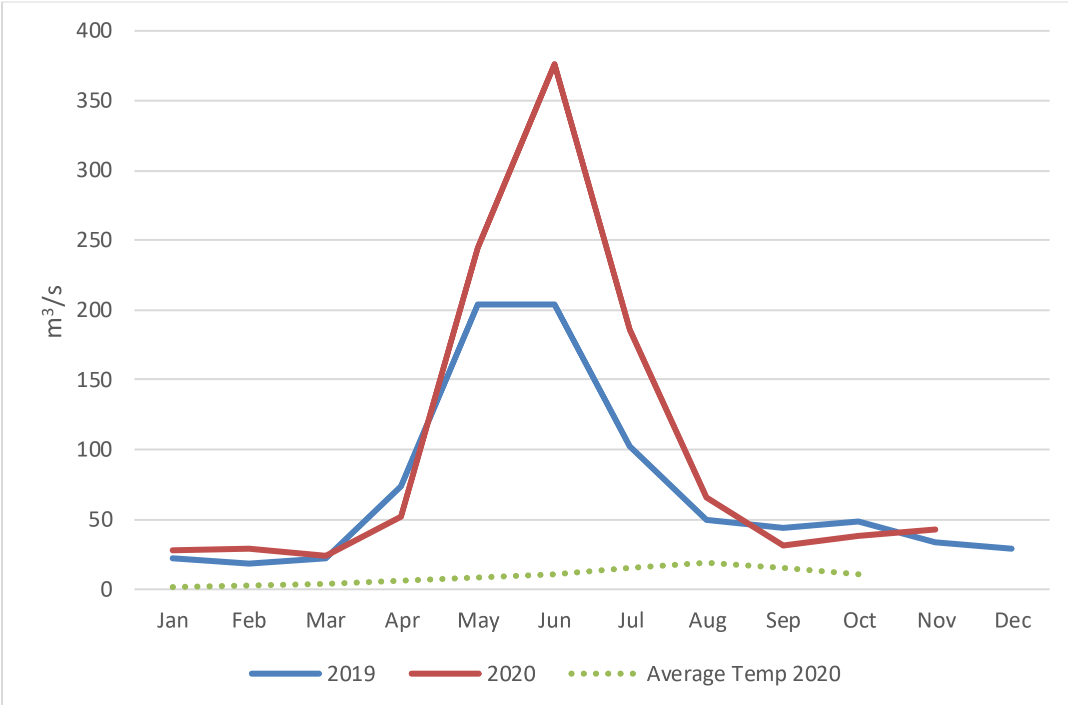

Figure 12. Real-Time Hydrometric Data for 2019 and 2020 of Slocan River near Crescent Valley (Environment Canada 2020).

Temperature Summary of Slocan River

Three MX22 Onset HOBO data loggers were installed in late August and early September 2019. Historic sites were used to repeat data collection from the past and are spread across the length of the river: Valhalla Camp, the furthest upstream and south of the Slocan Lake outflow; Winlaw, located south of the township of Winlaw; and South Slocan, the furthest downstream south of Crescent Valley (Figure 14). Data loggers in previous years were installed in May to July and removed in October, compared to current loggers which are left for the entire year in order to assess winter temperatures.

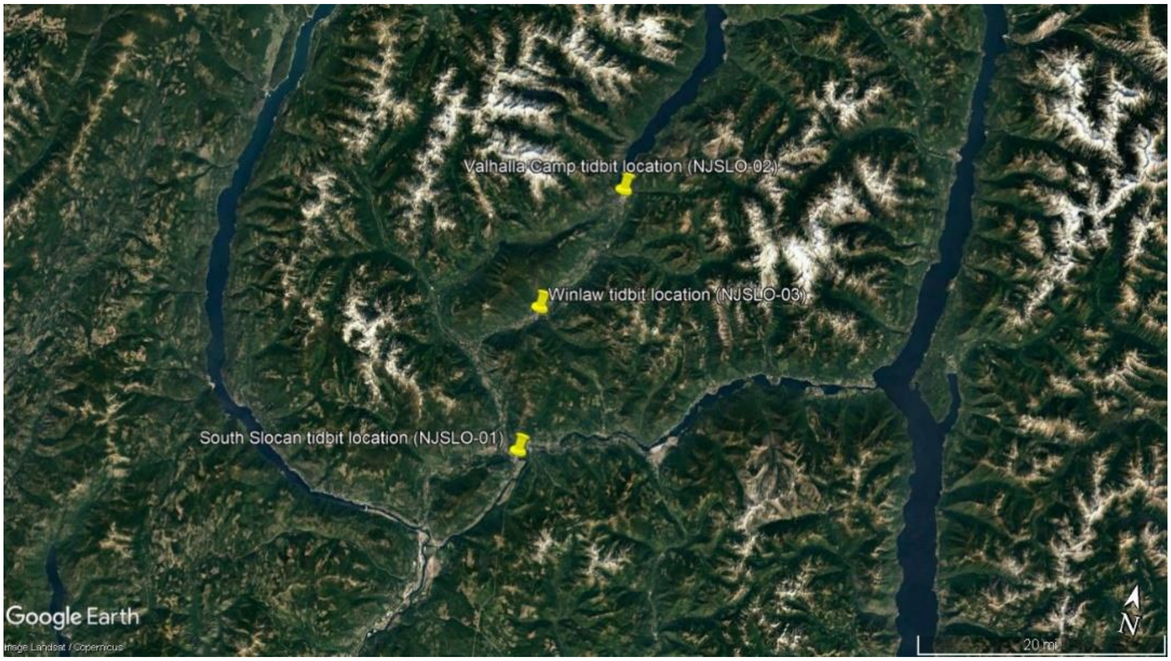

Figure 14. Location of data loggers in Slocan River 2019 (Google Earth, n.d.)

Data loggers are set to record temperature at 15-minute intervals. The 96 daily readings were used to calculate a mean, maximum and minimum temperature for each day. Depths of sensors varied from site to site with average depths of 0.35 m at Valhalla Camp, 1.0 m at Winlaw, and 1.2 m at South Slocan.

Summer Stream Temperatures

Stream temperatures were collected from the South Slocan, Valhalla, and Winlaw sites during the summer months (July – September) for the years 2003-2007, 2009-2012, 2014, and 2020, and are provided in Appendix A. Data from sensors installed in late summer 2019 and from the 2009 Valhalla site was omitted from the analysis due to a limited number of recordings obtained. Stream temperatures were used as a proxy by which to assess trout population health and effects of climate change in the region; the sensitivity of rainbow trout leaves them susceptible to slight changes in ambient temperatures and as a result are at a high risk. Cho and Kaushik (1990) state 15°C is the optimum growth and food utilization, and Avault (1996) defined 16-18°C as a maximum satisfactory temperature for rearing (cited in Arndt 1999).

