Upper Lillooet Hydro Project

Operational Environmental Monitoring: Year 2

Prepared for:

Upper Lillooet River Power Limited Partnership,
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EXECUTIVE SUMMARY

Ecofish Research Ltd. (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership (collectively, the Partnerships) to conduct year two of the operational environmental monitoring program (OEMP) for the Upper Lillooet Hydro Project (ULHP) (the Project). The Project is comprised of two hydroelectric facilities (HEF), the largest of which is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119). The other facility is located on Boulder Creek (WC: 119-848100).

The OEMP addresses the operational monitoring conditions identified during the environmental assessments (Lewis *et al.* 2012, Leigh-Spencer *et al.* 2012, Hedberg and Associates 2011, Lacroix *et al.* 2011a, b, c, d, NHC 2011) and conditions listed in Schedule B of the Environmental Assessment Certificate (EAC) E13-01 (EAO 2013). The aquatic components of the OEMP are also based on the *Fisheries and Oceans Canada (DFO) Long-term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects* (Lewis *et al.* 2013a). This report documents the field work and analysis conducted following Year 2 of the OEMP (Harwood *et al.* 2017).

Water Temperature

The objective of monitoring water temperature is to determine Project effects on stream temperature and assess whether project-related effects are biologically significant and affect growth, survival, or reproductive success of Upper Lillooet River and Boulder Creek fish populations. To achieve this, water temperature will be monitored continuously for the first five years of operation and compared to the baseline data using a Before-After-Control-Impact (BACI) design following completion of the monitoring program. Temperature metrics include daily and monthly temperature, length of the growing season, number of extreme temperature days, rate of temperature change, and mean weekly maximum temperature (MWMxT). These metrics are compared to water temperature BC Water Quality Guidelines (BC WQG) to assess potential impacts on aquatic life and on fish species present in the Project area.

The baseline thermal regime in the Upper Lillooet River and Boulder Creek was characterized between 2008 and 2013 using water temperature data from two monitoring sites in each watercourse: one upstream control site and one impact site located in the lower diversion reach. Baseline air temperature was characterized in the Upper Lillooet River from 2010 to 2013 and in Boulder Creek from 2010 to 2015 at locations adjacent to the water temperature sites.

In March 2018, water temperature data loggers were installed at a control site, a lower diversion impact site, in the tailrace, and a downstream impact site in both watercourses, with the exception of the upstream site in Boulder Creek which was installed in September 2018. Temperature loggers were also installed in North Creek in September 2018 to concurrently collect water temperature data for at least a year of operational monitoring. The purpose of concurrent monitoring is to establish if the Boulder Creek upstream site is influenced by groundwater and if so, to make minor adjustment to the baseline and operational data set to account for groundwater input. Following a year of data collection, a QP

will review the results to determine whether further concurrent data collection in North Creek is required.

The first full year of water temperature data collection was completed at most monitoring sites. The period of record spans two calendar years (March 2018 to October 2019) and corresponds to Year 1 and Year 2 of the monitoring program. The housing and anchor bolts for the upstream data loggers in Boulder Creek were destroyed during storm events, therefore operational data are not yet available at this location. New temperature data loggers were installed upstream in October 11, 2019.

Air temperature loggers were installed in the upstream control and downstream reaches in the Upper Lillooet River to aid in characterization of the thermal regime in March 2018. In Boulder Creek air temperature loggers were installed in the lower diversion in April 2018.

Baseline and operational results indicate that Upper Lillooet River and Boulder Creek are cold-water streams, where daily-average temperatures <1°C occur during the winter and daily average summer temperatures are consistently well below 18°C. During baseline monitoring the monthly average water temperatures considering all sites in the Upper Lillooet River ranged from 0.4°C to 7.3°. During operational monitoring the monthly average water temperatures ranged from 0.1°C to 7.6°C. In Boulder Creek, considering all sites, the monthly average water temperature during baseline ranged from 0.5°C to 7.9°C and during operational monitoring the monthly average water temperatures ranged from 0.6°C to 8.8°C.

In Upper Lillooet River, during the baseline period, the growing season start dates and end dates were variable; start dates occurred between late May and early July with end dates occurring in October. During operations the growing degree days were similar to baseline in the upstream sites, however at the diversion and downstream sites the growing degree days were higher than observed during baseline monitoring. The operational growing season start date occurred in mid to late May and ended from late September to early November (at downstream site).

Similarly, in Boulder Creek, during the baseline period, the growing season start dates and end dates were variable. Start dates were between late May and early August with end dates occurring from early October to early November. During operations, the growing degree days were generally higher than baseline with a slightly earlier start date (mid-May to early June) and similar end date (October). The operational growing season start date in Boulder Creek occurred from mid-May to early June and ended from early to late October.

Hourly rates of change in water temperature were screened against the BC WQG for the protection of aquatic life (MOE 2019), which specify that the hourly rate should not exceed ±1°C/hr. In Upper Lillooet River and Boulder Creek, the baseline conditions regarding this metric indicate a very small percentage of the data at each site (i.e., <0.7%) exceed this guideline. During operations, the percent exceedance was slightly higher than baseline (i.e., up to 1.3% of the record). The percent exceedance rates are low (i.e., <1.5% of the data set), however the operational rates were slightly higher than those observed during baseline monitoring.

During baseline monitoring, MWMxT ranged from 0.1°C to 10.8°C in Upper Lillooet River and from 0.02°C to 11.0°C in Boulder Creek. During operational monitoring to date (2018-2019) MWMxT ranged from 0.03°C to 10.7°C in Upper Lillooet River and from 0.1°C to 12.1°C in Boulder Creek (diversion and downstream sites only; no data were available for the upstream site).

MWMxT values in relation to species-specific optimal temperature ranges differed by species and location. In general, with the exception of Bull Trout, MWMxTs are within or below (cooler than) the optimal temperature ranges. Bull Trout prefer cooler temperatures overall in comparison to Cutthroat Trout and Coho Salmon, therefore fewer exceedances of the cooler temperature limits are observed for this species. Exceedances of the upper limit of the optimum temperatures for Bull Trout spawning and incubation were observed during baseline and operational monitoring in Upper Lillooet River and Boulder Creek.

Temperature metrics recorded during Year 1 and Year 2 were not substantially different from the baseline monitoring results, however higher temperatures overall were observed in 2018 and 2019. The warmest months on record, to date, considering both water and air temperature records occurred in July/August of 2018 and 2019. Similarly, some of the coolest periods on record were observed during winter 2019, in both the water and air temperature data sets. Any Project related effects on water temperature will be evaluated using a BACI design following completion of the monitoring program.

We recommend that the monitoring program continue in 2020 (Year 3), based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017). We recommend that water temperature at both upstream sites (ULL-USWQ02 and ULL-USWQ03) in the Upper Lillooet River continue to be collected to evaluate ground water influence in the upstream reach. Similarly, we recommend that water temperature data continue to be collected in the upstream reach of Boulder Creek (BDR-USWQ2) and North Creek (NTH-USWQ1) until sufficient concurrent data sets are available to determine a relationship between water temperatures in the two creeks, when North Creek can then be used as the control stream.

Frazil Ice Monitoring

A protocol was established in December 2017 to monitor frazil ice conditions in the Upper Lillooet River and Boulder Creek diversion reaches and its potential effect on the availability of fish habitat. The protocol involves an automatic alarm system that is triggered when five consecutive days of -5ºC or lower mean daily air temperatures are forecasted at the Pemberton Airport and/or Callaghan Valley stations. If these cold temperatures persist for three consecutive days after an alarm has been triggered, an Ecofish QP notifies the operators and requests photographs of the diversion reach at established photo monitoring points. If the photographs suggest frazil ice is forming and conditions persist, or if photographs from the photo monitoring points are unavailable and condition persist, a crew is mobilized to site to perform assessments at established frazil ice monitoring sites.

The air temperature data from Pemberton Airport confirmed there was a single occurrence of six consecutive days of temperatures averaging <-5°C in January 2020. In addition, two occurrences of three and seven consecutive days of temperatures averaging <-5°C in November 2019 and January 2020 respectively, were observed at the Callaghan Valley Station. The November event lasted three days and temperatures increased on the fourth day precluding the need for Innergex operators to provide photographs. The Upper Lillooet HEF was operating at low capacity during the November event (2.5 – 3.5 m^3/s, with downstream flows measured between 11 -11.5 m^3/s). The Boulder Creek HEF was offline during the November event for maintenance purposes.

Photographs of Boulder Creek and Upper Lillooet during the January 2020 event were provided by Innergex operations staff. Photographs were reviewed by an Ecofish QEP and it was determined that conditions did not warrant a site visit. No site visits were conducted in Year 2. We recommend continued monitoring for frazil ice using the current protocol prescribed in the OEMP in Year 2. Recommendations for refinement of the protocol and thresholds will be provided once additional data are collected.

Fish Community

The objective of the fish community monitoring program is to assess fish community response during operations and identify any changes in abundance, density, condition, distribution, or timing of migration relative to baseline primarily through a Before-After-Control-Impact (BACI) study design. This report presents data from Year 2 of operational monitoring (2019) on measures of fish abundance, condition, and distribution of juvenile and adult Cutthroat and Bull Trout populations within the diversion (impact) and upstream (control) reaches of the Upper Lillooet River as well as the diversion (impact) and downstream (control) reaches of Boulder Creek in support of the fish density and biomass component prescribed by the OEMP. It also presents data on the migration and distribution of spawning adult Bull Trout in both the HEF diversion and downstream reaches and on Cutthroat Trout abundance in an Upper Lillooet River HEF headpond tributary in support of an assessment of potential fish entrainment. Sampling sites and methods in 2019 were consistent with those used during baseline monitoring in 2010 through 2014. Juvenile fish monitoring was conducted through closed-site electrofishing within the Upper Lillooet River and mark re-sight snorkeling surveys in Boulder Creek. Adult migration and distribution monitoring was conducted through a mixture of angling, and bank walk spawning surveys.

Juvenile Density and Biomass

Upper Lillooet

Cutthroat Trout density continues to be low following the start of operations as in baseline results, averaging less than 2 fish/100 m^2 in any reach through the two-year monitoring period. Cutthroat Trout density has been variable during the baseline and operational periods in both the upstream (control) and diversion reaches, with fry absent from the upstream reach and adults absent from the diversion reach in some years.

Bull Trout density in the diversion reach averaged less than 3 fish/100 m^2 throughout the monitoring period. On average, with all age classes combined, Bull Trout density has decreased in the diversion reach by 0.6 fish/100 m^2 between the baseline and operational periods. Bull Trout are not present in the upstream control reach. During the baseline period (three years), Bull Trout fry were absent during one year and adults were absent during two years while, during operational monitoring (two years), all age classes were detected during each year.

With all age classes and Bull Trout and Cutthroat Trout combined, no clear change between the baseline and operational periods is apparent. Total fish density in the diversion reach continues to be higher than at the upstream control reach, as observed during the baseline period.

Boulder Creek

Bull Trout density with all age classes combined continues to be low in the diversion reach as in the baseline sampling following the start of operations, averaging less than 2 fish/100 m^2 through the monitoring period. With all age classes combined, Bull Trout density remained relatively consistent throughout the monitoring period in the diversion reach. Bull Trout density in the downstream reach is more variable than in the diversion reach, with operational monitoring results consistent with 2011 but not 2012 and 2013, when the highest densities of juvenile Bull Trout were measured. Bull Trout fry density has been variable through time, with fry not detected in the diversion reach during two years of baseline monitoring and one of the years of operational monitoring. With all age classes combined, average Bull Trout density has not changed in the diversion reach between the baseline and operational periods, but it has decreased in the downstream reach (a decrease of 1.8 fish/100 m^2).

Cutthroat Trout were not detected during the three baseline monitoring years; however, they were detected at low density in the diversion and downstream reaches during both operational monitoring years.

Abundance action thresholds (AAT) were defined by Harwood *et al.* (2012) and in the OEMP for individual age classes and all age classes combined of juvenile Bull Trout within the diversion reach of Boulder Creek. Densities of Bull Trout observed in Years 1 and 2 monitoring (for individual age classes, and all combined) were compared to these AATs, and although variable among years, there were no declines that exceeded AATs.

Non-operational factors between baseline and operational years may also have influenced the monitoring results and need to be considered in the assessment. Several stochastic natural events have influenced fish and fish habitat in the Project streams during baseline and operations. These include the Boulder Creek Wildfire (2015) that impacted a total of 6,735 ha of terrestrial habitat, including riparian areas along Boulder Creek and the Upper Lillooet River. Natural flood events occurred in November of 2016 and 2017, which caused substantial geomorphic changes in both the Upper Lillooet River and Boulder Creek, including within the sampling reaches. Changes were most apparent at Boulder Creek, where substantial scouring occurred in the diversion reach, and the downstream reach now occupies a new channel following floods in fall 2016. These events noticeably affected the habitat in these streams and likely affected the fish communities. This potentially confounds the detection of Project effects, if effects were to have occurred.

Adult Migration and Distribution

Adult fish distribution and migration during the spawning period within the diversion and downstream reaches of both the Upper Lillooet River and Boulder Creek were assessed through angling surveys in 2019. These surveys were conducted to determine if access to the diversion reach was impacted by water diversion. Adult Bull Trout were captured in the diversion and downstream reaches of Boulder Creek and the Upper Lillooet River. All assessed portions of the diversion reaches were also deemed to be accessible to fish, with no barriers to migration identified. Adult spawning surveys were also conducted in a reference tributary at km 29.2 of the Upper Lillooet River (29.2 km Tributary) and Alena Creek. The numbers of spawning adult Bull Trout in these reference streams were lower in 2019 than during baseline surveys in 2011 with only one Bull Trout in Alena Creek compared to the nine observed during baseline, and none observed in 29.2 km Tributary compared to eight during baseline. The reference stream data suggests that overall Bull Trout numbers may have been lower in 2019 than during baseline. Regardless, the lack of a build-up of Bull Trout below the powerhouses and detection of them in the diversion reaches suggests that movement into the diversion reach was not inhibited by operations at either HEF in 2019.

Assessment of Entrainment at the Upper Lillooet River Intake

The assessment of fish entrainment includes examining densities and biomass of Cutthroat Trout in a tributary to the headpond (at river km 87.0), and in two clusters of five mainstem upstream sites. Densities of Cutthroat Trout in the tributary in 2019 were similar to 2013 and 2018 for all age classes combined. Fry densities were more than double 2013 but similar to 2018. Parr 1+ and 2+ density in 2019 was slightly lower than 2018 but higher than 2013. Adults density showed a different trend with 2019 values being slightly higher than 2018 but lower than 2013. Densities of Cutthroat Trout within the upper and lower clusters of Upper Lillooet River upstream sites varied considerably by age class among years. Fry were observed within the lower cluster in 2012 and in the upper cluster in 2014 and 2019. Juveniles were absent from the lower cluster in 2014 only and were observed in the upper in 2014, 2018 and 2019. Adults were absent from both clusters in 2014, from the lower cluster in 2018 and 2019, and from the upper cluster in 2010 and 2012. Overall, considering all age classes together, in 2019, Cutthroat Trout densities in the lower cluster of five upstream sites were lower than those observed in 2010, 2012, and 2018 but were higher than those observed in 2014 when no Cutthroat were detected in these five sites. In 2019, overall Cutthroat Trout densities in the upper cluster of five upstream sites were lower than 2018 but higher than in 2010, 2012, and 2014. Overall, there is no evidence of a decline in the lower cluster of sites in the upstream reach or in the tributary, and therefore no evidence of entrainment into the Upper Lillooet facility resulting in changes in cutthroat trout density in the upstream reach.

Water Quality

The objective of water quality monitoring is to identify biologically significant changes to specific water quality parameters stemming from Project development and operation using a BACI design.

Year 1 (2018) operational data indicated that the parameters measured under operating conditions had very similar values compared to what was observed under baseline conditions. Parameter values were also within typical ranges for BC watercourses and within applicable BC WQG for the protection of aquatic life. No evidence of excessive gas entrainment during power generation through the Francis turbines was detected at the tailrace site during Year 1 (2018).

On-going monitoring of similar projects, which were reviewed by DFO (2016), suggest that biologically significant effects of Project operations on water quality are not likely to occur. In consideration of this and the operational monitoring results for the Project, it was recommended that the water quality monitoring component be removed from the OEMP in Years 2, 3, 4, and 5.

Wildlife Species Monitoring

Harlequin Ducks

The objective of Harlequin Duck (*Histrionicus histrionicus*) response monitoring, which is a requirement of the Project's EAC (Condition #3 of the TOC), is to confirm that Harlequin Ducks continue to use the ULR HEF area post-construction. Monitoring is being conducted through vantage point surveys (spot checks), using standardized protocols, along with the recording and compilation of incidental observations, to allow comparison of relative abundance among time periods (before and after construction). Spot checks were conducted by Innergex personnel at vantage points established at the intake and at the powerhouse during the pre-incubation period ("pair" survey conducted in May) and during the brood-rearing period ("brood" survey conducted in late July to late August). A summary table of Year 2 results is provided as an appendix to this report. Detailed reporting for this component will occur again in Years 3 and 5, in accordance with the Project's EAC (Condition #3 of the TOC) and as specified in the OEMP.

Species at Risk & Regional Concern

Wildlife species at risk and of regional concern are being monitored through the recording of incidental observations during the first five years of Project operations to contribute to the provincial database and to inform Project operations on situations that may require consideration of wildlife species likely to be present. A total of sixteen mammal species, one reptile species, and seven avian species, including seven species at risk and of regional concern, were incidentally observed in the Project area in 2019 by Ecofish personnel and Project operators. Incidental observations of species at risk and of regional concern in 2019 included those of Grizzly Bears (*Ursus arctos*), Moose (*Alces americanus*), Mountain Goats (*Oreamnos americanus*), Mule Deer (*Odocoileus hemionus)*, Wolverines (*Gulo gulo luscus*), Bald Eagles (*Haliaeetus leucocephalus*), and Harlequin Ducks.

To reduce the potential for human-wildlife conflict, and given observations of Grizzly Bears and Moose along the Lillooet River FSR, these two species are given special consideration by Project operations. Grizzly Bears were observed three times in the Project area in 2019: one yearling was seen in April, and two adults were seen in October. The yearling and one adult were observed along the Lillooet River FSR, and the second adult was observed on the Upper Lillooet River HEF intake access road. None of the Grizzly Bears or American Black Bears observed appeared to be habituated. A total of 12 Moose were observed in the Project area, including two cow and calf pairs and a pregnant cow. All except one Moose were observed along the Lillooet River FSR (a single juvenile was seen on the ULR HEF powerhouse access road). It is recommended that Project personnel continue to record and share wildlife sightings with other Project personnel, especially of Grizzly Bear and Moose, to raise awareness of where Grizzly Bears and Moose are more likely to be encountered when working outdoors and driving.

Wolverine tracks were observed three times in 2019: one set of tracks travelling toward the Boulder Creek HEF intake access road in January, and two sets of tracks crossing and travelling along the transmission line, to the west of the Boulder Creek HEF powerhouse in February.

Project operators and Ecofish field technicians will continue to document incidental observations of species at risk and of regional concern in the Project area during the first five years of Project operations.

Wildlife Habitat Monitoring – Habitat Restoration

Habitat restoration monitoring for Harlequin Ducks and Peregrine Falcons (*Falco peregrinus*) that confirmed that species-specific habitat restoration prescriptions were implemented was completed in Year 1.

Amphibian Habitat

The objective of amphibian habitat restoration compliance monitoring is to confirm that key habitat restoration prescriptions were implemented post-construction for Coastal Tailed Frog terrestrial (riparian) and instream habitat. Compliance monitoring was completed at transmission line crossings in Year 1 and no further monitoring is required at these crossings. Following recommendations made in Year 1, work was completed in the fall of 2019 to cover exposed geotextile within the riparian area and stream channel with additional rocky substrate at ULL-ASTR04. A spot check of instream Coastal Tailed Frog habitat at the penstock crossing (ULL-ASTR04) will be conducted in coordination with riparian revegetation monitoring at this location in Year 3 to evaluate potential exposure of geotextile.

Mammal Habitat

The objective of mammal habitat compliance monitoring was to confirm that habitat restoration measures had been implemented for Grizzly Bear, Moose, and Mule Deer that were prescribed due to potential effects to habitat and to the potential for sensory disturbance that may result from vegetation clearing or increased access. Monitoring involved: 1) confirming presence and adequacy (width and height) of vegetated screens between the transmission line RoW and active Forest Service

Roads (FSR), where the transmission line RoW is within 10 m of an active FSR and the transmission line RoW passes through legislated protected habitat (Ungulate Winter Range (UWR) or Wildlife Habitat Area (WHA)) or high value Grizzly Bear habitat; and 2) that the composition of planted stems met species-specific requirements, as required by conditions of the Project's EAC and GWM exemptions. For Grizzly Bears, compliance monitoring also confirmed deactivation of access tracks/roads within WHA 2-399 and adherence to food attractant management requirements (as per the Human-Bear Conflict Management Plan required by Condition #12 of the TOC).

Monitoring results from Year 1 indicated that, although at most sites a vegetated screen was confirmed to be present, many vegetation screens had not attained the required height (5 m) and some screens also did not have the required width, which is not unexpected for the first year of monitoring. In most cases, natural regeneration and vegetation growth is anticipated to create an adequate screen over time; however, future reassessment in Year 3 will be required to confirm that requirements have been met. No monitoring was therefore conducted in Year 2.

Following recommendations made in Year 1, an inspection was conducted at each of the facilities with waste management requirements where bear attractants had been observed in 2018 (ULR HEF powerhouse, Boulder Creek HEF powerhouse, and Boulder Creek HEF camp). There were no bear attractants observed outside of the facilities during the inspection on September 18, 2019. Thus, this monitoring component is now complete.

Wildlife Habitat Monitoring – Mitigation Effectiveness

Avian Collision Monitoring

Mitigation effectiveness monitoring for avian collisions with the powerline and for the Truckwash Creek portal design was completed in Year 1.

Mountain Goats – Boulder Creek HEF

The objectives of Mountain Goat effectiveness monitoring at the Boulder Creek HEF are to: 1) to evaluate the effectiveness of the gate in preventing public access to the intake during winter; and 2) to evaluate predator presence and behavior within the Mountain Goat Ungulate Winter Range in the vicinity of the Boulder Creek HEF intake post-construction, which will be used to assess potential access-related increase in predation risk to Mountain Goats. These monitoring objectives were met in Year 2 of post-construction monitoring through the use of remote infrared cameras placed along the access road and in the vicinity of the Boulder Creek HEF intake. Sensitive location and timing information has been removed to protect this species.

Access monitoring results obtained from the three remote infrared cameras installed along the Boulder Creek HEF access road indicated that the access road was inaccessible to the public by motorized vehicle when the gate was closed. Monitoring also indicated that the gate becomes non-functional during the winter months due to burial from snow and therefore will not impede snowmobile access. However, no incidents of the public passing the gate when it was buried in snow were documented, thus potential gate inadequacies during these conditions are not currently identified as an issue. Project personnel did not access the Boulder Creek HEF intake from November 20, 2019 to February 23, 2020; thus, snow along the access road did not get compacted during the winter of 2019-2020. Access to the Boulder Creek HEF intake is permitted year-round for Project personnel; however, Project personnel rarely require access to the intake during the winter and spring. In the spring of 2019, Project vehicles were photographed along the access road on one date in February, one date in March, five dates in April, seventeen dates in May, and seven dates in June.

Grey Wolves and Cougars were detected in the vicinity of the Boulder Creek HEF intake in Year 2, both on and off the access road. These two species had not been detected in the vicinity of the intake during baseline or Year 1 monitoring. However, owing to the typically low frequency of predator detections, which makes it difficult to obtain adequate sample sizes for meaningful comparison, and in accordance with requirements of the OEMP, continued predator monitoring in the following years is needed to document whether or not a notable increase in predator use of the area is observed, as the road receives less Project-related use during winter and predators potentially discover the road and adjust their habitat use.

Vegetation Monitoring

The objectives of vegetation monitoring are to qualify and quantify the re-growth of vegetation in terrestrial areas disturbed through the construction of the Project, to mitigate short-term habitat loss, and to prevent the introduction of invasive species that may occur through site disturbance. Although originally scheduled to occur annually for Years 1-5 (Harwood *et al*. 2017), subsequent revisions to the OEMP (proposed to MFLNRORD in February 2018; Harwood *et al*. 2018) included conducting vegetation monitoring only in Years 1, 3 and 5 which would match the riparian vegetation monitoring schedule. This revised schedule, which was recommended by Hedberg (Appendix C of Regehr *et al*. 2019), was adopted, although a survival survey was recommended for Year 2 (2019) to assess the general survival rates of trees planted in civil works sites in 2018. The methods and results of this survival survey, which was conducted by Hedberg, are presented as a separate report (Appendix A).

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1. INTRODUCTION

Ecofish Research Ltd. (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership (collectively, the Partnerships) to conduct Year 2 of the operational environmental monitoring program (OEMP) for the Upper Lillooet Hydro Project (ULHP) (the Project). The Project is comprised of two run-of-river hydroelectric facilities (HEFs) located in the Upper Lillooet watershed, northwest of Pemberton, BC (Map 1). The largest of the two HEFs is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119), and the smaller is located on Boulder Creek (WC: 119-848100). Infrastructure for each HEF includes a powerhouse and intake, and water is diverted, via penstock and/or tunnel, around approximately 3.8 km of the Upper Lillooet River, and around approximately 3.7 km of Boulder Creek, for the Upper Lillooet River HEF and the Boulder Creek HEF, respectively. Project infrastructure also includes a new 72 km long 230 kV transmission line that transports electricity produced by the Project to the point of interconnection, south of Pemberton, near Rutherford Creek (Map 1). A detailed effects assessment, addressing aquatic and terrestrial valued components, was completed for the HEFs and for the transmission line (Lewis *et al.* 2012, Leigh-Spencer *et al.* 2012, Hedberg and Associates 2011, Lacroix *et al.* 2011a, b, c, d, NHC 2011).

An operational environmental monitoring plan (OEMP) was developed for the Project by Ecofish Research Ltd. (Ecofish) to assess potential Project effects on the environment, fish communities, wildlife, and wildlife habitat present in the Project area (Harwood *et al.* 2017). The OEMP addresses the operational monitoring conditions identified during the environmental assessments (EAs) (Lewis *et al.* 2012, Leigh-Spencer *et al.* 2012, Hedberg and Associates 2011, Lacroix *et al.* 2011a, b, c, d, NHC 2011) and the conditions listed in Schedule B (Table of Conditions (TOC)) of the Project's Environmental Assessment Certificate (EAC) (E13-01; EAO 2013). The aquatic components of the OEMP are also based on the Fisheries and Oceans Canada (DFO) Long-term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects (Lewis *et al.* 2013a). Monitoring requirements address two types of effects: footprint and operational. Footprint effects are associated with Project structure and can be short or long-term, depending on the permanence of the infrastructure and associated disturbance, whereas aquatic operational effects result from changes to water flow for the purpose of project operation.

The OEMP prescribes three types of monitoring: compliance, effectiveness, and response. Compliance monitoring is conducted to ensure that conditions outlined in the EAC (EAO 2013), DFO Fisheries Act Authorization (09-HPAC-PA2-00303), and water licences are adhered to. Effectiveness monitoring is conducted to verify that mitigation and compensation measures implemented for a project are effective, and response monitoring is the long-term monitoring of environmental parameters to establish empirical links between project development and operation and any effects on the environment. Compliance and effectiveness monitoring are conducted at specific locations based on the parameter being monitored. Response monitoring often requires data collection at multiple sites, with the locations dependent on the parameter(s) in question, so that

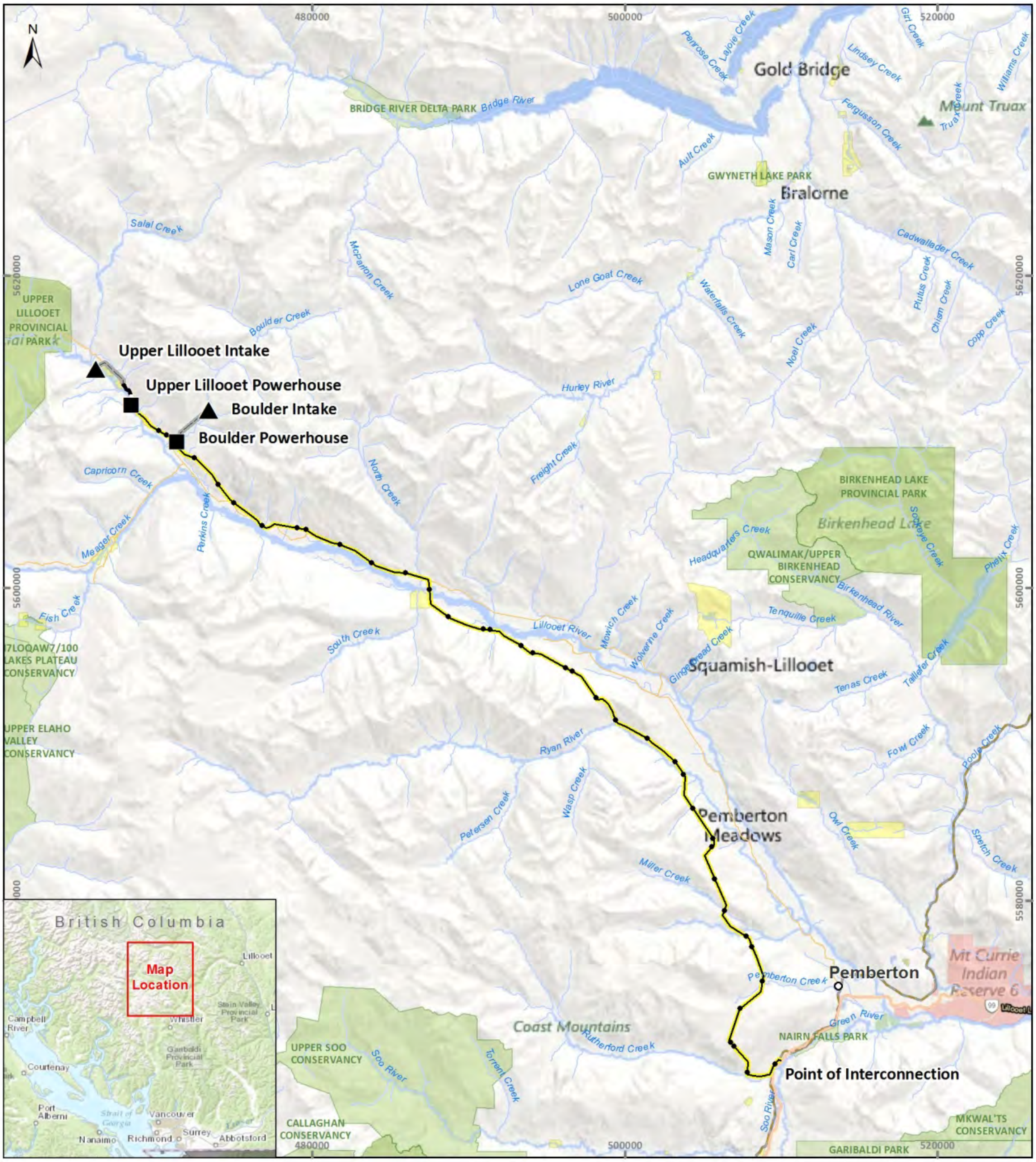
Project effects can be assessed through a comparative study design. Effectiveness and response monitoring can lead to, and facilitate, the adaptive management of impacts.

This report presents monitoring results from Year 2 (2019) of operational monitoring in accordance with requirements of the OEMP (Harwood *et al.* 2017). Aquatic and terrestrial monitoring parameters and components, which are summarized in Table 1 and Table 2, respectively, each have specific requirements, including frequency, duration, and reporting.

Aquatic monitoring requirements follow recommendations from Hatfield *et al.* (2007) and Lewis *et al.* (2013a) (with a few exceptions noted in Harwood *et al.* (2017)). Aquatic monitoring parameters include primary parameters (instream flow, mitigation and compensation, aquatic and riparian habitat, water temperature and icing (i.e., frazil ice), stream channel morphology, and fish abundance and behaviour (i.e., fish community)) and secondary parameters (water quality and species at risk and of concern) (Table 1). A number of aquatic monitoring components are only conducted once and have now been completed (see Year 1 report) or are not scheduled again until Year 3. These include footprint impact verification and water quality monitoring (both complete), as well as riparian revegetation assessment (to be assessed again in Year 3). As such, Year 2 monitoring results presented in this report consist of study components related to water temperature/icing and fish community. The monitoring program for the Project's fish habitat compensation project, Alena Creek, is presented in Appendix B as a standalone report. Stage and discharge monitoring for IFR and ramping compliance are monitored real time year-round and are presented in annual compliance reports submitted separately for the life of the Project.

Terrestrial monitoring parameters included in the OEMP are wildlife species, wildlife habitat, and vegetation (Table 2). Results of monitoring components scheduled for Year 2 and reported on here include response monitoring for species at risk and regional concern, and effectiveness monitoring for Boulder Creek access and predator monitoring. In addition, based on results from Year 1 compliance monitoring for Grizzly Bears (*Ursus arctos*), recommendations were made that compliance with proper disposal of bear attractants should be reassessed in Year 2 (Regehr *et al.* 2019); thus, results from the associated inspections are presented here. Additional habitat restoration monitoring for mammals was also recommended to confirm that vegetated screens had attained their required size; however, because vegetation growth is anticipated to improve over time, additional monitoring for vegetated screens was not recommended until Year 3. All other monitoring components that were scheduled to occur only in Year 1 (Table 2) have been completed, including the avian collisions and Truckwash Creek portal design subcomponents. As discussed in the Year 1 report, vegetation monitoring was recommended to occur next in Year 3 (contrary to Table 2), with the exception of a survival survey which was recommended for Year 2. This survey was completed by Hedberg and Associates Consulting Ltd. (Barker 2020) and is presented in Appendix A.

Project Overview



Legend

- Cities

ULHP Infrastructure

- Intake
- Powerhouse
- Penstock
- Tunnel
- Transmission Line
- Road
- First Nation Reserve
- Recreational Site
- Parks and Protected Areas

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 2 4 6 8 10 12 14 km

Scale: 1:350,000

NO.	DATE	REVISION	BY
1	14/04/2016	1095_ULP_ProjOverview_2014Jun26_CA	CGA
2			
3			
4			
5			

Date Saved: 14/04/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 1

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Overview\1095_ULP_ProjOverview_2014Jun26_CA.mxd

Table 1. Summary of aquatic monitoring parameters and components specified in the OEMP (Harwood *et al.* 2017).

Parameter	Project Component	Monitoring Type	Facility	Monitoring Requirements		
				Frequency	Duration[1]	Reporting[2]
Primary						
Instream flow	Flow magnitude and timing	Compliance	ULL, BDR	Continuous	Life of project	Annually
	Ramping rates	Compliance	ULL, BDR	Once[3]	Project commissioning	Once
		Compliance	ULL, BDR	Continuous	Life of project	Annually
Mitigation and compensation measures	Compensation projects	Compliance	ULL	Once	Immediately post-construction	Once
		Effectiveness	ULL	Annually	Years 1 to 5	Annually
Aquatic and riparian habitat	Footprint impact verification	Compliance	ULL, BDR	Once	Immediately post-construction	Once
	Revegetation assessment	Effectiveness	ULL, BDR	Annually	Years 1, 3 and 5	Annually
Water temperature and icing	Overall project	Response	ULL, BDR	Continuous	Life of project	Annually
Stream morphology	Overall project	Response	ULL, BDR	Once	Year 5, or after 1 in 10 year event	Once
Fish abundance and behaviour	Compensation projects	Effectiveness	ULL	Annually	Years 1 to 5	Annually
	Resident fish density (EF)	Response	ULL	Annually	Years 1 to 5	Annually
	Resident fish density (SN)		BDR	Annually	Years 1 to 5	Annually
	Migration and spawning (BT)	Response	ULL, BDR	Annually	Years 1 to 5	Annually
	Migration and spawning (CT)		ULL	Annually	Year 1	Annually
Secondary						
Water quality	Overall project	Response	ULL, BDR	Quarterly	Year 1	Annually
Species at risk or of concern[4]	BT and CT	Response	ULL, BDR	Annually	Years 1 to 5	Annually

ULL = Upper Lillooet River, BDR = Boulder Creek; EF = electrofishing, SN = snorkeling; BT = Bull Trout, CT = Cutthroat Trout.

1: Monitoring may be extended past the prerequisite minimum of five years following review of the results from the five year operational monitoring period.

2: Non-compliance must be reported on an accelerated schedule and measures taken to ameliorate risk. Non-compliance reports due shortly after event.

3: Ramping rate tests need only be conducted once if fry are present.

4: Bull Trout and Cutthroat Trout are both blue listed in BC (special concern) and will be monitored as part of regular fish response monitoring.

Table 2. Summary of terrestrial monitoring parameters and components specified in the OEMP (Harwood *et al.* 2017). Note that vegetation monitoring is not addressed in this report but is reported on separately (Appendix A).

Monitoring Parameters	Component	Sub-component	Monitoring Type	Facility	Monitoring Requirements		
					Frequency[1]	Duration	Reporting
Wildlife Species	Harlequin Ducks	-	Response	ULL	Multiple	Years 1, 3 and 5	Years 1, 3 and 5[2]
	Species at Risk & Regional Concern	-	Response	ULL	Continuous	Years 1 to 5	Annually[3]
Wildlife Habitat	Habitat Restoration	Coastal Tailed Frog Habitat	Compliance	ULL	Once[4]	Immediately post-construction	Once
		Harlequin Duck Habitat	Compliance	ULL	Once[4]	Immediately post-construction	Once
		Peregrine Falcon Habitat	Compliance	ULL	Once[4]	Immediately post-construction	Once
		Grizzly Bear	Compliance	ALL	Once[4]	Immediately post-construction	Once
		Moose & Mule Deer Habitat	Compliance	ULL	Once[4]	Immediately post-construction	Once
		Mountain Goat Habitat	Compliance	ULL, BDR	Once[4]	Immediately post-construction	Once
	Mitigation Effectiveness	Avian Collisions	Effectiveness	ULL	Bi-annually	Year 1[4]	Annually
		Truckwash Creek Portal Design for Mountain Goats	Effectiveness	ULL	Multiple	Year 1[4]	Annually
		Boulder Creek HEF Gate Winter Access Monitoring	Effectiveness	BDR	Multiple	Years 1 to 3[4]	Annually
		Boulder Creek Predator Presence & Behaviour Monitoring	Effectiveness	BDR	Multiple	Years 1 to 3[4]	Annually
Vegetation	Vegetation Restoration		Compliance/ Effectiveness	All	Annually	Years 1 to 5	Annually
	Invasive Plants		Compliance/ Effectiveness	All	Annually	Years 1 to 5	Annually

ULL = Upper Lillooet River, BDR = Boulder Creek

[1] Monitoring data collection may occur only once, annually, bi-annually, or on multiple occasions within a year.

[2] Data will compiled annually and results will be analyzed in years 1, 3, and 5.

[3] Reporting requirements consist of compilation of data and presentation in an appendix according to provincial format.

[4] Monitoring may be extended if required.

2. OBJECTIVES AND BACKGROUND

2.1. Instream Flow Monitoring

Instream flow monitoring, ramping rates and connectivity surveys were completed as independent reports (Faulkner *et al.* 2019a,b).

2.2. Mitigation and Compensation Measures

Habitat compensation for the Project was completed on Alena Creek. Monitoring results are included in Appendix B.

2.1. Water Temperature and Air Temperature

Water extraction has the potential to increase water temperature in the summer and decrease water temperature in the winter (Meier *et al.* 2003). Fish may be vulnerable to both small increases and decreases in water temperature, with tolerance levels varying between species and life-history stages. Water temperature will be monitored continuously in the Upper Lillooet River (Map 2) and Boulder Creek (Map 3) for the life of each of the two projects (Harwood *et al.* 2017). The objective of monitoring water temperature is to identify any biologically significant differences (as defined in Harwood *et al.* 2012) between baseline and operational temperature regimes in the streams. To achieve this, water temperature will be monitored continuously for the first five years of operation and compared to the baseline data using a Before-After-Control-Impact (BACI) design.

It was identified that there was a risk that the Upper Lillooet River upstream control water temperature loggers (ULL-USWQ02) could not be reliably accessed for data retrieval and maintenance due to access issues, therefore in November 2018 an additional upstream control site (ULL-USWQ03) was established to augment or replace the original site following a period of concurrent data collection (Map 2).

It was also identified that the baseline water temperature regime at the upstream site in Boulder Creek (BDR-USWQ) was influenced by groundwater from late fall to early spring, therefore a new upstream location was established for operational sampling in Boulder Creek (BDR-USWQ2) (Map 3). In addition, a site was established in North Creek for the purpose of replacing baseline data compromised by groundwater inflow during the late fall to early spring period, following a year of concurrent water temperature monitoring.

Therefore, commencing in Year 1 of operations (March 2018 at most sites), water temperature is monitored at five sites for each Project: two upstream sites, one site in the lower diversion, one site in the tailrace, and a downstream site (Map 2, Map 3).

This Year 2 (2019) annual monitoring data report provides a summary of baseline (2008-2013) and operational (March 2018 - October 2019) water and air temperature monitoring results for ULHP and Boulder Creek Projects. This report is intended to be primarily a data summary report. Any changes in water temperature related to the operation of each Projects will be evaluated with a BACI analysis following five years of operational water temperature data collection.

2.1.1. Frazil Ice

The objective of monitoring frazil ice is to mitigate potential adverse effects of frazil ice build-up on the availability of overwintering habitat for fish during Project operation. The formation of frazil ice is largely dictated by localized climatic factors, such as air temperature, humidity, and wind speed, as well as instream characteristics, such as water temperature, flow rates, and channel morphology. Generally, frazil ice forms when flowing water is super-cooled to less than 0.08°C by very cold air temperatures (Calkins 1993). For this reason, data from Environment Canada meteorological stations in the vicinity of the Project area (Pemberton Airport and Callaghan Valley) are being monitored for conditions that may result in ice formation. When the climate and weather conditions indicate that there is potential for frazil or anchor ice formation, a protocol is initiated that, depending on local air temperatures, the status of Project operations, and visible evidence of ice formation within the HEF diversion reaches, may result in a field survey to evaluate the extent of frazil ice formation and to determine the appropriate response. As stated in the OEMP, HEF shutdowns will be recommended if visual site assessments indicate that frazil ice displaces ≥50% of the fish holding habitat within the hydraulic units (monitoring sites) surveyed, otherwise HEF shutdowns will not be recommended but monitoring of air temperatures and monitoring sites will continue until the risk of frazil ice abates.

2.2. Stream Channel Morphology

Operational monitoring of stream morphology will be conducted 5 years after facility commissioning.

2.3. Fish Community Monitoring

The construction and operation of a run-of-river hydroelectric facility has the potential to directly or indirectly affect the health of the fish community. The objective of the fish community monitoring program is to assess fish community response during operations and identify any changes in abundance, density, condition, distribution, or timing of migration relative to baseline. As per the OEMP, the focal species of fish community monitoring are Cutthroat Trout (*Oncorhynchus clarkii*) and Bull Trout (*Salvelinus confluentus*) within the Upper Lillooet River, and Bull Trout within Boulder Creek. Cutthroat Trout is the only species present above Keyhole Falls in the upstream reach of the Upper Lillooet River.

Methods used for fish community monitoring should be appropriate for the system and fish species and/or life-stage of interest (Lewis *et al.* 2013). Accordingly, methods used for monitoring juvenile fish density and biomass differed between the Upper Lillooet River and Boulder Creek, reflecting differing characteristics of the study reaches and fish communities within them, with closed-site electrofishing conducted in the Upper Lillooet River and mark re-sight snorkel surveys conducted in Boulder Creek. The design of the monitoring study is described in detail in the OEMP (Harwood *et al.* 2017).

The monitoring program assesses potential Project effects on fish communities in response to Project operations using a Before-After-Control-Impact (BACI) study design and consists of the following three components:

1. Juvenile fish density and biomass, the objective of which is to identify potential changes in abundance, density, biomass, condition or size-at-age relationships in response to Project operations. Although referenced as juvenile fish monitoring for simplicity, this monitoring is also focussed on capturing the small bodied resident adults of Cutthroat Trout and Bull Trout present in these two streams.;
2. Adult migration and distribution, the objective of which is to ensure that IFR flows, along with local inflows and spill events, are adequate to allow the upstream spawning migration of Bull Trout into the Project streams, and the migration of spawning Cutthroat Trout into tributary streams; and
3. Assessment of entrainment at the Upper Lillooet River intake, the objective of which is to evaluate whether fish entrainment in the Upper Lillooet HEF intake is having a population-level effect on the Cutthroat Trout population upstream of the intake.

For the juvenile fish density and biomass component, monitoring is conducted in the diversion reach (impact) and the upstream reach (control) of the Upper Lillooet River and in the diversion reach (impact) and the downstream reach (control) of Boulder Creek. For the adult migration and distribution component, monitoring is conducted in the diversion and downstream reaches of both the Upper Lillooet River and Boulder Creek (impact reaches) as well as in two reference streams (tributary at river km 29.2 of the Upper Lillooet River and Alena Creek). Alena Creek is also the location of the fish habitat compensation for the Project. For the fish entrainment assessment component at the Upper Lillooet River intake, the monitoring sites within the upstream reach are split into two groups: those closest to the headpond which, along with sites in the km 87.0 Tributary represent impact sites, and those furthest from the headpond which represent a control group.

2.4. Water Quality

The objective of water quality monitoring is to identify biologically significant changes to specific water quality parameters stemming from Project development and operation using a BACI study design. Water use during operations can affect water quality indirectly by altering the volume of water remaining in a channel, or directly by returning water of altered quality to the river (Hatfield *et al.* 2007) During power generation, atmospheric gases can be entrained during passage through the turbines and the increase in pressure can result in elevated levels of total gas pressure (TGP) at the tailrace and downstream. Total dissolved gas supersaturation measured as ΔP (pressure mm Hg) is a common feature of many BC watercourses, therefore additional gas entrainment may result in TGP levels that exceed the BC WQG for the protection of aquatic life (MOE 2019).

Francis turbines, which may entrain gas during power generation, are used in the Upper Lillooet River HEF powerhouse, therefore monitoring of water quality parameters sensitive to run-of-river project operations including TGP at the tailrace, was recommended (Harwood *et al.* 2017). The requirement to sample water quality in Boulder Creek was removed, primarily due to the use of Pelton wheels at the Boulder Creek HEF; Pelton wheels fully aerate powerhouse flows and are therefore not expected to increase TGP in the tailrace or downstream of the Project.

General water quality parameters (pH, specific conductivity, total dissolved solids, total suspended solids and turbidity) and dissolved gases (dissolved oxygen and total gas pressure (TGP)) were monitored within the Upper Lillooet River for the first year of operations (2018) at four sites: upstream of the intake and headpond (control), in the diversion reach immediately upstream of the tailrace, in the tailrace, and downstream of the powerhouse. The tailrace site was specified to monitor potential increase in TGP during power generation.

Baseline water quality samples were collected in the Upper Lillooet River quarterly from April 2010 to April 2012 at two sites, one site was located upstream of the Project (control site), and the second was located in the lower diversion reach (details are provided in the water quality baseline report, Ganshorn *et al.* 2011).

Five operational water quality monitoring sites in the Upper Lillooet River were established and sampled in 2018. Sites were located upstream of the intake (ULL-USWQ02, ULL-USWQ03), in the diversion (ULL-DVWQ01) at the tailrace (ULL-TAILWQ; *in-situ* only) and downstream of the tailrace (ULL-DSWQ) (Regehr 2019). ULL-USWQ02 is a helicopter only access site, for this reason a new site ULL-USWQ03 was established in 2018 to provide easier access for water quality and water temperature monitoring moving forward.

Year 1 (2018) results indicated that the parameters measured under operating conditions have very similar values compared to what was observed under baseline conditions (Regehr 2019). Parameter values were also within typical ranges for BC watercourses and within applicable BC WQG for the protection of aquatic life. No evidence of excessive gas entrainment during power generation through the Francis turbines was detected at the tailrace site (Regehr 2019).

On-going monitoring of similar projects, which were reviewed by DFO (2016), suggest that biologically significant effects of Project operations on water quality are not likely to occur. In consideration of this and the first year of operational monitoring results for the Project, the water quality monitoring component was removed from the OEMP for Years 2, 3, 4, and 5. Annual water quality reporting is therefore no longer a requirement of the OEMP. Further detail will be provided under a separate cover (Faulkner *et al.* in prep).

Alkalinity will continue to be monitored once per year in conjunction with fish sampling for use in calculations of stream productivity (Harwood *et al.* 2017).

2.5. Wildlife Species Monitoring – Species at Risk & Regional Concern

Project footprint and operational effects are being evaluated for select wildlife species through response monitoring as prescribed in the OEMP with the objective of evaluating potential operational effects on select species and to thereby provide an opportunity for adaptively managing any such identified effects. Response monitoring for species at risk and of regional concern was conducted in Year 2 and will continue for the next three years. Annual monitoring continues for Harlequin Ducks (*Histrionicus histrionicus*) following the spot check protocol (Appendix C), with detailed reporting presented in Years 1, 3 and 5, and brief reporting, consisting of a summary table of results, presented in Years 2 (Appendix D) and 4. Response monitoring was also originally prescribed for Coastal Tailed Frogs (*Ascaphus truei*); however, due to impacts of the Boulder Creek wildfire in 2015, compliance monitoring of stream restoration was instead prescribed (Harwood *et al.* 2017) which is now complete (Section 2.6.1). Monitoring of Grizzly Bears is being conducted at a regional scale through financial support for the regional provincial population trend monitoring and collaboration on access management (see Harwood *et al.* 2017) and is therefore not a component of the OEMP.

Monitoring of species at risk and of regional concern (as identified within the Sea to Sky Land and Resource Management Plan (MAL 2008)) has two main objectives. First, the collection of data on the presence and distribution of wildlife species at risk and of regional concern will be used to determine occupancy and locations of occurrences relative to Project infrastructure. This will allow identification of occurrences that may be affected by Project operations and will inform Project operations on situations that may require consideration (e.g., modification of timing of activities). Second, collection and submission of data on occurrences of species at risk and of regional concern to the province will contribute to the provincial database.

2.6. Wildlife Habitat Monitoring

2.6.1. Habitat Restoration – Amphibian Habitat

The objective of amphibian habitat restoration compliance monitoring is to confirm that key habitat restoration prescriptions were implemented post-construction for Coastal Tailed Frog terrestrial (riparian) and instream habitat. Habitat restoration measures were prescribed for riparian Coastal Tailed Frog habitat where the transmission line crosses over suitable Coastal Tailed Frog streams, and for both riparian and instream habitat where the Upper Lillooet River HEF penstock crosses a tributary occupied by Coastal Tailed Frogs (ULL-ASTR04). Compliance monitoring was completed at transmission line crossings in Year 1 and no further monitoring is required. Following recommendations made in Year 1, work was completed in the fall of 2019 to cover exposed geotextile within the riparian area and stream channel with additional rocky substrate at ULL-ASTR04. A spot check of instream Coastal Tailed Frog habitat at the penstock crossing (ULL-ASTR04) will be conducted in coordination with riparian revegetation monitoring at this location in Year 3 to evaluate potential exposure of geotextile.

2.6.2. Habitat Restoration – Mammal Habitat

The focus of mammal (Grizzly Bear, Moose, and Mule Deer (*Odocoileus hemionus*)) habitat restoration monitoring was to confirm that habitat restoration measures had been implemented, such as the presence of vegetated screens between valuable mammal habitat and areas of human activity (FSR and the transmission line RoW), and that the composition of planted stems met species-specific requirements (see Year 1 report for details; Regehr *et al.* 2019). In accordance with recommendations made in Year 1, compliance with these measures will be reassessed in Year 3. For Grizzly Bears, compliance monitoring was also prescribed to confirm deactivation of access tracks/roads within WHA 2-399 and adherence to food attractant management requirements (outlined in the Human-Bear Conflict Management Plan (Regehr *et al.* 2014) as required by Condition #12 of the TOC). Results from Year 1 monitoring indicated that access roads had been deactivated but that some bear attractants had not been properly disposed of at both Project powerhouses. As such, additional compliance monitoring for Grizzly Bears was recommended for Year 2 which involves confirmation that "food waste is being disposed of in animal proof containers" (Table 14 in Harwood *et al.* 2017) at the locations where bear attractants were observed in 2018: the ULR HEF powerhouse, and the Boulder Creek HEF powerhouse and camp.

2.6.3. Mitigation Effectiveness – Avian Collisions and Mountain Goats at Truckwash Creek

Mitigation effectiveness monitoring is being used to confirm that key mitigation measures that had been developed to avoid and minimize potential adverse Project effects on wildlife were functioning as intended. Monitoring that evaluated measures developed to minimize avian mortality from transmission line collisions and to protect Mountain Goats (*Oreamnos americanus*) migrating along Truckwash Creek from sensory disturbance and movement disruption related to the ULR HEF was completed in Year 1 (Regehr *et al.* 2019). Two wildlife cameras were left in place along the Truckwash Creek migration corridor and observations of species at risk & regional concern from these cameras are included as incidental observations.

2.6.4. Mitigation Effectiveness - Mountain Goats at Boulder Creek

Mitigation effectiveness monitoring is also being conducted during at least the first three years of operations (after which a QP will evaluate the potential need for additional data collection) to evaluate protection of Mountain Goats within UWR u-2-002 UL12 in the lower Boulder Creek watershed from potential effects related to increased access by humans and predators (Table 2). The intake and ancillary components for the Boulder Creek HEF were placed within a Mountain Goat winter range (UWR u-2-002 UL 12) (Map 5). Thus, upgrades to a pre-existing road and construction of a new segment of road required for the intake presented potential risks to Mountain Goats through increased access into the winter range by people and Mountain Goat predators. The Project's TOC (Condition #15) and conditions of the GWM Exemption that was issued to allow construction and operation of the Boulder Creek HEF within the winter range (Berardinucci 2013a, Barrett 2015, Blackburn 2016) therefore required that a gate must be installed and kept closed to prevent motorized public access during winter and spring (November 1 to June 15; Barrett 2015) and that it must be effective in preventing such access. The GWM Exemption also required that the presence and behaviour of predators, which may have changed due to new access into the winter range, must be monitored to allow assessment of associated risk to Mountain Goats.

Given the requirements of the EAC and GWM Exemption, there are two objectives of Mountain Goat effectiveness monitoring at the Boulder Creek HEF: 1) to evaluate the effectiveness of the gate in preventing public access during winter; and 2) to evaluate predator presence and behavior within the UWR post-construction which will be used to assess potential access-related increase in risk to

Mountain Goats. Year 1 monitoring results indicated that the access road was accessible to the public by motorized vehicle on one occasion when the gate was required to be closed (preventing motorized public access) and that the gate becomes non-functional during the winter months due to burial from snow and therefore will not impede snowmobile access. Recommendations were made to improve gate effectiveness which additional monitoring would evaluate. Monitoring from Year 1 did not identify differences in predator use or activity between pre and post-construction; however, owing to the typically low frequency of predator detections which makes it difficult to obtain adequate sample sizes for meaningful comparison, continued predator monitoring in the following years, in accordance with requirements of the OEMP, was recommended.

2.7. Vegetation Monitoring

The objectives of vegetation monitoring are to qualify and quantify the re-growth of vegetation in terrestrial areas disturbed through the construction of the Project, to mitigate short-term habitat loss, and to prevent the introduction of invasive species that may occur through site disturbance. Although originally scheduled to occur annually for Years 1-5 (Harwood *et al.* 2017), subsequent revisions to the OEMP (proposed to MFLNRORD in February 2018; Harwood *et al.* 2018) included conducting vegetation monitoring only in Years 1, 3, and 5 which would match the riparian vegetation monitoring schedule. This revised schedule, which was recommended by Hedberg (Appendix C of Regehr *et al.* 2019), was approved by MFLNRORD on September 26, 2019 and adopted (Katamay-Smith, pers. comm. 2020), although a survival survey was recommended for Year 2 (2019) to assess the general survival rates of trees planted in civil works sites in 2018. The methods and results of this survival survey, which was conducted by Hedberg, are presented as a separate report (Appendix A).

3. METHODS

3.1. Water Temperature

3.1.1. Study Design

The Upper Lillooet River and Boulder Creek baseline and operational water and air temperature site names, site elevations, period of record, number of days with valid data, and the percent of the period of record where there are data gaps is summarized in Table 3 and Table 4, respectively. Representative site photos for each water temperature monitoring site are provided in Appendix E.

In the Upper Lillooet River, baseline water temperature was monitored continuously at the upstream control site (ULL-USWQ1; November 2008 to June 2013) and the lower diversion site (ULL-DVWQ; November 2010 to May 2013) (Table 3, Map 2). Air temperature was also monitored continuously at two sites established in close proximity to the water temperature sites, one upstream (ULL-USAT; April 2010 to May 2013) and one in the lower diversion (ULL-DVAT; April 2010 to May 2013). Detailed water and air temperature baseline methodology and data analysis are provided in the aquatic baseline report (Harwood *et al.* 2016a,b).

Operational water temperature monitoring in the Upper Lillooet River commenced in March 2018 at five monitoring sites: upstream (ULL-USWQ02, ULL-USWQ03), lower diversion (ULL-DVWQ01), tailrace (ULL-TAILWQ), and downstream (ULL-DSWQ) (Table 3, Map 2). Due to difficult access to ULL-USWQ02 (helicopter access only), a new more accessible upstream site (USWQ03) was established in November 2018 (Table 3).

Operational water temperature monitoring in Boulder Creek commenced in March 2018 at three monitoring sites: lower diversion (BDR-DVWQ), tailrace (BDR-TAILWQ) and downstream (BDR-DSWQ). Temperature loggers were installed in September 2018 at the upstream site (BDR-USWQ2), however no data were obtained due to the loss of temperature loggers at this site during storm events (Table 4, Map 3). It was identified in the OEMP that water temperature at the upstream site on Boulder Creek is influenced by groundwater during the late fall to early spring. An additional upstream site was established in nearby North Creek at NTH-USWQ in September, 2018 to provide overlapping water temperature data with BDR-USWQ2 (Table 4). Concurrent monitoring between BDR-USWQ2 and NTH-USWQ will be required for at least one full year of operational monitoring to establish the relationship between water temperatures at the two sites. Following a full year of data collection, a QP will review the results to determine whether further concurrent data collection is required. The relationship between temperatures at the two sites will be used to make minor adjustments to the baseline (2010 to 2013) record of late fall to early spring temperatures to more reliably represent baseline temperatures in the upstream reach of Boulder Creek. This analysis is expected to be completed in the Year 3 report, provided that a full record of data is available for both sites.

Air temperature data are collected at two sites in the Upper Lillooet River: upstream control (ULL-USAT01) and impact site in the downstream reach (ULL-DSAT) and in one site in Boulder Creek located in the lower diversion reach (BDR-DVAT) (Table 3, Table 4, Map 2, Map 3).

This Year 2 report presents water and air temperature data collected up to October 24, 2019. The period of record spans two calendar years (March 2018 to October 2019) and corresponds to Year 1 and Year 2 of the monitoring program (Table 3 and Table 4). Project related effects on water temperature will be evaluated using a BACI analysis following five years of data collection as specified in the OEMP (Harwood *et al.* 2017).

Table 3. Summary of water temperature site names, location and period of data record in Upper Lillooet River during baseline (2008 to 2013) and operational monitoring (2018-2019).

Type	Project Phase	Site	UTM Coordinates (10U)		Elevation	Periods of Record		Number of Data Records	No. of Days with Valid Data	Data Gaps (% Complete)
			Easting	Northing	(masl)[1]	Start Date	End Date			
Water	Baseline	ULL-USWQ1	466,097	5,614,105	666	19-Nov-08	3-Jun-13	1,658	1,654	100
		ULL-DVWQ	468,283	5,612,234	490	12-Nov-10	1-May-13	902	632	70
	Operation	ULL-USWQ02	464,122	5,614,982	684	28-Mar-18	11-Oct-19	563	561	100
		ULL-USWQ03	465,530	5,614,484	673	1-Nov-18	11-Oct-19	345	342	100
		ULL-DVWQ01	468,344	5,611,968	481	1-Nov-18	21-Oct-19	355	353	100
		ULL-TAILWQ	468,423	5,611,670	474	28-Mar-18	24-Oct-19	576	498	88
		ULL-DSWQ	468,601	5,611,202	463	28-Mar-18	13-Apr-19	382	380	100
Air	Baseline	ULL-USAT	466,097	5,614,105	666	7-Apr-10	1-May-13	1,121	1,084	97
		ULL-DVAT	468,375	5,612,158	483	7-Apr-10	1-May-13	1,121	763	69
	Operation	ULL-USAT01	464,141	5,614,996	687	28-Mar-18	11-Apr-19	380	307	81
		ULL-DSAT	468,677	5,611,155	463	28-Mar-18	11-Jun-19	441	440	100

[1] Estimated from Google Earth.

Table 4. Summary of water temperature site names, location and period of data record in Boulder Creek baseline (2008 to 2013) and operational monitoring (2018-2019).

Type	Project Phase	Site	UTM Coordinates (10U)		Elevation	Periods of Record		Number of Data Records	No. of Days with Valid Data	Data Gaps (% Complete)
			Easting	Northing	(masl)[1]	Start Date	End Date			
Water	Baseline	BDR-USWQ	474,102	5,614,069	1,007	22-Apr-10	1-May-13	1,106	1,082	99
		BDR-DVWQ	471,561	5,609,323	488	15-Nov-08	6-Jun-13	1,665	1,637	99
	Operation	NTH-USWQ1	484,433	5,605,934	911	24-Sep-18	11-Oct-19	383	381	100
		BDR-USWQ2[2]	474,580	5,614,356	1,030	-	-	0	0	0
		BDR-DVWQ	471,561	5,609,323	488	16-Mar-18	24-Oct-19	588	586	100
		BDR-DSWQ	470,972	5,609,176	488	16-Mar-18	24-Oct-19	588	586	100
		BDR-TAILWQ	471,326	5,609,383	488	16-Mar-18	24-Oct-19	588	490	87
Air	Baseline	BDR-DVAT	471,561	5,609,323	488	8-Apr-10	1-May-13	1,120	1,118	100
	Operation	BDR-DVAT	471,561	5,609,323	488	16-Mar-18	31-Mar-19	381	378	100

[1] Estimated from Google Earth.

[2] No data available due to loss of temperature loggers during storm events. New loggers were installed on October 11, 2019.

3.1.2. Fish Species Distribution

The fish distribution of the Upper Lillooet River has been described in previous baseline monitoring documents and in the OEMP (Harwood *et al.* 2017) (Table 5). The fish species targeted for temperature monitoring in the Upper Lillooet River and Boulder Creek are Bull Trout and Cutthroat Trout with the addition of Coho Salmon for the Upper Lillooet River only. Cutthroat Trout may be present at all temperature monitoring site locations in the Upper Lillooet River and the diversion and downstream locations on Boulder Creek, while Bull Trout is limited to the diversion and downstream locations of both the Upper Lillooet River and Boulder Creek. Coho Salmon have been detected in the lower diversion and downstream reaches of the Upper Lillooet River.

Bull Trout are the most thermally sensitive species present in both Project areas and this species prefers cooler temperatures overall than other species present. The BC WQG (MOE 2019) for water temperature specify optimum temperature ranges for rearing, spawning, incubation, and migration for these fish species (Table 5) and the applicable guideline range is defined as ± 1°C of the optimum temperature for each life stage.

Table 5. BC WQG optimum temperature range and fish species distribution in the Upper Lillooet River and Boulder Creek (MOE 2019).

Fish Species	Optimum Water Temperature Range (°C)				Fish Presence	Reach
	Spawning	Incubation	Rearing	Migration		
Cutthroat Trout	9.0 - 12.0	9.0 - 12.0	7.0 - 16.0	-	Upper Lillooet River	Upstream, diversion and downstream
					Boulder Creek	Lower diversion and downstream
Bull Trout	5.0 - 9.0	2.0 - 6.0	6.0 - 14.0	-	Upper Lillooet River	Diversion and downstream
					Boulder Creek	Lower diversion and downstream
Coho Salmon	4.4 - 12.8	4.0 - 13.0	9.0 - 16.0	7.2 - 15.6	Upper Lillooet River	Diversion and downstream

The BC WQG for water temperature is ± 1°C outside the optimum temperature range for each life stage.

3.1.3. Quality Assurance/Quality Control

Prior to analysis, temperature data are carefully inspected and QA'd to ensure that any suspect or unreliable data are excluded from data analysis and presentation. Excluded data includes instances where the water temperature sensor was suspected of being out-of-water/dry, affected by snow/ice or buried in sediment.

The accuracy of the TidbiT® temperature readings are evaluated by periodically performing *in-situ* spot temperature measurements and comparing these results to the corresponding data logged with the TidbiT® sensor.

Operational water temperature was recorded at intervals of 15 minutes, using self-contained TidbiT® data loggers. The loggers are accurate to ±0.2°C and have a resolution of 0.02°C. Two TidbiT® loggers were installed on separate anchors at each location. This redundancy ensures availability of data in case one of the loggers malfunctioned or was lost. In 2018, two loggers were lost at ULL-DVWQ01; new loggers were installed in November 2018 (Table 3). In 2019, two loggers were lost at BDR-USWQ2, new loggers were installed on October 2019. Air temperature was recorded at intervals of 15 minutes, using self-contained Onset® HOBO®U23-002 Temp/RH sensor (range of -40°C to 70°C, accuracy of ±0.21°C from 0°C to 50°C).

3.1.4. Data Collection and Analysis

Processing of water temperature data was conducted by first identifying and removing outliers as part of a thorough Quality Assurance/Quality Control (QA/QC) process (see Section 3.1.3). After identifying and removing outliers, the records from duplicate loggers were averaged and records from different download dates were combined into a single time-series for each monitoring site. The time series for all sites were then interpolated to a regular interval of 15 minutes (where data were not already logged on a 15-minute interval), starting at the full hour.

Data are presented in plots that were generated from water and air temperature data collected at, or interpolated to, 15-minute intervals. Analysis of the data involved computing the following summary statistics: monthly statistics (mean, minimum, and maximum water temperatures for each month of record, as well as differences in water temperature among sites), days with extreme mean daily temperature (e.g., >18°C and <1°C), days with exceedances of the minimum and maximum Bull Trout temperature thresholds, the length of the growing season, and the accumulated thermal units in the growing season (i.e., degree days), hourly rates of temperature change, and mean weekly maximum temperature (MWMxT). These statistics are defined and described in Table 6 and applicable guidelines are discussed in the following section.

3.1.5. Applicable Guidelines

The water temperature BC Water Quality Guidelines (BC WQG) for the protection of aquatic life (as per Oliver and Fidler 2001, MOE 2019) are discussed below.

Hourly Rates of Water Temperature Change

Rapid changes in heating or cooling of water temperature can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specifies that the hourly rate of water temperature change should not exceed ±1.0°C/hr (MOE 2019).

Daily Temperature Extremes

Extreme cold or warm temperatures are monitored as part of the water temperature component. The number of days when the daily mean temperature was <1°C was calculated, along with the number of days when the daily mean temperatures were >18°C and >20°C. The Upper Lillooet River and Boulder Creek are cool streams where maximum temperatures recorded to date did not exceed 15°C, therefore the number of days of water temperatures >20°C are not required. The maximum optimum temperature for the fish species present in the Project area is 16°C (Coho Salmon and Cutthroat Trout rearing life stage, Table 5).

Mean Weekly Maximum Temperature (MWMxT)

The MWMxT is an important indicator of prolonged periods of cold and warm water temperatures that fish may be exposed to. The water temperature BC WQG for the protection of aquatic life states "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary by ±1.0°C beyond the optimum temperature range of each life history phase for the most sensitive salmonid species present" (Oliver and Fidler 2001, MOE 2019). Accordingly, MWMxT values were compared to the optimum temperature ranges for the fish species present based on the life history and periodicity (Table 5).

Within each life history period, the completeness of the temperature data record (% complete) is calculated and results are only included if at least 50% of the data for the period are available. The minimum and maximum MWMxT values, % data within the optimum range and % exceedance of ±1.0°C of the optimal temperature range is calculated for each life history period to evaluate the suitability of the temperature regime for each fish species/reach during baseline and operational monitoring (Table 5, Table 6).

Table 6. Description of water temperature metrics and methods of calculation.

Metric	Description	Method of Calculation
Water temperature	Hourly or 15 minute data	Data (interpolated to 15 minute intervals where necessary) presented in graphical form.
Monthly statistics	Mean, minimum, and maximum on a monthly basis	Calculated from 15 minute data (interpolated where necessary) and presented in tabular format.
Degree days in growing season	The beginning of the growing season is defined as the beginning of the first week that mean stream temperatures exceed and remain above 5°C; the end of the growing season was defined as the last day of the first week that mean stream temperature dropped below 4°C (as per Coleman and Fausch 2007).	Daily mean water temperatures were summed over this period (i.e., from the first day of the first week when weekly mean temperatures reached and remained above 5°C until the last day of the first week when weekly mean temperature dropped below 4°C).
Number of Days of Extreme Daily Mean Temperature	Daily average temperature extremes for all streams	Total number of days with daily mean water temperature >18°C , >20°C , and <1°C.
Number of Days of Exceedance	Daily maximum and minimum temperature thresholds for streams with Bull Trout / Dolly Varden	# days maximum daily temperature is >15°C; # days maximum incubation temperature is >10°C; # days minimum incubation temperature is <2°C; and # days maximum spawning temperature is >10°C.
MWMxT (Mean Weekly Maximum Temperature)	Mean, minimum, and maximum on a running weekly (7 day) basis	Mean of the warmest daily maximum water temperature based on hourly data for 7 consecutive days; e.g., if MWMxT = 15°C on August 1, 2008, this is the mean of the daily maximum water temperatures from July 29 to August 4, 2008; this is calculated for every day of the year.

3.1.6. Frazil Ice

A protocol was established in December 2017 to monitor frazil ice conditions in the Upper Lillooet River and Boulder Creek diversion reaches and the potential effects of frazil ice formation on fish habitat availability. An automated alarm system was set up that triggers an email alert to Ecofish QPs when mean daily air temperatures of -5ºC or lower are forecasted for five consecutive days at the Pemberton Airport and/or Callaghan Valley meteorological stations. After three consecutive days of mean daily air temperatures of -5ºC or lower as measured at either station, if the HEFs are still operating, an Ecofish QP notifies the operators and requests photographs of the diversion reach taken from established photo monitoring points in the lower diversion reach of each HEF to determine if frazil ice is visible. If there is evidence of frazil ice and the HEFs remain operational, a crew is mobilized to site to perform assessments of the percentage of fish holding habitat displaced by frazil ice at established frazil ice monitoring sites. A total of five monitoring sites have been established in the diversion reach of each HEF (Map 6), located either in stranding sensitive monitoring sites (SSMSs) or closed-site electrofishing sites where fish are known to overwinter.

After a field survey has been conducted, an Ecofish QP reviews the results and provides a written communication to the Project Environment and Operations teams. The communication includes a professional evaluation of the severity of frazil ice accumulations and recommended actions, which may be: a) cease monitoring; b) continue monitoring at a defined schedule; or c) shut-down the HEF until mean daily air temperatures increase above -5ºC and/or a follow up survey indicates that the risk of additional ice formation has abated.

3.2. Fish Community

As outlined in the OEMP, the fish community in the Upper Lillooet River and Boulder Creek is being monitored through several components: juvenile fish density and biomass, adult fish distribution and migration, and assessment of fish entrainment in the Upper Lillooet River HEF intake (Harwood *et al.* 2017). Baseline ("before") data were collected in 2010 – 2014 (Harwood *et al.* 2016; Harwood *et al.* 2016b) and operational ("after") monitoring, which is required in years 1 through 5 of Project operations, commenced in 2018 (Regehr *et al.* 2019).

3.2.1. Juvenile Fish Density and Biomass

3.2.1.1. Overview

As described in the OEMP, and consistent with baseline sampling, methods to monitor juvenile fish density and biomass differ between the Upper Lillooet River and Boulder Creek according to differences in stream conditions, with closed-site electrofishing used for monitoring in the Upper Lillooet River and mark re-sight snorkel surveys used in Boulder Creek. Sampling of juvenile density and biomass is focussed on fry and juvenile resident and migratory species (e.g., Bull Trout and Cutthroat); however, resident adults of these species are also present and are included in the assessment.

Consistent with baseline monitoring, Year 2 juvenile fish sampling was conducted in March and April 2019 within both the Upper Lillooet River and Boulder Creek, when conditions are most suitable for closed-site electrofishing and mark-re-sight snorkel surveys (e.g., low flow and low turbidity). Consistent with baseline monitoring, sampling within both systems was conducted at night because salmonids are known to be nocturnal and hide in interstitial spaces during the day in the winter (Campbell and Neuner 1985, Thurow *et al.* 2006). Upper Lillooet River electrofishing sites are shown in Map 7 and Boulder Creek mark re-sight snorkel sites are shown in Map 8.

3.2.1.2. Upper Lillooet River

Closed-Site Electrofishing

Juvenile fish within the Upper Lillooet River were monitored using closed-site multi-pass electrofishing performed by experienced crews in a manner consistent with baseline sampling. In total, five sites have been established within the diversion reach and ten sites have been established in the upstream reach (Map 7). The five uppermost upstream sites were established in 2014, upstream of the five original upstream sites to act as additional control sites to assess potential facility-related entrainment effects within the original five sites located close to the Upper Lillooet River HEF intake. Three previously established sample sites were relocated in 2019 as the habitat had changed due to changes in channel morphology and were no longer representative of previous sampling conditions.

At each site, closed-site multi-pass removal electrofishing involved isolating a stream section, conducting electrofishing within this section, and collecting habitat data. Prior to conducting electrofishing, a section of stream was fully enclosed with one to two stop nets (0.5 cm mesh size) to prevent fish movements into or out of the site. Electrofishing was conducted in these enclosures using multi-pass removal methodology consistent with guidelines (Lewis *et al.* 2004; Hatfield *et al.* 2007) and the removal-depletion procedures described in Cowx (1983). A two-person crew fished two full circuits of the enclosure during each pass, with two to three passes conducted at each site. As a general rule, if during the second pass at least one fish was captured or observed then a third pass was conducted. Sample sites were left undisturbed for ~15-30 minutes between electrofishing passes while captured fish were processed and/or habitat data were collected. All electrofishing was conducted using a Smith-Root electrofisher unit (LR-24).

All captured fish were anaesthetized prior to processing. During processing, fish were identified to species, weighed (±0.1 g, or 1 g for fish over 200 g), measured for fork length (±1 mm), and photographed. Scale samples were collected from subsamples of Cutthroat Trout representing all life stages and were mounted directly on microscope slides in the field for future laboratory aging. To ensure adequate representation of each life stage in the scale samples, samples were collected from each reach from at least two suspected young-of-year (<60 mm), and from a representative sample of juvenile sized individuals (60 mm to 150 mm) and adults (>150 mm). Fin ray samples were collected from all Bull Trout ≥100 mm in length. Small fin clip samples were also collected from captured fish and preserved in 95% ethanol for future DNA analysis to verify species identification. Somatic fatty acid composition was measured in fish greater than 150 mm using a non-invasive Distell Model 992 Fish Fatmeter (Distell Inc., West Lothian, Scotland). All captured fish were scanned for passive integrated transponder (PIT) tags. If no PIT tags were detected, a PIT tag was implanted into the body cavity of each fish greater than approximately 60 mm in length to allow assessment of movement in future years. After processing, fish were placed in a bucket of fresh water to recover. Upon recovery, and after all electrofishing passes were completed, fish were released back into the sample site. Any fish mortalities associated with electrofishing activities were recorded.

Physical habitat data were collected at each of the sites in accordance with guidelines outlined in RISC (2001) and Appendix A of Lewis *et al.* (2004) and described in the OEMP. Alkalinity, water temperature, and conductivity were also recorded at each site. Water depth and velocity were measured along one or two representative transects within the site (to obtain a minimum of 10 verticals per site, each placed a minimum of 0.5 m apart). Depth and velocity were measured using a calibrated Swoffer velocity meter (Model 2100) and a 140 cm top-set rod (8.5 cm diameter propeller). The mean length and wetted width of each net enclosure were measured to determine the surface area of the site.

Age Analysis

Scale samples were aged using digital photographs taken with a dissecting microscope. Fish age was determined by two independent observers, with their results compared to identify discrepancies. Discrepancies were recorded and a final age determination was made based on professional judgement of a senior biologist.

The fish density and biomass analysis, and comparison between control and impact sites, requires that the fish species of interest be separated into age classes. To define discrete age classes of Cutthroat Trout, the length-frequency histograms for fish captured during electrofishing were reviewed along with all of the length at age data from the scale analysis. Based on a review of these data, discrete fork length ranges, that allow all fish to be assigned an age class based on fork length, were defined for each of the following age/life history classes: fry (0+), juvenile (1-2+) and adult (≥3+) for Cutthroat Trout and fry (0+), juvenile (1-3+) and adult (≥4+) for Bull Trout. For the juvenile fish sampling in the late spring, winter annuli from the previous winter are not detected on aging structures. Thus, the age classes presented for this sampling are consistent with the age classes for fall of the previous year, which matches the approach taken during baseline sampling (e.g., fry (0+) detected in the spring of 2019 actually emerged in 2018). Fin ray samples collected from Bull Trout were not processed and aged in 2019 because of the small sample size of this species and the uncertainty in the aging of Bull Trout fin ray samples in the Project area during the baseline period. For these reasons, age classes for this species were derived primarily from length-frequency results and are consistent with the baseline period. Fin ray samples have been collected and archived and may be examined in the future if required.

Fish Metrics and Condition

The analysis of data from individual fish consisted of defining age class structure and describing other characteristics of the fish populations, including length-frequency distributions, length-weight relationships, relative condition factor (K_r), and length at age. To overcome limitations of dependencies of the condition factor on fish length, the relative condition factor (K_r) was calculated as:

$$K_r = \left(\frac{W}{\widehat{W}}\right)$$

where W is the weight of the fish in g, and $\hat{W}$ is the predicted body weight from a length-weight relationship (Le Cren 1951). If K_r is equal to 1, the fish is in average condition, if K_r is below 1 the fish is in condition lower than average, and if K_r is larger than 1 then the fish is in condition better than average.

Density and Biomass Estimates

Fish density and biomass were calculated from abundance estimates by age class (fry (0+), juvenile, adult, and all ages combined) for each species in each electrofishing site. Individual fish were assigned to specific age classes based on the age-length relationship analysis described in Section 3.2.1.2 above. Fish abundance estimates were computed using the Carle-Strub K-Pass removal depletion function

(Carle and Strub 1978) within the FSA package (Ogle 2016) in R (R Core Team 2018). Site and age class-specific fish abundance estimates were then divided by site areas to standardize to fish numbers per unit area (i.e., density). Density estimates of each age class and age class grouping were then multiplied by the corresponding average biomass values to get an estimate of biomass per unit area. Fish density and biomass estimates are expressed as FPUobs (#/100 m²) and BPUobs (g/100 m²), respectively.

Fish density and biomass estimates were also adjusted to account for the habitat suitability within each site. The habitat suitability of each electrofishing site for Bull Trout and Cutthroat Trout was determined using the depth-velocity transect data and habitat suitability indices (HSI). For Bull Trout juveniles, the HSIs were derived using curves obtained from BC Hydro (EMA 1991). The HSIs for Cutthroat Trout juveniles were derived using curves obtained from Washington State (2008) for Rainbow Trout under winter conditions. These were considered more appropriate than the Washington State (2008) HSI criteria for Cutthroat Trout because of the similarity between the two species and because sampling in the Upper Lillooet River was conducted under winter conditions. Habitat suitability is expressed as a usability percentage, which is calculated by computing the weighted usable width (WUW) of the depth-velocity transect within the sample enclosures and dividing by the wetted width of the transect. Habitat suitability adjusted estimates were then calculated by dividing fish density and biomass estimates by the transect usability at each site to get habitat suitability adjusted density and biomass per unit area, expressed as FPUadj (#/100 m²) and BPUadj (g/100 m²), respectively. Non-adjusted and habitat suitability adjusted densities and biomass densities are presented for individual sites and as overall reach averages per age class and age class grouping.

3.2.1.3. Boulder Creek

Night Snorkelling Mark Re-sight

Juvenile fish within Boulder Creek were monitored using night snorkeling mark re-sight surveys performed by experienced crews in a manner consistent with baseline sampling and Year 1 OEM. As during baseline sampling, snorkel surveys were conducted within an impact stream reach located within the diversion reach and a control section within the downstream reach at sites composed of high-quality fish habitats that were selected through a stratified non-random process during baseline monitoring. Upstream of the Boulder Creek intake is non fish bearing therefore control sites were established in the downstream reach. In total, ten sites were sampled in 2019 (five sites in each reach; Map 8). Sites were first visited during daylight when sampling areas were measured, photographed, and marked with flagging tape.

Each site was sampled on two consecutive nights. During the first night of sampling, one to three snorkelers swam each site and captured fish using dip nets. All safely accessible areas of each site were sampled, and an attempt was made to capture all observed fish using dip nets. Captured fish were tagged and measured for fork length, but were not weighed or photographed to minimize disturbance, consistent with Korman *et al.* (2010). Fish were also not anaesthetized because of uncertainty about behavioural effects of the anaesthetic. Fish were tagged with hook tags applied to dorsal fins and scaled with fish size to minimize the effects of tagging on fish behaviour and to help in estimating their fork length during re-sight swims. After fish had recovered from tagging, they were released into a low velocity area near where they were first captured at the end of the mark survey.

On the second night of sampling, a re-sight swim was conducted within all safely accessible areas of each site by a crew of two snorkelers. Snorkelers recorded species, the presence of hook tags (marks), and estimated fork length (to the nearest 5 mm or 10 mm for fish $<$ or $\geq$ 100 mm, respectively) of all observed fish. The re-sight swims also included the 25 m upstream and downstream of the site in cases where sites were not constrained by a physical barrier, to evaluate emigration of fish from sites. Sampling these areas outside of the site boundaries allowed a test of the assumption that populations within mark re-sight sites are effectively closed to fish migration for the 24-hour period between the two sampling events.

Following the re-sight swim, snorkelers captured as many fish as possible using dip nets to collect data on weights, length at age, and to verify fork lengths estimated by snorkelers. Captured fish were processed using the same methods described in Section 3.2.1.2, including collection of fin ray and fin clips, scanning all fish for PIT tags, and PIT tagging fish greater than approximately 60 mm in length if none were detected in order to monitor recaptures and movement in future years. After sufficient recovery time, fish were released back into the sites where they were originally captured. Habitat data were collected and site conditions were recorded at each snorkel site as described in Section 3.2.1.2 above, with the exception of depth-velocity transects which were not collected in Boulder Creek, consistent with baseline sampling.

Age Analysis

Calculation of fish density estimates and comparison between control and impact sites, requires that fish be separated into age classes. Aging of scale samples was conducted following the same methods described above in the *Age Analysis* subsection of Section 3.2.1.2. Density analyses were conducted based on general age classes derived from combined length-frequency results from both reaches and all years of monitoring, rather than reach- and year-specific length at age data, consistent with the approach taken during baseline monitoring.

Fish Metrics and Condition

Data from individual captured fish were analyzed following the same methods described in the *Fish Metrics and Condition* subsection of Section 3.2.1.2 above. Length-frequency distributions were created using all fish lengths collected, including fish captured and marked on the first night of sampling and those captured following the re-sight swim on the second night. The length-weight relationship included fewer data points as only the fish captured following the re-sight swim were weighed.

Density Estimates

Fish abundance estimates for each observed age class of Bull Trout and Cutthroat Trout were calculated based on snorkel mark re-sight data in each site by correcting the total number of fish observed during each survey by the observer efficiency of snorkelers. Average observer efficiency for each age class was calculated separately for the diversion reach and downstream reach using the following equation (Korman *et al.* 2010):

$$oe = \frac{\sum_1^n \frac{R}{(M-O)}}{n}$$

where, *oe* is the average observer efficiency, *n* is the number of sites, *R* is the number of re-sighted fish at each site, *M* is the number of initially marked fish at each site, and *O* is the number of marked fish observed outside of the site. As indicated by the equation, any marked fish observed outside of the site were removed from the observer efficiency calculation by subtracting them from the number of initially marked fish.

Average observer efficiency was then used to calculate abundance estimates for each age class within each site using the following equation:

$$Abundance = \frac{O_{rs}}{oe}$$

where O_{rs} is the number of fish observed during the re-sight survey.

The standard assumptions in a mark recapture/re-sight study apply to adjustment of observed abundance by observer efficiency:

- the population is closed between sample dates;
- marked fish mix with all fish in the population;
- fish captured/observed are a random sample from the population; and
- the fish re-sighted during the re-sight swim are randomly sampled from the population.

Due to the low numbers of fish marked at each site, the mark re-sight data were pooled in order to calculate mean observer efficiency, as indicated by the equation above. The mean observer efficiency of Bull Trout was also used to calculate abundance estimates of Cutthroat Trout due to the exceptionally low number of Cutthroat Trout captured. The density per area (#/100 m^2) of each age class within each site was then calculated by dividing the abundance estimate by the sampled area of the site. Densities are presented for individual sites and as overall averages per age class and age class grouping. Biomass estimates were not calculated for fish in Boulder Creek due to the small sample size of captured fish.

Abundance Action Threshold (AAT)

Juvenile Bull Trout densities will also be compared to abundance action thresholds (AAT) set for the Boulder Creek HEF (Harwood *et al.* 2012). According to the AAT rules, observed declines in all age classes combined of juvenile Bull Trout density (e.g., 0+ to 3+) of ≥50% relative to average density during the three years of baseline study in the diversion reach, with no corresponding decrease evident in the corresponding control reach, would initiate an investigation into the cause of the decline. Similarly, an 80% reduction in the number of fish within a specific age class in a diversion reach during operations (relative to average abundance of that age class in the diversion reach during the three years of baseline study), would initiate an investigation if there was no corresponding decrease in the relevant control reach. The investigation is required to consist of analysis of the biotic (e.g., fish density, stranding observations) and abiotic (e.g., water temperature, water chemistry) data; supplemental data collection or comparison with additional data sources; data synthesis and interpretation, and; a professional judgement regarding the cause-effect relationship underlying the observed changes. If this investigation supports a professional opinion that Project operation are the cause of the decline, then additional mitigation measures should be developed to avoid these effects (Harwood *et al.* 2012).

3.2.2. Adult Migration and Distribution

3.2.2.1. Bull Trout Surveys

Bull Trout migration and spawning were monitored in downstream and diversion reaches of both Upper Lillooet River and Boulder Creek using angling surveys. Bull Trout migration and spawning was also monitored in three reference streams using bank walk surveys on 29.2 km and Alena Creek and angling surveys on North Creek. The sampling of the three reference streams is consistent with Table 9 of the OEMP (Harwood *et al.* 2017).

Angling surveys were conducted in the downstream and diversion reaches of the Upper Lillooet River and Boulder Creek, as well as a section on North Creek during the spawning migration window (September 17 to October 23 in 2019). The angling survey area on Boulder Creek included approximately 900 m downstream and 300 m upstream from the powerhouse. Angling effort upstream of the powerhouse was limited due to the safety concerns accessing the entrenched canyon section. The fish bearing reach on Boulder Creek is considered to extend from the confluence with Upper Lillooet upstream 2.64 km, with approximately 1.7 km of the diversion reach accessible to fish. The survey area on Upper Lillooet River was limited to approximately 500 m upstream and downstream of the powerhouse. The entire length of the diversion reach of Upper Lillooet River is fish bearing. Angling surveys were conducted at key sites, in high-grade Bull Trout habitat, as assessed by experienced fisheries technicians. Each survey was conducted by two experienced anglers, with effort scaled to account for the fishable area of each site, but for no less than 0.75 rod hours per site.

Angling was primarily conducted using roe as bait under a float because this proved to be most effective during baseline monitoring. All captured fish were processed as per methods described in Section 3.2.1.2 before being live released back into the location where they were captured. Relevant site characteristics and conditions were also collected during angling surveys in September 2019.

Visual assessments of the potential for fish passage and upstream access were also conducted during angling surveys during the spawning migration period on the lower 1.7 km of Boulder Creek. As crews were moving upstream, the potential for fish passage at critical locations identified during baseline studies (Faulkner *et al.* 2011) were visually assessed for connectivity, both at the observed flows and estimated maximum flows (determined from the high-water points on banks). Visual assessment of fish passage and upstream access was also assessed during angling surveys for approximately 500 m upstream of the Upper Lillooet powerhouse.

Bull Trout spawner surveys were conducted at three tributaries of the Upper Lillooet River: the tributary at km 29.2 of the Lillooet River (29.2 km Tributary) and Alena Creek as specified in the OEMP, and on North Creek to further increase effort. These three reference tributaries are being monitored to help assess potential confounding effects of the Capricorn/Meager slide in August 2010 on results of the monitoring program in the Upper Lillooet River and Boulder Creek. The additional monitoring allows an assessment of changes to the fish populations in the Project and reference streams by analyzing temporal trends in metrics to identify the recovery rate of both the Project and reference streams from the slide.

At 29.2 km Tributary and Alena Creek, spawner surveys were conducted by walking along the shore during the Bull Trout spawning period (between mid-September and early December) and recording the number of spawning fish, any carcasses, and redds. At North Creek, spawner surveys were conducted through angling.

