REVISED 2022 WATER QUALITY MONITORING PROGRAM RESULTS

Haslam Lang Community Watershed

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Client:
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EARTH WATER LAND

SUMMARY

The Powell River Salmon Society (PRSS) has monitored water quality within the Haslam Lang Community Watershed since 1997. The watershed supplies drinking water to the City of Powell River and the community of Brew Bay. It provides important habitat for salmon species, and the PRSS operates a hatchery on Lang Creek. Maintaining water quality is important for providing healthy drinking water and maintaining clean salmon habitat.

PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during the 2022 monitoring program and to compare the results with data from previous years. PRSS recorded water temperature, creek stage, turbidity, pH, and salinity twice per month at six locations within the watershed. The measurements were taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Anderson Creek, Blackwater Creek, Haslam Lake, and the weir at the outlet of Haslam Lake named Slough Station. The water quality monitoring program, which began in 1997, documents a long period within the watershed which is a valuable tool for establishing baseline conditions. This allows land managers to detect potential problems and implement solutions to maintain good water quality for fish and water users.

The watershed received 15% less precipitation in 2022 than the 30-year average from 1981 to 2010, but with 36% more falling between March and June, and a substantial and persistent drought with 67% less than normal falling from July to November. This resulted in high stage and discharge measurements during the first part of the year, and low measurements during the second half. The minimum Lang Creek stage measurements of 0.27 m were recorded on September 25 and October 5, and were the third lowest measurements on record.

The maximum bi-weekly water sampling temperatures in 2022 were cooler than in 2021 at most sites, except for Haslam Lake which was slightly warmer. This 2022 maximum was 0.4°C less than the maximum bi-weekly water temperature recorded within the watershed in 2021 due to a cooler heat wave. The maximum water temperature from continuous measurements on Lang Creek in 2022 was 1.8°C cooler than the 2021 maximum.

Turbidity, pH, and salinity generally varied within the normal and acceptable range for 2022. Maximum and average turbidity values in 2022 were lower in Lang, Blackwater, and Anderson

Creeks, and in Haslam Lake. The higher maximum and average turbidity measurements at Slough Station were likely caused by local events, such as by animal disturbance, and by woody debris disturbing sediment as it shifts. Duck Lake also had higher maximum and average turbidity in 2022, and that could be related to upstream channel changes from the fall 2021 floods. The average and minimum pH measurements were more basic (higher values) this year than in 2021. Average and maximum salinity values were lower in 2022 than in 2021. This water quality data suggests that forest management strategies intended to protect water quality within the watershed are successful.

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APPENDICES

1.0 INTRODUCTION

The Powell River Salmon Society (PRSS), with funding from the Powell River Community Forest (PRCF), British Columbia Timber Sales (BCTS), and Thichum Forest Products of the Tla'amin First Nation (Thichum), monitors streams and lakes within the Haslam Lang Community Watershed to identify how development and land use affect water quality and habitat. The watershed provides important habitat for several fish species and the PRSS operates a hatchery on Lang Creek. The watershed provides drinking water to the city of Powell River and the community of Brew Bay.

As part of the ongoing water quality monitoring program, the PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during 2022 and to compare the results with previous years of monitoring.

This report was revised on April 3, 2023, to amend the listed companies that fund the water quality monitoring program.

2.0 BACKGROUND

Land managers have prioritized sustainable development within the Haslam Lang Community Watershed for over two decades. Water quality monitoring within the watershed began in 1997 and a watershed management plan was implemented in 1999. Both initiatives aimed to study and maintain water quality to protect the communities and natural ecosystems that depend on the watershed.

The Haslam Lake and Lang Creek Integrated Watershed Management Plan (IWMP) and subsequent watershed assessments, most recently completed in 2020, have guided sustainable development within the watershed by identifying resources at risk and effectively managing public interests. Management planning, watershed assessments, stakeholder involvement, and implementation of best management practices have provided sound scientific and practical guidance for sustainable development in the watershed.

The water quality monitoring program provides important information to the watershed management plan process. The data analysis can identify short-term changes and long-term trends

in water quality that can only be identified with active monitoring. If the monitoring identifies potential problems, the data can guide management strategies to reduce risks within the watershed and to downstream resources. Land managers can use insights from these analyses to prioritize and respond to potential problems before they cause damage to watershed resources.

The monitoring program also ensures that water license operators meet sustainability requirements throughout the year. One requirement is to maintain a minimum flow greater than 15 ft^3/s (0.42 m^3/s) in Slough Creek downstream of the storage dam at all times of the year, and this minimum should be increased to 25 ft^3/s (0.71 m^3/s) during October and November to meet instream flow requirements for returning salmon runs. Maintaining the minimum flow requirements and good water quality is key for sustainable development within the watershed.

Four watershed assessments have been completed; the first in 1999 (Carson, 2000), the second in 2003 (Carson, 2003), and the third in 2015 (Carson Land Resource Management, 2015). Statlu completed the fourth and latest watershed assessment in 2020 (Statlu, 2020). Additionally, Carson (2010) assessed how PRCF operations affect water quality within the Powell River area, including areas within the PRCF but outside the community watershed.

3.0 METHODOLOGY

The water quality monitoring program includes bi-weekly measurements at six locations in the watershed, continuous water temperature monitoring at several locations, and continuous water temperature and discharge monitoring on Lang Creek at the Alex Dobler Salmon Centre. The bi-weekly measurements include stream stage, turbidity, pH, water temperature, and salinity. They are taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Blackwater Creek, Anderson Creek, Haslam Lake near the community water intake, and Haslam Lake at Slough Station (Figure 1 in Appendix 1). Continuous water temperature monitoring occurs in Duck Lake and in Lang, Anderson, and Blackwater Creeks. The data, along with general observations and photographs taken during the sampling, were sent to Statlu for analysis.

Statlu first compared monthly precipitation and temperature data recorded during 2022 to the latest average monthly data collected during the 30-year period from 1981 to 2010 (Environment Canada, 2023). Environment Canada has not yet published climate normal data conditions for the

1991 to 2020 interval. When those data are made publicly available, they will provide a more accurate baseline against which to compare recently measured conditions. The data was recorded at the Powell River A climate station, located 130 m above mean sea level at the Powell River Airport, about 7 km southwest of Haslam Lake. The 30-year average of precipitation and temperature is referenced as normal climate conditions.

Statlu then prepared two graphs for each water quality variable measured during the bi-weekly sampling (water temperature, stage, turbidity, pH, and salinity). The data for all six sites within the watershed are plotted on each graph. The first graph shows how one of the water quality variables changed at each of the six locations during 2022. The second graph compares the data recorded during 2022 to data recorded from 1997 to present. The long-term graph shows how water quality within the watershed has changed over the history of monitoring and allows anomalous long-term trends to be identified.

Statlu compared the six water quality variables to the continuous hydrograph data recorded on Lang Creek at the Alex Dobler Salmon Centre. We extracted the daily maximum and minimum discharge (water volume) from the continuous stream flow data and compared those values to previous years. We plotted the stream flow data with daily precipitation data collected at the Powell River A climate station, located at Powell River airport. Precipitation data from the Powell River climate station replaces missing Powell River A data on January 10 and 11, and November 11 and 12, 2022. The comparison of discharge to precipitation show how Lang Creek responds to short-term weather events. This also provides additional information about how the weather and climate affected water quality during the bi-weekly sampling, and what may have occurred between sampling dates.

The PRSS used to collect precipitation data at the Alex Dobler Salmon Centre, but analysis of several years of data show that the Powell River A and Powell River climate station data closely matches the means, range, and variability of the data collected in the watershed. Given the similarity between the climate data from the two locations, the Powell River data reasonably describes climactic conditions in the Lang Creek watershed. Accordingly, the PRSS decided to stop independently collecting climate data. This analysis uses data collected in Powell River (Environment Canada, 2023).

Statlu compared the continuous water temperature data recorded in Duck Lake and Lang, Anderson, and Blackwater Creeks to air temperature data recorded in Powell River. Statlu compared the daily water temperature data to the bi-monthly water quality data recorded within the watershed.

The PRSS endured several equipment failures and access troubles during 2022. The continuous monitoring station on Lang Creek was damaged beyond function between March 2 and March 23. As a result, continuous streamflow and temperature data are missing during this interval. The PRSS also had many tidbit failures. Tidbits are small water temperature data loggers, which continuously monitor temperature data in Anderson, Blackwater, and Lang Creeks, and in Duck Lake. In addition, snowy and icy roads prevented the manual bi-weekly sampling in Anderson Creek until February 24, missing the first three measurements of the year.

4.0 OBSERVATIONS

The PRSS made field observations and took photographs within the watershed to record conditions that could influence the data. The photographs are shown in Appendix 2. The PRSS observed sediment-laden water running off the road from near Duck Lake Bridge into the head of Lang Creek during heavy precipitation events (Photo 2, June 3). A bucket of hydraulic fluid was found in a ditch near Duck Lake (Photo 3, August 3). Two car accidents on Lang Bay bridge caused a car and bridge material to enter the creek. The car was removed, but the bridge debris was left in the creek for some time before finally being removed (Photo 4, August 8). A large cedar tree fell over on the bank of Lang Creek near the water intake for the residents of Brew Bay (Photo 5, June 9). The PRSS notes the tree was removed and that native seedlings were planted to help stabilize the bank in the future (Photo 6, June 9).