Over the years recorded, mean temperatures ranged from 15 – 18.5°C and maximum temperatures ranged from 19 – 22.6°C for the three sites (Tables 4-6). Temperature variations generally followed similar patterns for the three locations on a yearly scale apart from 2012 where South Slocan showed significant fluctuation in temperatures and Valhalla was not recorded. Peak temperatures were commonly recorded between late July and mid-August, with no decipherable trend evident between the yearly graphs (Appendix A).

Table 4: Descriptive stream temperature statistics for the South Slocan sampling site.

Year	Dates collected (MM/DD)	Temperature mean (°C)	Temperature maximum (°C)	% of days above 19°C	% of days above 20°C
2003	07/25 – 09/28	17.81	22.17	33%	17%
2004	07/15 – 09/30	17.67	22.01	37%	29%
2005	-	-	-	-	-
2006	07/01 – 09/30	17.89	22.55	35%	15%
2007	07/14 – 09/30	17.63	20.88	32%	24%
2009	07/01 – 09/30	17.68	22.06	28%	18%
2010	07/01 – 07/13; 07/28 – 09/30	16.91	20.41	18%	5%
2011	07/01 – 09/30	15.74	19.15	8%	0%
2012	07/01 – 09/30	15.21	21.69	12%	3%
2014	-	-	-	-	-
2020	07/01 – 09/30	16.84	21.32	21%	3%

Table 5: Descriptive stream temperature statistics for Valhalla sampling site.

Year	Dates collected	Temperature mean (°C)	Temperature maximum (°C)	% of days above 19°C	% of days above 20°C
2003	08/04 – 09/30	17.83	20.22	38%	5%
2004	07/15 – 09/30	18.38	22.10	41%	28%
2005	07/01 – 09/30	17.62	21.11	29%	4%
2006	07/01 – 09/30	18.44	22.6	42%	25%
2007	07/14 – 09/30	17.67	20.92	25%	5%
2009*	-	-	-	-	-
2010	07/01 – 09/30	16.95	20.48	24%	4%
2011	-	-	-	-	-

2012	-	-	-	-	-
2014	-	-	-	-	-
2020*	07/01 – 08/16	16.34	19.29	11%	0

* - limited or unreliable data

Table 6: Descriptive stream temperature statistics for the Winlaw sampling site.

Year	Dates collected	Temperature mean (°C)	Temperature maximum (°C)	% of days above 19°C	% of days above 20°C
2003	08/04 – 09/30	17.40	20.24	34%	3%
2004	07/15 – 09/30	18.01	22.13	38%	3%
2005	07/06 – 09/30	17.12	20.80	28%	7%
2006	07/01 – 09/30	18.08	22.25	39%	18%
2007	07/14 – 09/30	17.56	20.80	30%	10%
2009	07/01 – 09/30	17.54	21.91	26%	16%
2010	07/01 – 09/30	16.50	20.38	20%	3%
2011	07/01 – 09/30	15.95	19.63	5%	0
2012	07/01 – 09/30	16.02	20.11	13%	3%
2014	07/01 – 09/30	17.70	21.07	35%	14%
2020	07/01 – 09/30	16.92	20.94	21%	1%

Stream temperatures begin high in the early 2000's and reach a general low in 2011-2012, only to show a sudden increase in 2014 followed by a decrease in 2020 (Figure 15). Data from Shaw (2013) and Arndt (1999) was compared with recent data obtained by the Slocan River Streamkeepers, showing a trend of generally decreasing water temperatures. This could be explained by the increase in precipitation in 2020 and the higher flow rates into later months (Table 2; Figure 13). The data presented above is not sufficient to draw concrete conclusions; continued monitoring is necessary for valuable inferences to be further drawn.

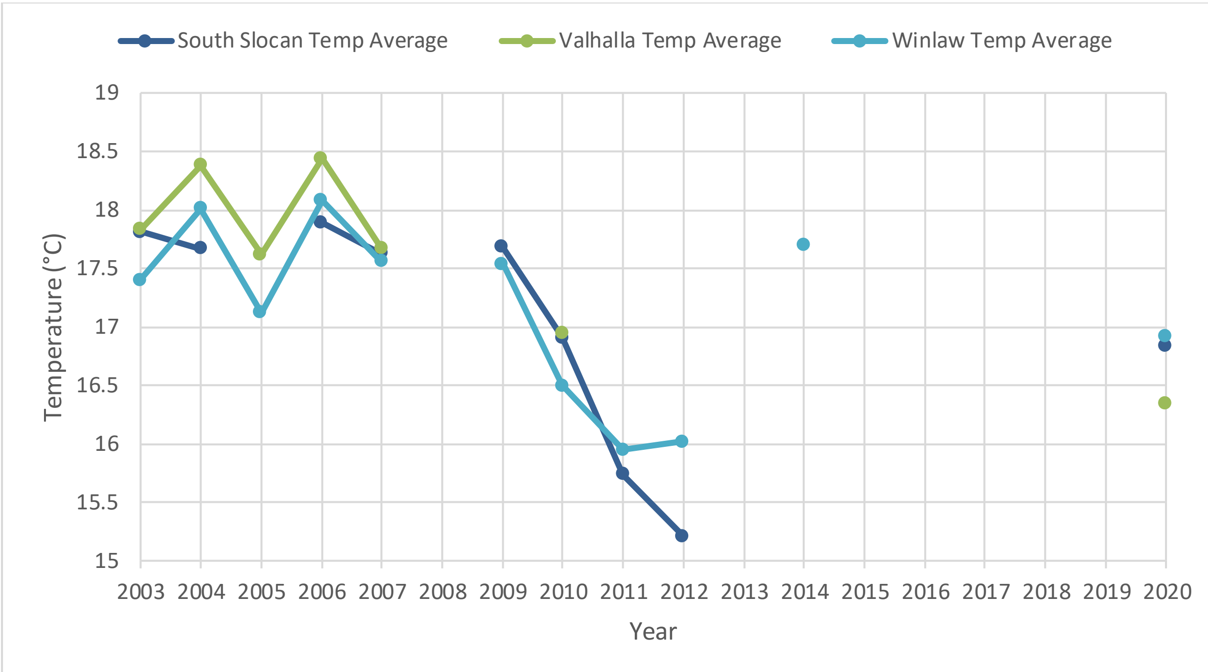

Figure 15: Average temperatures for South Slocan, Valhalla, and Winlaw between 2003-2020.