3.2.3. Assessment of Entrainment at the Upper Lillooet River Intake

Baseline sampling indicated that the Cutthroat Trout population in the upstream reach of the Upper Lillooet River is highly dependent on tributary habitat and movement by fish into and out of these tributaries creates a potential risk of entrainment in the Upper Lillooet River HEF intake. This risk is greatest for resident Cutthroat Trout in the mainstem, and those migrating back and forth between tributary and mainstem habitat, in the vicinity of the intake. Assessment of entrainment at the Upper Lillooet River HEF intake was conducted by sampling and tagging fish at three sites established in 2013 in the unnamed tributary that flows into the facility's headpond at the 87.0 km marker upstream from Lillooet Lake (hereafter referred to as "87.0 km Tributary") as well as in the original lower five upstream juvenile fish monitoring sites and the five additional uppermost upstream sites established in 2014. Recaptures of tagged fish are intended to provide a coarse assessment of movement within the mainstem, between the mainstem and tributary habitat, and how movements vary with season (spring and fall), in order to evaluate entrainment risk. As described above in Section 3.2.1.2, the five uppermost upstream sites also act as additional control sites to assess these potential facility-related entrainment effects within the original five sites and 87.0 km Tributary.

3.2.3.1. Closed-Site Electrofishing

Fish sampling was conducted through closed-site multi-pass removal electrofishing following the same methods described in Section 3.2.1.2 and at the same sites established during baseline studies in 2013. Due to morphological changes between sample years, some historic sites could not be sampled. In these cases, suitable sites with similar habitat were established in close vicinity to the site it replaced. The ten Upper Lillooet River upstream sites were sampled during annual fish monitoring in March but 87.0 km Tributary sites were sampled in October because it is covered in ice and snow in March when mainstem fish sampling is conducted. All captured fish were processed as per methods described in Section 3.2.1.2 including the collection of age and DNA tissue samples, and scanning for, and application of PIT tags. Aging and fish metrics and condition analyses were conducted following the corresponding methods described in Section 3.2.1.2.

Physical habitat data were collected at each of the sites in accordance with guidelines outlined in RISC (2001) and Appendix A of Lewis *et al.* (2004), following methods described in Section 3.2.1.2.

3.2.3.2. Density and Biomass Estimates

Fish abundance, density, and biomass per unit area were calculated by age class and age class grouping at each electrofishing site using the methods described in Section 3.2.1.2, and are similarly expressed as FPUobs (#/100 m²) and BPUobs (g/100 m²), respectively.

3.3. Wildlife Species Monitoring – Species at Risk & Regional Concern

All incidental observations of wildlife species at risk or of regional concern documented by Innergex and Ecofish personnel within the Project area in Year 2 were recorded and compiled. Incidental observations also include detections from the two remote infrared wildlife cameras (ULL-CAM02 and ULL-CAM15) left in place following the completion of the Mountain Goat mitigation effectiveness monitoring component associated with the ULR HEF portal (Section 2.6.3).

3.4. Wildlife Habitat Monitoring

3.4.1. Habitat Restoration – Mammal Habitat

In accordance with recommendations from the Year 1 report, compliance monitoring for Grizzly Bears in Year 2 involved confirming that disposal of food waste (bear attractants) is occurring as per Grizzly Bear compliance monitoring prescriptions at facilities with waste management requirements where bear attractants were observed in 2018 (ULR HEF powerhouse, Boulder Creek HEF powerhouse, and Boulder Creek camp). Inspections of these facilities occurred on September 18, 2019 and involved surveying the outsides of these facilities (areas accessible to bears) and documenting the presence and contents of any non-animal proof garbage or waste bins if present.

3.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek

Monitoring at the Boulder Creek HEF intake is being conducted to evaluate gate effectiveness in preventing public access and Mountain Goat predator presence and behaviour. The effectiveness of the gate on the access road to the Boulder Creek HEF intake in preventing public access into the upper Boulder Creek watershed and potentially into the Mountain Goat winter range (UWR u-2-002 UL 12) during winter (November 1 to June 15 as per Project's EAC) is being monitored through the strategic placement of three remote infrared cameras along the Boulder Creek HEF intake access road (Map 5). The first camera was placed at the gate (BDR-CAM03). The other two cameras (BDR-CAM01 and BDR-CAM02) were installed along the access road, past the gate (Map 5). Table 7 provides a summary of the locations and functionality of these three cameras (only BDR-CAM01, BDR-CAM02, and BDR-CAM03 are located along the access road and were used to conduct access monitoring). It should be noted that although all three cameras had periods where they were not functional, or the view of the road was obscured, at least one of the three cameras was fully functional during the entire monitoring period.

Potential changes in the presence and behaviour of Mountain Goat predators due to new access into the winter range (UWR u-2-002 UL 12) was also monitored in Year 2 through the use of remote infrared cameras. Although systematic winter ground-based surveys (snow-tracking surveys along transects) were specified in the Project's OEMP, these ground-based surveys were discontinued partway through Year 1 monitoring (in November 2018; Regehr *et al.* 2019) due to safety concerns in the vicinity of the Boulder Creek HEF intake and access road during winter (Newbury *et al.* 2018). To compensate, four additional remote infrared cameras were installed along the systematic winter ground-based survey transects on November 30, 2018. The three cameras that had been installed for the entire monitoring period (BDR-CAM01, BDR-CAM02, BDR-CAM03; Table 7) were the same ones used to evaluate gate effectiveness in preventing public access (note that this differs slightly from what is specified in the OEMP because one of the previous camera locations became unsuitable) (Map 5). Another camera (BDR-CAM04) had also been installed near the top of transect BDR-SNTR03 since May 8, 2018. The four additional cameras installed in 2018 that replaced the systematic winter ground-based surveys at the end of Year 1 are located along survey transects BDR-SNTR02 (BDR-CAM05 and BDR-CAM06) and BDR-SNTR03 (BDR-CAM07 and BDR-CAM08) (Table 7, Map 5). All photographs taken by the remote infrared cameras during the Year 2 monitoring period were viewed and data were compiled.

The Year 2 post-construction monitoring period for which data are presented in this report began on January 17, 2019, when the Year 1 monitoring period ended, and ended on February 25, 2020, when the last data from Year 2 camera monitoring were downloaded. Monitoring results for Year 1 (conducted from December 21, 2017 to January 17, 2019) are provided in the Year 1 report (Regehr *et al.* 2019), and baseline data from the pre-construction period (November 2010 to April 2014) are presented in the wildlife baseline monitoring report (Regehr *et al.* 2016).

Table 7. Remote infrared camera locations at the Boulder Creek HEF intake and intake access road and camera functionality during the Year 2 monitoring period (January 17 to June 15, 2019 and November 1, 2019 to February 25, 2020).

Camera	Location	UTM Coordinates (Zone 10U)	Functionality during Monitoring Period (January 17, 2019 to June 15, 2019 and November 1, 2019 to February 25, 2020)
BDR-CAM01	Sensitive location and timing information has been removed to protect this species.		Functional for the entire period, but snow had built up at some point between November 29, 2019 and February 25, 2020, partially obscuring the view from the lens so that the road was no longer visible.
BDR-CAM02	Sensitive location and timing information has been removed to protect		Camera was not functional from January 21 to February 25, 2020, because the tree the camera was mounted on fell down.
BDR-CAM03	Sensitive location and timing information has been removed to protect this species.		Camera was not functional from April 4 to May 7, 2019 because the tree that the camera was mounted on fell down.
BDR-CAM04	Sensitive location and timing information has been removed to protect this species.		Functional for the entire period.
BDR-CAM05	Sensitive location and timing information has		Functional for the entire period, but snow had pushed down on the tree the camera was mounted on so that the view from the camera was limited to a small patch of ground at some point between October 29, 2019 and February 25, 2020.
BDR-CAM06	Sensitive location and timing information has been removed to protect this species		Functional for the entire period.
BDR-CAM07	Sensitive location and timing information has		Functional for the entire period.
BDR-CAM08	Sensitive location and timing information has been removed to		Functional for the entire period.

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4. RESULTS

4.1. Water Temperature

4.1.1. Overview

The results of the baseline (2008-2013) and operational (2018-2019) water temperature metrics, for the Upper Lillooet River and Boulder Creek, are summarized in the following sections. Water temperature site photographs are presented in Appendix E, BC water quality guidelines, annual water temperature figures, and data summary tables are presented in Appendix F, and QA/QC spot temperature figures are presented in Appendix G.

The period of record at Upper Lillooet River and Boulder Creek monitoring sites for Years 1 and 2 (2018, 2019) is from March 2018 to October 2019 (Table 3, Table 4, Map 2, Map 3). Data availability are based on the most recent download of water temperature loggers. There are no data gaps in the Upper Lillooet River operational data set to date (Table 3), however temperature loggers were lost at one of the Boulder Creek upstream sites (BDR-USWQ2), therefore no operational data are currently available at this location.

The BDR-USWQ baseline site may influenced by groundwater during the fall and winter periods, therefore the upstream site in nearby North Creek (NTH-USWQ1) was established to augment the water temperature record (i.e., data influenced by localized groundwater inflow at BDR-USWQ can not be used as an effective baseline control record). Data from the upstream site located in North Creek was successfully retrieved for the period spanning September 2018 to October 2019 (Table 4).

The Upper Lillooet River and Boulder Creek baseline temperature record is presented in Figure 1 and Figure 3. The Upper Lillooet River and Boulder Creek operational temperature regimes are presented using a) daily average temperature data, b) daily maximum temperature data and c) daily minimum temperature data (Figure 2 and Figure 4 respectively). The interannual variability is similar between baseline and operational data, except for the upstream site in the Lillooet River (ULL-USWQ03), which exhibits relatively warmer temperatures in the fall and winter season than other sites likely due to groundwater influence. This site was established as a back up in case data from ULL-USWQ02 could not be accessed; however, in Year 2 data from ULL-USWQ02 was successfully collected. In this report, we will focus on the results from ULL-USWQ02 because this site does not appear to be influenced by localized groundwater.

The pattern of differences in water temperature between the upstream and diversion, tailrace, and downstream sites is similar for baseline (Figures provided in Appendix G) and operations in Upper Lillooet River and Boulder Creek, as depicted in the cumulative frequency distribution between the sites(Figure 5, Figure 6, respectively). In Upper Lillooet River, the ULL-USWQ03 site cumulative frequency distribution curve is likely influenced by groundwater for a portion of the data record (Figure 5). For Boulder Creek, NTH-USWQ1 was used as the reference site because no temperature data were available for BDR-USWQ2 (Table 4, Figure 6).

Figure 1. Daily mean water temperature collected during baseline monitoring in the Upper Lillooet River (2008 to 2013).

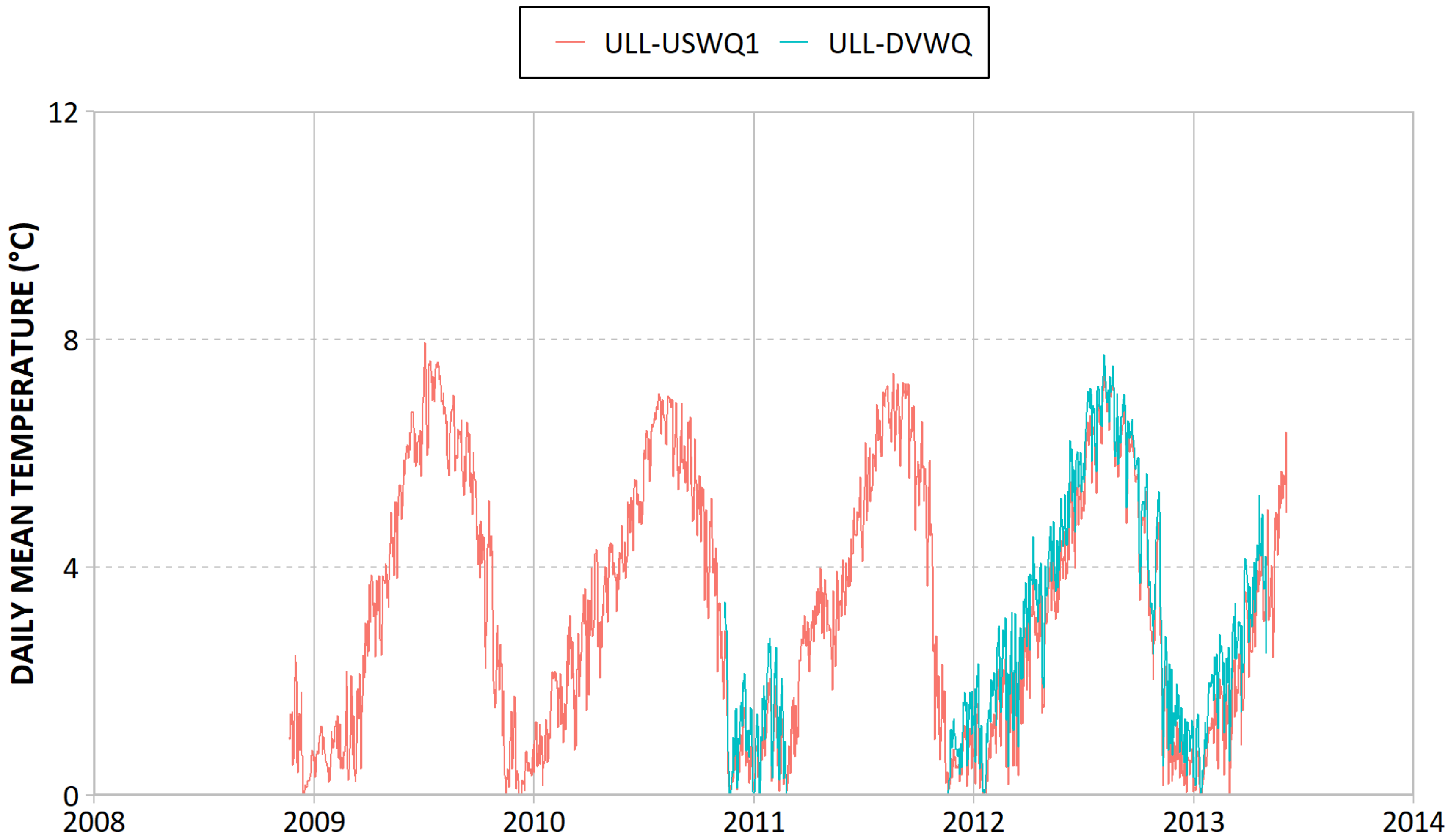
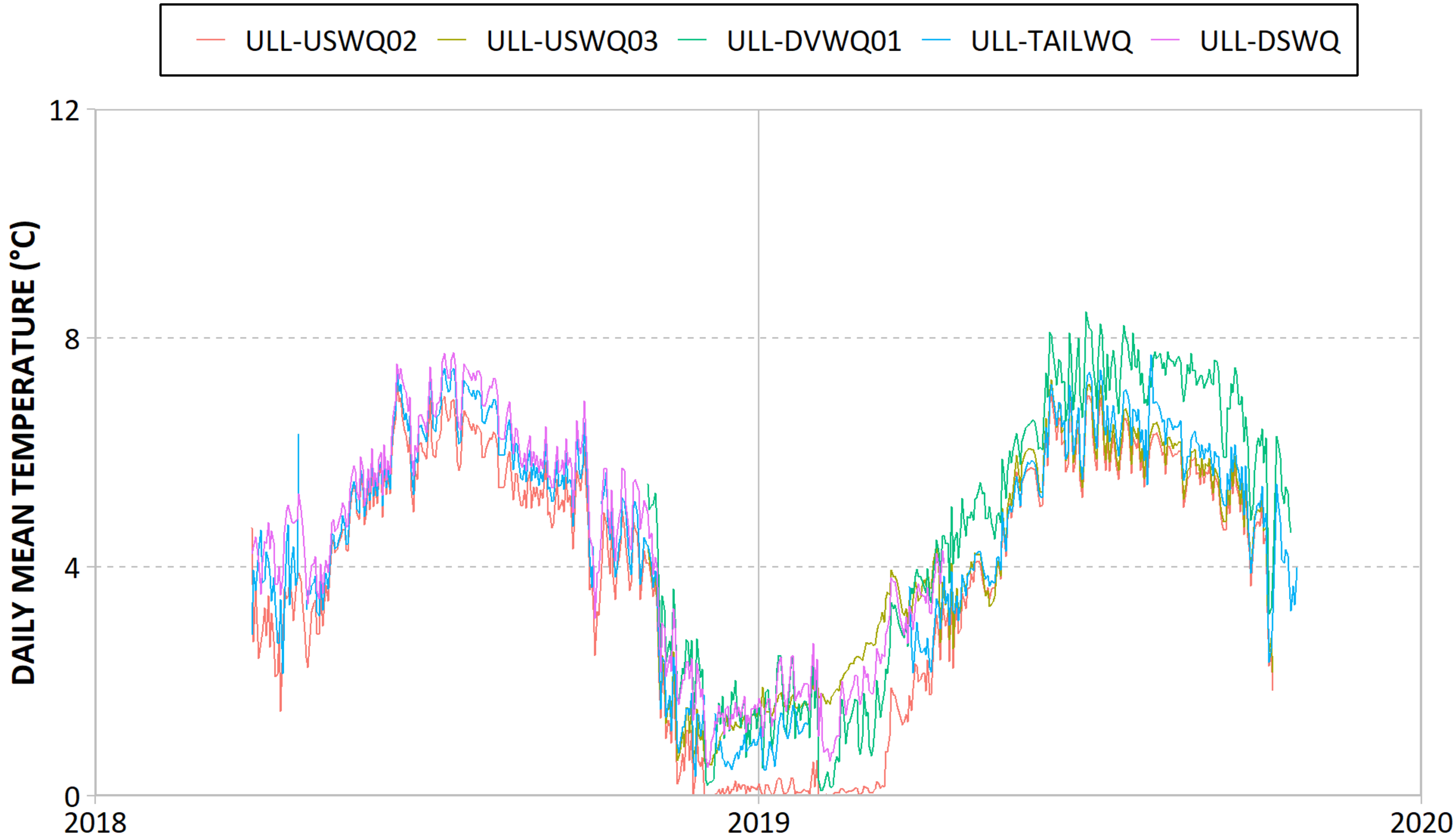
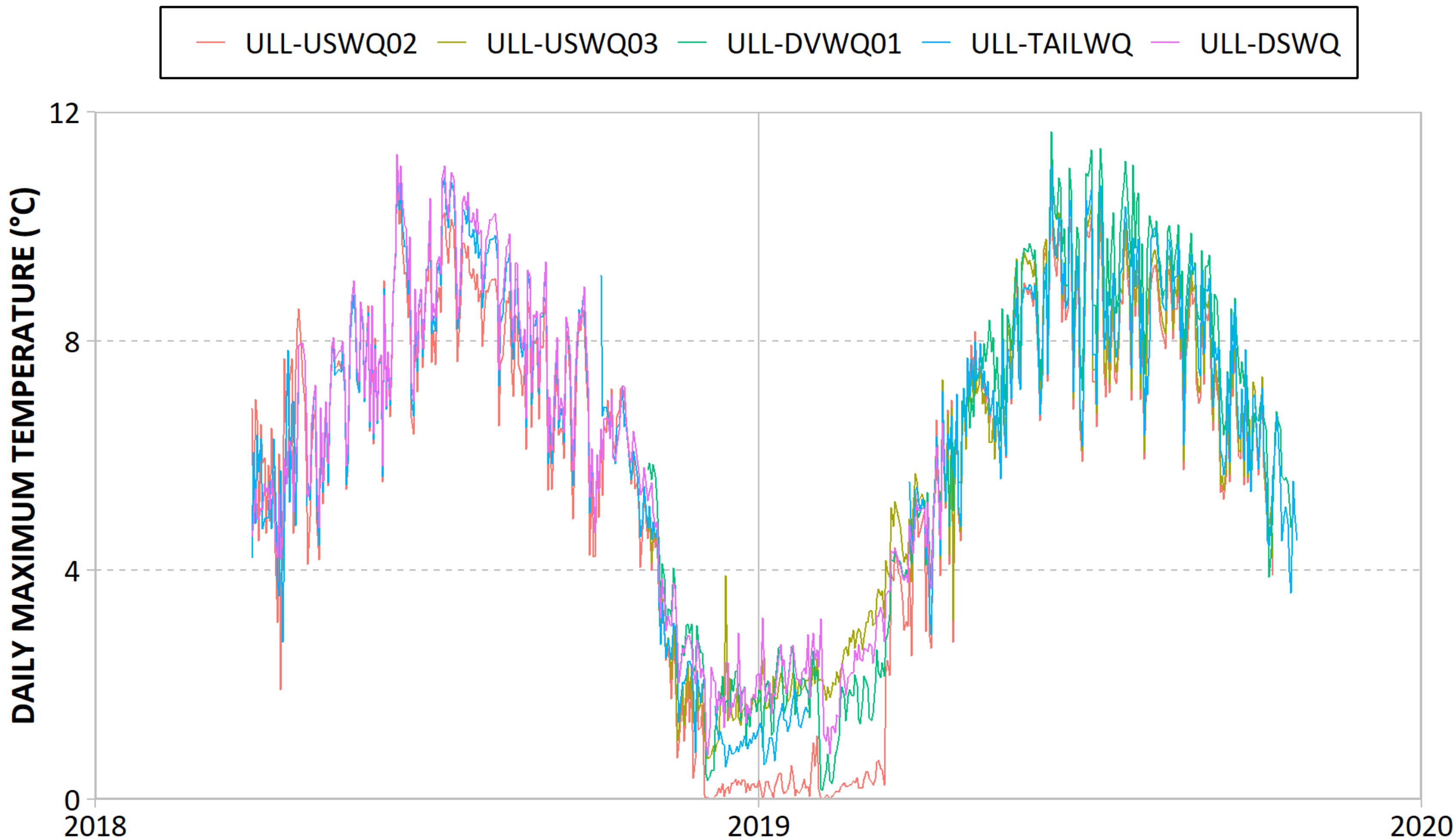


Figure 2. **Daily mean, maximum, and minimum water temperature collected in the Upper Lillooet River during operations (2018 to 2019).**

(a) Daily Average



(b) Daily Maximum



(c) Daily Minimum

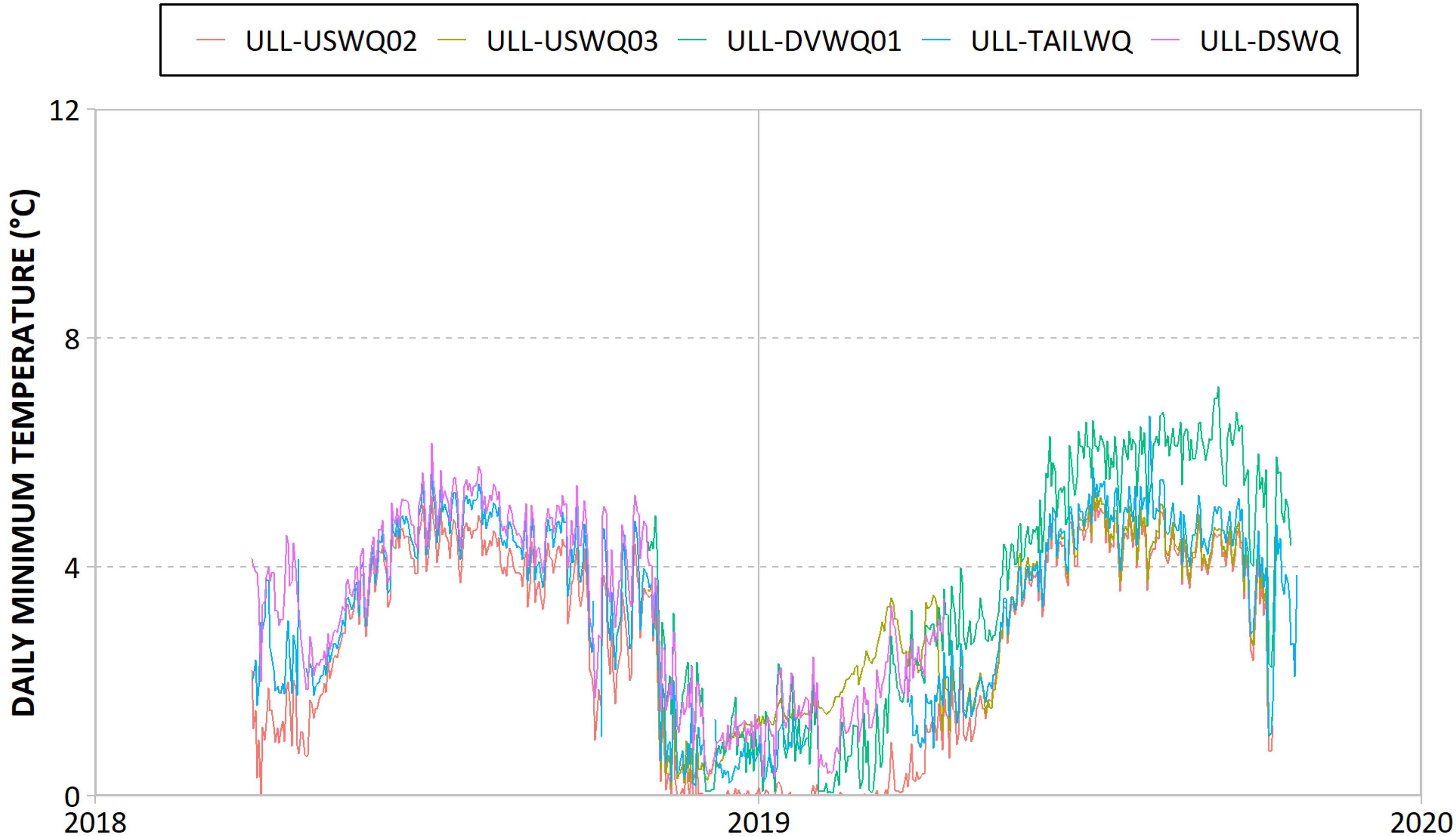


Figure 3. Daily mean water temperature collected during baseline monitoring in Boulder Creek (2008 to 2013).

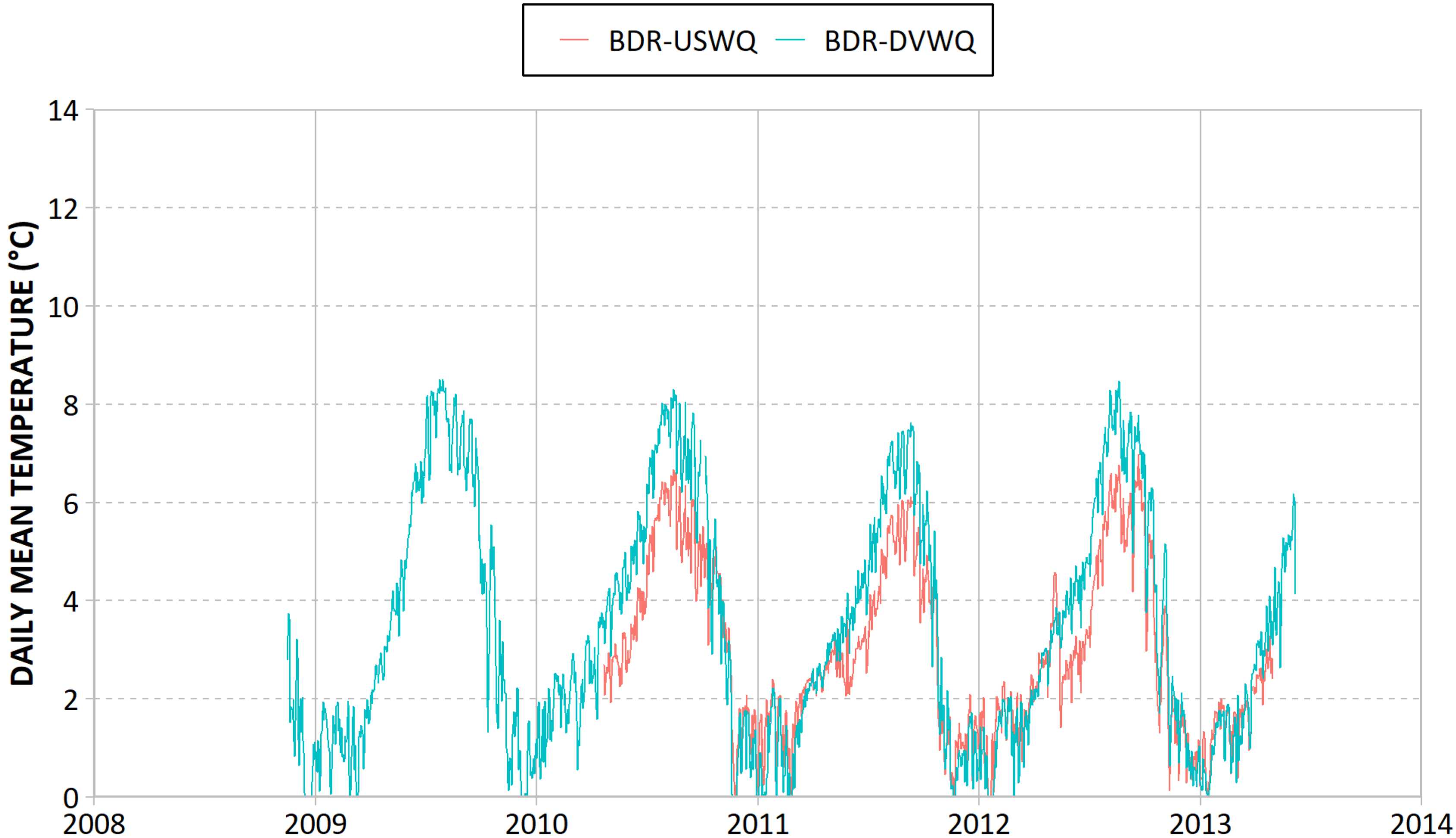
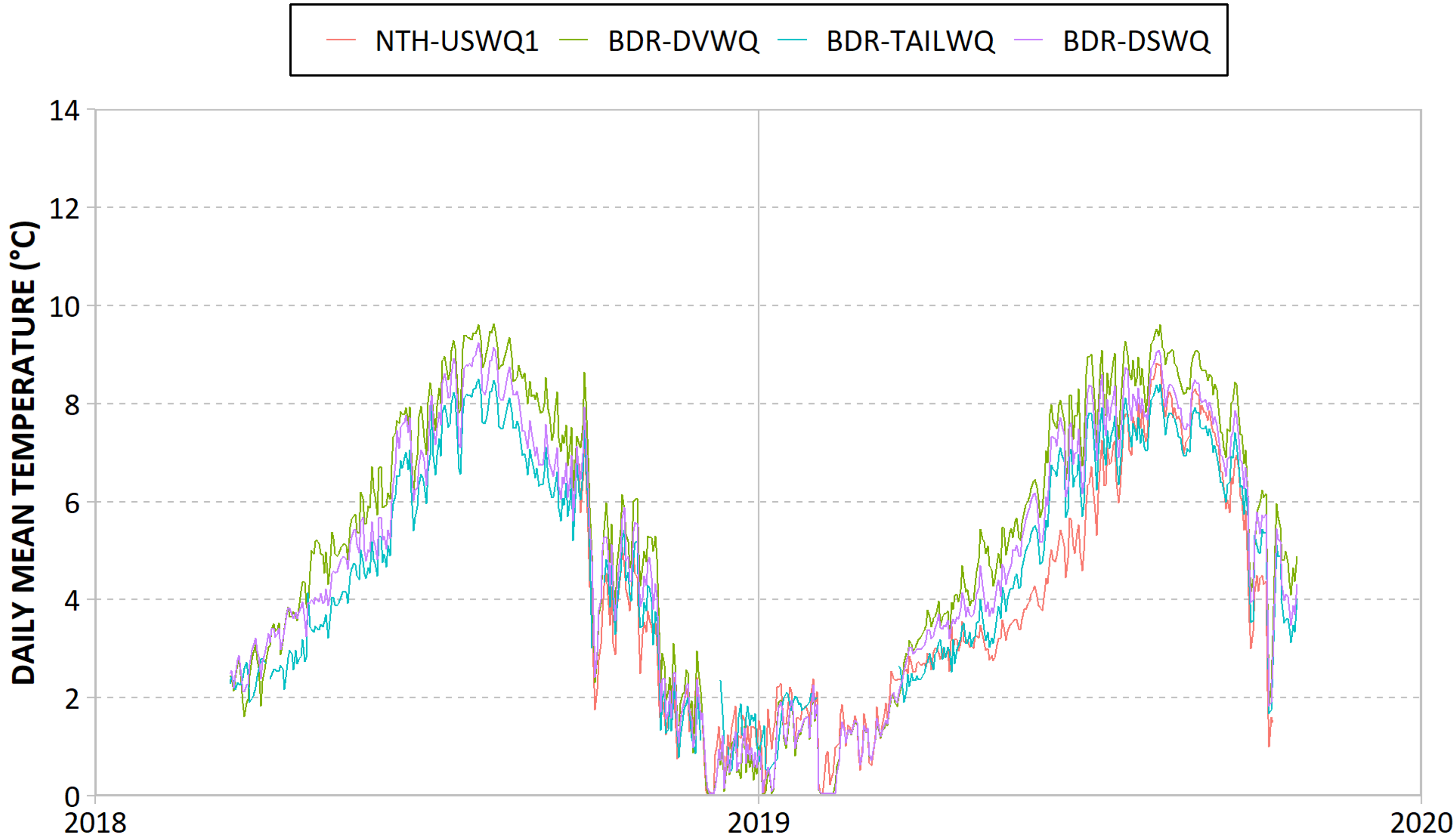
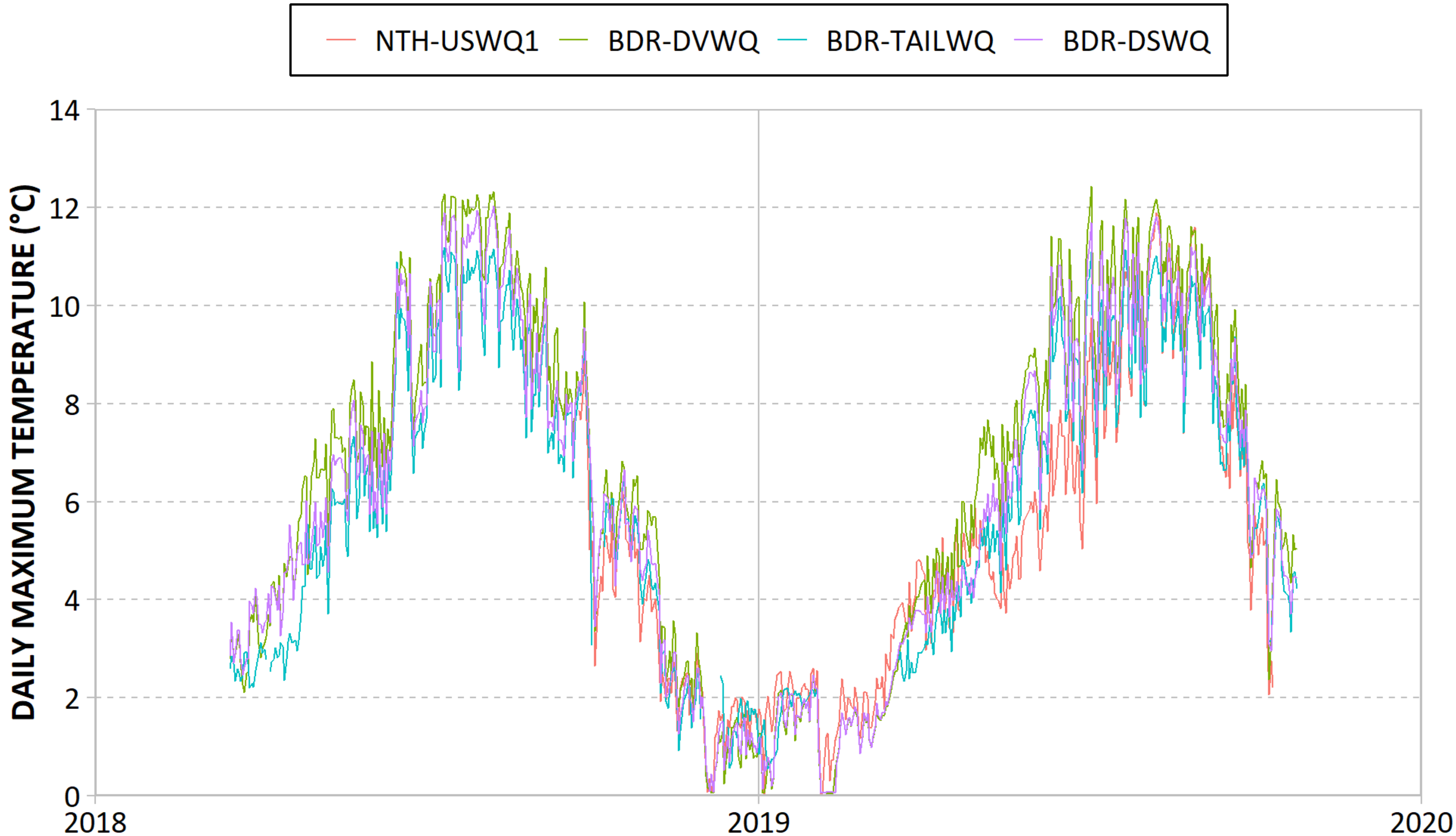


Figure 4. Daily mean, maximum, and minimum water temperature collected in Boulder Creek during operations (2018 to 2019).

(a) Daily Average



(b) Daily Maximum



(c) Daily Minimum

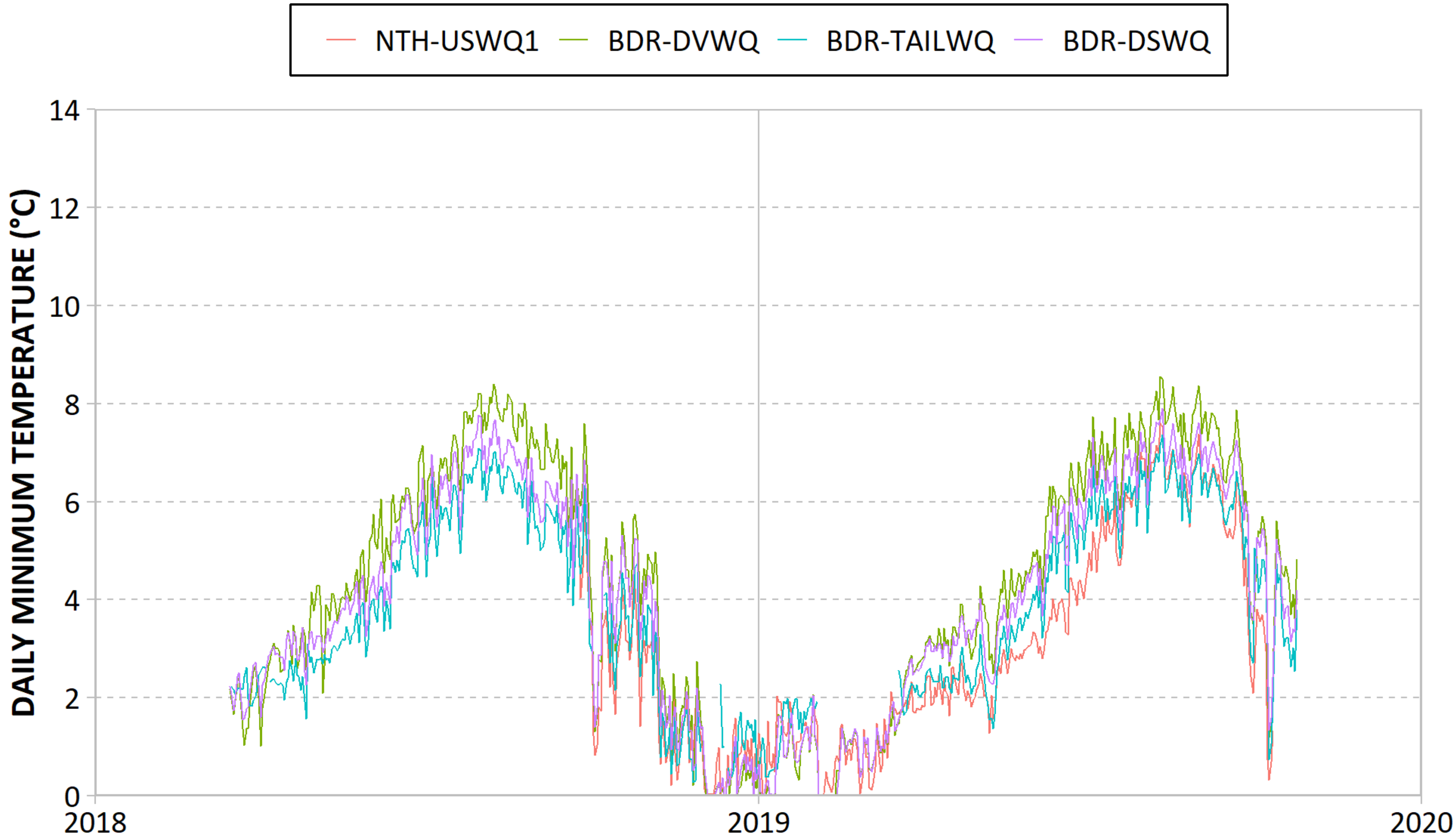


Figure 5. **Cumulative frequency distribution of instantaneous water temperature between the monitoring sites and ULL-USWQ02 during operations (2018 to 2019).**

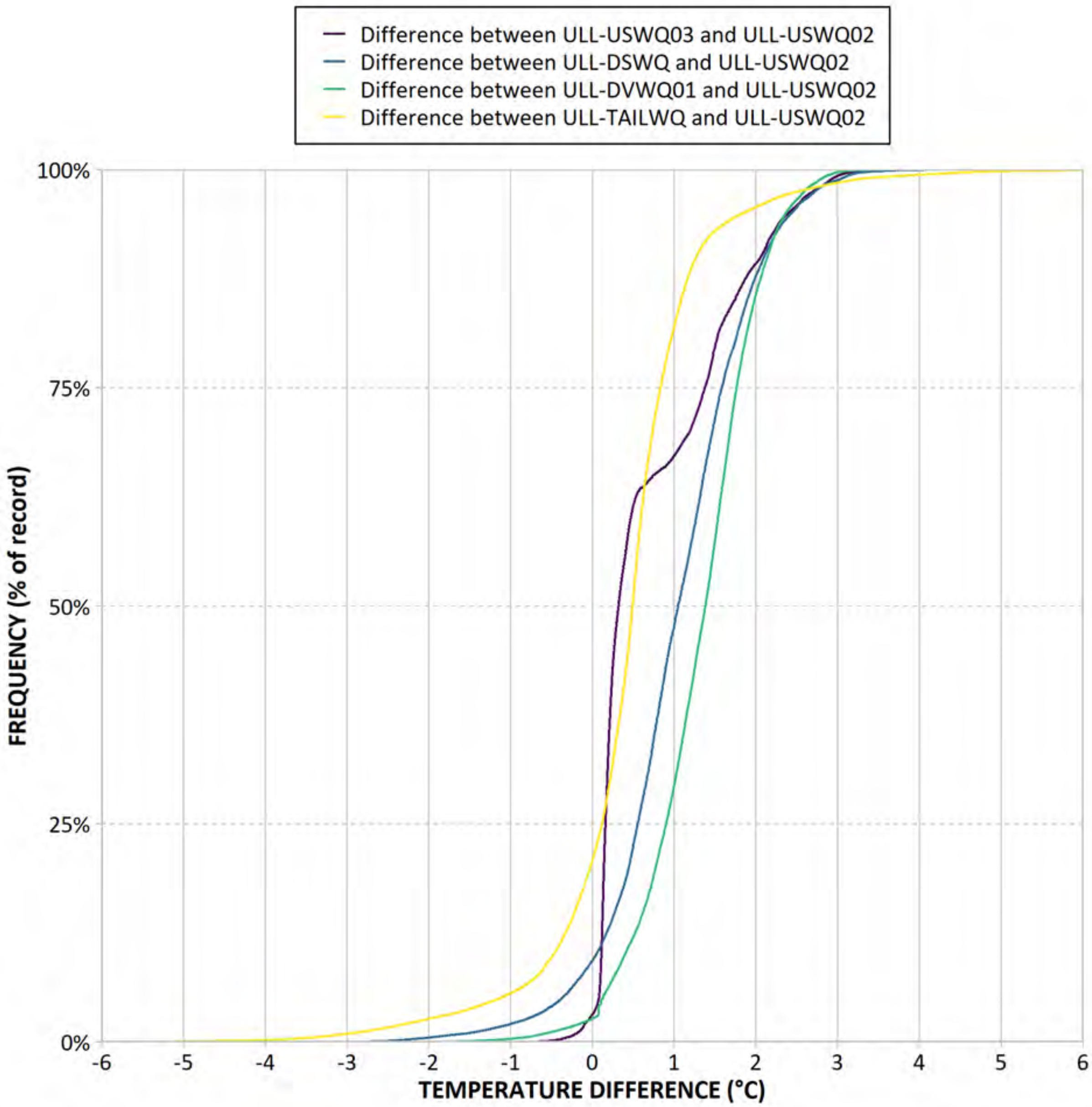
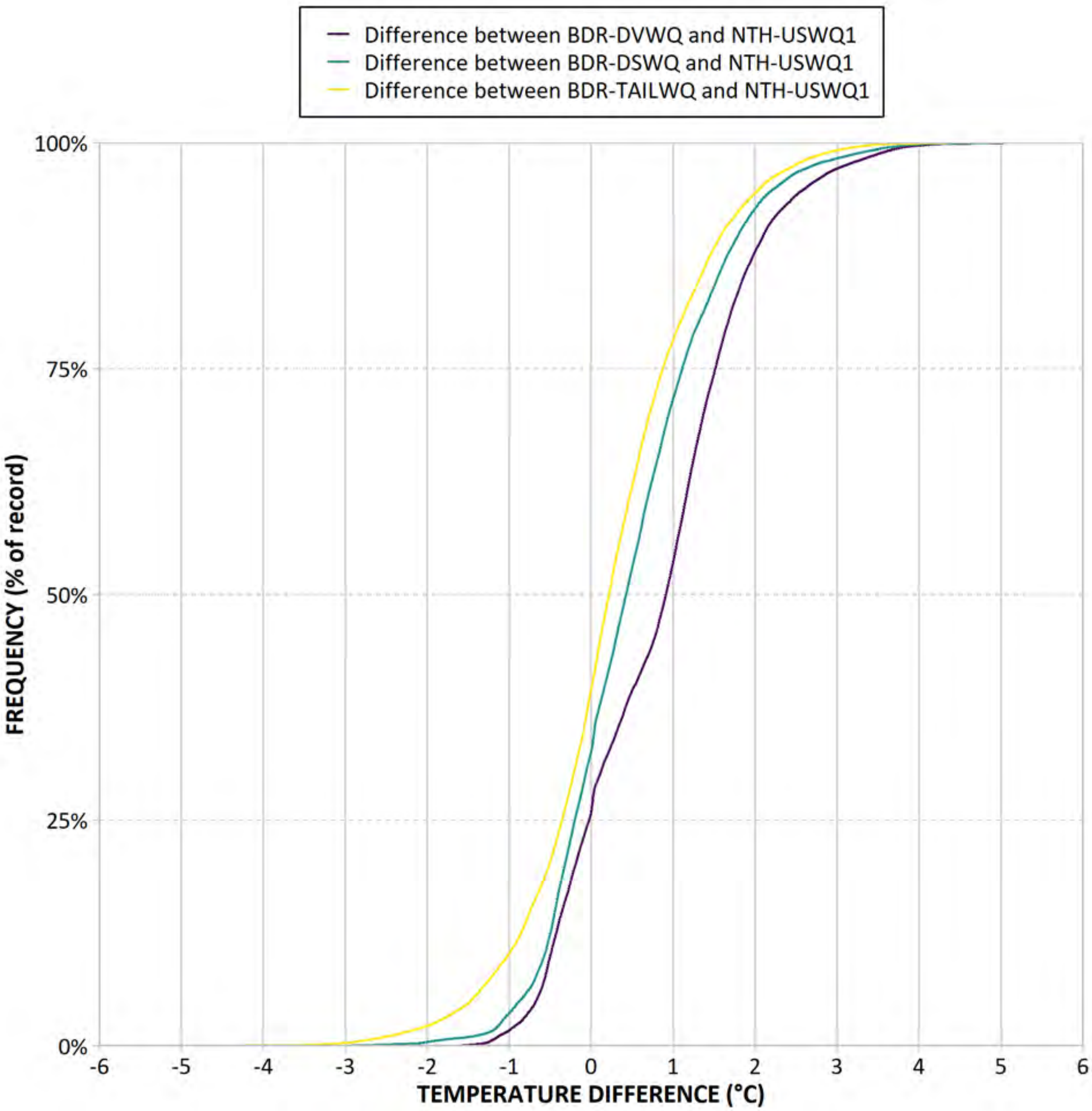


Figure 6. Cumulative frequency distribution of instantaneous water temperature between the Boulder Creek monitoring sites and the upstream site located in North Creek (NTH-USWQ1) during operations (2018-2019). NTH-USWQ1 data were used because no data were available at BDR-USWQ2.



4.1.2. Monthly Summary Statistics

The Upper Lillooet River and Boulder Creek mean/average, instantaneous minimum, instantaneous maximum, and standard deviation for water temperature for each month of the record are summarized for the baseline period (upstream and diversion) in Appendix G, and operational period (upstream, diversion, tailrace and downstream) in Section 4.1.2.1.

Mean/average, instantaneous minimum, instantaneous maximum, and standard deviation for air temperature for each month of the record are provided in Section 4.1.2.1 for both Upper Lillooet River (upstream and diversion/downstream sites) and Boulder Creek (diversion site only).

4.1.2.1. Water Temperature

The range in monthly average water temperature in the upstream reach of Upper Lillooet River was 0.4°C to 7.3°C during baseline monitoring and was 0.1°C to 6.4°C during operational monitoring to date (Table 8). The warmest month to date occurred during baseline in July 2009 and the coolest month to date occurred during operations in December 2018, January 2019, and February 2019 (Table 8). In the Upper Lillooet River diversion reach, monthly average water temperature ranged from 1.0°C to 6.9°C during baseline monitoring and from 0.9°C to 7.6°C during operational monitoring. The warmest month to date occurred in July 2019 and the coolest in February 2019; both occurred during operations. In the downstream reach monthly average water temperature ranged from 1.3°C to 7.2°C during operational monitoring (Table 8). The data collected at ULL-USWQ03 are provided in Table 8, however this site is influenced by groundwater, therefore the monthly average temperatures during the cooler months are higher than expected in comparison to the baseline data collected at ULL-USWQ and the operational data collected at ULL-USWQ02 (Appendix G, .Table 8).

Currently, no water temperature data are available for the BDR-USWQ2 site (Table 4). Data collected at NTH-USWQ are provided in Table 8 as the control site. The range in monthly average water temperature in the diversion reach of Boulder Creek was 0.5°C to 7.9°C during baseline monitoring and was 0.6°C to 8.8°C during operational monitoring to date (Appendix G, Table 9). Water temperature was collected at the same location (BDR-DVWQ) from 2010 to 2019; considering all the data at BDR-DVWQ the coldest month occurred in January 2012 and December 2018 and the warmest month occurred during operations in August 2019. At the Boulder Creek downstream site (BDR-DSWQ) the range in monthly data was 0.7°C and 8.2°C. The coldest month occurred in December 2018 and the warmest in July 2018 and August 2019 (Table 9).

Table 8. Upper Lillooet River monthly water temperature summary statistics measured during operations (2018 to 2019).

Year	Month	Water Temperature[1] (°C)																			
		ULL-USWQ02				ULL-USWQ03				ULL-DVWQ01				ULL-TAILWQ				ULL-DSWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2018	Apr	3.0	0.0	8.6	1.8	-	-	-	-	-	-	-	-	3.7	1.8	7.8	1.3	4.3	1.9	8.0	1.1
	May	4.3	1.4	8.8	1.8	-	-	-	-	-	-	-	-	4.5	1.8	8.8	1.7	4.8	2.1	9.1	1.7
	Jun	5.9	3.3	11.0	1.5	-	-	-	-	-	-	-	-	6.1	3.5	11.2	1.5	6.3	3.7	11.3	1.5
	Jul	6.4	3.7	10.3	1.6	-	-	-	-	-	-	-	-	6.9	4.1	10.9	1.7	7.2	4.4	11.1	1.7
	Aug	5.7	3.3	9.1	1.4	-	-	-	-	-	-	-	-	6.2	3.8	9.9	1.5	6.5	4.0	10.2	1.5
	Sep	5.2	2.2	8.8	1.2	-	-	-	-	-	-	-	-	5.6	2.8	9.3	1.2	5.8	3.1	9.4	1.1
	Oct	4.0	1.0	7.2	1.3	-	-	-	-	-	-	-	-	4.6	1.0	9.2	1.0	4.8	1.7	7.2	1.0
	Nov	1.6	0.0	5.0	1.3	1.8	0.2	5.1	1.2	3.0	0.8	5.9	1.2	2.0	0.2	5.1	1.2	2.7	0.8	5.5	1.0
	Dec	0.1	0.0	1.7	0.2	1.1	0.3	3.9	0.4	1.2	0.1	2.6	0.6	0.8	0.2	2.2	0.3	1.3	0.4	2.9	0.4
2019	Jan	0.1	0.0	1.0	0.2	1.6	1.2	2.5	0.2	1.6	0.1	2.7	0.6	1.1	0.3	1.9	0.3	1.8	0.3	3.2	0.4
	Feb	0.1	0.0	1.1	0.1	2.0	1.4	3.0	0.3	0.9	0.1	2.3	0.7	-	-	-	-	1.5	0.4	3.2	0.6
	Mar	1.1	0.0	5.4	1.2	3.3	2.2	5.7	0.7	2.5	0.1	5.1	1.2	-	-	-	-	2.9	1.2	5.2	0.8
	Apr	2.9	0.4	8.2	1.7	3.7	1.1	7.7	1.4	4.3	2.0	7.4	1.2	3.3	0.8	8.0	1.6	-	-	-	-
	May	4.6	1.4	9.1	1.9	4.7	1.4	9.5	2.0	5.6	2.7	9.7	1.8	4.7	1.6	9.0	1.8	-	-	-	-
	Jun	6.1	3.1	10.9	1.7	6.3	3.3	11.2	1.7	7.2	4.2	11.7	1.6	6.3	3.3	11.1	1.7	-	-	-	-
	Jul	6.2	3.6	10.2	1.4	6.4	3.7	10.4	1.5	7.6	4.9	11.4	1.5	6.7	3.9	10.7	1.5	-	-	-	-
	Aug	5.9	3.6	9.3	1.4	6.0	3.7	9.6	1.4	7.4	4.7	10.2	1.2	6.4	4.0	10.0	1.4	-	-	-	-
	Sep	5.2	2.4	8.8	1.1	5.3	2.6	9.0	1.1	6.8	4.0	9.6	1.0	5.5	2.8	9.3	1.1	-	-	-	-
	Oct	-	-	-	-	-	-	-	-	-	-	-	-	4.2	1.0	7.2	1.2	-	-	-	-

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

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Table 9. Boulder Creek monthly water temperature summary statistics measured during operations (2018 to 2019).

Year	Month	Water Temperature[1] (°C)															
		NTH-USWQ1				BDR-DVWQ				BDR-TAILWQ				BDR-DSWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2018	Apr	-	-	-	-	3.5	1.0	6.5	0.9	2.8	1.6	5.5	0.5	3.4	1.6	6.0	0.6
	May	-	-	-	-	5.2	2.1	8.5	1.2	4.1	2.5	7.3	1.1	4.7	2.9	8.1	1.1
	Jun	-	-	-	-	6.9	4.6	11.1	1.3	5.8	3.4	10.9	1.4	6.3	3.9	10.8	1.4
	Jul	-	-	-	-	8.6	5.5	12.3	1.6	7.6	4.5	11.2	1.6	8.2	4.9	11.9	1.6
	Aug	-	-	-	-	8.8	6.7	12.3	1.2	7.6	5.1	11.2	1.3	8.1	5.7	12.0	1.3
	Sep	-	-	-	-	7.5	4.5	10.8	0.9	6.3	3.1	9.6	1.0	6.7	3.6	10.2	1.0
	Oct	3.7	0.8	6.3	1.1	4.9	1.3	6.8	1.1	4.3	2.2	6.5	0.9	4.5	1.4	6.7	0.9
	Nov	2.1	0.2	4.5	0.9	2.8	0.2	5.8	1.3	2.0	0.3	4.8	1.1	2.4	0.5	5.4	1.1
	Dec	1.0	0.0	2.1	0.6	0.6	0.0	2.0	0.5	-	-	-	-	0.7	0.0	2.0	0.5
2019	Jan	1.6	0.0	2.6	0.6	1.1	0.0	2.4	0.7	1.5	0.4	2.2	0.6	1.2	0.0	2.5	0.6
	Feb	1.0	0.0	2.6	0.6	0.8	0.0	2.2	0.6	-	-	-	-	0.8	0.0	2.2	0.6
	Mar	2.0	0.1	4.8	0.9	2.0	0.5	4.3	0.8	-	-	-	-	2.0	0.5	3.8	0.8
	Apr	3.0	1.6	5.9	0.8	3.8	2.6	6.0	0.7	3.0	2.1	4.8	0.5	3.5	2.7	4.7	0.4
	May	3.4	1.3	6.0	0.9	5.2	2.5	9.0	1.3	4.0	1.4	7.9	1.2	4.6	2.3	8.6	1.2
	Jun	4.8	2.8	7.9	1.1	7.2	4.2	11.4	1.5	6.2	3.2	10.2	1.5	6.7	3.7	10.8	1.5
	Jul	6.9	4.6	10.8	1.3	8.5	5.8	12.4	1.4	7.3	4.9	11.1	1.3	7.9	5.4	11.8	1.3
	Aug	7.9	5.4	11.9	1.3	8.8	6.3	12.2	1.2	7.6	5.4	11.0	1.2	8.2	5.9	11.8	1.2
	Sep	6.4	2.1	11.2	1.5	7.5	3.5	11.3	1.4	6.5	2.7	10.2	1.3	7.0	3.6	10.7	1.3
	Oct	-	-	-	-	4.9	1.2	6.8	1.2	-	-	-	-	4.4	1.3	6.5	1.2

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

4.1.2.2. Air Temperature

Air temperature was collected in the upstream and diversion reach of the Upper Lillooet River during baseline monitoring (Table 3, Map 2). During operations air temperature sites were moved to coincide with the operational water temperature data loggers in the upstream (ULL-USAT01) and downstream reaches (ULL-DSAT) (Map 2). In Boulder Creek, air temperature was monitored at one site in the diversion reach (BDR-DVAT) during baseline and operational monitoring to date (Table 4, Map 3).

The range in monthly average air temperature in the upstream reach of Upper Lillooet River was -7.8°C to 15.3°C during baseline monitoring and was -5.8°C to 15.9°C during operational monitoring to date (Table 10). The warmest month occurred in July 2018 and the coolest in January 2013 (a data gap occurred in winter 2019).

In the Upper Lillooet River diversion and downstream reach monthly average air temperature ranged from -4.4°C to 16.7°C during baseline (diversion) monitoring and from -8.2°C to 18.5°C during operational (downstream) monitoring to date (Table 11, Map 2). The warmest month occurred in July 2018 and the coolest in February 2019.

The range in monthly average air temperature in the diversion reach of Boulder Creek was -4.2°C to 16.5°C during baseline monitoring and was -7.2°C to 18.8°C during operational monitoring to date (Table 12, Map 3). Since the air temperature was collected at the same location from 2010 to 2019, we have a record spanning the baseline and operational phase at this location. To date, considering all the data at BDR-DVWQ, the coldest month occurred in February 2019 and the warmest month occurred in July 2018 (Table 12). Similar trends are observed in the Upper Lillooet air temperature data with the exception of the ULL-USAT01, however data were not available for February 2019 at this site (Table 10, Table 11).

The air temperature observations are in accordance with the water temperature trends observed in the Upper Lillooet River and Boulder Creek (see Section 4.1.1 and Section 4.1.2.1). Since air temperature is one of the primary drivers of water temperature the air temperature data suggest that the water temperature trends observed in 2018 and 2019 are likely largely reflective of natural inter annual variation in climate conditions. Project related effects will be evaluated using a BACI analysis following 5 years of data have been collected.

Table 10. Upper Lillooet River baseline (2010 to 2013) air temperature monthly data summary statistics.

Year	Month	Air Temperature[1] (°C)							
		ULL-USAT				ULL-DVAT			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2010	Apr	2.6	-7.6	13.4	4.0	4.8	-4.7	17.1	4.0
	May	5.2	-3.3	17.0	4.8	8.9	-0.5	22.3	5.1
	Jun	10.4	0.5	24.4	5.5	12.2	4.4	26.0	4.8
	Jul	15.3	3.1	30.8	7.7	16.7	6.6	33.0	6.6
	Aug	13.9	0.8	31.2	7.0	15.3	5.1	32.8	5.8
	Sep	9.2	-1.4	24.2	4.4	10.6	2.1	25.8	3.7
	Oct	5.1	-3.6	16.0	3.3	6.8	-0.7	19.1	2.9
	Nov	-3.3	-19.9	5.6	6.0	-1.3	-16.7	9.3	5.3
	Dec	-4.9	-22.1	0.6	5.9	-2.7	-14.5	1.0	3.8
2011	Jan	-5.9	-23.8	2.0	6.4	-3.5	-15.6	2.8	4.4
	Feb	-5.8	-20.6	1.6	5.1	-3.7	-19.7	4.8	4.6
	Mar	-	-	-	-	0.5	-8.9	9.8	2.7
	Apr	1.3	-6.0	15.5	3.7	2.7	-3.3	13.8	3.2
	May	3.7	-3.5	15.1	3.8	-	-	-	-
	Jun	7.7	-0.5	21.2	5.4	-	-	-	-
	Jul	11.8	0.8	27.5	5.3	-	-	-	-
	Aug	13.1	1.9	26.5	6.5	-	-	-	-
	Sep	10.1	-0.2	27.7	5.7	-	-	-	-
	Oct	3.4	-4.5	12.6	3.5	-	-	-	-
	Nov	-3.5	-19.5	3.6	4.1	-	-	-	-
	Dec	-6.2	-17.6	0.1	4.9	-	-	-	-
2012	Jan	-5.6	-25.0	1.3	6.5	-	-	-	-
	Feb	-2.2	-10.3	0.6	2.5	-	-	-	-
	Mar	-1.4	-13.2	9.8	3.3	-	-	-	-
	Apr	2.3	-6.5	12.3	3.2	-	-	-	-
	May	5.0	-2.8	17.7	4.8	8.2	-0.5	23.4	5.2
	Jun	9.4	-0.2	24.1	5.2	11.3	3.0	24.9	4.3
	Jul	14.4	2.6	30.5	6.8	14.8	6.8	32.1	5.8
	Aug	14.5	2.3	32.3	7.2	15.6	6.8	32.3	5.4
	Sep	10.3	-1.1	27.8	6.4	12.8	2.7	27.6	4.7
	Oct	4.0	-4.6	17.8	4.1	6.0	-2.0	19.4	3.9
	Nov	-0.4	-10.7	7.6	3.9	1.2	-5.7	8.6	3.1
	Dec	-5.4	-16.4	1.5	3.9	-2.9	-9.0	2.4	2.5
2013	Jan	-7.8	-21.5	1.0	6.2	-4.4	-14.2	2.3	4.2
	Feb	-2.1	-13.0	2.6	2.9	0.1	-6.3	7.7	1.8
	Mar	-0.2	-10.4	11.2	3.7	1.6	-5.9	11.5	3.0
	Apr	2.9	-5.2	12.6	3.6	4.0	-2.2	15.0	3.2

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures with each Project phase.

Table 11. Operational (2018 to 2019) air temperature monthly data summary statistics.

Year	Month	Air Temperature[1] (°C)							
		ULL-USAT01				ULL-DSAT			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2018	Mar	-	-	-	-	-	-	-	-
	Apr	3.8	-6.5	20.0	4.8	4.5	-3.2	20.2	4.0
	May	9.8	-1.7	27.2	7.2	13.0	2.1	27.9	5.7
	Jun	12.0	0.2	32.1	6.3	13.4	3.9	33.1	5.6
	Jul	15.9	3.7	32.7	7.1	18.5	7.1	34.3	6.2
	Aug	14.7	3.0	31.6	6.8	17.5	7.6	33.7	5.5
	Sep	9.2	-0.1	27.0	4.9	10.5	2.9	26.3	3.7
	Oct	4.3	-4.3	19.5	4.9	5.5	-1.6	13.4	2.9
	Nov	-0.6	-8.8	11.5	3.7	1.1	-3.3	10.5	2.7
	Dec	-5.8	-18.5	1.6	5.7	-3.0	-11.1	1.5	3.2
2019	Jan	-	-	-	-	-2.8	-10.0	1.3	2.7
	Feb	-	-	-	-	-8.2	-19.7	2.5	5.2
	Mar	-	-	-	-	-0.9	-14.7	9.0	4.6
	Apr	-	-	-	-	3.4	-1.7	12.7	2.9
	May	-	-	-	-	12.3	1.2	29.3	6.1

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures with each Project phase.

Table 12. Boulder Creek baseline (2010 to 2013) and operational (2018 to 2019) air temperature monthly data summary statistics.

Phase	Year	Month	Air Temperature[1] (°C)			
			BDR-DVAT			
			Avg	Min	Max	SD
Baseline	2010	May	8.8	0.1	22.8	5.0
		Jun	11.7	4.4	26.9	5.0
		Jul	16.5	6.1	34.4	7.1
		Aug	15.4	4.9	32.9	6.1
		Sep	10.2	1.9	26.7	3.6
		Oct	6.5	-0.8	15.2	2.5
		Nov	-1.1	-15.4	7.2	5.0
		Dec	-2.6	-13.5	0.9	3.5
	2011	Jan	-3.5	-14.4	1.9	4.1
		Feb	-3.3	-14.0	2.4	3.5
		Mar	0.4	-8.4	12.1	2.8
		Apr	2.5	-2.7	13.1	3.1
		May	6.2	-0.3	22.7	4.3
		Jun	10.8	4.0	26.1	4.9
		Jul	11.9	4.2	28.0	4.8
		Aug	13.9	5.5	28.2	5.4
		Sep	11.4	3.3	27.3	4.6
		Oct	4.9	-1.2	12.7	3.0
		Nov	-1.4	-12.4	3.1	2.9
		Dec	-2.6	-9.6	1.2	2.5
	2012	Jan	-3.8	-20.4	1.8	5.6
		Feb	-0.6	-12.8	3.9	2.3
		Mar	-0.1	-8.3	9.3	2.4
		Apr	3.1	-2.9	14.6	2.7
		May	8.5	-0.1	24.3	5.2
		Jun	10.5	3.0	25.2	4.5
		Jul	14.1	5.3	32.4	6.3
		Aug	15.4	6.5	32.6	5.9
		Sep	12.4	2.1	28.2	4.6
		Oct	5.7	-1.8	16.2	3.4
		Nov	1.0	-6.0	8.5	3.0
		Dec	-2.9	-8.8	1.8	2.4

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicatres maximum temperaures with each Project phase.

Table 12. Continued

Phase	Year	Month	Air Temperature[1] (°C)			
			BDR-DVAT			
			Avg	Min	Max	SD
Baseline	2013	Jan	-4.2	-14.2	1.7	3.9
		Feb	-0.1	-6.4	4.5	1.5
		Mar	1.2	-5.9	10.8	2.5
		Apr	4.6	-2.0	19.6	3.7
Operations	2018	Apr	5.6	-3.1	25.5	4.7
		May	13.7	3.5	28.8	6.1
		Jun	13.6	4.3	34.2	5.8
		Jul	18.8	8.1	36.5	7.1
		Aug	18.3	8.4	35.9	6.1
		Sep	11.1	3.0	28.9	4.1
		Oct	6.0	-1.8	15.2	2.8
		Nov	1.6	-3.0	12.3	2.6
		Dec	-2.5	-10.0	3.8	2.9
	2019	Jan	-2.0	-9.3	2.9	2.4
		Feb	-7.2	-18.9	4.0	5.1
		Mar	0.0	-14.3	9.9	4.5

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicatres maximum temperaures with each Project phase.

4.1.3. Growing Season Degree Days

The start of the growing season based on the water temperature record is variable in the Upper Lillooet River. During baseline monitoring, the growing season start date at upstream and diversion sites varied from late-May to early-July, however during operations the start date occurred in mid- to late-May in both years (2018 and 2019) (Table 13). The growing season end dates occurred in October on most dates and for most sites, except in the downstream reach during operations when the growing season ended in early November. The length of the growing season during baseline monitoring at the upstream and diversion sites ranged from 644-degree days to 866-degree days, while the growing season ranged from 746-degree days (upstream) to 1,084- degree days (diversion) during operational monitoring (Table 13). The tailrace site is expected to consist of cooler water originating from the intake located upstream (Table 13).

In Boulder Creek, during the baseline period, the growing season start dates and end dates were variable. Start dates were between late-May and early August with end dates occurring from early

October to early November. The operational growing season start date occurred from mid-May to early June and ended from early to late October. The length of the growing season in Boulder Creek during baseline ranged from 367-degree days upstream to 898-degree days in the diversion. During operations the length of the growing season in the diversion, tailrace, and downstream sites ranged from 891-degree days to 1,167-degree days with the longest growing season recorded in 2019 at BDR-DVWQ (Table 14).

Table 13. Upper Lillooet River growing season length and degree days during baseline and operations.

Project Phase	Site	Year	No. of days with valid data	Growing Season				
				Start Date	End Date	Length (day)	Gap (day)	Degree Days
Baseline	ULL-USWQ1	2008	41	-	-	-	-	-
		2009	365	22-May-09	8-Oct-09	141	0	866
		2010	365	28-Jun-10	13-Oct-10	109	0	644
		2011	365	2-Jul-11	23-Oct-11	114	0	693
		2012	366	20-Jun-12	16-Oct-12	119	1	701
		2013	153	23-May-13	-	-	-	-
	ULL-DVWQ	2010	49	-	-	-	-	-
		2011	97	-	-	-	-	-
		2012	366	6-Jun-12	18-Oct-12	135	0	825
		2013	120	-	-	-	-	-
Operation	ULL-USWQ02	2018	278	23-May-18	30-Sep-18	132	0	746
		2019	283	20-May-19	6-Oct-19	141	0	798
	ULL-USWQ03	2018	60	-	-	-	-	-
		2019	282	18-May-19	7-Oct-19	143	0	839
	ULL-DVWQ01	2018	60	-	-	-	-	-
		2019	293	13-May-19	18-Oct-19	159	0	1,084
	ULL-TAILWQ	2018	259	21-May-18	3-Nov-18	167	6	965
		2019	239	-	-	-	0	-
	ULL-DSWQ	2018	278	19-May-18	4-Nov-18	171	0	1,019
		2019	102	-	-	-	-	-

Degree days are accumulated thermal units.

Table 14. Boulder Creek growing season length and degree days during baseline and operations.

Project Phase	Site	Year	No. of days with valid data	Growing Season				
				Start Date	End Date	Length (day)	Gap (day)	Degree Days
Baseline	BDR-USWQ	2010	235	6-Jul-10	2-Nov-10	120	11	632
		2011	364	2-Aug-11	12-Oct-11	71	0	367
		2012	366	23-Jul-12	15-Oct-12	86	1	475
	BDR-DVWQ	2008	45	-	-	-	-	-
		2009	365	31-May-09	8-Oct-09	130	0	898
		2010	351	14-Jun-10	29-Oct-10	139	11	885
		2011	354	7-Jul-11	14-Oct-11	99	2	616
		2012	366	3-Jul-12	19-Oct-12	109	0	726
		2013	156	23-May-13	-	-	-	-
Operation	NTH-USWQ1	2018	98	-	25-Oct-18	-	-	-
		2019	283	17-Jun-19	30-Sep-19	106	0	721
	BDR-DVWQ	2018	290	17-May-18	3-Oct-18	140	0	1,062
		2019	296	15-May-19	20-Oct-19	160	0	1,167
	BDR-TAILWQ	2018	255	9-Jun-18	29-Oct-18	143	8	919
		2019	235	29-May-19	7-Oct-19	132	4	891
	BDR-DSWQ	2018	290	20-May-18	2-Oct-18	136	0	959
		2019	296	23-May-19	8-Oct-19	138	0	997

Degree days are accumulated thermal units.

4.1.4. Hourly Rates of Water Temperature Change

Rapid changes in temperature (greater than ±1.0°C/hr) can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specify that the hourly rate of water temperature change should not exceed ±1.0°C/hr (MOE 2019). Based on Ecofish's experience collecting baseline temperature data on several other streams in British Columbia (file data), it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1.0°C/hr.

During baseline, the percentage (%) of record where exceedances were observed was low (<0.65%) in the Upper Lillooet River and Boulder Creek monitoring sites (Table 15, Table 16, Figure 7, Figure 8). Exceedances occurred more often during operations, particularly in the tailrace site, however exceedances as a percentage of the record were still relatively low (<1.35%; Table 15, Table 16).

Table 15. Upper Lillooet River hourly water temperature rate of change (°C/hr) summary statistics and occurrence of rate of change in exceedance of ± 1.0°C/hr.

Project Phase	Site	Period of Record		n	Occurrence		Min -ve	Percentile				Max +ve
		Start	End		No.	% of Record		1st	5th	95th	99th	
Baseline	ULL-USWQ1	19-Nov-08	3-Jun-13	39,741	243	0.61	-1.34	-0.74	-0.51	0.65	0.94	1.97
	ULL-DVWQ	12-Nov-10	1-May-13	15,213	10	0.07	-1.02	-0.68	-0.41	0.52	0.8	1.12
Operation	ULL-USWQ02	28-Mar-18	11-Oct-19	53,959	661	1.23	-1.42	-0.85	-0.61	0.76	0.99	2.42
	ULL-USWQ03	1-Nov-18	11-Oct-19	33,030	227	0.69	-2.73	-0.81	-0.55	0.68	0.92	2.07
	ULL-DVWQ01	1-Nov-18	21-Oct-19	33,993	94	0.28	-1.30	-0.72	-0.44	0.55	0.84	1.52
	ULL-TAILWQ	28-Mar-18	24-Oct-19	48,373	496	1.03	-4.56	-0.83	-0.60	0.75	0.96	5.05
	ULL-DSWQ	28-Mar-18	13-Apr-19	36,574	146	0.40	-1.89	-0.76	-0.48	0.60	0.85	2.30

n = number of datapoints.

Table 16. Boulder Creek hourly water temperature rate of change (°C/hr) summary statistics and occurrence of rate of change in exceedance of ± 1.0°C/hr.

Project Phase	Site	Period of Record		n	Occurrence		Min	Percentile				Max
		Start	End		No.	% of Record	-ve	1st	5th	95th	99th	+ve
Baseline	BDR-USWQ	22-Apr-10	1-May-13	26,274	59	0.22	-1.91	-0.6	-0.3	0.41	0.8	1.22
	BDR-DVWQ	15-Nov-08	6-Jun-13	39,576	159	0.40	-1.37	-0.5	-0.30	0.37	0.84	1.58
Operation	NTH-USWQ1	24-Sep-18	11-Oct-19	36,667	227	0.62	-1.53	-0.58	-0.35	0.48	0.89	1.38
	BDR-DVWQ	16-Mar-18	24-Oct-19	56,342	523	0.93	-3.21	-0.58	-0.38	0.50	0.98	1.78
	BDR-TAILWQ	16-Mar-18	24-Oct-19	48,960	652	1.33	-5.79	-0.61	-0.40	0.57	1.06	4.13
	BDR-DSWQ	16-Mar-18	24-Oct-19	56,343	632	1.12	-2.96	-0.58	-0.38	0.48	1.03	2.10

n = number of datapoints.

Figure 7. Upper Lillooet River summary of the hourly rate of change (°C/hr) during operations.

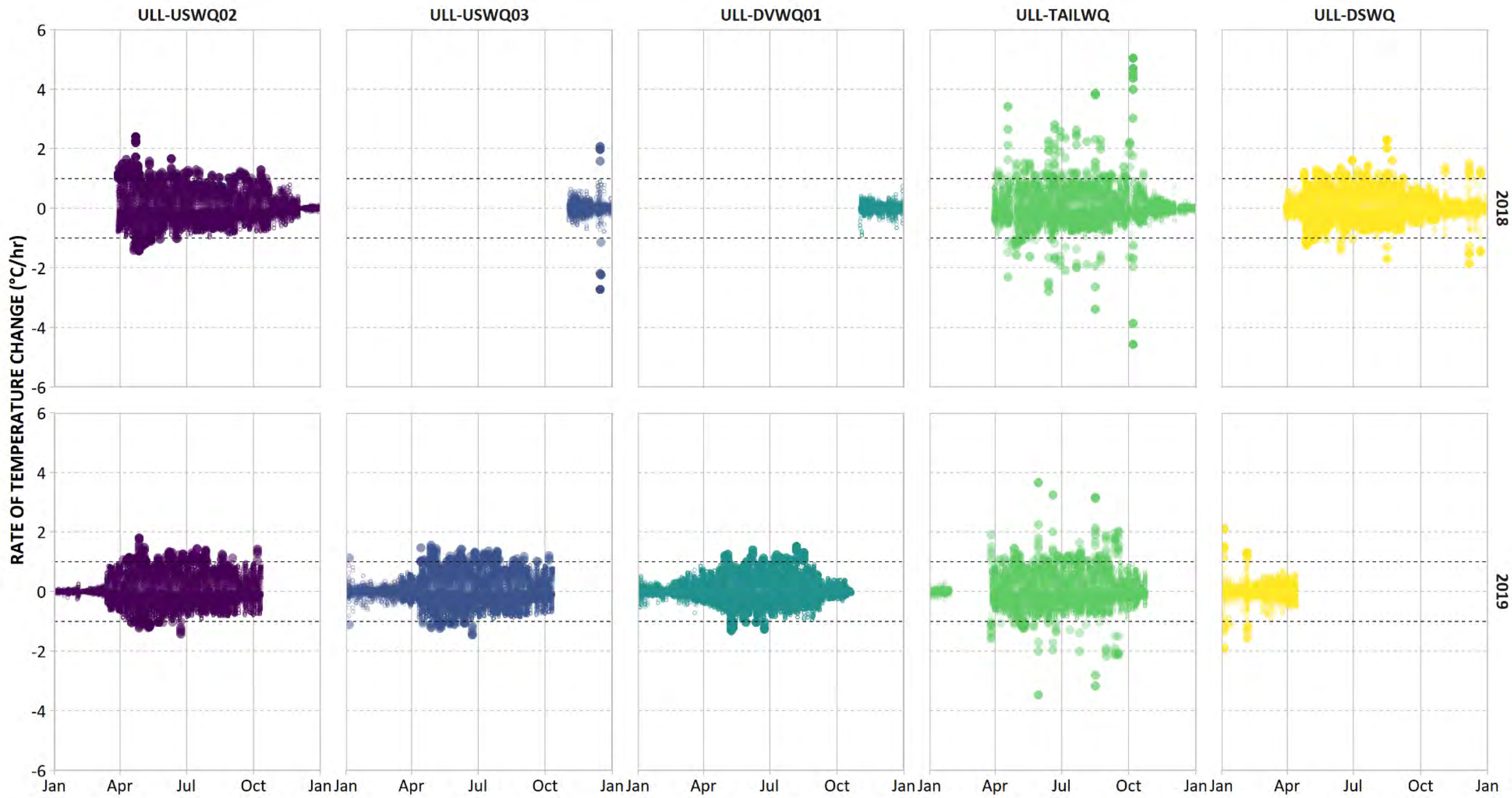
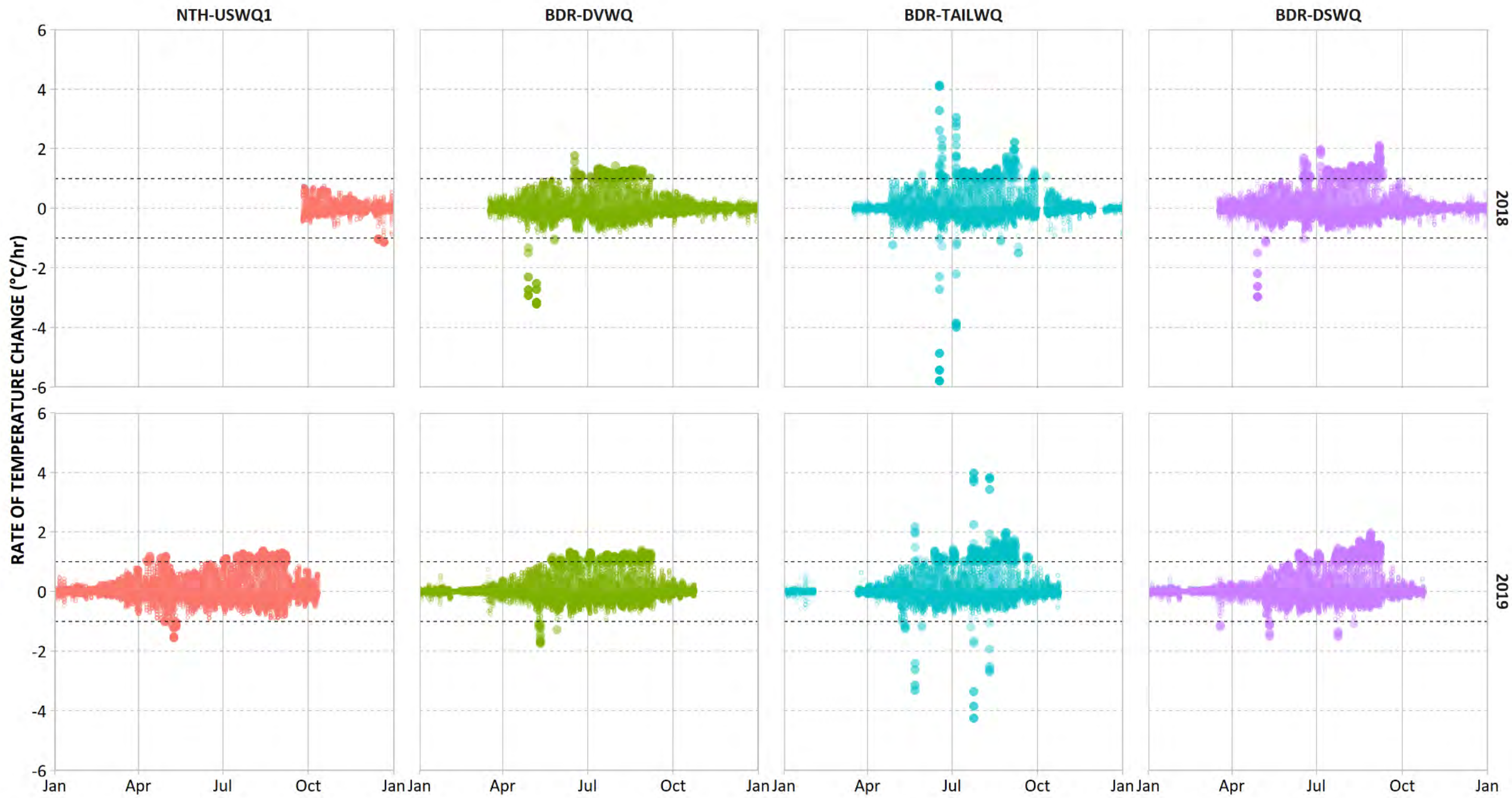


Figure 8. Boulder Creek summary of the hourly rate of change (°C/hr) for each year during operations.



4.1.5. Daily Temperature Extremes

Upper Lillooet River and Boulder Creek are classified as cool streams based on the lack of days with average water temperatures >18°C (Table 17, Table 18). Considering all sites and dates in the Upper Lillooet River, the maximum temperature was 11.7°C which was measured at ULL-DVWQ01 in June 2019 (Table 8). Considering all sites and dates in Boulder Creek, the maximum temperature was 12.4°C, which was measured at BDR-DVWQ in July 2019 (Table 9).

The number of days with daily average temperatures <1°C in Upper Lillooet River during baseline ranged from 32 to 95 and during operations ranged from 8 to 72 during operations (Table 17).

The number of days with daily average temperatures <1°C in Boulder Creek during baseline ranged from 15 to 83 and during operations the number of days ranged from 25 to 29 (Table 18).

Table 17. Upper Lillooet River summary of daily average water temperature extremes (number of days >18°C and <1°C).

Project Phase	Site	Year	n (days)	Days T_{water} > 18°C	Days T_{water} < 1°C
Baseline	ULL-USWQ1	2008	41	-	-
		2009	365	0	95
		2010	365	0	58
		2011	365	0	86
		2012	365	0	74
		2013	153	-	33
	ULL-DVWQ	2010	49	-	-
		2011	97	-	-
		2012	366	0	32
		2013	120	-	-
Operation	ULL-USWQ02	2018	278	0	-
		2019	283	0	72
	ULL-USWQ03	2018	60	-	-
		2019	282	0	-
	ULL-DVWQ01	2018	60	-	-
		2019	293	0	22
	ULL-DSWQ	2018	278	0	-
		2019	102	-	8
	ULL-TAILWQ	2018	259	0	-
		2019	239	0	-

n is the number of days that have observations for at least 23 hours.

Table 18. Boulder Creek summary of daily average water temperature extremes (number of days >18°C and <1°C).

Project Phase	Site	Year	n (days)	Days T_{water} > 18°C	Days T_{water} < 1°C
Baseline	BDR-USWQ	2010	235	0	15
		2011	364	0	42
		2012	366	0	47
		2013	118	0	19
	BDR-DVWQ	2008	45	-	-
		2009	365	0	66
		2010	351	0	33
		2011	354	0	83
		2012	366	0	58
		2013	156	0	31
Operation	BDR-DVWQ	2018	290	0	27
		2019	296	0	29
	BDR-TAILWQ	2018	255	0	-
		2019	235	0	-
	BDR-DSWQ	2018	290	0	25
		2019	296	0	29

n is the number of days that have observations for at least 23 hours.

4.1.6. Bull Trout Temperature Guidelines

Bull Trout specific water temperate guidelines (Table 5) were applied to the water temperature records by calculating the number of days of exceedance of the minimum and maximum temperature thresholds (Table 19). In BC, Bull Trout are considered to have the highest thermal sensitivity of the native salmonids evaluated in Oliver and Fiddler (2001), therefore more restrictive guidelines are applied to streams with this species.

During baseline and operational monitoring periods, the highest maximum daily temperatures did not exceed the prescribed thresholds for rearing (15°C) in Upper Lillooet River or Boulder Creek (Table 19, Table 20).

The number of days where daily maximum water temperatures were outside the Bull Trout thresholds for spawning and incubation (i.e., >10°C) were often zero and were 12 days or less in all cases in Upper Lillooet River. During operations, the number of days with maximum temperature >10°C is less than five (Table 19). In Boulder Creek, the number of days where daily maximum water temperatures were outside the thresholds for spawning and incubation (i.e., >10°C) ranged from 0 to 16 during baseline and from 8 to 30 during operations (Table 20).

The number of days where the minimum temperature was less than the incubation threshold (i.e., <2°C) were relatively high in both streams (Table 19, Table 20) due to cooler temperatures during the winter months (Figure 2, Figure 4). Overall, the number of exceedances of the lower temperature threshold of 2°C were less during operations to date (2018-2019), in comparison to the baseline record. However, the 2019 record does not yet include November or December data (Table 3).

Table 19. Upper Lillooet River summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout BC WQG thresholds (MOE 2019).

Project Phase	Site	Year	n (days)[1]	Rearing (Year Round)	Spawning (Aug.1 - Dec. 8)	Incubation (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
Baseline	ULL-USWQ1	2008	42	-	-	-	-
		2009	365	0	0	126	0
		2010	365	0	1	111	1
		2011	365	0	10	124	12
		2012	366	0	2	119	5
		2013	154	-	-	-	-
	ULL-DVWQ	2010	50	-	-	-	-
		2011	99	-	-	-	-
		2012	366	0	2	104	6
		2013	121	-	-	-	-
Operation	ULL-USWQ02	2018	278	0	0	61	0
		2019	283	0	0	-	-
	ULL-USWQ03	2018	60	-	-	-	-
		2019	282	0	0	-	-
	ULL-DVWQ01	2018	60	0	0	45	0
		2019	293	0	3	-	-
	ULL-DSWQ	2018	278	0	2	49	4
		2019	102	-	-	-	-
	ULL-TAILWQ	2018	259	0	0	48	0
		2019	239	-	-	-	-

[1] n is the number of days that have observations for at least 23 hours.

T_{water} is the total number of days where the minimum or maximum water temperature is outside the BC WQG threshold.

A dash (-) denotes values that are not reported due data gaps exceeding a threshold of 14 consecutive or 28 cumulative days during spawning or incubation periods, or less than 50% of the year for rearing.

Incubation spans two calendar years; the results are reported in the calendar year when the period started (i.e. August 2018 to March 2019 is reported in 2018).

Table 20. Boulder Creek summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout BC WQG thresholds (MOE 2019).

Project Phase	Site	Year	n (days)[1]	Rearing (Year Round)	Spawning (Aug.1 - Dec. 8)	Incubation (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
Baseline	BDR-USWQ	2010	235	0	0	44	0
		2011	364	0	0	127	0
		2012	365	0	0	120	0
		2013	118	-	0	-	-
	BDR-DVWQ	2008	45	-	-	-	-
		2009	365	0	7	124	11
		2010	351	0	12	92	16
		2011	354	0	2	125	2
		2012	366	0	12	112	16
		2013	156	-	-	-	-
Operation	BDR-DVWQ	2018	290	0	23	48	30
		2019	296	0	27	-	-
	BDR-TAILWQ	2018	255	0	8	-	13
		2019	235	0	10	26	14
	BDR-DSWQ	2018	290	0	15	52	21
		2019	296	0	20	-	-

[1] n is the number of days that have observations for at least 23 hours.