5.0 RESULTS

5.1 Precipitation and Air Temperature

I compared the total monthly precipitation and mean monthly air temperature, recorded at the Powell River A climate station during 2022, to the monthly 30-year averages (referred to as 'normal') recorded from 1981 to 2010 at the same location (Figure 1). Precipitation data from the Powell River climate station replaces missing Powell River A data on January 10 and 11, and November 11 and 12, 2022.

The total precipitation recorded during 2022 was 1007 mm, which is 15% less than the 1231 mm recorded in 2021, and 14% less than the 30-year average from 1981 to 2010 of 1206 mm per year (Environment Canada, 2023). The spring, from March to June, was 36% wetter than the 30-year average. The trend reversed in July, and from then to November total precipitation was 67% less than the 30-year average. The July to November drought was widespread across the region and affected much of the Lower Mainland and Vancouver Island.

Southwest BC had a cool spring and warm fall in 2022. Average air temperature was 2.3°C below normal in April and May, and 2.0°C above normal from June to October, before dipping 2.2°C below normal in November and December. The warmest month was August, with an average temperature of 19.8°C, which is 0.4°C more than the warmest average month in 2021 and 2.6°C more than the 30-year average warmest month temperatures of 17.2°C.

The Powell River A climate station recorded eight days above 30°C in 2022, which is one fewer than in 2021. Both 2021 and 2022 had five consecutive days with temperatures above 30°C. The maximum 2022 air temperature was 33.6°C on July 26, 3.4°C cooler than the 2021 maximum of 37.0°C, which occurred during the record-breaking June 2021 heat dome. During the 30-year average from 1981 to 2010, the Powell River A climate station recorded an average 1.6 days above 30°C per year. With eight days above 30°C in 2022 and nine days in 2021, that is a 400% and 463% increase from the 30-year average, respectively. It is likely that the average number of days above 30°C over the 1991 to 2020 climate interval will be shown to be more than 1.6 when that data is published.

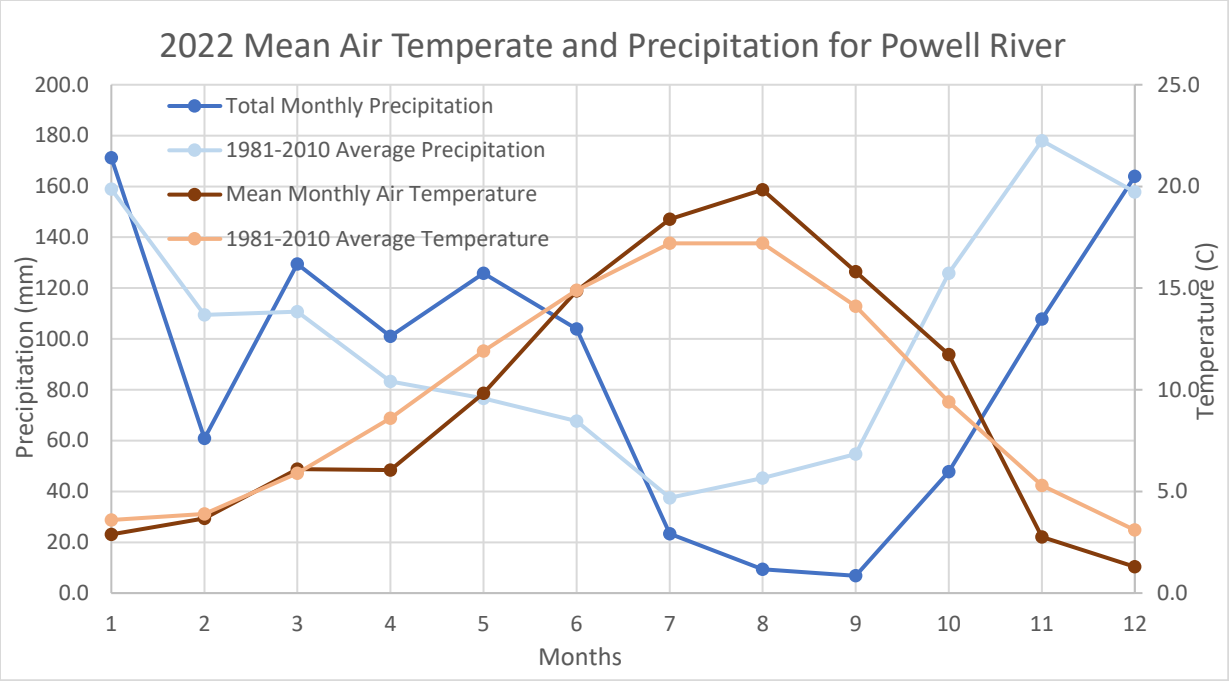

Figure 1: Mean air temperature (°C) and total monthly precipitation (mm) at the Powell River A climate station for 2022 compared to the 30-year average from 1981 to 2010. Precipitation data from the Powell River climate station replaces missing Powell River A data on January 10 and 11, and November 11 and 12, 2022.

5.2 Water Temperature

Continuous water temperature monitoring at Lang, Anderson, and Blackwater Creeks, and in Duck Lake, show how water temperature responded to weather events (Figure 2). The continuous water temperature data is compared to air temperature data recorded at the Powell River A and Powell River climate stations (Environment Canada, 2023). The data show that water temperature spikes closely follow air temperature spikes. Lang Creek and Duck Lake have larger temperature increases during summer than Anderson and Blackwater Creek. In winter, Duck Lake stays warmer than the minimum temperatures of the creeks. The maximum water temperatures occurred from July 29 to July 31, with 24.5°C in Duck Lake, 24.1°C in Lang Creek, 17.1°C in Blackwater Creek, and 16.2°C in Anderson Creek. These high temperatures were recorded during the second half of a 5-day period with daily maximum air temperatures above 30°C at the Powell River A climate station. The maximum water temperature on Lang Creek in 2022 was 1.8°C less than the 2021 maximum.

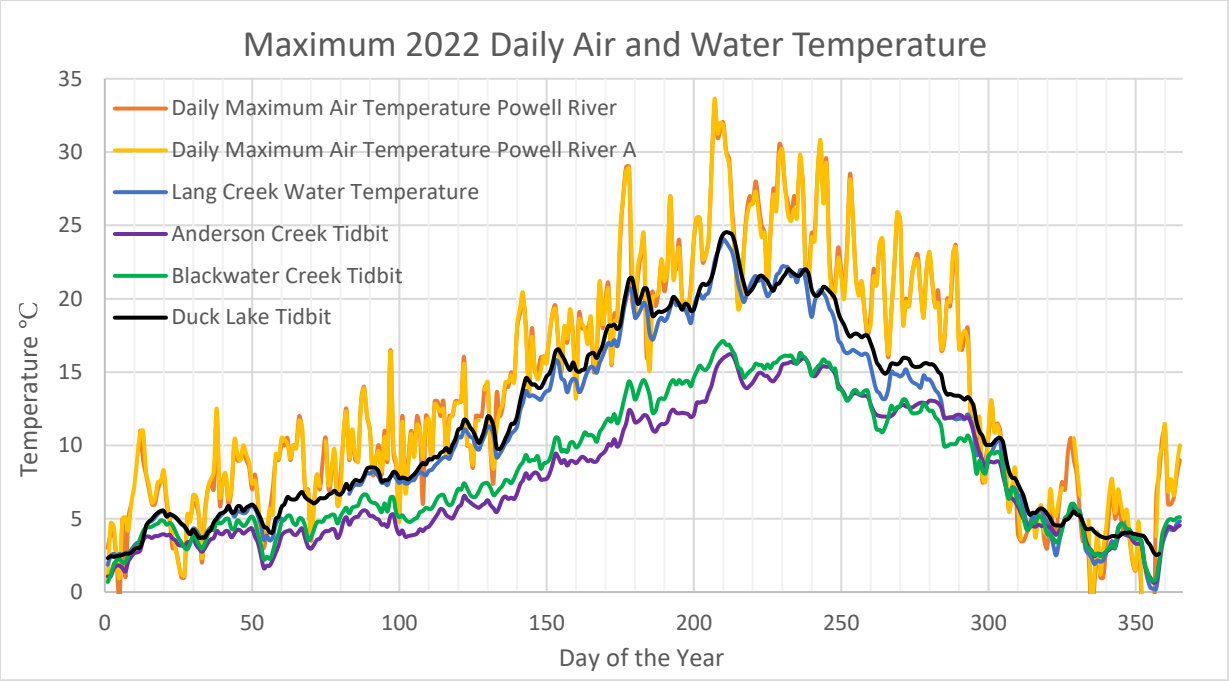

Figure 2: Comparison of maximum air temperature with maximum water temperatures in the watershed. Continuous water temperature data was recorded on Lang Creek recorded at the Alex Dobler Salmon Centre. Air temperature data is from the Power River and Power River A climate stations (Environment Canada, 2023).

Bi-monthly sampling throughout the watershed shows how temperatures at all six sites varied during the year. Average water temperatures within the watershed ranged from 7.5°C to 11.8°C, which is cooler than the 2021 averages from 8.6°C to 13.2°C. The temperatures are coldest during the winter and warmest during the summer (Figure 3). The maximum water temperatures recorded were 0.3°C to 2.4°C cooler than in 2021 at most sites, except for Haslam Lake which was 0.7°C warmer. Duck Lake historically has the highest maximum water temperature within the watershed, but in 2022, Haslam Lake was the warmest at 25.3°C. The 2022 maximum is 0.7°C warmer than the maximum temperature recorded in Haslam Lake in 2021, but is 0.4°C cooler than the 2021 maximum water temperature record in Duck Lake. The maximum bi-monthly water temperatures in 2021 remain within the normal variability recorded at the six sites from 1997 to present (Figure 4).