Winter Temperatures

Stream temperatures were collected for the winter months during the 2013 and 2019 seasons (defined as December 1 – March 31). Data was collected only from the Winlaw station in winter 2013. A similar jagged pattern is seen over both seasons at the Winlaw station, with higher temperatures shown over the month of December 2019 compared to 2013 (Appendix A). The 2019 season brought with it colder extreme temperatures, with a maximum of 5.13°C and minimum of -0.01°C observed in 2019 compared to 5.60°C and 0.04°C seen in 2013 (Table 7 and 8). Despite the colder maximum and minimum temperatures, Winlaw showed a mean temperature of 2.77°C in 2013 and 3.16°C for 2020, indicating a rise in overall winter temperatures.

Table 7: Winter temperatures for South Slocan, Valhalla, and Winlaw stations from December 2019 – March 2020.

Station	Mean Temperature (°C)	Maximum Temperature (°C)	Minimum Temperature (°C)
South Slocan	2.55	5.40	-0.05
Valhalla	3.83	5.97	2.75
Winlaw	3.16	5.13	-0.01

Table 8: Winter temperatures for Winlaw station from December 2013 – March 2014.

Station	Mean Temperature (°C)	Maximum Temperature (°C)	Minimum Temperature (°C)
Winlaw	2.77	5.60	0.04

Data from all three stations was obtained for the 2019 season, with mean temperatures of 2.55, 3.83, and 3.16°C for South Slocan, Valhalla, and Winlaw, respectively. Maximum and minimum temperatures obtained were 5.40 and -0.05°C for South Slocan, 5.97 and 2.75°C for Valhalla, and 5.13 and -0.01°C for Winlaw (Table 8). Valhalla temperatures were notably higher and showed less peaks than Winlaw and South Slocan for most of the study, indicating a more constant temperature. South Slocan was the coldest station and appeared to follow an almost identical temperature regime as Winlaw.

Rising water temperatures may significantly harm local ecosystem and can also be used to quantify the effects of global warming. Consequences of the slow rise of winter water temperatures are currently unknown and understudied and should be thoroughly monitored throughout the coming years in order to better understand the extent of this increase and its long-term implications.

Conclusions and Recommendations

The Slocan River is undoubtedly a unique and special place. It is important now more than ever to continue to protect the integrity of the ecosystem to protect aquatic diversity and human health. Having this data is of paramount value to monitor changes that are occurring within the watershed as the effects of climate change begin to emerge.

Through our community monitoring program, we have been able to identify:

- High turbidity values are occurring downstream of the landslide on Little Slocan River and affecting water quality for residents, fish and wildlife downstream. This ongoing degradation of drinking water quality poses a humanitarian concern which is beyond the scope of local institutions, and as such should be treated and restored by the government.

- Comparisons of current and historic flow regimes on small tributaries show that streamflows are not predictable with some creeks showing increasing flows and others showing decreasing flows. It is important to continue to collect this data to see how these patterns change. The installation of continuous gauges or the collection of multiple data points is recommended to get a better overall picture of current discharge rates.

- Although the turbidity values of Winlaw Creek were not particularly high, they were more often above the allowable limit of 1 NTU than in previous years. Furthermore, elevated fecal and E. coli counts, though not especially high are a reminder that Winlaw and other valley creeks, are at risk for contamination especially during fall after rain events.

- Although it is possible that Lemon Creek has recovered from the jet fuel spill, additional comparisons to reference sites over time are needed. Possible reference comparisons are to sample upstream of the spill as was done in 2012, or at another location that has been sampled in the past. There are still logging and mining developments occurring in the watershed that could affect the ecosystem health.

- Water temperatures of Slocan River are not necessarily following a constant pattern. However, temperatures above 19°C are continuing to occur and are potentially harmful to trout populations. Winter water temperatures are slowly rising and need to continue to be monitored to better understand the extent of this increase and its long-term implications. Monitoring efforts should be broadened include tributaries to identify cold water inputs and assess the influence of these inputs on the Slocan River.

The Slocan River Streamkeepers support the concept of riparian and wetland restoration as a sustainable approach to helping fish stocks, improving drinking water quality, moderating water temperature, and maintaining the aquatic environment. Where appropriate, stream bank re-vegetation, bank erosion control and small scale in-stream structures to provide habitat and reduce channel in-filling have all been put forward as effective ways to promote river health.