T_{water} is the total number of days where the minimum or maximum water temperature is outside the BC WQG.

A dash (-) denotes values that are not reported due data gaps exceeding a threshold of 14 consecutive or 28 cumulative days during spawning or incubation periods, or less than 50% of the year for rearing.

Incubation spans two calendar years; the results are reported in the calendar year when the period started (i.e. August 2018 to March 2019 is reported in 2018).

4.1.7. Mean Weekly Maximum Temperature (MWMxT)

MWMxT is an important indicator of prolonged periods of warm water temperatures that fish are exposed to. The guideline for the protection of aquatic life (Oliver and Fidler 2001) states "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary + or – 1 degrees C beyond the optimum temperature range of each life history phase (migration, incubation, rearing, and spawning) for the most sensitive salmonid species present"(MOE 2019).

A comparison of MWMxT temperature data to optimum temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout was completed for each species based on their distribution (Table 5) in the upstream (Table 21, Table 22), diversion (Table 23) and downstream (Table 24) reaches of the Upper Lillooet River and the diversion (Table 25) and downstream (Table 26) reaches of Boulder Creek. The upstream reach of Boulder Creek is non fish bearing.

Each of the MWMxT tables provides the percent complete of the data record for each life stage along with the minimum and maximum MWMxT range in each period. The percentage of data within each optimum temperature range is provided to evaluate the overall suitability of the temperate range for each fish species life stage. Exceedance of the BC WQG range (greater than ±1°C outside the optimum ranges) are highlighted in each summary table where blue indicates MWMxTs are cooler than the lower guidelines and red indicates temperatures are higher than the upper guidelines. MWMxT results were not calculated for the tailrace sites assuming that fish can not access or do not utilize that tailrace. Data from the Upper Lillooet River upstream site (ULL-USWQ03) were not included due to groundwater influence at this site (see Section 4.1.1).

The year-round range in MWMxT temperature corresponds to the rearing life stage for all the fish species. During baseline monitoring, MWMxT ranged from 0.1°C to 10.8°C in Upper Lillooet River and from 0.0°C to 11.0°C in Boulder Creek. During operational monitoring to date (2018-2019) MWMxT ranged from 0.0°C to 10.7°C in Upper Lillooet River and from 0.1°C to 12.1°C in Boulder Creek.

MWMxT values in relation to species-specific optimal temperature ranges differed by species and location. In general, with the exception of Bull Trout, MWMxTs are within or below (cooler than) the optimal temperature ranges. Bull Trout prefer cooler temperatures overall in comparison to Cutthroat Trout and Coho Salmon, therefore fewer exceedances of the cooler temperature limits are observed for this species. Exceedances of the upper limit of the optimum temperatures for Bull Trout spawning and incubation were observed during baseline and operational monitoring in Upper Lillooet River and Boulder Creek (see red shading in Table 23, Table 24, Table 25, and Table 26).

Table 21. Upper Lillooet River Upstream (ULL-USWQ1) baseline MWMxTs measured during Cutthroat Trout life history stages.

Species	Life Stage Data: Periodicity	Life Stage Data: Optimum Temperature Range (°C)	Life Stage Data: Duration (days)	Year	% Complete[1]	MWMxT: Min. (°C)	MWMxT: Max. (°C)	% of MWMxT: Below Lower Bound by >1°C	% of MWMxT: Within Optimum Range	% of MWMxT: Above Upper Bound by >1°C
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2008	0.0	-	-	-	-	-
				2009	100.0	5.2	10.5	60.9	20.7	0.0
				2010	100.0	4.4	8.1	96.7	0.0	0.0
				2011	100.0	3.8	7.0	100.0	0.0	0.0
				2012	100.0	3.1	7.6	100.0	0.0	0.0
				2013	66.3	4.4	7.8	100.0	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2008	0.0	-	-	-	-	-
				2009	100.0	6.5	10.8	24.2	46.0	0.0
				2010	100.0	5.7	9.9	50.8	25.0	0.0
				2011	100.0	3.8	10.1	65.3	17.7	0.0
				2012	99	5.1	10.0	55.3	22.8	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	366	2008	10.7	-	-	-	-	-
				2009	100.0	0.1	10.8	52.3	40.3	0.0
				2010	100.0	0.3	9.9	57.0	30.4	0.0
				2011	100.0	0.4	10.1	61.4	24.1	0.0
				2012	99.5	0.1	10.0	58.2	26.9	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 22. Upper Lillooet River Upstream (ULL-USWQ02) operational (2018-2019) MWMxTs measured during Cutthroat Trout life history stages.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2018	100.0	4.6	9.9	81.5	6.5	0.0
				2019	100.0	4.0	9.8	57.6	12.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	100	5.4	9.9	46.8	19.4	0.0
				2019	100.0	6.5	9.8	32.3	8.9	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	75.6	0.0	9.9	37.0	47.5	0.0
				2019	77.0	0.0	9.8	41.6	45.2	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 23. Upper Lillooet River Diversion Reach (ULL-DVWQ/ULL-DVWQ1) MWMxTs measured during Coho Salmon, Cutthroat Trout, and Bull Trout life history stages during baseline and operational monitoring.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2012	100.00	0.9	9.5	65.6	23.0	0.0
				2018	48	-	-	-	-	-
				2019	39.3	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2012	100.00	0.8	5.5	69.6	19.0	0.0
				2018	75	0.7	5.5	83.1	6.8	0.0
				2019	5.1	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2012	100.00	0.5	5.9	66.3	18.9	0.0
				2018	88.2	0.4	5.5	77.9	14.1	0.0
				2019	2.4	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2012	99.18	0.4	10.1	74.4	12.7	0.0
				2018	15.9	-	-	-	-	-
				2019	79.7	0.4	10.7	60.8	29.6	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.
2012 data were collected at ULL-DVWQ; 2018 and 2019 data were collected at ULL-DVWQ1.

Table 23 Continued.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2012	100.0	3.6	8.5	90.2	0.0	0.0
				2018	0.0	-	-	-	-	-
				2019	100.0	4.7	10.7	52.2	31.5	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2012	100.0	5.6	10.1	43.5	31.5	0.0
				2018	0	-	-	-	-	-
				2019	100.0	7.3	10.7	14.5	67.7	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2012	99.2	0.4	10.1	54.5	36.1	0.0
				2018	15.9	-	-	-	-	-
				2019	79.7	0.4	10.7	40.5	51.5	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2012	100.0	1.6	10.1	25.4	41.5	0.8
				2018	27	-	-	-	-	-
				2019	60.8	5.5	9.9	0.0	65.8	0.0
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2012	100.0	0.5	10.1	5.6	35.7	28.6
				2018	55.4	0.4	5.5	11.0	35.6	0.0
				2019	36.9	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2012	99.2	0.4	10.1	46.3	45.5	0.0
				2018	15.9	-	-	-	-	-
				2019	79.7	0.4	10.7	32.6	59.5	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.
2012 data were collected at ULL-DVWQ; 2018 and 2019 data were collected at ULL-DVWQ1.

Table 24. Operational (2018-19) MWMxTs measured during Cutthroat Trout, Bull Trout and Coho Salmon life history stages in the Upper Lillooet River Downstream Reach (ULL-DSWQ).

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2018	100	1.6	8.5	62.3	18.9	0.0
				2019	0.0	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2018	100	1.6	6.7	67.1	29.1	0.0
				2019	0.0	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2018	100.0	1.1	6.7	66.9	24.3	0.0
				2019	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2018	75.6	1.6	10.7	67.4	19.6	0.0
				2019	27.4	-	-	-	-	-
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2018	100.0	4.8	10.4	75.0	8.7	0.0
				2019	10.9	-	-	-	-	-
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	100	6.0	10.7	31.5	43.5	0.0
				2019	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	75.6	1.6	10.7	34.4	51.8	0.0
				2019	27.4	-	-	-	-	-

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 24. Continued.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2018	100	1.6	10.0	23.8	58.5	0.8
				2019	0.0	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2018	100.0	1.1	10.0	0.0	41.3	26.8
				2019	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2018	75.6	1.6	10.7	22.8	65.6	0.0
				2019	27.4	-	-	-	-	-

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 25. Baseline and Operational (2018-19) MWMxTs measured during Cutthroat Trout and Bull Trout life history stages in the Boulder Creek Diversion Reach (BDR-DVWQ).

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2008	0.0	-	-	-	-	-
				2009	100	2.5	10.3	76.1	4.3	0.0
				2010	97.8	3.2	7.8	100.0	0.0	0.0
				2011	92.4	2.8	5.7	100.0	0.0	0.0
				2012	100	2.6	6.1	100.0	0.0	0.0
				2013	68.5	3.4	7.8	100.0	0.0	0.0
				2018	100	3.2	10.6	79.3	12.0	0.0
				2019	100	4.2	10.8	60.9	23.9	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2008	0.0	-	-	-	-	-
				2009	100	4.5	11.0	32.3	45.2	0.0
				2010	99	5.1	10.8	50.4	42.3	0.0
				2011	93	3.6	9.4	72.2	7.8	0.0
				2012	100	4.0	10.5	57.3	22.6	0.0
				2013	27	-	-	-	-	-
				2018	100	6.3	12.1	34.7	57.3	0.0
				2019	100	6.4	11.9	21.0	67.7	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	366	2008	11.7	-	-	-	-	-
				2009	100	0.1	11.0	63.8	33.2	0.0
				2010	96.7	0.02	10.8	64.0	26.9	0.0
				2011	97.5	0.1	9.9	72.8	18.0	0.0
				2012	100	0.02	10.5	69.9	25.4	0.0
				2013	41.9	-	-	-	-	-
				2018	78.9	0.3	12.1	42.7	48.6	0.0
				2019	80.5	0.1	11.9	46.6	46.6	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 25. Continued.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2008	15	-	-	-	-	-
				2009	100	0.2	10.4	38.5	36.2	4.6
				2010	92	0.02	10.8	26.7	34.2	8.3
				2011	100	0.2	9.9	35.4	43.8	0.0
				2012	100	1.3	10.5	31.5	35.4	6.2
				2013	0.0	-	-	-	-	-
				2018	100	0.3	12.0	23.8	43.1	19.2
				2019	63.1	4.8	11.9	0.0	41.5	46.3
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	214	2008	48.4	-	-	-	-	-
				2009	100	0.1	10.4	11.7	36.2	27.2
				2010	95.3	0.02	10.8	20.7	20.2	27.1
				2011	100	0.02	9.9	18.2	12.6	24.8
				2012	100	0.1	10.5	18.8	16.9	31.0
				2013	0.0	-	-	-	-	-
				2018	100	0.1	12.0	17.8	24.9	28.2
				2019	38.3	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	366	2008	11.7	-	-	-	-	-
				2009	100	0.1	11.0	56.4	36.2	0.0
				2010	96.7	0.02	10.8	53.0	36.0	0.0
				2011	97.5	0.1	9.9	66.9	27.2	0.0
				2012	100	0.02	10.5	61.2	30.1	0.0
				2013	41.9	-	-	-	-	-
				2018	78.9	0.3	12.1	31.9	57.3	0.0
				2019	80.5	0.1	11.9	39.8	53.4	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 26. Operational (2018-19) MWMxTs measured during Cutthroat Trout and Bull Trout life history stages in the Boulder Creek Downstream Reach (BDR-DSWQ).

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2018	100	3.6	10.2	83.7	8.7	0.0
				2019	100	3.6	10.3	70.7	17.4	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	100	5.2	11.6	37.9	50.0	0.0
				2019	100	4.7	11.5	28.2	62.9	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	78.9	0.4	11.6	49.7	40.3	0.0
				2019	80.3	0.1	11.5	53.2	42.7	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2018	100	0.4	11.6	24.6	45.4	16.2
				2019	62.3	4.3	11.5	0.0	39.5	33.3
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	214	2018	100	0.1	11.6	14.1	27.2	28.2
				2019	37.9	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2018	78.9	0.4	11.6	34.7	50.3	0.0
				2019	80.3	0.1	11.5	45.1	46.8	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

4.1.8. Frazil Ice

Air temperature recorded at Callaghan Valley and Pemberton Airport weather stations was monitored from October 2019 to February 2020. The lowest monthly average and instantaneous air temperatures in Year 2 at Callaghan Valley and Pemberton airport weather stations were recorded in January 2019 (averages of -3.0°C and -2.6°C with instantaneous minimums of -17.8°C and -15.1°C respectively).

Analysis of air temperature data from Pemberton Airport weather station confirmed there was a single occurrence of six consecutive days of temperatures averaging <-5°C in January 2020 (Table 27, Figure 9). Two occurrences of three and seven consecutive days of temperatures averaging <-5°C in November 2019 and January 2020 respectively were observed at the Callaghan Valley Station (Table 27, Figure 10). The November event lasted three days and temperatures increased on the fourth day precluding the need for Innergex operators to provide photographs. The Upper Lillooet HEF was operating at low capacity during the November event (2.5 – 3.5 m^3/s, with downstream flows measured between 11 -11.5 m^3/s). The Boulder Creek HEF was offline during the November event for maintenance purposes.

Boulder Creek HEF was operating throughout the January event at very low capacity (0.28 m^3/s compared to the downstream flow measured at 1.54 m^3/s Jan 17th). Upper Lillooet HEF was shut down for most of the January event but came online near the end and was operating at 4.9 m^3/s compared to the downstream flow measured at 13.66 m^3/s (January 18th). As per the frazil ice monitoring protocol, site photographs were collected by operations staff for Upper Lillooet and Boulder Creek. Representative photos of the ice conditions on Boulder Creek on January 17 are shown below in Figure 11 to Figure 13. Representative photos of the ice conditions on Upper Lillooet on January 18th are shown below in Figure 14 to Figure 16. Photographs were reviewed and it was determined that conditions did not warrant a site visit as frazil ice was not detected.

Table 27. Summary of dates when air temperature was less than -5°C for at least three consecutive days during Year 2 (October 2019 to February 2020).

Weather Station Air Temperature	Year	Start Date	End Date	Length (days)
Callaghan Valley	2019	28-Nov	30-Nov	3
	2020	12-Jan	18-Jan	7
Pemberton Airport	2020	13-Jan	18-Jan	6

Figure 9. Average daily air temperature data from October 2019 to February 2020 at Callaghan Valley air temperature monitoring station

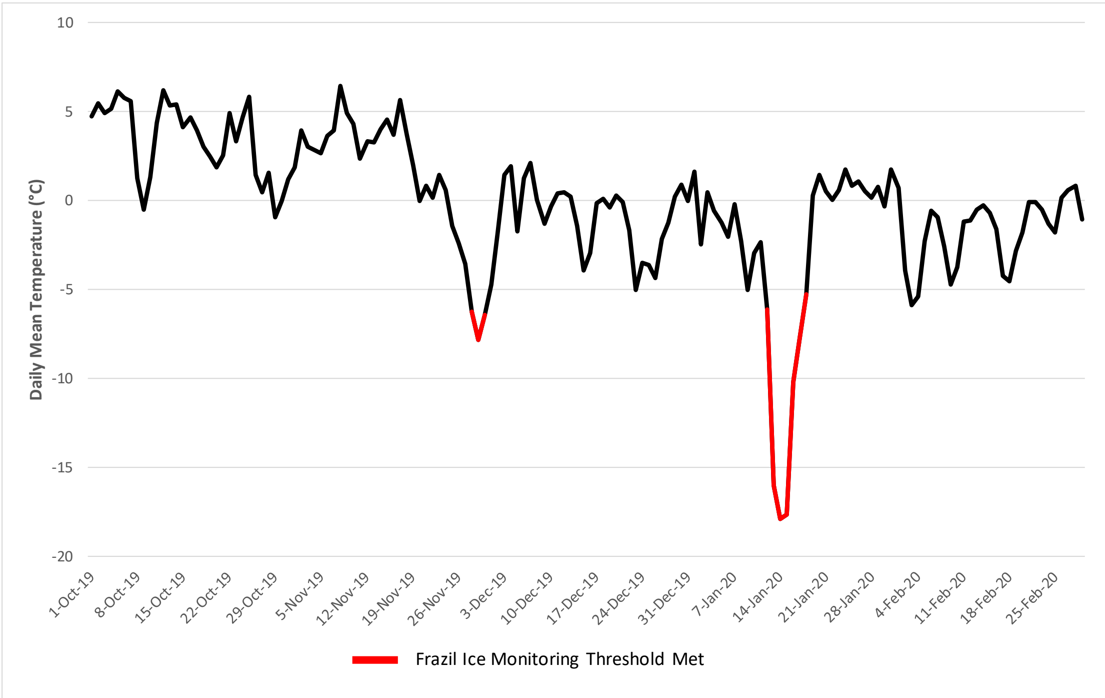


Figure 10. Average daily air temperature data from October 2019 to February 2020 at Pemberton Airport air temperature monitoring station

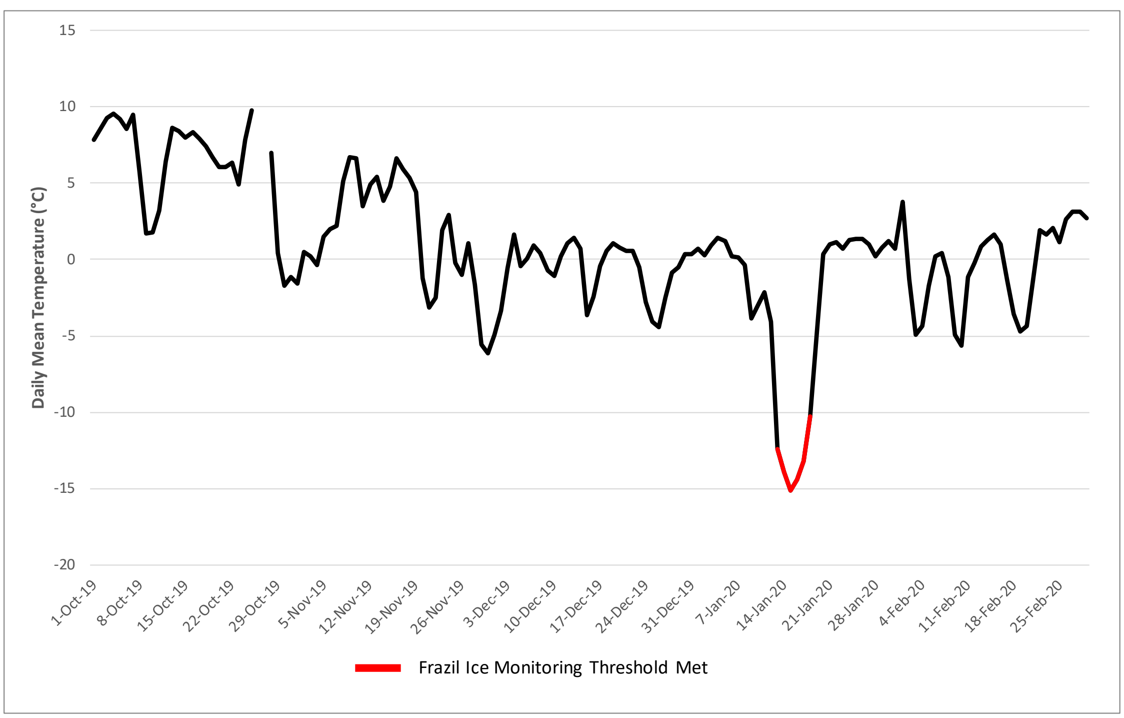


Figure 11. Looking at Boulder Creek tailrace on January 17, 2020.

Figure 12. Looking downstream at Boulder Creek diversion on January 17, 2020.

Figure 13. Looking river right to river left at Boulder Creek diversion on January 17, 2020.

Figure 14. Looking at Upper Lillooet tailrace on January 18, 2020.

Figure 15. Looking upstream at Upper Lillooet diversion reach from the tailrace on January 18, 2020.

Figure 16. Looking downstream at Upper Lillooet from the tailrace on January 18, 2020.

4.2. Fish Community

4.2.1. Juvenile Fish Density and Biomass

4.2.1.1. Upper Lillooet River

Closed-Site Electrofishing

Closed-site electrofishing was conducted from April 10 to 13, 2019. Habitat summaries, usability, and representative photographs of closed-site electrofishing sites are provided in Appendix H. Sites were similar in the diversion and upstream reaches; they were primarily composed of riffles, with some runs and glides, with average gradients ranging from 0.5% to 3.0%. Substrates varied considerably among sites, but were typically dominated by cobble, with either boulders or gravel and fines also comprising a large proportion of substrates in some sites. Cover primarily consisted of boulder and cobble.

Sites ranged from 13 m to 21 m in length and 89 m² to 159 m² in area in the diversion reach and from 12 m to 22 m in length and 56 m² to 104 m² in area in the upstream reach (Table 28). Sampling conditions were also similar among sites in the diversion reach and upstream reach at the time of sampling. Average daily flow was 4.2 m^3/s in the diversion reach. Flows upstream of the intake averaged 11.6 m^3/s. Conductivity ranged from 120 µS/cm to 170 µS/cm in the diversion and from 130 µS/cm to 180 µS/cm at upstream sites, and water temperature ranged from 4.3°C to 4.7°C and 2.0°C and 4.4°C in the diversion and upstream sites, respectively. Water turbidity was low within the diversion and the upstream sites, and alkalinity (as $CaCO_3$) measured in the diversion reach was 34 mg/L and 36 mg/L at all sites and between 23 mg/L and 50 mg/L in the upstream sites (Table 28).

Two to three electrofishing passes were conducted at all sites with total effort ranging from 1,797 seconds to 2,536 seconds in the diversion reach, and from 1,724 seconds to 1,846 seconds in the upstream reach (Table 28). In total, six Cutthroat Trout, 13 Bull Trout, and four Mountain Whitefish were captured during electrofishing in the diversion reach and eight Cutthroat Trout were captured in the upstream reach.

Table 28. Summary of closed-site electrofishing site characteristics, conditions, effort, and fish captures in the Upper Lillooet River in 2019.

Reach	Site	Sampling Date	Daily Average Flow (m^3/s)[1]	Conductivity (µS/cm)	Water Temp. (°C)	Turbidity	Alkalinity (mg/L)	Sampled Site Length (m)	Sampled Site Area (m^2)	Total Electrofishing Effort (sec) Pass 1	Pass 2	Pass 3	Total	Electrofishing Catch (# of fish): Cutthroat Trout Pass 1	Pass 2	Pass 3	Total	Bull Trout Pass 1	Pass 2	Pass 3	Total	Mountain Whitefish Pass 1	Pass 2	Pass 3	Total
Diversion	ULL-DVEF02b	13-Apr-19	2.36	170	4.5	Low	36	19	159	1,016	802	-	1,818	2	1	-	3	3	0	-	3	1	0	-	1
	ULL-DVEF04	13-Apr-19	2.36	120	4.7	Low	36	17	89	1,015	923	-	1,938	1	0	-	1	2	0	-	2	0	0	-	0
	ULL-DVEF06	13-Apr-19	2.36	170	4.5	Low	36	17	127	977	803	500	2,280	0	0	0	0	2	2	0	4	3	0	0	3
	ULL-DVEF07b	13-Apr-19	2.36	170	4.3	Low	34	21	91	1,004	868	664	2,536	0	1	0	1	4	0	0	4	0	0	0	0
	ULL-DVEF09	13-Apr-19	2.36	130	4.3	Low	36	13	128	989	808	-	1,797	1	0	-	1	0	0	-	0	0	0	-	0
							Diversion Total	**87**	**594**				**10,369**				**6**				13				4
							Diversion Average	**17**	**119**				**2,074**				**1**				3				1
Upstream	ULL-USEF01	10-Apr-19	-	130	3.3	Low	40	15	69	1,003	765	-	1,768	0	0	-	0	0	0	-	0	0	0	-	0
	ULL-USEF02b	10-Apr-19	-	180	4.4	Low	40	12	104	988	736	-	1,724	0	0	-	0	0	0	-	0	0	0	-	0
	ULL-USEF03	10-Apr-19	-	140	4.3	Low	40	17	103	981	782	-	1,763	1	0	-	1	0	0	-	0	0	0	-	0
	ULL-USEF06b	10-Apr-19	-	150	2.0	Low	23	20	74	990	772	-	1,762	2	0	-	2	0	0	-	0	0	0	-	0
	ULL-USEF08	10-Apr-19	-	180	3.0	Low	40	20	89	998	776	-	1,774	2	0	-	2	0	0	-	0	0	0	-	0
	ULL-USEF10	11-Apr-19	-	140	2.5	Low	50	18	68	1,034	812	-	1,846	0	0	-	0	0	0	-	0	0	0	-	0
	ULL-USEF11b	11-Apr-19	-	140	2.5	Low	40	14	72	1,003	791	-	1,794	0	0	-	0	0	0	-	0	0	0	-	0
	ULL-USEF13	11-Apr-19	-	150	2.2	Low	45	22	71	994	832	-	1,826	0	0	-	0	0	0	-	0	0	0	-	0
	ULL-USEF15	11-Apr-19	-	150	2.0	Low	28	18	104	995	774	-	1,769	3	0	-	3	0	0	-	0	0	0	-	0
	ULL-USEF16	11-Apr-19	-	180	2.0	Low	32	16	56	995	740	-	1,735	0	0	-	0	0	0	-	0	0	0	-	0
							Upstream Total	**171**	**809**				**17,761**				**8**				**0**				**0**
							Upstream Average	**17**	**81**				**1,776**				**1**				**0**				**0**
							Combined Total	**258**	**1,403**				**28,130**				**14**				**13**				**4**
							Combined Average	**17**	**94**				**1,875**				**1**				**1**				**0**

[1] Upstream flows are not available due to a data gap on survey dates.

Age Analysis

Length-frequency distributions, length-weight relationships, and length at age relationships of Bull Trout and Cutthroat Trout captured during 2019 in closed-site electrofishing surveys in the Upper Lillooet River diversion and upstream reaches, as well as data on individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix I. No Bull Trout fin ray samples were aged in 2019, but a total of five and six scale samples were aged from Cutthroat Trout captured in the diversion and upstream reaches, respectively. An additional four Mountain Whitefish scale samples were aged from the diversion reach. Based on a review of aging data and length-frequency distributions, discrete fork length ranges were defined for fry, juvenile, and adult age classes of both Bull Trout (Table 29) and Cutthroat Trout (Table 30). Juvenile Bull Trout included 1+ to 3+ fish, with ≥4+ fish considered adults, whereas for Cutthroat Trout which mature at an earlier age in the Upper Lillooet River, 1+ and 2+ fish were considered juveniles, and ≥3+ fish considered adults.

Table 29. Fork length range used to define age classes of Bull Trout captured in the Upper Lillooet River diversion reach in 2019. Bull Trout are not present in the upstream reach.

Age Class	Fork Length Range (mm)
Fry (0+)	80 - 91
Juvenile (1-3+)	104 - 147
Adult (≥4+)	≥ 201

Table 30. Fork length ranges used to define age classes of Cutthroat Trout in the Upper Lillooet River in 2019.

Age Class	Fork Length Range (mm)
Fry (0+)	43 - 63
Juvenile (1-2+)	103 - 200
Adult (≥3+)	≥ 212

Fish Metrics and Condition

Fork length, weight, and condition factor for all captured Bull Trout and Cutthroat Trout are summarized by age class and reach in Table 31 and Table 32, respectively. Weights were assigned to all fish not weighed in the field from the established length-weight relationships (Appendix I). Average condition factor was similar for all age classes of Bull Trout in the diversion reach. Comparison of average condition factor for Cutthroat Trout for all age classes combined suggests that fish in the diversion reach were in slightly better condition (1.02) than in the upstream reach (0.96), although there is uncertainty due to the small sample sizes.

Table 31. Summary of fork length, weight, and condition for Bull Trout captured during closed-site electrofishing in the Upper Lillooet River diversion reach in 2019. Bull Trout are not present in the upstream reach.

Age Class	Fork Length (mm)				Weight (g)				Relative Condition Factor			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	8	86	80	91	8	7.6	5.6	9.9	8	1.01	0.82	1.14
Juvenile (1-3+)	2	126	104	147	2	24.6	13.6	35.5	2	1.02	0.99	1.05
Adult (≥4+)	3	211	201	219	3	111.4	96.8	120.8	3	1.06	1.03	1.08
All	**13**	**121**	**80**	**219**	**13**	**34.1**	**5.6**	**120.8**	**13**	**1.02**	**0.82**	**1.14**

Table 32. Summary of fork length, weight, and condition for Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2019.

Reach	Age Class	Fork Length (mm)				Weight (g)				Relative Condition Factor			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	3	54	47	63	3	2.0	1.3	3.0	3	1.02	0.97	1.06
	Juvenile (1-2+)	3	134	103	186	3	33.9	14.5	71.3	3	1.02	0.93	1.16
	Adult (≥3+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	All	**6**	**94**	**47**	**186**	**6**	**17.9**	**1.3**	**71.3**	**6**	**1.02**	**0.93**	**1.16**
Upstream	Fry (0+)	2	44	43	45	2	1.0	0.8	1.1	2	0.94	0.85	1.02
	Juvenile (1-2+)	5	156	103	200	5	44.4	13.4	71.1	5	0.98	0.79	1.07
	Adult (≥3+)	1	212	212	212	1	98.4	98.4	98.4	1	0.92	0.92	0.92
	All	**8**	**135**	**43**	**212**	**8**	**40.3**	**0.8**	**98.4**	**8**	**0.96**	**0.79**	**1.07**

Density and Biomass Estimates

Bull Trout

During closed-site electrofishing in the Upper Lillooet River in 2019, Bull Trout fry, juveniles, and adults were captured within the diversion reach (Table 33, Table 34, and Figure 17). Bull Trout are not present in the upstream reach on the Upper Lillooet River.

Observed fish densities (FPUobs; #/100 m²) and biomass (BPUobs; g/100 m²) are the focus of the results below, with habitat adjusted values (FPUadj and BPUadj) provided in tables for reference (Table 33). Densities of Bull Trout fry were highest in 2019 among all age classes, while those of juveniles were lowest. Biomass was higher for adults than other age classes in 2019, which was also reported in 2018.

Table 33. **Observed and habitat suitability adjusted density and biomass by age class of Bull Trout determined from closed-site electrofishing in the Upper Lillooet River diversion reach in 2019. Bull Trout are not present in the upstream reach.**

A) Fry (0+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-DVEF02b	28.2%	1.9	15.1	6.7	53.6
ULL-DVEF04	36.4%	0.0	0.0	0.0	0.0
ULL-DVEF06	39.8%	1.6	10.6	4.0	26.6
ULL-DVEF07b	20.0%	3.3	25.2	16.5	126.4
ULL-DVEF09	35.3%	0.0	0.0	0.0	0.0

B) Juvenile (1-3+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-DVEF02b	28.2%	0.0	0.0	0.0	0.0
ULL-DVEF04	36.4%	0.0	0.0	0.0	0.0
ULL-DVEF06	39.8%	0.8	10.8	2.0	27.0
ULL-DVEF07b	20.0%	1.1	38.9	5.5	195.1
ULL-DVEF09	35.3%	0.0	0.0	0.0	0.0

C) Adult (≥4+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-DVEF02b	25.6%	0.0	0.0	0.0	0.0
ULL-DVEF04	41.8%	2.3	240.5	5.4	574.8
ULL-DVEF06	47.6%	0.8	95.5	1.7	200.5
ULL-DVEF07b	48.2%	0.0	0.0	0.0	0.0
ULL-DVEF09	27.6%	0.0	0.0	0.0	0.0

D) All

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-DVEF02b	25.6%	1.9	15.1	6.7	53.6
ULL-DVEF04	41.8%	2.3	240.5	5.4	574.8
ULL-DVEF06	47.6%	3.2	116.8	5.6	227.2
ULL-DVEF07b	48.2%	4.4	64.2	16.5	126.4
ULL-DVEF09	27.6%	0.0	0.0	0.0	0.0

[1] FPU_{obs} = Observed fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R. [3] FPUadj=FPUobs/Usability

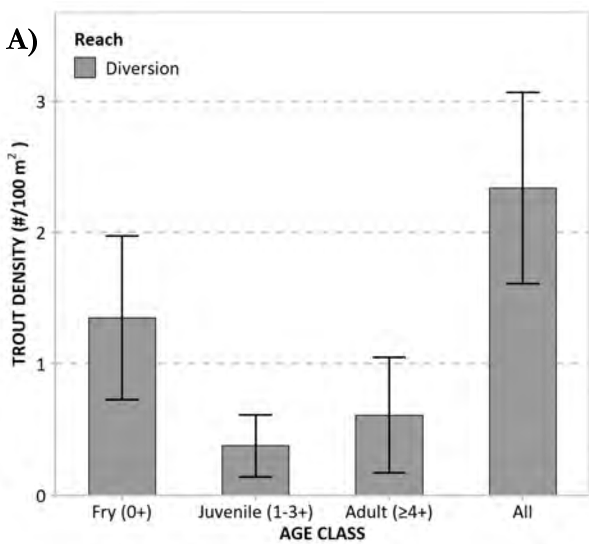
[2] BPU_{obs} = Biomass of fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R. [4] BPUadj=BPUobs/Usability

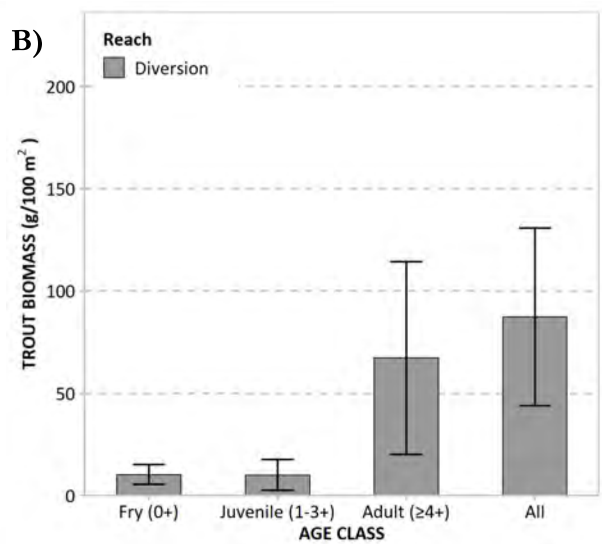
Table 34. **Observed and habitat-suitability-adjusted average Bull Trout densities and biomass by age class, as determined from closed-site electrofishing in the Upper Lillooet River diversion reach in 2019. Bull Trout are not present in the upstream reach.**

Age Class	FPUobs (#/100 m²)[1]		BPUobs (g/100 m²)[1]		FPUadj (#/100 m²)[1]		BPUadj (g/100 m²)[1]	
	Average	SE	Average	SE	Average	SE	Average	SE
Fry (0+)	1.4	0.6	10.2	4.8	5.4	3.0	41.3	23.5
Juvenile (1-3+)	0.4	0.2	9.9	7.5	1.5	1.1	44.4	38.0
Adult (≥4+)	0.6	0.4	67.2	47.1	1.4	1.0	155.1	111.9
All	2.3	0.7	87.3	43.4	6.8	2.7	196.4	102.0

[1] SE = Standard Error

Figure 17. **Average observed densities (± standard error) by age class of Bull Trout determined from closed-site electrofishing in the Upper Lillooet River diversion reach in 2019 presented as: A) fish density per 100 m² (FPUobs), and B) fish biomass per 100 m² (BPUobs). Bull Trout are not present in the upstream reach.**





Cutthroat Trout

In Year 2, Cutthroat Trout fry and juveniles were captured in both diversion and upstream reaches, while adults were only captured in the upstream reach.

Among the three age classes present within the upstream reach, observed densities were lowest for adults and highest for 1–2+ juveniles (Table 35, Table 36, Figure 18) In the diversion reach, densities were higher for fry than 1–2+ juveniles. For biomass, values were highest for 1–2+ juveniles in both reaches. In general, observed densities of all Cutthroat Trout age classes combined in 2019 were slightly higher in the diversion reach than in the upstream reach, whereas the observed biomass was higher in the upstream reach.

Table 35. Observed and habitat suitability adjusted density and biomass by age class of Cutthroat Trout per sampling site determined from closed-site electrofishing in the Upper Lillooet River in 2019.

A) Fry (0+)

Reach	Site	Usability (%)	Observed Densities[1,2] FPU_{obs} (#/100 m^2)	Observed Densities[1,2] BPU_{obs} (g/100 m^2)	Adjusted Densities[3,4] FPU_{adj} (#/100 m^2)	Adjusted Densities[3,4] BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	29.1%	0.6	1.0	2.2	3.5
	ULL-DVEF04	57.3%	1.1	1.5	2.0	2.6
	ULL-DVEF06	53.8%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	22.1%	1.1	3.3	5.0	14.9
	ULL-DVEF09	31.6%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	39.0%	0.0	0.0	0.0	0.0
	ULL-USEF02b	9.3%	0.0	0.0	0.0	0.0
	ULL-USEF03	18.8%	0.0	0.0	0.0	0.0
	ULL-USEF06b	43.1%	0.0	0.0	0.0	0.0
	ULL-USEF08	27.3%	2.3	2.1	8.3	7.9
	ULL-USEF10	50.6%	0.0	0.0	0.0	0.0
	ULL-USEF11b	25.2%	0.0	0.0	0.0	0.0
	ULL-USEF13	13.9%	0.0	0.0	0.0	0.0
	ULL-USEF15	27.5%	0.0	0.0	0.0	0.0
	ULL-USEF16	10.1%	0.0	0.0	0.0	0.0

B) Juvenile (1-2+)

Reach	Site	Usability (%)	Observed Densities[1,2] FPU_{obs} (#/100 m^2)	Observed Densities[1,2] BPU_{obs} (g/100 m^2)	Adjusted Densities[3,4] FPU_{adj} (#/100 m^2)	Adjusted Densities[3,4] BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	29.1%	1.3	53.9	4.3	185.2
	ULL-DVEF04	57.3%	0.0	0.0	0.0	0.0
	ULL-DVEF06	53.8%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	22.1%	0.0	0.0	0.0	0.0
	ULL-DVEF09	31.6%	0.8	12.3	2.5	39.1
Upstream	ULL-USEF01	39.0%	0.0	0.0	0.0	0.0
	ULL-USEF02b	9.3%	0.0	0.0	0.0	0.0
	ULL-USEF03	18.8%	1.0	53.0	5.2	282.4
	ULL-USEF06b	43.1%	2.7	73.0	6.3	169.4
	ULL-USEF08	27.3%	0.0	0.0	0.0	0.0
	ULL-USEF10	50.6%	0.0	0.0	0.0	0.0
	ULL-USEF11b	25.2%	0.0	0.0	0.0	0.0
	ULL-USEF13	13.9%	0.0	0.0	0.0	0.0
	ULL-USEF15	27.5%	1.9	109.6	7.0	399.2
	ULL-USEF16	10.1%	0.0	0.0	0.0	0.0

C) Adult (≥3+)

Reach	Site	Usability (%)	Observed Densities[1,2] FPU_{obs} (#/100 m^2)	Observed Densities[1,2] BPU_{obs} (g/100 m^2)	Adjusted Densities[3,4] FPU_{adj} (#/100 m^2)	Adjusted Densities[3,4] BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	44.4%	0.0	0.0	0.0	0.0
	ULL-DVEF04	40.1%	0.0	0.0	0.0	0.0
	ULL-DVEF06	43.4%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	64.5%	0.0	0.0	0.0	0.0
	ULL-DVEF09	49.3%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	38.7%	0.0	0.0	0.0	0.0
	ULL-USEF02b	63.1%	0.0	0.0	0.0	0.0
	ULL-USEF03	90.1%	0.0	0.0	0.0	0.0
	ULL-USEF06b	29.2%	0.0	0.0	0.0	0.0
	ULL-USEF08	73.6%	0.0	0.0	0.0	0.0
	ULL-USEF10	35.1%	0.0	0.0	0.0	0.0
	ULL-USEF11b	82.5%	0.0	0.0	0.0	0.0
	ULL-USEF13	78.0%	0.0	0.0	0.0	0.0
	ULL-USEF15	29.6%	1.0	94.9	3.3	320.1
	ULL-USEF16	74.2%	0.0	0.0	0.0	0.0

D) All

Reach	Site	Usability (%)	Observed Densities[1,2] FPU_{obs} (#/100 m^2)	Observed Densities[1,2] BPU_{obs} (g/100 m^2)	Adjusted Densities[3,4] FPU_{adj} (#/100 m^2)	Adjusted Densities[3,4] BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	44.4%	1.9	54.9	6.5	188.7
	ULL-DVEF04	40.1%	1.1	1.5	2.0	2.6
	ULL-DVEF06	43.4%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	64.5%	1.1	3.3	5.0	14.9
	ULL-DVEF09	49.3%	0.8	12.3	2.5	39.1
Upstream	ULL-USEF01	38.7%	0.0	0.0	0.0	0.0
	ULL-USEF02b	63.1%	0.0	0.0	0.0	0.0
	ULL-USEF03	90.1%	1.0	53.0	5.2	282.4
	ULL-USEF06b	29.2%	2.7	73.0	6.3	169.4
	ULL-USEF08	73.6%	2.3	2.1	8.3	7.9
	ULL-USEF10	35.1%	0.0	0.0	0.0	0.0
	ULL-USEF11b	82.5%	0.0	0.0	0.0	0.0
	ULL-USEF13	78.0%	0.0	0.0	0.0	0.0
	ULL-USEF15	29.6%	2.9	204.5	10.3	719.3
	ULL-USEF16	74.2%	0.0	0.0	0.0	0.0

[1] FPU_{obs} = Observed fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R. [3] FPUadj=FPUobs/Usability

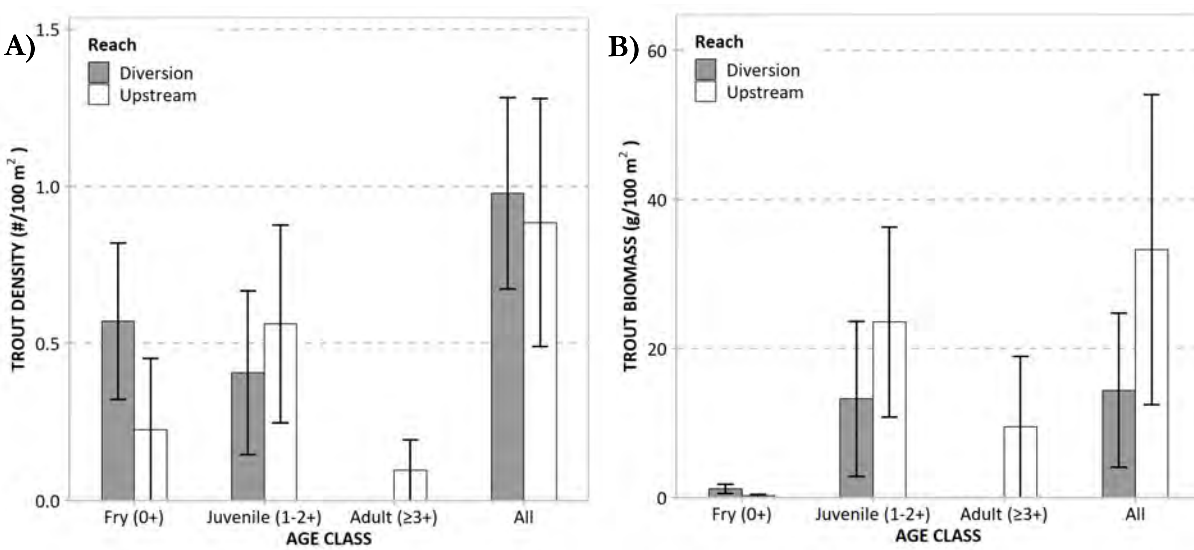
[2] BPU_{obs} = Biomass of fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R. [4] BPUadj=BPUobs/Usability

Table 36. Observed and habitat-suitability-adjusted average Cutthroat Trout densities and biomass by age class determined from closed-site electrofishing in the Upper Lillooet River in 2019.

Reach	Age Class	FPUobs (#/100 m²)[1]		BPUobs (g/100 m²)[1]		FPUadj (#/100 m²)[1]		BPUadj (g/100 m²)[1]	
		Average	SE	Average	SE	Average	SE	Average	SE
Diversion	Fry (0+)	0.6	0.2	1.2	0.6	1.8	0.9	4.2	2.8
	Juvenile (1-2+)	0.4	0.3	13.2	10.4	1.4	0.9	44.9	35.9
	Adult (≥3+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	All	1.0	0.3	14.4	10.3	1.8	0.9	4.2	2.8
Upstream	Fry (0+)	0.2	0.2	0.2	0.2	0.8	0.8	0.8	0.8
	Juvenile (1-2+)	0.6	0.3	23.6	12.7	1.8	1.0	85.1	46.6
	Adult (≥3+)	0.1	0.1	9.5	9.5	0.3	0.3	32.0	32.0
	All	0.9	0.4	33.3	20.8	1.2	0.9	32.8	31.9

[1] SE = Standard Error

Figure 18. Average observed densities (± standard error) by age class of Cutthroat Trout determined from closed-site electrofishing in the Upper Lillooet River in 2019 presented as: A) fish density per 100 m² (FPUobs), and B) fish biomass per 100 m² (BPUobs).



Comparison Among Years

Bull Trout

No trends in Bull Trout density and biomass during baseline and Years 1 and 2 operational monitoring were evident within the diversion reach for any age class (Figure 19, Figure 20) (Bull Trout are not present in the upstream reach on the Upper Lillooet River). Bull Trout fry densities and biomass in 2018 were similar to those in 2010, and those in 2019 were intermediate between 2010 and 2014.

Average juvenile densities and biomass in 2019 were the lowest of the five years sampled. Densities and biomass of Adult Bull Trout (which were only captured in 2012, 2018, and 2019) were highest in 2019; values in 2018 were lower than those in 2012. Overall, the density of all Bull Trout age classes combined was within the range observed in the three baseline years.

Cutthroat Trout

Cutthroat Trout density and biomass observed during Year 1 and Year 2 was within the ranges of values observed during the baseline period (Figure 21, Figure 22). Average fry and juvenile densities and biomass in 2019 were within the ranges measured in previous monitoring years. Although average fry biomass in the upstream reach was lower in 2019 than 2012 or 2014, values have been highly variable with some years capturing no fry (2010, 2018). Average adult density and biomass within the upstream reach has an overall decreasing trend however none were observed during year 3 of baseline sampling (2014) demonstrating the high variability between sampling years.

Figure 19. Average observed Bull Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River, before (2010, 2012, 2014) and after (2018, 2019) Project operations began, presented by age class: A) fry (0+); B) juveniles (1-3+); C) adult (≥4+); and D) all age classes combined.

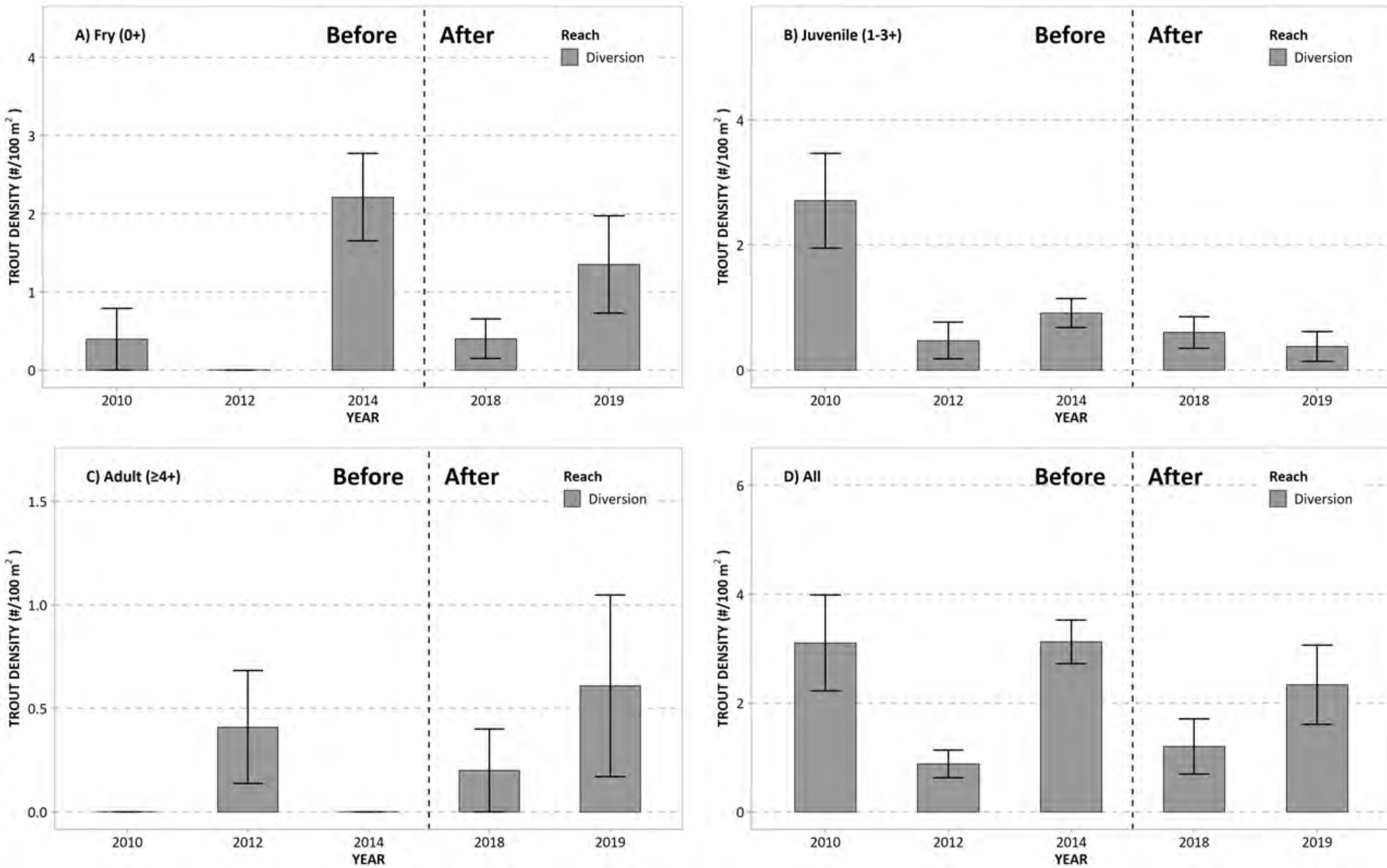


Figure 20. Average observed Bull Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River, before (2010, 2012, 2014) and after (2018, 2019) Project operations began, presented by age class: A) fry (0+); B) juveniles (1-3+); C) adult (≥4+); and D) all age classes combined.

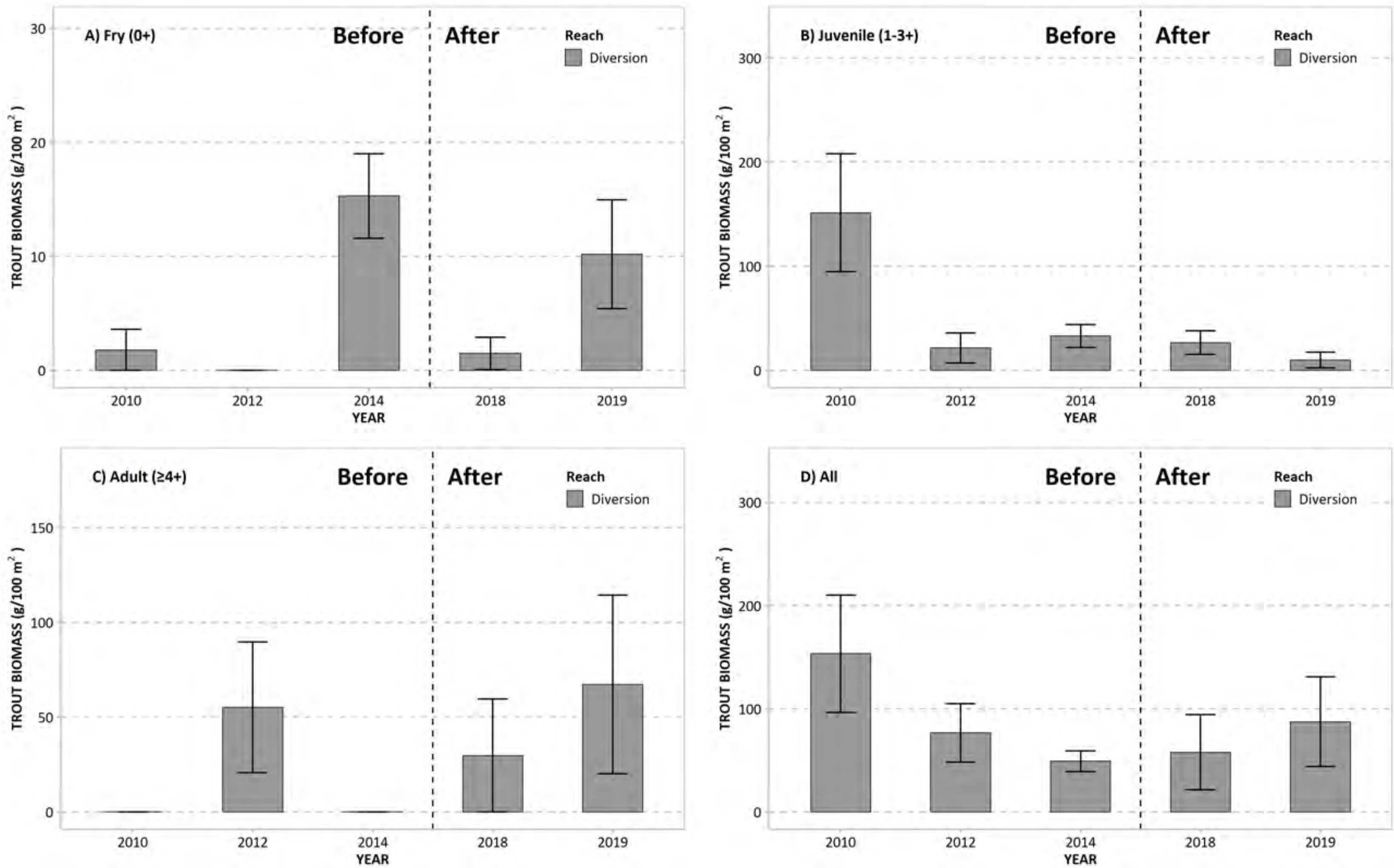


Figure 21. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River, before (2010, 2012, 2014) and after (2018, 2019) Project operations began, presented by age class: A) fry (0+); B) juveniles (1-2+); C) adult (≥3+); and D) all age classes combined.

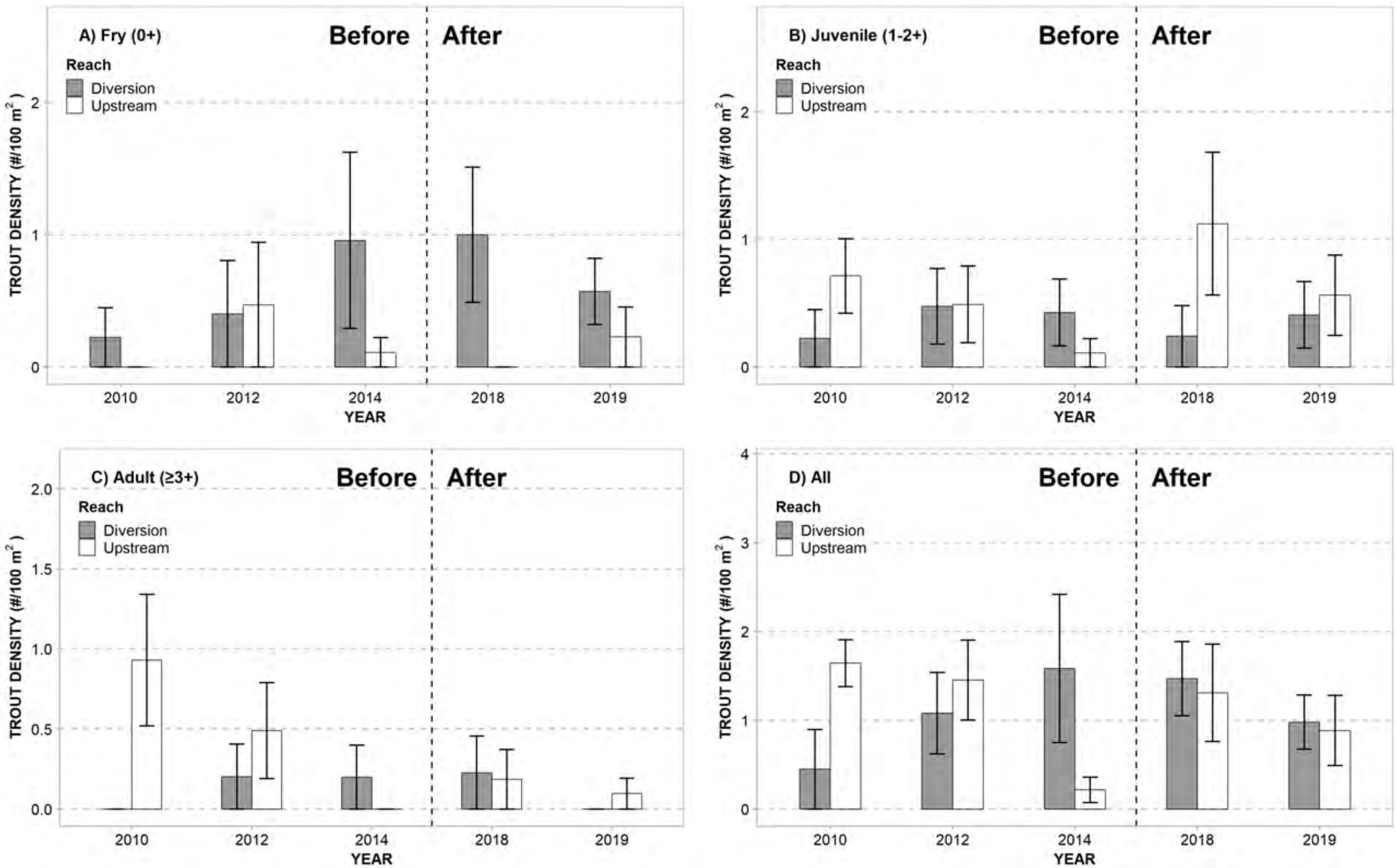
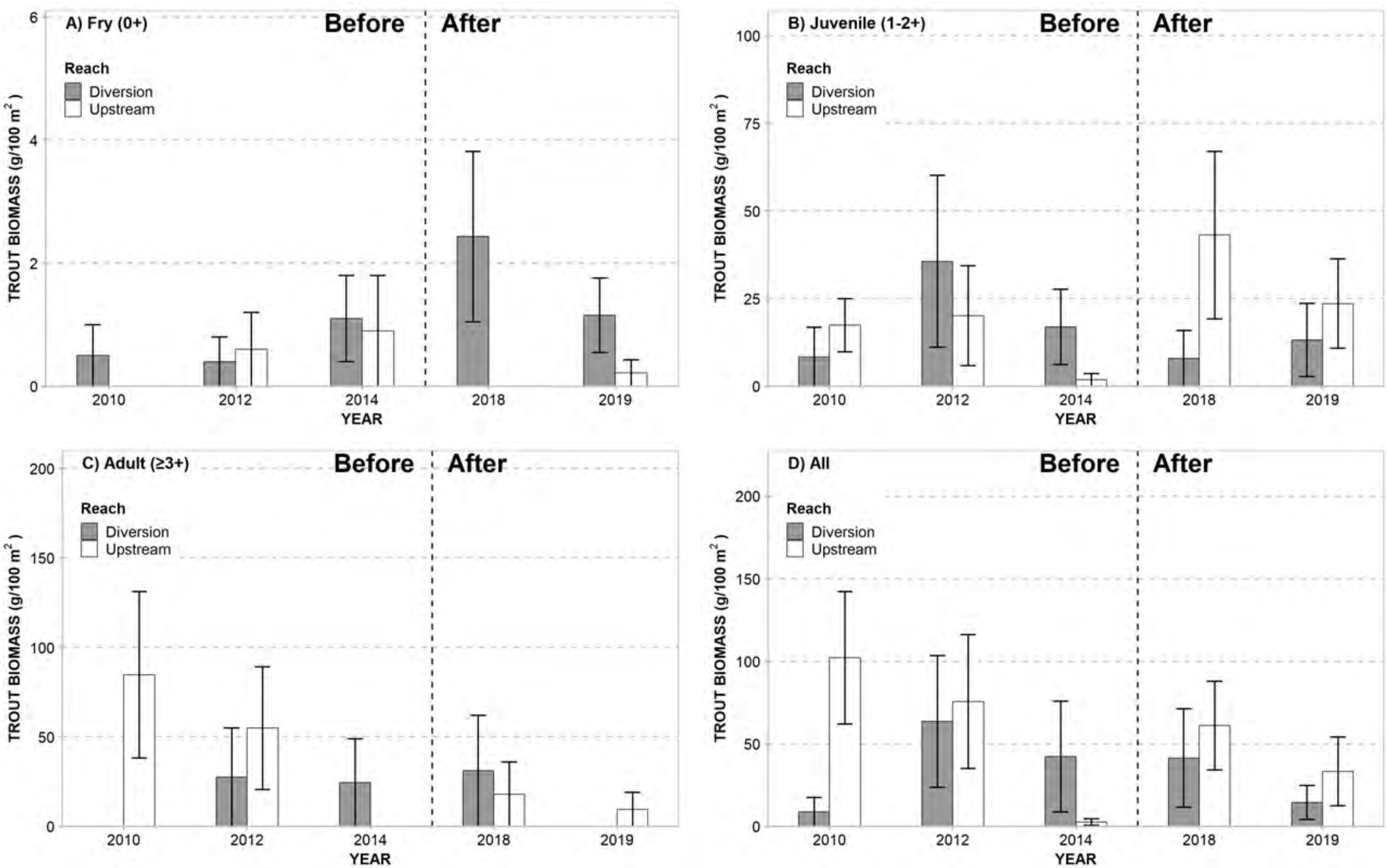


Figure 22. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River, before (2010, 2012, 2014) and after (2018, 2019) Project operations began, presented by age class: A) fry (0+); B) juveniles (1-2+); C) adult (≥3+); and D) all age classes combined.



4.2.1.2. Boulder Creek

Night Snorkelling Mark Re-sight

Night snorkelling mark re-sight surveys were conducted in Boulder Creek from March 28 to 31, 2019. Habitat summaries and representative photographs of mark re-sight sites are provided in Appendix J. Sites were composed of cascade, cascade/pool or riffle mesohabitat types and had average gradients that ranged from 3.0% to 8.0%. Stream substrate was primarily boulder, cobble, and gravel, and cover was provided primarily by boulder and cobble.

Sites ranged from 87 m to 124 m in length and 1,007 m² to 1,435 m² in area in the diversion reach and from 95 m to 115 m in length and 886 m² to 1,396 m² in area in the downstream reach. Maximum depths of sites were similar in both reaches, ranging from 0.8 m to 1.8 m. Due to the large size and depth of snorkel sites, and considerable flow rates at the channel thalweg, only 45% to 88% of their total areas were surveyed (resulting in sampled areas ranging from 530 m² to 1,265 m²; Table 37). At the time of sampling, the water temperature was between 2.0°C and 4.0°C. Water visibility was low during sampling with the exception of March 30th, 2019 when it was assessed as moderate during the mark sampling in the downstream reach. Visibility was estimated to be between 0.75 m and 2.0 m. Average daily flow was 2.13 m^3/s during sampling in the diversion reach, and ranged from 2.95 m^3/s to 3.18 m^3/s during sampling in the downstream reach.

During the first night of snorkelling, 28 Bull Trout were observed in the diversion reach (zero to 12 fish observed at individual sites, of which 19 were measured and marked (Table 38). In the downstream reach, 30 Bull Trout were observed (one to 10 fish observed at individual sites), of which 16 were measured and marked. A single Cutthroat Trout was observed in the diversion reach which was captured, measured, and marked (Table 39). Four Cutthroat Trout were observed in the downstream reach but none were captured, thus none could be measured or marked (Table 39).

During the second (re-sight) night of snorkelling on March 29, 2019, 32 Bull Trout were observed in the diversion reach, of which nine were marked (Table 38). In the downstream reach, 40 Bull Trout were observed, of which seven were marked. During the re-sight swim, a single marked Cutthroat Trout was observed in the diversion reach, within same site as it was observed the previous day, and a single unmarked Cutthroat Trout was observed in the downstream reach (Table 39).

Observer efficiency for Bull Trout ranged from 0.25 to 1.00 within individual sites and was 0.46 when considering all marked and re-sighted fish from both reaches (Table 38). For Cutthroat Trout, observer efficiency could only be calculated for a single site in the diversion reach where one fish was observed and re-sighted, resulting in an observer efficiency of 1.0 (Table 39).

As noted in the Year 1 report, 2018 was the first year that Cutthroat Trout were observed during mark re-sight snorkelling surveys in Boulder Creek (though one juvenile and one adult Cutthroat Trout were captured through electrofishing and angling, respectively in the downstream reach during baseline assessments) and the first time they were observed in any year within the diversion reach. In 2019, Cutthroat Trout were again observed in the diversion and downstream reaches during mark re-sight snorkelling surveys.

Age Analysis

Length-frequency distributions, length-weight relationships, and length at age relationships of Bull Trout and Cutthroat Trout captured in 2019 during snorkel mark re-sight surveys in the Boulder Creek diversion and downstream reaches, as well as data for individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix K. As with Upper Lillooet River sampling, no Bull Trout fin ray samples were aged in 2019, but scale samples were aged from two Cutthroat Trout; one adult from the diversion reach and one juvenile from the downstream reach. Based on reviewing age data and length-frequency distributions from baseline years, 2018 and 2019, discrete fork length ranges were defined for fry, juvenile, and adult age classes of Bull Trout (Table 40), whereas only two juvenile (95–171 mm) and three adult Cutthroat Trout (≥ 172 mm) were observed or captured in 2019. In line with age class assignment of fish captured in the Upper Lillooet River, 1+ to 3+ and ≥4+ Bull Trout were considered juveniles and adults, respectively, whereas for Cutthroat Trout, 1+ to 2+ and ≥3+ fish were considered juveniles and adults, respectively.

Fish Metrics and Condition

Fork lengths, weights, condition factor, and percent fat are summarized by age class and reach for all captured Bull Trout in Table 41 and for Cutthroat Trout in Table 42. Bull Trout condition factors were similar between locations and among age classes. Percent fat content was slightly higher in the downstream reach than the diversion reach (3.6% vs. 3.1 % when adult fish are compared), although the sample sizes were small. No comparisons could be made for Cutthroat Trout, given that only one adult and one juvenile were captured and weighed in the diversion and downstream reach, respectively.

Density Estimates

Bull Trout

Bull Trout densities (observed and adjusted for observer efficiency) for 2019 are presented by site in Table 43. The average adjusted density for all age classes was 1.29 fish/100 m^2 (± 0.42 standard error (SE)) in the diversion reach and 2.22 fish/100 m^2 (± 0.56 SE) in the downstream reach. Densities of fry (0+), juveniles (1-3+), and all age classes combined were higher in the downstream reach than the diversion. Adult (≥4+) densities were slightly higher in the diversion than the downstream reach.

Cutthroat Trout

Cutthroat Trout densities (observed and adjusted for observer efficiency) for 2019 are presented by site in Table 44. Year 2 (2019) is the second year that Cutthroat Trout have been observed during mark re-sight snorkel surveys in Boulder Creek (2018 was the first year). Juveniles were only observed in the downstream reach in 2019 (average adjusted density was 0.07 fish/100 m^2 (± 0.04 SE)). Adults were observed in both the diversion and downstream reaches (average adjusted densities of

0.04 fish/100 m^2 (± 0.04 SE) and 0.07 fish/100 m^2 (± 0.04 SE), respectively). No fry were observed in either the downstream or diversion reach in 2019.

Table 37. Summary of mark re-sight snorkeling site characteristics, conditions, effort, and fish observations in Boulder Creek in 2019.

Project Reach	Sampling Type[1]	Site	Date	Water Temp. (°C)	Estimated Visibility (m)	Daily Average Flow (m^3/s)[2]	Sampled Area (m^2)	Snorkeling Effort (min)	Number of Fish[3]			
									BT	**CT**	**MW**	**Total**
Diversion	Mark	BDR-DVSN01	28/Mar/19	3.3	2.0	2.13	930	110	6	0	0	6
		BDR-DVSN02	28/Mar/19	2.0	1.5	2.13	988	110	12	0	0	12
		BDR-DVSN03	28/Mar/19	2.0	1.5	2.13	1,265	130	8	0	0	8
		BDR-DVSN04	28/Mar/19	2.0	2.0	2.13	606	110	0	1	0	1
		BDR-DVSN05	28/Mar/19	2.0	1.5	2.13	712	50	2	0	0	2
	Re-sight	BDR-DVSN01	29/Mar/19	3.5	1.5	2.13	930	805	9	0	0	9
		BDR-DVSN02	29/Mar/19	3.5	1.5	2.13	988	99	9	0	0	9
		BDR-DVSN03	29/Mar/19	3.5	1.5	2.13	1,265	113	12	0	0	12
		BDR-DVSN04	29/Mar/19	3.0	1.5	2.13	606	63	0	1	0	1
		BDR-DVSN05	29/Mar/19	3.0	1.5	2.13	712	58	2	0	0	2
						Mark Total	**4,499**	**511**	**28**	**1**	**0**	**29**
						Re-sight Total	**4,499**	**1,138**	**32**	**1**	**0**	**33**
Downstream	Mark	BDR-DSSN01B	30/Mar/19	2.0	0.8	2.95	530	90	1	2	0	3
		BDR-DSSN02B	30/Mar/19	2.0	1.0	2.95	610	140	9	0	0	9
		BDR-DSSN03	30/Mar/19	2.0	1.0	2.95	774	120	10	2	0	12
		BDR-DSSN04	30/Mar/19	2.0	0.8	2.95	611	90	3	0	0	3
		BDR-DSSN05	30/Mar/19	3.0	0.8	2.95	768	76	7	0	0	7
	Re-sight	BDR-DSSN01B	31/Mar/19	3.0	1.3	3.18	530	85	1	1	2	4
		BDR-DSSN02B	31/Mar/19	2.5	1.3	3.18	610	82	7	0	0	7
		BDR-DSSN03	31/Mar/19	2.5	1.5	3.18	774	122	16	0	0	16
		BDR-DSSN04	31/Mar/19	2.5	1.5	3.18	611	103	9	0	0	9
		BDR-DSSN05	31/Mar/19	2.5	1.5	3.18	768	103	6	0	0	6
						Mark Total	**3,292**	**516**	**30**	**4**	**0**	**34**
						Re-sight Total	**3,292**	**494**	**39**	**1**	**2**	**42**
						Grand Mark Total	**7,791**	**1,027**	**58**	**5**	**0**	**63**
						Grand Re-sight Total	**7,791**	**1,631**	**71**	**2**	**2**	**75**

[1] Mark = The initial sample night, where fish were captured and marked, Re-sight = The second sample night, occuring 24 hr after the mark, where fish were observed or captured and the presence or absence of a mark was recorded.

[2] Diversion flow was calculated by subtracting powerhouse flows from downstream flows as measured at BDR-DSLG02.

[3] BT = Bull Trout, CT = Cutthroat Trout and MW = Mountain Whitefish; includes both captured and observed fish.

Table 38. Summary of the number of observed, marked, and re-sighted Bull Trout, and species-specific observer efficiency, during mark re-sight snorkelling surveys in Boulder Creek in 2019.

Project Reach	Site	Number of Fish[1] T	M	C	R	Observer Efficiency
Diversion	BDR-DVSN01	6	4	9	3	0.75
	BDR-DVSN02	12	8	9	2	0.25
	BDR-DVSN03	8	6	12	3	0.50
	BDR-DVSN04	0	0	0	0	-
	BDR-DVSN05	2	1	2	1	1.00
	Average ± SE	**28**	**19**	**32**	**9**	**0.63 ± 0.16**
Downstream	BDR-DSSN01B	1	0	1	0	-
	BDR-DSSN02B	9	6	7	3	0.50
	BDR-DSSN03	10	6	17	2	0.33
	BDR-DSSN04	3	0	9	0	-
	BDR-DSSN05	7	4	6	2	0.50
	Average ± SE	**30**	**16**	**40**	**7**	**0.44 ± 0.06**
	Overall Total	**58**	**35**	**72**	**16**	**0.46**

[1] T = total number of fish observed or captured during on the mark night; M = the number of fish marked on the mark night; C = total number of fish observed or captured during the re-sight night; R = the number of fish observed or captured on the re-sight night that were marked.

Table 39. Summary of the number of observed, marked, and re-sighted Cutthroat Trout, and species-specific observer efficiency, during mark re-sight snorkelling surveys in Boulder Creek in 2019.

Project Reach	Site	Number of Fish[1] T	M	C	R	Observer Efficiency
Diversion	BDR-DVSN01	0	0	0	0	-
	BDR-DVSN02	0	0	0	0	-
	BDR-DVSN03	0	0	0	0	-
	BDR-DVSN04	1	1	1	1	1.00
	BDR-DVSN05	0	0	0	0	-
	Average ± SE	**1**	**1**	**1**	**1**	**-**
Downstream	BDR-DSSN01B	2	0	1	0	-
	BDR-DSSN02B	0	0	0	0	-
	BDR-DSSN03	2	0	0	0	-
	BDR-DSSN04	0	0	0	0	-
	BDR-DSSN05	0	0	0	0	-
	Average ± SE	**4**	**0**	**1**	**0**	**-**
	Overall Total	**5**	**1**	**2**	**1**	**1.00**

[1] T = total number of fish observed or captured during on the mark night; M = the number of fish marked on the mark night; C = total number of fish observed or captured during the re-sight night; R = the number of fish observed or captured on the re-sight night that were marked.

Table 40. Fork length ranges used to define age classes of Bull Trout captured in Boulder Creek in 2019.

Age Class	Fork Length Range (mm)
Fry (0+)	25-112
Parr (1-3+)	113-204
Adult (≥4+)	205+

Table 41. Summary of fork length, weight, condition, and percent fat of Bull Trout captured during mark re-sight snorkeling within Boulder Creek in 2019.

Reach	Age Class	Fork Length (mm)[1]				Weight (g)[1]				Relative Condition Factor[1]				Percent Fat (%)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	22	96	79	112	12	10	5	14	12	1.02	0.94	1.18	0	n/a	n/a	n/a
	Juvenile (1-3+)	2	195	190	199	2	75	70	80	2	1.00	1.00	1.01	0	n/a	n/a	n/a
	Adult (≥4+)	12	287	229	350	5	244	128	331	5	1.03	0.93	1.12	5	3.1	2.5	3.9
	All	**36**	**165**	**79**	**350**	**19**	**78**	**5**	**331**	**19**	**1.02**	**0.93**	**1.18**	**5**	**3.1**	**2.5**	**3.9**
Downstream	Fry (0+)	15	91	78	98	6	8	6	9	6	0.99	0.95	1.02	0	n/a	n/a	n/a
	Juvenile (1-3+)	16	186	141	201	10	64	29	83	10	1.00	0.95	1.08	6	4.4	4.1	4.8
	Adult (≥4+)	5	224	210	239	3	111	93	131	3	0.94	0.89	0.99	3	3.6	3.2	3.9
	All	**36**	**151**	**78**	**239**	**19**	**54**	**6**	**131**	**19**	**0.99**	**0.89**	**1.08**	**9**	**4.1**	**3.2**	**4.8**

[1]Summary only includes measured values.

Table 42. Summary of fork length, weight, condition, and percent fat of Cutthroat Trout captured during mark re-sight snorkeling within Boulder Creek in 2019.

Reach	Age Class	Fork Length (mm)[1]				Weight (g)[1]				Relative Condition Factor[1]				Percent Fat (%)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-2+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Adult (≥3+)	2	267	265	268	1	187	187	187	1	0.99	0.99	0.99	1	1.3	1.3	1.3
	All	**2**	**267**	**265**	**268**	**1**	**187**	**187**	**187**	**1**	**0.99**	**0.99**	**0.99**	**1**	**1.3**	**1.3**	**1.3**
Downstream	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-2+)	1	123	123	123	1	18	18	18	1	0.96	0.96	0.96	0	n/a	n/a	n/a
	Adult (≥3+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	All	**1**	**123**	**123**	**123**	**1**	**18**	**18**	**18**	**1**	**0.96**	**0.96**	**0.96**	**0**	**n/a**	**n/a**	**n/a**

[1]Summary only includes measured values.

Table 43. Observed and observer-efficiency-adjusted densities of Bull Trout by age determined from mark re-sight snorkelling in Boulder Creek in 2019.

A) Fry (0+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1] Mark	Re-sight	Observed Density (fish/100 m²) Mark	Re-sight	Average	Adjusted Density[2] (fish/100 m²) Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	4	7	0.43	0.75	0.59	0.94	1.65	1.29
	BDR-DVSN02	988	6	5	0.61	0.51	0.56	1.33	1.11	1.22
	BDR-DVSN03	1,265	5	9	0.40	0.71	0.55	0.86	1.56	1.21
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.29**	**0.39**	**0.34**	**0.63**	**0.86**	**0.74**
				SE	**0.12**	**0.17**	**0.14**	**0.27**	**0.36**	**0.30**
Downstream	BDR-DSSN01B	530	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	610	7	4	1.15	0.66	0.90	2.51	1.43	1.97
	BDR-DSSN03	774	1	3	0.13	0.39	0.26	0.28	0.85	0.57
	BDR-DSSN04	611	1	4	0.16	0.66	0.41	0.36	1.43	0.90
	BDR-DSSN05	768	5	4	0.65	0.52	0.59	1.42	1.14	1.28
				Mean	**0.42**	**0.44**	**0.43**	**0.92**	**0.97**	**0.94**
				SE	**0.21**	**0.12**	**0.15**	**0.47**	**0.27**	**0.33**

B) Juveniles (1-3+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1] Mark	Re-sight	Observed Density (fish/100 m²) Mark	Re-sight	Average	Adjusted Density[2] (fish/100 m²) Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	1	1	0.11	0.11	0.11	0.24	0.24	0.24
	BDR-DVSN02	988	2	2	0.20	0.20	0.20	0.44	0.44	0.44
	BDR-DVSN03	1,265	0	2	0.00	0.16	0.08	0.00	0.35	0.17
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.06**	**0.09**	**0.08**	**0.14**	**0.20**	**0.17**
				SE	**0.04**	**0.04**	**0.04**	**0.09**	**0.09**	**0.08**
Downstream	BDR-DSSN01B	530	1	1	0.19	0.19	0.19	0.41	0.41	0.41
	BDR-DSSN02B	610	1	2	0.16	0.33	0.25	0.36	0.72	0.54
	BDR-DSSN03	774	7	11	0.90	1.42	1.16	1.98	3.11	2.54
	BDR-DSSN04	611	1	5	0.16	0.82	0.49	0.36	1.79	1.07
	BDR-DSSN05	768	2	1	0.26	0.13	0.20	0.57	0.28	0.43
				Mean	**0.34**	**0.58**	**0.46**	**0.74**	**1.26**	**1.00**
				SE	**0.14**	**0.24**	**0.19**	**0.31**	**0.53**	**0.40**

C) Adults (≥4+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1] Mark	Re-sight	Observed Density (fish/100 m²) Mark	Re-sight	Average	Adjusted Density[2] (fish/100 m²) Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	1	1	0.11	0.11	0.11	0.24	0.24	0.24
	BDR-DVSN02	988	4	2	0.40	0.20	0.30	0.89	0.44	0.66
	BDR-DVSN03	1,265	3	1	0.24	0.08	0.16	0.52	0.17	0.35
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	2	2	0.28	0.28	0.28	0.61	0.61	0.61
				Mean	**0.21**	**0.13**	**0.17**	**0.45**	**0.29**	**0.37**
				SE	**0.07**	**0.05**	**0.06**	**0.15**	**0.11**	**0.12**
Downstream	BDR-DSSN01B	530	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	610	1	1	0.16	0.16	0.16	0.36	0.36	0.36
	BDR-DSSN03	774	2	3	0.26	0.39	0.32	0.57	0.85	0.71
	BDR-DSSN04	611	1	0	0.16	0.00	0.08	0.36	0.00	0.18
	BDR-DSSN05	768	0	1	0.00	0.13	0.07	0.00	0.28	0.14
				Mean	**0.12**	**0.14**	**0.13**	**0.26**	**0.30**	**0.28**
				SE	**0.05**	**0.07**	**0.06**	**0.11**	**0.16**	**0.12**

D) All

Project Reach	Site	Area (m²)	Number of Fish Observed[1] Mark	Re-sight	Observed Density (fish/100 m²) Mark	Re-sight	Average	Adjusted Density[2] (fish/100 m²) Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	6	9	0.65	0.97	0.81	1.41	2.12	1.77
	BDR-DVSN02	988	12	9	1.21	0.91	1.06	2.66	1.99	2.33
	BDR-DVSN03	1,265	8	12	0.63	0.95	0.79	1.38	2.08	1.73
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	2	2	0.28	0.28	0.28	0.61	0.61	0.61
				Mean	**0.55**	**0.62**	**0.59**	**1.21**	**1.36**	**1.29**
				SE	**0.20**	**0.20**	**0.19**	**0.45**	**0.44**	**0.42**
Downstream	BDR-DSSN01B	530	1	1	0.19	0.19	0.19	0.41	0.41	0.41
	BDR-DSSN02B	610	9	7	1.48	1.15	1.31	3.23	2.51	2.87
	BDR-DSSN03	774	10	17	1.29	2.20	1.74	2.83	4.81	3.82
	BDR-DSSN04	611	3	9	0.49	1.47	0.98	1.07	3.22	2.15
	BDR-DSSN05	768	7	6	0.91	0.78	0.85	1.99	1.71	1.85
				Mean	**0.87**	**1.16**	**1.01**	**1.91**	**2.53**	**2.22**
				SE	**0.24**	**0.34**	**0.26**	**0.53**	**0.74**	**0.56**

[1] Only Bull Trout were included in density analysis.

[2] Density corrected by mean observer efficiency for all age classes of Bull Trout combined of 0.46.

Table 44. Observed and observer efficiency adjusted densities of Cutthroat Trout by age class determined from mark re-sight snorkelling in Boulder Creek in 2019.

A) Fry (0+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1]		Observed Density (fish/100 m²)			Adjusted Density[2] (fish/100 m²)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	988	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	1,265	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Downstream	BDR-DSSN01B	530	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	610	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	774	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN04	611	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	768	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

B) Juveniles (1-2+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1]		Observed Density (fish/100 m²)			Adjusted Density[2] (fish/100 m²)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	988	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	1,265	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	606	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Downstream	BDR-DSSN01B	530	1	0	0.19	0.00	0.09	0.41	0.00	0.21
	BDR-DSSN02B	610	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	774	1	0	0.13	0.00	0.06	0.28	0.00	0.14
	BDR-DSSN04	611	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	768	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.06**	**0.00**	**0.03**	**0.14**	**0.00**	**0.07**
				SE	**0.04**	**0.00**	**0.02**	**0.09**	**0.00**	**0.04**

C) Adults (≥3+)

Project Reach	Site	Area (m²)	Number of Fish Observed[1]		Observed Density (fish/100 m²)			Adjusted Density[2] (fish/100 m²)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	988	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	1,265	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	606	1	0	0.17	0.00	0.08	0.36	0.00	0.18
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.03**	**0.00**	**0.02**	**0.07**	**0.00**	**0.04**
				SE	**0.03**	**0.00**	**0.02**	**0.07**	**0.00**	**0.04**
Downstream	BDR-DSSN01B	530	1	0	0.19	0.00	0.09	0.41	0.00	0.21
	BDR-DSSN02B	610	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	774	1	0	0.13	0.00	0.06	0.28	0.00	0.14
	BDR-DSSN04	611	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	768	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.06**	**0.00**	**0.03**	**0.14**	**0.00**	**0.07**
				SE	**0.04**	**0.00**	**0.02**	**0.09**	**0.00**	**0.04**

D) All

Project Reach	Site	Area (m²)	Number of Fish Observed[1]		Observed Density (fish/100 m²)			Adjusted Density[2] (fish/100 m²)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	930	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	988	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	1,265	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	606	1	0	0.17	0.00	0.08	0.36	0.00	0.18
	BDR-DVSN05	712	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Average	**0.03**	**0.00**	**0.02**	**0.07**	**0.00**	**0.04**
				SE	**0.03**	**0.00**	**0.02**	**0.07**	**0.00**	**0.04**
Downstream	BDR-DSSN01B	530	2	1	0.38	0.19	0.28	0.83	0.41	0.62
	BDR-DSSN02B	610	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	774	2	0	0.26	0.00	0.13	0.57	0.00	0.28
	BDR-DSSN04	611	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	768	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Average	**0.13**	**0.04**	**0.08**	**0.28**	**0.08**	**0.18**
				SE	**0.08**	**0.04**	**0.06**	**0.18**	**0.08**	**0.12**

[1] Only Cutthroat Trout were included in density analysis.

[2] Density corrected by mean observer efficiency for all age classes of both Bull Trout and Cutthroat Trout combined of as too few Cutthroat Trout were observed to measure observer efficiency for this species.

Comparison Among Years

Bull Trout

Adjusted Bull Trout densities varied considerably between reaches and among years (Figure 23). Overall densities of all Bull Trout age classes were higher and more variable in the downstream reach than in the diversion reach, and were highest in 2013 and lowest in 2018 (with the exceptions that adult densities were higher in the diversion reach in 2018 and 2019). Though densities were relatively consistent in the diversion reach, the age class that dominated the catch differed among years.

Overall, higher density of Bull Trout in the downstream reach is likely due to a combination of factors such as better habitat quality and greater accessibility from the Upper Lillooet River than sites in the diversion reach. However, following the channel forming flows in the late fall of 2016 and again in 2017, the channel in the downstream reach was re-aligned which resulted in a large influence on fish habitat there. These flows also resulted in changes to the diversion reach but to a lesser extent.

In the diversion reach, juvenile Bull Trout density was highest in 2012 (1.04 fish/100 m^2) and lowest in 2013 (0.13 fish/100 m^2). Densities in 2019 were 0.17 fish/100 m^2 only slightly higher than 2013. Adult Bull Trout density in the diversion reach has been relatively consistent, although the density measured in 2019 (0.37 fish/100 m^2) was lower than the density measured in the previous four years (0.40–0.75 fish/100 m^2). Fry and 1–3+ juvenile densities have been more variable than adult densities. Fry densities in 2019 in the diversion reach were the highest observed to date and the second highest in the downstream reach (2013 highest). Juvenile (1–3+) densities in the diversion reach in 2019 were lower than in three of the previous four years.

Cutthroat Trout

Cutthroat Trout were only detected in both the diversion and downstream reach in 2018 and 2019 (not detected during baseline surveys). In 2019, densities were slightly lower in the diversion and slightly higher in the downstream reach than in 2018 (Figure 24).

Figure 23. Average observer efficiency adjusted densities (± standard error) of Bull Trout determined from mark re-sight snorkelling in Boulder Creek in 2011, 2012, 2013, 2018, and 2019 for: A) fry (0+), B) juveniles (1-3+), C) adults (≥4+), and D) all age classes combined.