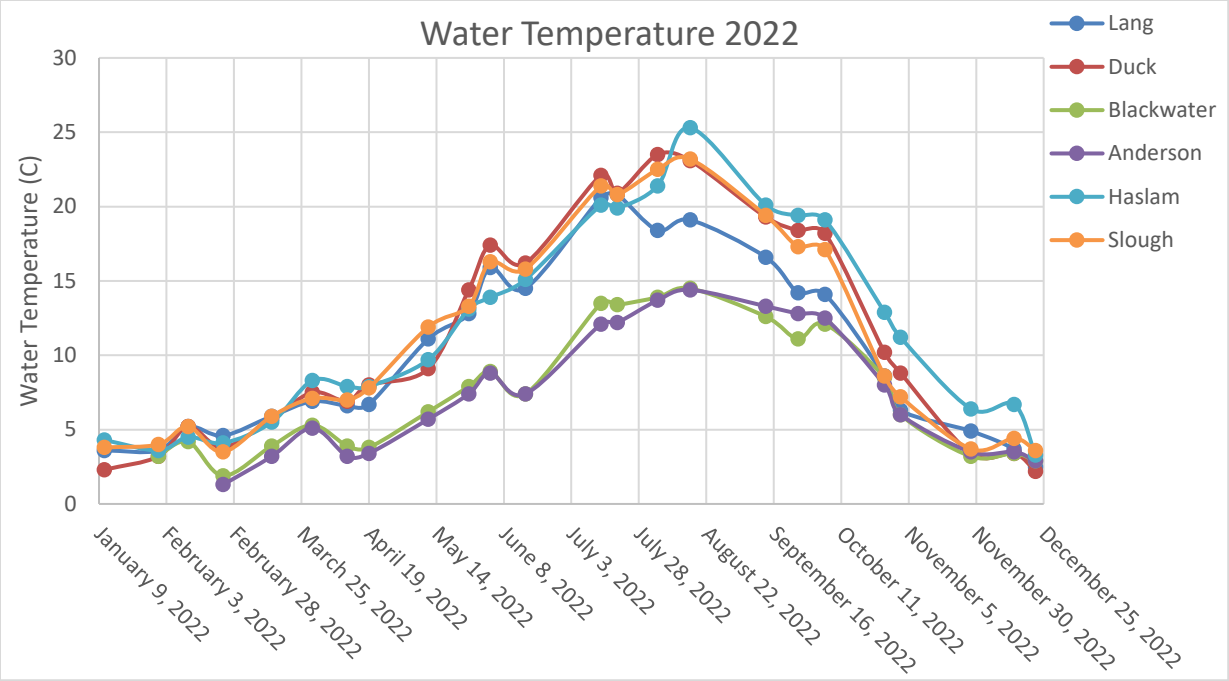

Figure 3: Water temperature measured at six sites within the Haslam Lang Community watershed.

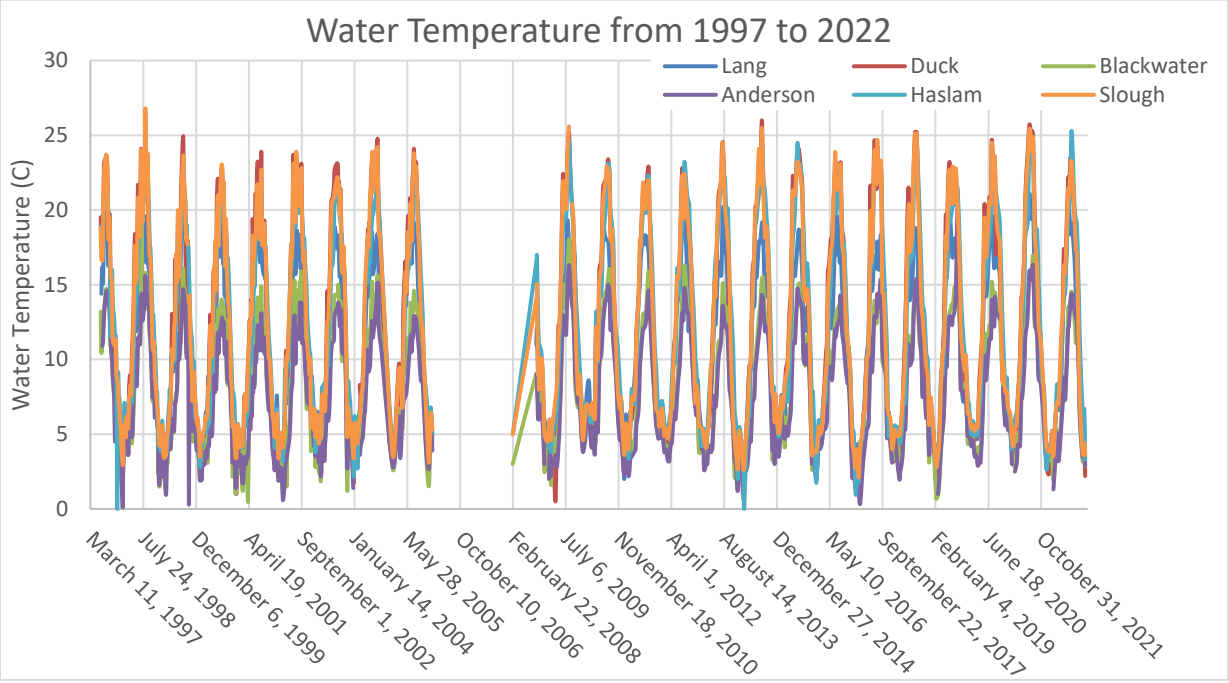

Figure 4: Water temperature at six sites within the Haslam Lang Community watershed between 1997 and present.

5.3 Stage and Hydrograph

Stage measurements record the height of the water surface relative to a known reference elevation (Figure 5). The stage data for Haslam Lake and Slough Station are plotted on a secondary axis as their stage reference points are geodetic elevations, which differ from the other four sampling locations. Despite having two different reference points, the stage data for all six sites shows similar water level variations within the watershed during 2022.

The stage measurements at all six sites started high, reached minimum levels in fall, and ended the year lower than they started, in response to precipitation and temperature patterns (Figure 5). Most stage measurements in 2022 are lower than in 2021, with a few exceptions. The average stage measurements at all six sites range from the same to 0.13 m (18% less) lower than the 2021 measurements. The average stage was the same at Slough Station, and 18% lower in Lang Creek. The minimum stage measurements in 2022 on all creeks range from 0.04 m (13%) higher to 0.07 m (18%) lower than in 2021. Anderson and Blackwater Creeks and Haslam Lake recorded higher minimum stage measurements, while Duck Lake and Lang Creek recorded lower minimum stage measurements. The minimum stage measurements on Lang Creek of 0.27 m on September 25 and October 5 were the third lowest on record (Figure 6). The stage measurements remained within the range of previous measurements in the watershed.

The wetter than normal spring resulted in high stage measurements in Haslam Lake in June. The maximum stage occurred on June 3 and was 0.73 m and 0.76 m higher than in 2021, measured at the Powell River water intake and Slough Station respectively. According to the PRSS, this high measurement could have been caused by debris blocking the outlet of the lake at Slough Station. The maximum stage measurements in Duck Lake and in Lang, Blackwater, and Anderson Creeks are from 0.51 m (34%) to 0.08 m (10%) lower than in 2021, but are similar to the normal range of values recorded since 1997 (Figure 6). The bi-weekly measurements did not capture that maximum Land Creek discharge on January 13 (Figure 7), but did capture a peak on March 29 which occurred after several days of rain.

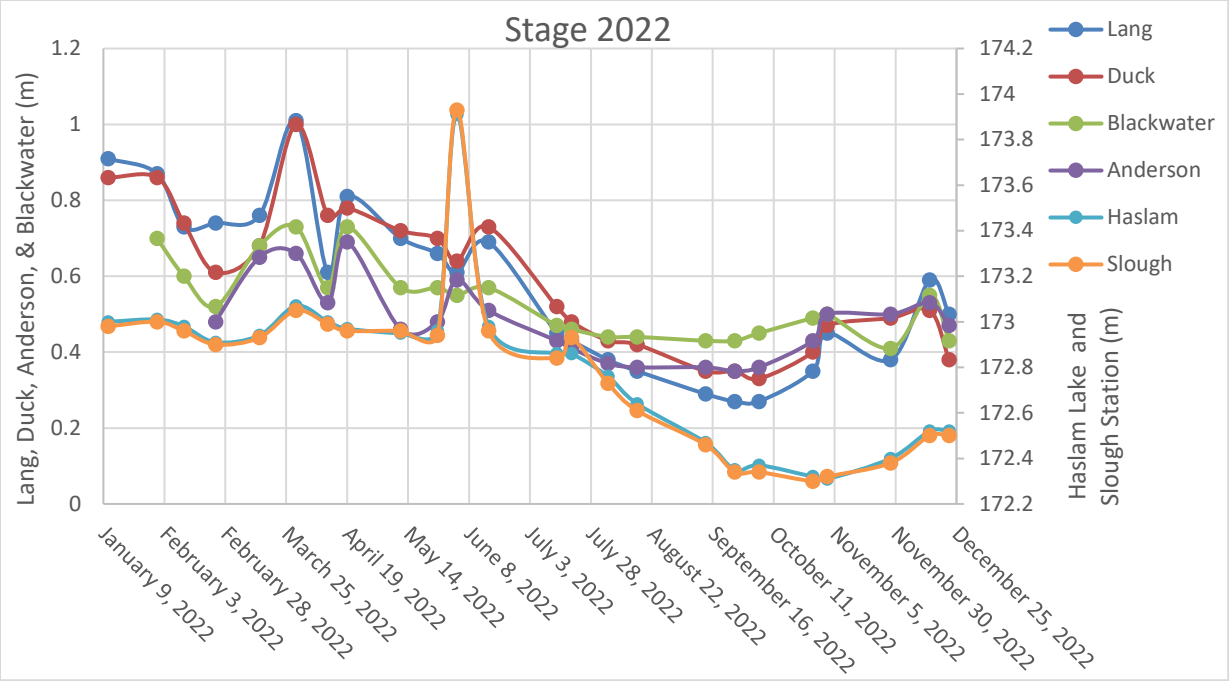

Figure 5: Stage level at six sites within the community watershed during 2022. Stage measurements for Haslam Lake and Slough Station are graphed on the secondary (right) axis.