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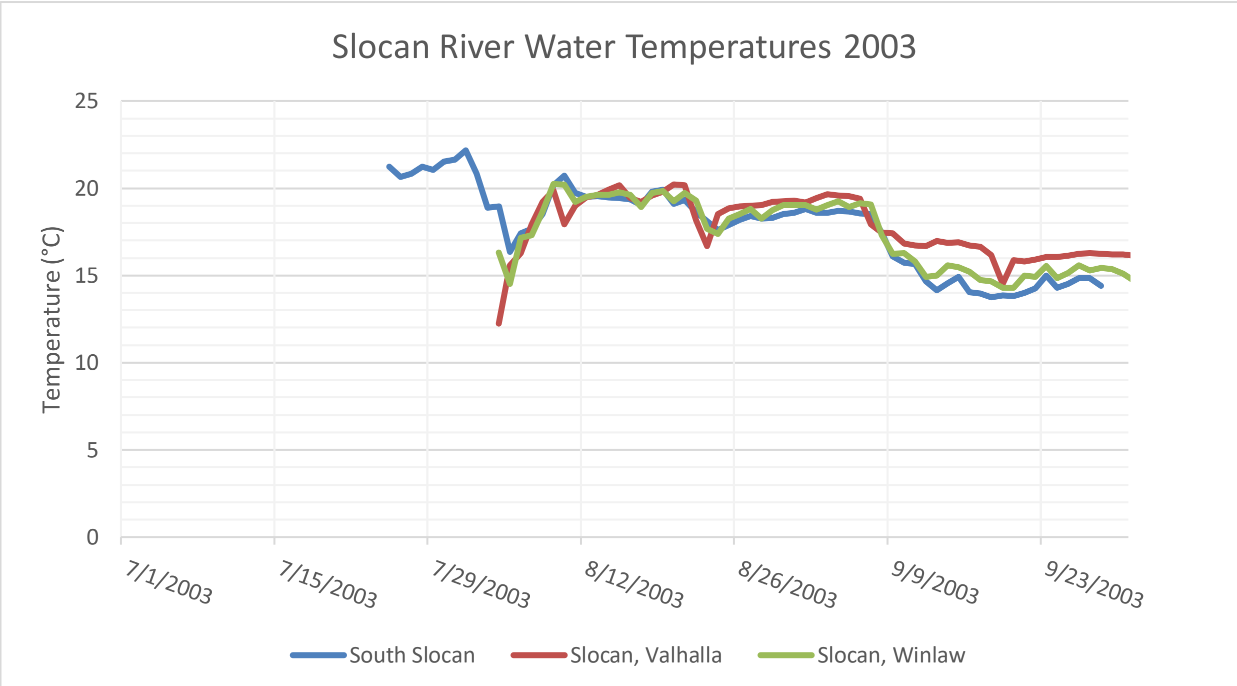
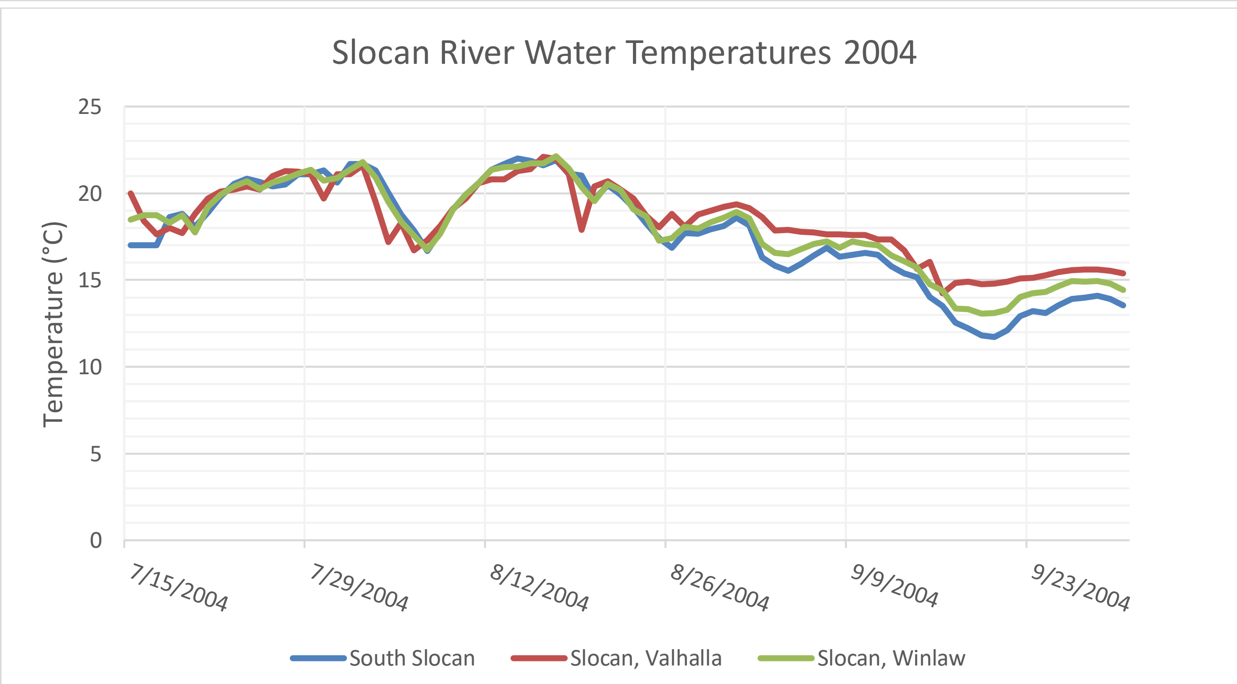
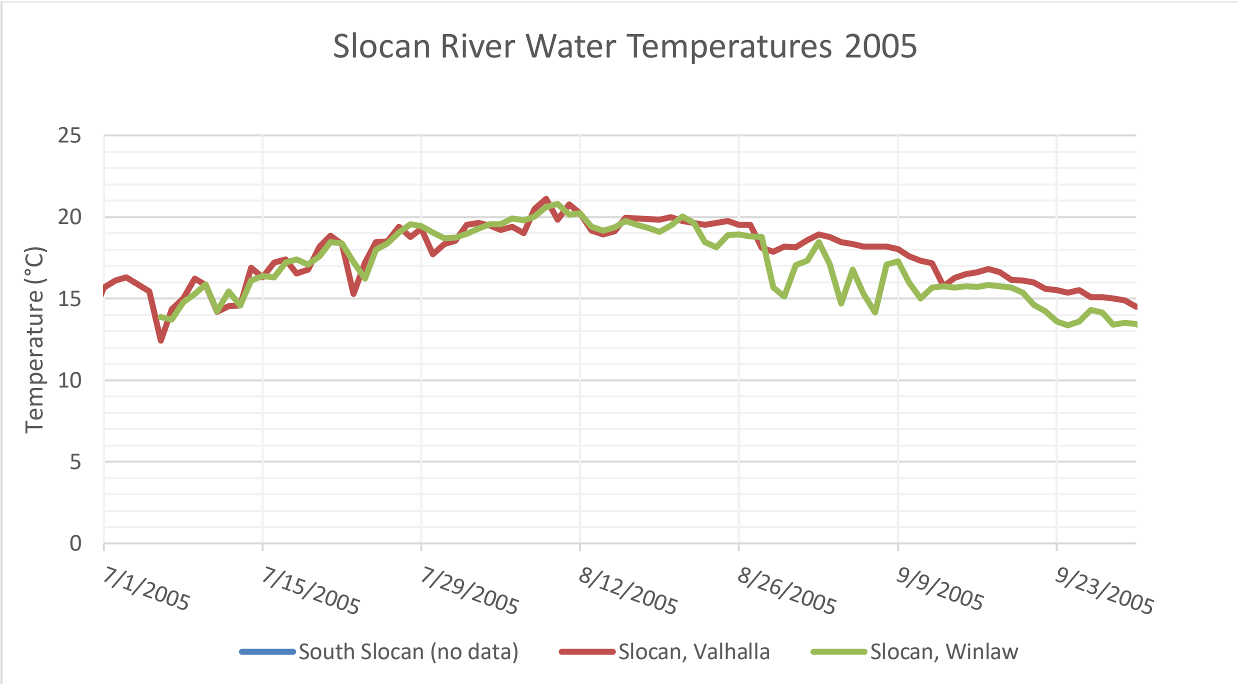
Appendix A: Historical Summer Temperatures of the Slocan River