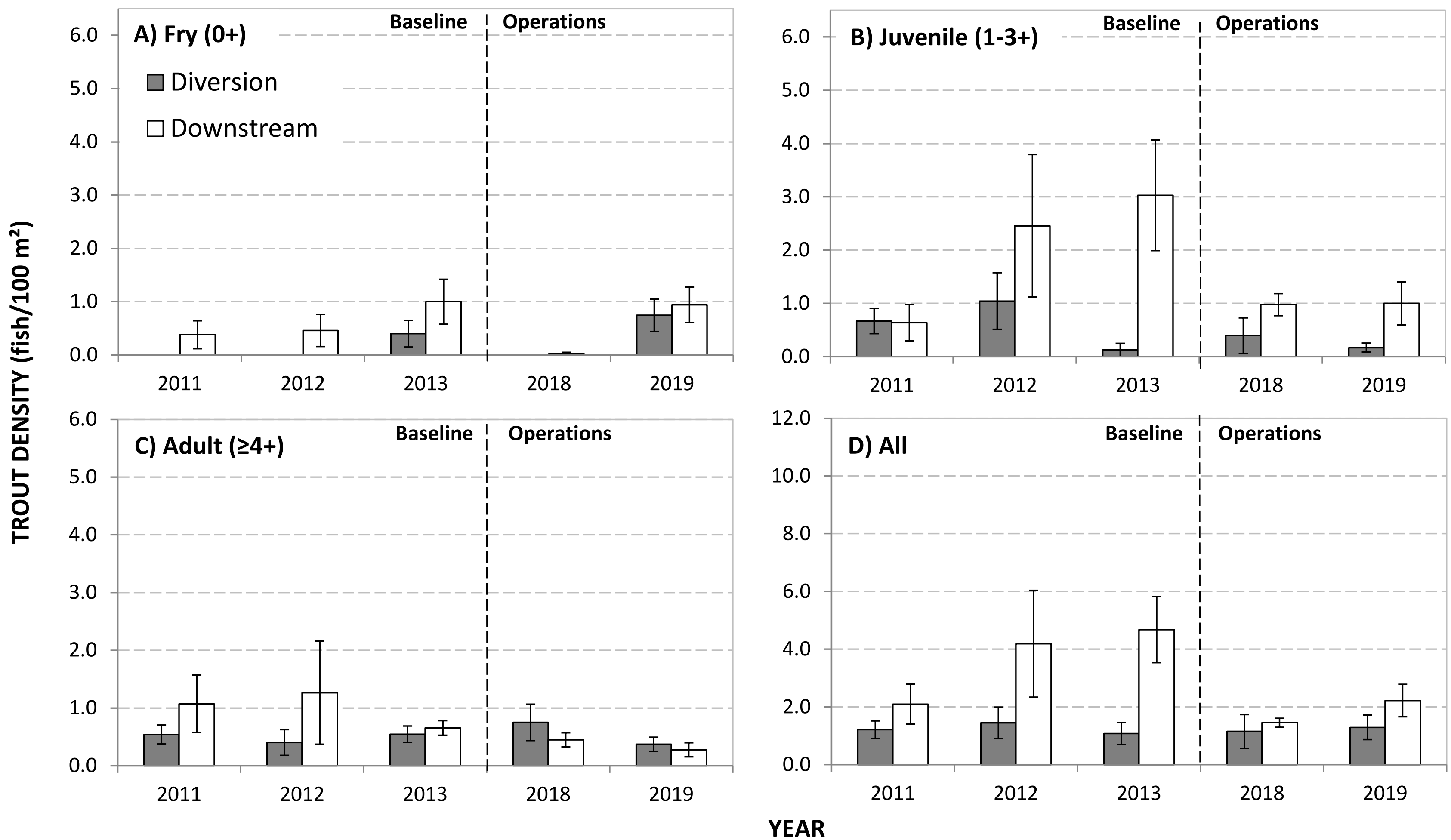
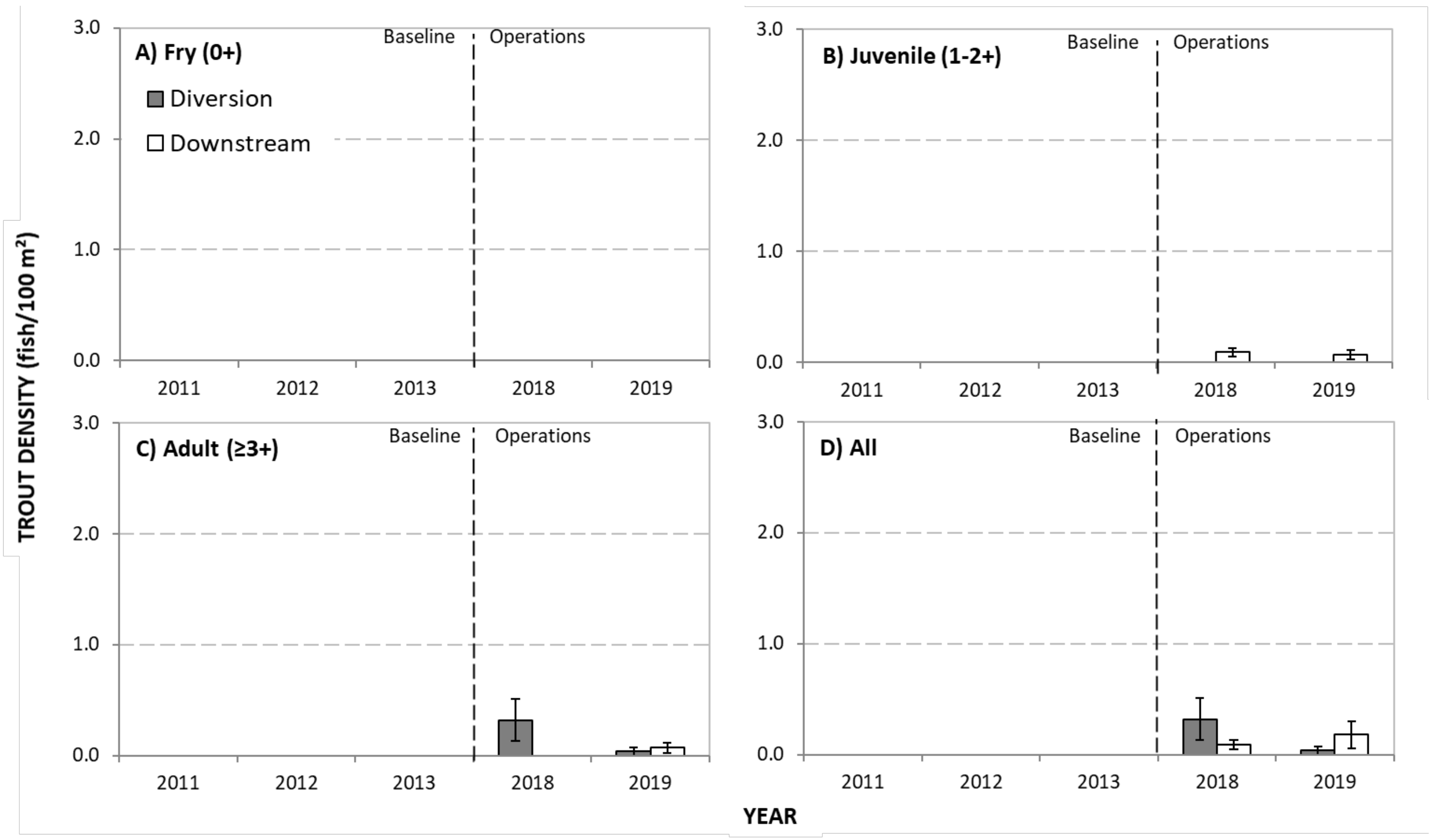


Figure 24. Average observer efficiency adjusted densities (± standard error) of Cutthroat Trout determined from mark re-sight snorkelling in Boulder Creek in 2011, 2012, 2013, 2018, and 2019 for: A) fry (0+), B) juveniles (1-2+), C) adults (≥4+), and D) all age classes combined.



Abundance Action Threshold (AAT)

Abundance action thresholds (AAT) were defined by Harwood *et al.* (2012) and in the OEMP for individual age classes and all age classes combined of juvenile Bull Trout within the diversion reach of Boulder Creek. Densities of Bull Trout juveniles observed in Year 2 monitoring (for individual age classes, and all combined) were compared to these AATs, and although variable among years, there were no declines that exceeded AATs in the diversion reach of Boulder Creek that were not mirrored by similar or more severe declines in the downstream control reach.

Fry density relative to the average for the three years of baseline data has increased in the diversion reach by 458% and increased by 54% in the downstream reach. This is an indicator that fry recruitment with both reaches has increased. The fry observed within the diversion reach are likely those that have emerged there, as the steep gradient would limit upstream migration of this age class. Juvenile densities (1+ to 3+) in the diversion reach were 72% lower than the baseline average, with a corresponding 51% decline in the downstream reach. Densities of adult Bull Trout have also declined by 25% from the average baseline value in the diversion reach; however, this was considerably less than the decline observed in the downstream reach of 72%. Overall densities of Bull Trout (all age classes combined) are 3% higher than the baseline average in the diversion, compared to a 39% decline in the downstream reach.

Non-operational factors between baseline and Year 2 of operations may have influenced the monitoring results and need to be considered in the assessment. Boulder Creek was subject to a forest fire in the summer of 2015 and large flood events during the fall of 2016 and 2017, between the baseline and operational monitoring periods. In particular, the flood event in November 2016 led to large geomorphological changes in the diversion and downstream reaches, which were exacerbated by the large flood event in November 2017. These geomorphic changes affected fish habitat but the influence on the fish community is unknown. However, with all age classes combined there was no evidence of a decline in Bull Trout density in the diversion reach in 2019 relative to baseline. As prescribed in the OEMP, densities of Bull Trout juveniles within the diversion and control reach will continue to be compared to AATs in the remaining years of operational monitoring and additional monitoring will be initiated in the event that any exceedances occur that are deemed to be due to Boulder Creek HEF operation.

4.2.2. Adult Migration and Distribution

4.2.2.1. Angling Surveys

Habitat summaries and representative photographs of angling sites in the Upper Lillooet River, Boulder Creek, and North Creek are presented in Appendix L. Capture results from angling surveys are presented in Table 45 and site-specific results and individual fish data are provided in Appendix L. For reference, Bull Trout with fork lengths greater than 370 mm have been found to have a high probability (>0.8) of undergoing seasonal migrations (Monnot *et al.* 2008) and are considered to be migratory adults. As observed during baseline studies, the presence of such large Bull Trout in both HEF streams suggests that a proportion of these fish are migratory.

Upper Lillooet

A total of nine Bull Trout were captured with approximately 40–50% of the Bull Trout captured in the diversion reach sexually mature compared to 0% in the downstream reach. Bull Trout captured ranged from 168 mm to 410 mm in fork length with the largest fish captured in the downstream reach. No barriers to migration were observed in the 500 m of the lower diversion reach immediately upstream of the powerhouse during angling surveys. The absence of Bull Trout holding below the powerhouses and detection of them in the diversion reach suggests that movement into the diversion reaches was not inhibited by operations in 2019.

Boulder Creek

A total of 19 Bull Trout were captured of which 33% were sexually mature in the diversion, 0–33% in the tailrace, and ranged from 25–50% in the downstream reach. Bull Trout captured ranged from 161 mm to 412 mm in fork length with the largest fish also captured in the downstream reach (Table 46). No barriers to migration were observed during the assessment of fish passage and upstream access conducted during angling surveys within the lower 1.3 km of Boulder Creek. The fish bearing reach on Boulder Creek is considered to extend from the confluence with Upper Lillooet upstream 2.64 km, with approximately 1.7 km of the diversion reach accessible to fish. The absence of Bull Trout holding below the powerhouse and detection of them in the diversion reach suggests that movement into the diversion reaches was not inhibited by operations in 2019.

North Creek

A total of four Bull Trout were captured in North Creek with sexual maturity ranging from 50-100%. Bull Trout captured ranged from 244 mm to 385 mm in fork length (Table 46). Sexual maturity and lengths were similar to that of fish captured on both Upper Lillooet River and Boulder Creek.

4.2.2.1. Tributary Spawner Surveys

A summary of effort and fish observations during spawning surveys in Alena Creek and 29.2 km Tributary in the fall of 2019 are presented in Table 47. Surveyed distances ranged from 1,750 m to 2,300 m in Alena Creek, and 724 m in 29.2 km Tributary. No live adults, carcasses or redds were observed in 29.2 km Tributary during any of the three surveys. In Alena Creek, a single adult Bull Trout (275 mm estimated fork length) was observed on October 1, 2019. In addition, 1 redd was identified on this survey date which was identified as a Bull Trout redd based on spawn timing and the observation of an adult Bull Trout during the survey.

Table 45. Summary of Bull Trout capture data during angling surveys conducted in the Upper Lillooet River, Boulder Creek, and North Creek during the fall of 2019.

Stream	Date	Project Area	# of Sites	Effort (rod hrs)	Bull Trout Captures	CPUE (fish/hr)	% Sexually Mature
Upper Lillooet River	17-Sep	Diversion	2	3.1	0	0.0	n/a
	17-Sep	Tailrace	1	0.9	0	0.0	n/a
	17-Sep	Downstream	3	2.9	0	0.0	n/a
	29-Sep	Diversion	2	2.0	5	2.5	40%
	29-Sep	Tailrace	1	1.5	0	0.0	n/a
	29-Sep	Downstream	2	2.0	1	0.5	0%
	21-Oct	Diversion	2	2.0	2	1.0	50%
	21-Oct	Tailrace	1	1.0	0	0.0	n/a
	21-Oct	Downstream	3	3.1	1	0.3	0%
2019 Total:		**Diversion**	**6**	**7.1**	**7**	**1.0**	**43%**
		Tailrace	**3**	**3.4**	**0**	**0.0**	**n/a**
		Downstream	**8**	**8.0**	**2**	**0.3**	**0%**
Boulder Creek	18-Sep	Diversion	3	3.0	0	0.0	n/a
	18-Sep	Tailrace	1	1.1	2	1.8	0%
	18-Sep	Downstream	4	4.2	0	0.0	n/a
	30-Sep	Diversion	3	3.1	3	1.0	33%
	30-Sep	Tailrace	1	1.1	3	2.8	33%
	30-Sep	Downstream	3	3.2	4	1.2	50%
	22-Oct	Diversion	3	3.0	0	0.0	n/a
	22-Oct	Tailrace	1	1.0	3	3.0	0%
	22-Oct	Downstream	4	4.2	4	1.0	25%
2019 Total:		**Diversion**	**9**	**9.1**	**3**	**0.3**	**33%**
		Tailrace	**3**	**3.2**	**8**	**2.5**	**13%**
		Downstream	**11**	**11.6**	**8**	**0.7**	**38%**
North Creek	1-Oct	N/A	6	5.1	3	0.6	67%
	23-Oct	N/A	5	5.0	1	0.2	100%
2019 Total:		**N/A**	**11**	**10.1**	**4**	**0.4**	**75%**

Table 46. Summary of fork length, weight, and condition factor for Bull Trout captured during angling surveys in the Upper Lillooet River, Boulder Creek, and North Creek in the fall of 2019.

Stream	Project area	Fork Length (mm)				Weight (g)				Condition Factor (K)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Upper Lillooet River	Diversion	7	274	237	320	7	206	143	298	7	0.98	0.91	1.07
	Tailrace	0	-	-	-	0	-	-	-	0	-	-	-
	Downstream	2	289	168	410	2	379	51	707	2	1.05	1.03	1.08
	Total:	9	277	168	410	9	244	51	707	9	1.00	0.91	1.08
Boulder Creek	Diversion	3	222	161	325	3	145	45	329	3	1.03	0.96	1.08
	Tailrace	8	246	205	278	8	157	91	228	8	1.01	0.93	1.08
	Downstream	8	289	207	412	8	261	87	626	8	0.95	0.90	0.99
	Total:	19	260	161	412	19	199	45	626	19	0.99	0.90	1.08
North Creek	N/A	4	312	244	385	4	315	147	536	4	0.97	0.94	1.01
	Total:	4	312	244	385	4	315	147	536	4	0.97	0.94	1.01

Table 47. Summary of results from spawning surveys conducted in Alena Creek and 29.2 km Tributary in the fall of 2019.

Stream	Date	Survey Time (hrs)	Survey Distance (m)	Number Observed[1]								
				Live Adults			Adult Carcasses			Redds		
				BT	CT	CO	BT	CT	CO	BT	CT	CO
Alena Creek	17-Sep-19	1.5	1,750	0	0	0	0	0	0	0	0	0
	1-Oct-19	1.9	2,300	1	0	0	0	0	0	1	0	0
	22-Oct-19	2.0	2,300	0	0	0	0	0	0	0	0	0
	Total:	**14.5**	**13,250**	**1**	**0**	**265**	**0**	**0**	**41**	**1**	**0**	**49**
29.2 km Tributary	18-Sep-19	0.9	724	0	0	0	0	0	0	0	0	0
	29-Sep-19	1.0	724	0	0	0	0	0	0	0	0	0
	23-Oct-19	0.9	724	0	0	0	0	0	0	0	0	0
	Total:	**2.8**	**2,172**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

[1] BT = Bull Trout, CT = Cutthroat Trout, CO = Coho Salmon

4.2.2.2. Comparison Among Years

Upper Lillooet

Catch per unit effort in the diversion reach has remained relatively consistent between baseline and operational years with no apparent trend. Catch per unit effort in the diversion reach varied from 0.05 fish per hour in 2011 to 1.16 fish per hour in Year 2 (2019) coinciding with total catches ranging from one to seven (Table 48). Catches in the tailrace decreased from 1.19 fish per hour in Year 1 (2018) to 0 fish per hour in Year 2 (2019) with total catches ranging from zero to four fish. Captures in the downstream reach have increased between baseline and operational years; however, no fish were captured in the downstream reach during baseline. Catches in the downstream reach ranged from zero fish per hour during baseline (2010, 2011) to 0.96 fish per hour in Year 1 (2018) with total catches ranging from zero to ten fish. A total of 10 Bull Trout were captured in Year 1 (2018), representing an increase from baseline monitoring (zero fish). This increase is not considered due to reduced fish passage to the diversion reach caused by facility operations. This is because the facility was not operating during the expected peak spawning migration period and therefore passage conditions were not affected by the facility at that time. This is supported by the observed presence of spawning Bull Trout in the diversion reach during Year 1 (2018), demonstrating that access to the diversion reach was possible. In Year 2 (2019) a total of two Bull Trout were captured in the downstream reach compared to seven in the diversion reach and there was no evidence of restricted access to the diversion reach. The catch and catch per unit effort in the being similar to or greater during operations compared to the two baseline years suggests that movement into the diversion reaches was not inhibited by operations in either operational years.

Boulder Creek

Catch per unit effort in the diversion reach has remained relatively low between baseline and operational years; however, there appears to be a slight increasing trend. Catch per unit effort in the diversion reach varied from 0.1 fish per hour in 2011 to 0.4 fish per hour in Year 1 (2018) with total catches ranging from two to four fish (Table 49). Catches in the tailrace increased from 1.4 fish per hour in Year 1 (2018) to 2.5 fish per hour in Year 2 (2019) with total catches ranging from zero to four fish. Catches in the downstream reach ranged from 0.7 per hour in Year 2 (2019) to 1.8 fish per hour in 2010 with total catches ranging from four to 16 fish. Catch per unit effort in the downstream reach have decreased between baseline and operational years; however, total catches have been highly variable ranging from four fish captured in 2010 to 16 fish captured in Year 1 (2018). Overall, increasing captures in the diversion reach suggest that access was not inhibited by operations in either operational years.

North Creek

North Creek is used as a control stream to compare catches from Upper Lillooet River and Boulder Creek. North Creek was sampled in 2010 and 2011 (baseline) and in Year 2 of operations (2019). Catch per unit effort in Year 2 (2019) was lower than 2010, but similar to 2011. Catch per unit effort varied from 0.3 fish per hour in 2011 to 1.2 fish per hour in 2010 (Table 50). Although catch per unit effort was variable, total captures remained relatively consistent between years ranging from three to four fish.

Tributary Spawner Surveys

Tributary spawner surveys were conducted on Alena Creek and 29.2 km tributary in September and October during the Bull Trout spawning period. A single survey was conducted on Alena Creek in 2011 where nine Adult Bull Trout were observed over a distance of 700 m (2012 and 2013 were not sampled, Table 51). Two surveys were completed in Year 1 (2018) and three surveys in Year 2 (2019) of operations with peak counts of two and one adult Bull Trout, respectively. Survey distances in Year 1 and 2 ranged from 1,631 m to 2,300 m; however, averaged 1,675 and 2,117 m respectively, notably longer than the 700 m survey distance during baseline.

A single spawner survey was conducted on 29.2 km tributary in 2011 where eight adult Bull Trout were observed over a distance of 560 m (Table 52). Three surveys were completed in both Year 1 (2018) and 2 (2019) of operations with peak counts of two and zero adult Bull Trout, respectively. Survey distance in Year 1 and 2 was 724 m, slightly longer than the 560 m survey distance during baseline.

Peak counts observed in operational Year 1 and 2 on Alena Creek and 29.2 km tributary were lower than baseline counts.

Table 48. Upper Lillooet Adult Bull Trout captures and catch per unit effort comparison between Baseline and Operational Years 1 and 2.

Metric	Reach	Baseline		Operational	
		2010	2011	2018	2019
Surveys	Diversion	3	11	5	6
	Tailrace	-	-	3	3
	Downstream	3	5	8	8
Captures	Diversion	4	1	6	7
	Tailrace	-	-	4	0
	Downstream	0	0	10	2
Effort (hr)	Diversion	3.90	11.68	5.98	7.09
	Tailrace	-	-	3.37	3.40
	Downstream	2.40	4.03	10.42	8.00
CPUE (fish/hr)	Diversion	1.03	0.05	1.01	1.16
	Tailrace	-	-	1.19	0.00
	Downstream	0.00	0.00	0.96	0.27

Table 49. Boulder Creek Adult Bull Trout captures and catch per unit effort comparison between Baseline and Operational Years 1 and 2.

Metric	Reach	Baseline		Operational	
		2010	2011	2018	2019
Surveys	Diversion	2	6	11	9
	Tailrace	-	-	3	3
	Downstream	3	8	12	11
Captures	Diversion	2	2	4	3
	Tailrace	-	-	6	8
	Downstream	4	13	16	8
Effort (hr)	Diversion	6.56	7.83	13.32	9.10
	Tailrace	-	-	3.97	3.20
	Downstream	3.81	8.93	14.35	11.60
CPUE (fish/hr)	Diversion	0.16	0.12	0.35	0.33
	Tailrace	-	-	1.38	2.52
	Downstream	1.79	1.65	1.14	0.73

Table 50. North Creek Adult Bull Trout captures and catch per unit effort comparison between Baseline and Operational Years 1 and 2.

Metric	Baseline		Operational	
	2010	2011	2018	2019
Surveys	5	7	-	12
Captures	4	3	-	4
Effort (hr)	8.20	7.71	-	11.10
CPUE (fish/hr)	1.21	0.26	-	0.38

Table 51. Alena Creek Spawner Survey comparison between Baseline and Operational Years 1 and 2.

Date	Survey Time (hrs) [1]	Survey Distance (m)	Adult Bull Trout Observed		
			Live	Carcasses	Redds
04-Oct-11	n/c	700	9	0	0
14-Sep-18	1.47	1,631	0	0	0
11-Oct-18	4.12	1,719	2	0	0
17-Sep-19	1.50	1,750	0	0	0
01-Oct-19	1.88	2,300	1	0	1
22-Oct-19	2.00	2,300	0	0	0

[1] n/c = not collected

Table 52. 29.2 KM Spawner Survey comparison between Baseline and Operational Years 1 and 2.

Date	Survey Time (hrs) [1]	Survey Distance (m)	Adult Bull Trout Observed		
			Live	Carcasses	Redds
04-Oct-11	n/c	560	8	0	0
13-Sep-18	1.32	724	0	0	0
28-Sep-18	0.75	724	0	0	0
09-Oct-18	0.75	724	2	0	0
18-Sep-19	0.93	724	0	0	0
29-Sep-19	0.97	724	0	0	0
23-Oct-19	0.92	724	0	0	0

[1] n/c = not collected

4.2.3. Assessment of Entrainment at the Upper Lillooet River Intake

4.2.3.1. Closed-Site Electrofishing in Tributary

Closed-site electrofishing was completed within the unnamed tributary at 87.0 km on the Upper Lillooet River (87.0 km Tributary) on October 19 and 20, 2019. A total area of 440 m^2 was surveyed and the total electrofishing effort for all sites combined was 7,661 seconds (Table 53 and Table 54). Numbers of captured fish ranged from 29 to 45 Cutthroat Trout per site, and a total of 108 individuals were captured at all sites combined (Table 54). No other species were captured during sampling, which is consistent with the known fish distribution upstream of Keyhole Falls, where only Cutthroat Trout have been detected.

Table 53. Summary of closed-site electrofishing site characteristics and conditions during sampling in 87.0 km Tributary in 2019.

Site	Sampling Date	Conductivity (µS/cm)	Water Temp. (°C)	Turbidity	Sampling Length (m)	Sampling Area (m^2)
ULL-HPTB87.0EF01	19-Oct-19	51	5	Clear	40	110
ULL-HPTB87.0EF02	19-Oct-19	51	5.5	Clear	43	137.6
ULL-HPTB87.0EF03	19-Oct-19	51	5	Clear	54	192.24
Tributary Total:					**137**	**440**

Table 54. Summary of closed-site electrofishing effort and fish captures in 87.0 km Tributary in 2019.

Site	Sampling	Total Electrofishing Effort (sec)				CT Captures (# of fish)			
	Date	Pass 1	Pass 2	Pass 3	Total	Pass 1	Pass 2	Pass 3	Total
ULL-HPTB87.0EF01	2019-10-19	1047	821	609	2,477	17	9	3	29
ULL-HPTB87.0EF02	2019-10-19	1163	819	660	2,642	22	11	1	34
ULL-HPTB87.0EF03	2019-10-19	1019	822	701	2,542	35	7	3	45
Tributary Total:		**3,229**	**2,462**	**1,970**	**7,661**	**74**	**27**	**7**	**108**

4.2.3.2. Age Analysis

The length-frequency distribution, length-weight relationship, and length at age relationship of Cutthroat Trout captured during closed-site electrofishing surveys in 87.0 km Tributary in 2019, as well as data on individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix I. Based on a review of aging data and length-frequency distributions, discrete fork length ranges were defined for age classes fry (0+), juveniles (1-2+), and adults (≥3+) of Cutthroat Trout (Table 55).

Table 55. Fork length ranges used to define age classes of Cutthroat Trout captured in 87.0 km Tributary in 2019.

Age Class	Fork Length Range (mm)
Fry 0+	28-39
Juvenile (1-2+)	48-124
Adult (≥3+)	≥127

4.2.3.3. Fish Metrics and Condition

Fork length, weight, and condition factor for all captured Cutthroat Trout are summarized by age class in Table 56. Weights were assigned to all fish not weighed in the field from the established length-weight relationships (Appendix I).

Table 56. Summary of fork length, weight and condition of Cutthroat Trout captured in 87.0 km Tributary in 2019.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Min	Max	Avg	n	Min	Max	Avg	n	Min	Max	Avg
0+	11	28	39	34	11	0.1	0.7	0.4	11	0.5	1.7	1.0
1+	23	48	76	67	23	2.1	5.3	3.7	23	1.1	2.0	1.2
2+	37	82	124	104	37	6.6	18.5	12.1	37	0.9	1.3	1.1
≥3+	37	127	200	155	37	19.7	89.5	38.8	37	0.6	1.2	1.0
Total	**108**	**28**	**200**	**107**	**108**	**0.1**	**89.5**	**18.3**	**108**	**0.5**	**2.0**	**1.1**

4.2.3.4. Density and Biomass Estimates

Observed and habitat-adjusted density and biomass estimates of Cutthroat Trout determined from closed-site electrofishing in 87.0 km Tributary are summarized by age class in Table 57. Observed fish densities (FPUobs; #/100 m²) and biomass (BPUobs; g/100 m²) are the focus of the results below, with habitat adjusted values (FPUadj and BPUadj) provided in Table 58. Observed densities and biomass of Cutthroat Trout are compared by age class in Figure 25 and Figure 26. Density was highest for 1–2+ juveniles at approximately 14 fish/100 m², while fry and adult densities were approximately 4.1 fish/100 m² and 7.1 fish/100 m² respectively. Although densities of adults were lower than those of juveniles, biomass was greater for adults than other age classes, reflecting their greater size.

Table 57. Density and biomass of Cutthroat Trout determined per sampling site from closed-site electrofishing in 87.0 km Tributary in 2019.

A) Fry (0+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	72.8%	8.2	11.9	11.2	16.4
ULL-HPTB87.0EF02	67.4%	2.2	0.5	3.2	0.8
ULL-HPTB87.0EF03	44.2%	2.1	3.8	4.7	8.7

B) Parr (1-2+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	33.9%	13.6	116.5	40.2	343.4
ULL-HPTB87.0EF02	28.4%	15.3	171.7	53.7	603.9
ULL-HPTB87.0EF03	23.0%	12.0	132.9	52.1	578.2

C) Adult (≥3+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	33.9%	4.5	157.6	13.4	464.83
ULL-HPTB87.0EF02	28.4%	7.3	239.8	25.6	843.09
ULL-HPTB87.0EF03	23.0%	9.4	431.3	40.7	1,876.59

D) All

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	33.9%	27.3	295.9	64.9	824.6
ULL-HPTB87.0EF02	28.4%	24.7	412.0	82.5	1,447.7
ULL-HPTB87.0EF03	23.0%	23.4	568.1	97.5	2,463.5

[1] FPU_{obs} = Observed fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R.

[2] BPU_{obs} = Biomass of fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R.

[3] FPU_{adj} = FPU_{obs}/Usability (%)

[4] BPU_{adj} = BPU_{obs}/Usability (%)

Table 58. Observed and habitat-suitability-adjusted average Cutthroat Trout densities and biomass by age class determined from closed-site electrofishing in 87.0 km Tributary in 2019.

Age Class	FPUobs (#/100 m²)[1]		BPUobs (g/100 m²)[2]		FPUadj (#/100 m²)[3]		BPUadj (g/100 m²)[4]	
	Average	SE [5]	Average	SE	Average	SE	Average	SE
Fry (0+)	4.1	2.0	5.4	3.4	6.4	2.5	8.6	4.5
Parr (1-2+)	13.6	1.0	140.4	16.4	48.6	4.2	508.5	82.9
Adult (3+)	7.1	1.4	276.2	81.1	26.6	7.9	1,061.5	421.9
All	25.1	1.1	425.3	78.9	81.6	9.4	1,578.6	477.6

[1] FPU_{obs} = Observed fish per unit (100 m²) based on population estimates computed using the removal (K-pass) function in the FSA package in R.

[2] BPU_{obs} = Biomass of fish per unit (100 m²) based on population estimates computed using the removal (K-pass) function in the FSA package in R.

[3] $FPU_{adj} = FPU_{obs}$/Usability (%)

[4] $BPU_{adj} = BPU_{obs}$/Usability (%)

[5] SE = Standard Error

Figure 25. Observed densities by age class of Cutthroat Trout in 87.0 km Tributary determined from closed-site electrofishing presented as fish density per 100 m² (FPUobs).

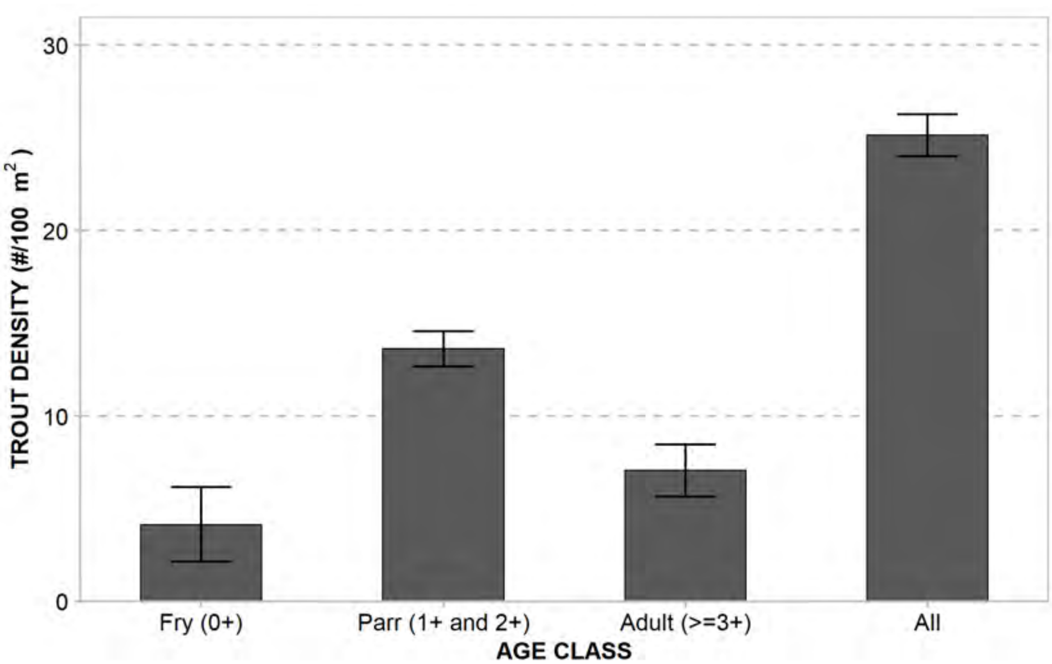
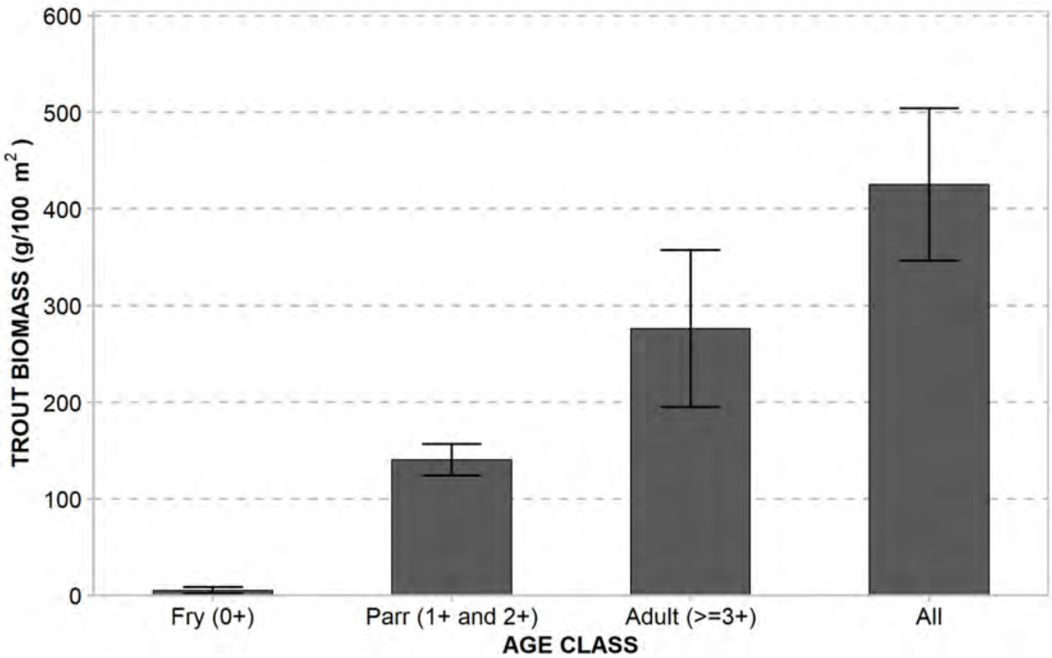


Figure 26. Observed biomass densities by age class of Cutthroat Trout in 87.0 km Tributary determined from closed-site electrofishing presented as fish biomass per 100 m² (BPUobs).



4.2.3.5. Comparison Among Years

Observed densities and biomass of Cutthroat Trout by age class and among years are compared in Figure 27 and Figure 28, respectively. Density of Cutthroat Trout in the tributary in 2019 was similar to density in 2013 and 2018 when all age classes were combined, although there were some larger differences among years for individual age classes (Figure 27). Biomass of Cutthroat Trout in 2019 was similar to 2018 but lower than 2013 for all age classes combined (Figure 28). Fry densities in 2019 were more than double those in 2018 but similar to those in 2013. Fry biomass in 2019 was almost five times higher than 2018 and approximately double fry biomass in 2013. Density and biomass of parr (1+ and 2+) were both slightly lower in 2019 than 2018 but substantially higher than 2013. Adults density and biomass values showed a different trend with 2019 values being slightly higher than 2018 but substantially lower than 2013.

Densities and biomass of Cutthroat Trout within the upper and lower clusters of Upper Lillooet River upstream sites varied considerably by age class among years (Figure 29, Figure 30). Results from these Upper Lillooet River upstream sites are presented together in Section 4.2.1.1. The lack of Cutthroat Trout detections of certain age classes in some years, coupled with low abundance values, make it difficult to distinguish trends between the two areas of the upstream reach, and between baseline years and Year 1 and 2 of operations, but overall, there is no evidence of a decline in the lower cluster of sites in the upstream reach or in the tributary during Project operations.

Figure 27. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in 87.0 km Tributary in 2013, 2018 and 2019 presented by age class for: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined.

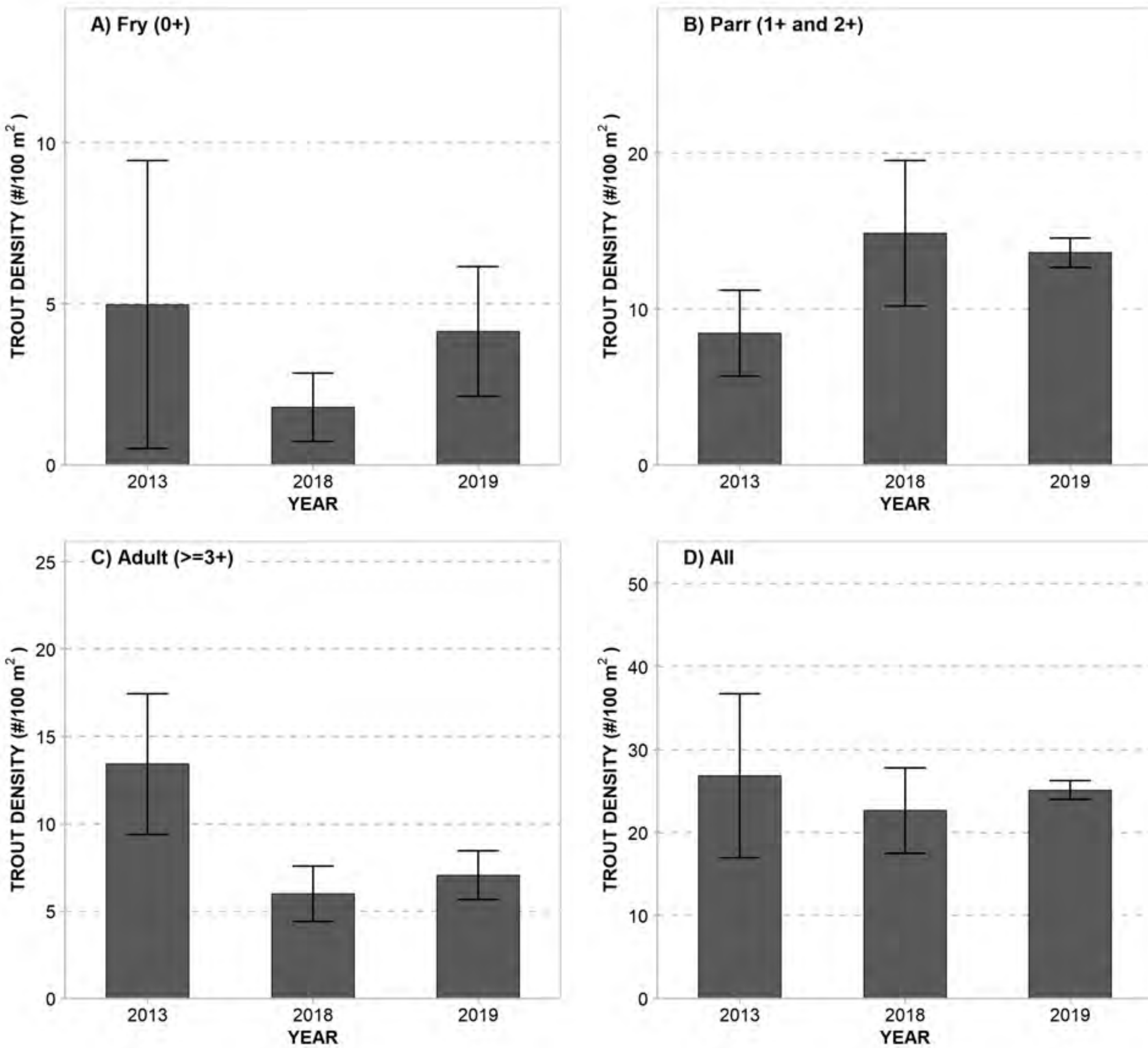


Figure 28. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in 87.0 km Tributary in 2013, 2018 and 2019 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined.

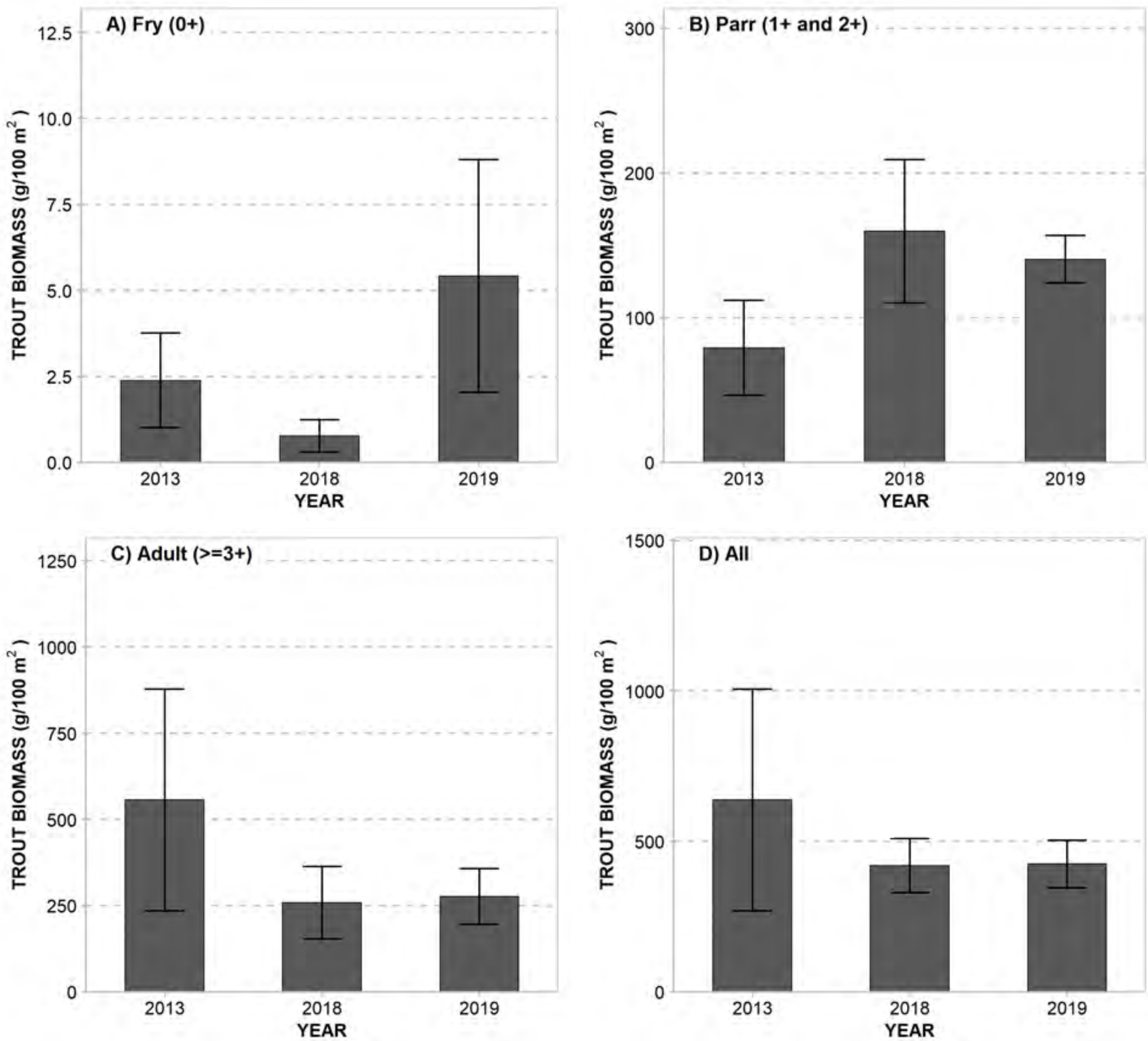


Figure 29. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in the upper and lower clusters of upstream sites in 2010, 2012, 2014, 2018, and 2019 presented by age class for: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined. Note that the upper cluster of sites was not added until 2014.

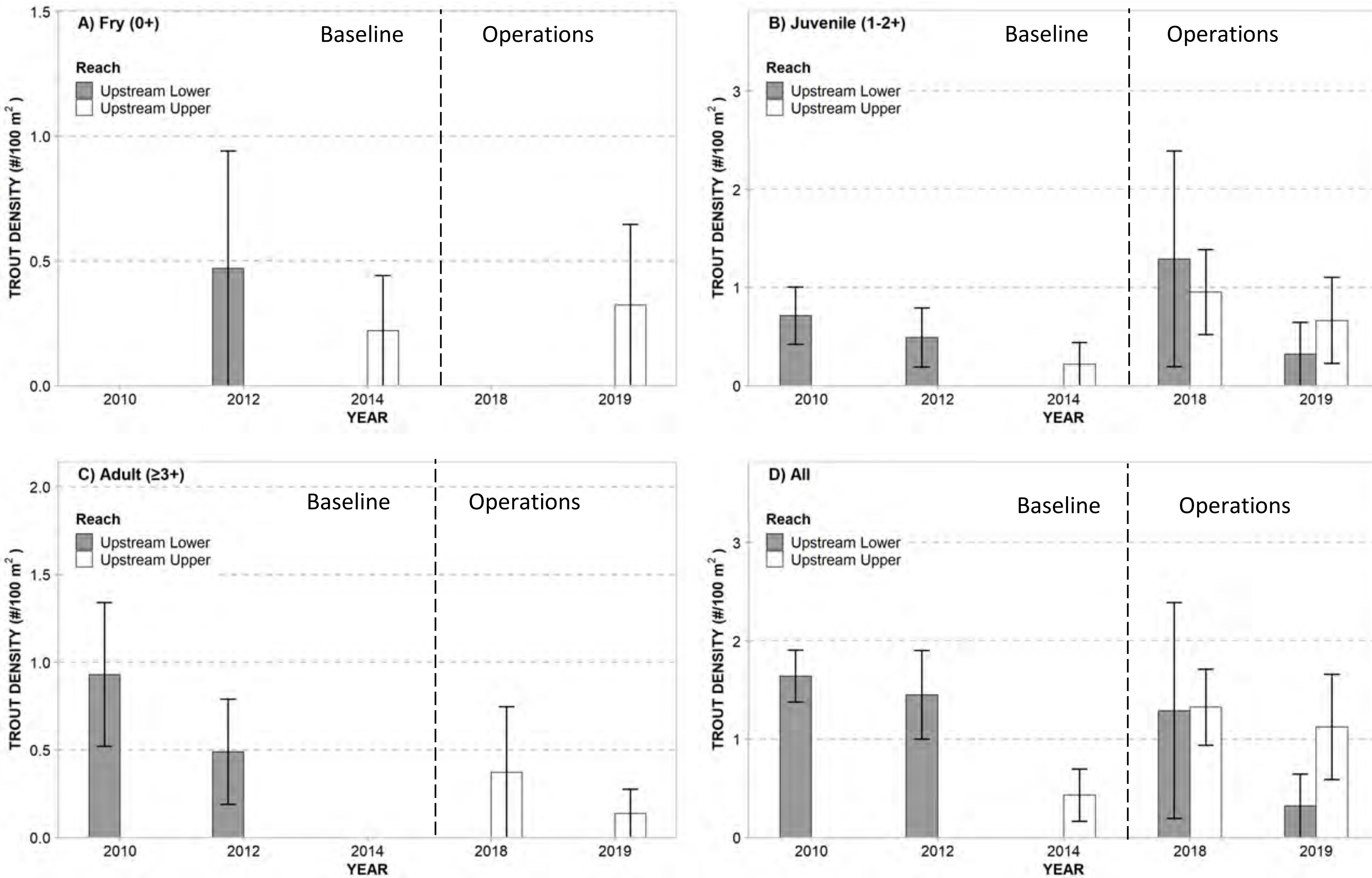
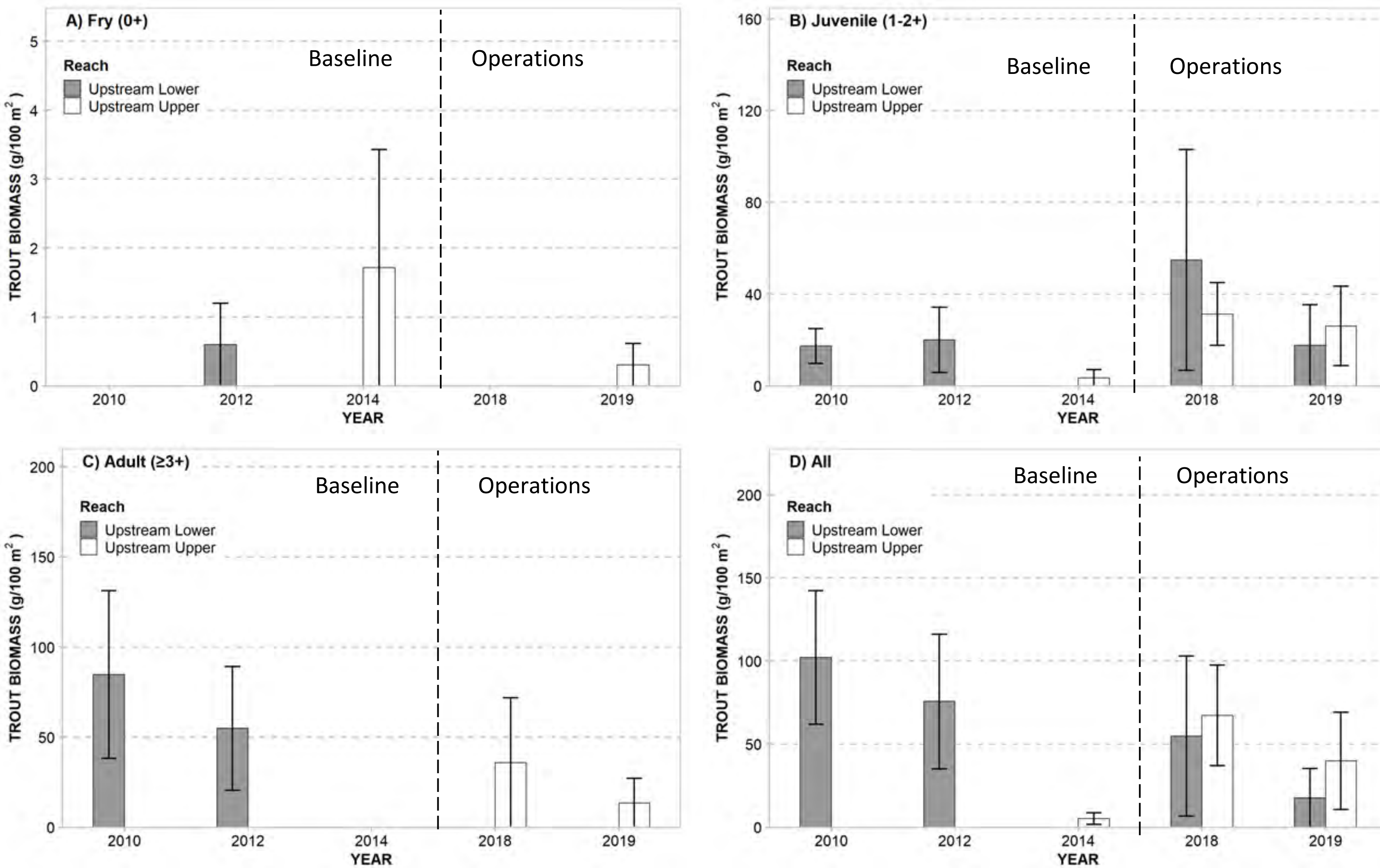


Figure 30. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the upper and lower clusters of upstream sites in 2010, 2012, 2014, 2018, and 2019 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined. Note that the upper cluster of sites was not added until 2014.



4.3. Wildlife Species Monitoring – Species at Risk & Regional Concern

A total of sixteen mammal species (including unidentified mammals, rodents, and shrew species), one reptile species, and seven avian species (including two observations of an unknown accipiter species, and an unknown eagle species) were incidentally observed and recorded by Ecofish personnel and Project operators in the Project area in 2019 (Table 59, Appendix M, Map 4). Incidental observations of species at risk and of regional concern in 2019 included those of Grizzly Bears, Moose, Mountain Goats, Mule Deer, Wolverines (*Gulo gulo luscus*), Bald Eagles (*Haliaeetus leucocephalus*), an unidentified eagle species, and Harlequin Ducks. In order to reduce the potential for human-wildlife conflict, observations of Grizzly Bears and Moose, especially Moose along the Lillooet River FSR, are given special consideration by Project operations (i.e., sightings are recorded and shared among Project operators to raise awareness of where Grizzly Bears and Moose are more likely to be encountered when working outdoors and driving). The 2019 incidental observations of species at risk and regional concern are described below. These results do not include observations of species at risk and regional concern from the wildlife cameras along Boulder Intake Road which are summarized in Section 4.4.2.

Grizzly Bears and American Black Bears

Grizzly Bears (which are provincially blue-listed and federally listed as Special Concern (CDC 2020)), were recorded incidentally on three occasions in 2019. A single yearling was observed at 40.5 km along the Lillooet River FSR on April 26. Two adults were observed: one on October 25 at 46 km along the Lillooet River FSR, and one on October 29 on the ULR HEF intake access road.

American Black Bears (*Ursus americanus*) were observed eleven times and tracks were documented once within the Project area in 2019. On April 23, a bear of unknown age was observed at the 2.5 km mark on the Lillooet River FSR. An American Black Bear was photographed by a remote infrared camera at Truckwash Creek (ULL-CAM15) on April 24 and May 11. On August 11, an adult female and two yearlings were spotted along the Lillooet River FSR at the 12 km mark. Several hours later, an adult was spotted at the 39 km mark along the Lillooet River FSR. There were a total of five incidental observations in September 2019: an adult was observed on September 5 near the Boulder Creek Compound (Boulder Creek HEF powerhouse and camp); a cub-of-the-year was observed on September 7 at the Boulder Creek Compound; a bear of unknown age was observed at 41 km along the Lillooet River FSR on September 15; a cub-of-the-year was observed on September 18 at the 31 km mark of the Lillooet River FSR; and finally, a cub-of-the-year was observed on September 20 on the ULR HEF powerhouse access road. Tracks from an adult bear were observed at Alena Creek on November 13, 2019.

None of the Grizzly Bears or American Black Bears observed appeared to be habituated. They all exhibited normal behaviour, avoiding people, including the two American Black Bears observed near the Boulder Creek HEF powerhouse and camp.

Moose

There were 12 incidental observations of Moose recorded by Ecofish and Innergex personnel within the Project area in 2019. All observations were along the Lillooet River FSR, with the exception of a single juvenile Moose seen at the ULR HEF powerhouse access road on May 13, 2019. A cow and a calf were seen on two separate occasions: from 14 -17 km on April 23, 2019, and at 11 km on August 28, 2019. Individual Moose were observed seven other times along the Lillooet River FSR, including a pregnant cow at 13 km on March 12, 2019.

Mountain Goat

Mountain Goats (provincially Blue-listed (CDC 2020)) were incidentally observed within the Project area once in 2019: Sensitive location and timing information has been removed to protect this species.

Mule Deer

Mule Deer were incidentally observed within the Project area once in 2019: on June 28, 2019, a female was seen at a gravel bar at ULL-DSSD01. In addition, one of the wildlife cameras (ULL-CAM15) along Truckwash Creek photographed animals recorded as unidentified mammals on May 8, 9, and 10, 2019, that were likely Mule Deer; however, photographic evidence was inconclusive. Incidental observations are not an indication of Mule Deer population size though, noting that Mule Deer were the most commonly photographed species by the remote infrared cameras set at the Boulder Creek HEF intake (Section 4.4.2).

Wolverine

Wolverine (provincially blue-listed and federally listed as Special Concern (CDC 2020)) tracks were incidentally observed three times within the Project area in 2019. Tracks were observed heading down to the Boulder Creek HEF intake access road on January 17. On February 26, tracks were observed twice, crossing and travelling along the ULL transmission line around 38 – 39.7 km, to the west of the Boulder Creek HEF powerhouse.

Harlequin Duck and Other Waterbirds

Six Harlequin Ducks were incidentally observed within the Project area in 2019. An adult male and female were observed feeding together at the Boulder Creek HEF intake on May 10, and another adult male and female were observed together in the Boulder Creek HEF headpond on May 11. On the Lillooet River, a single female was seen flying downstream on May 29, and another female was observed on June 18. Harlequin Duck survey results for the ULR HEF in 2019 are summarized in Appendix D.

All other water birds observed in 2019 were in the ULR HEF headpond: at least three Bufflehead and six to eight Mallards were observed on April 10 and at least two Bufflehead and ten Mallards were observed on April 15. Two male and one female Bufflehead were observed in the headpond on May 15 and three female and two male Mallards were observed in the headpond on September 16.

Bald Eagle

Bald Eagles were incidentally observed six times within the Project area in 2019, all of which were at Alena Creek. Three Bald Eagles were observed near Alena Creek on November 13. On November 24, a single Bald Eagle was observed a short distance away from a group of five Bald Eagles. On December 5, two Bald Eagles were observed perched in the trees. On December 9, a group of six Bald Eagles was feeding on fish carcasses, in addition to four more Bald Eagles observed in the area.

Table 59. Wildlife incidentally observed in the Project area in 2019.

Category	Species		Number of Individuals Observed	Number of Sign (e.g., tracks, scat) Observations
	Common Name	Scientific Name		
Species at Risk and of Regional Concern				
	Grizzly Bear	*Ursus arctos*	3	-
	Moose	*Alces americanus*	12	-
	Mountain Goat	*Oreamnos americanus*	4	-
	Mule Deer	*Odocoileus hemionus*	1	-
	Wolverine	*Gulo gulo*	-	3
	Harlequin Duck	*Histrionicus histrionicus*	6	-
	Bald Eagle	*Haliaeetus leucocephalus*	21	-
	Eagle	*unidentified species*	2	-
Other Species				
Avian	Accipiter	*unidentified species*	1	1
	Bufflehead	*Bucephala albeola*	8	-
	Mallard	*Anas platyrhynchos*	21	-
	Chukar	*Alectoris chukar*	15	-
Mammals	American Beaver	*Castor canadensis*	-	1
	American Black Bear	*Ursus americanus*	12	2
	American Marten	*Martes americana*	2	-
	Cougar	*Puma concolor*	1	-
	Coyote	*Canis latrans*	-	1
	Ermine	*Mustela erminea*	1	-
	Grey Wolf	*Canis lupus*	1	2
	mammal	*unidentified species*	3	1
	rodent	*unidentified species*	4	-
	shrew	*unidentified species*	1	-
	squirrel	*unidentified species*	7	-
	Snowshoe Hare	*Lepus americanus*	1	1
Reptiles	Northwestern Alligator Lizard	*Elgaria coerulea principis*	2	-

4.4. Wildlife Habitat Monitoring

4.4.1. Habitat Restoration – Mammal Habitat

Results of the inspections conducted to confirm that disposal of food waste is occurring as per Grizzly Bear compliance monitoring prescriptions are summarized in Table 60. All areas inspected were found to be generally neat and tidy and there were no bear attractants observed outside of the facilities.

Table 60. Summary of inspections conducted on September 18, 2019 to determine if disposal of food waste at facilities with waste management requirements is occurring in accordance with prescriptions for Grizzly Bears.

Location	Comments
ULR HEF powerhouse	No garbage can outside and no bear attractants. Open mesh metal recycling bin outside contained some wood and industrial plastic. The surrounding area was tidy and organized.
BDR HEF camp	No garbage can outside and no bear attractants. Area was clean and tidy.
BDR HEF powerhouse	No garbage can outside and no bear attractants. All materials and work equipment are stored near the parking area, neat and tidy.

4.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek

Monitoring results from remote cameras indicted that the gate across the Boulder Creek HEF access road prevented motorized public access during the sensitive winter period in Year 2. In accordance with Year 1 OEMP Report recommendations, a lock block was placed on the upslope side of the gate in 2019 to prevent potential motorized access around the gate (Figure 31). The only member of the public photographed above the gate during the sensitive winter period in Year 2 was a mountain biker, photographed by BDR-CAM01 and BDR-CAM02 along the intake access road on November 2, 2019 (Table 61, Figure 32). The mountain bike was not photographed by BDR-CAM03, Sensitive location, even though the camera was functional on this date (Table 7). Later in the winter, the gate became non-functional due to snow height; however, no members of the public were photographed crossing over the gate, or along the road above the gate, when there was snow on the ground.

Access to the Boulder Creek HEF intake is permitted year-round for Project personnel; however, Project personnel rarely require access to the intake during the winter and spring. Snowmobile access would have been challenging along the ungroomed access road during the 2019-2020 winter season given that Project personnel did not access the Boulder Creek HEF intake from November 20, 2019 to the end of the Year 2 monitoring period (February 23, 2020); thus, snow along the access road did not get compacted in the winter of 2019-2020. The first time Project vehicles were photographed along the access road in 2019 was on February 13 when the Project snow-cat travelled along the access road. The project snow-cat was also photographed along the access road on March 29, 2019.

Maintenance works at the Boulder Creek HEF intake during the spring 2019 required Project personnel to travel along the access road on five dates in April, seventeen dates in May, and seven dates in June.

Results from predator monitoring identified a number of potential Mountain Goat predators within the survey area in the vicinity of the Boulder Creek HEF intake (Table 62, Map 5). Remote infrared cameras photographed American Black Bear), Cougar (*Puma concolor*), Coyote (*Canis latrans*), Grey Wolf (*Canis lupus*), Grizzly Bear , and Wolverine , during the monitoring period (Table 62, Map 5), all of which are considered predators of Mountain Goats (Shackleton 1999). Cougars and Grey Wolves are considered main predators of Mountain Goats, while the other species are considered occasional predators (Shackleton 1999). Year 2 was the first time Cougars and Grey Wolves were detected in the vicinity of the Boulder Creek HEF intake. A single Cougar was detected on November 6 and December 5, 2019, and a pack of six Grey Wolves was detected on January 18 and March 27, 2019. The first time the Grey Wolves were photographed they were ascending the steep valley slope and not using the road (Figure 33). Approximately 2 months later they were photographed both on and off the road on a night when travel on or off the road would have been similarly easy due to a thick crust on the snow at this time. The Cougar photographed on November 6 was moving along the Boulder Creek HEF intake access road; and thus, may have used the road to access the area. However, there was no snow on the ground on November 6 and the Cougar was also photographed moving through the forest on December 5 (Figure 34). No kills were seen.

Sensitive location and timing information has been removed to protect this species.

Baseline surveys are not directly comparable to operation monitoring surveys as survey methods differed; nevertheless, it is worth noting that Sensitive location and timing information has been removed to protect this species.

Other species photographed included Snowshoe Hare, Squirrel, and Mule Deer. Mule Deer were the most commonly photographed species during the Year 2 monitoring period. They were photographed on 13 dates in May, 20 dates in June, 7 dates in July, and 1 date in October (note that cameras were removed on July 22 and reinstalled on October 29).

Figure 31. Lock block placed on the upslope side of the gate across the Boulder Creek HEF intake access road (BDR-CAM03) in 2019 to prevent potential motorized access around the gate.

Figure 32. Mountain biker photographed by BDR-CAM01 along the Boulder Creek HEF intake access road, above the gate, on November 2, 2020.

Figure 33. Pack of Grey Wolves moving up the slope in the vicinity of the Boulder Creek HEF intake photographed by BDR-CAM04 on January 18, 2019.

Figure 34. Cougar in the vicinity of the Boulder Creek HEF intake photographed by BDR-CAM06 on December 5, 2019.

Figure 35. Sensitive location and timing information has been removed to protect this species.

Sensitive location and timing information has been
removed to protect this species.

Sensitive location and timing information has been removed to protect this species.

Figure 36. Sensitive location and timing information has been removed to protect this species.

Sensitive location and timing information has been removed to protect this species.

Table 61. Human activity that was not associated with the Project along the Boulder Creek HEF intake access road documented with remote infrared cameras during the Year 2 monitoring period.

Non-Project Human Activity	Date	Time	Camera	Comments
Mountain Biker	2-Nov-2019	16:46	BDR-CAM02	mountain biker riding bike towards the intake
		16:54	BDR-CAM02	mountain biker pushing bike back up from the intake
		17:01	BDR-CAM01	mountain biker pushing bike back up from the intake

Table 62. Potential predators of Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road during the Year 2 monitoring period (January 17 to June 15, 2019 and November 1, 2019 to February 25, 2020).

Species		Camera	Date	Time	Number of Individuals
Common Name	Scientific Name				
American Black Bear	*Ursus americanus*	BDR-CAM01	25-Apr-2019	06:47:00	1
				11:25:00	1
			19-May-2019	09:32:00	1
		BDR-CAM02	29-Apr-2019	06:33:00	1
			19-May-2019	16:28:43	1
			09-Jun-2019	13:52:00	1
		BDR-CAM04	02-May-2019	19:16:00	2
			08-Jun-2019	12:06:00	1
			11-Jun-2019	13:09:00	1
			15-Jun-2019	10:03:00	1
				13:00:00	1
		BDR-CAM06	21-Apr-2019	15:38:00	1
			07-May-2019	17:39:00	1
			05-Jun-2019	17:23:00	1
		BDR-CAM07	15-Jun-2019	12:29:00	1
		BDR-CAM08	11-Jun-2019	13:16:00	1
Bear	unknown species	BDR-CAM02	14-May-2019	01:52:00	1
		BDR-CAM04	12-Jun-2019	13:02:00	1
Cougar	*Puma concolor*	BDR-CAM01	06-Nov-2019	19:20:00	1
		BDR-CAM06	06-Nov-2019	09:05:00	1
			05-Dec-2019	11:10:00	1
Coyote	*Canis latrans*	BDR-CAM04	12-Apr-2019	08:35:00	1
		BDR-CAM08	29-Apr-2019	18:22:00	2
Grey Wolf	*Canis lupus*	BDR-CAM01	27-Mar-2019	03:40:00	5
		BDR-CAM02	27-Mar-2019	04:36:00	1
		BDR-CAM04	18-Jan-2019	15:09:00	6
		BDR-CAM06	27-Mar-2019	05:06:00	6
Grizzly Bear	*Ursus arctos*	BDR-CAM02	25-Apr-2019	13:16:00	1
		BDR-CAM03	23-May-2019	07:52:00	1
		BDR-CAM05	25-Apr-2019	13:32:00	1
Wolverine	*Gulo gulo*	BDR-CAM01	31-Mar-2019	08:25:00	1
		BDR-CAM03	18-Mar-2019	18:11:00	1
		BDR-CAM04	31-Mar-2019	08:56:00	1
			04-May-2019	11:41:00	1
		BDR-CAM07	04-Feb-2019	12:46:00	1
		BDR-CAM08	04-May-2019	11:35:00	1

Sensitive location and timing information has been removed to protect this species.

5. RECOMMENDATIONS

5.1. Water Temperature

Temperature metrics recorded during Year 1 and Year 2 were not substantially different from the baseline monitoring results, however generally warmer and cooler temperatures were observed in 2018 and 2019, respectively. The warmest months on record, to date, considering both water and air temperature occurred in July/August of 2018 and 2019. Similarly, some of the coolest periods on record were observed during winter 2019, in both the water and air temperature data sets.

We recommend that the monitoring program continue in 2020 (Year 3), based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017). We recommend that water temperature at both upstream sites (ULL-USWQ02 and ULL-USWQ03) in the Upper Lillooet River continue to be collected to evaluate ground water influence in the upstream reach and that ULL-USWQ03 be moved if required to avoid groundwater influence. Similarly, we recommend that water temperature data continue to be collected in the upstream reach of Boulder Creek (BDR-USWQ2) and North Creek (NTH-USWQ1) until sufficient concurrent data sets are available to determine a relationship between water temperatures in the two creeks, when North Creek can then be used as the control stream.

5.1.1. Frazil Ice

The frazil ice assessment protocol has been implemented since December 2017 and crews have responded to two alarms since this date. As stated in the OEMP, our understanding of the effect of flow on frazil ice development and effects on frazil ice on fish habitat is limited. We recommend that future monitoring is continued in each of the Upper Lillooet River and Boulder Creek diversions in accordance with the protocols used in Year 1 and 2. As specified in the OEMP, the effectiveness and suitability of this monitoring and management protocol should continue to be evaluated annually for the duration of the five-year monitoring period under the direction of an Ecofish QP.

Recommendations for refinement of the protocol and thresholds will be provided once additional data are collected and analysed.

5.2. Fish Community

5.2.1. Juvenile Density and Biomass

Juvenile fish densities and biomass monitoring was successfully implemented in Year 2 using closed-site electrofishing surveys in the diversion and upstream reaches of the Upper Lillooet River and through mark re-sight snorkeling surveys within the diversion and downstream reaches of Boulder Creek. Based on results to date, we recommend that Years 3 and 4 be removed. The recommendation and rationale for the recommendation will be provided as a separate submission (Faulkner *et al.* in prep.).

5.2.2. Adult Fish Migration and Distribution

Adult Bull Trout and Cutthroat Trout migration and distribution monitoring was successfully implemented in Year 2 through a combination of angling surveys in the diversion and downstream reaches of the Upper Lillooet River and Boulder Creek, and spawning surveys in the reference streams 29.2 km Tributary and Alena Creek). We recommend using the same methods used in Year 2 for Years 3 to 5 of operational monitoring, as specified in the OEMP.

5.2.3. Assessment of Entrainment at the Upper Lillooet River Intake

Monitoring of the Headpond tributary at km 87.0 and ten upstream sites on the Upper Lillooet River through closed-site electrofishing surveys was successfully implemented in support of an assessment of fish entrainment at the Upper Lillooet River HEF intake in Year 2. Based on results to date, we recommend that Years 3 and 4 be removed. The recommendation and rationale for the recommendation will be provided as a separate submission (Faulkner *et al.* in prep.).

5.3. Water Quality Monitoring

Water quality monitoring was removed following evaluation of Year 1 (2018) operational results which indicated that the parameters measured under operating conditions had very similar values compared to what was observed under baseline conditions. The rational and details pertaining to the approved changes to the water quality monitoring program will be summarized in a separate submission (Faulkner *et al.* in prep.).

5.4. Wildlife Species Monitoring – Species at Risk & Regional Concern

Incidental wildlife observations in Year 2 have provided valuable information on the timing and locations of species at risk and of regional concern within the Project area, that would otherwise not be available. Documenting incidental observations of these species will continue in Years 3 through 5, as specified in the OEMP. To reduce the potential for human-wildlife conflict, it is recommended that Project personnel continue to record and share wildlife sightings with other Project personnel, especially of Grizzly Bear and Moose, to raise awareness of where Grizzly Bears and Moose are more likely to be encountered when working outdoors and driving.

5.5. Wildlife Habitat Monitoring

5.5.1. Habitat Restoration – Mammal Habitat

Mammal habitat restoration compliance monitoring for Grizzly Bear, Moose, and Mule Deer in Year 1 indicated that for most of the restoration monitoring sites (23 of 29 sites), future reassessment in Year 3 will be required (Regehr *et al.* 2019).

Inspections of facilities with waste management requirements where bear attractants had been observed in Year 1 indicated that garbage and food waste was being disposed of properly and this monitoring component is now considered complete.

5.5.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek

Results from mitigation effectiveness monitoring conducted to evaluate the effectiveness of the gate in preventing public access to the Boulder Creek HEF intake area within the Mountain Goat winter range during winter indicated that the access road was not accessible to the public by motorized vehicle; however, the gate becomes non-functional during the winter months due to burial from snow and therefore will not impede snowmobile access. No incidents of the public passing the gate during mid-winter when the gate was buried in snow were documented, thus potential gate inadequacies during these conditions are not currently an issue. Monitoring will continue for at least one more year, in accordance with the OEMP.

Predator Monitoring

Grey Wolves and Cougars were detected in the vicinity of the Boulder Creek HEF intake in Year 2, both on and off the access road. These two species had not been detected in the vicinity of the intake during baseline or Year 1 monitoring. Sensitive location and timing information has been removed to protect this species.

However, owing to the typically low frequency of predator detections, which makes it difficult to obtain adequate sample sizes for meaningful comparison, and in accordance with requirements of the OEMP, continued predator monitoring in the following years is needed to document whether or not a notable increase in predator use of the area is observed, as the road receives less Project-related use during winter and predators potentially discover the road and adjust their habitat use over time.

6. CLOSURE

The OEMP outlines the operational monitoring frequency and duration for each monitoring component. The monitoring objectives for Year 2 were achieved. Based on the results from the first two years of monitoring, changes to the monitoring programs being conducted under the Project's OEMP are being considered and will be included in a separate submission for review and approval by regulatory agencies.

REFERENCES

Barrett, J. 2015. Further Exemption from General Wildlife Measures for Ungulate Winter Range Related to the Boulder Creek Hydroelectric Facility (78700-35/06 UWR). Letter to J. Mancinelli, Boulder Creek Power Limited Partnership from S. Barrett, Ministry of Forests, Lands and Natural Resource Operations. November 13, 2013.

Barker, S. 2020. Upper Lillooet Hydro Project: Survival Surveys Report – Civil Works Sites. Consultant's report prepared for Upper Lillooet River Power Limited Partnership and Boulder Creek Limited Partnership, Vancouver, BC

Berardinucci, J. 2013. Exemption from General Wildlife Measures for Ungulate Winter Range related to the Boulder Creek Hydroelectric Facility. Letter to J. Mancinelli, Upper Lillooet River Power Limited Partnership from J. Berardinucci, Ministry of Forests, Lands and Natural Resource Operations. August 7, 2013.

Blackburn, I. 2016. Additional Exemption from General Wildlife Measures for Ungulate Winter Range Related to the Boulder Creek Hydroelectric Facility. Letter to J. Mancinelli, Innergex Renewable Energy Inc. from I. Blackburn, Ministry of Forests, Lands and Natural Resource Operations. April 29, 2016.

Calkins, J.D. 1993. Major river ice types and covers. Chap. In Environmental Aspects of River Ice. p. 4-11. National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, Canada: Prowse, T.D. and Gridley, N.C. editors.

Campbell, R.F. and J.H. Neuner. 1985. Seasonal and diurnal shifts in habitat utilization by resident rainbow trout in Western Washington Cascade mountain stream. Pp. 39-48. In; F.W. Olson, R.G. White and R.H. Hamre (ed.) Symposium on Small Hydropower and Fisheries, Amer. Fish. Soc., Western Div., Denver.

Carle, F. L. and M.R. Strub. 1978. A new method for estimating population size from removal data. Biometrics, 34, 621-830.

CDC (BC Conservation Data Centre). 2020. BC Species and Ecosystems Explorer. Available online at: http://a100.gov.bc.ca/pub/eswp/. Accessed on March 30, 2020.

Coleman, M.A. and K.D. Fausch. 2007. Cold summer temperature limits recruitment of age-0 cutthroat trout in high-elevation Colorado streams. Transactions of the American Fisheries Society 136(5):1231-1244.

Cowx, I.G. 1983. Review of the methods for estimating fish population size from survey removal data. Fisheries Management 14: 67–82. Fisheries Management 14:67–82.

DFO (Department of Fisheries and Oceans Canada). 2016. Review of Long Term Monitoring results from small hydro projects to Verify Impacts of Instream Flow Diversion on Fish and Fish Habitat. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/048.

EAO (BC Environmental Assessment Office). 2013. Upper Lillooet Hydro Project Environmental Assessment Certificate #E13-01. January 8, 2013.

EMA. 1991. Round 3 of Delphi Analysis for BT Habitat Requirements. Prepared for Montana Department of Fish Wildlife and Parks (Tom Weaver, contact).

Faulkner, S.G., A. Yeomans-Routledge, and A. Lewis. 2011. Upper Lillooet Hydro Project. Environmental Background – Fish Habitat. Report 3: Fish Habitat and Fish Community V.3. Consultant's report prepared by Ecofish Research Ltd. for Creek Power Inc.

Faulkner, S., S. Nicholl, A. Parsamanesh, M. Sparling, and A. Lewis. 2019a. Upper Lillooet Hydroelectric Facility: Ramping Summary Report. Draft V1. Consultant's report prepared for Innergex Renewable Energy Inc. by Ecofish Research Ltd, February 26, 2019.

Faulkner, S., S. Nicholl, A. Parsamanesh, M. Sparling, and A. Lewis. 2019b. Boulder Creek Hydroelectric Facility: Ramping Summary Report. Draft V1. Consultant's report prepared for Innergex Renewable Energy Inc. by Ecofish Research Ltd, March 14, 2019.

Faulkner, S and A. Lewis. *in prep*. Upper Lillooet Hydro Project Updated Operational Environmental Monitoring Plan. Memorandum prepared by Ecofish Research Ltd. for Innergex Renewable Energy Inc., *in prep*.

Ganshorn, K., K. Poetker, I. Mencke, and A. Lewis. 2011. Upper Lillooet Hydro Project Environmental Background – Fish Habitat Report 2: Water Quality. V.1. Consultant's report prepared by Ecofish Research Ltd.

Harwood, A., S. Faulkner, T. Hatfield and A. Lewis. 2012. Request for clarification on the monitoring of effects for the ULHP Project. Memo prepared by Ecofish Research Ltd. for Innergex Renewable Energy Inc. December 19, 2012.

Harwood, A., S. Faulkner, A. Yeomans-Routledge, K. Ganshorn, E. Smyth, and D. Lacroix. 2016a. Upper Lillooet River and Transmission Line Hydroelectric Facilities – Aquatic Baseline Report (Years 1-3). Consultant's report prepared by Ecofish Research Ltd., July 12, 2016.

Harwood, A., E. Smyth, Y. Imam, S. Faulkner, A. Yeomans-Routledge, D. West, K. Ganshorn, T. Jensma, S. Buchanan, and D. Lacroix. 2016b. Boulder Creek Hydroelectric Facility Aquatic Baseline Report (Years 1-3). Consultant's report prepared by Ecofish Research Ltd., January 23, 2018.

Harwood, A., S. Faulkner, K. Ganshorn, D. Lacroix, A. Newbury, H. Regehr, X. Yu, D. West, A. Lewis, S. Barker and A. Litz. 2017. Upper Lillooet Hydro Project: Operational Environmental Monitoring Plan. Consultant's report prepared for the Upper Lillooet River Power Limited Partnership and the Boulder Creek Power Limited Partnership. March 17, 2017.

Hatfield, T., A.F. Lewis, and S. Babakaiff. 2007. Guidelines for the collection and analysis of fish and fish habitat data for the purpose of assessing impacts from small hydropower projects in

British Columbia. Prepared by Solander Ecological Research Ltd. and Ecofish Research Ltd. for the BC Ministry of Environment, Surrey BC. Available online at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/best-management-practices/guidelinesifrv5_2.pdf. Accessed on April 14, 2020.

Hedberg (Hedberg and Associates Ltd.). 2011. Forest Resource Impact Assessment Upper Lillooet Hydro Project. Consultant's report prepared by Ecofish Research Ltd. for Creek Power Inc.

Korman, J., A.S. Decker, B. Mossop, and J. Hagen. 2010. Comparison of electrofishing and snorkeling mark-recapture estimation and detection probability and abundance of juvenile steelhead in a medium-sized river. North American Journal of Fisheries Management 30:1280-1302.

Lacroix, D., A. Newbury, M. Schulz, and M. Sloan. 2011a. Upper Lillooet Hydro Project: Wildlife Environmental Study and Assessment: Breeding Birds, Harlequin Ducks, and Raptor/Heron Nests. Consultant's report prepared by Ecofish Research Ltd. for Creek Power Ltd.

Lacroix, D., A. Newbury, M. Schulz, T. Jensma and M. Sloan. 2011b. Upper Lillooet Hydro Project: Wildlife Environmental Study and Assessment: Amphibians, Reptiles and Invertebrates, Version 1 Consultant's report prepared by Ecofish Research Ltd.

Lacroix, D., A. Newbury, M. Schulz, and M. Sloan. 2011c. Upper Lillooet Hydro Project: Wildlife Environmental Study and Assessment: Northern Goshawk (subspecies *laingi)* and Peregrine Falcon (subspecies *anatum*). Consultant's report prepared by Ecofish Research Ltd. for Creek Power Inc.

Lacroix, D., B. Schroeder and A. Newbury. 2011d. Upper Lillooet Hydro Project: Wildlife Environmental Study and Assessment: Spotted Owl and Western Screech-Owl. Version 2. Consultant's report prepared by Ecofish Research Ltd.

Le Cren, E. D. 1951. J. Anim. Ecol. 20, 201.

Leigh-Spencer, S., H. Bears, D. Lacroix, A. Newbury, and M. Schulz. 2012. Upper Lillooet Hydro Project: Wildlife Environmental Assessment - Mammals. Consultant's report prepared by Ecofish Research Ltd., Ecological Consulting Ltd., and Zoetica Wildlife Research Services for Creek Power Inc.

Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. Assessment methods for aquatic habitat and instream flow characteristics in support of applications to dam, divert, or extract water from streams in British Columbia. Report prepared for the Ministry of Water, Land and Air Protection and the Ministry of Sustainable Resource Management. Available online at: http://www.env.gov.bc.ca/wld/documents/bmp/assessment_methods_instreamflow_in_bc.pdf. Accessed on May 23, 2018.

Lewis, A., D. Urban, S. Buchanan, M. Schulz, S. Faulkner, K. Ganshorn, K. Healey, A. Harwood, M. Sloan, T. Jensma, and G. Stewart. 2012. Upper Lillooet Hydro Project. Aquatic Environmental

Assessment Final Report. Consultant's report prepared by Ecofish Research Ltd. January 18, 2012.

Lewis, F.J.A., A.J. Harwood, C. Zyla, K.D. Ganshorn, and T. Hatfield. 2013a. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88p. Available online at: https://waves-vagues.dfo-mpo.gc.ca/Library/40622617.pdf Accessed on April 14, 2020.

MAL (BC Ministry of Agriculture and Lands). 2008. Sea-to-Sky LRMP (Land and Resource Management Plan). April 2008. Available online at: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/southcoast-region/seatosky-lrmp/plan/seatosky_lrmp_plan_apr2008.pdf. Accessed on April 14, 2020.

Meier, W., C. Bonjour, A. Wüest and P. Reichert. 2003. Modeling the effect of water diversion on the temperature of mountain streams. Journal of Environmental Engineering, 129: 755-764.

MOE (B.C. Ministry of Environment). 2019. Approved Water Quality Guidelines. Available online at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-guidelines/approved-water-quality-guidelines. Accessed on November 30, 2018.

Monnot, L., J. B. Dunham, T. Hoem, and P. Koetsier. 2008. Influences of Body Size and Environmental Factors on Autumn Downstream Migration of Bull Trout in the Boise River, Idaho. North American Journal of Fisheries Management 28:231–240, 2008.

Newbury, A., V. Woodruff, D. Lacroix. 2018. Boulder Creek HEF Mitigation Effectiveness Monitoring for Mountain Goats – Revision to Monitoring Methodology. Consultant's memorandum prepared for the Boulder Creek Power Limited Partnership by Ecofish Research Ltd. December 10, 2018.

NHC (Northwest Hydraulic Consultants). 2011. Upper Lillooet Hydro Project Overview-Level Geomorphological Assessment. Consultant's report prepared by Northwest Hydraulic Consultants Ltd. for Creek Power Inc. November 24, 2011.

Ogle, D. 2016. R package "FSA": Function for Simple Fisheries Stock Assessment Methods. Version 0.8.5 Available online at: https://github.com/droglenc/FSA

Oliver, G.G. and L.E. Fidler. 2001. Towards a water quality guideline for temperature in the Province of British Columbia. Prepared for Ministry of Environment, Lands and Parks, Water Management Branch, Water Quality Section, Victoria, B.C. Prepared by Aspen Applied Sciences Ltd., Cranbrook, B.C., 53 pp + appnds. Available online at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/temperature-tech.pdf. Accessed on April 14, 2020.

R Core Team 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Regehr, H., D. Lacroix, A. Newbury, and S. Leigh-Spencer. 2014. Environmental Protection Plan: Human-bear conflict management plan. Consultant's Environmental Protection Plan prepared for Upper Lillooet Hydro Project by Ecofish Research Ltd.

Regehr, H., D. Lacroix, A. Newbury, and L. Ballin. 2016. Upper Lillooet Hydro Project: Wildlife Baseline Monitoring Report V2. Consultant's report prepared for Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership by Ecofish Research Ltd. July 14, 2016.

Regehr, H. A. Newbury, N. Swain, A. Yeomans-Routledge, S. Johnson, S. Sharron, S. Whyte, V. Woodruff, M. Dyck, T. Jensma, S. Faulkner, K. Ganshorn, T. Hicks, and D. Lacroix. 2019. Upper Lillooet Hydro Project Terrestrial and Wildlife OEM: Year 1. Consultant's report prepared for Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership by Ecofish Research Ltd., April 25, 2019.

RIC (Resources Inventory Committee). 1998. Inventory Methods for Riverine Birds: Harlequin Duck, Belted Kingfisher and American Dipper. Prepared by British Columbia Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee. Available online at: http://www.ilmb.gov.bc.ca/risc/pubs/tebiodiv/rbirds/assets/rbirds.pdf. Accessed on January 3, 2013.

RISC (Resources Information Standards Committee). 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory Standards and Procedures. Available online at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/recce2c.pdf. Accessed on April 14, 2020.

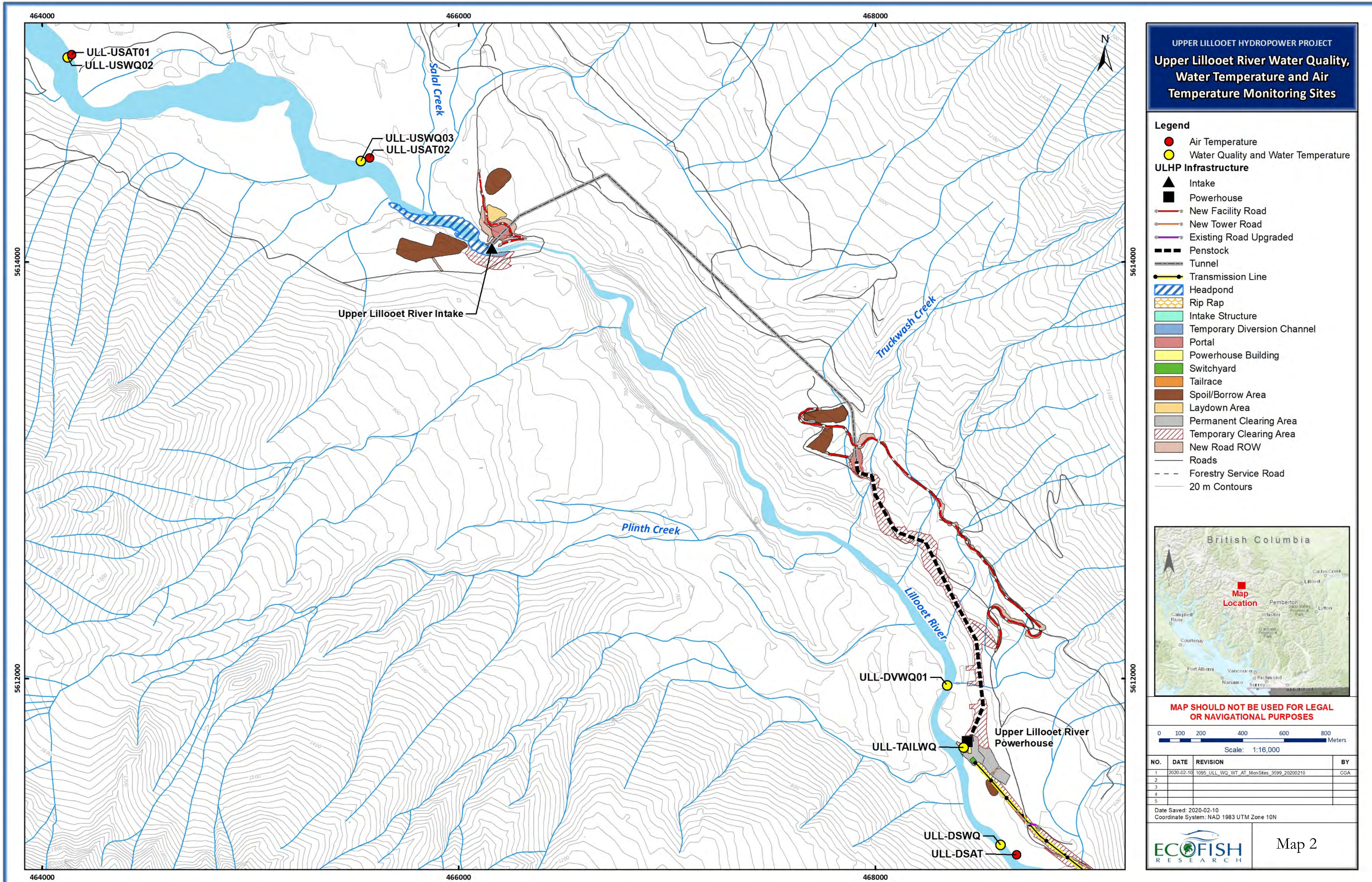
Shackleton, D. M. 1999. The Hoofed Mammals of British Columbia. Volume 3: The Mammals of British Columbia. Royal British Columbia Museum, Victoria, and UBC Press, Vancouver. 268 pp.

Thurow R.F., J.T Peterson, and J.W. Guzevish. 2006. Utility and validation of day and night snorkel counts for estimating bull trout abundance in 1st to 3rd order streams. N. Amer. J. Fish. Man. 26:117-132

Personal Communications

Katamay-Smith, T. 2020. Coordinator – Environment, Innergex. Email communication with A. Newbury, Ecofish Research Ltd. April 16, 2020.