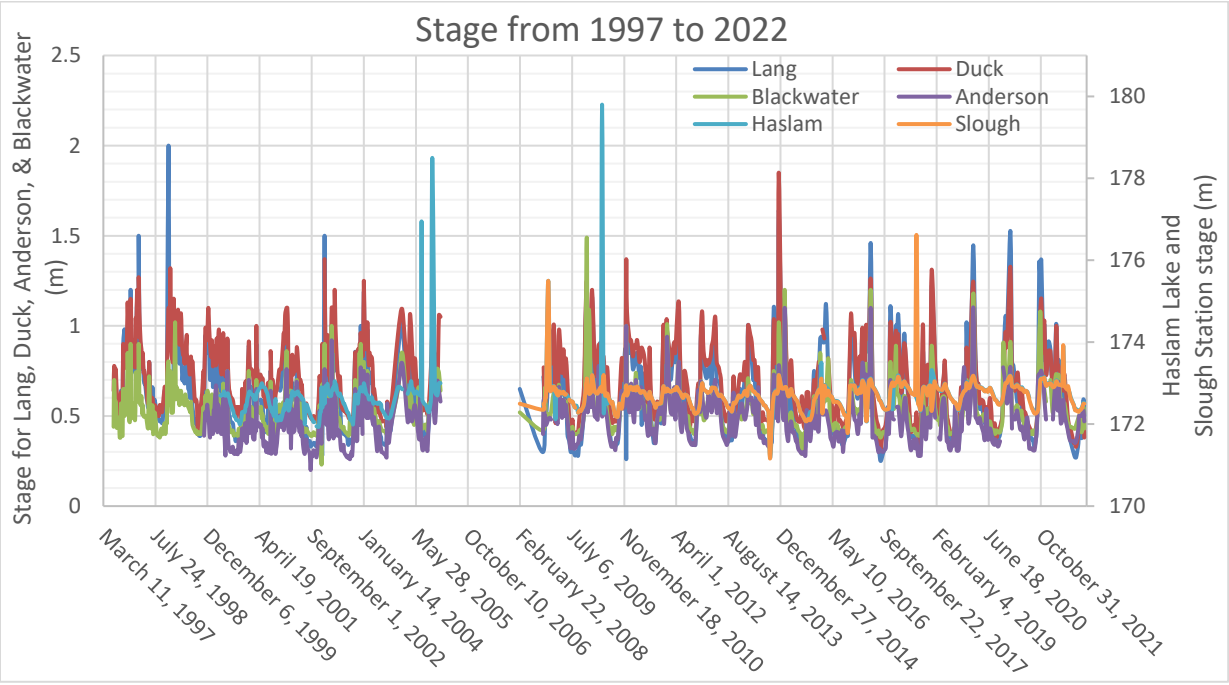

Figure 6: Stage discharge at six sites within the community watershed between 1997 and present. The stage for Haslam Lake and Slough Station is graphed on the secondary (right) axis.

Continuous data recording in Lang Creek during 2022 measured discharge rates throughout 2022 (Figure 7). The maximum peak discharge in Lang Creek was recorded on January 13 at 38.1 m^3/s. The lowest discharge was on October 6 and 8 at 0.282 m^3/s. The average discharge through 2021 was 3.94 m^3/s and the median discharge was 2.17 m^3/s. The 2022 maximum, median, and average discharge values are less than those recorded in 2021 (Table 1, Figure 8). The maximum discharge is 46% lower, the average discharge is 48% lower, and the median discharge is 47% lower than the 2021 values. The minimum discharge of 2022 is 42% lower than 2021 minimum and is the lowest minimum discharge observed in the last five years (Table 1, Figures 6 and 8).

The highest peak flows occurred during rain-on-snow precipitation events. The highest peak flows occurred on January 13 and December 13, 2022. In both cases, the preceding week was cool with precipitation falling as snow. Temperatures then increased up to 11°C and 11.4°C respectively over a period of several days, and rain fell during several preceding days. The combination of melting snow and rain caused higher peak flows then the largest single day rainfall of 2022, which occurred in May and caused a much smaller spike discharge (Figure 7).

Haslam Lake was below the weir from about July 19 to about October 27, resulting in low and consistent flow in Lang Creek. Several rainstorms around day 300 refilled Haslam Lake, overtopped the weir, and allowed water to raise the level of Lang Creek. After this date, smaller single day rain events in November and December resulted in discharge spikes because Haslam Lake was no longer storing some of the precipitation.

Table 1: Yearly discharge rates of Lang Creek from 2018 to 2021.

Year	Maximum (m^3/s)	Average (m^3/s)	Median (m^3/s)	Minimum (m^3/s)
2018	49.9	6.02	3.99	0.382
2019	23.3	3.77	2.38	0.472
2020	59.1	6.07	2.70	0.722
2021	70.1	7.56	4.14	0.490
2022	**38.1**	**3.94**	**2.18**	**0.282**

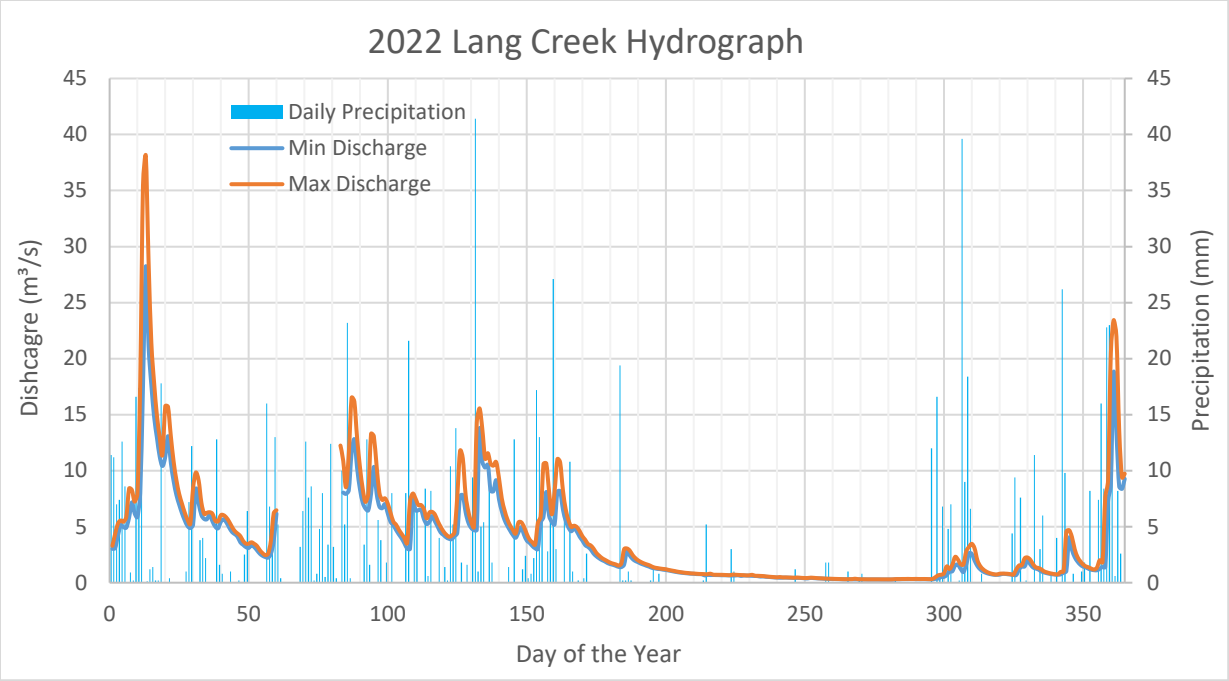

Figure 7: 2022 Hydrograph for Lang Creek. The minimum and maximum daily discharge (m³/s) for Lang Creek is plotted against the total daily precipitation (mm) recorded at the Powell River A climate station. Precipitation data from the Powell River climate station replaces missing Powell River A data on January 10 and 11, and November 11 and 12, 2022.