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Temperature (°C)
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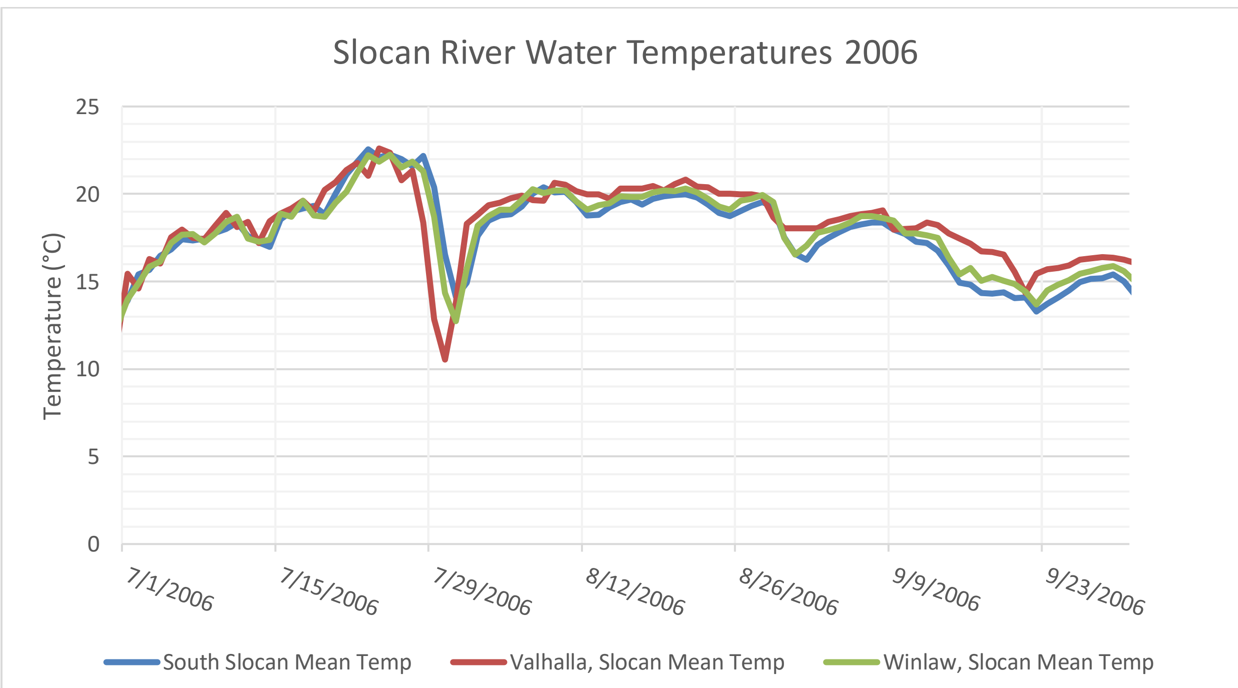
9/23/2005
South Slocan (no data)
Slocan, Valhalla
Slocan, Winlaw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Temperature (°C)
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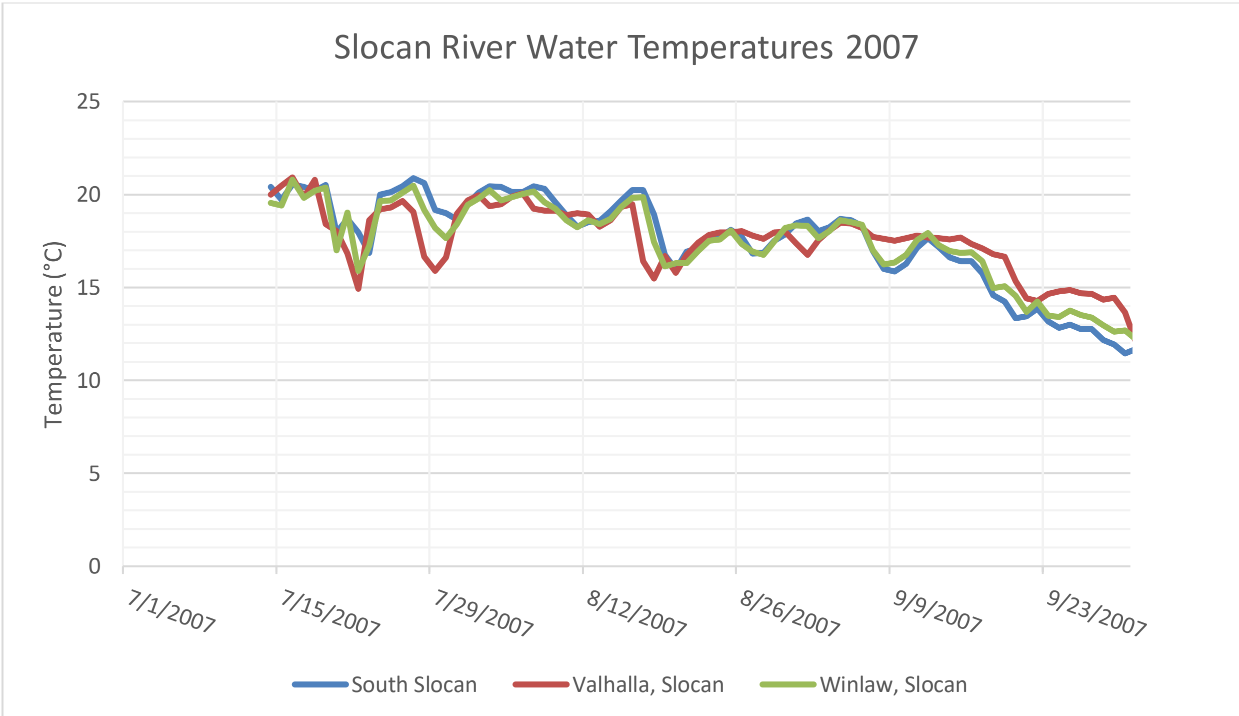
9/23/2006
South Slocan Mean Temp
Valhalla, Slocan Mean Temp
Winlaw, Slocan Mean Temp