PROJECT MAPS



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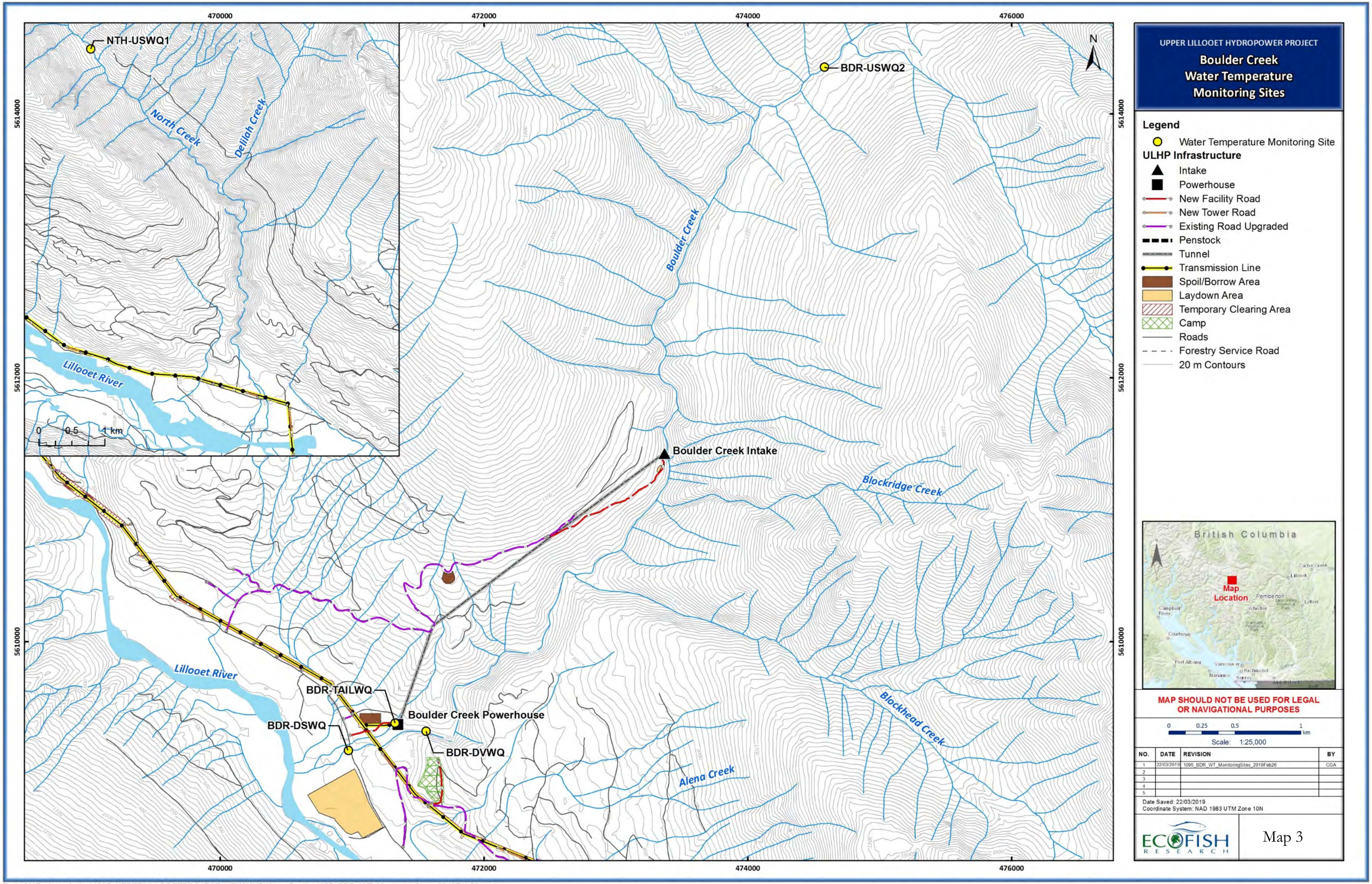

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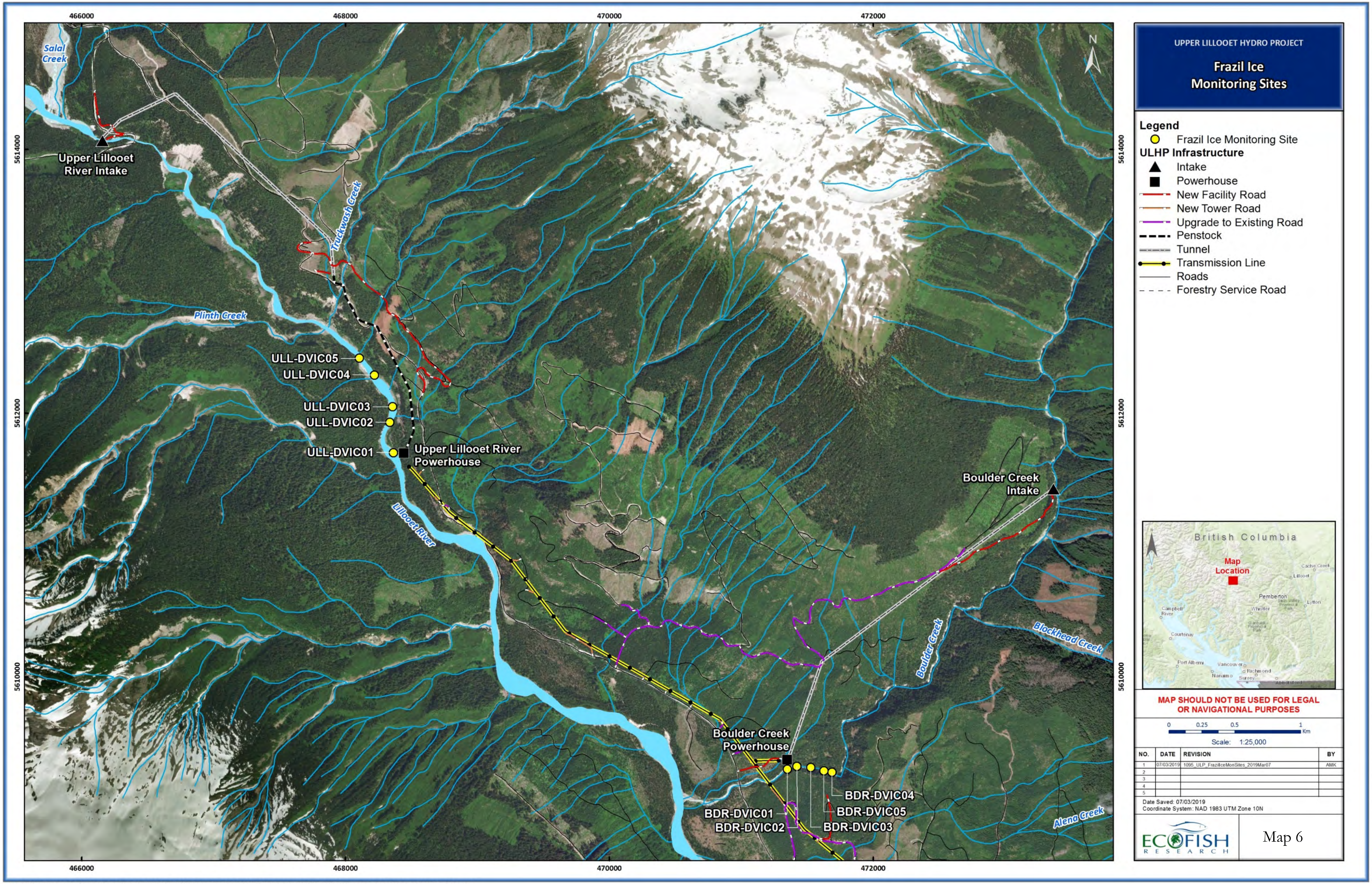

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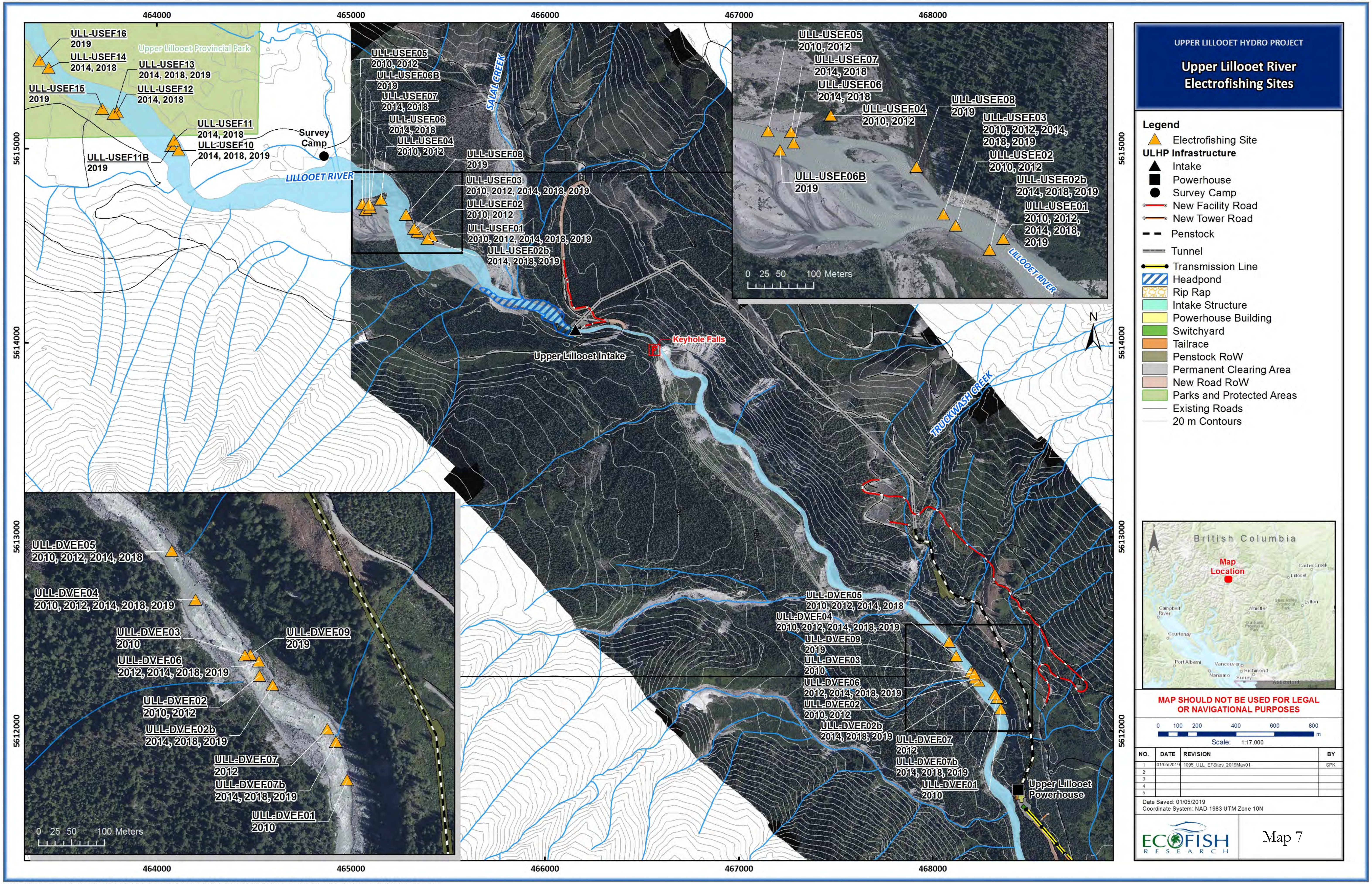

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APPENDICES

Appendix A. Vegetation Survival Survey (Barker 2020)

Upper Lillooet Hydro Project
Survival Survey Report - Civil works Sites Planted in 2018
Year 2 - 2019 Monitoring Year

Prepared for:

Upper Lillooet River Power Limited Partnership and Boulder Creek Limited Partnership

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Citation:

Barker, S. 2020. Upper Lillooet Hydro Project: Survival Surveys Report - Civil Works Sites. Consultant’s report prepared for Upper Lillooet River Power Limited Partnership and Boulder Creek Limited Partnership, Vancouver, BC.

Sara Barker, MSc

Disclaimer:

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List of Tables and Figures

1. Introduction

The Upper Lillooet Hydro Project ("ULHP") is owned and operated by the Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership (collectively, the Partnerships). The project is comprised of two run-of-river hydroelectric facilities, the largest of which is located on the mainstem of the Upper Lillooet River and a second facility located on Boulder Creek.

As a condition of the Project's Conditional Water License, Environmental Assessment Certificate, General Wildlife Measure Exemption Approvals and *Fisheries Act* Authorization, an Operational Environmental Management Plan ("OEMP") was finalized in March 2017 (Harwood et al, 2017). Revisions to the OEMP were proposed in 2018, including an updated vegetation monitoring frequency for Years 1, 3 and 5 only (Harwood et al, 2018). The revision to the vegetation monitoring program was approved in September 2019 by MFLNRORD (Katamay-Smith, personal communication, March 23, 2020). One of the requirements outlined in the OEMP was to complete long-term vegetation monitoring of sites that were rehabilitated and/ or revegetated following project construction.

As part of this overall OEMP program, Hedberg and Associates Consulting Ltd. ("HAC") was retained by the Partnerships to measure the survival of the planting program that occurred in October 2018. Although not directly part of the official OEMP monitoring program, the survival surveys were completed to monitor survival success following planting in the interim year (Year 2 of the program). The survival surveys were carried out one year following planting in 2018.

The following report details the revegetation efforts in 2018 as well as the survival of the planting efforts in 2019 -Year 2 (Note that official OEMP monitoring years are considered Year 1 (2018), 3 (2020) and 5 (2022).

2. Reforestation Sites – Fall 2018

The reforestation works that occurred at the ULHP civil works sites in October 2018 were carried out by HAC and their subcontractors. HAC was retained by the Partnerships to prepare planting prescriptions, and to coordinate and supervise the reforestation works. This is detailed in the memorandum prepared for Tanya Katamay-Smith titled Memorandum: Reforestation summary of October 2018 tree planting for civil works sites at the Upper Lillooet Hydroelectric Project (Barker 2019). It is also reproduced in part in the subsection below. The seedlings used for this project were sown in 2017 and were grown by Woodmere Nursery, in Telkwa, BC. In total, there were 69,410 trees planted as shown in Table 1 below. The seedlings were planted from October 9 - 16th, 2018. The treeplanting labour for this project was completed by Rainforest Field Services Ltd. Codie Johnston of HAC carried out the field verification of the planting prescriptions and the Quality Control of the treeplanting program. The weather conditions during planting were warm, sunny and dry.

The 2018 reforestation works were carried out at 19 civil works sites along the ULHP as shown in Table 1 below. A detailed breakdown of the species planted and at what density can be found in Appendix A. The reforestation prescriptions for each site in Table 1 and Appendix A were prepared by Wes Staven, RPF of HAC and are detailed in the "Final Revegetation Assessment for the Upper Lillooet Hydro Project" report by Barker and Staven (2017). The prescriptions reflected the biogeoclimatic zone and site series association within which the sites were located. Planting densities ranged depending on the difficulty rating and expected survival rates for each site, with high densities prescribed on sites that were expected to have a higher planting difficulty and lower survival, in an attempt to achieve an adequately reforested area without the need for a follow-up fill plant (Barker and Staven 2017). Planting densities that were prescribed were somewhat higher than what are typical for a Forest Licensee planting activity, but this was recommended due to the lack of an overstory seed source due to the wildfire that would normally provide for additional natural ingress (Barker and Staven 2017).

Table 1: ULHP Reforestation sites in Fall 2018

Zone	Elevation (m)	Latitude	Civil Works Site Name	Area (Ha)	Total Trees	SPH
1	450	50.03.00 - 50.04.00	38km Laydown	13.0	23,400	1,800
	550		Camp	6.5	10,400	1,600
	450		Operators residence	1.4	2,240	1,600
2	500		Explosive Magazine	2.5	1,500	600
	500		Boulder Spoil #4	0.4	720	1,800
	800		Boulder Spoil #7	0.6	360	600
3	500		Upper Spoil #5	1.1	1,980	1,800
	500		41.7km Laydown	1.1	1,760	1,600
4	650		Upper Spoil #6	1.0	1,800	1,800
	650		Upper Spoil #7	1.3	2,250	1,800
5	700		Upper Spoil #3	1.1	1,540	1,400
	700		Upper Spoil #4	1.6	2,240	1,400
	700		Upper Spoil #8	2.2	3,520	1,600
6	700		Upper Spoil #1	2.4	3,840	1,600
	700		Upper Spoil #2 & Settling Basins	2.8	4,480	1,600
	700		Upper Intake & Laydown (Contoured)	1.6	1,920	1,200
	700		Upper Intake & Laydown (Mounded)	0.8	1,280	1,600
	700		Keyhole Laydown	0.1	180	1,800
	700		Diversion Channel Slopes	2.5	4,000	1,600
Total				44.0	69,410	

3. Survival Surveys

The 2019 survival surveys were carried out by Wes Staven, RPF, Codie Johnston RFT, Hayley Auld and Sara Barker M.Sc., FIT. The fieldwork for the 2019 survival survey program was carried out from September to November, 2019. Plot data collection comprised a methodology similar to the process used for assessing commercial tree stocking on harvested areas (BC silviculture stocking survey procedure – FS658). Plot information that was collected included documenting the total number of live planted and natural trees, their percent cover and average heights, as well a description of shrub species contributing to revegetation/ or potential brush competition of the sites.

A minimum of one plot per site was established on sites smaller than one hectare. For areas greater than one hectare, one plot per hectare was used to evaluate a given site (also called stratum on the data collection cards in Appendix B). Each fixed radius plot measured 3.99 metres (m) in radius or 50 m^2 in area. Plots were pre-selected using a random GPS grid to avoid surveyor bias. Within each plot, the surveyors input the values into a computer program called "SNAP." Shrub and tree density values were calculated in the office based on the number of live stems counted for each species multiplied over the given area. For the conifer tree component, the recommended target stocking was set at 1000 stems per hectare, as recommended by the Registered Professional Forester (Wes Staven, RPF) assigned to this project. He based this target on the ecology of the area, the biogeoclimatic zone, similar project success rates and other site-specific variables.

4. Results

The majority of the sites had minimal topsoil (sites were typically lacking an LFH layer) and were typically rocky and rapidly-drained. Soils were de-compacted as per the ULHP Project Environmental Protection Plans and Construction and Environmental Management Plan. Some overburden was replaced where possible and coarse woody debris was present on all of the sites. The sites had little overstory in some of the adjacent areas (particularly in fire disturbed zones) to protect the newly regenerating trees or act as a seed source. In addition, the soil profile disturbance meant there was much less topsoil available to support colonization.

The results of the surveys are summarized in Table 2 below, which shows that nearly all sites met the target density of 1000 stems per hectare. The densities at all sites surveyed ranged between 400 stems per hectare to 5,400 stems per hectare, and although some of the regenerated conifers were showing signs of drought stress, widespread mortality is not expected but this will be monitored in future assessments.

There were three sites (highlighted in green) that did not meet the survival target of 1000 stems per hectare. A small fill plant program is recommended to address these deficient sites (see Section 5).

Table 2: Upper Lillooet Survival Survey Results 2019

Upper Lillooet Reforestation Survival Survey Results 2019								
Zone	Elevation (m)	Latitude	Project Site	Area (Ha)	2018 Planted SPH	2019 SPH	Target	Fill plant recommended
1	450	50.30 - 50-40	38km Laydown	13.0	1,800	1,500	1,000	no
	550		Camp	6.5	1,600	1,933	1,000	no
	450		New spoil area for boulder operators residence excavation	1.4	1,600	1,000	1,000	no
2	500		Explosive Magazine	2.5	600	1,400	1,000	no
	500		Boulder Spoil #4	0.4	1,800	1,200	1,000	no
	800		Boulder Spoil #7	0.6	600	1,000	1,000	no
3	500		Upper Spoil #5	1.1	1,800	400	1,000	yes
	500		41.7km Laydown	1.1	1,600	7,000	1,000	no
4	650		Upper Spoil #6	1.0	1,800	5,400	1,000	no
	650		Upper Spoil #7	1.3	1,800	1,800	1,000	no
5	700		Upper Spoil #3	1.1	1,400	1,400	1,000	no
	700		Upper Spoil #4	1.6	1,400	1,200	1,000	no
	700		Upper Spoil #8	2.2	1,600	1,700	1,000	no
6	700		Upper Spoil #1	2.4	1,600	3,733	1,000	no
	700		Upper Spoil #2 & Settling Basins	2.8	1,600	800	1,000	yes
	700		Upper Intake & Laydown(Contoured)	2.4	1,400	1,720	1,000	no
	700		Keyhole Laydown	0.1	1,800	600	1,000	yes
	700		Diversion Channel Slopes	2.5	1,600	1,640	1,000	no
Total				44.0				

Sites which did not meet the target stocking level had the following qualities:

- Upper Spoil #5 – This site has cobbly till soils with little to no organic matter. The upper portion is quite compact and the fill slopes are loose and prone to raveling. Animal browse was not an issue as all the dead seedlings were still visible at the time of the survey. Mortality was likely due to drought conditions on this steep south-facing site, or perhaps due to cold air pooling adjacent to the Lillooet River.
- Upper Spoil #2 – This site has compacted soils, minimal organics, and is prone to desiccation. Stocking was quite variable due to shading/ exposure from the mounds and varying compaction of the planted microsite. The site's edges were contoured and compact with a high component of rock in the soils.
- Keyhole Laydown: This site has increased shrub and grass cover, resulting in increased competition for light, water and nutrients potentially making seedling establishment more difficult.

The survey data collection cards (Appendix C) show that a diverse range of species are regenerating at many of the sites. The conifers present on the sites included: Douglas fir, Spruce, Lodgepole pine, Amabilis Fir, Western redcedar, Ponderosa Pine, Western hemlock. The hardwood species consisted of Red Alder, and Black Cottonwood. The surveys also found that although there was some competition, none of the brush densities were significant enough to warrant brushing at this time. The pioneering species present on site are currently providing shade in the dry and open sites thus contributing to the current success of the revegetation program. There was no evidence of snow press from competing vegetation and only minor evidence of browse at some of the lower elevation sites.

Photos of each site are shown in Appendix D, which will be reproduced in subsequent surveys to view the succession of the sites.

5. Conclusions and recommendations

In general, observations from the 2019 Year 2 survival surveys showed that the survival was well within and/or above the target densities on the majority of sites, but that a small fill plant is recommended on three of the sites. Details are shown in Table 3 below. The fill plant will require 3,020 trees in total.

Table 3: Fill plant for the sites with low survival success

Project Site	Area (Ha)	Total Trees	SPH TO PLANT	2019 Total SPH
Upper Spoil #5	1.1	1,540	1,400	400
Upper Spoil #2 & Settling Basins	1.4	1,120	800	800
Upper Intake & Laydown	0.2	240	1,200	0
Keyhole Laydown	0.1	120	1,200	600
	2.8	**3,020**		

No invasive species treatments are required at this time. No major erosion issues were noted, and slope shaping / decompaction treatments are providing for successful root penetration of the newly established vegetation.

Conifers and early pioneering species such as thimbleberry, alder, cottonwood and other early colonizers were present, and appeared vigorous and healthy with no major disease infestations or damage.

In conclusion, the areas assessed in 2019 are on target to meet project requirements. Each site will be closely monitored in future OEMP monitoring years (Year 3 and Year 5).

6. References

Barker, 2019. Memorandum prepared for Tanya Katamay-Smith of for Upper Lillooet River Power Limited Partnership and Boulder Creek Limited Partnership, prepared March 26, 2019 Re: Reforestation summary of October 2018 tree planting for civil works sites at the Upper Lillooet Hydro Project.

Harwood, A., S. Faulkner, K. Ganshorn, D. Lacroix, A. Newbury, H. Regehr, X. Yu, D. West, A. Lewis, S. Barker and A., Litz. Upper Lillooet Hydro Project Operational Environmental Monitoring Plan. Consultant's Report prepared for the Upper Lillooet River Power Limited Partnership and the Boulder Creek Limited Partnership. March 17, 2017.

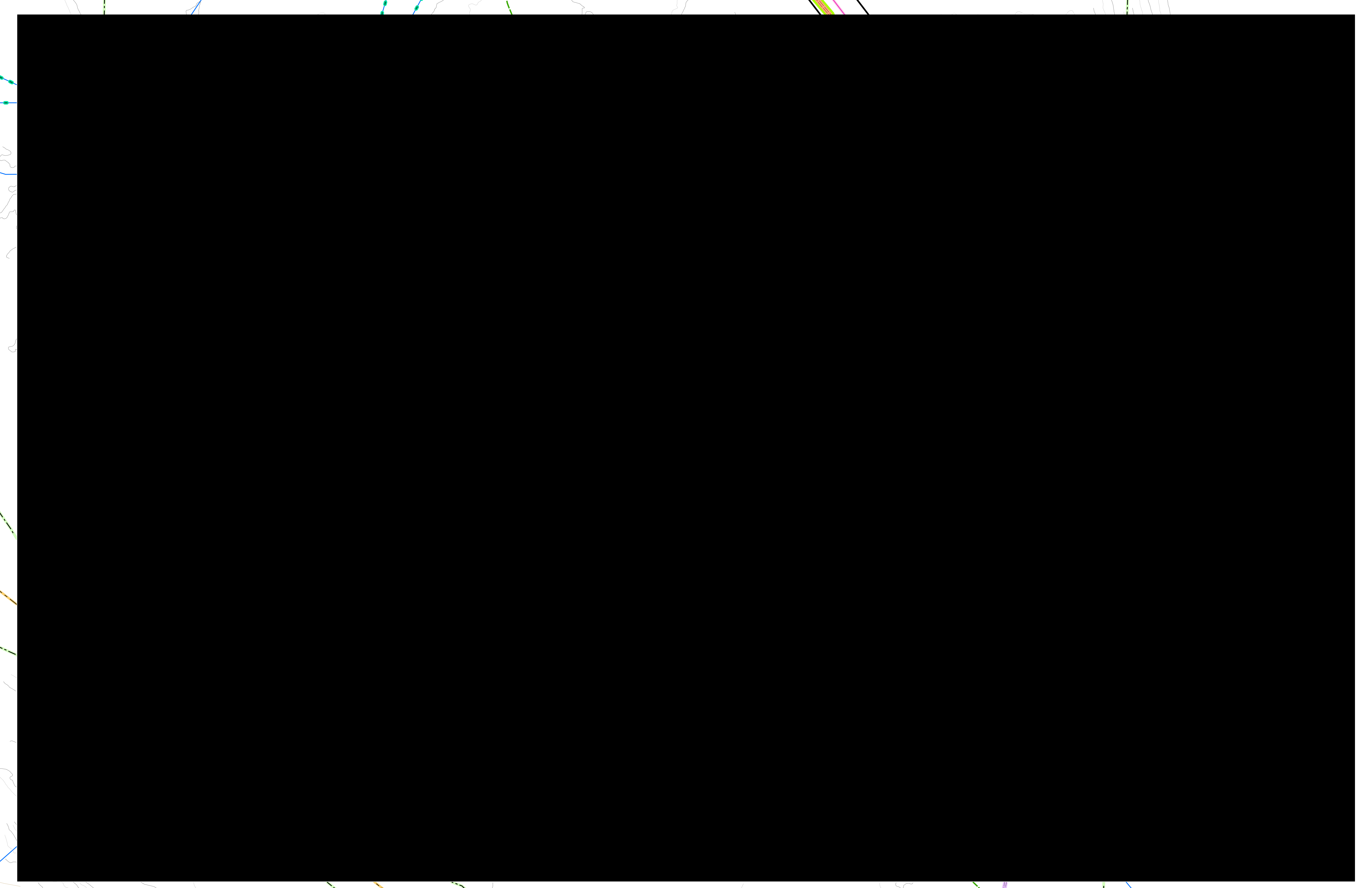
Faulkner, S., A. Harwood and D. Lacroix. 2019. Upper Lillooet Hydro Project Updated Operational Environmental Monitoring Plan. Consultant's memo prepared for the Upper Lillooet River Power Limited Partnership and the Boulder Creek Limited Partnership. February 8, 2018.

7. Appendices

7.1. Appendix A: Upper Lillooet Reforestation 2018 Planting Summary

Upper Lillooet Reforestation 2018 Planting Summary							Tree Species % of Each Site					Tree Species Numbers per Site					Fertilizer Pack Numbers per Site		
Zone	Elevation (m)	Latitude	Civil Works Site Name	Area (Ha)	Total Trees	SPH	% Fdc	% Cw	% Ba	% Plc	% Sx	Fdc	Cw	Ba	Plc	Sx	20 Gr Worms	20 Gr Bio Char	10 Gr Chilcotin
	450		38km Laydown	13.0	23,400	1,800	55%	10%	0%	25%	10%	12,870	2,340	0	5,850	2,340	7,800	7,800	7,800
1	550		Camp	6.5	10,400	1,600	65%	10%	0%	25%	0%	6,760	1,040	0	2,600	0		10,400	
	450		Operators residence	1.4	2,240	1,600	40%	10%	20%	10%	20%	896	224	448	224	448		1,050	
	500		Explosive Magazine	2.5	1,500	600	80%	20%	0%	0%	0%	1,200	300	0	0	0			1,120
2	500		Boulder Spoil #4	0.4	720	1,800	60%	10%	0%	30%	0%	432	72	0	216	0			720
	800		Boulder Spoil #7	0.6	360	600	50%	0%	20%	0%	30%	180	0	72	0	108		360	
3	500		Upper Spoil #5	1.1	1,980	1,800	10%	10%	30%	0%	50%	198	198	594	0	990		1,980	
	500		41.7km Laydown	1.1	1,760	1,600	30%	10%	20%	10%	30%	528	176	352	176	528		3,200	
4	650		Upper Spoil #6	1.0	1,800	1,800	40%	0%	20%	0%	40%	720	0	360	0	720			1,800
	650		Upper Spoil #7	1.3	2,250	1,800	40%	0%	20%	0%	40%	900	0	450	0	900			2,250
	700	50.30 - 50-40	Upper Spoil #3	1.1	1,540	1,400	30%	10%	30%	0%	30%	462	154	462	0	462			1,540
5	700		Upper Spoil #4	1.6	2,240	1,400	50%	20%	20%	0%	10%	1,120	448	448	0	224			2,240
	700		Upper Spoil #8	2.2	3,520	1,600	30%	20%	20%	0%	30%	1,056	704	704	0	1,056	3,960		
	700		Upper Spoil #1	2.4	3,840	1,600	10%	10%	40%	0%	40%	384	384	1,536	0	1,536	3,840		
	700		Upper Spoil #2 & Settling Basins	2.8	4,480	1,600	10%	10%	40%	0%	40%	448	448	1,792	0	1,792		4,480	
6	700		Upper Intake & Laydown(Contoured)	1.6	1,920	1,200	10%	10%	50%	0%	30%	192	192	960	0	576		1,920	
	700		Upper Intake & Laydown(Mounded)	0.8	1,280	1,600	10%	10%	40%	0%	40%	128	128	512	0	512		1,280	
	700		Keyhole Laydown	0.1	180	1,800	0%	0%	50%	0%	50%	0	0	90	0	90			180
	700		Diversion Channel Slopes	2.5	4,000	1,600	20%	15%	30%	0%	35%	800	600	1,200	0	1,400		4,500	
Total				44.0	69,410							29,274	7,408	9,980	9,066	13,682	15,600	36,970	17,650

7.2. Appendix B: Maps



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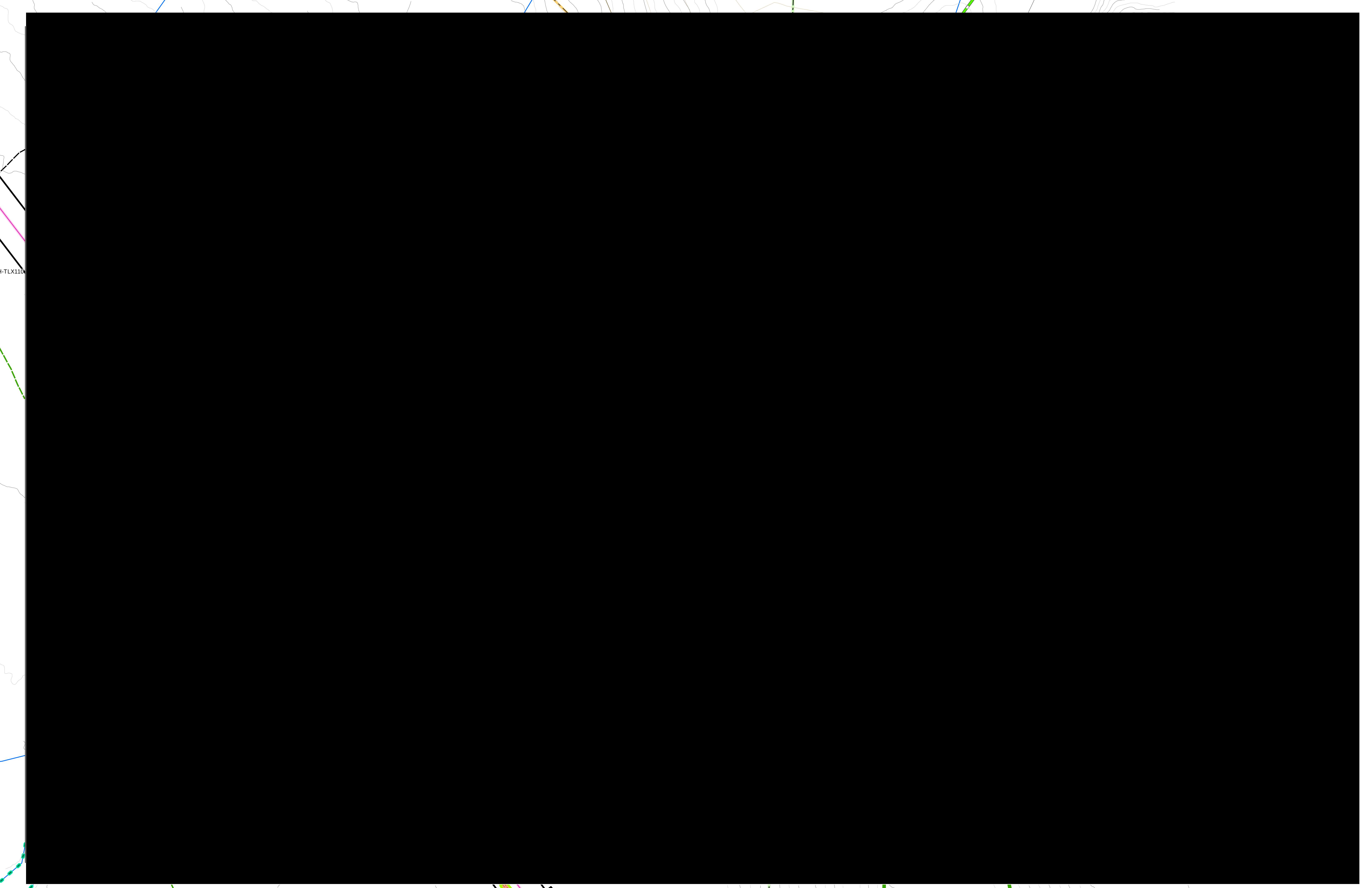

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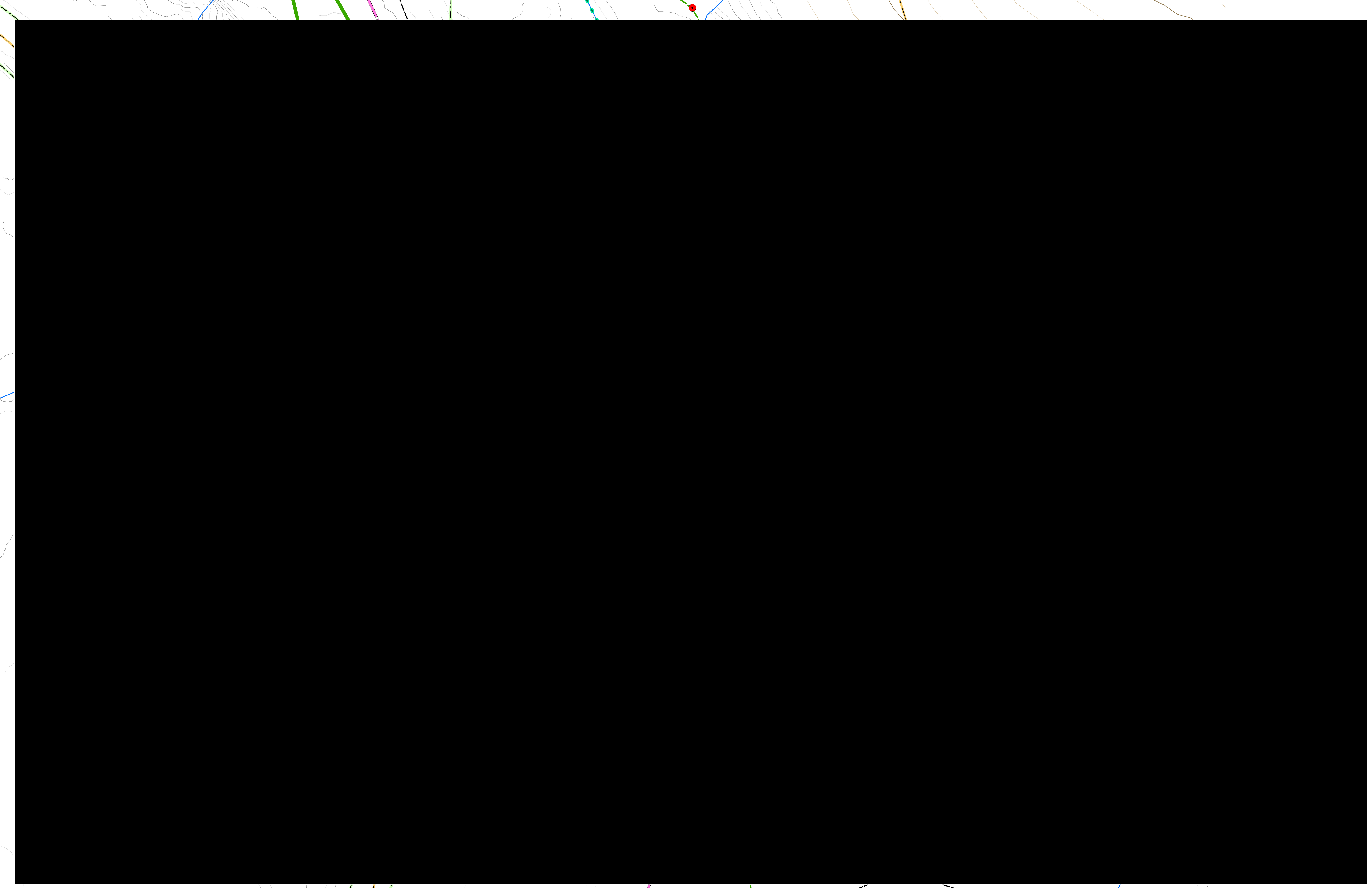

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7.3. Appendix C: Civil Works Sites Survival Surveys Plot Data

Project: Year 2 Survival Surveys

							Percentage Cover			Forest Health			
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)	Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
38 Km Laydown	W1	Oct 22, 2019 12:53	5608973	470990	Amabalis Fir	3	Black Cottonwood	2	30	ND Drought	Amabalis Fir	0	1
					Douglas Fir	2	Fireweed	2	25	ND Drought	Western Red Cedar	0	1
					Lodgepole Pine	4	Grass	2	25				
							Red Alder	1	20				
							Red raspberry	4	40				
							Thimbleberry	3	30				
							Willow	2	25				
						9							
	W2		5608885	471039	Douglas Fir	8		0	0	ND Drought	Fdc	0	1
						8							
	W3		5608800	471084	Lodgepole Pine	7		0	0			0	0
					Spruce	3							
						10							
	W4		5608711	471134	Lodgepole Pine	1	Black Cottonwood	5	50			0	0
					Spruce	5	Fireweed	15	50				
							Grass	3	25				
							Lupine	5	25				
						6							
	W5		5608622	471174	Douglas Fir	3		0	0	ND Drought	Western Red Cedar	0	1
					Spruce	2							
					Western Red Cedar	2							
						7							
	W6		5608573	471087	Douglas Fir	3		0	0	ND Drought	Douglas Fir	0	2
					Lodgepole Pine	1							
					Spruce	1							
					Western Red Cedar	1							
						6							
	W7		5608665	471039	Douglas Fir	3		0	0	AD Deer	Douglas Fir	2	0
					Lodgepole Pine	4				ND Drought	Western Red Cedar	0	1
					Spruce	2							
					Western Red Cedar	2							
						11							
	W8		5608625	470951	Douglas Fir	5		0	0			0	0

Project: Year 2 Survival Surveys

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percentage Cover: Species	% Cover	Height (cm)	Forest Health: Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
					Spruce	4							
						9							
	W9		5608709	470893	Douglas Fir	6		0	0	ND Drought	Douglas Fir	0	1
					Lodgepole Pine	1							
						7							
	W10		5608757	470982	Douglas Fir	6		0	0			0	0
					Spruce	2							
						8							
	W11		5608822	471009	Douglas Fir	2		0	0	AD Deer	Western Red Cedar	1	0
					Spruce	1				ND Drought	Douglas Fir	0	3
					Western Red Cedar	1				ND Drought	Western Red Cedar	0	1
						4							
	W12		5608850	470945	Douglas Fir	4		0	0	ND Drought	Douglas Fir	0	1
					Spruce	4							
						8							
	W13		5608793	470857	Amabalis Fir	2		0	0	ND Drought	Amabalis Fir	0	4
					Spruce	2							
						4							
	W14		5608888	470809	Amabalis Fir	1		0	0			0	0
					Douglas Fir	1							
					Lodgepole Pine	3							
						5							
	W15		5608935	470901	Amabalis Fir	5		0	0			0	0
					Douglas Fir	1							
					Lodgepole Pine	3							
					Western Red Cedar	1							
						10							
						112							
41.7 Km Laydown	H16	Sep 25, 2019 12:48	5611558	468606	Douglas Fir	2		0	0	ND Drought	Douglas Fir	2	0
					Spruce	4				ND Drought	Spruce	4	0
						6							
	H17	Sep 25, 2019 12:58	5611558	468724	Black Cottonwood	33		0	0			0	0
					Douglas Fir	6							

Project: Year 2 Survival Surveys

							Percentage Cover			Forest Health			
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)	Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
					Red Alder	25							
						64							
						70							
Boulder Powerhouse and Spoil	A2	Sep 25, 2019 15:11	5609312	471217	Douglas Fir	3	Black Cottonwood	3	75	AD Deer	Douglas Fir	2	0
							Pearly Everlasting	2	60				
						3							
	H24	Sep 25, 2019 15:07	5609405	471124	Douglas Fir	6		0	0			0	0
						6							
	SE2	Sep 25, 2019 15:06	5609462	471192	Douglas Fir	4	Black Cottonwood	2	12	AD Deer	Western Hemlock	1	0
					Lodgepole Pine	1							
					Western Hemlock	1							
						6							
						15							
Boulder Spoil #4	SE1	Sep 25, 2019 14:42	5610156	470078	Douglas Fir	1	Fireweed	1	5	AD Deer	Spruce	1	0
					Spruce	5	Red Raspberry	2	45	ND Drought	Spruce	1	0
							Thimbleberry	1	30				
						6							
						6							
Boulder Spoil #7	H27	Nov 8, 2019 10:54	5610524	471599	Douglas Fir	5		0	0			0	0
						5							
						5							
Camp	C3	Nov 8, 2019 11:24	5608816	471650	Amabalis Fir	3							
					Black Cottonwood	5							
					Douglas Fir	5							
					Lodgepole Pine	4							
					Ponderosa Pine	4							
						21							
	C4	Nov 8, 2019 11:36	5608898	471580	Douglas Fir	4		0	0	ND Drought	Douglas Fir	0	2
					Lodgepole Pine	1							
					Ponderosa Pine	1							
						6							
	C5	Nov 8, 2019 11:45	5608900	471650	Black Cottonwood	1		0	0			0	0

Project: Year 2 Survival Surveys

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percentage Cover: Species	% Cover	Height (cm)	Forest Health: Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
					Douglas Fir	3							
					Lodgepole Pine	3							
					Ponderosa Pine	1							
						8							
	H28	Nov 8, 2019 11:27	5609001	471645	Douglas Fir	5		0	0			0	0
					Lodgepole Pine	5							
						10							
	H29	Nov 8, 2019 11:33	5609103	471613	Douglas Fir	6		0	0			0	0
						6							
	H30	Nov 8, 2019 11:38	5609003	471582	Douglas Fir	6		0	0			0	0
					Lodgepole Pine	1							
						7							
						58							
Diversion Channel Slopes	C1	Nov 8, 2019 09:38	5613965	466234	Amabalis Fir	11	Fireweed	10	120			0	0
					Douglas Fir	1	Grass	35	25				
					Spruce	1	Vaccinium	5	25				
					Western Red Cedar	1							
						14							
	H3	Sep 19, 2019 11:20	5613978	466102	Amabalis Fir	1		0	0			0	0
					Douglas Fir	1							
					Red Alder	2							
					Spruce	2							
						6							
	H4	Sep 19, 2019 11:27	5613943	466128	Amabalis Fir	2	Grass	8	25	ND Drought	Douglas Fir	4	0
					Douglas Fir	4				ND Drought	Spruce	1	0
					Spruce	1							
						7							
	H25	Nov 8, 2019 09:39	5614034	466250	Douglas Fir	5		0	0			0	0
					Spruce	2							
						7							
	S3	Sep 19, 2019 11:14	5614044	465997	Amabalis Fir	2	Fireweed	5	36	ND Drought	Amabalis Fir	0	0
					Red Alder	1	Willow	3	140	ND Drought	Spruce	0	0
					Spruce	4							

Project: Year 2 Survival Surveys

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percentage Cover: Species	% Cover	Height (cm)	Forest Health: Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
						7							
						41							
Explosive Magazine	A1	Sep 25, 2019 14:52	5610401	469957	Douglas Fir	6		0	0			0	0
						6							
	H23	Sep 25, 2019 14:52	5610460	469847	Douglas Fir	8	Horsetail	5	20			0	0
							Red Raspberry	10	85				
							Thimbleberry	5	35				
						8							
						14							
Keyhole Laydown	H5	Sep 19, 2019 12:01	5614078	466441	Amabalis Fir	3	Grass	10	30			0	0
							Red Raspberry	10	8				
							Vaccinium	5	50				
						3							
						3							
Upper Intake and Laydown	H6	Sep 19, 2019 12:16	5614256	466100	Amabalis Fir	1	Black Cottonwood	4	75			0	0
					Black Cottonwood	15	Pearly Everlasting	2	25				
					Douglas Fir	1	Red Raspberry	8	80				
					Spruce	4							
					Western Red Cedar	1							
						22							
	H7	Sep 19, 2019 12:27	5614156	466145	Western Hemlock	1	Red Osier Dogwood	5	58	ND Drought	Spruce	0	2
					Western Red Cedar	1							
						2							
	H8	Sep 19, 2019 12:40	5614171	466214	Red Alder	1		0	0	ND Drought	Amabalis Fir	0	1
					Spruce	3							
					Western Red Cedar	1							
						5							
	H9	Sep 19, 2019 12:47	5614211	466222	Spruce	5		0	0	ND Drought	Spruce	5	0
						5							
	H10	Sep 19, 2019 12:54	5614243	466168	Amabalis Fir	1		0	0			0	0
					Douglas Fir	3							
					Red Alder	1							

Project: Year 2 Survival Surveys

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percentage Cover: Species	% Cover	Height (cm)	Forest Health: Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
					Spruce	2							
					Western Hemlock	2							
						9							
						43							
Upper Spoil #1	H2	Sep 19, 2019 10:12	5614059	465743	Douglas Fir	3		0	0	ND Drought	Douglas Fir	2	1
					Spruce	3				ND Drought	Spruce	3	0
						6							
	S1	Sep 19, 2019 10:12	5614073	465828	Amabalis Fir	1	Black Cottonwood	5	100	ND Drought	Amabalis Fir	0	1
					Black Cottonwood	20	Fireweed	3	80	ND Drought	Douglas Fir	4	1
					Douglas Fir	6	Vaccinium	2	30	ND Drought	Spruce	5	0
					Lodgepole Pine	2							
					Spruce	5							
						34							
	S2	Sep 19, 2019 10:58	5614048	465895	Amabalis Fir	1	Grass	3	30	ND Drought	Amabalis Fir	0	0
					Red Alder	9				ND Drought	Spruce	0	0
					Spruce	5				ND Drought	Western Red Cedar	0	0
					Western Red Cedar	1							
						16							
						56							
Upper Spoil #2 & Settling Basin	S4	Sep 19, 2019 12:15	5614300	466145	Douglas Fir	1		0	0	ND Drought	Douglas Fir	1	0
					Spruce	2				ND Drought	Spruce	2	0
						3							
	S5	Sep 19, 2019 12:33	5614379	466183	Amabalis Fir	3		0	0	ND Drought	Amabalis Fir	0	0
					Douglas Fir	2				ND Drought	Douglas Fir	0	0
					Spruce	1				ND Drought	Spruce	0	0
						6							
	S6	Sep 19, 2019 12:42	5614411	466235	Spruce	5		0	0	ND Drought	Spruce	6	0
						5							
	S7	Sep 19, 2019 12:53	5614415	466170	Amabalis Fir	1		0	0	ND Drought	Amabalis Fir	1	0
					Spruce	1				ND Drought	Douglas Fir	0	1
										ND Drought	Spruce	1	1
										ND Drought	Western Red Cedar	0	1

Project: Year 2 Survival Surveys

							Percentage Cover			Forest Health			
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)	Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
						2							
						16							
Upper Spoil #3	H13	Sep 25, 2019 11:50	5613276	467724	Amabalis Fir	2	Pearly Everlasting	2	45			0	0
					Douglas Fir	2	Red Raspberry	4	80				
					Spruce	3							
						7							
						7							
Upper Spoil #4	H14	Sep 25, 2019 12:15	5613156	467756	Amabalis Fir	2	Grass	4	35			0	0
					Douglas Fir	4							
					Western Red Cedar	1							
						7							
	H15	Sep 25, 2019 12:27	5613128	467689	Amabalis Fir	1		0	0			0	0
					Douglas Fir	1							
					Spruce	1							
					Western Red Cedar	2							
						5							
						12							
Upper Spoil #5	H18	Sep 25, 2019 13:15	5611443	468557	Spruce	3		0	0	ND Drought	Spruce	3	0
						3							
	H19	Sep 25, 2019 13:20	5611506	468513	Spruce	4		0	0			0	0
						4							
	H20	Sep 25, 2019 13:23	5611460	468507	Spruce	2		0	0			0	0
						2							
	H21	Sep 25, 2019 13:26	5611421	468535	Amabalis Fir	1		0	0			0	0
					Spruce	1							
						2							
	H22	Sep 25, 2019 13:28	5611394	468579		0		0	0			0	0
						0							
						11							
Upper Spoil #6	C2	Nov 8, 2019 10:19	5612465	468294	Black Cottonwood	14							
					Douglas Fir	10							
					Red Alder	2							
					Spruce	1							

Project: Year 2 Survival Surveys

							Percentage Cover			Forest Health			
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)	Pest Code	Host Spp	Live Trees Affected	Dead Trees Affected
						27							
						27							
Upper Spoil #7	H1	Nov 8, 2019 10:17	5612213	468524	Douglas Fir	7							
					Lodgepole Pine	2							
						9							
						9							
Upper Spoil #8	H11	Sep 25, 2019 11:22	5613388	467799	Douglas Fir	1	Thimbleberry	4	30	AD Deer	Cw	5	0
					Spruce	2	Vaccinium	2	35				
					Western Red Cedar	7							
						10							
	H12	Sep 25, 2019 11:30	5613451	467724	Amabalis Fir	3		0	0			0	0
					Douglas Fir	2							
					Spruce	2							
						7							
						17							
						522							

Civil Sites

Boulder Powerhouse and Spoil

Project Information

Project: 2nd Year Survival Surveys
Site: Boulder Powerhouse and Spoil
Location: Upper Lillooet Hydro Project
Mapsheet: BO-1
Net Area: 1.4 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld, A. Tait, S. Enns
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 3

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	867	87			0.36	2
Lodgepole Pine	67	7			0.40	3
Western Hemlock	67	7			0.08	1
Summary:	***1,000***	***100***	***-***	***-***	***0.31***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
Black Cottonwood	3	44
Pearly Everlasting	2	60

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
AD Deer	DOUGLAS FIR,WESTERN HEMLOCK	-	200	20	21	22

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Civil Sites
38 Km Laydown

HEDBERG ASSOCIATES
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Project Information

Project: 2nd Year Survival Surveys
Site: 38 Km Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1
Net Area: 13.0 Ha

Contractor: Hedberg Associates
Surveyor(s): W. Staven
Field Start: June 13, 2019
Field Finish: June 13, 2019
# of Plots: 15

Stocking Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Douglas Fir	587	39			40.50	2
Spruce	347	23			31.30	2
Lodgepole Pine	320	21			29.86	2
Amabalis Fir	147	10			19.00	2
Western Red Cedar	93	6			26.40	2
Summary:	***1,493***	***100***	***-***	***-***	***31.89***	***2***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*
Black Cottonwood	4	40
Fireweed	9	38
Grass	3	25
Lupine	5	25
Red Alder	1	20
Red raspberry	4	40
Thimbleberry	3	30
Willow	2	25

Pest / Disease	*Host Species*	*Dead Trees (SPH)*	*Live Trees (SPH)*	*% Total Affected*	*% Conifers Affected*	*% Host Trees Affected*
AD Deer	DOUGLAS FIR,WESTERN RED CEDAR	-	40	3	5	5
ND Drought	AMABALIS FIR,WESTERN RED CEDAR,FDC,DOUGLAS FIR	227	-	13	22	20

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Civil Sites

41.7 Km Laydown

INNERGEX

Project Information

Project: 2nd Year Survival Surveys
Site: 41.7 Km Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 2

Stocking Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Black Cottonwood	3,300	47			0.90	3
Red Alder	2,500	36			0.70	3
Douglas Fir	800	11			0.38	2
Spruce	400	6			0.41	2
Summary:	***7,000***	***100***	**-**	**-**	***0.55***	***2***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*

Pest / Disease	*Host Species*	*Dead Trees (SPH)*	*Live Trees (SPH)*	*% Total Affected*	*% Conifers Affected*	*% Host Trees Affected*
ND Drought	DOUGLAS FIR,SPRUCE	-	600	9	16	86

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Forest Professional	Date	

Civil Sites

Boulder Spoil #4

Project Information

Project: 2nd Year Survival Surveys
Site: Boulder Spoil #4
Location: Upper Lillooet Hydro Project
Mapsheet: MAP 3
Net Area: 0.4 Ha

Contractor: Hedberg Associates
Surveyor(s): S. Enns
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 1

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Spruce	1,000	83			0.50	4
Douglas Fir	200	17			0.20	1
Summary:	***1,200***	***100***	***-***	***-***	***0.35***	***3***

Veg / Brush	% Cover	Avg Ht. (cm)
Fireweed	1	5
Red Raspberry	2	45
Thimbleberry	1	30

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
AD Deer	SPRUCE	-	200	17	17	21
ND Drought	SPRUCE	-	200	17	17	21

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Sites
Boulder Spoil #7

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Project Information

Project: 2nd Year Survival Surveys
Site: Boulder Spoil #7
Location: Upper Lillooet Hydro Project
Mapsheet: BO-4
Net Area: 0.6 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: November 8, 2019
Field Finish: November 8, 2019
# of Plots: 1

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	1,000	100			0.52	2
Summary:	***1,000***	***100***	***-***	***-***	***0.52***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
None		

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

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Forest Professional	**Date**	

Civil Sites

Camp

Project Information

Project: 2nd Year Survival Surveys
Site: Camp
Location: Upper Lillooet Hydro Project
Mapsheet: MAP 6
Net Area: 6.5 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld, C. Johnston
Field Start: November 8, 2019
Field Finish: November 8, 2019
# of Plots: 6

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	967	50			0.52	2
Lodgepole Pine	467	24			0.30	2
Black Cottonwood	200	10			0.93	2
Ponderosa Pine	200	10			0.38	2
Amabalis Fir	100	5			0.25	2
Summary:	***1,933***	***100***	***-***	***-***	***0.45***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
ND Drought	DOUGLAS FIR	67	-	3	4	6

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Civil Sites
Diversion Channel Slopes

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT — INNERGEX

Project Information

Project: 2nd Year Survival Surveys
Site: Diversion Channel Slopes
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld, S. Barker, C. Johnston
Field Start: September 18, 2019
Field Finish: November 8, 2019
# of Plots: 5

Stocking Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Amabalis Fir	640	39			0.23	2
Douglas Fir	440	27			0.41	2
Spruce	400	24			0.40	2
Red Alder	120	7			0.26	2
Western Red Cedar	40	2			0.15	2
Summary:	***1,640***	***100***	***-***	***-***	***0.33***	***2***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*
Fireweed	8	78
Grass	22	25
Vaccinium	5	25
Willow	3	140

Pest / Disease	*Host Species*	*Dead Trees (SPH)*	*Live Trees (SPH)*	*% Total Affected*	*% Conifers Affected*	*% Host Trees Affected*
ND Drought	DOUGLAS FIR,SPRUCE,AMABALIS FIR	-	280	17	18	19

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Civil Sites

Explosive Magazine

Project Information

Project: 2nd Year Survival Surveys
Site: Explosive Magazine
Location: Upper Lillooet Hydro Project
Mapsheet: MAP 3
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld, A. Tait
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 2

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	1,400	100			0.41	2
Summary:	***1,400***	***100***	***-***	***-***	***0.41***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
Horsetail	5	20
Red raspberry	10	85
Thimbleberry	5	35

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**

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Civil Sites

Keyhole Laydown

Project Information

Project: 2nd Year Survival Surveys
Site: Keyhole Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 0.1 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 19, 2019
Field Finish: September 19, 2019
# of Plots: 1

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Amabalis Fir	600	100			0.21	2
Summary:	***600***	***100***	***-***	***-***	***0.21***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
Grass	10	30
Red Raspberry	10	8
Vaccinium	5	50

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

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Forest Professional	Date	

Civil Sites

Upper Intake and Laydown

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Intake and Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.4 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 19, 2019
Field Finish: September 19, 2019
# of Plots: 5

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Black Cottonwood	600	35			0.40	3
Spruce	560	33			0.32	2
Douglas Fir	160	9			0.23	2
Western Hemlock	120	7			0.61	3
Western Red Cedar	120	7			0.54	2
Amabalis Fir	80	5			0.13	2
Red Alder	80	5			0.63	1
Summary:	***1,720***	***100***	***-***	***-***	***0.41***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
Black Cottonwood	4	75
Pearly Everlasting	2	25
Red Osier Dogwood	5	58
Red Raspberry	8	80

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
ND Drought	SPRUCE,AMABALIS FIR	120	200	17	31	50

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NATURAL RESOURCE MANAGEMENT

Civil Sites
Upper Spoil #1

INNERGEX

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #1
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.4 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld, S. Barker
Field Start: September 19, 2019
Field Finish: September 19, 2019
# of Plots: 3

Stocking Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Black Cottonwood	1,333	36			0.85	3
Spruce	867	23			0.39	2
Douglas Fir	600	16			0.39	2
Red Alder	600	16			0.21	2
Amabalis Fir	133	4			0.22	2
Lodgepole Pine	133	4			0.25	2
Western Red Cedar	67	2			0.32	2
Summary:	***3,733***	***100***	***-***	***-***	***0.36***	***2***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*
Black Cottonwood	5	100
Fireweed	3	80
Grass	3	30
Vaccinium	2	30

Pest / Disease	*Host Species*	*Dead Trees (SPH)*	*Live Trees (SPH)*	*% Total Affected*	*% Conifers Affected*	*% Host Trees Affected*
ND Drought	DOUGLAS FIR,SPRUCE,AMABALIS FIR,WESTERN RED CEDAR	200	933	29	59	67

Declaration	
Forest Professional	**Date**

Civil Sites
Upper Spoil #2 & Settling Basin

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #2 & Settling Basin
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.8 Ha

Contractor: Hedberg Associates
Surveyor(s): S. Barker
Field Start: September 19, 2019
Field Finish: September 19, 2019
# of Plots: 4

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Spruce	450	56			0.45	2
Amabalis Fir	200	25				
Douglas Fir	150	19			0.09	2
Summary:	***800***	***100***	***-***	***-***	***0.33***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
ND Drought	DOUGLAS FIR,SPRUCE,AMABALIS FIR,WESTERN RED CEDAR	150	700	89	89	89

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	

Civil Sites
Upper Spoil #3

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #3
Location: Upper Lillooet Hydro Project
Mapsheet: UL-4
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 1

Stocking Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Spruce	600	43			0.37	2
Amabalis Fir	400	29			0.35	2
Douglas Fir	400	29			0.16	1
Summary:	***1,400***	***100***	***-***	***-***	***0.29***	***2***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*
Pearly Everlasting	2	45
Red Raspberry	4	80

Pest / Disease	*Host Species*	*Dead Trees (SPH)*	*Live Trees (SPH)*	*% Total Affected*	*% Conifers Affected*	*% Host Trees Affected*

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	Date	

Civil Sites
Upper Spoil #4

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #4
Location: Upper Lillooet Hydro Project
Mapsheet: UL-4
Net Area: 1.6 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 2

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	500	42			0.43	2
Amabalis Fir	300	25			0.24	2
Western Red Cedar	300	25			0.30	2
Spruce	100	8				
Summary:	***1,200***	***100***	***-***	***-***	***0.32***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)
Grass	4	35

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**

Affix Professional Seal Here

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Sites
Upper Spoil #5

INNERGEX

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #5
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 5

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Spruce	400	91			0.19	2
Amabalis Fir	40	9				
Summary:	***440***	***100***	***-***	***-***	***0.19***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
ND Drought	SPRUCE	-	120	27	27	30

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**

Affix Professional Seal Here

Civil Sites
Upper Spoil #6

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #6
Location: Upper Lillooet Hydro Project
Mapsheet: UL-2/UL-3
Net Area: 1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: November 8, 2019
Field Finish: November 8, 2019
# of Plots: 1

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Black Cottonwood	2,800	52			0.60	2
Douglas Fir	2,000	37			0.55	2
Red Alder	400	7			1.10	2
Spruce	200	4			0.43	2
Summary:	***5,400***	***100***	***-***	***-***	***0.67***	***2***

Veg / Brush	% Cover	Avg Ht. (cm)

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	

Civil Sites

Upper Spoil #7

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #7
Location: Upper Lillooet Hydro Project
Mapsheet: UL-2
Net Area: 1.3 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: November 8, 2019
Field Finish: November 8, 2019
# of Plots: 1

Stocking Information

Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Douglas Fir	1,400	78			0.25	1
Lodgepole Pine	400	22			0.45	1
Summary:	***1,800***	***100***	***-***	***-***	***0.35***	***1***

Veg / Brush	% Cover	Avg Ht. (cm)

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	Date	

Civil Sites
Upper Spoil #8

Project Information

Project: 2nd Year Survival Surveys
Site: Upper Spoil #8
Location: Upper Lillooet Hydro Project
Mapsheet: UL-4
Net Area: 2.2 Ha

Contractor: Hedberg Associates
Surveyor(s): H. Auld
Field Start: September 25, 2019
Field Finish: September 25, 2019
# of Plots: 2

Stocking Information

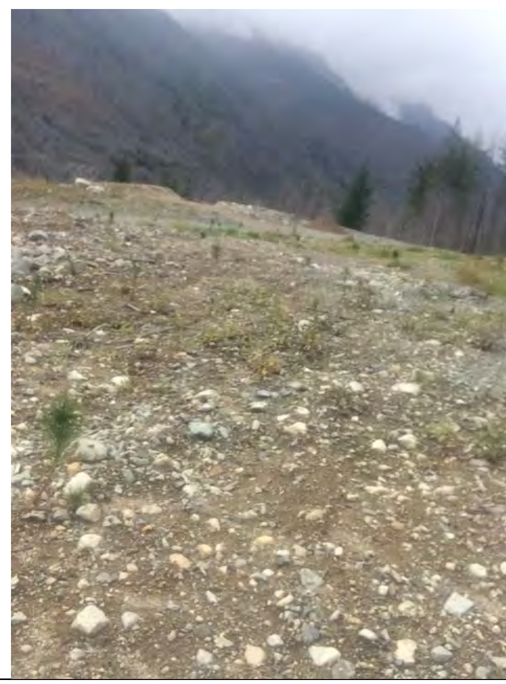
Species	TS (SPH)	TS %	Ocular SPH	Ocular %	Inv Ht (m)	Inv Age
Western Red Cedar	700	41			0.48	2
Spruce	400	24			0.46	2
Amabalis Fir	300	18			0.24	2
Douglas Fir	300	18			0.56	2
Summary:	***1,700***	***100***	***-***	***-***	***0.44***	***2***

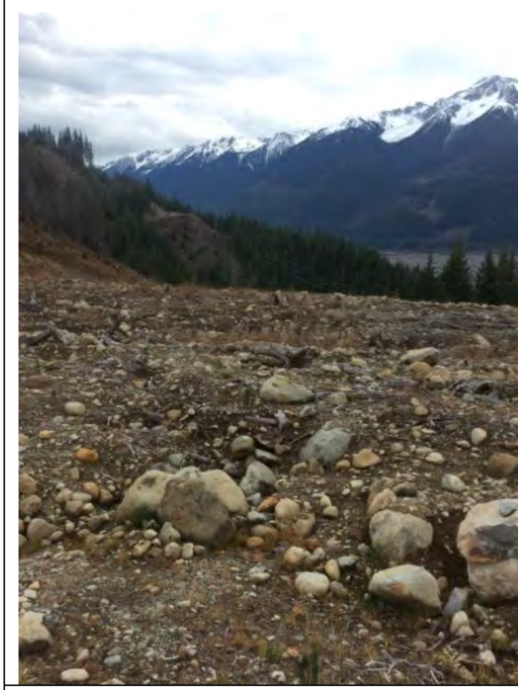
Veg / Brush	% Cover	Avg Ht. (cm)
Thimbleberry	4	30
Vaccinium	2	35

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
AD Deer	CW	-	500	29	29	-

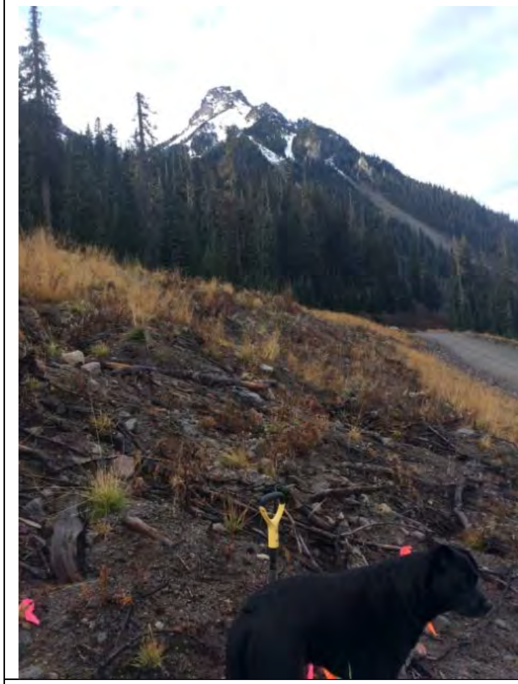
Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	

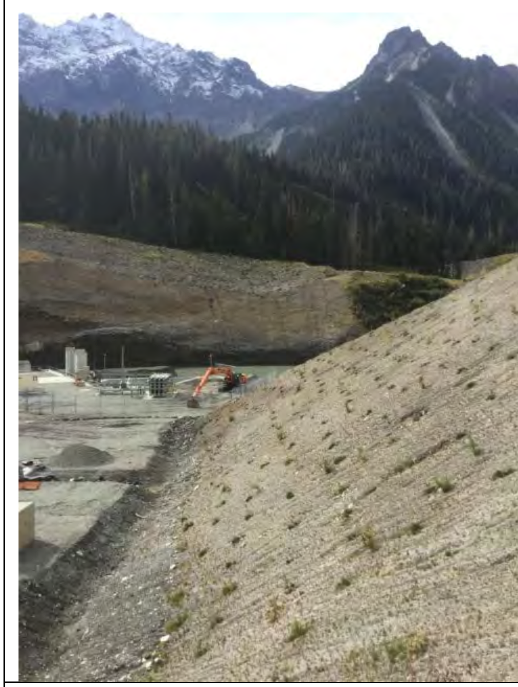
Appendix D: Inspection Site Photos

	
Boulder powerhouse and spoil – Douglas fir	Boulder powerhouse and spoil-Douglas fir
	
Boulder powerhouse and spoil overviewl	Boulder powerhouse and spoil overview

	
Boulder Spoil #7-Dougls fir	Camp – Dougls fir
	
Camp overview	Camp – Lodgepole pine

	
Camp Lodgepole Pine	Camp Lodgepole pine
	
Diversion Channel Slopes -Amablis fir	Diversion Channel Slopes-Douglas fir

	
Diversion Channel overview	Diversion channel Spruce spp.
	
Explosive magazine Douglas fir	Explosive magazine overview

	
Keyhole laydown – Amablis fir	Keyhole laydown overview
	
Upper intake and laydown overview	Upper Spoil 1 – Amablis fir

	
Upper Spoil 1- Western redcedar	Upper Spoil 1 – Red Alder
	
Upper Spoil 1 overview	Upper Spoil 1 – Spruce spp. – note drought effect

	
Upper Spoil 2- Spruce spp.	Upper Spoil 2 -Spruce spp.
	
Upper Spoil 6 Douglas fir	Upper Spoil 6 – Spruce spp – overview

	
38 km laydown – Amablis fir	38 km laydown – deer browsed
	
38km laydown overview	38km laydown overview

Appendix B. Alena Creek Fish Habitat Enhancement Project: Year 3 Monitoring Report

Alena Creek Fish Habitat Enhancement Project

Year 3 Monitoring Report

Prepared for:

Upper Lillooet River Power Limited Partnership
200 – 666 Burrard Street
Vancouver, BC, V6C 2X8

April 28, 2020

Prepared by:

Ecofish Research Ltd.

Published by Ecofish Research Ltd., Suite F, 450 8th St., Courtenay, B.C., V9N 1N5

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Certification: *stamped version on file.*

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Fisheries Scientist/Project Manager

Disclaimer:

EXECUTIVE SUMMARY

This report provides results of Year 3 (2019) of the long-term monitoring program to evaluate the effectiveness of the Fish Habitat Enhancement Project (FHEP) constructed on Alena Creek (also known as Leanna Creek) as per the *Fisheries Act* Authorization issued for the Upper Lillooet Hydro Project (the Project). Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to conduct monitoring of the FHEP constructed on Alena Creek. The FHEP was designed to offset the footprint and operational habitat losses incurred by the Project. Alena Creek is a tributary to the Upper Lillooet River located approximately 4.1 km downstream of the confluence of Boulder Creek with the Upper Lillooet River.

Historical fish and fish habitat data from Alena Creek and long-term monitoring requirements for the FHEP were originally described in the Alena Creek Long-Term Monitoring Program (Harwood *et al.* 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2017). Baseline data were collected for Alena Creek in 2013 and 2014. Post-construction (i.e., post-enhancement) monitoring started in fall of 2016 and has continued through 2017 (Year 1), 2018 (Year 2) and 2019 (Year 3).

Fish Habitat

A stability assessment was conducted to monitor the stability and functionality of each of the FHEP features and ensure that any remedial action required to maintain the effectiveness of habitat features is identified so that it can be promptly undertaken. To assist in the stability assessments, photo-points were established during the as-built survey in 2016 at a total of eight survey transects and repeated in each subsequent year. At each of the transects, a panorama of photographs was taken to evaluate changes in habitat conditions over time. Qualitative observations were also made along the entire FHEP enhanced reaches.

Excessive erosion that reduces the quality of the constructed habitat has not occurred to date. The channel adjustments that occurred after the November 2016 peak flow event were modest and have largely stabilized since then due to vegetation establishment and natural sorting of sediment. However, three locations were identified where remediation is required to limit potential loss of habitat quality. First and foremost is the beaver dam complex located immediately upstream of Reach 3. This beaver dam has begun to cause flows to partially bypass Reach 3 and deliver fine sediment that is eroded from newly cut channels. Maintaining a lower beaver dam height at the dam that is blocking flow to the mainstem is recommended to keep flows in the channel and limit fine sediment loading. At the downstream extent of Reach 3, the last riffle has incised, which could cause progressive head-cutting and associated incision upstream. Rebuilding this riffle is recommended, which can likely be done without the need for excavators. Lastly, a log jam just upstream of ALE-XS1 has formed in Reach 1 where a channel-spanning log collapsed. This jam should be monitored to ensure it does not grow. If the jam grows and begins to cause backwatering of upstream riffles and associated fine sediment

deposition, then it should be removed. Continued monitoring and the repairs to Reach 3 are recommended to occur during summer 2020.

Fish Community

The adult fish community in Alena Creek was assessed by bank walk spawner surveys focusing on Coho Salmon, the dominant species within Alena Creek, completed over three surveys between November and December 2019. The peak count of adult spawning Coho Salmon (*Oncorhynchus kisutch*) was 153 in 2019, which was slightly higher than the baseline years (127 and 111) and 2017 (132) but less than the first post-enhancement monitoring survey in fall 2016 (192). A comparison of the results across years highlights the variability in run timing between years, with the peak live count recorded on November 14 in 2016, December 5 in 2017, and November 5 in 2010 and 2018, and December 9 in 2019. The peak counts provide a general indication of use and demonstrate that Alena Creek supports equivalent or potentially greater use by Coho Salmon spawners compared to pre-enhancement.

Minnow trapping surveys were conducted at eight sites in Alena Creek on September 23, 2019. The objective of minnow trapping was to measure catch-per-unit-effort (CPUE) by species and life history stage to continue monitoring juvenile fish abundance and compare to CPUE prior to enhancement. Of the eight sites, five are in the enhanced reaches of Alena Creek.

The average Cutthroat Trout (*Oncorhynchus clarkii*) CPUE across sites in 2019 (1.1 fish per 100 trap hours) was most similar to 2017 (0.8 fish per 100 trap hours) and less than 2013 and 2018 (1.8 and 1.6 fish per 100 trap hours respectively), while CPUE in 2014 is not comparable due to sampling bias. In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+ parr, with low numbers of fry. The low numbers of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence of fry in late September and early October when sampling occurs.

The average Coho Salmon CPUE across sites in 2018 and 2019 (83.8 and 33.3 fish per 100 trap hours respectively) was higher than values observed in 2013 and 2017. Similar high CPUE was found in 2014 for Coho Salmon as described above for Cutthroat Trout. The majority of Coho Salmon captured in all years were 0+ (fry); however, 1+ parr have also been detected in Alena Creek each year.

Relatively high captures in the newly established sites in the FHEP are indicative that the enhanced reach is high quality habitat for both juvenile Cutthroat Trout and Coho Salmon.

Hydrology

Seasonal trends in the Alena Creek hydrograph in 2019 were consistent with a coastal, snow-dominated watershed. Seasonal hydrograph patterns remained broadly consistent with observations from baseline and Year 1 and 2 post-construction monitoring. Stage readings in 2019 remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, then increased during snow melt in spring (March and April). Stage remained low during monitoring in late-summer and early fall (August 23 to October) when precipitation was minimal.

The daily maximum stage during 2019 at the FSR bridge was recorded on April 19, 2019 (0.47 m) corresponding with spring snowmelt. This was less than the maximum stage measured since records began in May 2013, which was recorded on November 9, 2016 (0.95 m) during a 1-in-20 year return flood event on the Upper Lillooet River, but was consistent with peak values recorded during baseline monitoring. The minimum daily stage during the winter of 2019 (0.14 m) was slightly lower than stage recorded previously during monitoring from November 2016 to January 2019.

During 2019, the stage trends at the FSR bridge and R1 gauge closely aligned, indicating that backwatering from Upper Lillooet River to the FSR bridge did not occur. We recommend continued stage monitoring at both the FSR bridge and the upstream R1 gauge.

Water Temperature

The objective of water temperature monitoring is to ensure that conditions within the FHEP support functional use for spawning, incubation, and rearing by the fish species in Alena Creek. To achieve this, water temperature will be monitored continuously for the first five years post-construction and compared to the pre-construction data using a before-after-control-impact (BACI) design.

Pre-construction water temperature monitoring occurred from April 17, 2013 to December 31, 2014 at the upstream site (upstream of all FHEP works) and from August 27, 2013 to December 31, 2014 at the downstream site (located within the FHEP) (Map 3); winter season water temperatures at the upstream site were not fully captured pre-construction due to data gaps in the winter/early spring 2014 data set. Therefore, direct comparison of pre- and post-construction monitoring for cooler temperature metrics are limited for the upstream site.

Post-construction monitoring commenced at both sites on November 23, 2016. Year 3 data are available up to September 23, 2019 for the upstream site and to October 23, 2019 for the downstream site. No substantial data gaps were recorded post-construction. Analysis of the data included calculating the following temperature metrics: monthly statistics (average, minimum, and maximum water temperatures for each month of record), differences in water temperature between the upstream and downstream monitoring sites, number of days with extreme mean daily temperature (e.g., >18°C, and <1°C), the length of the growing season, exceedance of Bull Trout temperature thresholds, and mean weekly maximum temperature (MWMxT). These metrics are compared to water temperature BC WQG (Oliver and Fidler 2001, MOE 2019) to assess suitability of the water temperature for aquatic life and specifically, Coho Salmon, Cutthroat Trout, and Bull Trout (*Salvelinus confluentus*).

Alena Creek is classified as a cool stream with no days with mean daily water temperatures >18°C in either pre- or post-construction conditions at both sites, and only a few days at the downstream site when the mean daily temperature was <1°C. Despite the small elevation (11 m) difference and short distance (~1 km) between the two sites, the downstream site exhibits greater variability in water temperature and is generally warmer than the upstream site in the summer and cooler in the winter. The water temperature at the upstream site is moderated by groundwater inflow and there is a tributary that enters Alena Creek between the two sites, which may account for some of the cooler temperature downstream in the winter and warmer temperature downstream in the summer.

Overall, considering inter-annual variably in temperature, no substantial change in monthly temperature statistics has been observed in Year 3 in comparison to previous post-construction and pre-construction data. The range in monthly average temperatures at the upstream site was 5.0°C to 8.1°C pre-construction and 4.0°C to 8.1°C post-construction. No pre-construction data are available for the upstream site from mid-January to mid-March, therefore the monthly minimum of 5.0°C measured in December 2014 may not be representative of the coolest monthly average at this site pre-construction.

At the downstream site monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction, and from 1.2°C to 11.7°C post-construction. Minimum monthly temperatures in each year occurred in December or February. In 2019 monthly average temperatures were the highest (11.7°C) and lowest (1.2°C) on record to date, occurring at the downstream site, however, similar instantaneous temperature ranges were observed in the pre- (0.0°C to 14°C) and post-construction (0.0°C to 14.5°C) periods.

Water temperatures at the monitoring sites were generally sub-optimally cool for Cutthroat Trout and Coho Salmon during pre- and post-construction periods, although some sub-optimally warm temperatures were recorded for Bull Trout and Cutthroat Trout incubation and spawning at the downstream site.

In general, it appears the upstream site is more suitable than the downstream site for spawning and incubation of Bull Trout across the stated periodicity for this species. Fewer cool temperature exceedances of the BC WQG occurred upstream during the winter months and overall fewer exceedances of the warm temperature BC WQG in the summer months. Warm surface waters at the upstream site, during incubation stages may be partially mitigated by the groundwater upwelling, such that temperature within the redds may be lower than that measured at the temperature logger.

Results to date indicate that the FHEP provides water temperatures typical of the area, with beneficial moderating effects due to groundwater inflow upstream of the habitat. Overall, temperatures are more suitable for Bull Trout than Coho Salmon and Cutthroat Trout due to the generally cooler optimum temperature ranges for Bull Trout.

Overall, no substantial differences were observed in the pre- and post-construction temperature regimes. We recommend that the monitoring program continue for 5 years post-construction based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017).

Riparian Habitat

The Alena Creek FHEP detailed specific restoration and enhancement prescriptions for the Alena Creek riparian FHEP area to increase the density of conifers and ensure planting success to improve riparian habitat function for fish (Hemmera 2015). The objective of the riparian restoration effectiveness monitoring program is to qualify and quantify revegetation and planting success, including confirming that a diversity of native tree and shrub species, including a component of coniferous trees, become established.

Vegetation in the Alena Creek FHEP area is establishing well and this component of the program is meeting the intended objectives of the FHEP and OEMP (Hemmera 2015, Harwood *et al.* 2013, Harwood *et al.* 2017). In 2019, the density of woody vegetation was 79,900 ± 48,103 stems/ha, far surpassing the overall minimum target of 2,309 stems/ha. Similarly, the density of trees in the FHEP area in 2019 was 50,350 ± 45,222 stems/ha, surpassing the target for mature trees of 1,200 stems/ha, and the overall density of shrubs in the FHEP area was 20,550 ± 11,491 stems/ha, surpassing the shrub specific target of 2,000 stems/ ha. In addition, the cover of vegetation was estimated at 86%, surpassing the target of 80%. In 2019 conifer species accounted for 29% of all trees with a density of 1,700 stems/ha, as compared to the 50 stems/ha, accounting for 0.1% of all trees, in plots prior to restoration (Harwood *et al.* 2016). No mortality of planted or naturally regenerating western redcedar was observed, and overall survival of the species, as well as all coniferous species is assumed to be 100%. The success of conifer regeneration, as well as the observed diversity of tree and shrub species, demonstrates the success of the habitat in progressing towards a mixed coniferous/ deciduous forest from a deciduous forest and in providing a diverse riparian habitat.

The observed high stem densities and vegetation cover within the FHEP area are indicators of a stable site, and no signs of erosion were noted during 2019 field sampling. Thus, no erosion control or soil conditioning appears to be necessary at this time. Similarly, no additional planting or remediation measures are recommended at this time. However, additional thinning of black cottonwood (*Populus trichocarpa)* and red alder (*Alnus rubra*) may be necessary in the long-term if they appear to be suppressing the growth of target conifer species. Monitoring for the presence of invasive species should continue during revegetation surveys, and the thistle species noted in ALE-PR03 should be identified to determine management requirements. If the species is deemed a noxious weed, treatment prescriptions should be developed and implemented. The next revegetation monitoring visit is planned for Year 5 (Harwood *et al.* 2017) and should be conducted in late August or early September before vegetation dies off for the season.

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1. INTRODUCTION

This report provides results of Year 3 (2019) of the long-term monitoring program to evaluate the effectiveness of the Fish Habitat Enhancement Project (FHEP) constructed on Alena Creek (also known as Leanna Creek) as per the *Fisheries Act* Authorization issued for the Upper Lillooet Hydro Project (the Project). Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to monitor the FHEP on Alena Creek northwest of Pemberton, BC. The FHEP was designed by Hemmera Envirochem Inc. (Hemmera 2015) and Ecofish (Appendix A) to offset the habitat losses incurred due to the footprint and operation of the Project. The Project is composed of two hydroelectric facilities (HEFs) on the Upper Lillooet River and Boulder Creek, and a 72-km-long 230 kV transmission line. Alena Creek is a tributary to the Upper Lillooet River located approximately 4.1 km downstream of the confluence of Boulder Creek with the Upper Lillooet River, and is therefore downstream of the two HEFs (Map 1).

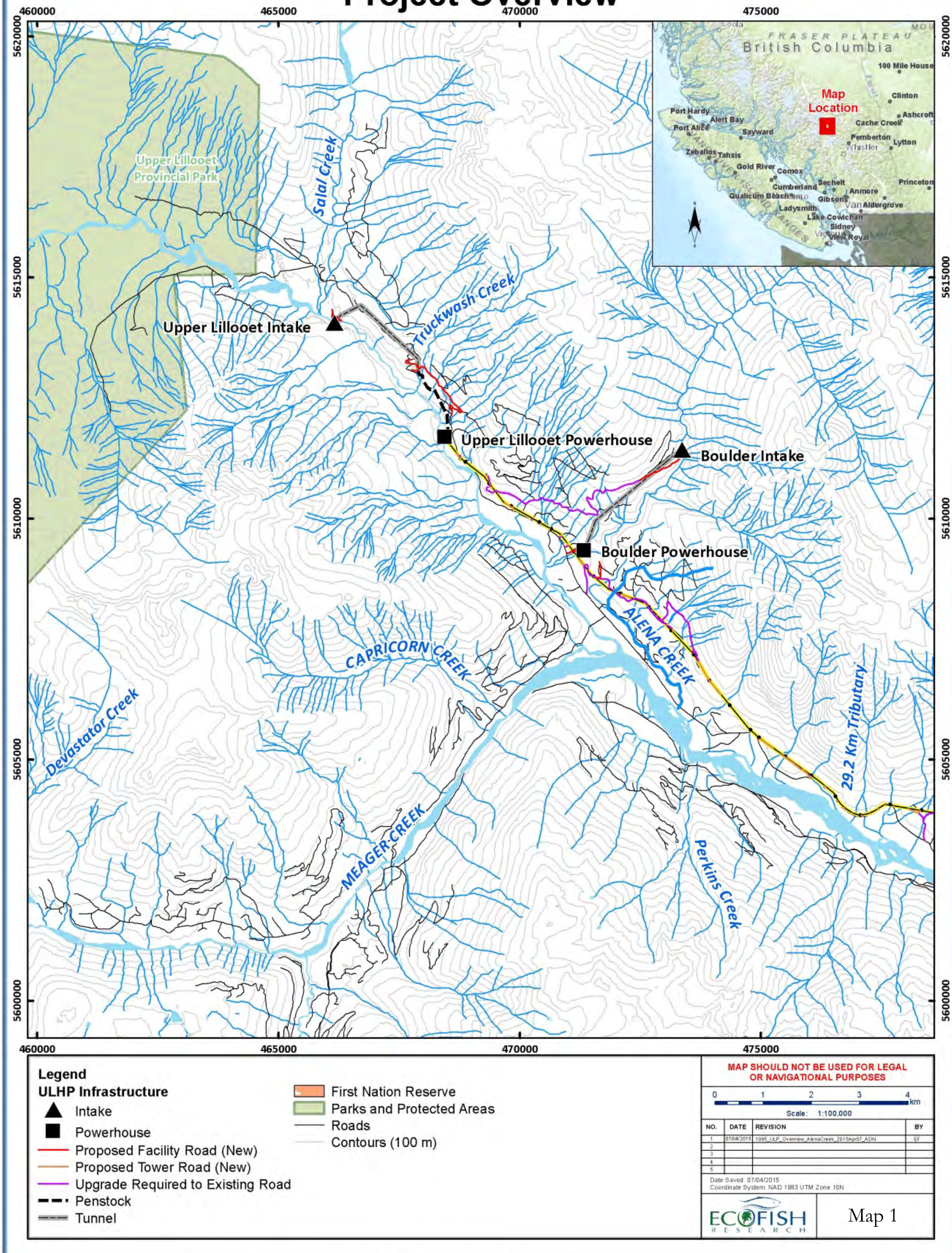
Details of the predicted habitat losses incurred by Project construction and operation are provided in the aquatic and riparian footprint reports for the HEFs and the transmission line (Buchanan *et al.* 2013a, b). These habitat losses were authorized by Fisheries and Oceans Canada (DFO) through the issuance of a *Fisheries Act* Authorization (09-HPAC-PA2-00303) on September 26, 2013. The Authorization was amended on June 17, 2014. The amended Authorization requires the enhancement of 2,310 m^2 of instream habitat to offset the permanent loss of 1,935 m^2 of fish habitat associated with the construction of the Upper Lillooet HEF intake. Under the amended Authorization, there were no offset requirements associated with construction and operation of the Boulder Creek HEF, or with impacts to riparian habitat.

The offsetting plan involved fish habitat enhancement in Alena Creek, which was heavily impacted by the Capricorn/Meager Creek slide (hereafter referred to as the Meager Creek slide): a natural, catastrophic event that occurred on August 6, 2010 and deposited a large amount of woody debris and a thick slurry of sediment in and around Alena Creek. In addition to heavily impacting aquatic habitat, the slide affected riparian habitat either by uprooting trees or by smothering root systems with a thick layer of sediment. The FHEP constructed in the summer of 2016, created a new section of channel and enhanced both the aquatic and riparian habitat of Alena Creek and will therefore benefit Coho Salmon (*Oncorhynchus kisutch*), Cutthroat Trout (*O. clarkii*) and Bull Trout (*Salvelinus confluentus*). The FHEP consists of a downstream (Reach 1) and upstream reach (Reach 3) separated by a naturally recovering low gradient reach (Reach 2) (Map 2). The actual location and geometry of constructed design features was summarized in the as-built drawings (West *et al.* 2017).

Historical fish and fish habitat data from Alena Creek, and long-term monitoring requirements for the FHEP, were originally described in the Alena Creek Long-Term Monitoring Program (Harwood *et al.* 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2017). Results of Years 1 and 2 of Alena Creek pre-construction monitoring are documented in Harwood *et al.* (2016).

Results of Year 1 and 2 (2017, 2018) of post-construction monitoring are presented in Harwood *et al.* (2019). Results from Year 3 (2019) are summarized below.

Project Overview



Map 1

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Compensation\1095_ULP_Overview_AlenaCreek_2015Apr07_ADN.mxd

2. OBJECTIVES AND BACKGROUND

2.1. Fish Community

The goal of enhancing aquatic and riparian habitat in Alena Creek was to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout, and to support equivalent or greater fish use (based on fish abundance) in Alena Creek relative to pre-project conditions. Fish habitat use in Alena Creek was assessed by comparing adult Bull Trout and Coho Salmon spawner abundance and juvenile Cutthroat Trout and Coho Salmon abundance under baseline and post-enhancement conditions. The adults were sampled by counting fish during bank walks during the Coho Salmon spawning season in early November to early December. The juveniles were sampled using minnow traps deployed at eight sites in Alena Creek. The catch per unit effort (CPUE) for minnow trapping can be compared among years to assess changes in fish abundance over time.