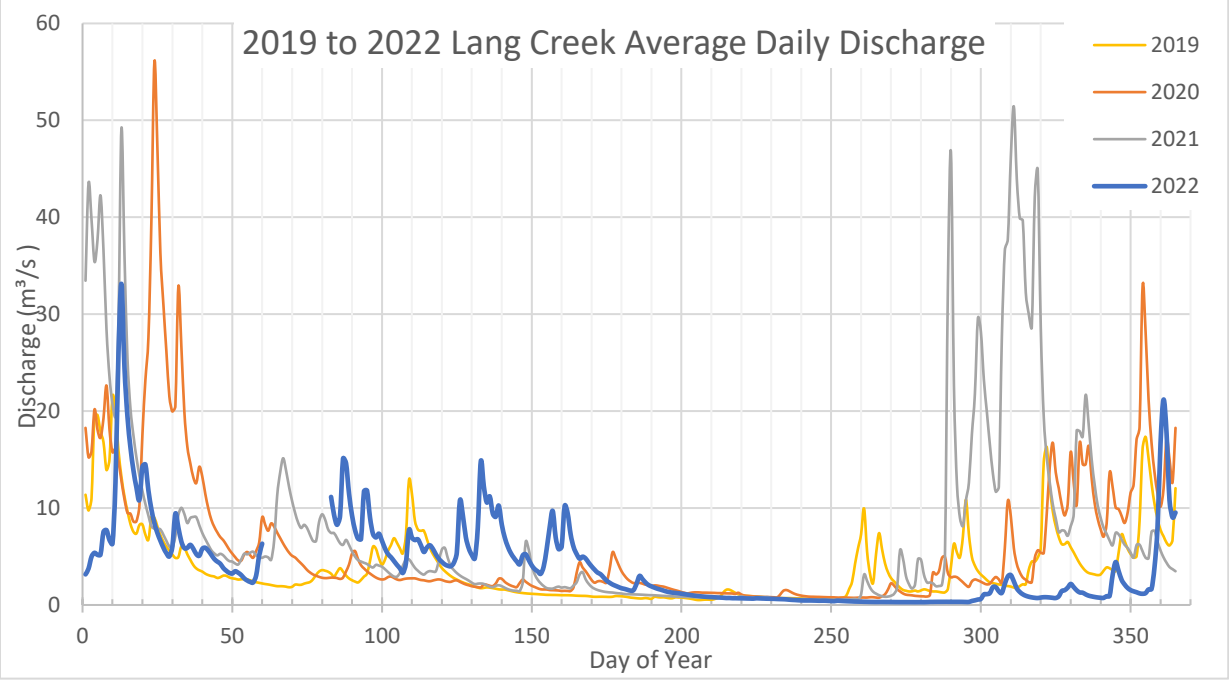

Figure 8: Average daily discharge data for Lang Creek comparing 2019 to 2022 data. The data shows the wetter than normal spring in 2022 and the abnormally low minimum flow during fall.

5.4 Turbidity

The bi-monthly turbidity measurements in 2022 were between approximately 0.21 NTU and 5.6 NTU, with average readings between 0.38 NTU and 1.33 NTU (Figure 9). The highest turbidity readings occurred on January 31, 2022, on Lang Creek and Duck Lake. Other elevated readings on Lang Creek occurred on January 11, February, 11, and October 27. All other turbidity readings were below 2 NTU.

The turbidity levels in 2022 are generally lower than in 2021. The maximum turbidity on Lang Creek (5.6 NTU) is 35% less than 2021 bi-monthly maximum of 8.6 NTU. The maximum and average turbidity measurements in Lang, Blackwater, and Anderson Creeks, and in Haslam Lake, are 9% to 56% lower than in 2021. Haslam Lake at Slough Station and Duck Lake recorded higher average turbidities, with 18% and 17% increases from 2021, respectively. The maximum turbidity reading of 3.2 NTU on Duck Lake was 159% greater than 2021 levels. The 1.76 NTU maximum at Slough Station was 89% higher than the 2021 maximum.

Turbidity data from 1997 to present shows low average turbidity with episodic spikes through the years (Figure 10). The 2022 data shows that average turbidity levels within the watershed are normal and that maximum turbidity levels are well below other turbidity spikes in previous years.

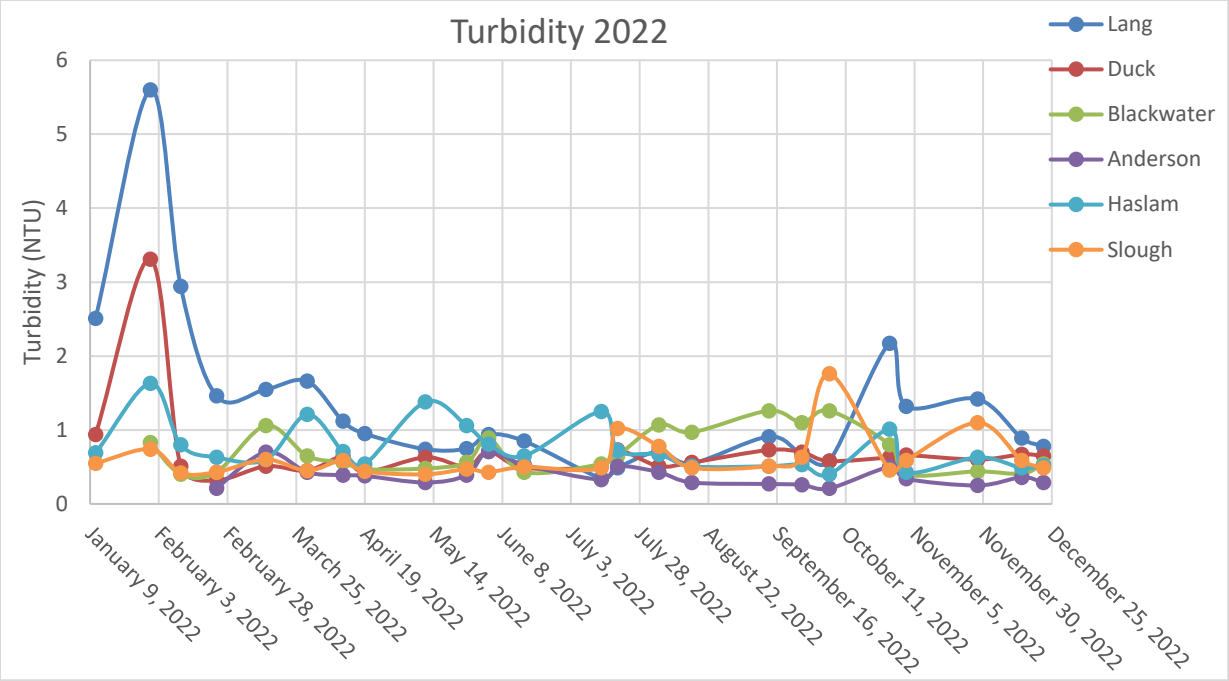

Figure 9: Turbidity measurements through 2022 at six sites within the Haslam Lang Community watershed.

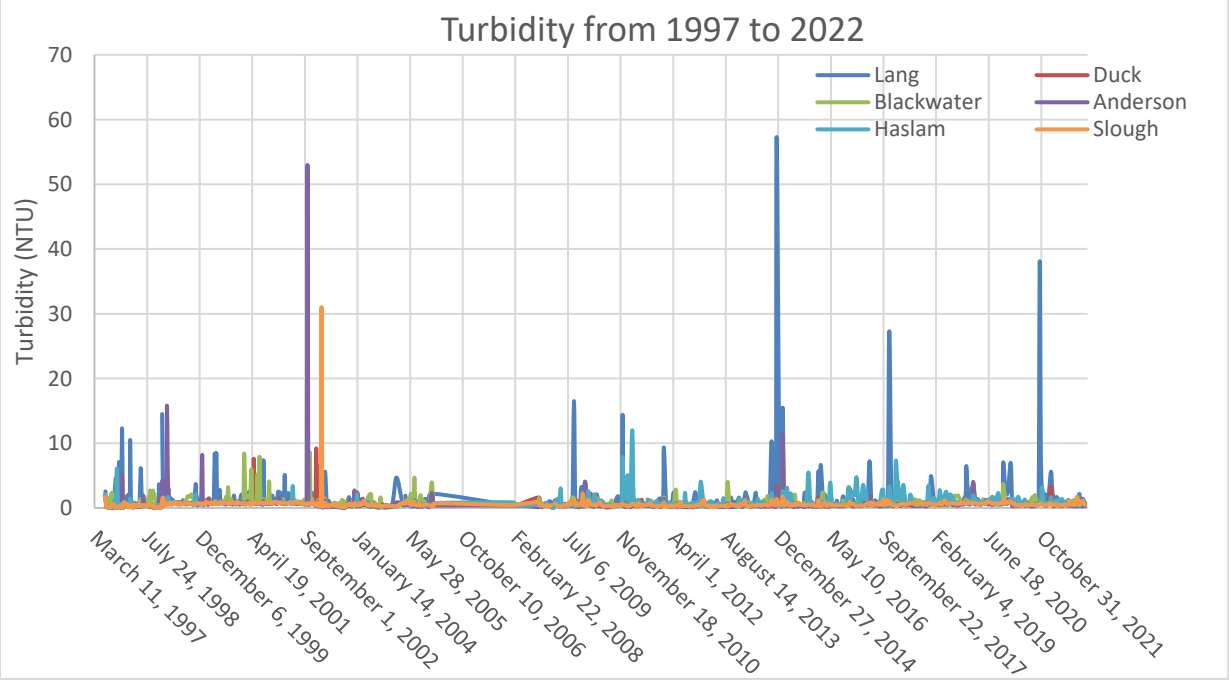

Figure 10: Turbidity at six sites within the Haslam Lang Community watershed between 1997 and present.