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South Slocan
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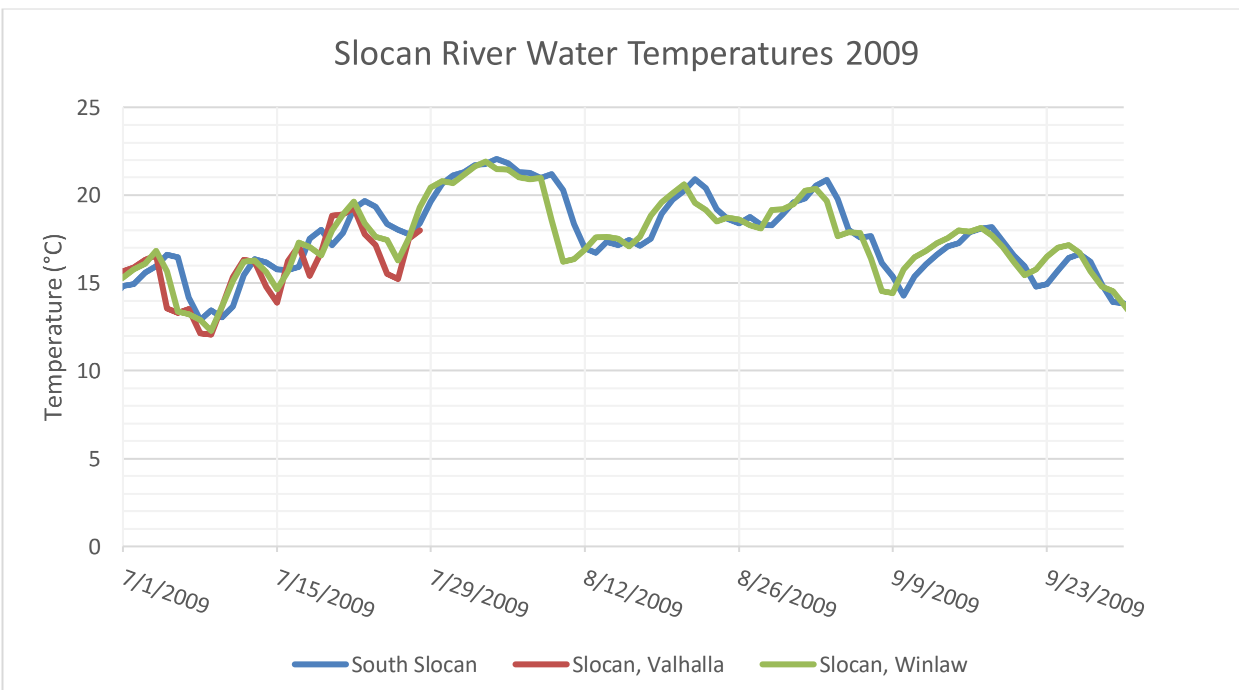
Winlaw, Slocan