2.2. Fish Habitat

In 2016, thirteen riffles and more than 120 pieces of large wood were installed in Reach 1 with total creation of 1,387 m^2 of enhanced fish habitat. A total of 668 m^2 of new instream habitat and 1,139 m^2 of floodplain was created in Reach 3 in 2016. Twelve cobble riffles and over 100 pieces of large woody debris were installed in this reach as part of the FHEP. A stability assessment has been conducted annually to monitor the establishment and functionality of each of the FHEP habitat features to promptly identify whether any remedial action is required to maintain the effectiveness of habitat features.

2.3. Hydrology

Water level data provide useful information on inter-seasonal variation in flow and assist in interpreting changes in the other monitoring components (e.g., water temperature and fish abundance). The hydrological monitoring program in Alena Creek was undertaken by Knight Piésold Ltd (KPL).

2.4. Water Quality

Sampling at two sites during pre-construction monitoring and Year 1 showed that water quality in Alena Creek has generally improved since pre-construction sampling began in 2013 (Harwood *et al.* 2019). Further, monitoring data in Year 1 showed that water quality in the FHEP is generally suitable for aquatic life, including salmonids. Considering these observations, and that instream habitat enhancement is not expected to result in adverse effects on water quality, water quality sampling was discontinued after Year 1 based on a recommendation in the Year 1 annual report (Harwood *et al.* 2018).

2.5. Water Temperature

Small incremental changes in water temperature can potentially affect stream biota, including fish. Fish are vulnerable to both small increases and decreases in water temperature, with tolerance levels varying between species and life-history stages and dependent on existing conditions. The objective of water temperature monitoring is to ensure that conditions within the Alena Creek FHEP support functional use for migration, spawning, incubation, and rearing by the fish species present. Collection of continuous water temperature data will allow for a comparison of pre- and post-construction temperature data to track changes within the FHEP over time. Water temperature may be influenced by the instream enhancement features and maturation of the riparian vegetation planted during the habitat restoration.

Water temperature is monitored continuously at two sites (Map 3) for the first five years post-construction. One site is located upstream of the restoration works and the other is in the downstream end of the FHEP. Alena Creek is classified as a cool stream with no days with mean daily water temperatures >18°C in either pre- or post-construction conditions at both sites. Despite the small elevation (11 m) difference and short distance (~1 km) between the two sites, the downstream site exhibits greater variability in water temperature and is generally warmer than the upstream site in the summer and cooler in the winter (Map 3). The water temperature at the upstream site is moderated by groundwater inflow and there is a tributary that enters Alena Creek between the two sites which may account for some of the cooler temperature downstream in the winter and warmer temperature downstream in the summer.

This Year 3 (2019) annual monitoring data report provides a summary of pre-construction (2013-2014), and post construction (2016-2019), water temperature monitoring results. This report is intended to be primarily a data summary report; any changes in water temperature related to the construction of the FHEP will be evaluated with a BACI analysis following 5 years of post-construction water temperature data collection.

2.6. Riparian Habitat

Riparian areas contribute to fish habitat quality through thermal regulation, minimizing sedimentation by stabilizing stream banks and intercepting run-off, and by providing nutrients, channel-stabilizing large woody debris (LWD), and cover (Gregory *et al.* 1991, Naiman and Decamps 1997, Naiman *et al.* 2000, Richardson 2004). To provide these benefits, a goal of the Alena Creek FHEP is to expedite succession of the riparian area from an early-successional deciduous stand towards a mixed coniferous/deciduous forest. As such, the FHEP included specific restoration and enhancement prescriptions for the riparian area (defined as the terrestrial area within 30 m of the high-water mark of each bank of the stream) to increase the density of conifers and ensure planting success (Hemmera 2015).

The objective of the riparian restoration effectiveness monitoring program, as per the OEMP, is to qualitatively and quantitatively describe the natural regeneration and planting success in the riparian area, and to confirm that a diversity of well-established native tree and shrub species with low observed mortality rates are present within the Alena Creek FHEP area (Harwood *et al.* 2016; Harwood *et al.* 2017). Successful revegetation is defined by several targets: 1) survival of at least 80% of vegetation between monitoring years overall (considered to be 2,309 stems/ ha and 80% cover), and of the planted western redcedar (*Thuja plicata*) stock specifically (DFO and MELP 1998; Harwood *et al.* 2013, Harwood *et al.* 2017); 2) target densities equal to or more than 1,200 tree stems/ ha and 2,000 shrub stems/ha (Harwood *et al.* 2017); and 3) a diversity of healthy vegetation including a transition to a mixed conifer/ deciduous stand from a deciduous stand (Harwood *et al.* 2017, Hemmera 2015).

To evaluate regeneration and planting success, results from the third year of monitoring are compared with three benchmarks: 1) as-built surveys conducted immediately following restoration work in 2016 (Harwood *et al.* 2016) and Year 1 monitoring in 2017 (Harwood *et al.* 2019), 2) data collected four years after the slide prior to restoration work (Harwood *et al.* 2016), and 3) data collected prior to the Meager Creek slide (as estimated from typical characteristics of floodplain sites in the same biogeoclimatic zone; Green and Klinka 1994).

3. METHODS

3.1. Fish Habitat

Reach 1 and 3 of Alena Creek were enhanced as a part of the FHEP. To assess the stability of the enhancements, initial photos were taken at photo-points established during the as-built survey (completed shortly following the construction in 2016). A total of eight transects were surveyed at that time. At each transect, a panorama of photographs was taken to support evaluation of changes in habitat conditions over time. Photographs were taken looking downstream, upstream, from river left to river right, and from river right to river left. The photograph aspects were oriented to provide a full view of the bankfull channel and floodplain, with the transect tape included in the photo to provide a visual reference to aid with analysis of the topographic transect surveys. The transect photos have been repeated during each year since construction (Harwood *et al.* 2016; 2017; 2018; 2019) to allow for detection of changes in channel conditions. Additional photos were also taken throughout Reach 1 and 3 at key points.

3.2. Fish Community

3.2.1. Adult Spawner Abundance

Coho Salmon, Bull Trout, and Cutthroat Trout were captured in Alena Creek during the monitoring studies. Spawner surveys in Alena Creek focused on Coho Salmon and Bull Trout. Spawner surveys for Bull Trout consisted of bank walks conducted approximately every two weeks between September 17 and October 22, 2019 (a total of three surveys). In addition, Coho spawner surveys were conducted every two weeks between November 13 and December 9, 2019 (a total of three surveys). Consistent with previous years, bank walks to count both live fish and carcasses occurred from the downstream confluence with the Upper Lillooet River to the upstream end of Alena Creek at the groundwater spring at the Lillooet River FSR crossing at kilometer 36.5. Due to the meandering nature of the Upper Lillooet River, the downstream confluence with Alena Creek has varied over the survey years by up to ~1 km.

It is important to note that the carcasses counted in Alena Creek are quickly consumed by wildlife in the area, as evidenced by the fact that they are not often whole and show signs of being eaten by wildlife. Often only the pyloric caeca, which animals prefer not to eat, is left behind.

3.2.2. Juvenile Abundance

3.2.2.1. Minnow Trapping

Minnow trapping surveys were conducted in Alena Creek commencing in Year 3 on September 23, 2019. The objective of minnow trapping was to monitor the change among years in the relative abundance of juvenile fish, based on catch-per-unit-effort (CPUE) for individual species and life stages.

A total of eight sites were selected in 2019, the same as 2018 but compared to six in previous years. Four to 10 traps were installed at each site. At ALE-MT06 site, 10 traps were set because it was a large pool that required a higher level of sampling effort. Sampling was conducted in five of the six sites sampled in previous years (ALE-MT01, ALE-MT02, ALE-MT03, ALE-MT05 and ALE-MT06); however, due to beaver activity in previous years, sampling at ALE-MT04 was discontinued in 2018 and 2019 as recommended in the Year 1 report (Harwood *et al.* 2019). Additionally, three new sites established in 2018 in FHEP habitat were sampled, specifically one site in Reach 1 (ALE-MT07) and two sites in Reach 3 (ALE-MT08 and ALE-09; Map 4). The Year 1 report had recommended that one of the additional sites be located just upstream of Reach 1 at the gravel augmentation pile installed as part of the enhancement works; however, due to beaver dam and stability issues at this location, the site was located just downstream of the gravel augmentation pile and in the Reach 1 FHEP area (ALE-MT07).

The minnow traps were baited using salmon roe and left overnight. When the traps were retrieved, captured fish were identified and measured (discussed below).

3.2.2.2. Biological Information

All captured fish were enumerated and identified to species using standard field keys. The fork length of each captured fish was determined using a measuring board (±1.0 mm) and then each fish was weighed using a field scale (±0.1 g).

Aging samples were taken from a sub-sample of captured fish and these were aged at the Ecofish laboratory in Campbell River. Scale samples collected in the field were examined under a dissecting microscope for aging purposes: three representative scales were photographed, and apparent annuli noted on a digital image. Fish age was determined by a biologist and QA'd by a senior biologist. Where discrepancies were identified, they were discussed, and final age determination was based on the professional judgement of the senior biologist.

3.2.2.3. Data Analysis

Individual Fish Data

Biological data from the captured fish were analyzed to define the age structure, size structure, length-weight relationship, length at age, and condition factor by species. Discrete age classes were based on size bins established using length-frequency histograms and age data from the scale analysis. Discrete classes were defined for fry (0+), parr (1+), parr (2+) and adults (3+). These discrete classes allowed all fish to be assigned an age class based on fork length. Based on a review of the aging data and length-frequency histograms, discrete fork length ranges were defined for each age class.

The condition of fish, which is an indication of overall health, can be calculated in a variety of ways, such as Fulton K or relative weight (W_r) (Blackwell *et al.* 2000). A potential problem with the use of Fulton K is an assumption of isometric growth (Blackwell *et al.* 2000); however, in this instance, the condition of fish was calculated separately for each age classes, so violations of this assumption were not expected. The condition of fish was consequently assessed by calculating Fulton's condition factor (*K*) and creating plots of species-specific length-weight relationships. Fulton's condition factor (*K*) was calculated for each fish captured by species and year using the following equation:

$$K = \left(\frac{W}{L^3}\right) 100{,}000$$

where W is the weight in g, L is the length in mm, and *100,000* is a scaling constant (Blackwell *et al.* 2000).

Relative Abundance

Relative abundance was evaluated using CPUE for minnow trap data, which was calculated as the number of fish captured per 100 trap hours.

3.3. Hydrology

KPL began monitoring water level at Alena Creek in April 2013. Two water level loggers were originally installed in Alena Creek; one at the Lillooet River FSR crossing (Alena Bridge) and another at the upstream end of the project area (Alena Upstream) (Map 3). For post-construction monitoring, water level data were collected at the Alena Bridge site in 2016, 2017 and 2018. A second gauge (R1) was installed based on recommendation by Harwood *et al.* (2018) on August 23, 2018 at approximately 125 m upstream from the Alena Bridge gauge. The purpose of the second gauge is to examine for potential backwater effects that may be caused by the Upper Lillooet River side channel when flows were high, and to ensure the stage data collected are representative of Alena Creek water levels.

3.4. Water Temperature

3.4.1. Study Design

Pre-construction monitoring occurred from April 17, 2013 to December 31, 2014 at the upstream site and from August 27, 2013 to December 31, 2014 at the downstream site. Post-construction monitoring commenced at both sites on November 23, 2016. Year 3 data are available up to September 23, 2019 for the upstream site and to October 23, 2019 for the downstream site (Table 1).

During the post-construction period, water temperature data were recorded at 15-minute intervals, using self-contained Tidbit v2 loggers made by Onset (details provided in Section 3.4.3) at two monitoring sites: ALE-USWQ1, located upstream of the enhancement works, and ALE-BDGWQ, located at the downstream end of the works, within the enhanced area and just upstream of the FSR bridge (Table 1, Map 3, Appendix B).

During the pre-construction monitoring period, there were gaps in the datasets from mid January 2014 to mid March 2014 at the upstream site, and from the end of March through early April 2014 at the downstream site due to the suspected build-up of ice (McCarthy, pers. comm. 2014) (Table 1). At the upstream site, less than three weeks of water temperature data were available for January, February and March 2014. Therefore, not all summary statistics and temperature metrics (see Section 3.4.4) could be calculated for these months, limiting the available winter season pre-construction data (Table 1). At the downstream site, less than three weeks of data were available for March 2014, limiting the available spring season pre-construction data (Table 1). No data gaps were observed post-construction (i.e., data set is 100 % complete, Table 1).

Table 1. Summary of water temperature site names, logging details and period of data record in Alena Creek pre-construction (2013, 2014) and post-construction (November 2016 through 2019).

Type	Site	UTM Coordinates (10U)		Elevation (masl)[1]	Project Phase	Periods of Record		Number of Data Records	Logging Interval (min.)	No. of Days with Valid Data	% Complete[2]
		Easting	Northing			Start Date	End Date				
Upstream	ALE-USWQ1	472,976	5,606,870	391	Pre-construction	17-Apr-13	31-Dec-14	54,395	60	561	91.0
					Post-construction	23-Nov-16	23-Sep-19	99,236	15	1,035	100
Downstream	ALE-BDGWQ	473,336	5,606,095	382	Pre-construction	27-Aug-13	31-Dec-14	44,075	60	453	93.6
					Post-construction	23-Nov-16	23-Oct-19	102,158	15	1,062	100

[1] Estimated from Google Earth.

Pre-construction (2013-2014) water temperature was monitored via hydrometric gauges maintained by KPL. Post-construction Tidbit temperature loggers were installed.

[2] The pre-construction data gap at the upstream site occurred between mid January and mid March 2014 due to icing concerns, therefore a complete month of data (i.e., more than three weeks) for February 2014 are not available during this phase.

The pre-construction data gap at the downstream site occurred at the end of March through early April 2014, therefore a complete month of data (i.e., more than three weeks) for March are not available during this phase.

3.4.2. Fish Species Distribution

The fish community in Alena Creek consists of Coho Salmon, Cutthroat Trout and Bull Trout (Table 2, Table 3). The BC WQG for water temperature specify optimum temperature ranges for rearing, spawning, incubation, and migration as applicable for these fish species (Table 2). The timing of life history stages in Alena Creek (Harwood *et al.* 2016) is used to define the start and end dates for each of the applicable life stages for Coho Salmon, Cutthroat Trout, and Bull Trout (Table 3).

Table 2. Optimum water temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout during spawning, incubation, rearing and migration (MOE 2019).

Species	Optimum Water Temperature Range (°C)			
	Spawning	Incubation	Rearing	Migration
Coho Salmon	4.4 - 12.8	4.0 - 13.0	9.0 - 16.0	7.2 - 15.6
Cutthroat Trout	9.0 - 12.0	9.0 - 12.0	7.0 - 16.0	-
Bull Trout	5.0 - 9.0	2.0 - 6.0	6.0 - 14.0	-

The BC WQG for water temperature is ± 1°C outside the optimum temperature range for each life stage.

Table 3. Fish species periodicity.

Coho Salmon	Cutthroat Trout	Bull Trout
Spawning (Oct. 15 to Jan. 01)	Spawning (Apr. 01 to Jul. 01)	Spawning (Aug. 01 to Dec. 08)
Incubation (Oct. 15 to Apr. 01)	Incubation (May. 01 to Sep. 01)	Incubation (Aug. 01 to Mar. 01)
Rearing (Jan. 01 to Dec. 31)	Rearing (Jan. 01 to Dec. 31)	Rearing (Jan. 01 to Dec. 31)
Migration (Sep. 01 to Dec. 31)	-	-

3.4.3. Quality Assurance / Quality Control

Pre-construction temperature data were recorded at 60-minute intervals using hydrometric gauges maintained by Knight Piésold Ltd. (KPL). The temperature sensors incorporated into the gauges were installed in aluminum standpipes and had an accuracy of ±0.3°C, a resolution of ±0.001°C. Post-construction temperature data were recorded at 15-minute intervals, using self-contained Tidbit v2 loggers made by Onset. The loggers have a range of -20°C to +70°C, are accurate to ±0.2°C, and have a resolution of 0.02°C. Water temperature at ALE-BDGWQ was concurrently logged by two Onset Tidbit loggers installed on separate anchors; this redundancy ensured availability of data in case one of the loggers malfunctioned or was lost. A second Tidbit logger was installed at ALE-USWQ1 in 2019.

Temperature data were carefully inspected and QA'd to ensure that any suspect or unreliable data were excluded from data analysis and presentation. Excluded data included instances where the water temperature sensor was suspected of being out-of-water/dry, affected by snow/ice or buried in sediment. Only data that were definitively ice-affected were removed prior to analysis, and this only occurred pre-construction in 2014 (Table 1).

3.4.4. Data Analysis and Collection

Processing of water temperature data was conducted by first identifying and removing outliers and then compiling data into a time series for all sites. Identification and removal of outliers was conducted as part of a thorough Quality Assurance/Quality Control (QA/QC) process which ensured that any suspect or unreliable data were excluded from analysis and presentation Excluded data included, for example, data where the sensor was suspected of being out of the water, affected by snow or ice, or buried in sediment.

After identifying and removing outliers, the records from duplicate loggers were averaged and records from different download dates were combined into a single time-series for each monitoring site. The time series for all sites were then interpolated to a regular interval of 15 minutes (where data were not already logged on a 15-minute interval), starting at the full hour.

Data are presented in plots that were generated from temperature data collected at, or interpolated to, 15-minute intervals. Analysis of the data involved computing the following summary statistics: monthly statistics (mean, minimum, and maximum water temperatures for each month of record, as well as differences in water temperature among sites), days with extreme mean daily temperature (e.g., >18°C and <1°C), days with exceedances of the minimum and maximum Bull Trout temperature thresholds, the length of the growing season, and the accumulated thermal units in the growing season (i.e., degree days), hourly rates of temperature change, and mean weekly maximum temperature (MWMxT). Table 4 defines these statistics and describes how they were calculated.

The calculation of the end date of the length of the growing season (as defined in Table 4) was modified from 4°C (as per Coleman and Fausch 2007) to 5°C, because the MWMxTs at the upstream site were >4°C in the winter data set for the first year of pre-construction monitoring.

3.4.4.1. Applicable Guidelines

The water temperature BC Water Quality Guidelines (BC WQG) for the protection of aquatic life (as per Oliver and Fidler 2001, MOE 2019) are discussed below.

Hourly Rates of Water Temperature Change

Rapid changes in heating or cooling of water temperature can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specifies that the hourly rate of water temperature change should not exceed ±1.0°C/hr (MOE 2019).

Daily Temperature Extremes

Extreme cold or warm temperatures are monitored as part of the water temperature component. The number of days when the daily mean temperature was <1°C was calculated, along with the number of days when the daily mean temperature >18°C and >20°C. Alena Creek is a cool stream where maximum temperatures recorded to date did not exceed 15°C, therefore the number of day >18°C and >20°C are not required. The maximum optimum temperature for the fish species present in the Project area is 16°C (Coho Salmon and Cutthroat Trout rearing life stage, Table 2).

Mean Weekly Maximum Temperature (MWMxT)

The MWMxT is an important indicator of prolonged periods of cold and warm water temperatures that fish are exposed to. The water temperature BC WQG for the protection of aquatic life states "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary by ±1.0°C beyond the optimum temperature range of each life history phase (incubation, rearing, migration and spawning) for the most sensitive salmonid species present" (Oliver and Fidler 2001, MOE 2019). Accordingly, MWMxT values were compared to the optimum temperature ranges for the fish species present based on the life history and periodicity (Table 2, Table 3).

Within each life history period, the completeness of the temperature data record (% complete) is calculated and results are only included if at least 50% of the data for the period is available. The minimum and maximum MWMxT values, % data within the optimum range and % exceedance of ±1.0°C of the optimal temperature range is calculated for each life history period to evaluate the suitability of the temperature regime for each fish species, at each monitoring site, pre- and post-construction.

Bull Trout Temperature Guidelines

Additional BC WQG (MOE 2018) water temperature guidelines are specified for streams with Bull Trout and Dolly Varden (Oliver and Fidler 2001; Table 1 in Appendix C). When either of these fish species are present, the guidelines state that:

- maximum daily water temperature is 15°C;
- maximum daily incubation temperature is 10°C;
- minimum daily incubation temperature is 2°C; and
- maximum daily spawning temperature is 10°C.

The number of days where these thresholds are exceeded are calculated using the appropriate daily maximum or minimum temperature values for each site where Bull Trout are present (Table 4).

Table 4. Water temperature metrics and method of calculation.

Metric	Description	Method of Calculation
Water temperature	Hourly or 15 minute data	Data (interpolated to 15 minute intervals where necessary) presented in graphical form.
Monthly statistics	Mean, minimum, and maximum on a monthly basis	Calculated from 15 minute data (interpolated where necessary) and presented in tabular format.
Rate of water temperature change	Hourly rate of change	Calculated from 15 minute data (interpolated where necessary); presented in summary tables and graphical form.
Degree days in growing season[1]	The beginning of the growing season is defined as the beginning of the first week that mean stream temperatures exceed and remain above 5°C; the end of the growing season was defined as the last day of the first week that mean stream temperature dropped below 4°C (as per Coleman and Fausch 2007).	Daily mean water temperatures were summed over this period (i.e., from the first day of the first week when weekly mean temperatures reached and remained above 5°C until the last day of the first week when weekly mean temperature dropped below 4°C).
Number of Days of Extreme Daily Mean Temperature	Daily average temperature extremes for all streams	Total number of days with daily mean water temperature >18^{o}C , >20^{o}C , and <1^{o}C.
Number of Days of Exceedance	Daily maximum and minimum temperature thresholds for streams with Bull Trout / Dolly Varden	# days maximum daily temperature is >15°C; # days maximum incubation temperature is >10°C; # days minimum incubation temperature is <2°C; # days maximum spawning temperature is >10°C.
MWMxT (Mean Weekly Maximum Temperature)	Mean, minimum, and maximum on a running weekly (7 day) basis	Mean of the warmest daily maximum water temperature based on hourly data for 7 consecutive days; e.g., if MWMxT = 15°C on August 1, 2008, this is the mean of the daily maximum water temperatures from July 29 to August 4, 2008; this is calculated for every day of the year.

[1]The end of the growing season was defined as the last day of the first week than mean stream temperatures dropped below 5°C for Alena Creek.

3.5. Riparian Habitat

Three types of data were evaluated to monitor the success of the riparian restoration works and the overall function of the riparian habitat; these were: (1) vegetation density estimates from permanent revegetation monitoring plots; (2) vegetation ground cover estimates from randomly placed quadrats; and (3) photographs taken over multiple years at permanent photopoint monitoring locations. Methods are discussed in more detail below. Any regionally or provincially designated noxious invasive species were also documented when observed.

3.5.1. Permanent Revegetation Monitoring Plots

Woody vegetation is the primary focus of riparian revegetation monitoring due to its long-term contribution to the maintenance and enhancement of riparian habitat function. Consequently, the density (stems per hectare) of woody vegetation is an important metric and indicator of restored riparian habitat quality. Permanent revegetation monitoring plots are used to sample the density of perennial woody vegetation within 50 m^2 circular plots, as per the BC Silviculture Stocking Survey Procedures (MOF 2009) and vegetation tally procedures employed by the Forest and Range Evaluation Program's Stand Development Monitoring Protocol (MOF 2011).

Four permanent revegetation monitoring plots were established in 2014, prior to construction of the FHEP; however, only one of these four plots (ALE-PRM03) ended up within the restored area. As such, three additional plots were established in 2016, following construction of the FHEP, so that a total of four plots were assessed in 2016 (as-built), 2017 (Year 1) and 2019 (Year 3). These four permanent revegetation monitoring plots will be assessed for the duration of the monitoring program (Map 4).

Perennial woody vegetation includes long-lived species such as trees and shrubs, but excludes forbs, grasses, and mosses. The surveyors counted the number of stems of all native perennial woody plants and conducted health and mortality checks. Plants showing signs of abiotic stress, insect damage, fungal blights, or other afflictions were all counted as living, but incidences of the afflictions and the host plant species were noted. Stems were defined as those stems of a plant that were individually distinct at ground level. Tree or shrub seedlings with secondary leaves that were the size of a quarter or larger were counted. No minimum height requirements were applied.

The DFO and MELP effective revegetation criteria provided a spacing target of 2.0 m for planting (DFO and MELP 1998). When 80% survival is considered, this equates to an overall target of 2,309 stems/ha, as written in the original proposed long-term monitoring program for Alena Creek (Harwood *et al.* 2013). The current OEMP set minimum targets of 1,200 stem/ha for trees and 2,000 stems/ha for shrubs for revegetated areas associated with temporary riparian habitat loss created during project construction, however the performance measure set for the success of riparian revegetation within the FHEP area is 80% survival with no differentiation between tree or shrub densities (Harwood *et al.* 2017). These target densities for tree and shrub species, as well as overall densities, were considered when assessing whether an adequate density of woody vegetation is growing within the FHEP area. The variability in the stem density estimates was assessed using a two-tailed students t-test and a 90% confidence interval (t value = 2.35). In addition, the presence and relative number of stems of each species were considered to assess if a diverse assemblage of native tree and shrub species is becoming established within the Alena Creek FHEP area, and if the species composition is indicative of expedited succession to a mixed coniferous/ deciduous forest. The overall survival rate of vegetation, as well as the survival of western red cedar (*Thuja plicata*) specifically, was calculated by dividing the total number of live plants by the total number of live and dead plants combined, as observed in any given year.

3.5.2. Percent Vegetation Cover Estimates

Vegetated ground cover, including herbaceous and small woody species, is an indicator of substrate stabilization and suitable growing conditions early in the revegetation process. A target of 80% cover has been adopted for the monitoring program (DFO and MELP 1998; Harwood *et al.* 2013, Harwood *et al.* 2017. Quadrat sampling was employed to determine the percent ground cover of all herbaceous and woody vegetation, excluding lichens, fungi and mosses. Quadrat sampling provides a method for accounting for regeneration of the forb and grass layer, which is not captured by counting perennial woody vegetation within the permanent monitoring plots. This method is most informative during the early vegetation re-establishment period when all vegetation is low to the ground. The quadrat method consists of counting the number of 10 × 10 cm quadrat squares that contain vegetation within the 0.25 m^2 quadrat. Ten quadrat replicates were randomly located within the vicinity of the permanent revegetation monitoring plots and results from the ten replicates were averaged to provide an average percent cover for the site. Photos of each quadrat replicate were taken and are available upon request.

3.5.3. Photopoint Comparison

Photopoint monitoring, employed by taking repeat photographs over time, provides insight into how the riparian condition and associated functions change over time. Photographs were taken facing 0° (north), 90° (east), 180° (south) and 270° (west) from 1.3 m above each permanent monitoring plot centre to qualitatively document change over time. The north facing photographs are appended to this report, whereas additional photographs are available upon request. Additional descriptive photographs were also taken of the monitoring sites.

4. RESULTS

4.1. Fish Habitat

4.1.1. Overview

Photos were taken at established photo-point locations in the enhanced reaches (Reach 1 and Reach 3) of Alena Creek on November 13, 2019. A comparison of all photos is available in Appendix D. Overall, the riparian vegetation has increased since 2016 and the channel has remained stable over this time. Grasses and herbaceous vegetation continue to establish well throughout the reaches and protect the bank from excessive erosion, while also providing cover for small salmonids. No substantial changes to the stream channel were noted that were not anticipated based on the dynamic stability criteria of the design. Historical beaver activity has created significant damming upstream of both Reach 1 and Reach 3, which has been managed in accordance with best management practices for dam removal provided by a licensed trapper from EBB Environmental Consulting Inc. Fortunately, beaver dams have not been constructed within Reach 1 or Reach 3 since channel works were completed. A description of channel condition and geomorphic processes is provided for the two reaches in the following section.

4.1.2. Reach 1

Reach 1 is the most downstream reach of Alena Creek and extends up from the Lillooet River Forest Service Road (FSR, Map 4) bridge. A summary of observations at each cross section is provided below.

- **ALE-XS1** - Channel had previously avulsed onto river left floodplain and created a side-channel less than 10 m long. This channel appears to have been less active in 2019 compared to 2018 but this could be a result of difference in flow between surveys. The riffle is still composed of gravel and is relatively free of fines but has some algae growth. No concerns for long term stability (Figure 1 to Figure 4).
- **ALE-XS2** - Channel may be more backwatered in this location due to a collapse of one of the channel-spanning logs downstream (Figure 5). Some undercutting has occurred on river left under a longitudinally aligned log, which appears to be stable and has created good cover habitat. Root wads on river right continue to provide good cover habitat. A downstream collapsed log should be monitored closely in future years to ensure the jam is not causing excessive fines deposition or full channel avulsion.
- **ALE-XS3** - Channel hydraulic diversity remains as designed, and the riffle has low fines content; no concerns for long term stability.
- **ALE-XS4** - Pool depth has remained as designed with minimal aggradation of fines. Root wads continue to provide good cover conditions. No concerns for long term stability.

Figure 1. **Looking from river left to river right at ALE-XS1 on September 19, 2016.**

Figure 2. **Looking from river left to river right at ALE-XS1 on November 10, 2017.**

Figure 3. **Looking from river left to river right at ALE-XS1 on November 5, 2018.**

Figure 4. **Looking from river left to river right at ALE-XS1 on November 13, 2019.**

Figure 5. Log that has collapsed between ALE-XS1 and ALE-XS2 (left) causing moderate side-channel formation (right and shown in Figure 1 to Figure 4) and partial backwatering of a riffle. Photos taken on June 20, 2019.

4.1.3. Reach 3

The channel is still recovering from a peak flow event that occurred shortly after construction on November 9, 2016. Following this flow event, a mid-channel bar formed just upstream of the ALE-XS6 site as the result of erosion along the right bank (Figure 6). The channel widening at this location caused a moderate reduction in gravel quality at the adjacent riffle, but minimal reduction in salmonid habitat quality overall. Bank erosion has also caused channel widening and down-cutting in section at the riffle-crest downstream of ALE-XS5 (Figure 7). Repairs are recommended in this reach, as described in Section 5.1.

Beaver damming activity has been increasing upstream of Reach 3. The dams may restrict fish migration to the upstream spawning reach, impede gravel supply to Reach 3, and cause diversion of flow around the Reach 3 constructed channel. Furthermore, a sudden dam breach could cause a pulse of fine sediment to be delivered to, and deposited in, Reach 3. Two new channels have already formed on the west side of Reach 3 due to a large beaver pond approximately 30–50 m upstream of Reach 3. These channels are cutting into fine sediment and delivering it to Reach 3. One channel enters Reach 3 approximately 40 m downstream from the head of Reach 3 (Figure 8) and the other enters where the construction access road came in midway through the reach (Figure 9).

A summary of observations at each cross section is provided below.

- **ALE-XS5** - Channel hydraulic diversity remains as designed, and the riffle has low fines content despite moderate bank erosion upstream. One channel-spanning log has collapsed but is only subtly affecting hydraulics. Root wads upstream of the riffle continue to provide good cover conditions; there are no concerns for long term stability.

- **ALE-XS6** - Some sand deposition has occurred on riffle material, likely originating partially from upstream supply and from bank erosion that largely occurred during the November 2016 high flow event. Grass and herbaceous bank vegetation have established that should prevent excessive erosion in the future. No concerns for long term stability.
- **ALE-XS7** - Pool has aggregated with sand to some extent and may now be at an equilibrium depth with the upstream sand supply. Rootwads continue to provide cover habitat, and riffles are generally free of fines; there are no concerns for long term stability.
- **ALE-XS8** – The riffle is still relatively free of fines and excessive erosion has not occurred. Fines deposition has occurred on the glide that is unavoidable given upstream sediment supply; there are no concerns for long term stability.

Figure 6. Mid-channel bar just upstream of ALE-XS6. Photo taken on June 20, 2019.

Figure 7. Bank erosion and channel down-cutting at ALE-XS5 requiring repair. Photo taken on June 20, 2019.

Figure 8. Entry point of upper new channel formed near upstream extent of Reach 3. Photo taken on November 13, 2019.

Figure 9. Entry point of lower new channel formed near upstream extent of Reach 3. Photo taken on June 20, 2019.

4.2. Fish Community

4.2.1. Adult Spawner Abundance

The peak count of Coho Salmon spawners observed in 2019 was 153 live fish and 20 carcasses on December 9, 2019 (Table 5). The peak count of adult spawning Coho Salmon was 153 in 2019, which was slightly higher than the baseline years (127 and 111) and 2017 (132) but less than 2016 (192) (Table 6). A comparison of observations among years also highlights the variability in run timing, with the annual peak live count recorded on November 5 in 2010 and 2018, November 14 in 2016, December 5 in 2017, and December 9 in 2019. The peak counts provide a general indication of use and demonstrate that Alena Creek supports equivalent or potentially greater use by Coho Salmon spawners compared to pre-enhancement, although among-year variability in spawner abundance is strongly affected by other factors such as marine survival. An example photograph of spawning Coho Salmon observed December 9, 2019 is provided in Figure 10. A single Bull Trout was observed on October 1, 2019 (Table 5).

Table 5. Summary of adult fish observed during fall spawner surveys in 2019.

Stream	Date	Survey Time	Survey Distance	# of Live Adults Observed[1]			# of Adult Carcasses Observed[1]		
				BT	CT	CO	BT	CT	CO
Alena Creek	17-Sep-19	1.5	1,750	0	0	0	0	0	0
	1-Oct-19	1.9	2,300	1	0	0	0	0	0
	22-Oct-19	2.0	2,300	0	0	0	0	0	0
	13-Nov-19	4.7	2,300	0	0	21	0	0	2
	24-Nov-19	1.9	2,300	0	0	91	0	0	19
	9-Dec-19	2.5	2,300	0	0	153	0	0	20
Alena Creek Total:		**14.5**	**13,250**	**1**	**0**	**265**	**0**	**0**	**41**

[1] BT = Bull Trout, CT = Cutthroat Trout, CO = Coho Salmon

Table 6. Peak Coho Salmon spawner counts during baseline (2010, 2011) and post-construction monitoring (2016, 2017, 2018 and 2019).

	2010 Peak Count (05-Nov-10)		2011 Peak Count (02-Dec-11)		2016 Peak Count (27-Nov-16)		2017 Peak Count (05-Dec-17)		2018 Peak Count 5-Nov-18		2019 Peak Count (09-Dec-19)	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
	127	0	110	1	174	18	110	22	**126**	**0**	153	20
Total	**127**		**111**		**192**		**132**		**126**		**173**	

Figure 10. Spawning Coho Salmon observed on December 9, 2019.

4.2.2. Juvenile Abundance

4.2.2.1. Overview

On September 23, 2019, 44 minnow traps were set overnight in riffle, pool, and glide habitats ranging in depth from 0.2 to 1.2 m (Table 7). A total of 436 fish were captured during minnow trap sampling consisting of 423 Coho Salmon and 13 Cutthroat Trout (Table 7). No juvenile Bull Trout were captured in 2019. Raw data tables and representative photographs of minnow trapping sites are presented in Appendix E.

Table 7. Summary of minnow trapping habitat characteristics and fish captures in Alena Creek on September 24, 2019.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Mesh Size (mm)	Habitat Type	Trap Depth Range (m)	Total Captures		
								BT	CO	CT
ALE-MT01	24-Sep-19	Enhanced	5	116.4	3	Glide, Riffle	0.3 - 0.4	0	7	2
ALE-MT02	23-Sep-19	Enhanced	5	117.1	3-6	Pool, Riffle	0.3 - 0.5	0	15	0
ALE-MT07	23-Sep-19	Enhanced	5	120.7	3-6	Pool	0.4 - 0.8	0	25	2
ALE-MT03	23-Sep-19	Unenhanced	4	100.1	3-6	Pool, Glide	0.2 - 0.6	0	68	4
ALE-MT06	23-Sep-19	Unenhanced	10	261.7	3-6	Pool	0.3 - 1.2	0	138	3
ALE-MT08	23-Sep-19	Enhanced	5	141.1	3-6	Pool, Riffle	0.3 - 0.7	0	54	0
ALE-MT09	23-Sep-19	Enhanced	5	140.9	3-6	Pool, Riffle	0.2 - 0.3	0	26	1
ALE-MT05	23-Sep-19	Unenhanced	5	142.1	6	Pool	0.3 - 0.4	0	90	1
Grand Total:			**44**	**1,139.9**				**0**	**423**	**13**
Grand Average:			**5.5**	**142.5**				**0**	**53**	**2**

4.2.2.2. Cutthroat Trout

A total of 13 Cutthroat Trout, ranging in length from 46 to 121 mm, were captured during the 2019 sampling program (Table 10). Based on a review of the length-frequency histogram (Figure 11) and aging data from scale analysis (Figure 13), discrete fork length ranges were defined for each age class (Table 10). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 11. Catch per unit effort (CPUE) ranged from 0 fish per 100 trap hours at ALE-MT08 to 4.0 fish per 100 trap hours in ALE-MT03 (Table 12). The average CPUE was 1.2 fish per 100 trap hours and the standard deviation was 1.3 fish per 100 trap hours.

Cutthroat Trout Fry (0+)

A total of three Cutthroat Trout fry (0+) were captured in 2019. A single fry was captured at ALE-MT01 (enhanced), ALE-MT07 (enhanced), and ALE-MT03 (unenhanced).

Cutthroat Trout Parr (1+)

Cutthroat Trout parr (1+) were distributed throughout Alena Creek and were captured at all sites except for ALE-MT02 and ALE-MT08 (enhanced) and ALE-MT05 (unenhanced) (Table 20). A total of 9 Cutthroat Trout 1+ parr were captured, with the largest number of fish captured in ALE-MT03 and ALE-MT06.

Cutthroat Trout Parr (2+)

A single Cutthroat Trout 2+ parr was captured in 2019 in ALE-MT05 (unenhanced reach).

Figure 11. Fork length frequency for juvenile Cutthroat Trout captured (minnow trapping) in Alena Creek in 2019.

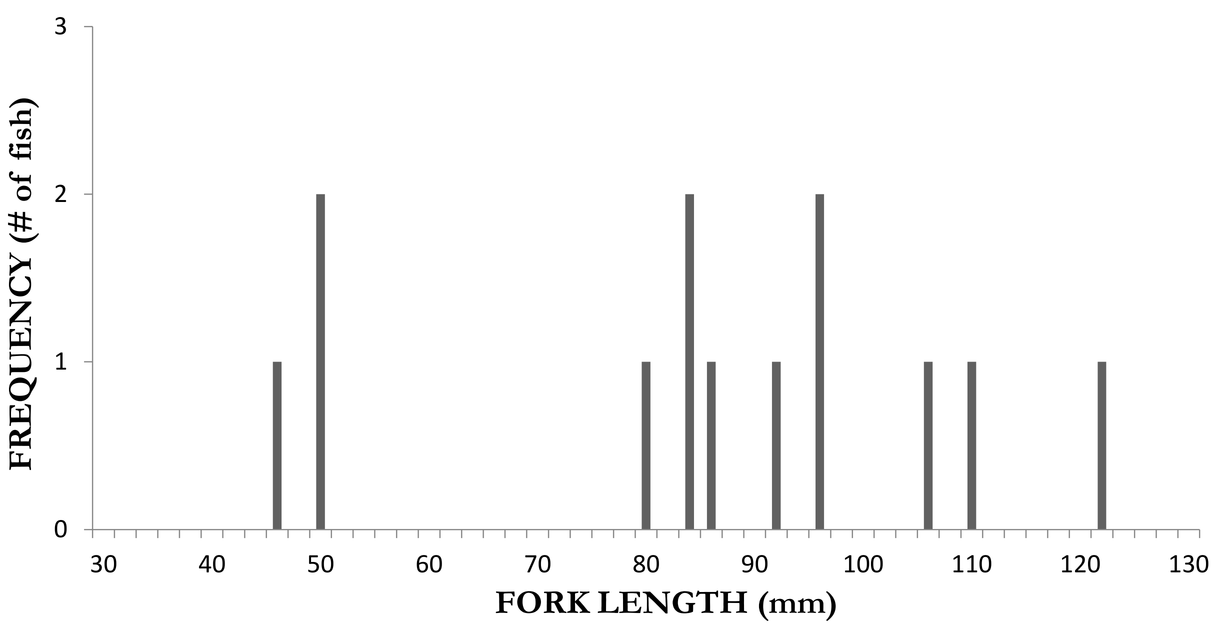


Figure 12. Fork length versus age for juvenile Cutthroat Trout captured in Alena Creek in 2019.

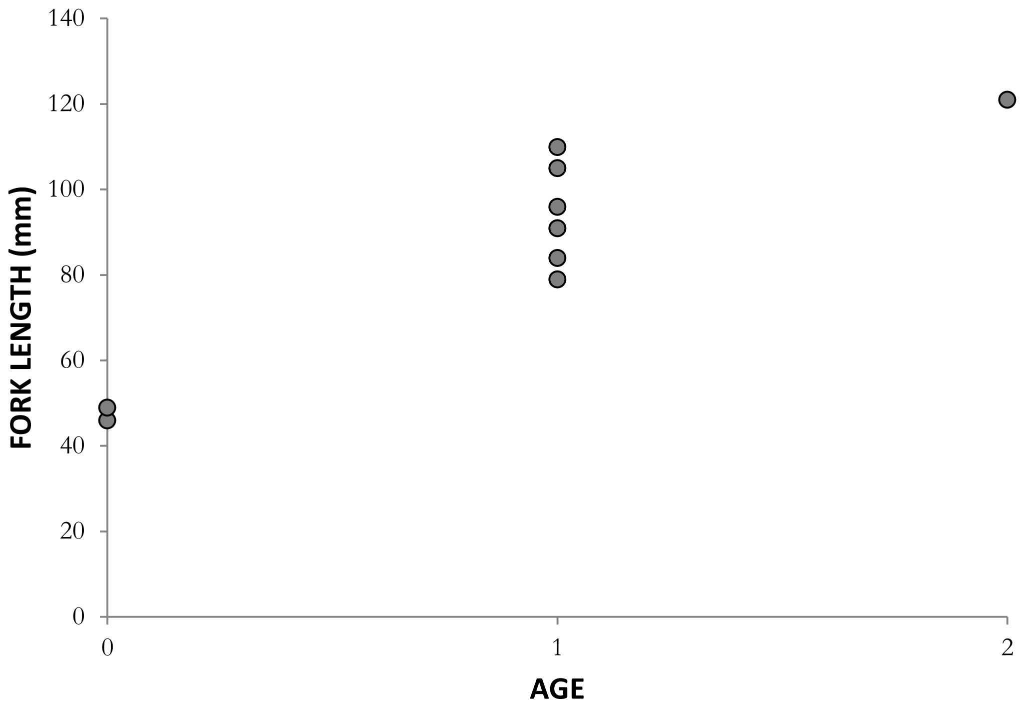


Table 8. Age size bins for juvenile Cutthroat Trout captured in Alena Creek in 2019.

Age Class	Fork Length Range (mm)
Fry (0+)	46-49
Parr (1+)	79-110
Parr (2+)	121+

Table 9. Summary of fork length, weight and condition for juvenile Cutthroat Trout captured in Alena Creek in 2019.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	3	48	46	49	3	1.0	1.0	1.0	3	0.91	0.85	1.03
Parr (1+)	9	92	79	110	6	9.0	5.0	13.0	9	0.97	0.84	1.13
Parr (2+)	1	121	121	121	0	0.0	0.0	0.0	0	-	-	-
All	**13**	**84**	**46**	**121**	**9**	**6.3**	**1.0**	**13.0**	**13**	**0.95**	**0.84**	**1.13**

Table 10. Catch and CPUE for Cutthroat Trout captured by minnow trapping in Alena Creek in 2019.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Minnow Trap Catch (# of Fish)				Minnow Trap CPUE (# of Fish/100 Trap hrs)			
					0+	1+	2+	All	0+	1+	2+	All
ALE-MT01	24-Sep-19	Enhanced	5	116.4	1	1	0	**2**	0.9	0.9	0.0	**1.7**
ALE-MT02	23-Sep-19	Enhanced	5	117.1	0	0	0	**0**	0.0	0.0	0.0	**0.0**
ALE-MT07	23-Sep-19	Enhanced	5	120.7	1	1	0	**2**	0.8	0.8	0.0	**1.7**
ALE-MT03	23-Sep-19	Unenhanced	4	100.1	1	3	0	**4**	1.0	3.0	0.0	**4.0**
ALE-MT05	23-Sep-19	Unenhanced	5	142.1	0	0	1	**1**	0.0	0.0	0.7	**0.7**
ALE-MT06	23-Sep-19	Unenhanced	10	261.7	0	3	0	**3**	0.0	1.1	0.0	**1.1**
ALE-MT08	23-Sep-19	Enhanced	5	141.1	0	0	0	**0**	0.0	0.0	0.0	**0.0**
ALE-MT09	23-Sep-19	Enhanced	5	140.9	0	1	0	**1**	0.0	0.7	0.0	**0.7**
Grand Total:			**44**	**1,139.9**	**3**	**9**	**1**	**13**	**2.7**	**6.5**	**0.7**	**9.9**
Grand Average:			**5.5**	**142.5**	**0**	**1**	**0**	**2**	**0.3**	**0.8**	**0.1**	**1.2**
Grand Standard Deviation:				**50.4**	**1**	**1**	**0**	**1**	**0.5**	**1.0**	**0.2**	**1.3**

4.2.2.3. Coho Salmon

A total of 423 juvenile Coho Salmon were captured during minnow trap sampling in Alena Creek on September 24, 2019. Based on a review of the length-frequency histogram (Figure 13) and aging data from scale analysis (Table 11), discrete fork length ranges were defined for each age class (Table 12). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 12. CPUE ranged from 6.0 fish per 100 trap hours at ALE-MT01 (enhanced reach) to 68.3 fish per 100 trap hours in ALE-MT05 (unenhanced) (Table 13). The total average CPUE was 35.0 fish per 100 trap hours and the standard deviation was 24.0 fish per 100 trap hours (Table 13).

Coho Salmon Fry (0+)

Coho Salmon fry (0+) were captured at all sampling sites in 2019 and are distributed throughout the sampled reaches of Alena Creek (Table 13). Coho Salmon fry were most abundant at ALE-MT03 and ALE-MT06 in the unenhanced reach (Reach 2) and ALE-MT08 in the enhanced reach (Reach 3).

Coho Salmon Parr (1+)

Coho Salmon 1+ parr were captured at most sites in 2019 except for ALE-MT02 and ALE-MT09 (Table 13). They were most abundant in ALE-MT05, in the unenhanced reach (Reach 4).

Figure 13. Fork length frequency for juvenile Coho Salmon captured (minnow trapping) in Alena Creek in 2019.

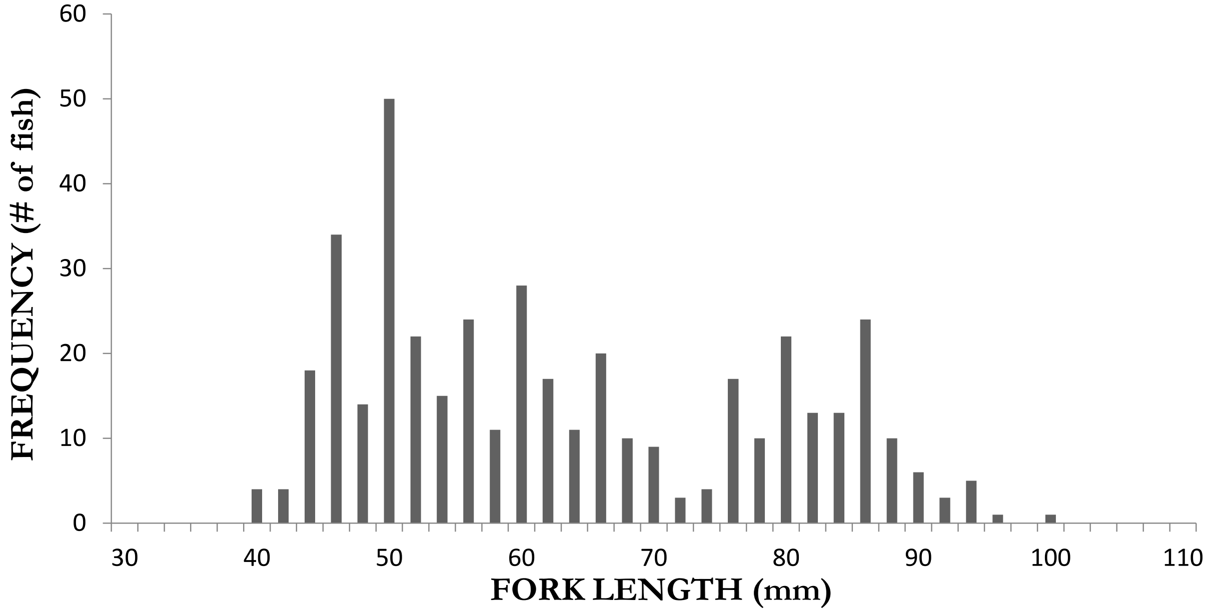


Figure 14. Fork length versus age for Coho Salmon captured in Alena Creek in 2019.

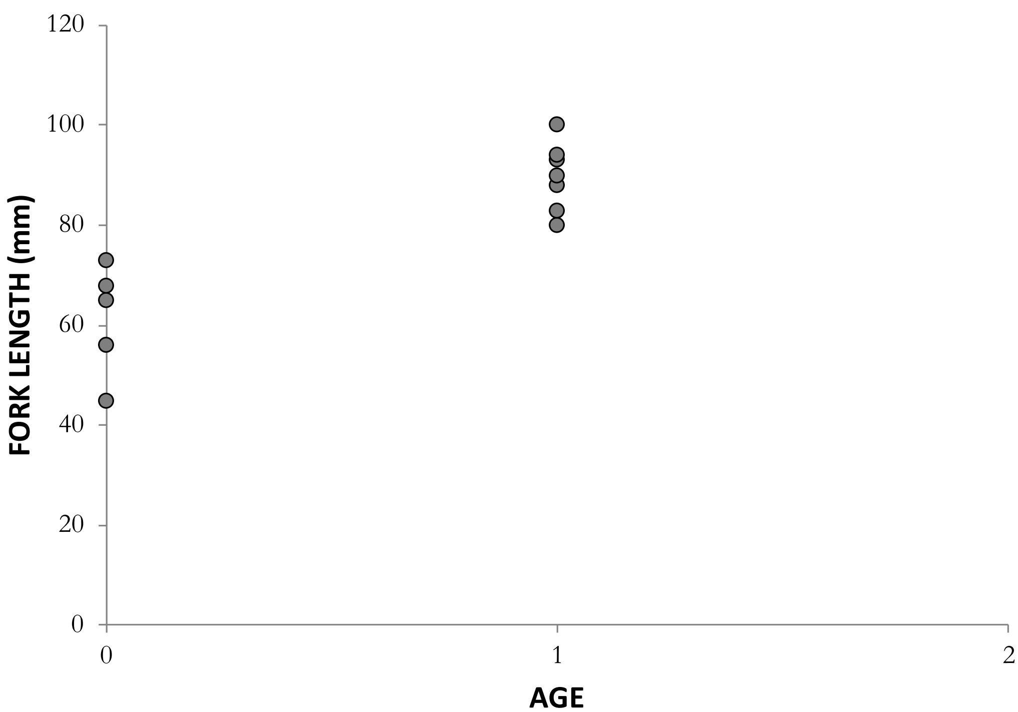


Table 11. Age size bins for Coho Salmon captured in Alena Creek in 2019.

Age Class	Fork Length Range (mm)
Fry (0+)	40-73
Parr (1+)	74-100

Table 12. Summary of fork length, weight and condition for Coho Salmon captured in Alena Creek in 2019.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	297	54	40	73	220	2.0	0.4	6.0	297	1.27	0.47	2.85
Parr (1+)	126	83	74	100	63	6.8	5.0	12.0	126	1.21	0.76	1.56
All	**423**	**63**	**40**	**100**	**283**	**3.1**	**0.4**	**12.0**	**423**	**1.26**	**0.47**	**2.85**

Table 13. Catch and CPUE for Coho Salmon captured in Alena Creek in 2019.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Minnow Trap Catch (# of Fish)				Minnow Trap CPUE (# of Fish/100 Trap hrs)			
					0+	1+	2+	All	0+	1+	2+	All
ALE-MT01	24-Sep-19	Enhanced	5	116.4	6	1	0	**7**	5.2	0.9	0.0	**6.0**
ALE-MT02	23-Sep-19	Enhanced	5	117.1	15	0	0	**15**	12.8	0.0	0.0	**12.8**
ALE-MT07	23-Sep-19	Enhanced	5	120.7	20	5	0	**25**	16.6	4.1	0.0	**20.7**
ALE-MT03	23-Sep-19	Unenhanced	4	100.1	52	16	0	**68**	52.0	16.0	0.0	**68.0**
ALE-MT06	23-Sep-19	Unenhanced	10	261.7	93	45	0	**138**	35.5	17.2	0.0	**52.7**
ALE-MT08	23-Sep-19	Enhanced	5	141.1	50	4	0	**54**	35.4	2.8	0.0	**38.3**
ALE-MT09	23-Sep-19	Enhanced	5	140.9	26	0	0	**26**	18.5	0.0	0.0	**18.5**
ALE-MT05	23-Sep-19	Unenhanced	5	142.1	35	55	0	**90**	24.6	38.7	0.0	**63.3**
Grand Total:			**44**	**1,139.9**	**297**	**126**	**0**	**423**	**200.6**	**79.7**	**0.0**	**280.3**
Grand Average:			**5.5**	**142.5**	**37**	**16**	**0**	**53**	**25.1**	**10.0**	**0.0**	**35.0**
Grand Standard Deviation:				**50.4**	**28**	**22**	**0**	**45**	**15.1**	**13.5**	**0.0**	**24.0**

4.2.2.4. Bull Trout

No Bull Trout were captured in Alena Creek minnow traps in 2019.

4.2.2.5. Comparison Among Years

Cutthroat Trout

The average CPUE across sites in 2019 (1.1 fish per 100 trap hours) was most similar to 2017 (0.8 fish per 100 trap hours) and less than 2013 and 2018 (1.8 and 1.6 fish per 100 trap hours respectively) (Figure 15). The average CPUE in 2014 (7.2 fish per 100 trap hours) was higher than other years; however, the 2014 CPUE results are biased high by the short daytime sets and the likelihood that catchability is not constant throughout the trap soak time, with a high initial catch rate that diminishes over time (Harwood *et al.* 2016). There were more sites sampled in 2018 and 2019 (eight sites versus six sites in previous years)

In 2019, Cutthroat Trout were relatively evenly distributed in low numbers throughout Alena Creek; this is similar to previous years although the standard deviation was slightly higher in 2019 (Figure 16). Specifically, the standard deviation of CPUE among sites was 1.0 fish per 100 trap hours compared to 0.8 fish per 100 trap hours in 2018 and 0.7 fish per 100 trap hours in 2017 and 2013.

In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+ parr. Three fry were captured in 2019 compared to zero captured in 2017 and 2018. Similar to 2019, three fry were also captured during two sampling events in September 2013 and one fry was captured in October 2014. The low abundance of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence of fry in late September / early October.

Figure 15. Comparison of minnow trap CPUE for Cutthroat Trout during baseline (2013 and 2014) and post-construction (2017, 2018, and 2019). Error bars represent standard error. Note that 2014 CPUE may be an overestimation due to shorter soak time at some sites due to bear activity.

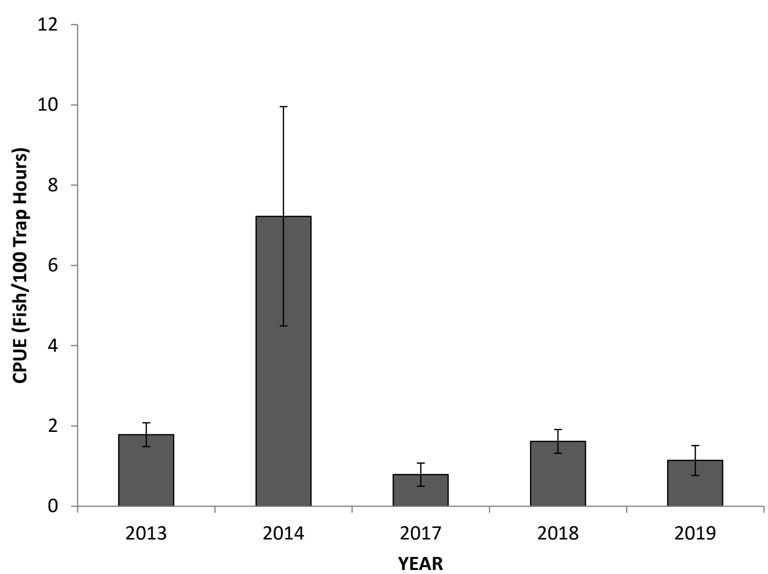
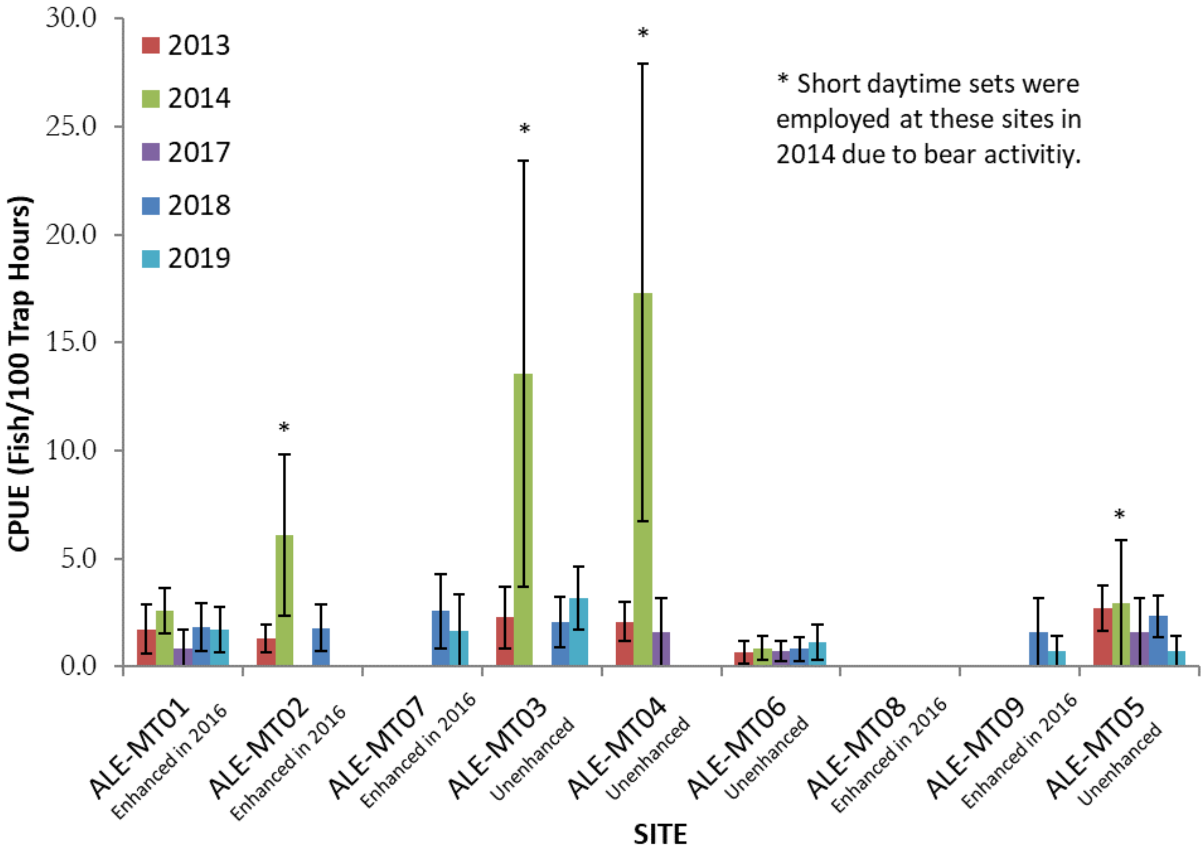


Figure 16. **Comparison of minnow trap CPUE for Cutthroat Trout at each site during baseline (2013 and 2014) and post-construction (2017, 2018, and 2019). Error bars represent standard error.**



Coho Salmon

The average CPUE across sites in 2018 and 2019 (83.8 and 33.3 fish per 100 trap hours respectively) was higher than values observed in 2013 and 2017 (Figure 17). There were more sites sampled in 2018 and 2019 (eight sites versus six sites in previous years), although this should not directly affect CPUE as it is a standardized metric.

In 2019, Coho Salmon fry were captured at all sites, with parr present at most sites similar to previous years (Figure 18). The standard deviation of CPUE among sites in 2019 was within range of previous years.

Figure 17. Comparison of minnow trap CPUE for Coho Salmon during baseline (2013 and 2014) and post-construction (2017, 2018, and 2019) monitoring periods. Error bars represent standard error. Note that 2014 CPUE may be an overestimation due to shorter soak time at some sites due to bear activity.

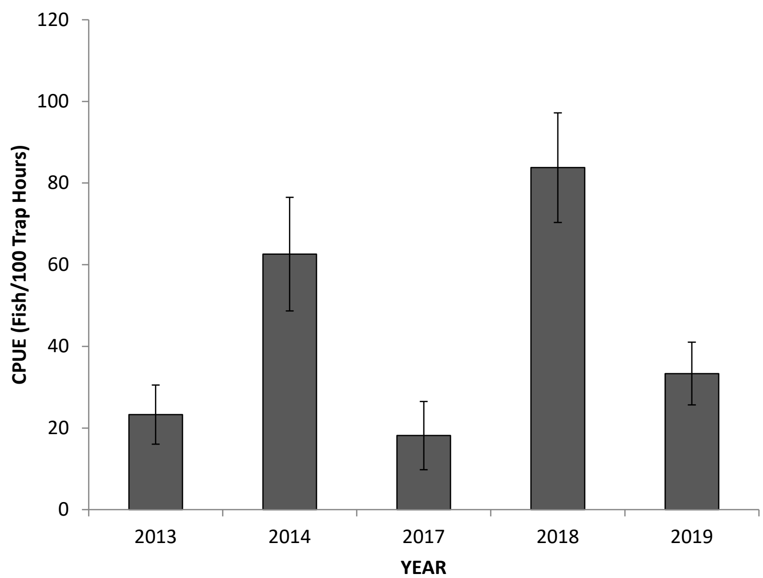
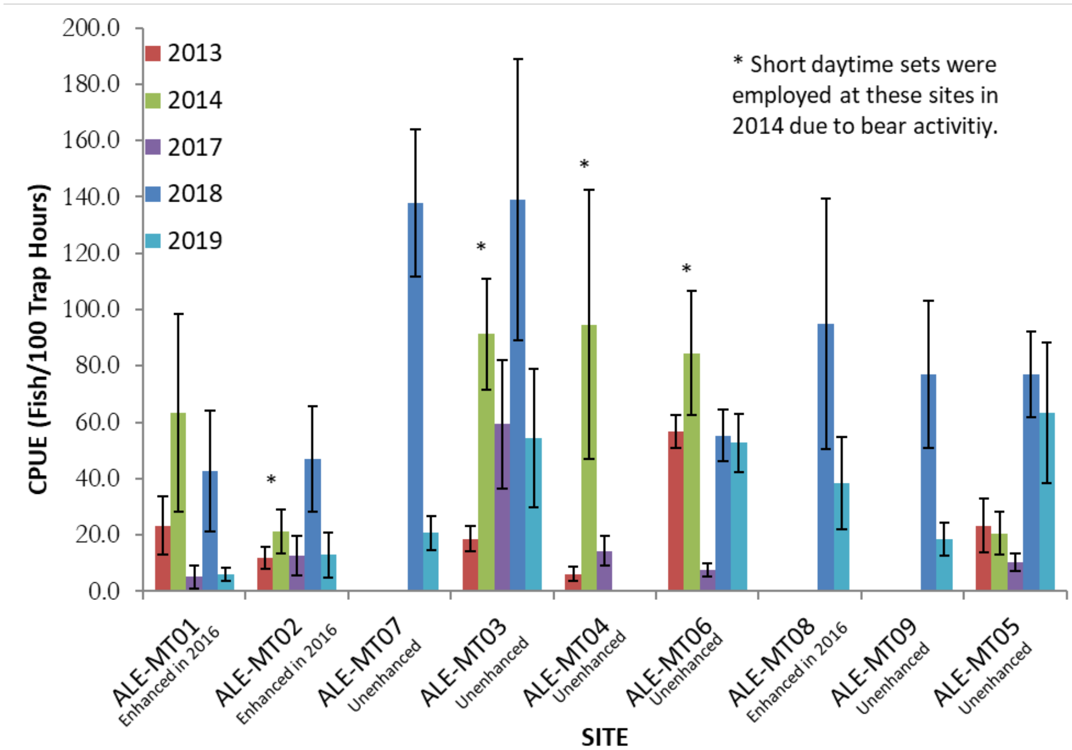


Figure 18. Comparison of minnow trap CPUE for Coho Salmon at each site during baseline (2013 and 2014) and post-construction (2017, 2018, and 2019). Error bars represent standard error.



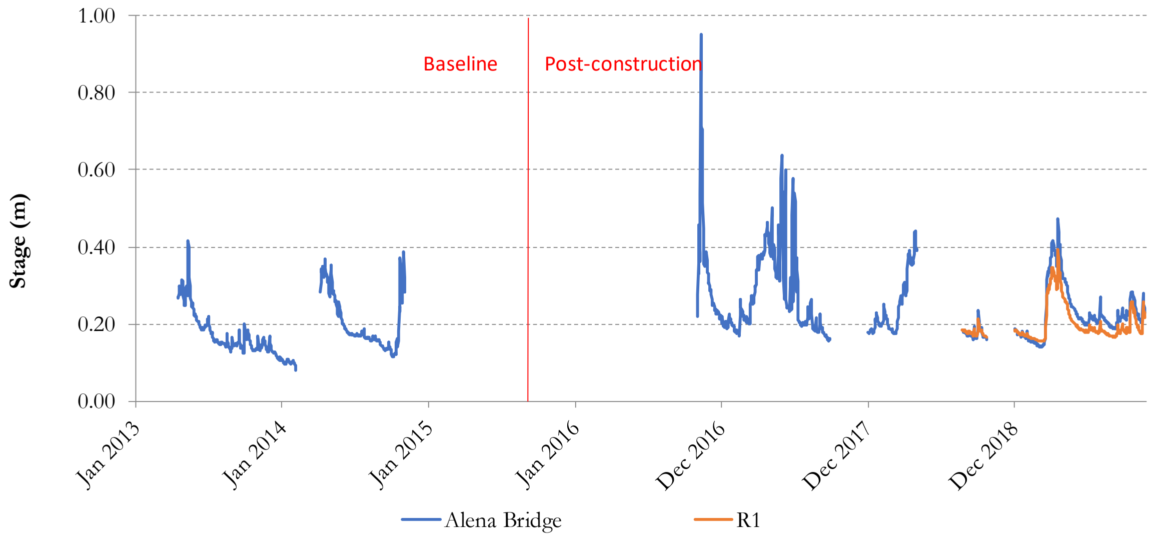
4.3. Hydrology

Seasonal trends in the Alena Creek hydrograph in 2019 were consistent with a coastal, snow-dominated watershed. Seasonal hydrograph patterns remained broadly consistent with observations from baseline and Year 1 and 2 post-construction monitoring. Stage readings in 2019 remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, then increased during snow melt in spring (March and April). Stage remained low during monitoring in late-summer and early fall (August 23 to October) when precipitation was minimal (Figure 19).

The daily maximum stage during 2019 at the FSR bridge was recorded on April 19, 2019 (0.47 m) corresponding with spring snowmelt. This was less than the maximum stage measured since records began in May 2013, which was recorded on November 9, 2016 (0.95 m) during a 1-in-20 year return flood event on the Upper Lillooet River (McCoy, pers. comm. 2016), but was consistent with peak values recorded during baseline monitoring (Figure 19). Several higher stage values were also recorded in 2017 between mid-May to early-July (Figure 19). Overall mean daily stage at the FSR bridge measured from January to November of 2019 was 0.23 ± 0.07 m, and dropped below 0.16 m for 36 days from February 9, 2019 to March 16, 2019 with a minimum of 0.14 m. This minimum value is slightly lower than stage recorded previously during monitoring from November 2016 to January 2019.

During 2017, high stage readings were recorded at the FSR bridge that were suspected to be a result of backwatering from Upper Lillooet River (Harwood *et al.* 2018). A second gauge (R1) was installed on August 23, 2018 approximately 125 m upstream of the Alena Bridge gauge for comparison to assess backwater effects. During 2019, the stage trends at the FSR bridge and R1 gauge closely aligned (Figure 19), indicating that backwatering from Upper Lillooet River to the FSR bridge was no longer occurring.

Figure 19. Stage in Alena Creek at the Lillooet River FSR bridge during baseline (April 2013 to November 2014), and Year 1 to Year 3 of post-construction monitoring (November 2016 to November 2019).



4.4. Water Temperature

4.4.1. Overview

The results of the pre-construction and post construction water temperature metrics, including Year 3 (2019) data, are summarized in the following sections. Water temperature site photographs are presented in Appendix B and annual water temperature figures and BC WQG for water temperature are presented in Appendix C. This report is intended to be primarily a data summary report; any changes in water temperature related to the construction of the FHEP will be evaluated with a BACI analysis following 5 years of post-construction water temperature data collection.

Years 1, 2, and 3 (2017, 2018, 2019) complete nearly three full years of post-construction water temperature data collection at the upstream (control; ALE-USWQ) and downstream site (impact; ALE-BDGWQ). The period of record is from November 23, 2016 to September 23, 2019 (Table 1, Map 3). Data availability is based on the most recent download of water temperature loggers. There are no data gaps in the post-construction data set to date (Table 1). Data gaps occurred pre-construction due to icing issues and out of water events in the winter of 2014. These data gaps resulted in a loss of winter season data at the upstream site, therefore temperature minima may not have been fully captured upstream of the FHEP works pre-construction.

The temperature regime is presented using a) daily average temperature data, b) daily maximum temperature data and c) daily minimum temperature data (Figure 20). The pattern of differences in water temperature between the two sites during the winter and summer seasons is largely the same pre- and post-construction, as depicted in the cumulative frequency distribution between the sites (Figure 21). Despite the small difference in elevation (11 m) and short distance (~1 km) between the sites, the downstream site is generally warmer than the upstream site in the summer and cooler in the winter (Figure 20, Figure 21). In addition to the influence of groundwater upstream, there is a tributary that enters Alena Creek between the two sites, which may account for some of the cooler temperatures downstream in the winter and warmer temperatures downstream in the summer (Figure 20, Figure 21, Map 3).

In general, water temperature upstream (ALE-USWQ1) varied over a narrower range than observed downstream (ALE-BDGWQ) (Figure 20). The moderation of the water temperature regime upstream is likely due to the presence of groundwater inflow at this site. The daily average temperatures recorded at both sites were higher post-construction than pre-construction in the warmer months and the increase is more pronounced at the downstream site, likely due to the moderating effect of the groundwater inflow at the upstream site (Figure 20). Trends in the data attributable to the FHEP will be evaluated following five years of data collection through a BACI analysis.

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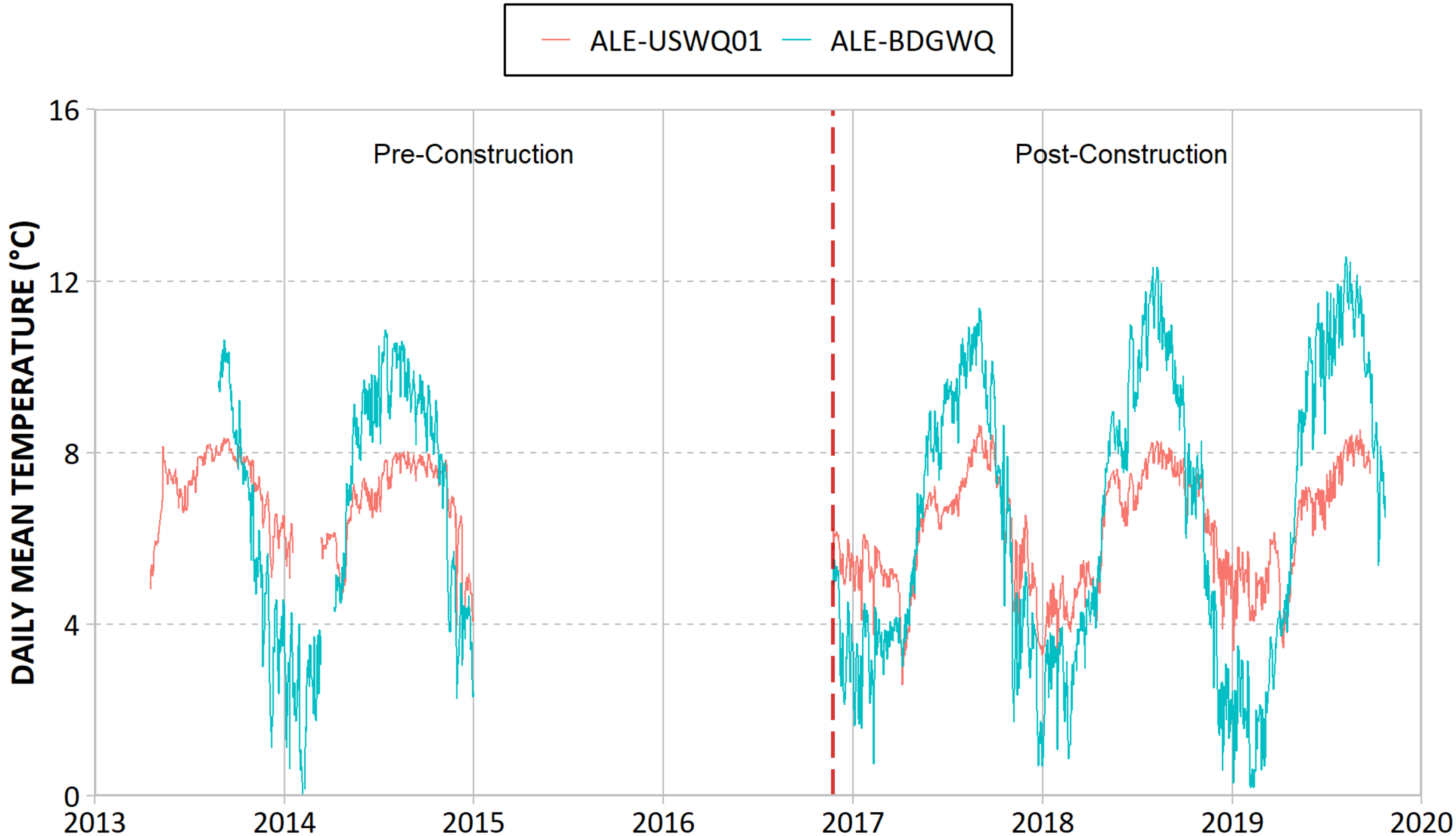
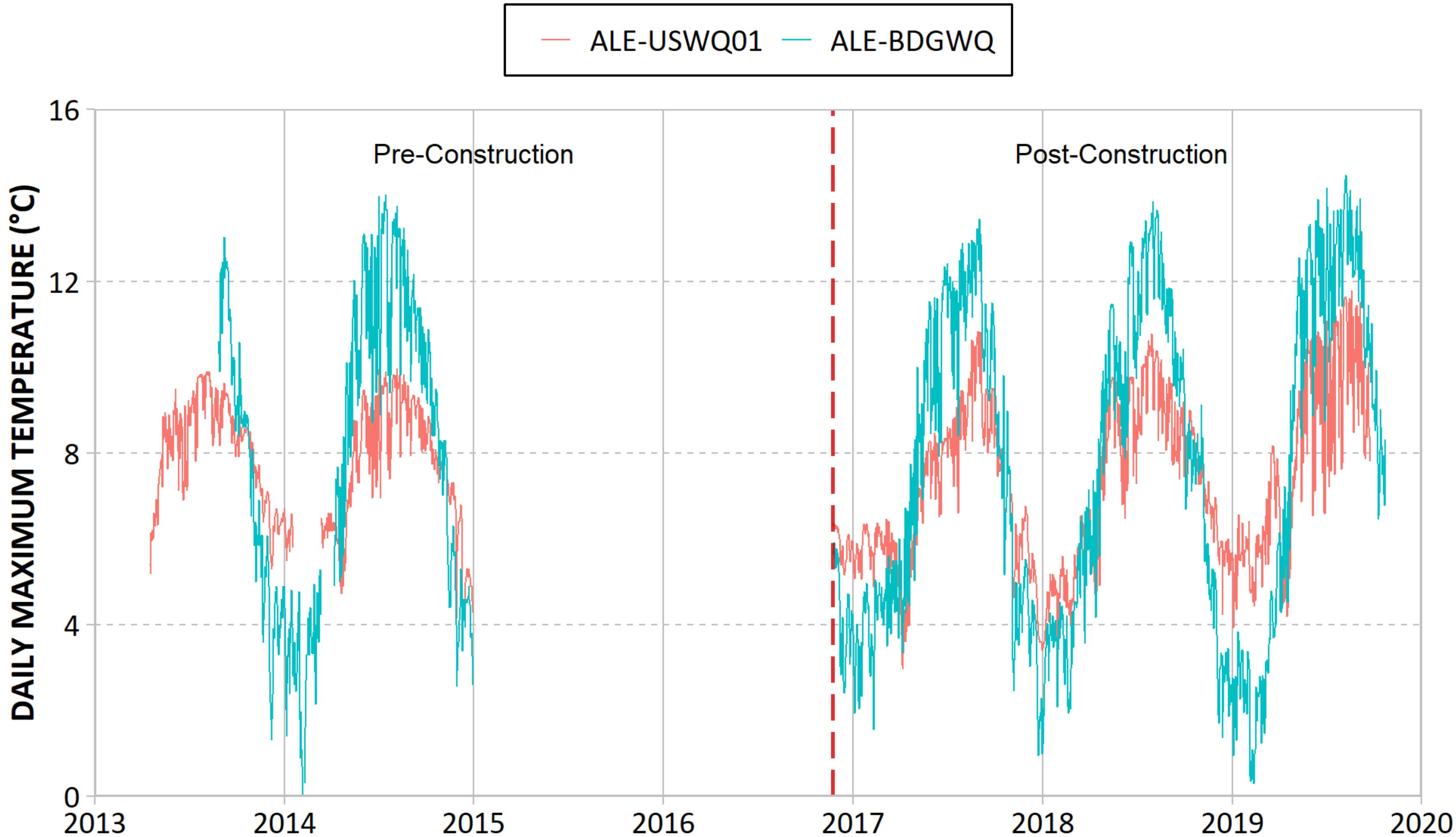
Figure 20. Overall average, maximum and minimum temperature regime in Alena Creek pre-construction (2014 to 2015) and post-construction (2017 to 2019).

(a) Daily Average



(b) Daily Maximum



(c) Daily Minimum

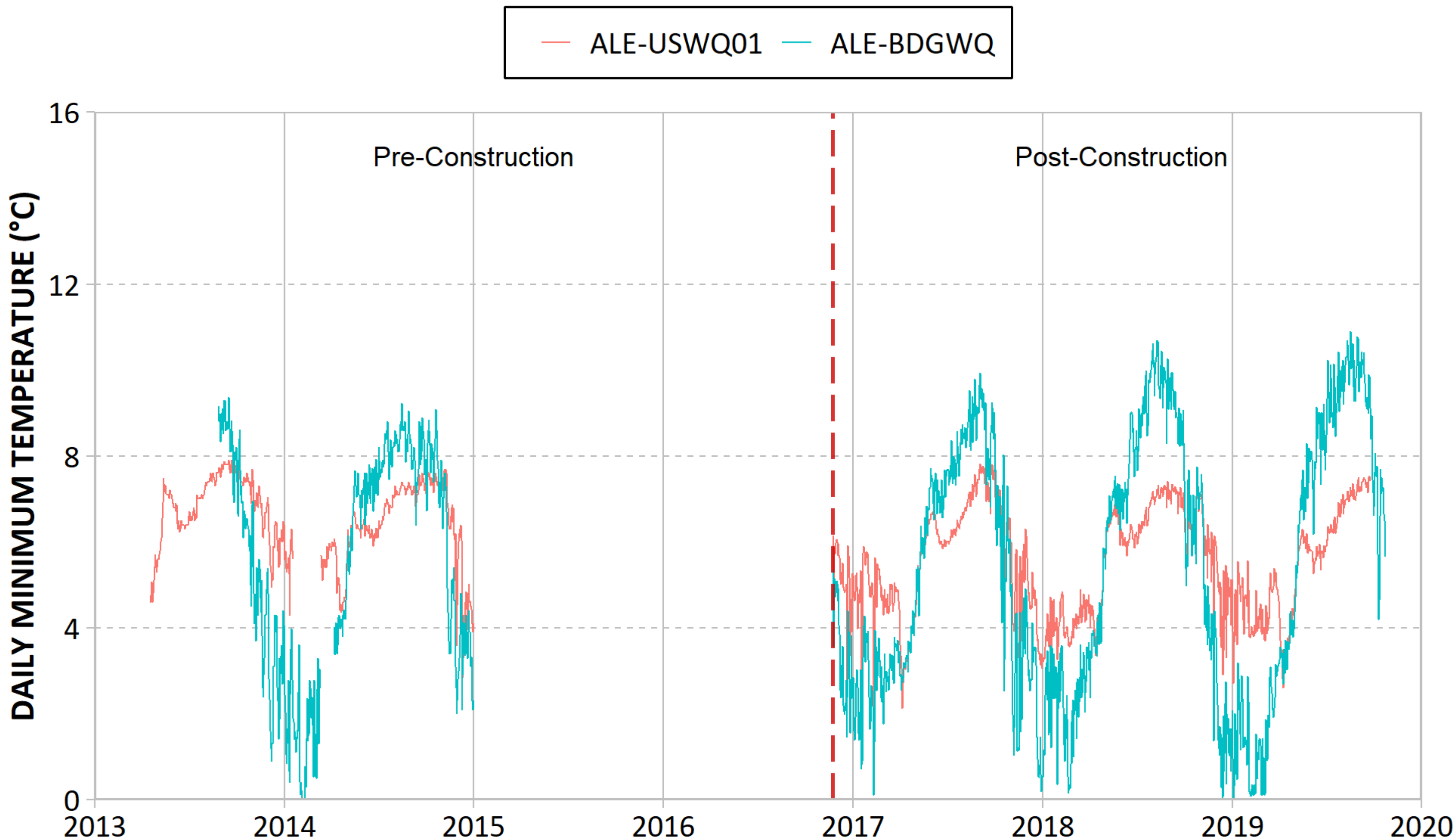
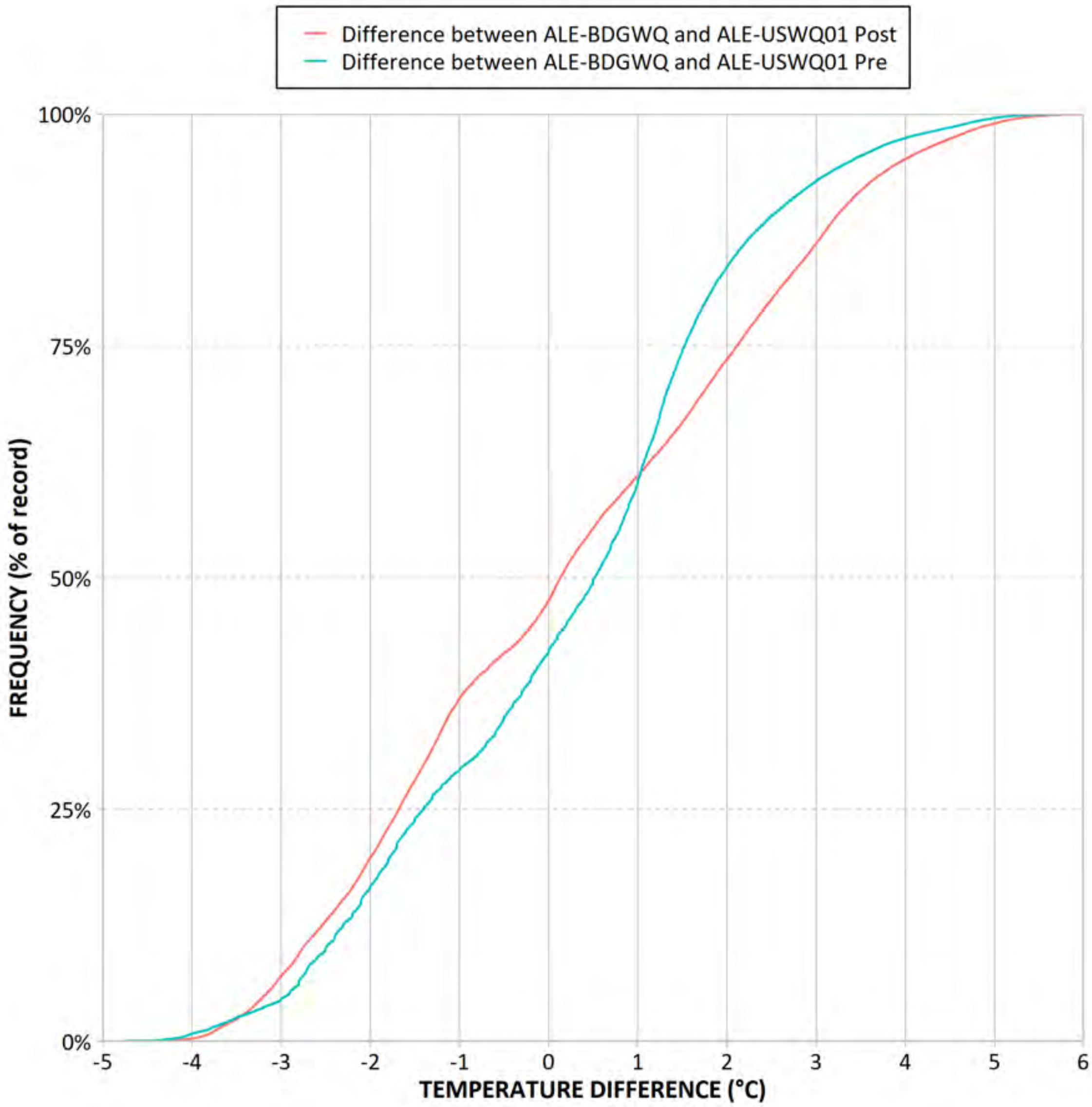


Figure 21. Cumulative frequency distribution of differences in pre-construction (2013-2014) and post-construction (2016-2019) instantaneous water temperature between the downstream site (ALE-BDGWQ) and the upstream site (ALE-USWQ1) (positive values indicate warmer temperatures at ALE-BDGWQ).



4.4.2. Monthly Summary Statistics

The mean, instantaneous minimum, instantaneous maximum, and standard deviation for water temperature for each month of the record are summarized for the pre-construction period in Table 14 and for the post-construction period in Table 15. Overall, no substantial change in monthly temperature statistics has been observed in Year 3 in comparison to Year 1 at the upstream sites where the range in monthly average temperatures at the was 5.0°C to 8.1°C pre-construction and 4.0°C to

8.1°C post-construction. No data are available for February or March pre-construction at the upstream site, therefore the monthly average minimum of 5.0°C measured in December 2014 may not be representative of the coolest monthly average pre-construction.

At the downstream site monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction (Table 14), and from 1.2°C (February 2019) to 11.7°C (August 2019) post-construction (Table 15). To date 2019 exhibits the highest and lowest average monthly temperatures at the downstream sites.

Pre-construction minimum and maximum instantaneous temperatures ranged from 2.8°C (December 2014) to 10.0°C (July and August 2014) at the upstream site and 0.0°C (February 2014) to 14.0°C (July 2014) at the downstream site. Post-construction, instantaneous minimum and maximum temperatures ranged from 0.8°C (February 2017) to 11.8°C (August 2019) at the upstream site and 0.0°C (January 2019) to 14.5°C (August 2019) at the downstream site.

Table 14. Alena Creek monthly water temperature summary statistics measured pre-construction (May 2013 to December 2014).

Year	Month	Water Temperature (°C)							
		ALE-USWQ1				ALE-BDGWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2013	May	7.2	5.4	9.0	0.8	-	-	-	-
	Jun	7.0	6.2	9.5	0.6	-	-	-	-
	Jul	7.6	6.5	9.9	0.9	-	-	-	-
	Aug	8.0	7.3	9.9	0.6	-	-	-	-
	Sep	8.1	7.3	9.6	0.4	9.6	6.9	13.0	1.2
	Oct	7.8	6.9	8.9	0.3	7.5	4.5	10.6	1.0
	Nov	7.0	6.1	8.1	0.4	5.2	2.4	7.6	1.0
	Dec	6.1	5.0	7.1	0.5	3.4	0.9	5.5	1.1
2014	Jan	-	-	-	-	2.7	0.4	4.9	1.1
	Feb	-	-	-	-	2.2	0.0	5.0	1.2
	Mar	-	-	-	-	-	-	-	-
	Apr	5.4	4.4	6.4	0.6	5.0	3.4	9.6	1.1
	May	6.7	5.3	8.9	0.6	7.9	5.3	12.0	1.4
	Jun	7.0	5.9	9.5	0.8	9.1	6.4	13.1	1.6
	Jul	7.4	6.3	10.0	0.9	9.9	7.4	14.0	1.7
	Aug	7.9	7.1	10.0	0.7	10.1	7.9	13.8	1.4
	Sep	7.7	6.6	9.4	0.5	9.2	6.4	12.2	1.1
	Oct	7.6	6.9	8.9	0.3	8.4	6.7	10.9	0.8
	Nov	6.9	3.6	8.0	0.9	5.4	2.0	8.3	1.6
	Dec	5.0	2.8	6.8	0.9	3.9	2.1	5.3	0.7

Monthly statistics were not generated for months with less than three weeks of data.