5.5 pH

The pH ranged between 6.6 and 7.5 within the watershed during 2022 (Figure 11). Overall, pH varies with a level trend during the year with some higher pH measurements during the fall. Average pH measurements at all sites were higher (less acidic) than recorded in 2021. The 2022 averages were between 7.0 and 7.1, up to 0.1 (2%) more than the 2021 pH averages of 6.9 to 7.0. Maximum pH measurements of 7.4 to 7.5 occurred in Duck Lake on March 14 and Lang Creek on October 10. These readings are 0.2 to 0.3 (2% to 4%) more than the maximum pH recorded in 2021. The minimum pH measurements of 6.6 on Haslam Lake and 6.7 at Slough Station occurred on February 11 and November 28, respectively. These readings are up to 2% less than the 2021 minimums recorded at these locations, but are 0.1 (2%) more than the minimum 2021 pH value recorded on Lang Creek in 2021.

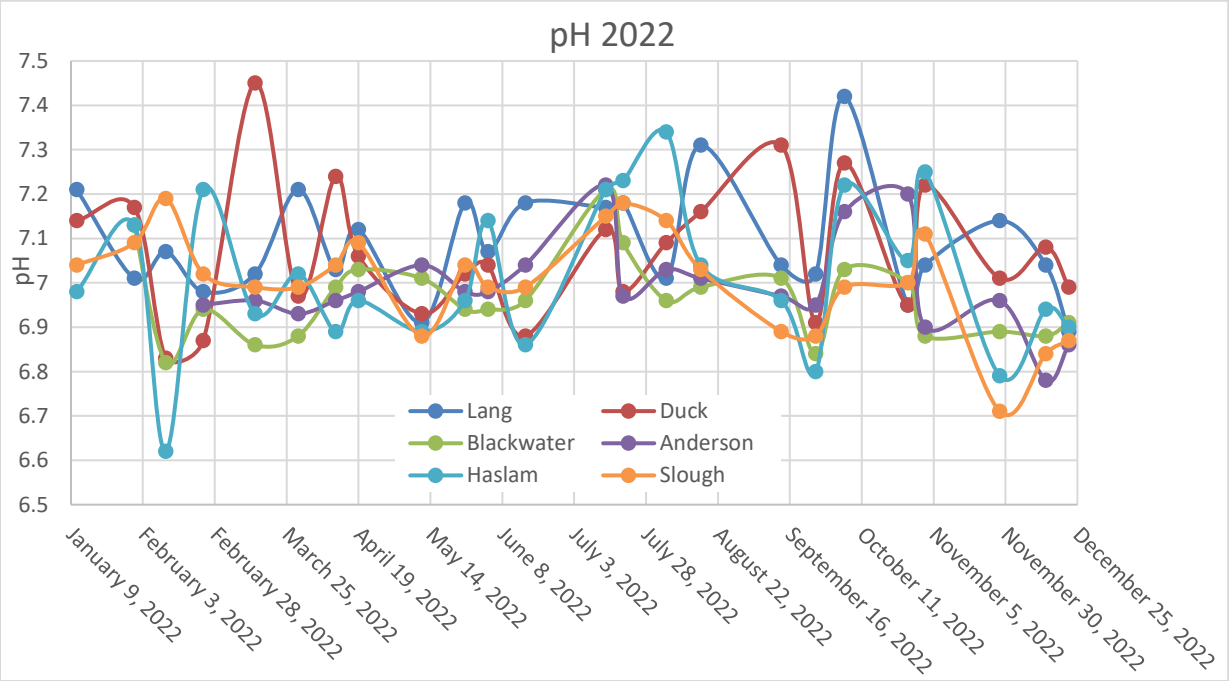

Figure 11: pH at six sites within the Haslam Lang Community watershed.

Variations in pH for the recorded history for all sites are shown in Figure 12. The pH values over the last two years show slightly more variability than between 2016 and 2021, where the pH generally varied between 6.7 and 7.3 (with the exception of one low pH spike in 2019). But, the pH

range over the last 2 years remains within normal variability and is much less than pH variation recorded from 1997 to 2013.

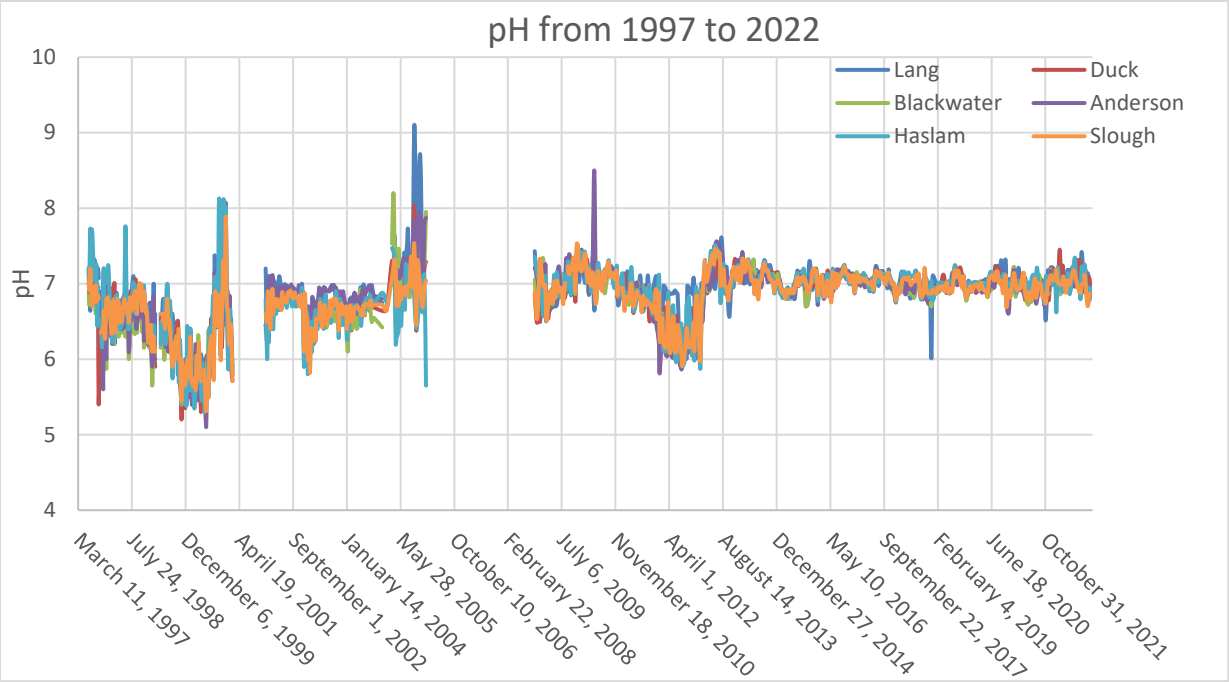

Figure 12: pH at six sites within the Haslam Lang Community watershed between 1997 and 2022.

5.6 Salinity

Salinity varied from about 1 ppm to 17 ppm at the six sites during 2022 (Figure 13). Average 2022 salinity ranged from 7 ppm to 11 ppm, which is less than the 2021 averages between 9 ppm and 12 ppm. The average salinity in Lang, Anderson, and Blackwater Creeks was 24% to 36% less than in 2021. Slough Station and Haslam Lake sampling recorded 12% and 17% lower average salinities that in 2021. The smallest change occurred in Duck Lake, where average salinity was 3% less than in 2021.

The two maximum 2022 salinity measurements occurred on July 14 and August 4 on Blackwater Creek, at 15 ppm and 17 ppm respectively. A reading of 5 ppm was recorded on July 20 between the high readings. Overall, the maximum salinity readings either stayed the same or decreased by up to 36% at all six sites compared to 2021.

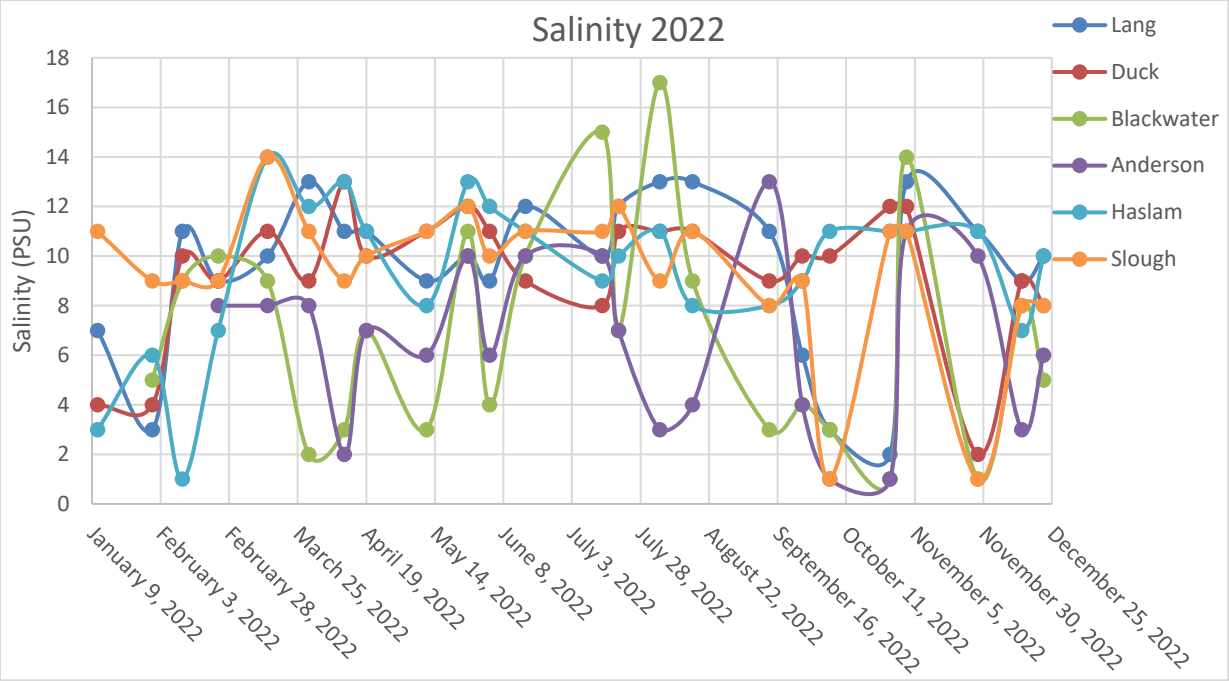

Figure 13: Salinity at six sites within the Haslam Lang Community watershed.