Slocan River Water Temperatures 2009
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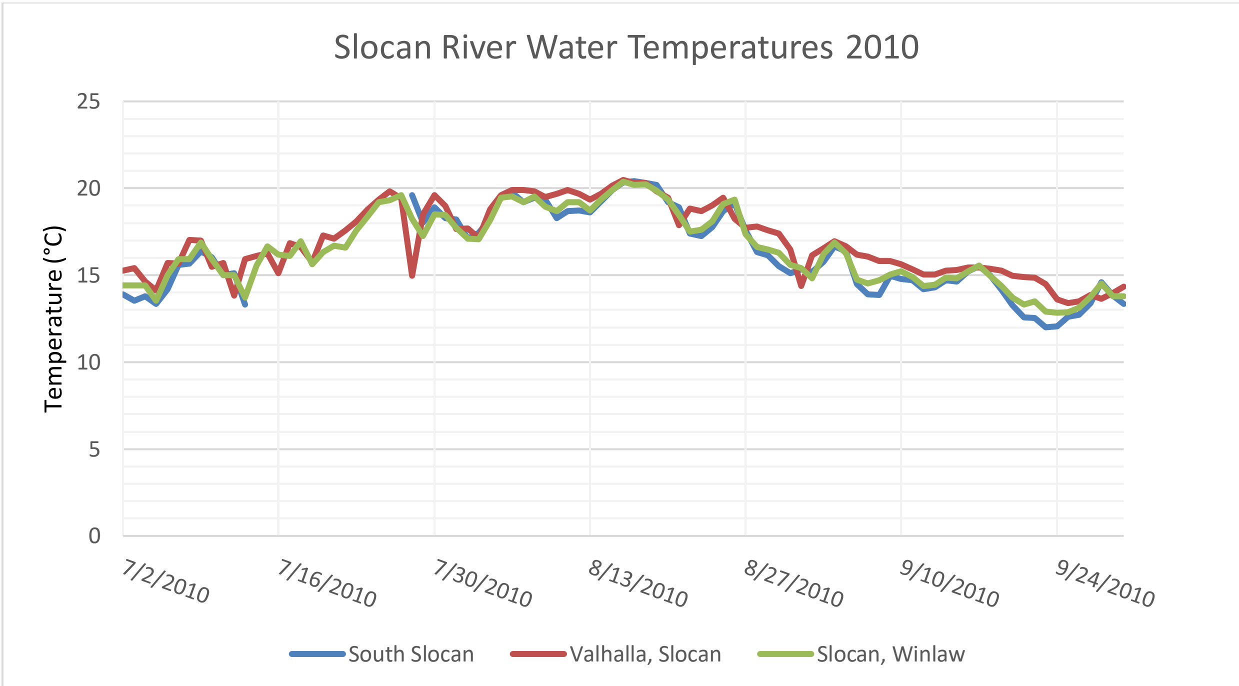
South Slocan
Slocan, Valhalla
Slocan, Winlaw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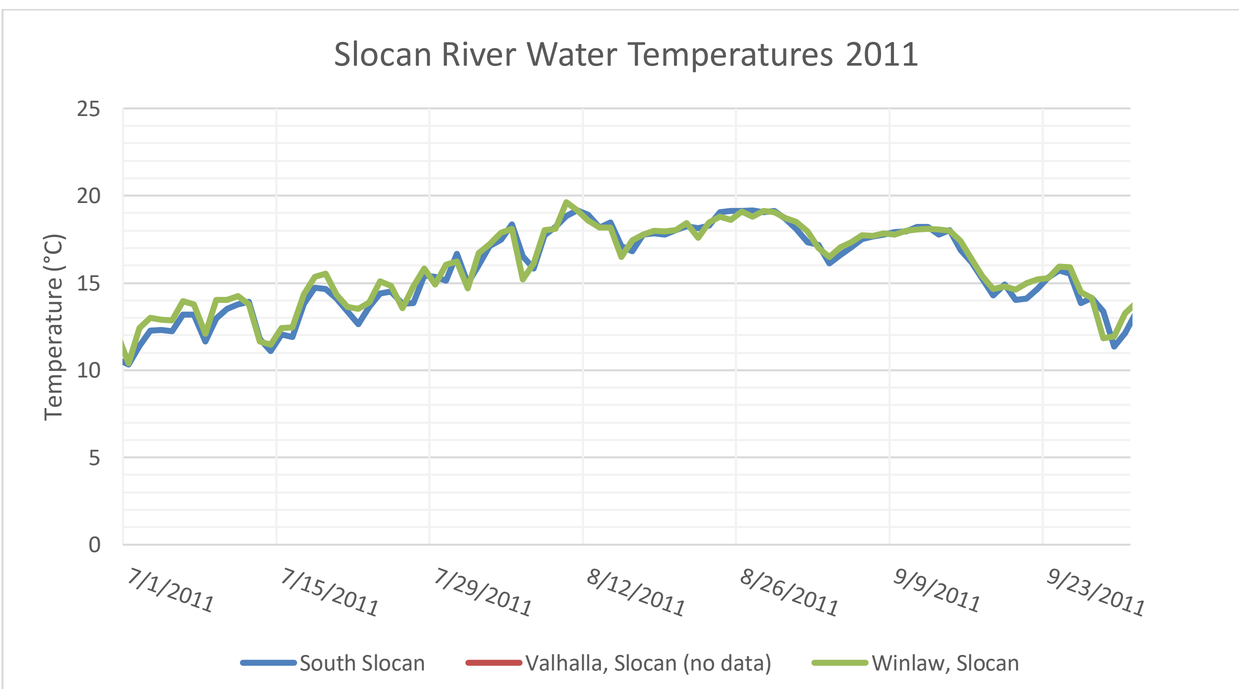
Valhalla, Slocan
Slocan, Winlaw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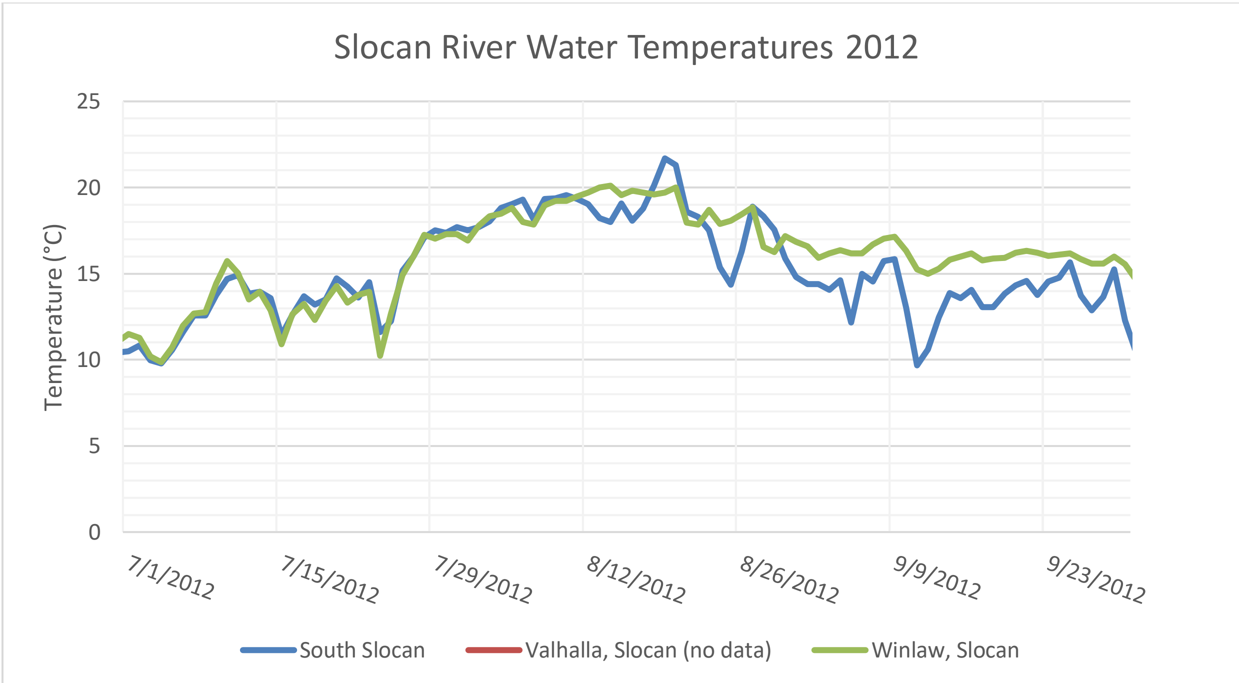
South Slocan
Valhalla, Slocan (no data)
Winlaw, Slocan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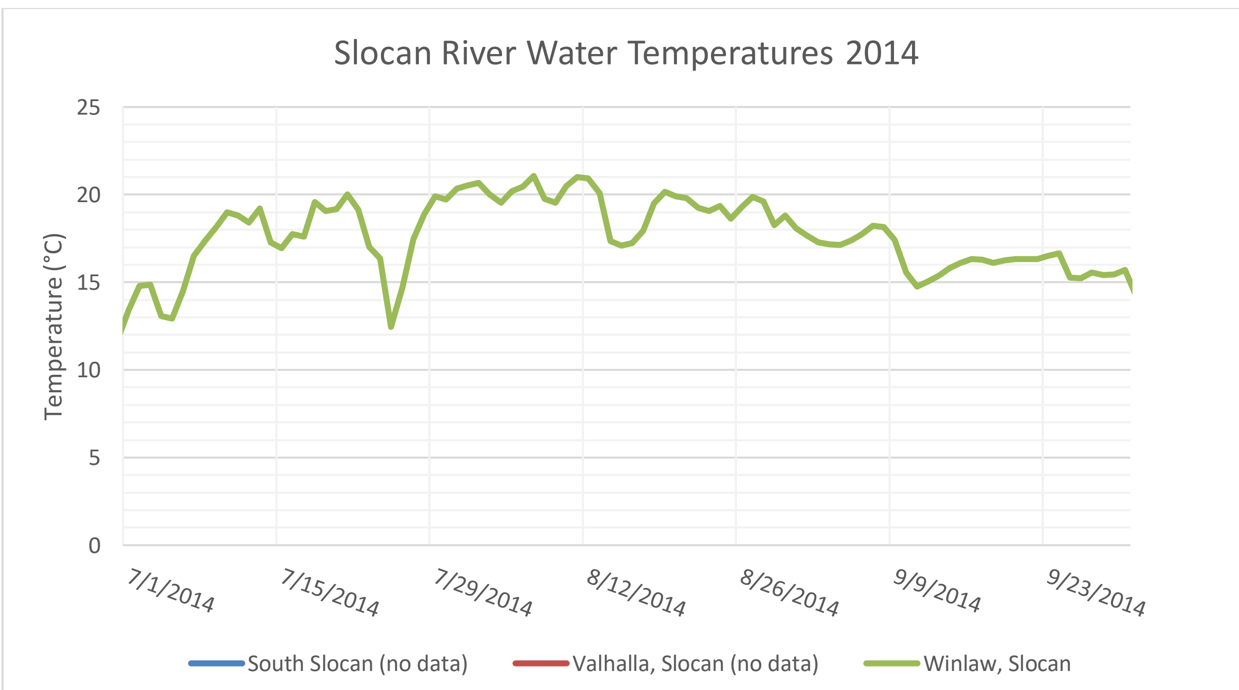