Instantaneous maximum (red shading) and instantaneous minimum (blue shading) are highlighted for the monitoring period.

Table 15. Alena Creek monthly water temperature summary statistics measured post-construction (December 2016 to September 2019).

Year	Month	Water Temperature (°C)							
		ALE-USWQ1				ALE-BDGWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2016	Dec	5.5	2.5	6.3	0.4	3.5	1.5	5.7	0.9
2017	Jan	5.4	2.0	6.4	0.5	3.2	0.7	5.0	1.0
	Feb	5.3	0.8	6.4	0.5	3.2	0.1	5.1	0.9
	Mar	5.1	4.3	6.5	0.3	3.8	2.5	6.0	0.6
	Apr	4.0	2.1	6.4	0.9	4.3	2.5	8.3	1.1
	May	6.4	4.5	8.3	0.7	7.3	4.3	11.5	1.4
	Jun	6.7	5.8	8.5	0.6	8.5	6.5	12.3	1.4
	Jul	6.9	5.9	9.5	0.8	9.5	7.3	12.9	1.4
	Aug	7.9	6.6	10.8	0.9	10.4	8.1	13.2	1.3
	Sep	8.1	6.7	10.8	0.7	9.7	6.8	13.5	1.1
	Oct	6.9	3.8	8.8	0.8	6.9	2.5	9.8	1.2
	Nov	5.4	3.3	7.1	0.8	3.8	1.0	6.6	1.2
	Dec	4.6	3.1	6.6	0.9	2.8	0.2	5.3	1.3
2018	Jan	4.2	3.2	5.2	0.5	2.9	0.4	4.3	0.9
	Feb	4.3	3.6	5.6	0.4	2.5	0.1	4.5	1.1
	Mar	5.0	3.8	6.8	0.6	3.8	1.0	7.1	1.0
	Apr	5.1	3.4	8.5	1.0	5.2	2.4	9.9	1.4
	May	7.3	5.5	9.8	0.8	8.3	5.4	11.5	1.3
	Jun	6.9	5.7	9.8	0.8	9.0	6.4	12.9	1.5
	Jul	7.6	5.9	10.8	1.1	10.8	7.7	13.6	1.4
	Aug	8.0	6.8	10.4	0.8	11.1	8.3	13.9	1.1
	Sep	7.6	6.7	9.8	0.6	9.7	7.4	11.9	0.8
	Oct	7.2	5.6	9.0	0.6	7.2	5.0	8.8	0.8
	Nov	6.4	3.9	8.4	0.6	5.2	1.4	9.1	1.4
	Dec	5.2	2.9	6.8	0.6	2.1	0.1	4.8	0.9
2019	Jan	5.1	2.7	6.6	0.6	2.2	0.0	3.8	0.8
	Feb	4.6	3.8	6.4	0.6	1.2	0.1	3.2	0.8
	Mar	5.4	3.7	8.2	0.9	2.8	0.1	5.9	1.1
	Apr	4.5	2.6	7.7	0.9	4.8	2.7	9.6	1.4
	May	6.7	4.8	10.7	1.2	8.8	4.4	13.3	2.0
	Jun	6.8	5.3	10.8	1.2	10.0	6.2	13.9	1.6
	Jul	7.4	5.9	11.3	1.2	10.9	8.4	14.2	1.3
	Aug	8.1	6.7	11.8	1.2	11.7	9.2	14.5	1.2
	Sep	-	-	-	-	10.2	6.6	13.9	1.2

Monthly statistics were not generated for months with less than three weeks of data.

Instantaneous maximum (red shading) and instantaneous minimum (blue shading) are highlighted for the monitoring period.

Post construction water temperature monitoring commenced on November 23, 2016.

4.4.3. Growing Season Degree Days

The fall and early winter (October to December 31) weekly and maximum average temperatures upstream of the FHEP area are relatively mild, remaining above 4°C during the pre- and post-construction monitoring periods. Therefore, the growing season end date was calculated based on weekly average temperatures reaching 5°C rather than 4°C (see Section 3.4.4).

The start of the growing season based on the water temperature record at each site is consistently observed at the middle to end of April both pre- and post-construction (Table 16). The growing season end dates were more variable upstream ranging from late December pre-construction to early November to mid December post-construction. At the downstream site, the growing season end dates were in late November pre-construction and early to mid November post-construction.

Considering both sites which define the downstream and upstream extent of the FHEP, the growing season varied from 1,740 to 1,897-degree days pre-construction to 1,345 to 1,872 degree days post-construction. The shortest growing season occurred upstream in 2017 (1,345 days, Table 16).

Table 16. Growing season length and degree days upstream and downstream of the FHEP in Alena Creek pre- and post-construction.

Site	Project Phase	Year	No. of days with valid data	Growing Season Data Summary				
				Start Date	End Date	Length (day)	Data Gap (day)	Degree Days
Upstream (ALE-USWQ1)	Pre-construction	2013	256	20-Apr	28-Dec	253	2	1,836
		2014	306	24-Apr	31-Dec	252	3	1,740
	Post-construction	2017	364	28-Apr	4-Nov	191	1	1,345
		2018	365	20-Apr	10-Dec	235	0	1,670
		2019	264	22-Apr	-	-	-	-
Downstream (ALE-BDGWQ)	Pre-construction[1]	2013	125	-	22-Nov	-	-	-
		2014	329	20-Apr	30-Nov	225	1	1,897
	Post-construction	2017	364	23-Apr	1-Nov	193	1	1,645
		2018	365	17-Apr	11-Nov	209	0	1,872
		2019	295	20-Apr	-	-	-	-

[1]Temperature monitoring at ALE-BDGWQ began in August 2013, therefore the start date and accumulated thermal units for the 2013 growing season could not be calculated.

4.4.4. Hourly Rates of Water Temperature Change

Rapid temperature changes in temperature (greater than ±1.0°C/hr) can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specify that the hourly rate of water temperature change should not exceed ±1.0°C/hr (Table 17, Figure 22).

Based on Ecofish's experience collecting pre-construction data on several other streams in British Columbia (file data), it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1.0°C/hr.

During pre- and post-construction of the FHEP, the percentage of record where exceedances were observed was low (<1.00%). Exceedances occurred less often post-construction at the downstream site, however more exceedances (0.83%) were observed at the upstream site post-construction in comparison to pre-construction (0.17%) (Table 17).

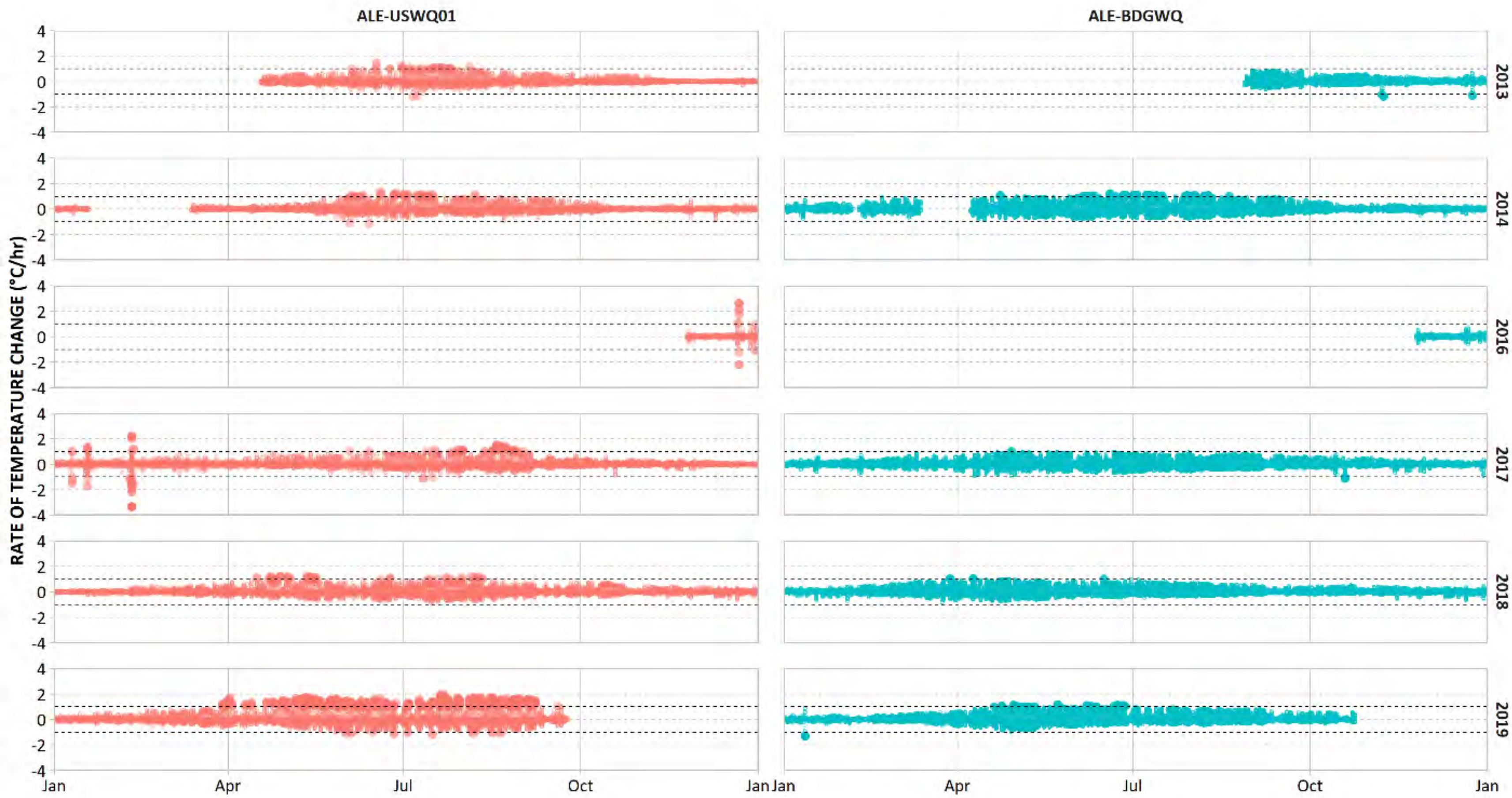
The magnitude of the water temperature increase/decrease was highest during the summer months at the upstream site post-construction, which is likely to be a consequence of groundwater inflow at this location.

Table 17. Hourly rate of change (°C/hr) summary statistics and occurrence of rate of change in exceedance of ± 1.0°C/hr.

Site	Project Phase	Period of Record		n	Occurrence		Max -ve	Percentile				Max +ve
		Start Date	End Date		No.	% of Record		1st	5th	95th	99th	
ALE-USWQ1	Pre-Construction	17-Apr-13	30-Dec-14	54,395	94	0.17	-1.15	-0.44	-0.25	0.32	0.77	1.45
	Post-Construction	23-Nov-16	23-Sep-19	99,191	821	0.83	-3.32	-0.59	-0.30	0.42	0.91	2.63
ALE-BDGWQ	Pre-Construction	27-Aug-13	30-Dec-14	44,075	102	0.23	-1.15	-0.61	-0.40	0.55	0.88	1.23
	Post-Construction	23-Nov-16	23-Oct-19	102,158	60	0.06	-1.28	-0.53	-0.34	0.52	0.79	1.17

n = number of datapoints.

Figure 22. Summary of the hourly rate of change (°C/hr) for each year pre-construction (2013 and 2014) and post- construction (2016, 2017, 2018 and 2019).



4.4.5. Daily Temperature Extremes

Alena Creek is classified as a cool stream with no days with average water temperatures >18°C observed in either pre- or post-construction conditions (Table 18). Considering all sites and dates, the maximum monthly water temperature was 14.0°C pre-construction (July 2014) and 14.5°C post-construction (August 2019), both of which occurred at the downstream site (Table 14, Table 15).

At the upstream site, there were no days when the daily average temperature was <1°C pre- or post-construction. In contrast, at the downstream site, one day was observed during pre-construction (2014) and three to 19 days per year were observed post-construction (2019) with daily average temperatures <1°C. The coolest temperatures measured to date at the downstream site were observed in 2019.

Table 18. Summary of daily average water temperature extremes (number of days >18°C and <1°C) at ALE-USWQ1 and ALE-BDGWQ.

Site	Project Phase	Year[1]	n (days)	Days T_{water} > 18°C	Days T_{water} < 1°C
ALE-USWQ01	Pre-construction	2013	256	0	0
		2014	306	0	0
	Post-construction	2016	38	-	-
		2017	364	0	0
		2018	365	0	0
		2019	264	0	0
ALE-BDGWQ	Pre-construction	2013	125	0	0
		2014	328	0	1
	Post-construction	2016	38	-	-
		2017	364	0	3
		2018	365	0	5
		2019	295	0	19

n is the number of days that have observations for at least 23 hours.

4.4.1. Bull Trout Temperature Guidelines

Bull Trout specific water temperate guidelines (see Section 3.4.4.1) were applied to the pre- and post-construction water temperature records by calculating the number of days of exceedance of the minimum and maximum temperature thresholds (Table 19). In BC, Bull Trout are considered to have the highest thermal sensitivity of the native salmonids evaluated in Oliver and Fiddler (2001), therefore more restrictive guidelines are applied to streams with this species.

During both pre- and post-construction monitoring periods, the highest maximum daily temperatures did not exceed the prescribed thresholds for rearing (15°C) at either site (Table 19).

The number of days where daily maximum water temperatures were outside the Bull Trout thresholds for spawning and incubation (i.e., >10°C) were higher overall at the downstream site (ALE-BDGWQ) in comparison to the upstream site (ALE-USWQ1), due to warmer temperatures in August and September at the downstream site (Table 19, Figure 20). In general, water temperatures at the downstream site do not cool below 10°C until late September/October (Table 14 and Table 15, Appendix C). Warmer temperatures (i.e., more days with exceedances of the 10°C limit) post-construction in comparison to pre-construction were observed at both the upstream and downstream sites suggesting this is due to natural inter-annual variability.

The number of days where the minimum temperature was less than the incubation threshold (i.e., <2°C) was also higher at the downstream site due to cooler temperatures at this site during the winter months; while the upstream site has a warmer temperature regime in the winter due to the groundwater input (Figure 20). These results suggest that temperature regime may be more suitable for Bull Trout at the upper end of the FHEP during spawning and incubation where there are fewer days with temperatures >10°C and <2°C. (Table 19).

Table 19. Summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout thresholds BC WQG (MOE 2019).

Site	Project Phase	Year	n (days)[1]	Temperature Thresholds			
				Rearing (Year Round)	Spawning (Aug.1 - Dec. 8)	Incubation (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
ALE-USWQ1	Pre-construction	2013	256	0	0	0	0
		2014[2]	328	0	0	0	0
	Post-construction	2017	364	0	14	2	14
		2018	365	0	5	0	10
		2019	295	0	23	0	28
ALE-BDGWQ	Pre-construction	2013	125	0	28	9	28
		2014	329	0	51	34	58
	Post-construction	2017	364	0	46	39	53
		2018	365	0	10	0	47
		2019	295	0	48	49	55

[1] n is the number of days that have observations for at least 23 hours.

[2] Pre-construction data collected at the upstream site excludes February 2014 data based on suspected ice/frozen temperature loggers.

4.4.2. Mean Weekly Maximum Temperatures (MWMxT)

MWMxT is an important indicator of prolonged periods of warm water temperatures that fish are exposed to. The guideline for the protection of aquatic life (Oliver and Fidler 2001) states "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary + or – 1 degrees C beyond the optimum temperature range of each life history phase (migration, incubation, rearing, and spawning) for the most sensitive salmonid species present"(Table 2).

A comparison of MWMxT temperature data to optimum temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout was completed for each species using pre- and post-construction data collected at the upstream site (Table 20, Table 21) and the downstream site (Table 22, Table 23).

Each of the tables provides the percent complete of the data record for each life stage along with the minimum and maximum MWMxT range in each period. The percentage of data within each optimum temperature range is provided to evaluate the overall suitability of the temperate range for each fish species life stage. Exceedance of the BC WQG range (greater than ±1°C outside the optimum ranges) are highlighted in each summary table (blue indicates MWMxTs are cooler than the lower guideline and red indicates temperatures are higher than the upper guidelines). The year-round range in MWMxT temperature corresponds to the rearing life stage for all the fish species. At the upstream site, post-construction, MWMxT ranged from 3.5°C to 11.5°C to date, while pre-construction MWMxTs ranged from 4.4°C to 9.9°C (Table 20, Table 21). During February 2014 data were not included due to icing concerns, therefore the minimum MWMxT value may not be representative of the pre-construction period. In 2019, the highest MWMxT value of 11.5°C was recorded.

At the downstream site, post-construction, MWMxT ranged from 0.6°C to 14.0°C to date, while pre-construction MWMxTs ranged from 1.7°C to 13.7°C (Table 22, Table 23). In 2019, both the lowest and the highest MWMxT values were recorded (0.6°C to 14.0°C).

MWMxT values in relation to species-specific optimal temperature ranges differed by species and location. Bull Trout prefer cooler temperatures overall in comparison to Cutthroat Trout and Coho Salmon (Table 2), therefore fewer exceedances of the cooler temperature limits are observed for this species. In general, the exceedances of the cooler temperature limits were more prevalent at the downstream site (ALE-BDGWQ). The upstream location (ALE-USWQ) was warmer during the winter months, likely due to the influence of groundwater at this location. General trends for each species are discussed below.

4.4.2.1. Coho Salmon:

During pre- and post-construction periods, at the upstream site, MWMxT values for Coho Salmon were largely within optimal temperature ranges during spawning and incubation but were sub-optimally cool on occasion during migration and rearing (blue shading in summary tables; Table 20, Table 21). During pre- and post-construction periods at the downstream site, exceedances of the cooler temperature limits (blue shading) were observed during all life stages, while no exceedances of the upper temperature limits were observed (Table 22, Table 23).

4.4.2.2. Cutthroat Trout:

During pre- and post-construction periods, at the upstream site, MWMxT values for Cutthroat Trout were sub-optimally cool on occasion during spawning, incubation and rearing (blue shading; Table 20, Table 21). During pre- and post-construction periods at the downstream site, exceedances of the cooler temperature limits were observed during all life stages; however, exceedances were generally observed less often during incubation and occasional exceedances of the higher temperature limits (red shading) were observed during incubation and spawning (post-construction only; Table 22, Table 23).

4.4.2.3. Bull Trout:

During pre- and post-construction periods, at the upstream site, MWMxT values were largely within optimal ranges with exceedances of the upper limit during incubation and occasionally during spawning (post-construction only). Occasionally, exceedances of the lower limits were observed during rearing (Table 20, Table 21). During pre- and post-construction periods at the downstream site, exceedances of the cooler temperature limits were observed during all life stages; however, exceedances were observed less often during incubation and exceedances of the higher temperature limits (red shading) were observed during incubation and spawning (Table 22, Table 23).

Warmer surface waters during Bull Trout incubation at the upstream site may be partially mitigated by groundwater upwelling, which would result in lower temperature within the redds during the warmer months (Table 20, Table 21).

Cooler and warmer MWMxTs occurred in 2019 than in previous years. Evaluation of any increased heating or cooling attributable to the FHEP will be completed following five years of data collection. Overall, no substantial change in the range of MWMxTs were observed between pre- and post-construction phases considering natural inter-annual variability in water temperature and considering that there were data gaps during the cooler months in the pre-construction data set.

Table 20. Pre-construction MWMxTs during Coho Salmon, Cutthroat Trout and Bull Trout life stages at ALE-USWQ1.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	100	5.6	9.4	6.6	63.1	0.0
				2014	95.1	4.4	9.3	21.6	62.9	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	100	5.6	8.5	0.0	100.0	0.0
				2014	91.1	4.4	7.9	0.0	98.6	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	67.5	5.6	8.5	0.0	100.0	0.0
				2014	42.6	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	70.1	5.6	9.9	35.9	23.4	0.0
				2014	83.0	4.4	9.7	53.5	18.5	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	79.3	5.9	8.9	42.5	0.0	0.0
				2014	98.9	5.0	9.3	58.2	6.6	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	100	6.9	9.9	16.1	35.5	0.0
				2014	99.2	6.3	9.7	18.7	37.4	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	70.1	5.6	9.9	3.1	78.1	0.0
				2014	83.0	4.4	9.7	13.9	66.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	100	5.6	9.9	0.0	73.8	0.0
				2014	98.5	5.8	9.7	0.0	71.1	0.0
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	79.3	5.6	9.9	0.0	5.9	64.5
				2014	69.0	4.4	9.7	0.0	14.3	78.2
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	70.1	5.6	9.9	0.0	96.9	0.0
				2014	83.0	4.4	9.7	3.0	86.1	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 21. Post-construction MWMxT for Coho Salmon, Cutthroat Trout and Bull Trout life stages at ALE-USWQ1.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2016	28.7	-	-	-	-	-
				2017	100	3.5	10.5	43.4	44.3	0.0
				2018	100	5.3	9.3	23.8	55.7	0.0
				2019	16.4	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2016	45.6	-	-	-	-	-
				2017	100	3.5	7.8	0.0	84.8	0.0
				2018	100	5.2	8.6	0.0	100.0	0.0
				2019	0	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	74.6	4.6	6.3	0.0	100.0	0.0
				2017	100	3.5	7.8	0.0	91.1	0.0
				2018	99.4	4.8	8.6	0.0	100.0	0.0
				2019	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2016	9.6	-	-	-	-	-
				2017	99.7	3.5	10.6	70.3	11.3	0.0
				2018	100	3.5	10.4	56.7	20.8	0.0
				2019	71.8	4.7	11.5	46.6	38.5	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2016	0	-	-	-	-	-
				2017	98.9	3.5	8.4	87.9	0.0	0.0
				2018	100.0	5.3	9.7	44.6	26.1	0.0
				2019	100.0	4.7	10.4	35.9	35.9	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2016	0	-	-	-	-	-
				2017	99.2	6.2	10.6	40.7	22.8	0.0
				2018	100.0	7.3	10.4	10.5	58.9	0.0
				2019	100.0	7.6	11.5	2.4	73.4	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2016	0	-	-	-	-	-
				2017	99.7	3.5	10.6	40.4	46.7	0.0
				2018	100.0	3.5	10.4	33.7	55.1	0.0
				2019	71.8	4.7	11.5	30.2	62.6	0.0

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 21. Continued.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2016	9.2	-	-	-	-	-
				2017	100	5.2	10.6	0.0	71.5	9.2
				2018	100	5.7	10.3	0.0	76.9	1.5
				2019	39.2	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2016	44.6	5.4	6.3	0.0	70.5	0.0
				2017	100	3.5	10.6	0.0	50.7	41.3
				2018	99.5	4.8	10.3	0.0	41.0	47.6
				2019	23.8	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2016	9.6	-	-	-	-	-
				2017	99.7	3.5	10.6	9.9	59.6	0.0
				2018	100	3.5	10.4	15.1	66.3	0.0
				2019	71.8	4.7	11.5	5.3	69.8	0.0

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 22. Pre-construction MWMxT for Coho Salmon, Cutthroat Trout and Bull Trout stages at ALE-BDGWQ.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	99.2	2.1	12.5	43.0	49.6	0.0
				2014	96.7	3.5	11.7	39.0	59.3	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	98.7	2.1	8.8	9.0	70.5	0.0
				2014	93.7	3.5	9.1	0.0	75.7	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	83.4	1.7	8.8	15.6	48.9	0.0
				2014	43.8	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	33.7	-	-	-	-	-
				2014	89.6	1.7	13.7	44.6	49.8	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	0.0	-	-	-	-	-
				2014	92.4	5.8	12.7	24.7	60.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	2	-	-	-	-	-
				2014	99.2	8.5	13.7	0.0	61.0	13.8
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	33.7	-	-	-	-	-
				2014	89.6	1.7	13.7	34.3	59.9	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	76.9	2.1	12.5	6.0	47.0	25.0
				2014	99.2	3.5	13.3	3.9	29.5	48.1
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	83.1	1.7	12.5	0.0	54.2	36.2
				2014	69.5	3.5	13.3	0.0	31.1	67.6
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	33.7	-	-	-	-	-
				2014	89.6	1.7	13.7	30.0	65.4	0.0

Blue shading indicates exceedance of the lower bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates exceedance of the upper bound of the BC WQG optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 23. Post-construction MWMxT for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-BDGWQ.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2016	29.5	-	-	-	-	-
				2017	100	1.6	12.9	50.0	44.3	0.0
				2018	100	2.3	11.5	43.4	54.9	0.0
				2019	41.0	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2016	46.8	-	-	-	-	-
				2017	100	1.6	8.1	19.0	45.6	0.0
				2018	100	2.2	8.1	38.0	59.5	0.0
				2019	7.59	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	75.1	2.8	5.7	1.6	58.3	0.0
				2017	100	1.6	8.1	14.2	53.3	0.0
				2018	100	0.6	8.1	50.9	38.5	0.0
				2019	3.5	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2016	9.8	-	-	-	-	-
				2017	99.7	1.6	13.1	56.3	37.6	0.0
				2018	100	1.8	13.4	53.2	41.9	0.0
				2019	80.3	0.6	14.0	42.3	53.6	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2016	0	-	-	-	-	-
				2017	98.9	4.4	12.2	38.5	41.8	0.0
				2018	100	5.7	12.6	23.9	60.9	0.0
				2019	100	5.1	13.1	26.1	45.7	4.3
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2016	0	-	-	-	-	-
				2017	99.2	7.5	13.1	4.1	58.5	0.8
				2018	100	8.8	13.4	0.0	59.7	12.1
				2019	100	9.8	14.0	0.0	35.5	18.5
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2016	9.8	-	-	-	-	-
				2017	99.7	1.6	13.1	46.4	50.5	0.0
				2018	100	1.8	13.4	40.0	55.6	0.0
				2019	80.3	0.6	14.0	35.5	62.5	0.0

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).

[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

Table 23. Continued.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT		
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Within Optimum Range	Above Upper Bound by >1°C
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2016	10.0	-	-	-	-	-
				2017	100	3.3	13.1	6.2	26.9	43.8
				2018	100	2.4	13.4	5.4	36.9	34.6
				2019	62.3	7.6	14.0	0.0	22.2	69.1
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2016	45.1	-	-	-	-	-
				2017	100	1.6	13.1	0.0	51.6	40.8
				2018	100	0.6	13.4	3.3	45.5	46.0
				2019	37.9	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2016	9.8	-	-	-	-	-
				2017	99.7	1.6	13.1	42.3	53.6	0.0
				2018	100	1.8	13.4	30.7	60.0	0.0
				2019	80.3	0.6	14.0	29.4	63.8	0.0

Blue shading indicates provincial guideline exceedance of the lower bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
Red shading indicates provincial guideline exceedance of the upper bound of the optimum temperature range by more than 1°C (Oliver and Fidler 2001).
[1] If less than 50 % of the data are available for the life stage period, the statistics are not calculated and data are not included in the summary table.

4.5. Riparian Habitat

4.5.1. Permanent Revegetation Density Monitoring Plots

The 2019 revegetation monitoring plot results show that stem densities have recovered to pre-treatment values since the construction and replanting of the FHEP in 2016 (Table 24; Figure 23). Replanting of western redcedar has been successful, and the density of western redcedar continues to increase (e.g., Figure 24). Douglas-fir (*Pseudotsuga mensiesii*) and western hemlock (*Tseuga heterophylla*) stem densities remained the same or increased slightly from 2017 but have decreased overall since planting in 2016. Neither species was present in any of the pre-construction plots in 2014, including ALE-PRM03, demonstrating that the FHEP work is meeting the objective of expediting the transition to a mixed coniferous/deciduous forest. Red alder and black cottonwood stem densities have also increased significantly since 2016 due to natural regeneration. Although the stem density of red alder is now similar to 2014, its relative abundance is lower, again indicating that the FHEP area is meeting the objective of increased conifer abundance. Overall shrub diversity has increased slightly since 2016 (by one species), and the number of species in ALE-PRM03 is the same as it was in 2014.

In October 2019, the mean estimated stem density of woody vegetation for all four monitoring plots was 79,900 ± 48,103 stems/ha, in consideration of a 90% confidence interval, surpassing the minimum target for all vegetation of 2,309 stems/ha (Table 24). Stem densities in individual plots ranged from 24,400 stems/ha to 122,400 stems/ha. The mean stem density in 2019 nearly doubled relative to 2017, when it was 43,200 ± 36,210 stems/ha, while the stem density following treatment in 2016 was only 5,002 ± 5,700 (Table 24). In 2014, the overall density of woody vegetation in the Alena Creek riparian area was estimated as 46,250 ± 32,469 stems/ha (Harwood *et al.* 2016), therefore the mean density of woody vegetation in the FHEP area has greatly increased as compared to prior to construction, however, the confidence intervals of the two surveys overlap, limiting our confidence in the change. The current stem density is appropriate for early establishment but is much higher than expected or desired for a mature stand. The stem density is expected to naturally decrease over time as trees increase in size and competition results in self-thinning. Thus, a future decrease in stem density should not be a cause for alarm *per se*, but rather it should be expected as part of the natural succession of forests post-disturbance. As trees mature and increase in size, they provide deeper roots for ground and bank stabilization, larger canopies for thermoregulation (including shade) and litter drop, and eventually provide larger woody debris contributions to the stream channel (Hemmera 2015).

Overall, the density of trees in the FHEP area in 2019 was 50,350 ± 45,222 stems/ha, far surpassing the target for mature trees of 1,200 stems/ha. Similarly, the overall density of shrubs in the FHEP area was 20,550 ± 11,491 stems/ha, far surpassing the shrub specific target of 2,000 stems/ ha.

In 2019, three conifer species were observed in the permanent monitoring plots: western hemlock, western redcedar, and Douglas-fir, with a combined density of 1,700 stems/ha (Table 25). Conifer tree species accounted for 29% of trees in 2019, whereas they accounted for 19% in 2017, 40% in 2016 immediately after construction, and 0.1% in 2014 prior to restoration (Harwood *et al.* 2016). Overall, a comparison of the density of coniferous trees in 2019 to 2016 shows an increase of 162%.

The decrease in conifers in Year 1 can be attributed to slight declines in western hemlock and Douglas-fir, whereas the rebound observed in Year 3 can largely be attributed to an increase in naturally regenerating western redcedar, as well as survival and growth of existing plants (Figure 24). Western hemlock stem densities remained the same in 2019 as in 2017, at 50 ± 118 stems/ha, a decrease from 150 ± 225 stems/ha in 2016 (i.e.., a single tree was observed in one of the plots in 2019 and 2017, down from three in 2016). A single Douglas-fir was observed in 2019, whereas Douglas-fir was not present at all in 2017. However overall, the Douglas-fir stem density dropped slightly in 2019 from post-treatment planting in 2016, when the stem density was 100 ± 118 (i.e., two stems were found in one plot). In 2019, the density of western redcedar increased from 2016 and 2017 to 1,600 ± 2,078 stems/ha. In 2014, prior to the restoration treatment, no western hemlock or Douglas-fir were observed in any monitoring plots, and only a single western redcedar was observed in each plot (although this was in a different set of plots). No mortalities of any tree species were observed in 2019 (Table 26), as opposed to 2017, when one red alder, one Douglas-fir, and three western redcedar were observed to be dead. Therefore, survival of the single western redcedar between 2018 and 2019 is 100%, exceeding the minimum survival threshold of 80% and indicating that planting can be deemed successful.

The density of deciduous trees is increasing in the FHEP area. The estimated stem density of both black cottonwood and red alder was high in 2019, at 33,700 ± 26,356 and 23,950 ± 25,831 stems/ha, respectively (Table 25; Figure 24). This represents an increase from both 2017 and 2016, when the restoration treatment reduced the stem density of black cottonwood to 250 ± 445 and the stem density of red alder to 1,350 ± 3,177. The stem density of red alder along Alena Creek is now similar to pre-treatment in 2014, when red alder dominated both the overstory in general and the overstory of the previous permanent monitoring plots specifically, including ALE-PRM03, with an average of 33,950 ± 34,582 stems/ha (Harwood *et al.* 2016).

Vegetation data for the Meager Creek slide area and for the Alena Creek FHEP area prior to the landslide are limited, but similar sites within the Coastal Western Hemlock southern dry sub maritime biogeoclimatic zone (CWHds1) provide some information (Green and Klinka 1994). In mid-bench riparian habitats in this zone, early successional stands of red alder and black cottonwood are typically complemented with western redcedar in later stages (Green and Klinka 1994). Monitoring in 2014 indicated that, prior to the Meager Creek slide, ALE-PRM03 was in an area that was dominated by mature red alder (Harwood *et al.* 2016), thus the addition of conifers demonstrates an advancement of successional stage. As the riparian FHEP area was designed to have a low gradient, floodplain conditions will likely continue.

The diversity of shrub species in the FHEP area increased in 2019, as compared to previous monitoring years and is about the same as pre-construction. In 2019, nine shrub species were identified in the monitoring plots, an increase from six in 2017 and seven in 2016 (Table 25), and a slight decrease from 10 detected during baseline pre-construction surveys (Harwood *et al.* 2016). Two new shrub species were observed in 2019: falsebox (*Paxistima myrsinites*) and hardhack (*Spirea douglasii*). Otherwise, shrub species composition remained the same as in 2017, although relative abundances changed. In

2019, the unknown willow species (or multiple species) was the most abundant shrub species, at 14,000 ± 10,657 stems/ha, a significant increase from previous years (e.g., in 2016 it was 150 ± 353 stems/ha). Thimbleberry (*Rubus parviflora*), red-osier dogwood (*Cornus stolonifera*), and devil's club (*Oploplanax horridus*) were the next most abundant shrubs in 2019. These three species were also the most abundant shrub species in 2017, and the latter two were the most abundant, along with Sitka willow (*Salix sitchensis*), in 2016. ALE-PRM03 had the highest shrub diversity of the four plots in 2019, with six identified species and the unidentified willow species. This could possibly be related to the relatively low abundance of competing vegetation, specifically black cottonwood and red alder. This is the same number of species that were found in the plot in 2014, before the restoration treatment (Harwood *et al.* 2016).

In 2019, a potentially invasive thistle species was observed in ALE-PRM03. Year 5 monitoring should aim to identify the thistle to the species level, as management implications will differ depending on the species. Some thistles, such as Canada thistle (*Cirsium arvense*) are considered noxious weeds and are provincially regulated under the *Weed Control Act* (*Weed Control Act*, RSBC 1996, c 487; *Weed Control Regulation* B.C. Reg. 143/2011) and land occupiers are legally required to manage. Other thistle species have management recommendations by regional weed committees but are otherwise unregulated, such as bull thistle (*Cirsium vulgare*). No other provincially or regionally noxious or invasive plant species were detected within the FHEP area, and none have been found in previous years. Although riparian monitoring is focused on the permanent revegetation monitoring plots, Ecofish crews watch for noxious plant species while conducting other fieldwork within the FHEP area, particularly in the vicinity of areas with high susceptibility to invasion such as access roads, construction areas, and riparian areas. The OEMP lays out steps for invasive plant monitoring, including measuring the extent and location of the invasive plants, developing treatment options, and reporting to the owner and IAPP program (Harwood *et al.* 2017).

Table 24. Summary of riparian habitat data collected for the Alena Creek FHEP in 2019 (Year 3) and 2017 (Year 1) of effectiveness monitoring; in 2016 (baseline), immediately after riparian restoration works; and in 2014, four years after the Meager Creek slide.

Permanent Revegetation Monitoring Plot	UTM (Zone 10U)		Year[1]	Woody Vegetation Density			Estimated Vegetation Cover (%)	Revegetation Area (Site) Comments
	Easting	Northing		Count of Live Stems/Plot	Count of Dead Stems/Plot	Estimated Live Vegetation Density (stems/ha)		
ALE-PRM03	473335	5606225	2019	122	0	24,400	100	Lots of natural regeneration, some invasive thistle observed in the site. Generally good survival of the planted stock and abundant ground cover. Two planted western redcedar along the stream bank are dead. Leaves have dropped from deciduous trees.
			2017	62	3	12,400	80	Good revegetation with horsetail, grass, and ferns. Most of the planted plugs have survived.
			2016	60	0	12,000	30	-
			2014[2]	305	0	61,000	88	Extensive natural regeneration of red alder under a mostly dead red alder overstory, with a few large living red alder.
ALE-PRM05	473014	5606707	2019	409	0	81,800	97	Lots of natural regeneration. Abundant horsetail ground cover. Planted stock is thriving and growing tall. Leaves have dropped from deciduous trees.
			2017	107	2	21,400	37	Some natural revegetation occurring, especially along and within 10 m of the streambank.
			2016	18	0	3,600	8	-
ALE-PRM06	473348	5606089	2019	612	0	122,400	64	Dense natural regeneration, including abundant grass and other ground cover vegetation. 100% survival for planted conifers and lots of western redcedar regeneration. Leaves have dropped from deciduous trees.
			2017	327	0	65,400	59	Good natural regeneration, high survival of planted vegetation.
			2016	22	0	4,400	16	-
ALE-PRM07	473338	5606166	2019	455	0	91,000	89	Dense natural regeneration. Lots of grass, moss, and fireweed. All planted conifers have survived and are looking very healthy.
			2017	368	0	73,600	66	Good natural regeneration of horsetail, grass, bunchberry, fireweed, ferns, red alder and black cottonwood, especially in concave microtopographies.
			2016	14	0	2,800	39	-
2019 Estimated Density (stems/ha)						**79,900**		
Confidence Interval (±stems/ha)						**48,103**		
2017 Estimated Density (stems/ha)						**43,200**		
Confidence Interval (±stems/ha)						**36,210**		
2016 Estimated Density (stems/ha)						**5,002**		
Confidence Interval (±stems/ha)						**5,700**		

[1]Compensation/ restoration treatments were conducted in 2016, thus 2016 is considered the baseline as-built survey for the restoration works. 2017 was Year 1 of the effectiveness monitoring program for Alena Creek and 2019 was Year 3 of effectiveness monitoring (the second year of revegetation monitoring). In addition a baseline survey was conducted in 2014, prior to restoration works.

[2]ALE-PRM03 was the only plot (of four) established in 2014, prior to restoration works, that fell within the construction area and was thus sampled again in 2016 and 2017.

Table 25. Live species counted within each of the permanent revegetation monitoring plots in 2019 (Year 3). Stem density summaries are included for 2017 (Year 1) and 2016 (baseline).

Year	Permanent Revegetation Monitoring Plot	Trees						Shrubs												*Total*
		western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	Douglas-fir (*Pseudotsuga menziesii*)	black cottonwood (*Populus balsamifera ssp. trichocarpa*)	red alder (*Alnus rubra*)	*Subtotal*	devil's club (*Oplopanax horridus*)	falsebox (*Paxistima myrsinites*)	hardhack (*Spiraea douglasii*)	red elderberry (*Sambucus racemosa*)	red-osier dogwood (*Cornus stolonifera*)	black raspberry (*Rubus leucodermis*)	thimbleberry (*Rubus parviflorus*)	salmonberry (*Rubus spectabilis*)	Sitka willow (*Salix sitchensis*)	trailing blackberry (*Rubus ursinus*)	willow (unknown species) (*Salix* sp.)	*Subtotal*	
2019	ALE-PRM03	0	2	0	3	37	*42*	20	0	3	1	0	0	24	1	0	17	14	*80*	*122*
	ALE-PRM05	0	3	1	247	18	*269*	0	1	0	0	4	0	10	1	0	0	124	*140*	*409*
	ALE-PRM06	1	21	0	224	243	*489*	0	0	10	0	27	0	0	8	0	0	78	*123*	*612*
	ALE-PRM07	0	6	0	200	181	*387*	0	0	0	0	2	0	1	1	0	0	64	*68*	*455*
	Mean (stems/ plot)	0.25	8.00	0.25	168.50	119.75	*296.75*	5.00	0.25	3.25	0.25	8.25	0.00	8.75	2.75	0.00	4.25	70.00	*102.75*	*399.50*
	Confidence Interval (± stems/plot)	0.59	10.39	0.59	131.78	129.16	*226.11*	11.77	0.59	5.55	0.59	14.83	0.00	13.08	4.12	0.00	10.00	53.29	*40.32*	*240.51*
	Estimated Density (stems/ha)	**50**	**1,600**	**50**	**33,700**	**23,950**	***59,350***	**1,000**	**50**	**650**	**50**	**1,650**	**0**	**1,750**	**550**	**0**	**850**	**14,000**	***20,550***	***79,900***
	Confidence Interval (± stems/ha)	**118**	**2,078**	**118**	**26,356**	**25,831**	***45,222***	**2,353**	**118**	**1,110**	**118**	**2,967**	**0**	**2,616**	**824**	**0**	**2,000**	**10,657**	***8,064***	***48,103***
2017	**Estimated Density (stems/ha)**	**50**	**700**	**0**	**23,100**	**15,800**	***39,650***	**650**	**0**	**0**	**350**	**650**	**0**	**1,100**	**450**	**0**	**250**	**100**	***3,550***	***43,200***
	Confidence Interval (± stems/ha)	**118**	**781**	**0**	**20,115**	**17,600**	-	**1,377**	**0**	**0**	**353**	**703**	**0**	**1,129**	**778**	**0**	**588**	**235**	-	***36,210***
2016	**Estimated Density (stems/ha)**	**150**	**800**	**100**	**250**	**1,350**	***2,650***	**850**	**0**	**0**	**50**	**700**	**200**	**250**	**350**	**500**	**0**	**150**	***3,050***	***5,700***
	Confidence Interval (± stems/ha)	**225**	**508**	**235**	**445**	**3,177**	-	**1,542**	**0**	**0**	**118**	**804**	**471**	**353**	**556**	**891**	**0**	**353**	-	***5,002***

Table 26. Dead tree species counted within each of the permanent revegetation monitoring plots in 2019 (Year 3). Stem density summaries of dead trees are included for 2017 (Year 1) and 2016 (baseline), from which survival estimates can be calculated overall and by species.

Year	Permanent Vegetation Monitoring Plot	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	Douglas-fir (*Pseudotsuga menziesii*)	black cottonwood (*Populus balsamifera ssp. trichocarpa*)	red alder (*Alnus rubra*)	*Total*
2019	ALE-PRM03	0	0	0	0	0	*0*
	ALE-PRM05	0	0	0	0	0	*0*
	ALE-PRM06	0	0	0	0	0	*0*
	ALE-PRM07	0	0	0	0	0	*0*
	Mean (stems/ plot)	0.00	0.00	0.00	0.00	0.00	*0.00*
	Confidence Interval (± stems/plot)	0.00	0.00	0.00	0.00	0.00	*0.00*
	Estimated Density (stems/ha)	**0**	**0**	**0**	**0**	**0**	***0***
	Confidence Interval (± stems/ha)	**0**	**0**	**0**	**0**	**0**	***0***
2017	**Estimated Density (stems/ha)**	**0**	**150**	**50**	**0**	**50**	***250***
	Confidence Interval (± stems/ha)	**0**	**225**	**118**	**0**	**118**	***353***
2016	**Estimated Density (stems/ha)**	**0**	**0**	**0**	**0**	**0**	***0***
	Confidence Interval (± stems/ha)	**0**	**0**	**0**	**0**	**0**	***0***

Figure 23. Overview of FHEP channel taken from ALE-PRM05, demonstrating revegetation success of trees and shrubs, on October 29, 2019.

Figure 24. Revegetation success observed at ALE-PRM07. Photo is representative of western redcedar growth and the regeneration of other shrub and herb species, as well as the potential future condition in the background, on October 29, 2019.

4.5.2. Percent Vegetation Cover Estimates

In 2019, the mean percent cover of vegetation among all four plots was 86%, surpassing the target of 80% survival (assuming the natural regeneration potential cover of 100%), and an increase from 61% in 2017 and 23% post-treatment in 2016 (Table 24). This is similar to the pre-treatment mean percent cover of 82% estimated in 2014. In 2019, the percent cover of individual plots ranged from 64% cover at ALE-PRM06, to 100% cover at ALE-PRM03. ALE-PRM03 also had the highest percent cover in 2017, possibly due to the dominance of undisturbed soil. In 2017, ALE-PRM05 had the lowest percent cover (37%) of all sites, which was attributed to its location within the Meager Creek slide path, resulting in substrate with low organic content. However, in the 2019 survey, percent cover at ALE-PRM05 had increased to 97%, due to increases in cover of horsetail (*Equisetum* spp.) (Figure 25). Horsetail is an indicator of disturbed sites and is associated with sandy or silty soils and streambanks, as it can fix its own nitrogen (Klinka *et al.* 1989). The plot with the lowest percent cover in 2019 was ALE-PRM06, at 64%. Leaf litter was abundant in quadrats within ALE-PRM06, and it is possible that the relatively low percent cover observed in this plot was an artefact of sampling late in the season when many leaves had already senesced, and that the high amounts of leaf litter will contribute to future soil enhancements and growth (Figure 26).

Figure 25. High percent vegetation cover of primarily horsetail in a sampling quadrat at ALE-PRM05, located within the Meager Creek slide path, October 29, 2019.

Figure 26. Relatively low percent vegetation cover in sampling quadrat at ALE-PRM06 October 29, 2019 due to abundance of leaf litter.

4.5.3. Photopoint Comparison

Standard photographs taken in 2016, 2017, and 2019 from 1.3 m above the plot centre, facing 0 degrees (north) are presented in Appendix F to compare site and vegetation condition among years at each plot. Representative photos of the general site conditions surrounding each permanent monitoring plot are also provided. Additional photographs taken in the remaining three cardinal directions (east, south, west) from 1.3 m above the plot centre are available upon request. The replicate standard photographs show an increase in vegetation abundance from 2016 to 2017, and further infilling of woody shrubs (possibly red alder or black cottonwood) in 2019 at all sites. Thus, photographic monitoring supports data from the stem density monitoring plots (Section 4.5.1) that demonstrate an increase in stem density in the first three years of the monitoring program, as well as vegetation cover results (Section 4.5.2) that show an increase in ground cover, especially of horsetail.

5. SUMMARY AND RECOMMENDATIONS

The success of the FHEP will be judged according to the criteria in the *Fisheries Act* Authorization, namely that the habitat enhancement is physically stable, maintains suitable flows, has been demonstrated to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout of not less than 2,310 m^2, and supports equivalent or greater fish usage relative to pre-project densities in Alena Creek. Details of the monitoring to be conducted to evaluate the effectiveness of the FHEP are described in the Project's OEMP (Harwood *et al.* 2017); however, based on the results of Year 3 monitoring we recommend the following adjustments be made.

5.1. Fish Habitat

The overall function and quality of the FHEP remains high despite the flood event that occurred a few months after construction. In the downstream reach, Reach 1, we recommend continued monitoring of the bank erosion at 0+185 m just upstream of ALE-XS1. In Reach 3, we recommend undertaking instream repairs during the least risk timing window in August 2020. We anticipate that all repairs can be completed by hand with a crew of four over 1–2 days including a qualified professional to lead the work. At ALE-XS5, material from the constructed riffle crest that is currently dewatered can be utilized to reconstruct the weir in the wetted width. This will alleviate the risk of head-cutting that could cause incision upstream. The erosion issues upstream of both ALE-XS6 and ALE-XS7 should also be repaired. It may be possible to complete the repairs utilizing materials on site (e.g., cobbles and large wood pieces), or in nearby deposits on the side of the FSR. Establishment of herbaceous plants along the constructed channel banks has been suitable to protect the channel banks. Installing additional live stakes was considered, but is not recommended since it could increase local beaver activity.

Beavers were trapped within the Alena Creek FHEP area and dams were removed in the fall of 2018 and 2019 by a licensed trapper from EBB Environmental Consulting Inc. Beaver damming has been ongoing since this time in the reach upstream of Reach 3, causing disruption of flow and sediment supply to the upper section of Reach 3, and causing fine sediment loading to Reach 3 where the diverted flow re-enters. We recommend ongoing management of the beaver dams upstream of

Reach 3, and in particular, lowering of the dam that is blocking flow to the mainstem in order to prevent flow diversion. Lastly, a log jam just upstream of ALE-XS1 has formed in Reach 1 where a channel-spanning log collapsed. This jam should be monitored to ensure it does not grow. If the jam grows and begins to cause backwatering of upstream riffles and associated fine sediment deposition, then it should be removed.

5.2. Fish Community

The fish community component of the Alena Creek FHEP monitoring was successfully implemented in 2019. We recommend that the monitoring program continue in 2020 following the methods used in 2019.

5.3. Hydrology

Simultaneous monitoring of stage at FSR bridge and R1 upstream locations during spring and summer (April to the end of July) is needed to accurately account for the backwatering of the gauge at the FSR bridge over Alena Creek when flows in the Upper Lillooet River are high, and to ensure the stage data collected are representative of Alena Creek water levels. We recommend continuing hydrometric monitoring at both locations. Future monitoring efforts should also include standard practice of gauge maintenance recommended by RISC (2009) prior to spring snowmelt and throughout monitoring period to avoid future issues with missing data during this critical period.

5.4. Water Temperature

FHEP pre-construction water temperature monitoring occurred from April 17, 2013 to December 31, 2014 at the upstream site (upstream of the FHEP) and from August 27, 2013 to December 31, 2014 at the downstream site (within the FHEP) (Map 3); winter season water temperatures at the upstream site were not fully captured pre-construction due to data gaps in the winter/early spring 2014 data set. Therefore, direct comparison of pre- and post-construction monitoring for the cooler temperature metrics are limited for the upstream site.

Post-construction monitoring commenced at both sites on November 23, 2016. Year 3 data are available up to September 23, 2019 for the upstream site and to October 23, 2019 for the downstream site. No substantial data gaps were recorded.

Monthly average temperatures were the highest (11.7°C) and lowest (1.2°C) on record to date in 2019, occurring at the downstream site, however, no substantial in the instantaneous temperature range were observed in the pre- (0.0°C to 14°C) and post-construction (0.0°C to 14.5°C) periods.

Results to date indicate that the FHEP provides water temperatures typical of the area, with beneficial moderating effects due to groundwater inflow upstream of the habitat. Overall temperatures are more suitable for Bull Trout than Coho Salmon and Cutthroat Trout due to the generally cooler optimum temperature ranges for Bull Trout.

Considering inter-annual variability, no substantial differences were observed in the pre- and post-construction temperature regimes. We recommend that the monitoring program continue for 5 years post-construction based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017).

5.5. Riparian Habitat

The goal of the restoration treatment is on the trajectory of being met, namely to ensure that a diversity of well-established native tree and shrub species with low observed mortality rates are present within the Alena Creek FHEP area, including successfully replanting western redcedar to expedite succession from a deciduous stand to a mixed coniferous/ deciduous stand, to enhance the riparian habitat for fish. Furthermore, results from Year 3 of monitoring indicate that stem densities and vegetation cover within the Alena Creek riparian FHEP area have well surpassed minimum targets and are similar to prior to the revegetation treatment (Harwood *et al.* 2016). Therefore, no additional planting or remediation measures are recommended at this time, but additional thinning of black cottonwood and red alder may be necessary to reach the longer-term goal if these species appear to be suppressing target conifer species.

The high stem densities (Section 4.5.1) and vegetation cover are indicators of good growing conditions and stable substrate, and no signs of erosion were noted during 2019 field sampling. Thus, no erosion control or soil conditioning appears to be necessary at this time.

Monitoring for the presence of invasive species should continue during revegetation surveys, and the thistle species noted in ALE-PR03 should be identified to determine management requirements. If the species is deemed a noxious weed, treatment prescriptions should be developed and implemented. The next revegetation monitoring visit is planned for Year 5 and should be conducted in late August or early September before vegetation dies off for the season.

6. CLOSURE

The OEMP outlines the operational monitoring frequency and duration for each monitoring component. The monitoring objectives for Year 3 were achieved. Based on the results from the first year of monitoring, changes to the WQ monitoring program were recommended. Further detail will be provided in a separate submission for review by regulatory agencies.

REFERENCES

Blackwell, B.G, Brown, M.L., and D.W. Willis. 2000. Relative Weight (Wr) Status and Current Use in Fisheries Assessment and Management. Rev. Fish. Sci., 8: 1-44.

Buchanan, S., A. Newbury, S. Faulkner, A. Harwood, and D. Lacroix. 2013a. Upper Lillooet Hydro Project: Upper Lillooet River Hydroelectric Facility Summary of Aquatic and Riparian Footprint Impacts. Consultant's report prepared for Upper Lillooet River Power Limited Partnership by Ecofish Research Ltd., May 2, 2013.

Buchanan, S., A. Harwood, A. Newbury, and D. Lacroix. 2013b. Upper Lillooet Hydro Project: Boulder Creek Hydroelectric Facility Summary of Aquatic and Riparian Footprint Impacts. Consultant's report prepared for Boulder Creek Power Limited Partnership by Ecofish Research Ltd., May 2, 2013.

Coleman, M.A. and K.D. Fausch. 2007. Cold summer temperature limits recruitment of age-0 cutthroat trout in high-elevation Colorado streams. Transactions of the American Fisheries Society 136(5):1231-1244.

DFO and MELP (Fisheries and Oceans Canada and Ministry of Environment, Land and Parks). 1998. Riparian Revegetation. Available online at: http://www.dfo-mpo.gc.ca/Library/315523.pdf. Accessed on November 24, 2014.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 41: 540–51

Green, R.N. and Klinka, K. 1994. A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region, Land Management Handbook Number 28. Province of British Columbia. Available online at: https://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh28.pdf. Last accessed: April 13, 2020.

Harwood, A., A. Yeomans-Routledge, S. Faulkner, and A. Lewis. 2013. Upper Lillooet Hydro Project: Pre-construction and LTMP Report for Alena Creek Compensation Habitat. Consultant's report prepared for Upper Lillooet River Power Limited Partnership by Ecofish Research Ltd. August 15, 2013.

Harwood, A. E. Smyth, D. McDonnell, A. Newbury, P. Dinn, A. Baki, T. Jensma, and D. Lacroix. 2016. Alena Creek Fish Habitat Enhancement Project: Pre-construction Aquatic Report Years 1 & 2. Consultant's report prepared for Upper Lillooet River Power Limited Partnership by Ecofish Research Ltd., July 14, 2016.

Harwood, A., S. Faulkner, K. Ganshorn, D. Lacroix, A. Newbury, H. Regehr, X. Yu, D. West, A. Lewis, S. Barker and A. Litz. 2017. Upper Lillooet Hydro Project: Operational Environmental Monitoring Plan. Consultant's report prepared for the Upper Lillooet River Power Limited Partnership and the Boulder Creek Power Limited Partnership. March 17, 2017.

Harwood, A., S. Faulkner, K. Ganshorn, D. Lacroix, A. Newbury, H. Regehr, X. Yu, D. West, A. Lewis, S. Barker and A. Litz. 2018. Upper Lillooet Hydro Project: Operational Environmental Monitoring Plan. Consultant's report prepared for the Upper Lillooet River Power Limited Partnership and the Boulder Creek Power Limited Partnership. February 8, 2018.

Harwood, A., V. Woodruff, A. Parsamanesh, S. Faulkner, A. Baki, S. Buchanan, T. Jensma, K. Ganshorn, A. Newbury, and D. Lacroix. 2019. Alena Creek Fish Habitat Enhancement Project: Year 1 Monitoring Report. Consultant's report prepared for Upper Lillooet River Power Limited Partnership by Ecofish Research Ltd., March 12, 2019.

Hemmera (Hemmera Envirochem Inc.). 2015. Upper Lillooet Hydro Project Offsetting Plan. Consultant's report prepared for the Upper Lillooet River Power Limited Partnership by Hemmera Envirochem Inc. January 2015.

Klinka, K., V. J. Krajina, A. Ceska, and A. Scagel. 1989. Indicator Plants of Coastal British Columbia. UBC Press, Vancouver.

MOE (B.C. Ministry of Environment). 2019. Summary of Water Quality Guidelines: Aquatic Life, Wildlife and Agriculture. Available online at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf. Accessed on April 19, 2019.

MOF (BC Ministry of Forests). 2009. Silviculture Surveys Procedures Manual: stocking and free-growing. Forest Practices Branch, Ministry of Forests Lands, and Natural Resource Operations. Available online at: http://www.for.gov.bc.ca/hfp/publications/00099/Surveys/Silviculture%20Survey%20Procedures%20Manual-April%201%202009.pdf. Accessed on October 30, 2014.

MOF (BC Ministry of Forests). 2011. FREP Stand Development Monitoring Protocol. Ministry of Forests, Lands, and Natural Resource Operations. Available online at: http://www.for.gov.bc.ca/ftp/HFP/external/!publish/FREP/Indicators/SDM%20Protocol%202011.pdf. Accessed on October 30, 2014.

Naiman, R.J. and H. Decamps. 1997. The ecology of interfaces: riparian zones. Annual Review of Ecology and Systematics. 28: 621-658

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian Ecology and Management in the Pacific Coastal Rainforest. Bioscience. 50: 996-1011.

Oliver, G.G. and L.E. Fidler. 2001. Towards a water quality guideline for temperature in the Province of British Columbia. Prepared for Ministry of Environment, Lands and Parks, Water Management Branch, Water Quality Section, Victoria, B.C. Prepared by Aspen Applied Sciences Ltd., Cranbrook, B.C., 53 pp + appnds. Available online at: http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/index.html. Accessed on May 23, 2012.

Richardson, J.S. 2004. Meeting the conflicting objectives of stream conservation and land use through riparian management: another balancing act. Pp. 1 - 6 In: G. J. Scrimgeour, G. Eisler, B. McCulloch, U. Silins and M. Monita (Eds.) Forest-Land-Fish Conference II - Ecosystem Stewardship Through Collaboration. Proc. Forest-Land-Fish Conf. II, April 26-28, 2004, Edmonton, Alberta.

RISC (Resources Information Standards Committee). 2009. Manual of British Columbia Hydrometric Standards. Prepared by the BC Ministry of Environment, Science and Information Branch. Available online at: https://www.for.gov.bc.ca/hts/risc/pubs/aquatic/hydrometric/man_BC_hydrometric_stand_V1.0.pdf. Accessed on December 3, 2013.

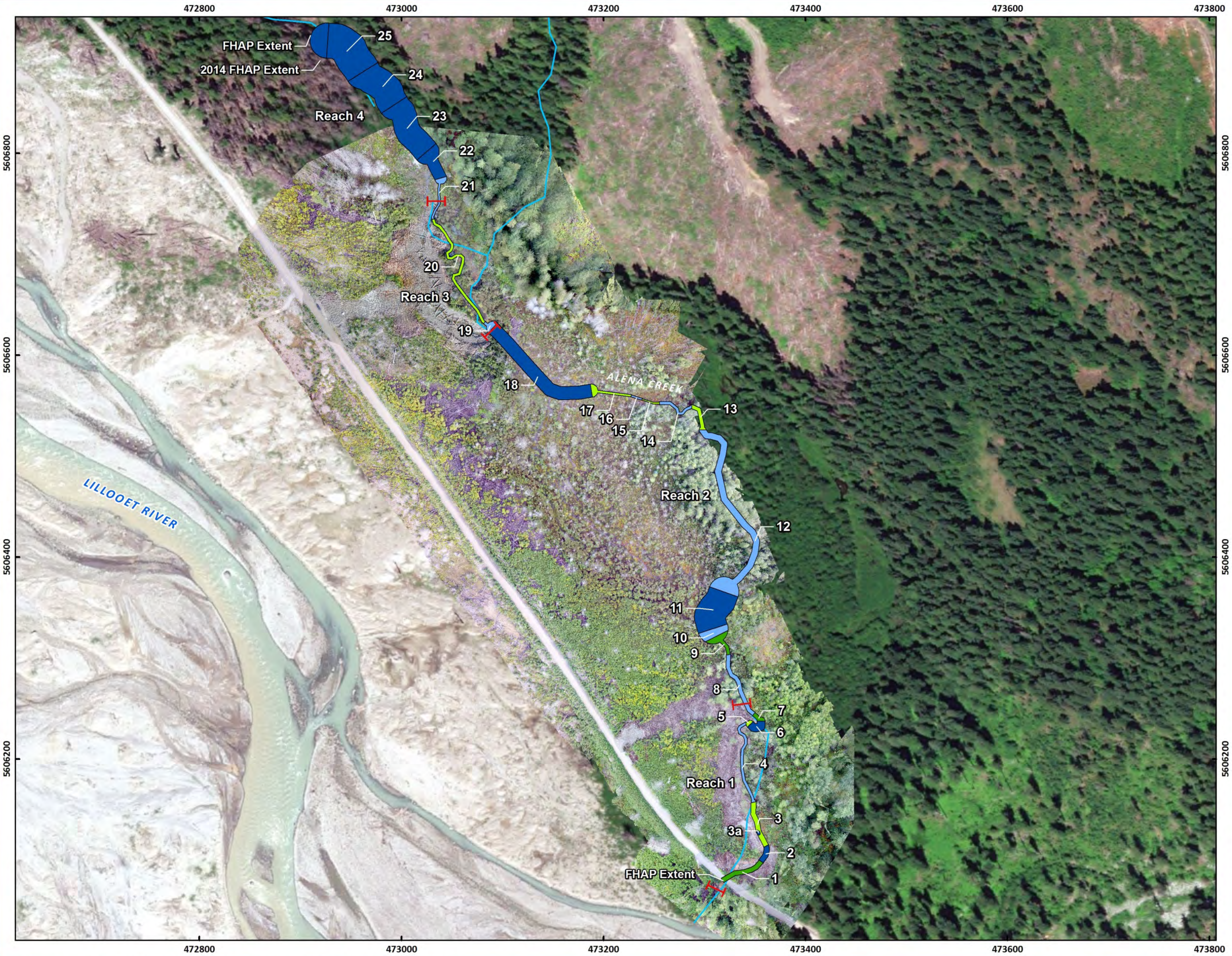
West. D, V. Woodruff and A. Harwood. 2017. Alena Creek Fish Habitat Enhancement Project As-Built Survey. Consultant's report prepared for Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership by Ecofish Research Ltd. March 7, 2017.

Personal Communications

McCarthy, C. 2014. Senior Engineer, Knight Piésold Ltd., Vancouver, BC. Email communication with J. Mancinelli, Innergex Renewable Energy Inc., March 31, 2014

McCoy, D. 2016. Engineering Manager, Innergex Renewable Energy Inc. Email communication with J. Mancinelli, Innergex Renewable Energy Inc., November 14, 2016.

PROJECT MAPS



UPPER LILLOOET HYDRO PROJECT

Alena Creek Fish Habitat Assessment

Legend

FHAP Type

- Glide
- Pool
- Riffle
- Run
- Reach Break
  The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- Streams

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:3,600

NO.	DATE	REVISION	BY
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2			
3			
4			
5			

Date Saved: 17/04/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 2

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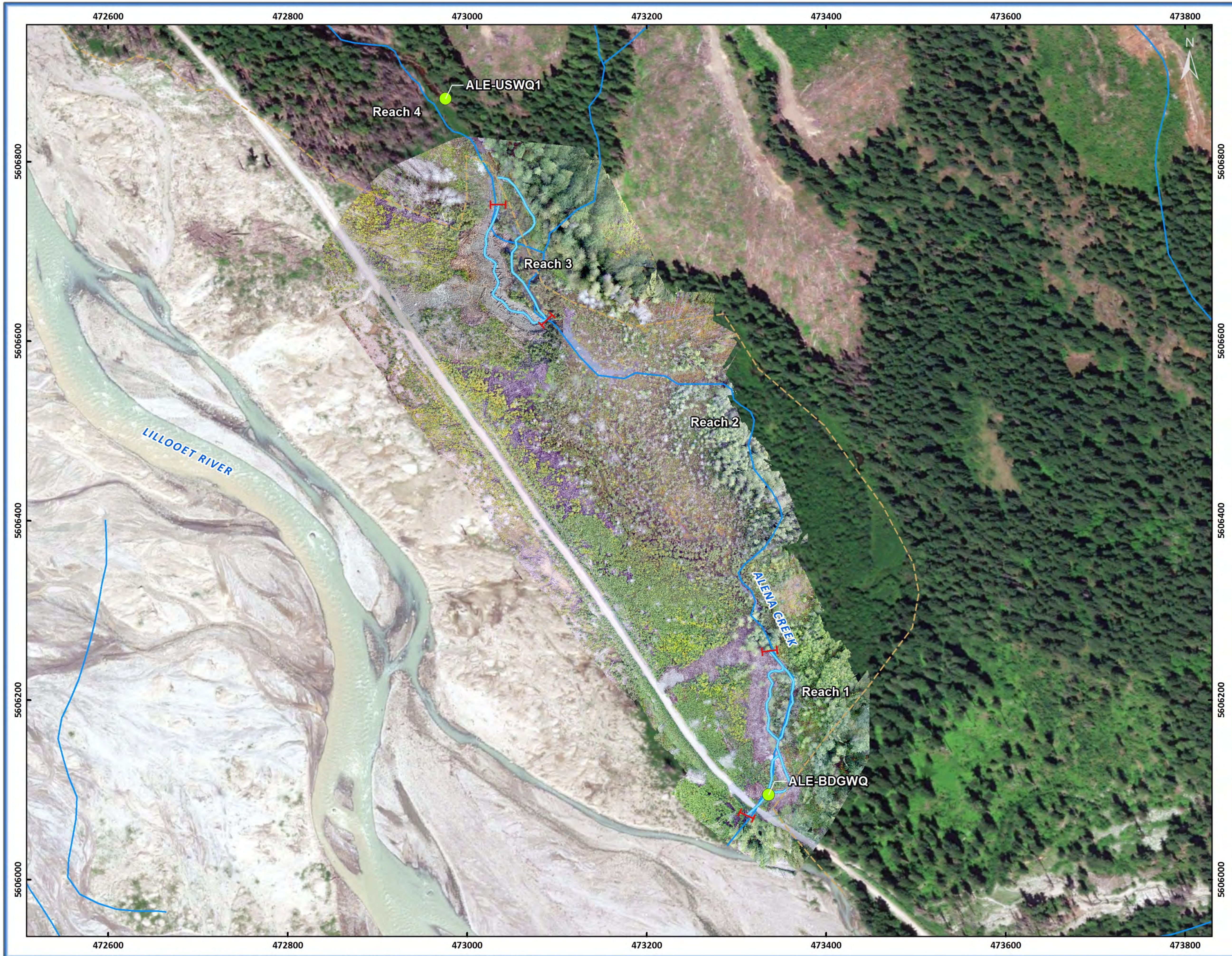

UPPER LILLOOET HYDRO PROJECT

Alena Creek Water Temperature Monitoring Sites

Legend

- Water Temperature Monitoring Site
- Reach Break: The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- Meager Creek Slide Extent
- Enhanced Reaches
- Streams (Hedberg)

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:4,000

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4			
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ECOFISH RESEARCH

Map 3

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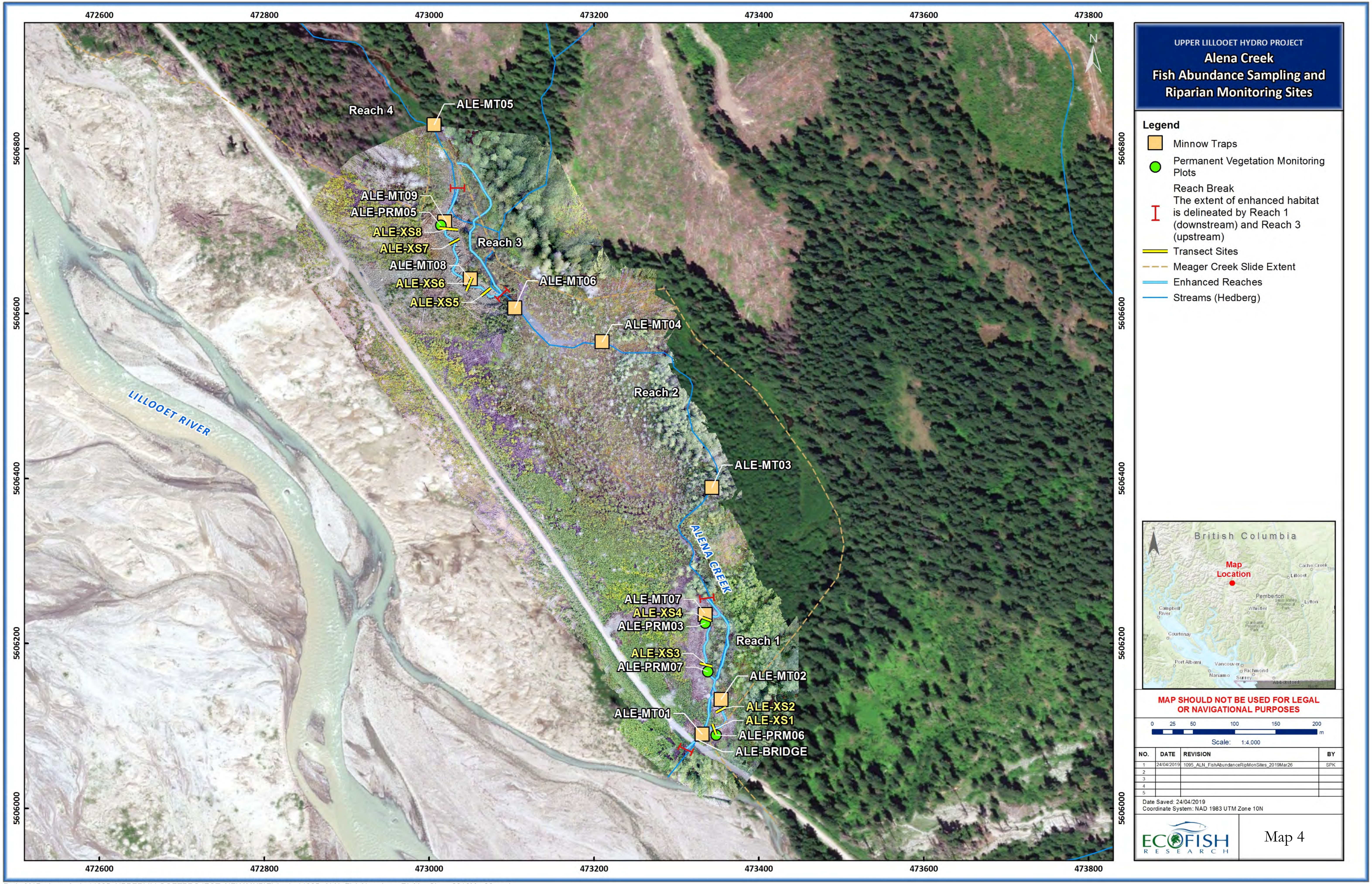

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APPENDICES

Appendix C. Upper Lillooet Hydro Project Standard Operating Procedure: Harlequin Duck Spot Check Protocol

ECOFISH RESEARCH

UPPER LILLOOET HYDRO PROJECT

STANDARD OPERATING PROCEDURE

Harlequin Duck Spot Check Protocol

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1. INTRODUCTION

Harlequin Duck spot checks are a requirement of the Upper Lillooet Hydro Project (the Project) Operational Environmental Monitoring Plan. Spot checks are intended to record the presence or absence of Harlequin Ducks and any evidence of successful breeding in the Project area. Spot checks are scans that are conducted from specific vantage points and at specific times during the Harlequin Duck breeding season. It is important to record some information every time a spot check is conducted, even if no Harlequin Ducks are observed. Timing, locations, and methods of spot checks should be consistent so that annual results are comparable.

2. SPOT CHECK METHODS

Specific methods should be followed for each spot check to keep data comparable. The methods to be followed are:

- Always conduct spot checks from the same vantage point for each Location ID (Table 1).
- Conduct a thorough scan of the visible area from the vantage point using binoculars and/or a spotting scope. Note that female Harlequin Ducks and juveniles are much less conspicuous than males and extra effort is required to spot them. Pay close attention to riparian areas where ducks may be partly concealed in overhanging riparian vegetation and scan exposed instream rocks where birds may haul out. Due to their brownish colour, females that are hauled out on rocks may blend in and can be difficult to see. Foraging birds may be diving in which case they will be underwater part of the time thus several scans of the water are required.

2.1. Locations

Spot checks will be conducted at the intake and powerhouse to focus on the locations where Harlequin Ducks were observed during baseline studies. Harlequin Ducks were also observed approximately 600 m upstream of the powerhouse, incidentally during baseline data collection for other monitoring components; however, this area is not visible from an easily accessible vantage point so observations in this area will continue to be collected incidentally when Ecofish crews download the logger and conduct potential fish stranding searches in this area. Spot checks should always take place from the same vantage points, and any deviation in methodology must be recorded. Each location has a label (ID) that should be entered into the "Location" field of the datasheet (Table 2). Each Location ID is associated with UTM coordinates. Spot check locations were flagged in May 2018 and are described below.

- Harlequin Ducks will be monitored from one of two vantage points at the intake to capture potential activity in the headpond as well as slightly upstream and downstream (ULL-HADU01a, ULL-HADU01b; Table 1, Figure 2). The vantage point at ULL-HADU01a is accessible early in the season when snow prohibits safe access to potential vantage points closer to the river. The vantage point at ULL-HADU01b is only accessible when snow does not prevent safe access. When monitoring from ULL-HADU01b it is recommended that the surveyor walk out onto the intake for the best view.

- Harlequin Ducks will be monitored from a vantage point at the powerhouse to capture potential activity near the tailrace as well as slightly upstream and downstream (NST-HADU02; Table 1, Figure 3).

Table 1. Harlequin Duck monitoring points at the intake.

Infrastructure	Location ID	UTM Coordinates (Zone 10U)		Description
		Easting	Northing	
Intake	ULL-HADU01a	466156	5614170	Above the road at the intake. To be used when snow prevents access to ULL-HADU01b.
	ULL-HADU01b	466105	5614110	Adjacent to the intake fence. To be used when accessible. To get the best view, walk out onto the intake from here when safe.
Powerhouse	ULL-HADU02	468416	5611634	On the boulders immediately downstream of the powerhouse.

Figure 1. View of ULL-HADU01a on April 30, 2018.

Figure 2. View of ULL-HADU01b on May 31, 2018.

Figure 3. View of ULL-HADU02 on May 3, 2018.

2.2. Timing

There are two time periods that are most valuable for conducting spot checks. These are:

1) the pre-incubation period (month of May), when Harlequin Duck pairs are on the river but before the female begins to incubate. Once incubation begins the male leaves and the female becomes secretive; and
2) the brood-rearing period (late July to late August) after ducklings hatch, adult males have departed, and the female is rearing her brood. At this time family groups, as well as females that have not bred successfully, can be seen on the river.

Spot checks will be scheduled to occur during these two time periods. Each time a spot check is conducted, the date and time will be recorded on the datasheet (Table 2).

2.2.1. Pre-incubation (May)

- Three spot checks will be conducted at each location during May; spot checks should be at least five days apart.

2.2.2. Brood-rearing (August 1 – August 30)

- Three spot checks will be conducted at each location from August 1 through to August 30; spot checks should be at least five days apart, with two of the spot checks occurring between August 1 and August 15.

2.3. What to Record

All required information listed below must be recorded on the Harlequin Duck spot check survey datasheet (Table 2) every time a spot check is conducted, regardless of what is seen. Please review the **Harlequin Duck Fact Sheet** for important information on identification and species biology.

Information that must be recorded includes:

- Date of the spot check.
- Time of the spot check.
- Initials of the person(s) conducting the spot check.
- Location of the spot check (specify the Location ID).
- The total number of Harlequin Ducks seen, including "0" if none were seen (enter in "Total Number" field in the datasheet). The numbers of each sex/age category should be entered into the appropriate fields of the datasheet. Including the total numbers of:
  - adult males;
  - adult female-like birds (note that juveniles are hard to distinguish from adult females and are therefore included in this group);
  - ducklings (smaller than adults early in the brood-rearing period); and
  - individuals of unknown sex (cannot be identified as adult males or adult female-like birds, and are not ducklings that can be distinguished by size).

- Record comments in the "Comments" column of the datasheet for every spot check:
  - if no Harlequin Ducks are seen, state this in words;
  - pair(s) (male and female close together) or family group (for example: a female with three female-like birds that may be juveniles based on their proximity and synchronous behaviour);
  - other species (e.g., American Dippers, mergansers, Barrow's Goldeneye); and
  - visibility limitations (e.g., due to poor weather, or if the water level in the river is unusually high or low.
- Take photos of all Harlequin Ducks and other wildlife observaed and record photo numbers in the appropriate field of the data sheet.

2.4. Equipment Required

Equipment required for spot check includes:

- Clipboard with datasheets and Harlequin Duck Fact Sheet.
- Binoculars and/or spotting scope.
- Digital Camera.

Table 2. Harlequin Duck spot check datasheet.

Ecofish Research Ltd.
Suite F, 450 8th Street,
Courtenay, B.C.
V9N 1N5

Date	Time	Location[1]	Total Number[2]	Number of Adult Males	Number of female-like[3]	Number of Ducklings	Number of Unknown Sex	Comments (describe behaviour and other observations of interest such as weather conditions and other species observed)[4]	Photo Number	Observer Initials

[1] Location ID as described in Spot Check Protocols. If location is different, note at UTM or mark on a map.

[2] Indicate zero if no Harlequin Ducks are seen.

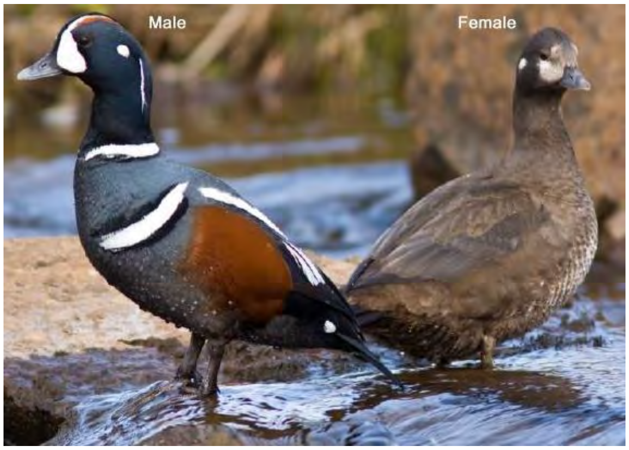
[3] Includes adult females and large juveniles that look like adult females.

[4] Describe behaviour (e.g., feeding, preening, hauled out on rocks, flying upstream or downstream) and wether birds are behaving as a group (e.g., "feeding together; appear to be a pair"); note any other observations of interest such as other riverine species (e.g., American Dippers); any limitations on survey methods (e.g., poor visibility due to poor weather) or unusual conditions (e.g., water levels very high). Include some comments for every spot check.

3. HARLEQUIN DUCK FACT SHEET

3.1. Physical Description

Male



- Dark from a distance, white streaks and colourful patches can be seen closer up;
- Slate blue plumage and belly, chestnut sides and streaks of white on the head and body; and
- Crown has a black stripe with a larger white patch in front of the eye and a small white ear patch.

Female

- Plain brownish-grey with lighter underside;
- The face in front of the eye is light in colour and has distinctive white ear patch; and
- Roughly half the size of a Mallard duck.

Immature

- After hatching, ducklings can be distinguished by their small size relative to the adult female;
- When larger but while still on the breeding stream, juveniles of both sexes resemble the adult female; and
- Young males begin to look like adults in fall, but they do not gain full adult plumage until the next summer.

3.2. Life History

- Arrive on breeding streams shortly after spring break-up;
- Females lay 3-10 eggs that hatch after approximately one month;

- Males leave the breeding stream once the female begins to incubate;
- Females and their young return to the coast together in late September; and
- Individuals often return to the same breeding site year after year.

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3.3. Habitat

- Spend their winters at the coast and breed near fast-flowing rivers and streams;
- Require streams with adequate amounts of aquatic invertebrates for consumption;
- Riparian vegetation is an important component of their habitat requirements;
- Usually nest under shrubs within 30 m of the stream; and
- Ducklings require overhanging vegetation along stream banks for protection from predators.

4. OTHER WATERFOWL COMMON IN HEADPONDS

4.1. Barrow's Goldeneye and Common Goldeneye

Barrow's Goldeneye and Common Goldeneye are usually slightly larger than Harlequin Ducks.

Female

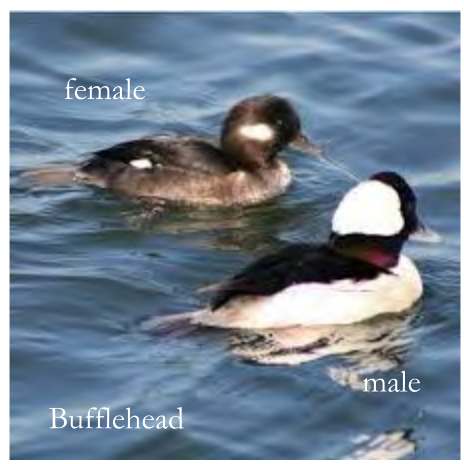
- Can be distinguished from Harlequin Ducks by their orange bills and dark grey bodies which contrast with their brown heads. (Harlequin Duck females and juveniles have uniformly brown bodies and heads.)

Male

- Can be distinguished from Harlequin Ducks by their black and with bodies, and dark green heads with a single white spot near the bill.

4.2. Bufflehead

Buffleheads are smaller than Harlequin Ducks.



Female

- Can be distinguished from Harlequin Ducks by their single cheek spot and their smaller size. (Harlequin Duck females and juveniles have a large pale patch near their bill in addition to a small white spot further back on their cheek.)

Male

- Can be distinguished from Harlequin Ducks by their wedge shaped white patch from their eyes to the back of their head, as well as their solid black back and solid white sides.

4.3. Common Merganser

Common Mergansers are larger than Harlequin Ducks.

Female

- Can be distinguished from Harlequin Ducks by their reddish head and bill, greyish body plumage, white chest and their larger size.

Male

- Can be distinguished from Harlequin Ducks by their red bill, dark green head, black and grey back, white body and chest plumage and their larger size.

Appendix D. Harlequin Duck Survey Results

Table 1. Harlequin Duck spot check survey results in 2019.

Survey Type	Date	Infrastructure	Spot Check Vantage Point UTM Coordinates (Zone 10U)		Harlequin Ducks Observed	Other Waterbirds Observed
			Easting	Northing		
pair	17-May-2019	intake	466156	5614170	0	-
		powerhouse	468416	5611634	0	-
	23-May-2019	intake	466105	5614110	0	-
		powerhouse	468416	5611634	0	-
	26-May-2019	intake	466105	5614110	0	-
		powerhouse	468416	5611634	0	-
brood	3-Aug-2019	intake	466105	5614110	0	-
		powerhouse	468416	5611634	0	-
	8-Aug-2019	intake	466105	5614110	0	-
		powerhouse	468416	5611634	0	-
	21-Aug-2019	intake	466105	5614110	0	-
		powerhouse	468416	5611634	0	-

Appendix E. Representative Water Temperature and Air Temperature Site Photographs, 2019

LIST OF FIGURES

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Figure 3. Looking upstream at ULL-USWQ03 on April 12, 2019.

Figure 4. Looking downstream at ULL-USWQ03 on April 12, 2019.

Figure 5. Looking upstream at ULL-USWQ03 on October 11, 2019.

Figure 6. Looking downstream at ULL-USWQ03 on October 11, 2019.

Figure 7. Looking at ULL-USAT01 on April 11, 2019.

Figure 8. Looking at ULL-USAT02 on October 24, 2019.

Figure 9. Looking upstream at ULL-DVWQ01 on October 21, 2019.

Figure 10. Looking downstream at ULL-DVWQ01 on October 21, 2019.

Figure 11. Looking upstream at ULL-TAILWQ on April 14, 2019.

Figure 12. Looking RR to RL at ULL-TAILWQ on April 14, 2019.

Figure 13. Looking at tidbit location at ULL-TAILWQ on October 24, 2019.

Figure 14. Looking upstream at ULL-TAILWQ on October 24, 2019.

Figure 15. Looking upstream at ULL-DSWQ on April 13, 2019.

Figure 16. Looking at tidbits location at ULL-DSWQ on April 13, 2019.

Figure 17. Looking upstream at ULL-DSWQ on October 21, 2019.

Figure 18. Looking at ULL-DSAT on October 24, 2019.

2. BOULDER CREEK

Figure 19. Looking upstream at BDR-USWQ2 on October 11, 2019.

Figure 20. Looking downstream at BDR-USWQ2 on October 11, 2019.

Figure 21. Looking upstream at NTH-USWQ1 on October 11, 2019.

Figure 22. Looking downstream at NTH-USWQ1 on October 11, 2019.

Figure 23. Looking upstream at BDR-DVWQ on March 29, 2019.

Figure 24. Looking upstream at BDR-DVWQ on October 24, 2019.

Figure 25. Looking upstream at BDR-TAILWQ on March 31, 2019.

Figure 26. Looking downstream at BDR-TAILWQ on October 11, 2019.

Figure 27. Looking upstream at tidbit 1 at BDR-DSWQ on March 31, 2019.

Figure 28. Looking upstream at tidbit 2 at BDR-DSWQ on March 31, 2019.

Figure 29. Looking upstream at tidbit 1 at BDR-DSWQ on October 24, 2019.

Figure 30. Looking upstream at tidbit 2 at BDR-DSWQ on October 24, 2019.

Appendix F. Water Temperature Guidelines and Data Summary

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1. WATER TEMPERATURE GUIDELINES

Table 1. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001, MOE 2019).

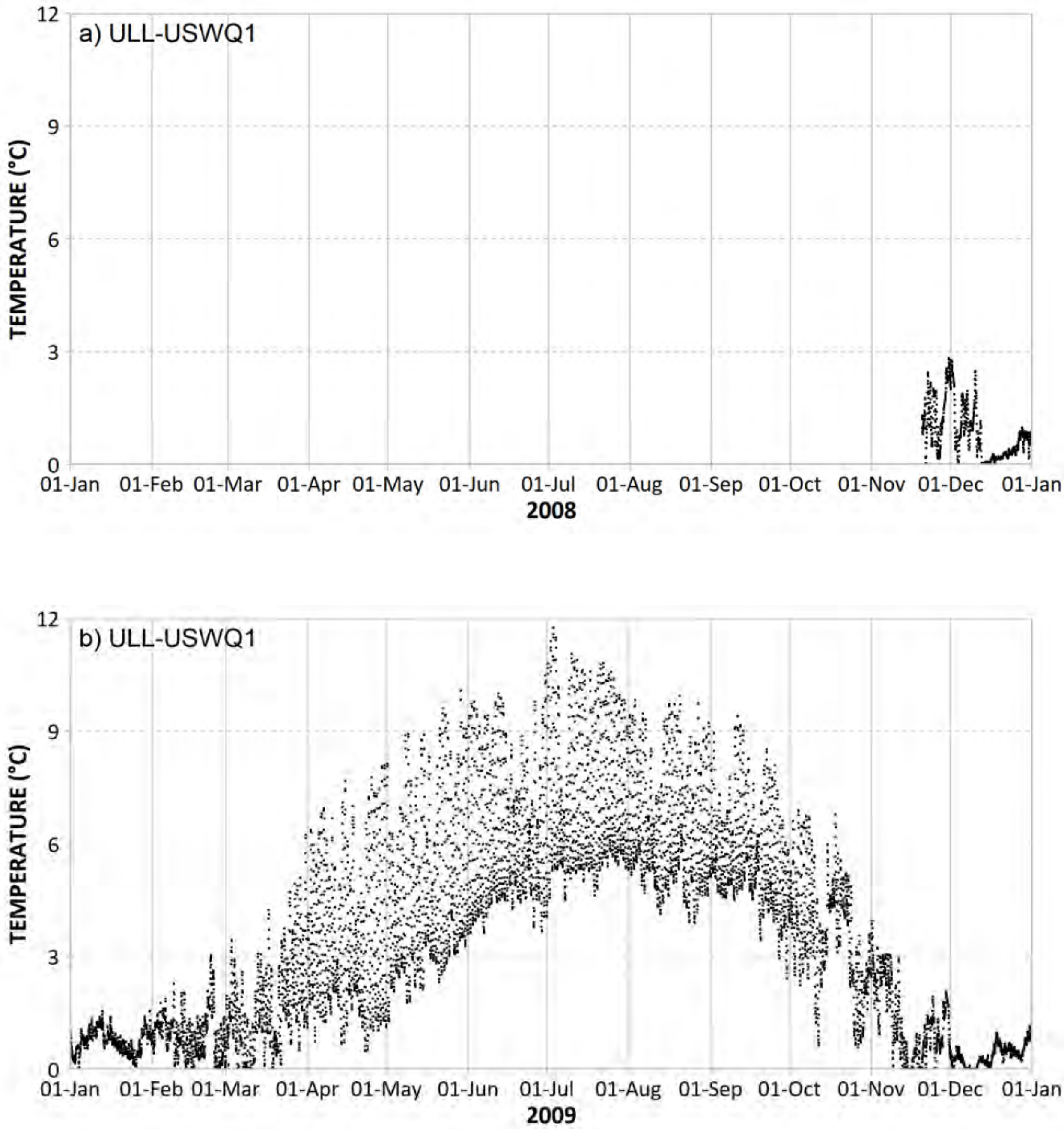
Category	Guideline[1]
All Streams	the rate of temperature change in natural water bodies not to exceed 1°C/hr
	temperature metrics to be described by the mean weekly maximum temperature (MWMxT)
Streams with Known Fish Presence	mean weekly maximum water temperatures should not exceed ±1°C beyond the optimum temperature range for each life history phase of the most sensitive salmonid species present[1]
Streams with Bull Trout or Dolly Varden	maximum daily temperature is 15°C
	maximum incubation temperature is 10°C
	minimum incubation temperature is 2°C
	maximum spawning temperature is 10°C
Streams with Unknown Fish Presence	salmonid rearing temperatures not to exceed MWMxT of 18°C
	maximum daily temperature not to exceed 19°C
	maximum temperature for salmonid incubation from June until August not to exceed 12°C

[1] The guidelines state that "the natural temperature cycle characteristic of the site should not be altered in amplitude or frequency by human activities". Accordingly, it is implied that when conditions are naturally outside of guidelines, human activities should not increase the magnitude and/or frequency to which conditions are outside of guidelines.