Blackwater and Anderson Creeks have variable salinity, that on average, increases from winter to summer and decreases from summer back to winter. Haslam Lake has low salinity readings early in the year, before increasing and remaining around 9 ppm on average. Slough Station salinity fluctuates around 10 ppm until mid-September, then records large variations for the rest of the year. Duck and Lang Creeks have low salinity readings in January, then readings that vary near 10 ppm until about mid-September, after which variation increases.

Salinity data from 1997 to present are graphed on Figure 14 with a gap between 2006 and 2008 when no monitoring occurred. Salinity data recorded from 1997 to 2006 are greater than salinity data recorded from 2008 to 2019. The abrupt decrease in salinity could result from equipment or measuring differences between the two periods. From 2009 to 2018, the salinity data for all six creeks varies from 0 ppm to 16 ppm and has average values between 4 ppm and 6 ppm. Salinity values started to increase at the end of 2018, and they continued to increase through 2019. The PRSS purchased a new salinity probe in 2020. It recorded similar, but slightly lower salinity levels in 2020 and again in 2021. In 2022, average salinity levels are similar to 2021, and remain within normal salinity levels for the watershed.

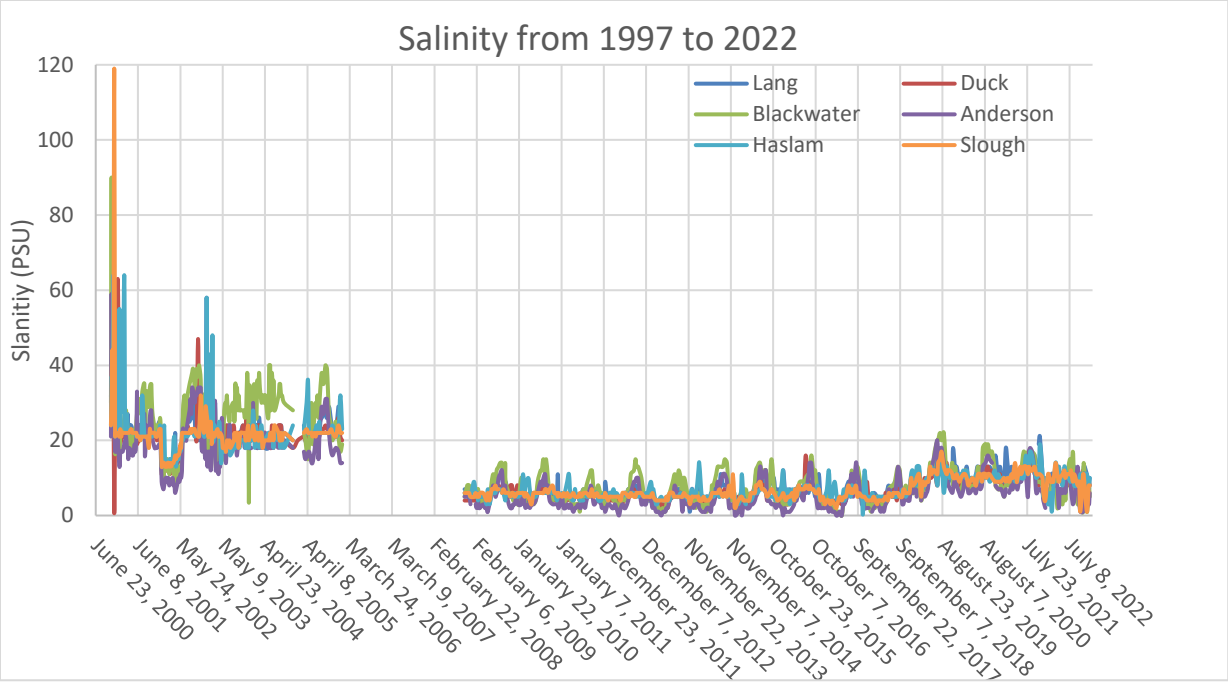

Figure 14: Salinity at six sites within the Haslam Lang Community watershed between 2009 and present.

6.0 DISCUSSION

Climate, weather, and land use affect water quality within the Haslam-Lang community watershed. Precipitation controls the volume and timing of water that enters the watershed, which determines how much erosive power streams have and the proportion of stream flow composed by runoff and groundwater. Variances of these properties control the physical and chemical characteristics of the stream such as temperature, discharge, turbidity, pH, and salinity. Land use within the watershed affects the amount of dust and sediment on road surfaces and the amount of potential contaminants within the watershed. Forest harvesting can affect runoff and forest cover near streams, which influences discharge and water temperature. This section compares water quality measurements within the watershed to identify trends between variables and understand how the hydrology of the Haslam Lang Community watershed is changing.

Maintaining suitable water temperature is important for maintain healthy habitat within the watershed, as increasing water temperature results in lower water oxygen levels, which can kill aquatic organisms. Water temperatures are closely related to air temperature. The 2022 monthly average air temperatures in Powell River were 2.3°C below average in May and June, and 2.0°C

above average from July to October. Both 2022 and 2021 had five consecutive days with air temperatures above 30°C, which produced the warmest annual temperature on Lang Creek in each year. The warmest 2022 Lang Creek water temperature was 1.8°C less than in 2021. Bi-monthly sampling also recorded cooler maximum water temperatures in 2022 than in 2021 at five sites within the watershed. Only Haslam Lake recorded a higher maximum water temperature. This might result from the warmest 2022 heat wave occurring a month later than it did 2021, at the end of July rather than the end of June, when lake levels would have been lower and already warmer due to the preceding month of summer heat. With less water in the lake, a warmer starting temperature, and less inflow of new cooler water, the cooler 2022 heat wave could have caused the higher maximum water temperature.

Continuous water temperature monitoring in Duck Lake and in Lang, Anderson, and Blackwater Creeks show how water temperature varies in the watershed. The highest water temperatures occur on Duck Lake and Lang Creek, while Anderson and Blackwater creeks are much cooler. The larger surface area of Duck Lake and Lang Creek, along with the north-south orientation of Lang Creek, likely allow more solar heating than in Anderson and Blackwater Creeks, which flow roughly east-west and are shaded by forest. Additionally, the storage time of water in Duck Lake allows more solar heating than the flowing water in Anderson and Blackwater Creeks.

The 30-year average from 1981 to 2010 recorded 1.6 days above 30°C in Powell River. The last two years in 2021 and 2022 recorded 9 and 8 days above 30°C respectively, a 463% and 400% percent increase from this interval. The most recent climate normal interval from 1991 to 2020 remains unpublished. We expect the 1991 to 2020 interval will have more annual days above 30°C than from 1981 to 2010. Despite the increased number of warmer days, water temperatures within the watershed remain within normal values recorded since 1997, and are even lower than some years between 1997 and 2013. The suitable water temperatures may be helped by effective land management strategies related to riparian retention that help maintain water temperature during the heat waves.

Precipitation and temperature control runoff, groundwater, evaporation, and the intensity of floods and droughts. January was 8% wetter than normal, February was 44% drier than normal, and the spring from March to June was 36% wetter than normal. This resulted in high stage

measurements through the first part of 2022, resulting from high ground water levels following fall 2021, which was 78% wetter than normal, and the wetter than normal January and spring in 2022. Peak flow in Lang Creek occurred in January during warm temperatures and rain-on-snow precipitation. Other rainstorms with similar intensity occurred during the spring and in December but did not cause peak discharges as large as in January. The wetter than normal fall in 2021 likely contributed to the peak flow, causing elevated ground water levels into January and resulting in higher than typical runoff during the rainstorms and snowmelt. As groundwater levels decreased into February, as indicated by lower stage measurements in the creeks, the infiltration capacity of the land increased and reduced runoff and floods from similar rainstorms later in spring. Similarly, the rain-on-snow event in December occurred after a dry fall, and the lower groundwater levels likely reduced peak discharge.

Following June, precipitation was 67% less than normal from July to November, and resulted in annual precipitation that was 18% less than normal. This period was also 2.0°C warmer than normal, resulting in higher evaporation along with minimal precipitation. This resulted in a minimum discharge in Lang creek of 0.282 m^3/s on October 6 and October 8, which was 42% lower than the 2021 minimum, and was the lowest minimum discharge recorded during the last five years. This minimum flow occurred despite the wetter than normal spring. For comparison, the driest three-month period in 2021 was from June to August, with 67 mm of rain. In 2022, the driest three-month period from July to September only received 40 mm of rain, a 40% decrease. October was only marginally wetter, with 48 mm of rain, and remained well below average. Similar to discharge, the minimum and average stage measurements at most sites within the watershed were lower in 2022 than in 2021. The minimum stage and discharge in Lang Creek occurred one month later in 2022 than in 2021. This measurement was the third lowest on record and the lowest since 2017. Interestingly, the minimum stage measurements in Anderson Creek, Haslam Lake, and Slough Station were slightly higher than in 2021, which might suggest that more water could have been released from Haslam Lake to help maintain minimum flow in Lang Creek. Water managers maintained typical minimum flows in 2021, despite drier than normal summer conditions, but with 40% less rain over three months, and 32% less rain over four months, water managers did not maintain similar minimum flows in 2022.