Winlaw, Slocan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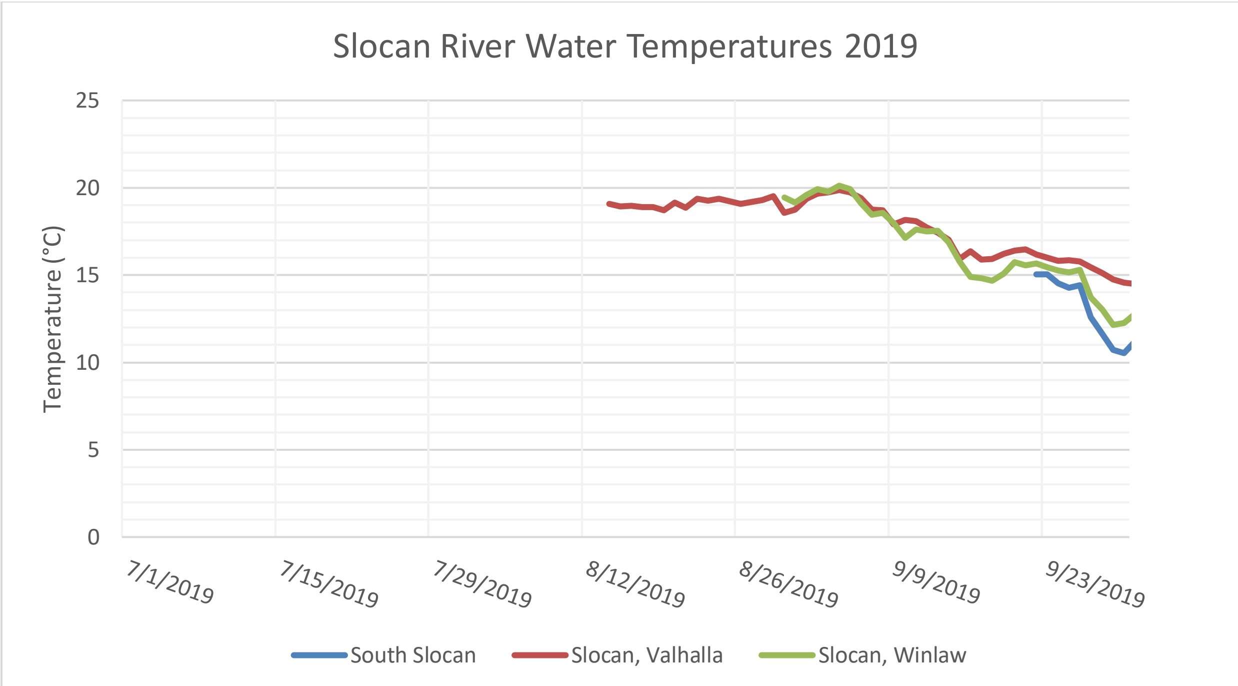
Valhalla, Slocan (no data)
Winlaw, Slocan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Temperature (°C)
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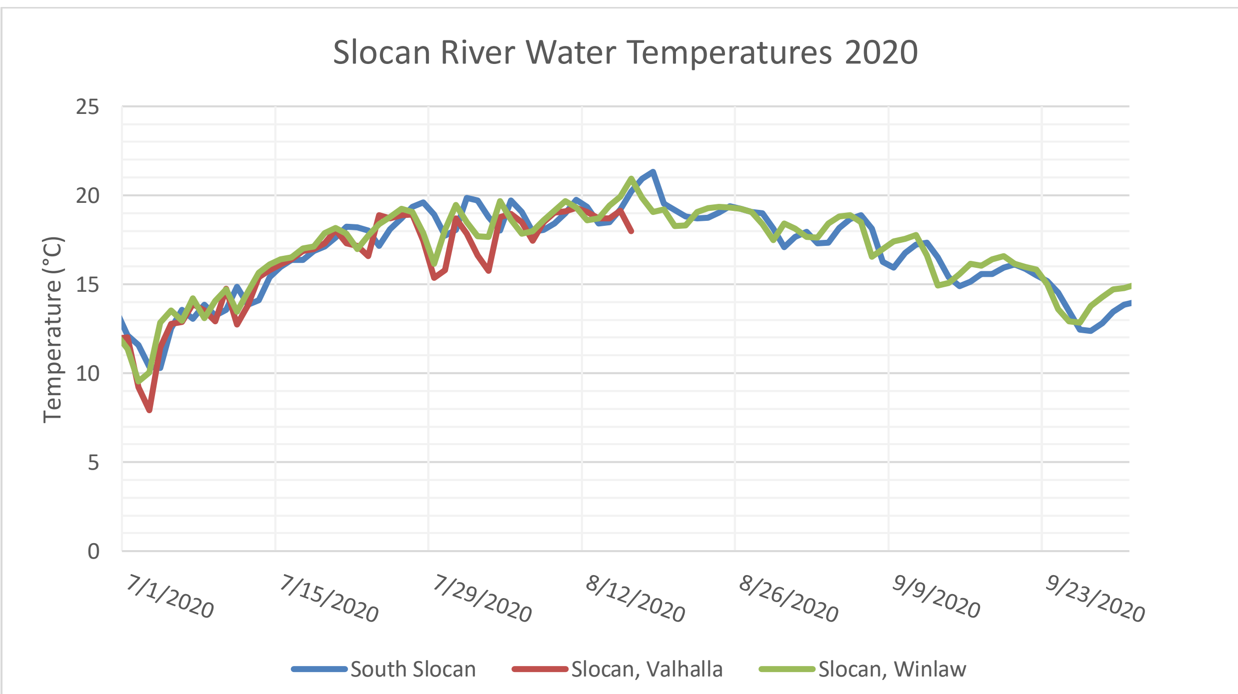
Slocan, Valhalla
Slocan, Winlaw


Slocan River Water Temperatures 2020
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South Slocan
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