The Lang Creek discharge data shows little variability between about July 9 (Day 190) and October 27 (Day 300) suggesting that water levels in Haslam Lake fell below the elevation of the weir that controls water flow into Lang Creek. Water levels likely overtopped the weir after several rainstorms in late October, and all subsequent spikes represent the full drainage area of the watershed.

Turbidity levels were lower in Lang, Blackwater, and Anderson Creek, and in Haslam Lake in 2022 than in 2021. Duck Lake and Haslam Lake at Slough Station recorded higher turbidity measures. The turbidity spikes in most creeks are associated with elevated stage and discharge readings. The highest turbidity readings on Lang Creek, Duck Lake, and in Haslam Lake, occurred in late January, about two weeks after the peak discharge. The higher-than-normal precipitation in fall 2021 and high flows earlier in January could have exposed sediment that maintained high turbidity. The high turbidity readings also occurred as temperatures warmed and snow melted. Melting snow and ice could have resulted in sediment-laden runoff from roads and small sloughs on stream banks, especially in areas where the fall 2021 floods resulted in eroded stream banks and exposed sediment. The PRSS observed muddy water flowing from a road into the head of Lang Creek from the Duck Lake Bridge during heavy rains, which may have contributed to the spike. In the second half of the year, the absence of large rainstorms maintained low turbidity levels within the watershed in many creeks, until Haslam Lake overtopped the weir and resulted in higher stream flow and higher turbidity in Lang Creek on October 27 (Day 300).

Higher average and maximum turbidity measurements were recorded at Slough Station in 2022 than in 2021. The maximum reading in Slough Station occurred on October 5, close to the lowest flows in the watershed. Only trace precipitation and typical wind gusts were recorded during the preceding week at the Powell River and Powell River A climate stations. The high turbidity reading could be caused by a local anomaly, such as an animal disturbing sediment near the sampling location prior to the measurement. The higher average turbidity measurements could be caused by more debris disturbing sediment as it shifts.

Other elevated turbidity readings occurred in Haslam Lake and Blackwater Creek. Several small turbidity spikes occurred periodically on Haslam Lake through the first part of the year, likely due to precipitation events increasing inflow turbidity or wind events stirring sediment near the

sampling location. In Blackwater Creek, turbidity measurements are often elevated in summer due to low water levels and muddy stream banks from wildlife and/or human activity. This trend continued in 2022, but the highest measurements were lower than in 2021.

Salinity and pH levels are related to the ratio of groundwater to surface runoff comprising stream flow. Groundwater contains dissolved solids that increase pH and salinity while rainstorms can capture air pollution that decreases pH and dilutes salinity. Past salinity and pH measurements are generally greater during the dry season when groundwater comprises a greater portion of stream flow, and lower during the wet season when precipitation runoff is greater. The 2022 salinity and pH measurements are variable with weak trends. The lowest pH and salinity values occurred during higher stream flows during the first and last parts of the year. Most of the highest pH measurements occurred from July to October, when groundwater predominantly contributed to streamflow. The salinity data varies with no consistent trend.

The variability in both salinity and pH could result from the highly variable precipitation over 2021 and 2022, which switched from well above average to well below average several times. Precipitation can both increase and decrease pH and salinity results. When the ground is saturated, precipitation runs directly into stream, both diluting groundwater and potentially adding contaminants, thereby decreasing pH and salinity. At lower precipitation rates or immediately after dry conditions, precipitation can recharge ground water levels and increase the outflow of older ground water entering streams, thereby increasing salinity and pH. Additionally, periods of below average precipitation could have resulted in each rainstorm delivering more concentrated pollutants to the creeks, resulting in larger decreases and variable data. Overall, both pH and salinity varied within a smaller range in 2022 than in 2021, and are within the normal variability recorded from 1997 to present. The data suggests that management practices within watershed have been effective at maintaining water quality.

The 2019 and 2020 water quality reports by Statlu identified that salinity increased from 2018 to 2019 and remained elevated from 2019 to 2020. The PRSS purchased a new salinity probe for the 2021 monitoring program to ensure that the increased salinity measurements were not caused by equipment error. The measured salinity in 2021 was about 10% lower than in 2020 but remained greater than values recorded in early 2018. The salinity measurements in 2022 are similar to 2021.

If the increased salinity resulted from equipment error, the salinity would have abruptly returned to early 2018 levels after the probe was replaced. The gradual increase and then decrease of salinity since 2018 indicates the trend is real and not a result of equipment error.

The 2022 data shows that water quality remains within acceptable levels within the watershed. The relatively low levels of turbidity and salinity, along with stable pH values, suggest that watershed management practices have been effective in limiting sediment production and reducing the volume of water that transports sediment and contaminants from roads and ditches directly into streams.

The PRSS has noted that the sloughs are popular recreation areas and garbage can be left near the water. Water sampling for general chemistry parameters such as fecal coliform, total metals, and $CaCO_3$ equivalent were last completed in 2010 (Carson, 2017). Additional data collection of these parameters could quantify how human activity affects water quality and would be useful to maintain a robust baseline monitoring program.

7.0 CONCLUSION

The Powell River Salmon Society (PRSS) has monitored water quality within the Haslam Lang Community Watershed since 1997. The watershed supplies drinking water to the City of Powell River and the community of Brew Bay. It provides important habitat for salmon species, and the PRSS operates a hatchery on Lang Creek. Maintaining water quality is important for providing healthy drinking water and maintaining clean salmon habitat.

PRSS retained Statlu Environmental Consulting Ltd. (Statlu) to analyze water quality data collected during the 2022 monitoring program and to compare the results with data from previous years. PRSS recorded water temperature, creek stage, turbidity, pH, and salinity twice per month at six locations within the watershed. The measurements were taken at Lang Creek near the Alex Dobler Salmon Centre, the outlet of Duck Lake, Anderson Creek, Blackwater Creek, Haslam Lake, and the weir at the outlet of Haslam Lake named Slough Station. The water quality monitoring program, which began in 1997, documents a long period within the watershed which is a valuable tool for establishing baseline conditions. This allows land managers to detect potential problems and implement solutions to maintain good water quality for fish and water users.

The watershed received 15% less precipitation in 2022 than the 30-year average from 1981 to 2010, but with 36% more falling between March and June, and a substantial and persistent drought with 67% less than normal falling from July to November. This resulted in high stage and discharge measurements during the first part of the year, and low measurements during the second half. The minimum Lang Creek stage measurements of 0.27 m were recorded on September 25 and October 5, and were the third lowest measurements on record.

The maximum bi-weekly water sampling temperatures in 2022 were cooler than in 2021 at most sites, except for Haslam Lake which was slightly warmer. This 2022 maximum was 0.4°C less than the maximum bi-weekly water temperature recorded within the watershed in 2021 due to a cooler heat wave. The maximum water temperature from continuous measurements on Lang Creek in 2022 was 1.8°C cooler than the 2021 maximum.

Turbidity, pH, and salinity generally varied within the normal and acceptable range for 2022. Maximum and average turbidity values in 2022 were lower in Lang, Blackwater, and Anderson Creeks, and in Haslam Lake. The higher maximum and average turbidity measurements at Slough Station were likely caused by local events, such as by animal disturbance, and by woody debris disturbing sediment as it shifts. Duck Lake also had higher maximum and average turbidity in 2022, and that could be related to upstream channel changes from the fall 2021 floods. The average and minimum pH measurements were more basic (higher values) this year than in 2021. Average and maximum salinity values were lower in 2022 than in 2021. This water quality data suggests that forest management strategies intended to protect water quality within the watershed are successful.

8.0 LIMITATIONS

The recommendations provided in this report are based on observations made by Statlu and are supported by information Statlu gathered. Observations are inherently imprecise. Conditions other than those indicated above may exist on the site. If such conditions are observed or if additional information becomes available, Statlu should be contacted so that this report may be reviewed and amended accordingly.

This report was prepared considering circumstances applying specifically to Powell River Salmon Society and the forestry organizations which provide funding for the water quality sampling. It is intended only for internal use by the client for the purposes for which it was commissioned and for use by government agencies regulating the specific activities to which it pertains. It is not reasonable for other parties to rely on the observations or conclusions contained herein.

Statlu prepared the report in a manner consistent with current provincial standards and on par or better than the level of care normally exercised by Professional Geoscientists and Professional Agrologists currently practicing in the area under similar conditions and budgetary constraints. Statlu offers no other warranties, either expressed or implied.

9.0 CLOSURE

Please contact me should you have any questions or if you require further clarification.

Yours truly,

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Figure 1: Monitoring Stations within Haslam Lang Community Watershed

1:100,000

Client: PRSS
Date Saved: Mar 24, 2023
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APPENDIX 2: PHOTOS

Photo 1: Sampling on Duck Lake. Photo taken on March 3, 2022.

Photo 2: Sediment-laden water flowing into Duck Lake from a road. Photo taken on June 3, 2022.

Photo 3: The PRSS found a bucket of hydraulic fluid in a ditch near Duck Lake. Photo taken on August 16, 2022.

Photo 4: Two vehicle crashes left debris in Lang Creek below the highway. Photo taken on August 3, 2022.

Photo 5: A large cedar tree fell over near the Brew Bay residential water intake. Photo taken on June 6, 2022.

Photo 6: Tree seedlings were planted to stabilize the bank where the cedar fell over. Photo taken on June 6, 2022.