2. WATER TEMPERATURE DATA

2.1. Upper Lillooet River

Figure 1. Baseline water temperature at ULL-USWQ1 from 2008 to 2013. Black dots show water temperature at intervals of 15 minutes.



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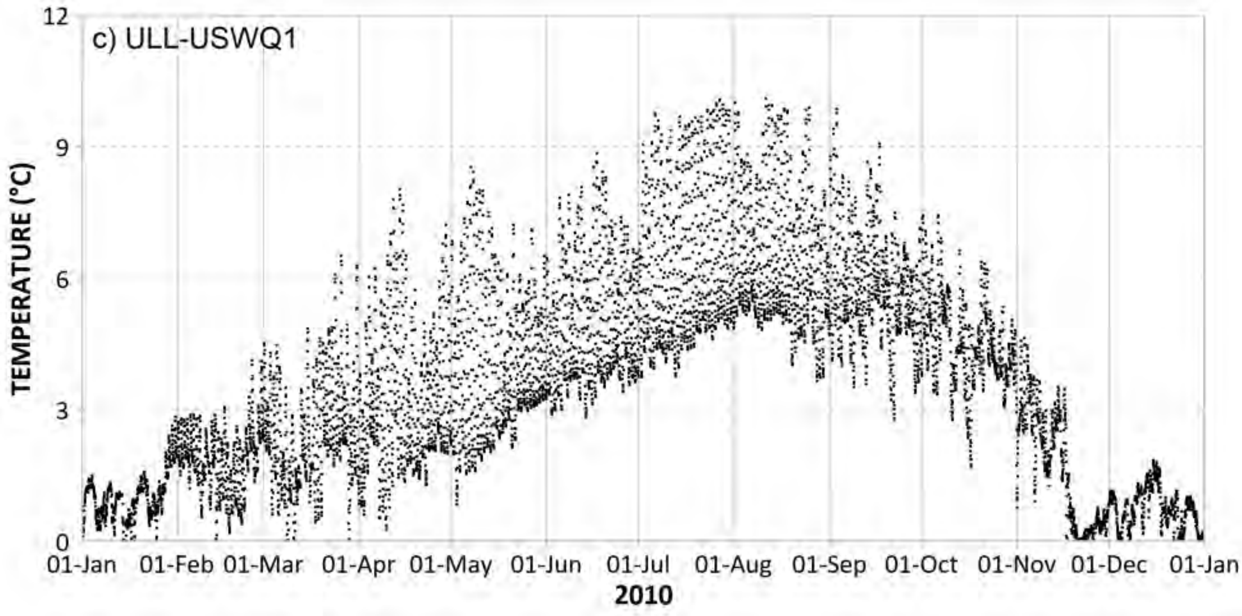

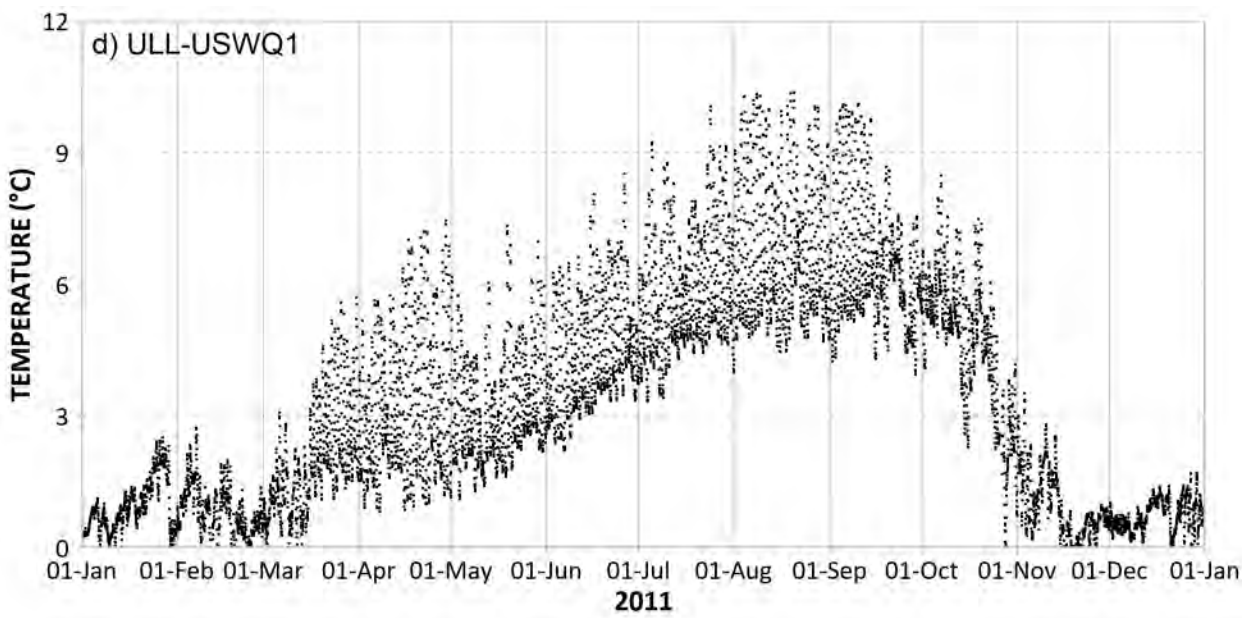

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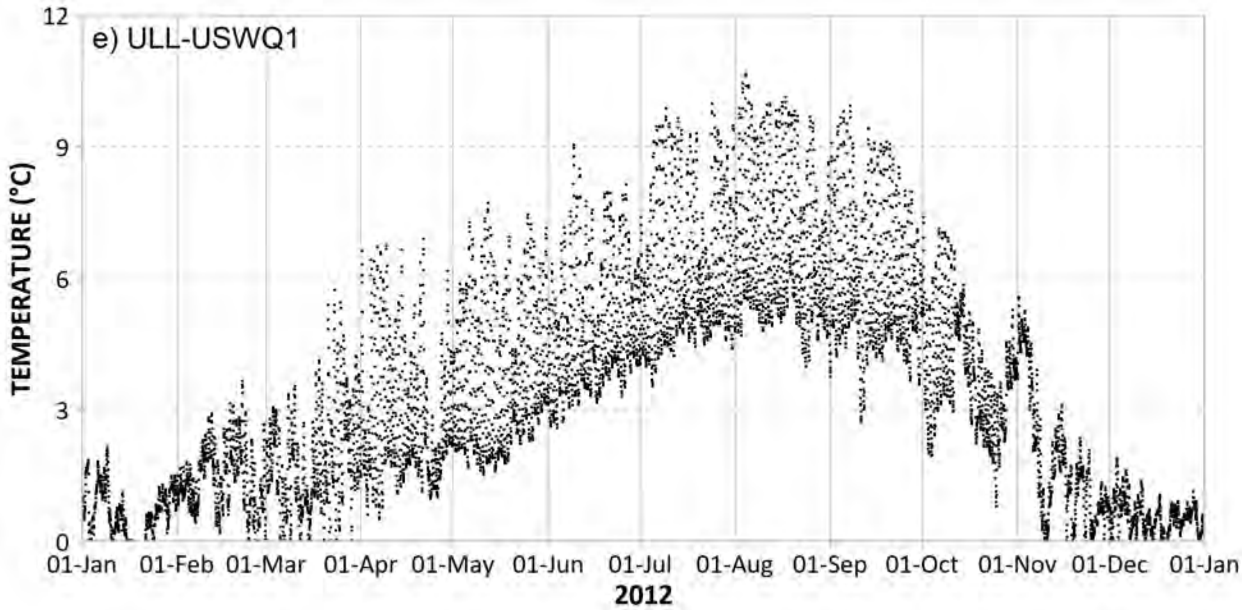


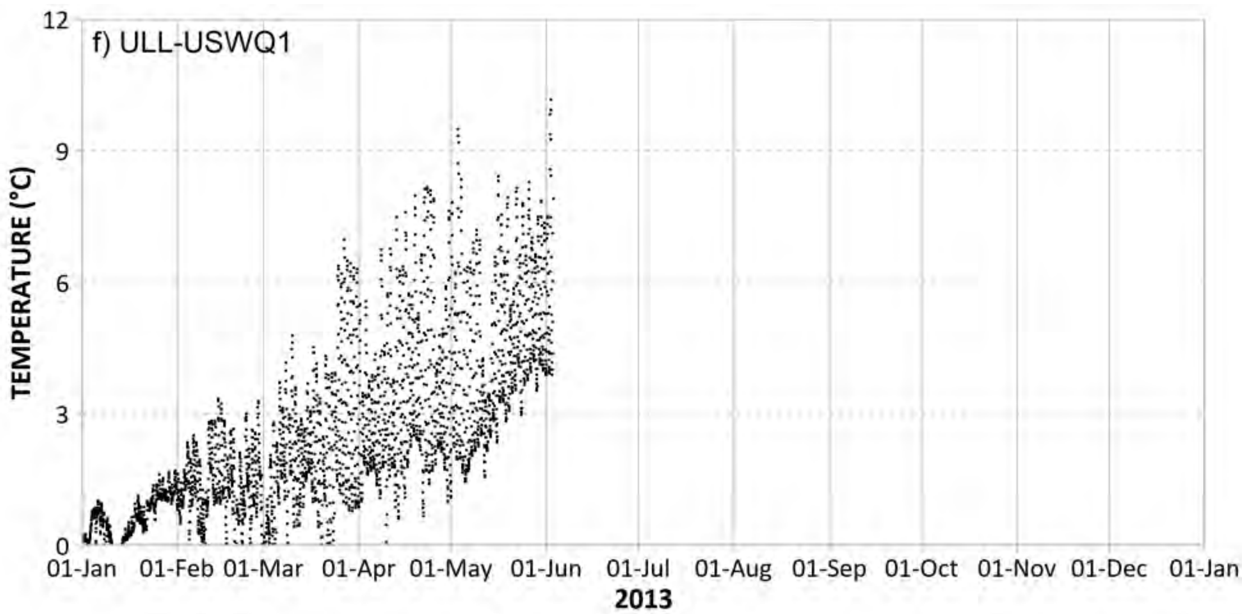
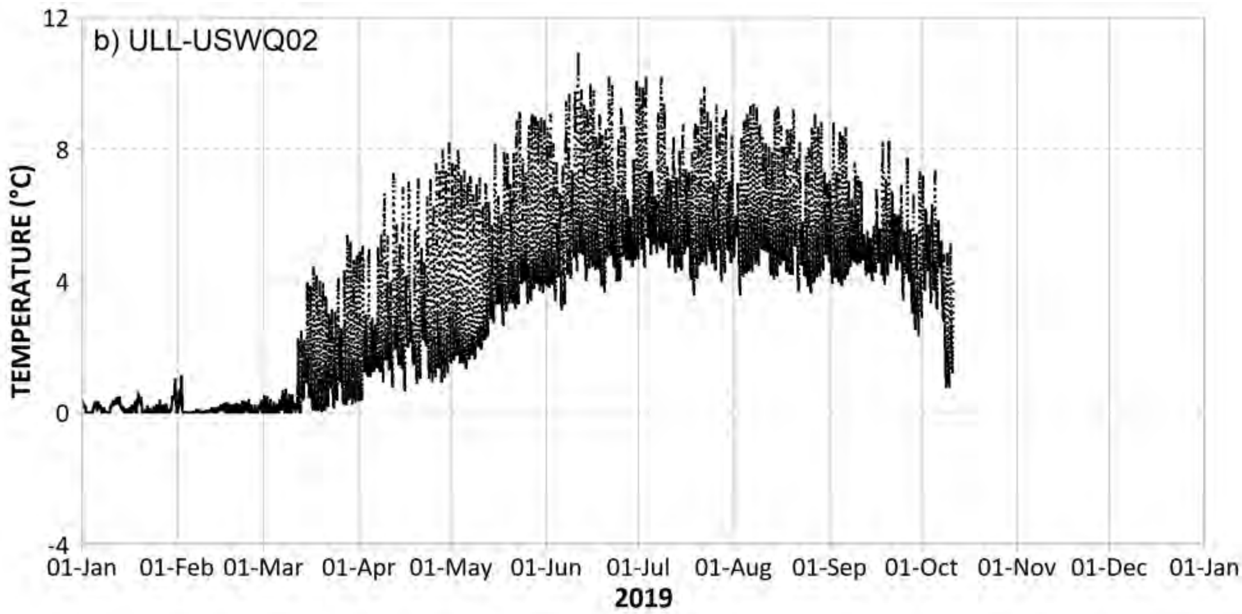


Figure 2. Operational water temperature at ULL-USWQ02 from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.



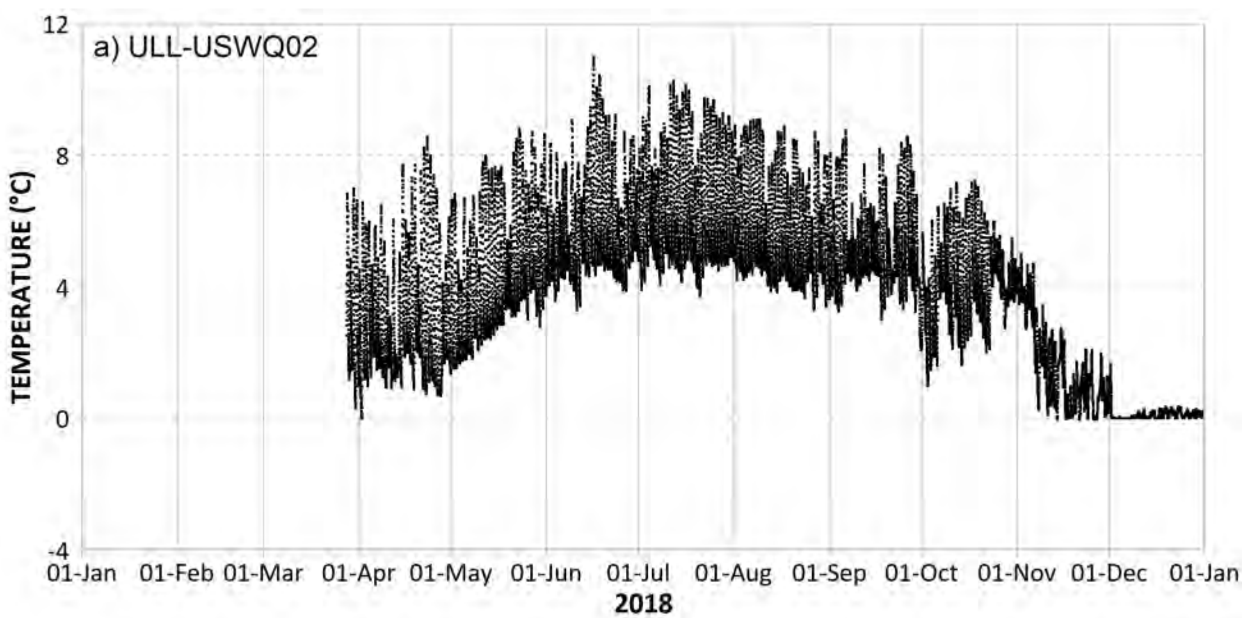


Figure 3. Operational water temperature at ULL-USWQ03 from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.

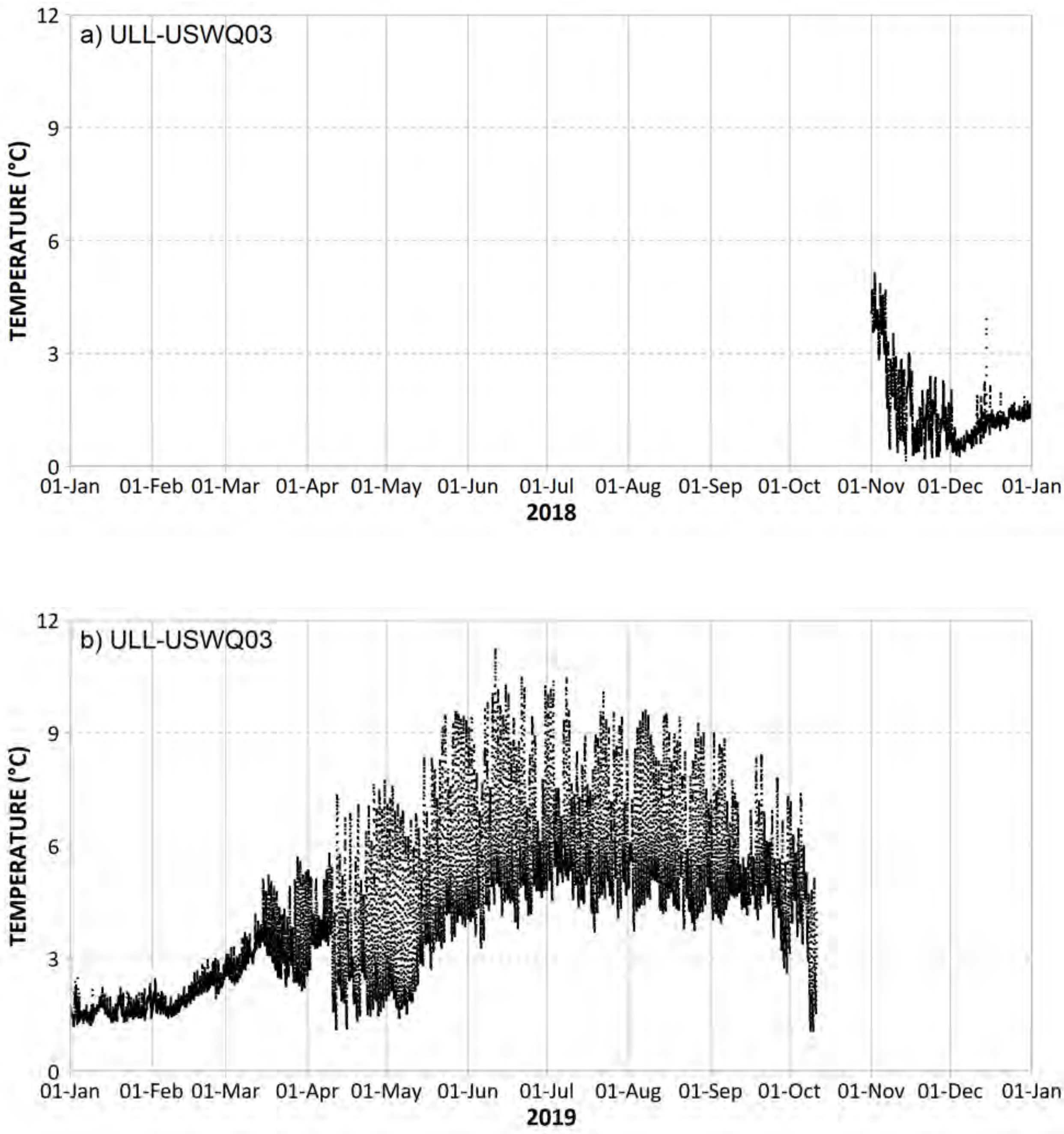
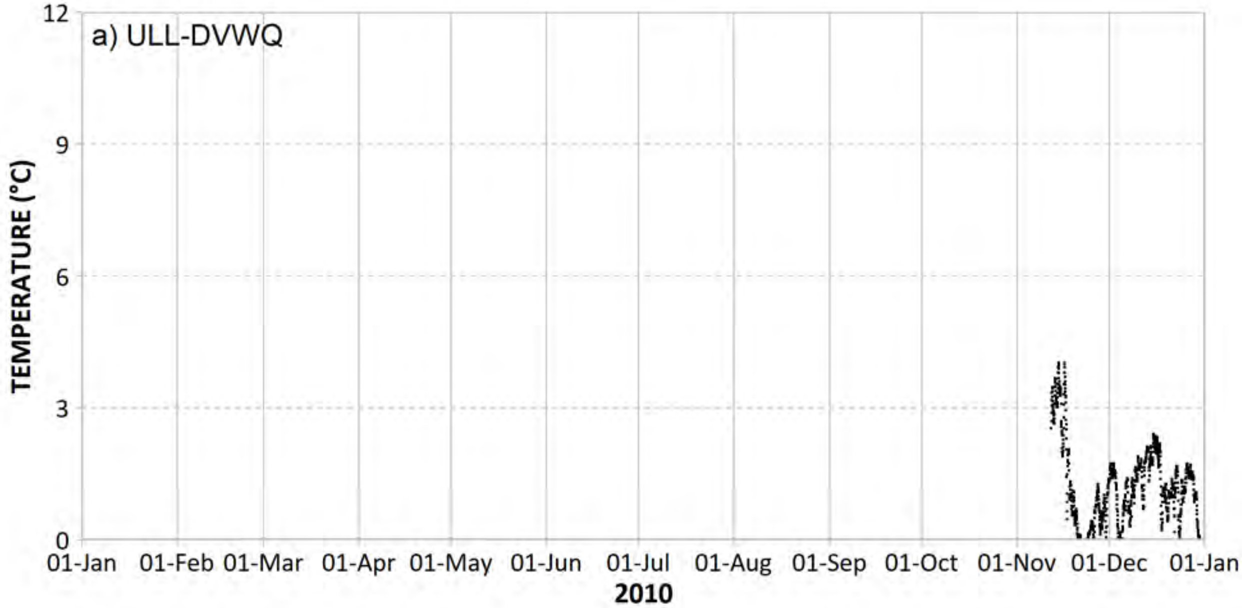
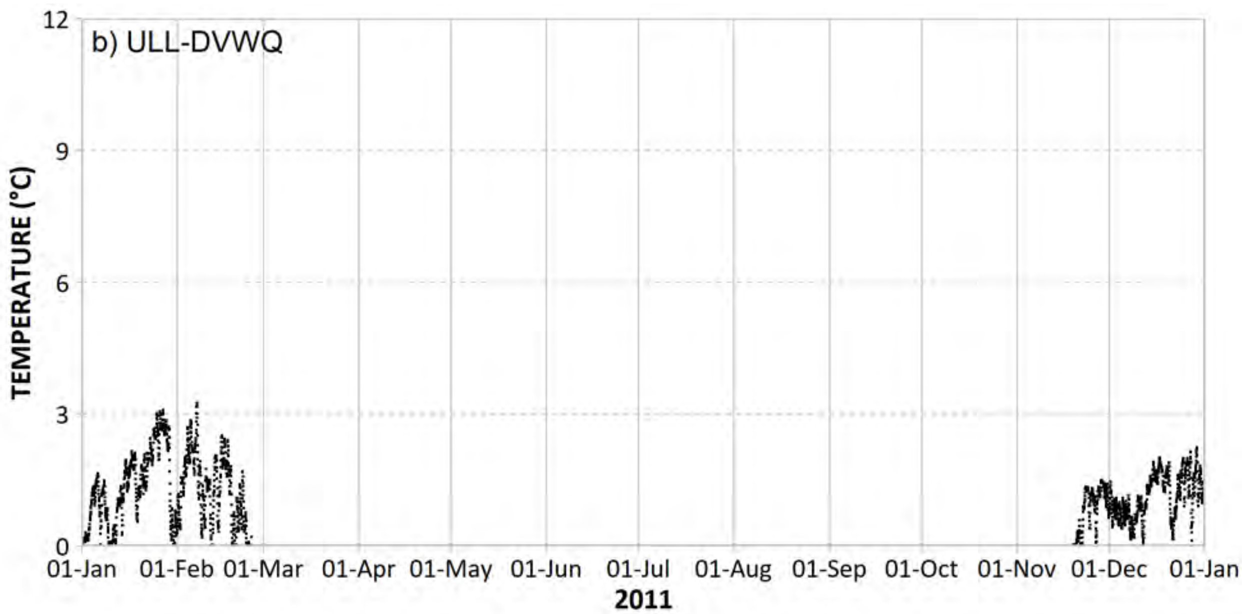


Figure 4. Baseline water temperature at ULL-DVWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.





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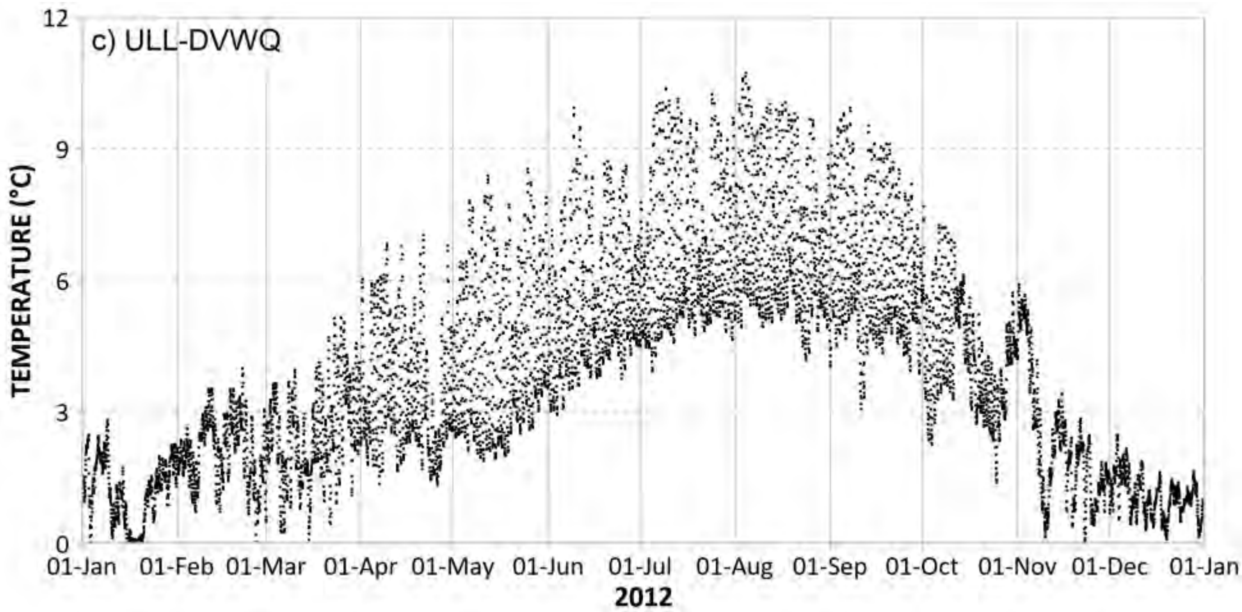


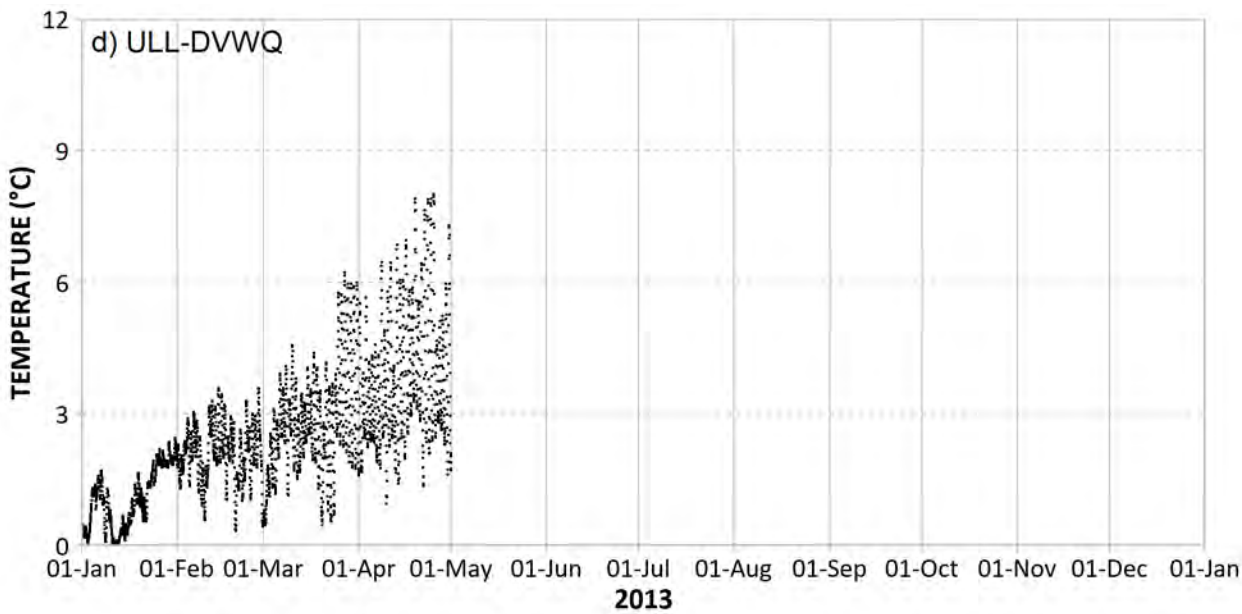
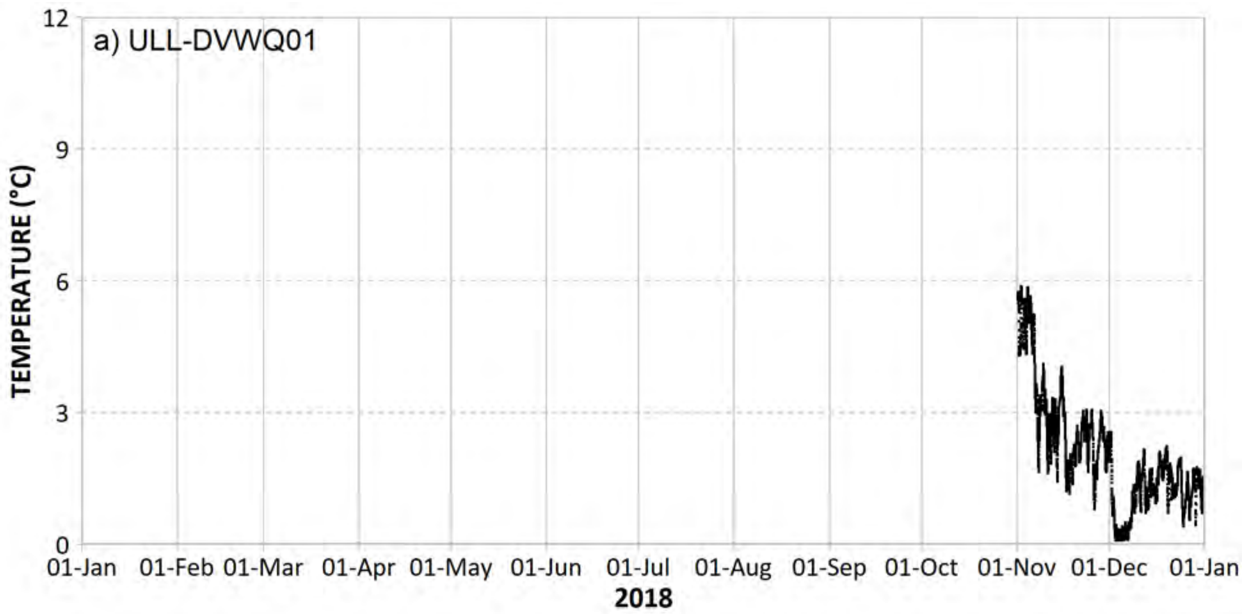


Figure 5. **Operational water temperature at ULL-DVWQ01 from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.**



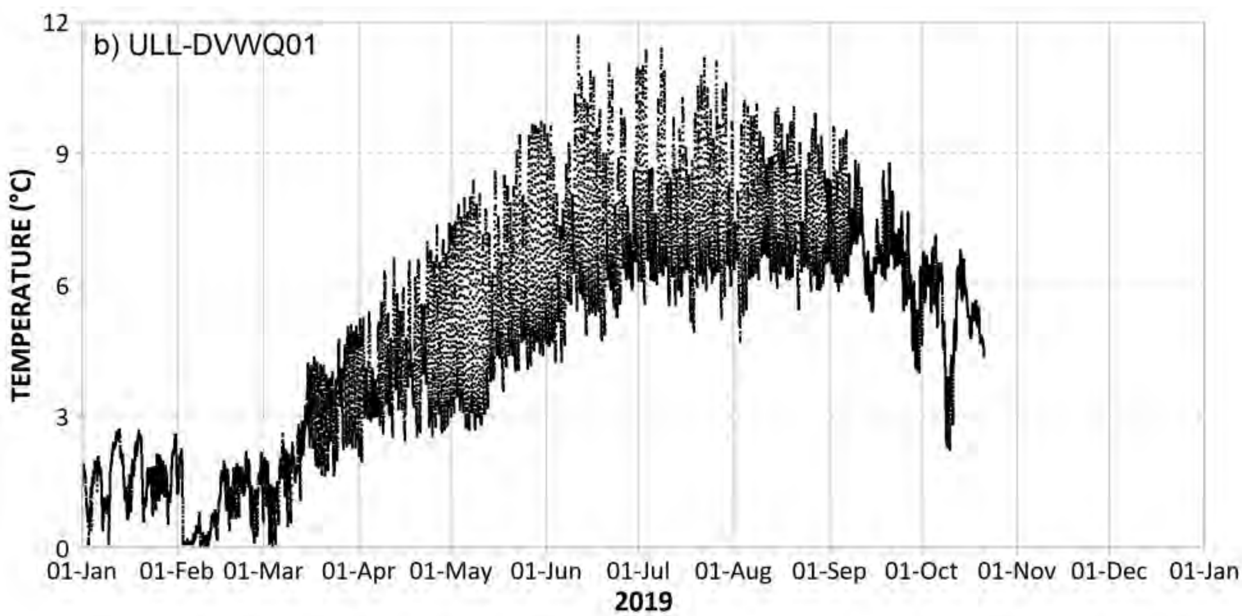
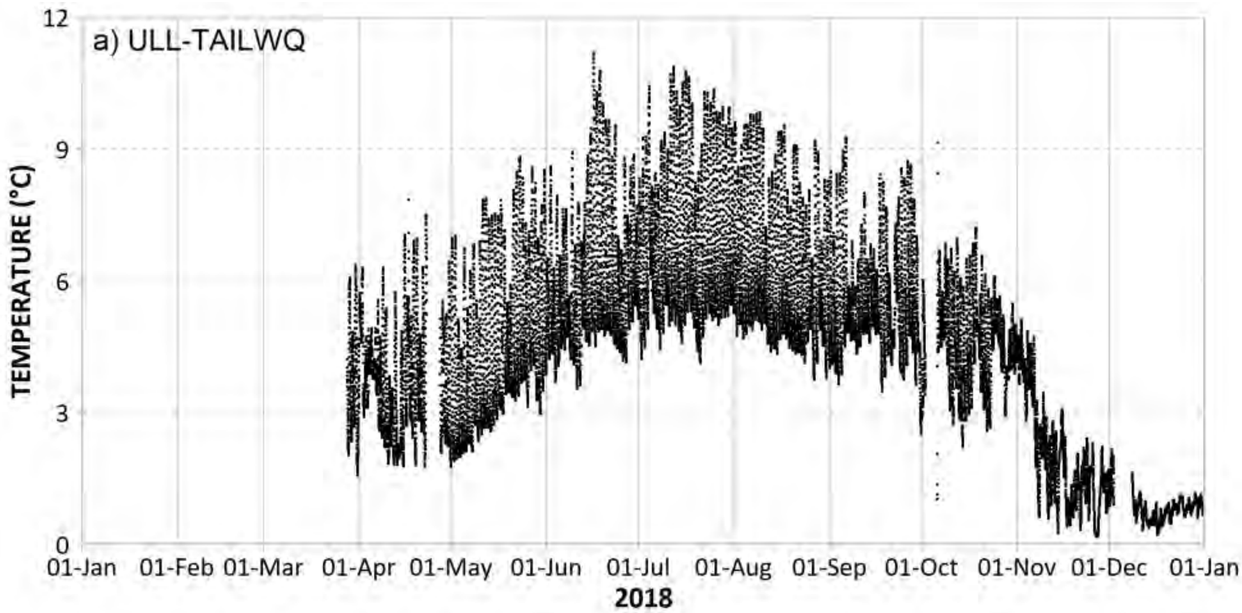


Figure 6. **Operational water temperature at ULL-TAILWQ from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.**



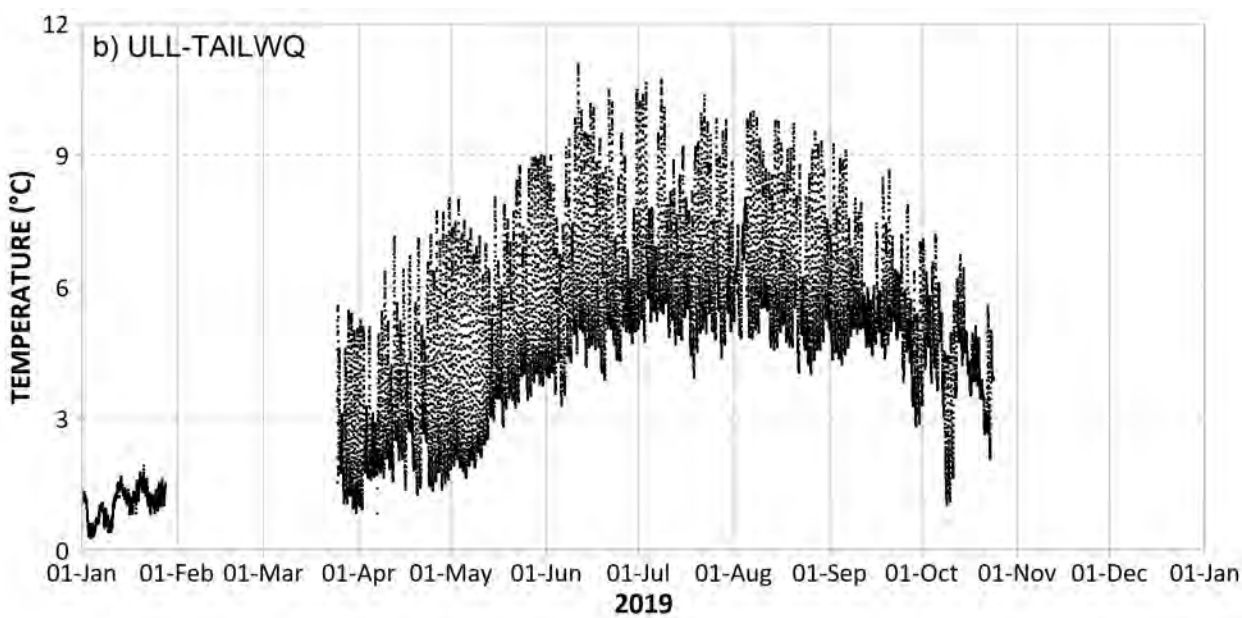
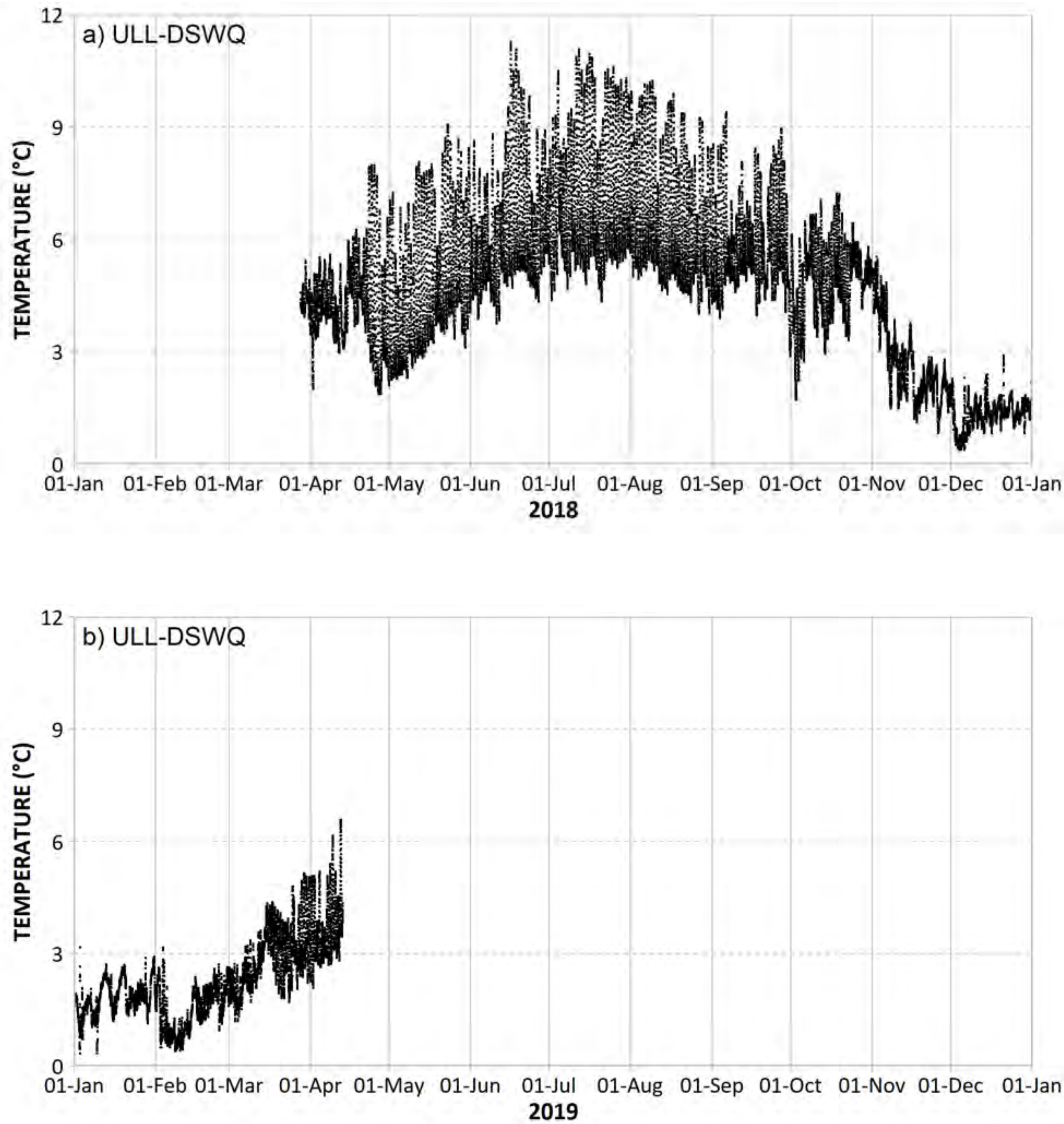
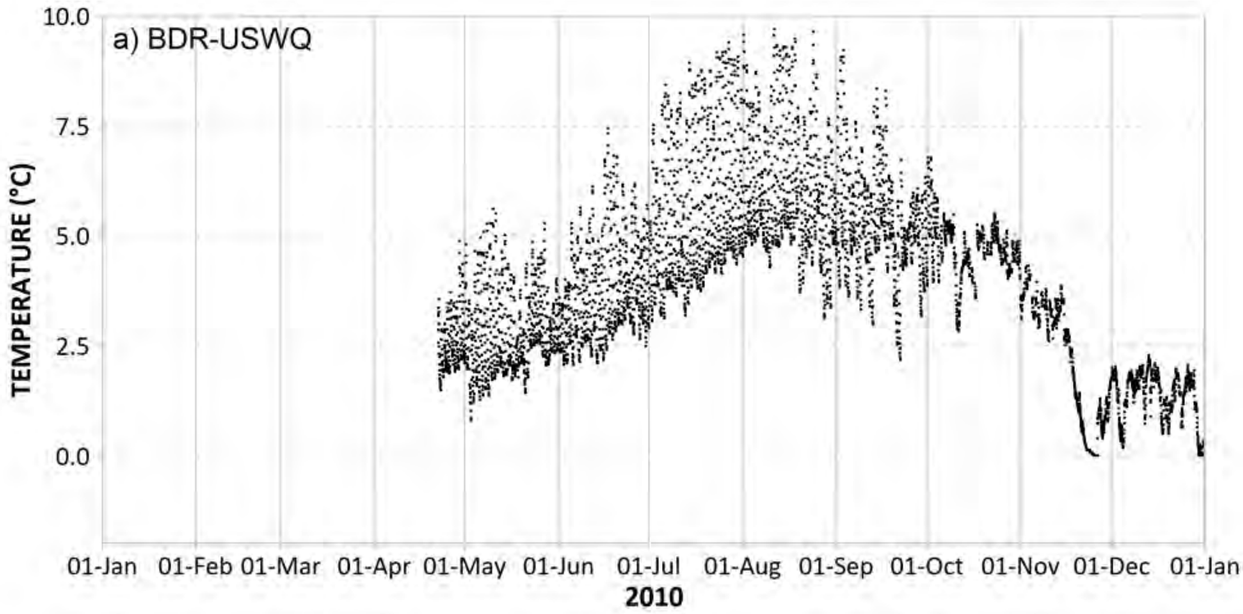


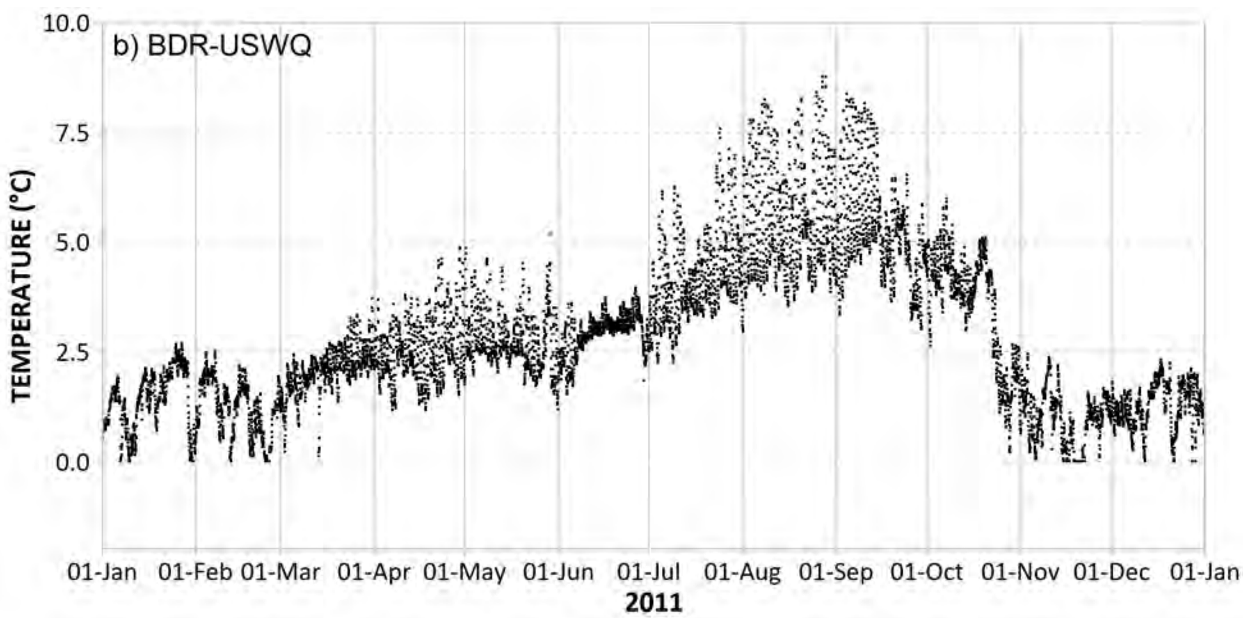
Figure 7. Operational water temperature at ULL-DSWQ from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.



2.2. Boulder Creek

Figure 8. Baseline water temperature at BDR-USWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.





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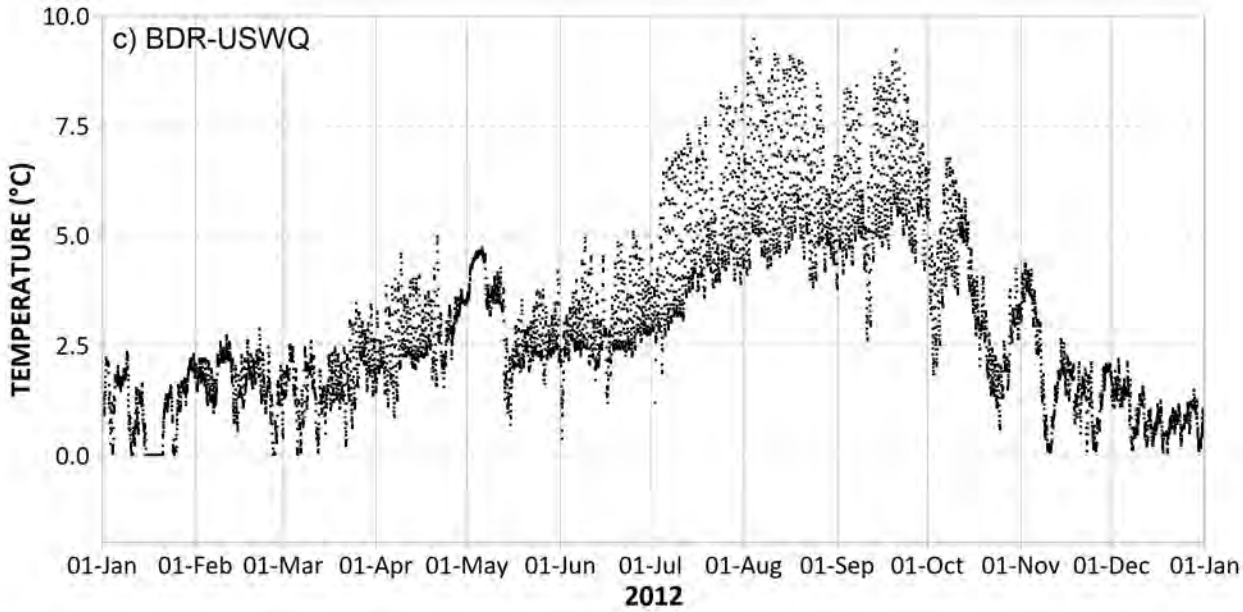


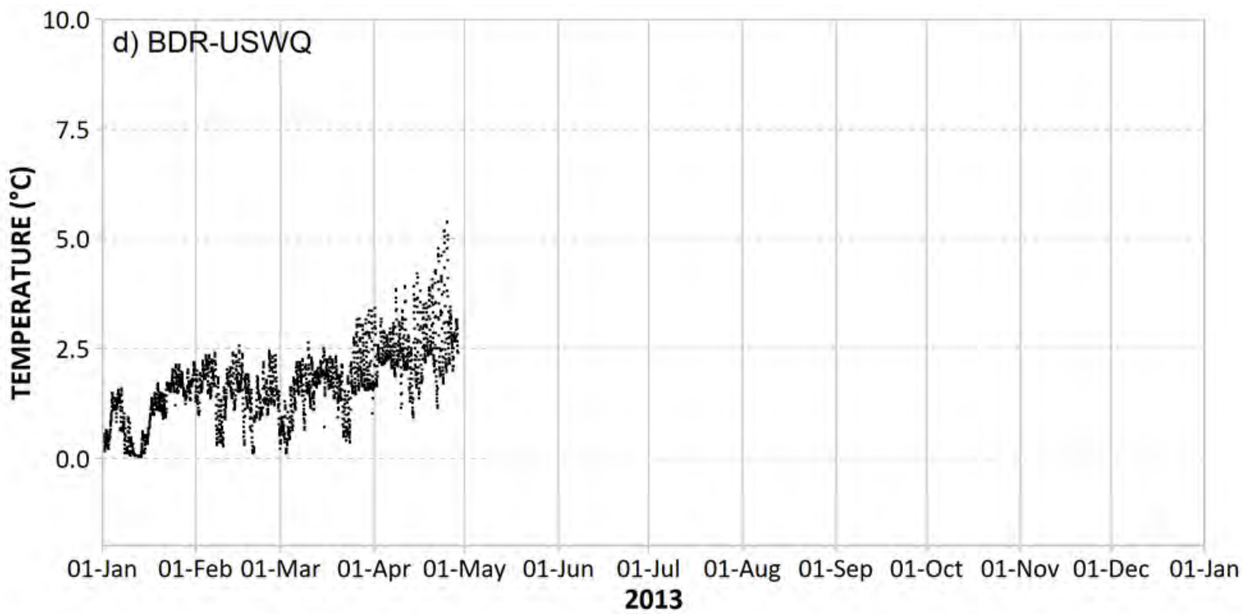
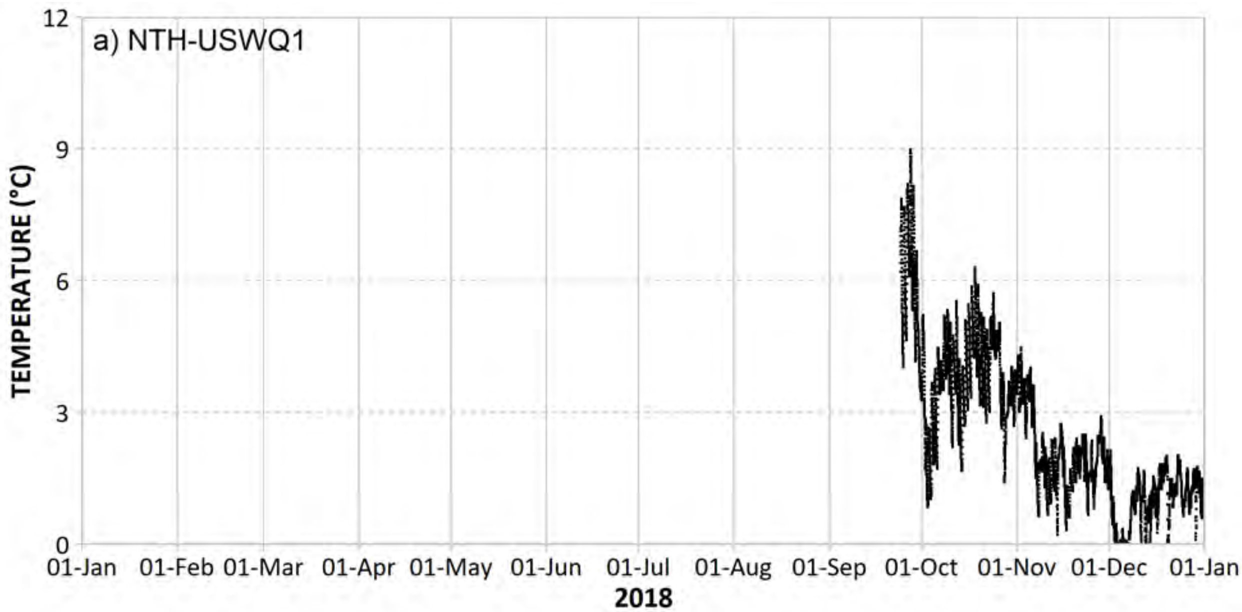


Figure 9. Operational water temperature at NTH-USWQ1 from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.



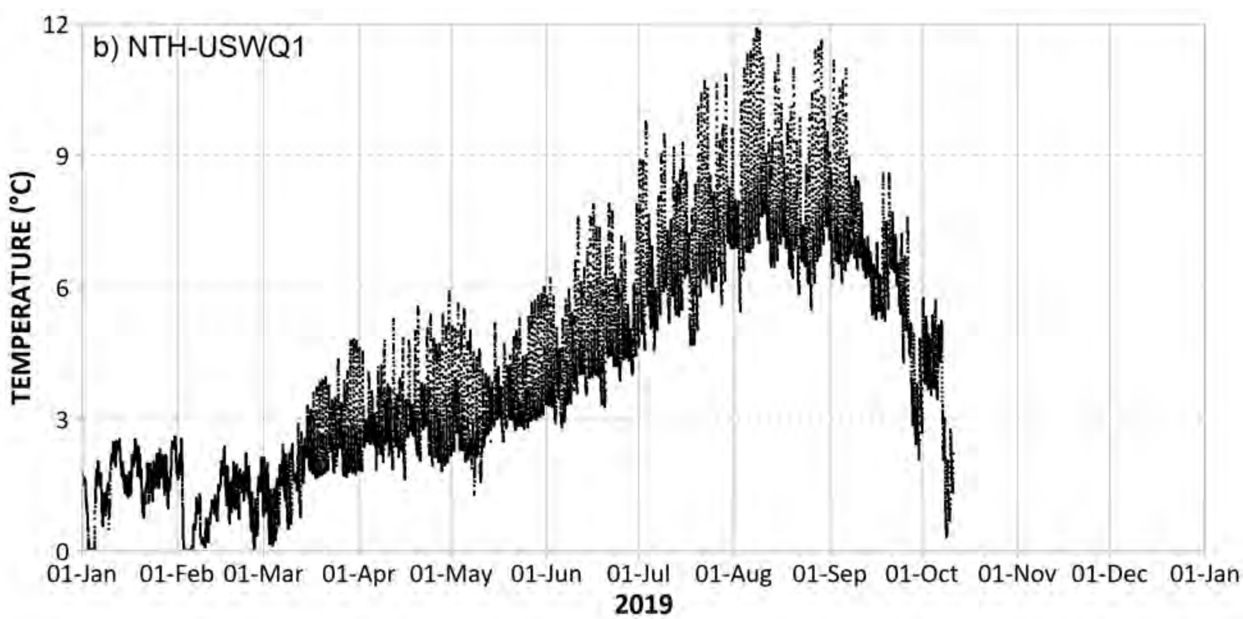
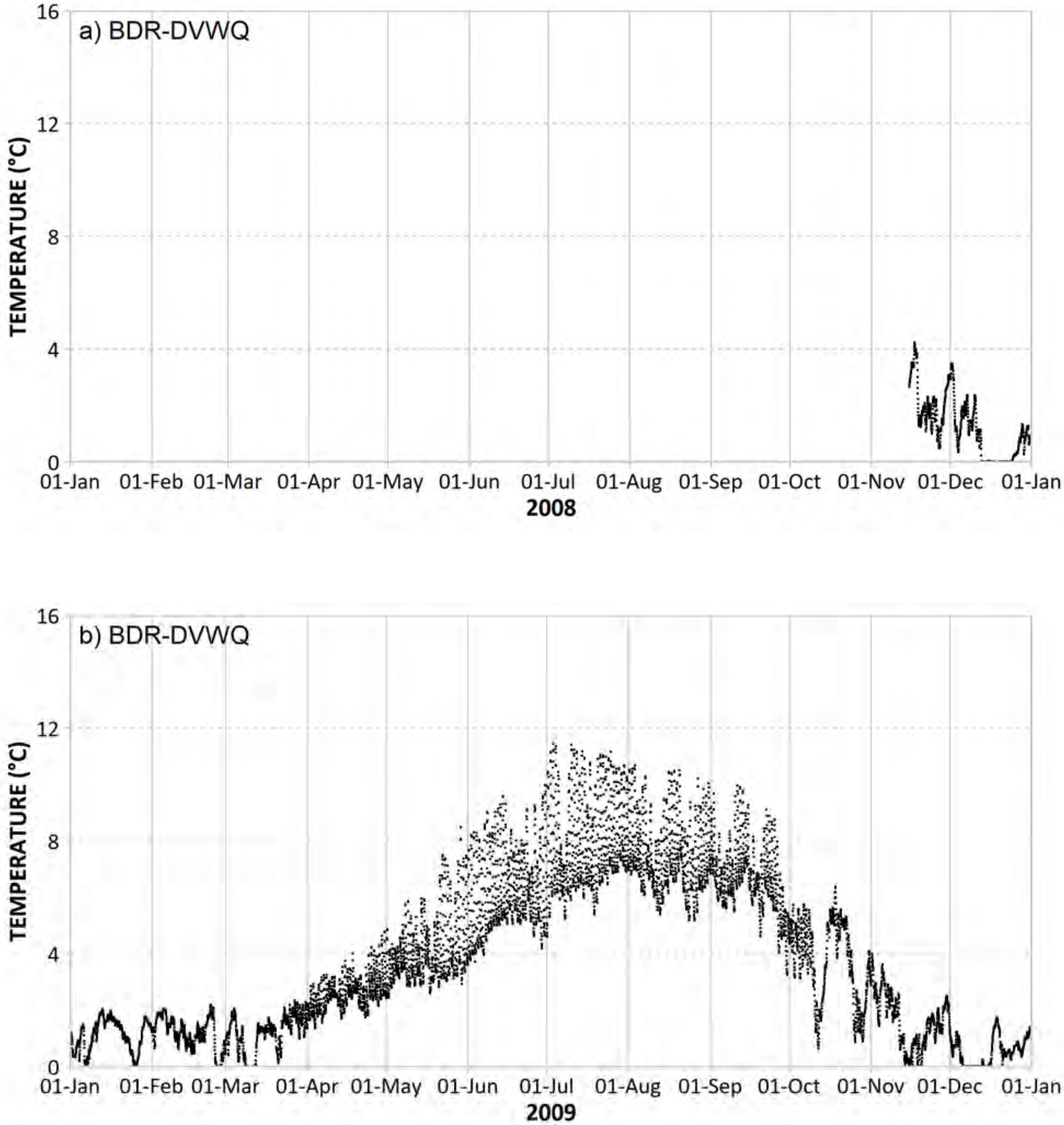


Figure 10. Baseline (2008-2013) and operational (2018-2019) water temperature at BDR-DVWQ. Black dots show water temperature at intervals of 15 minutes.



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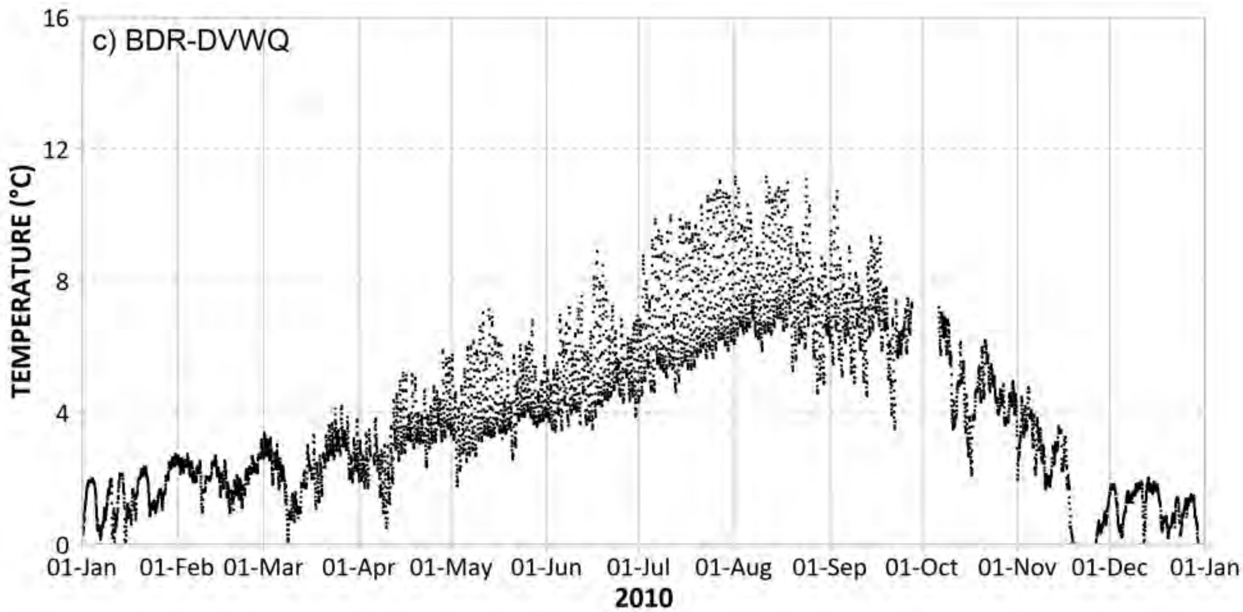

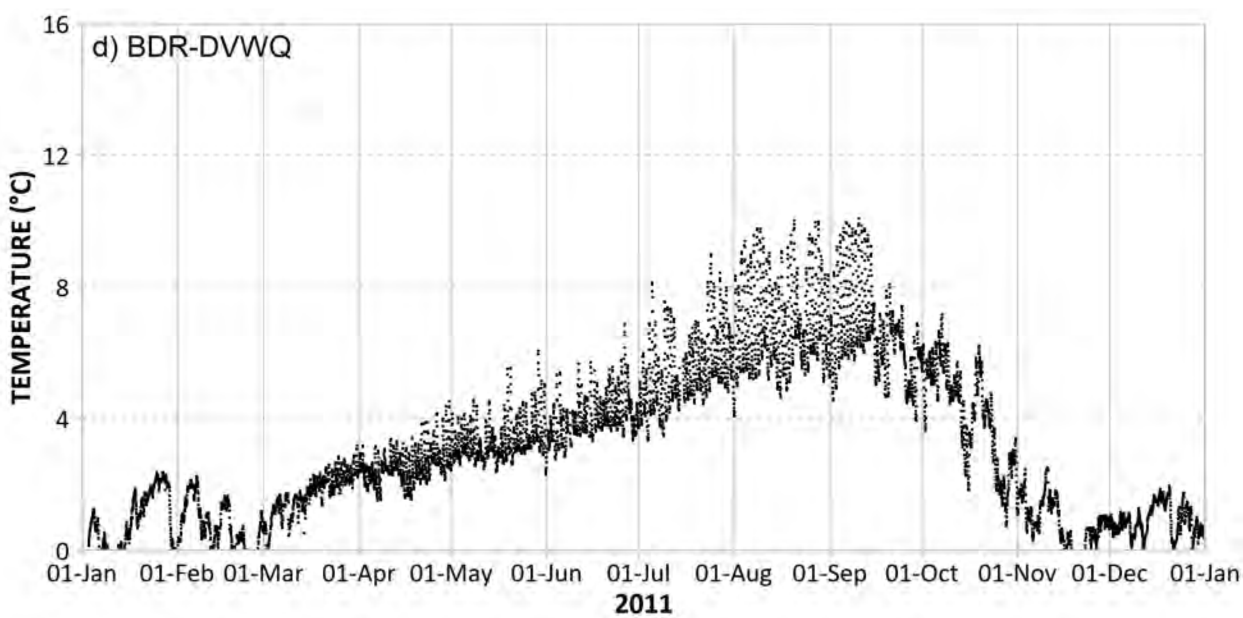

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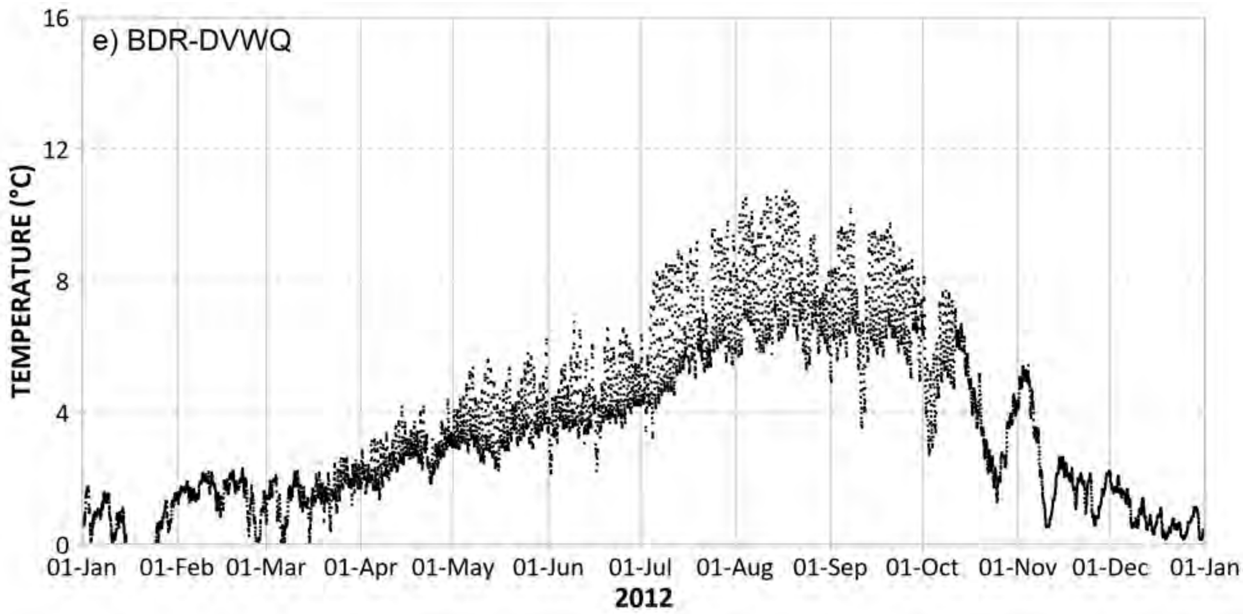

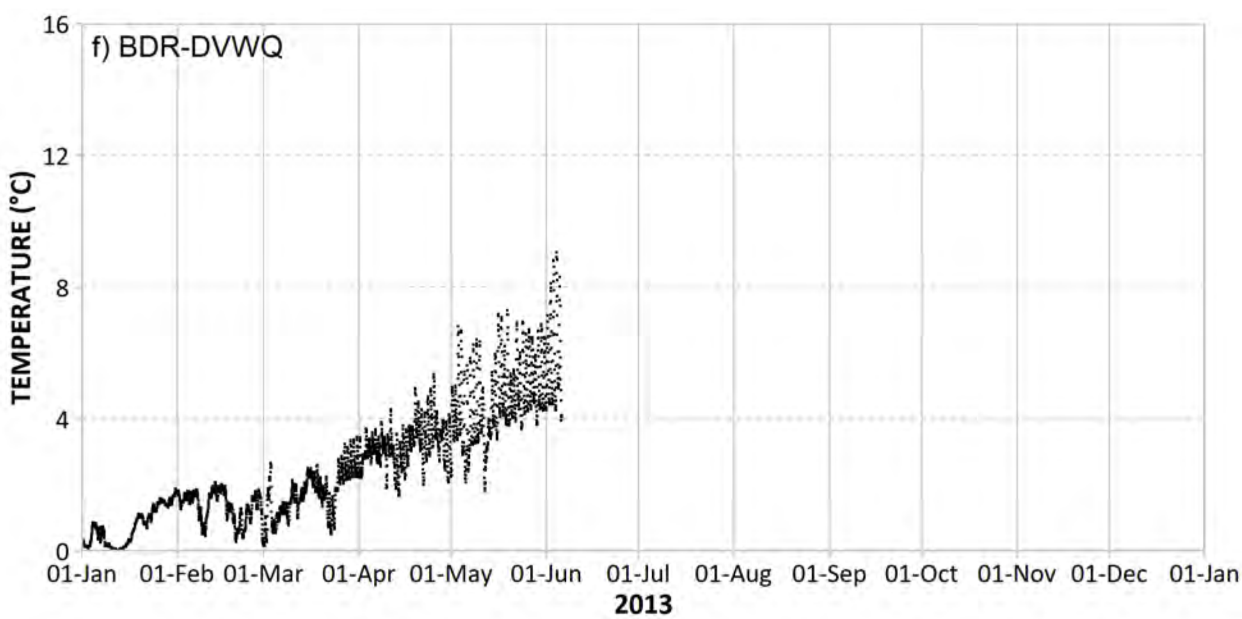

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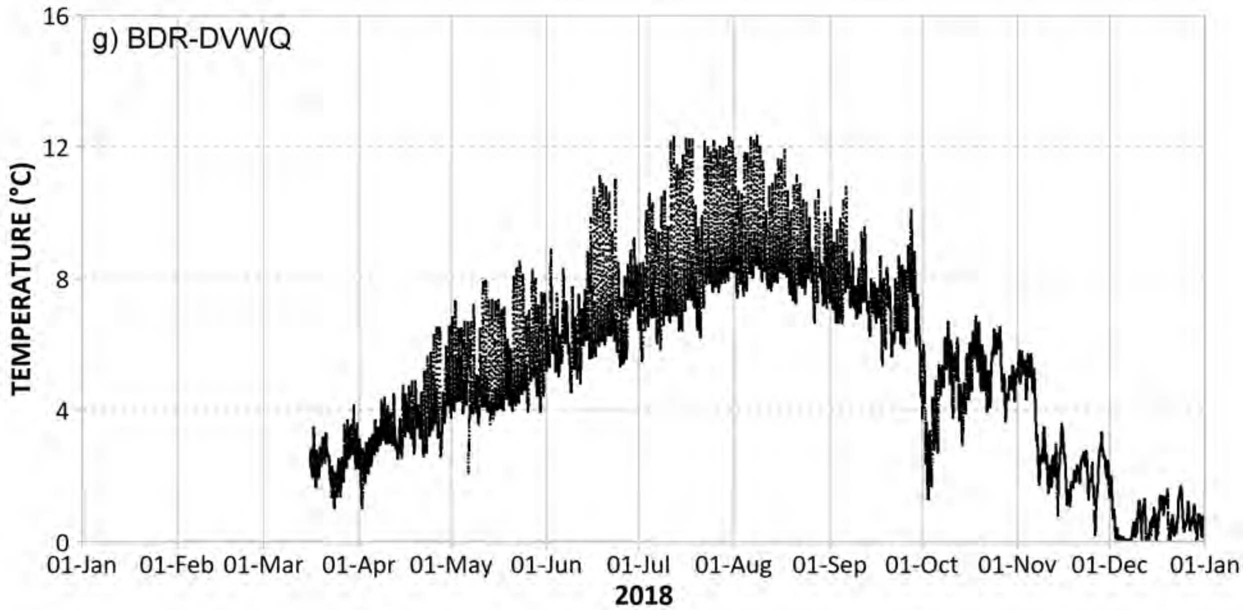

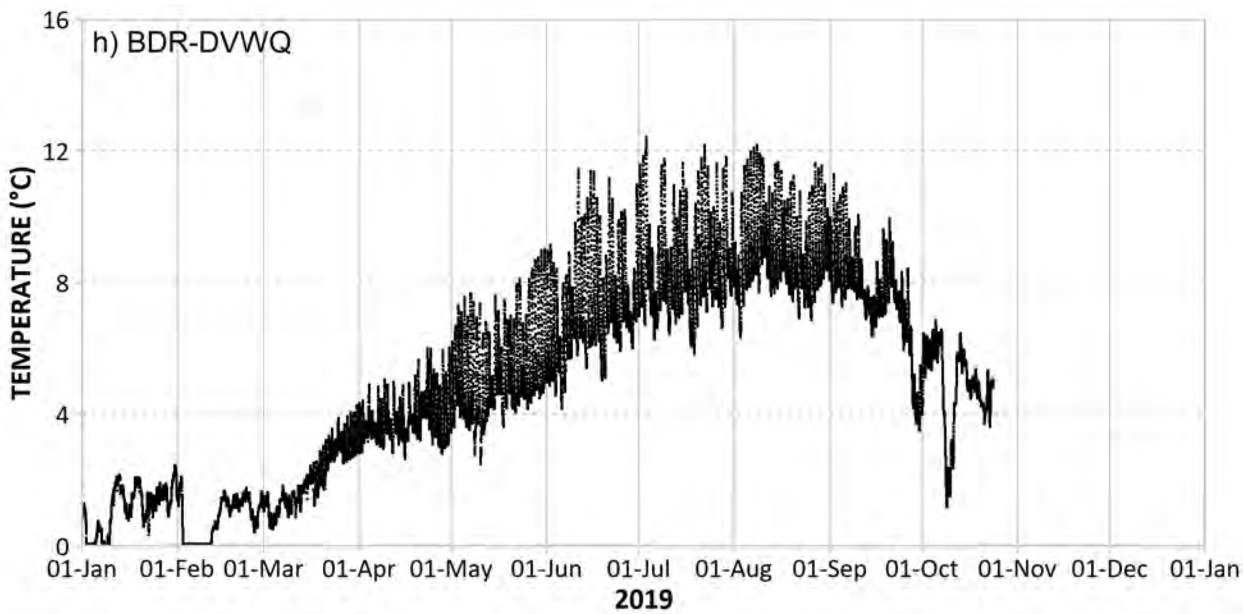

Figure 11. Operational water temperature at BDR-TAILWQ from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.

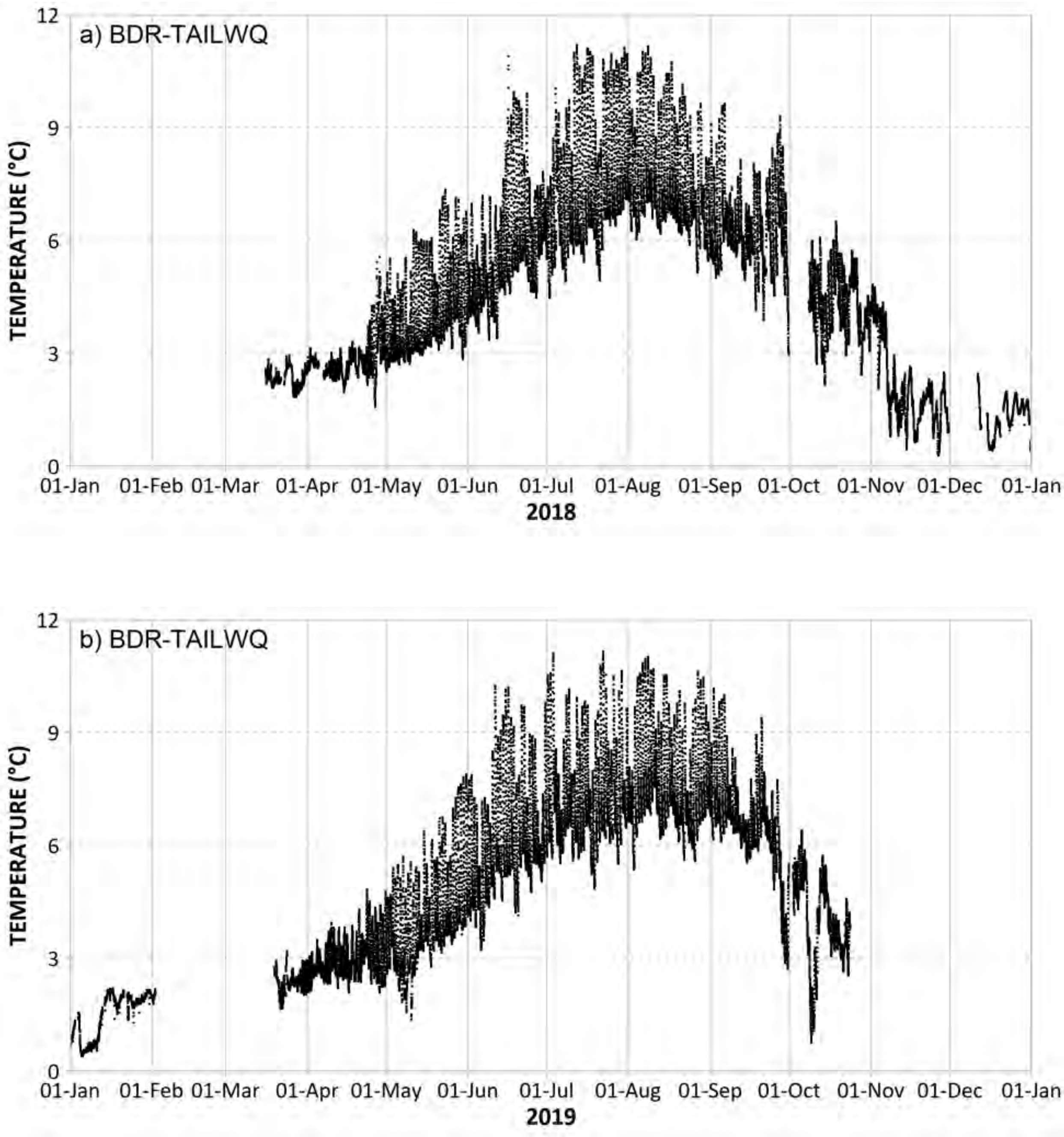

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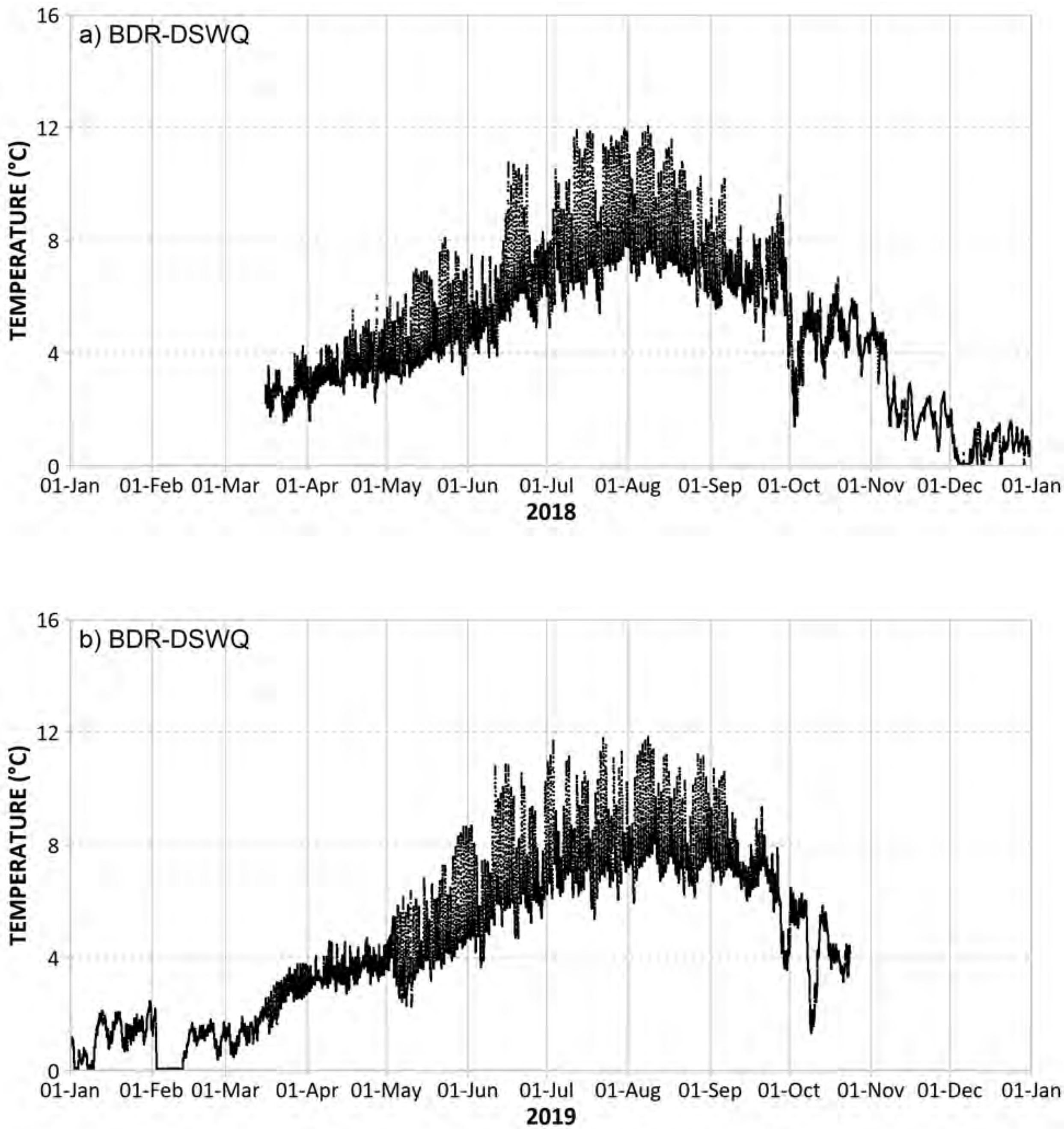
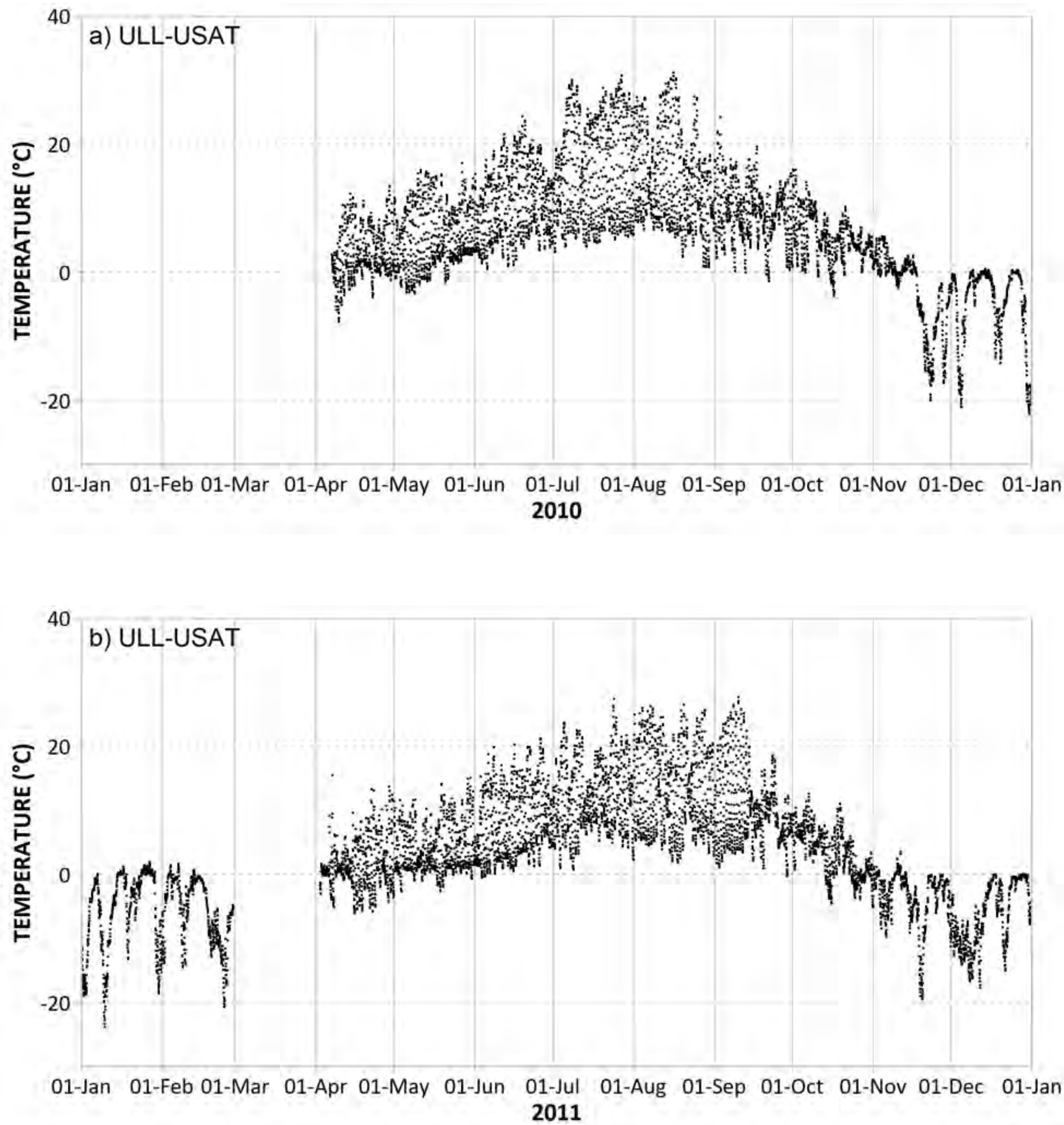
Figure 12. Operational water temperature at BDR-DSWQ from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.



3. AIR TEMPERATURE DATA

3.1. Upper Lillooet River

Figure 13. Baseline air temperature at ULL-USAT from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.



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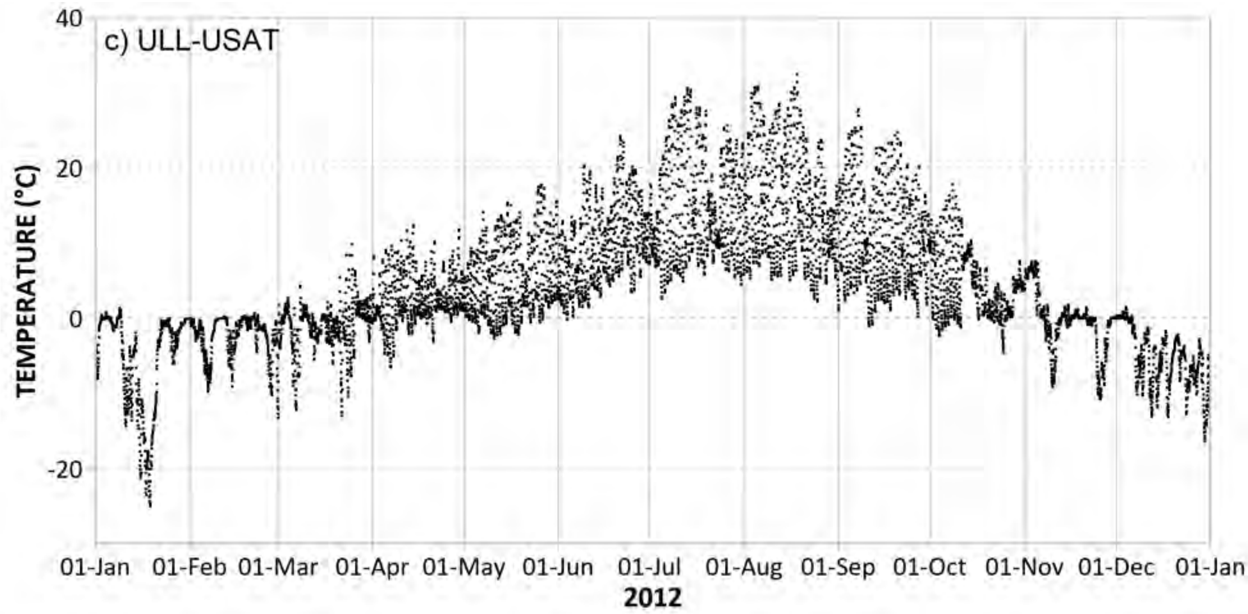


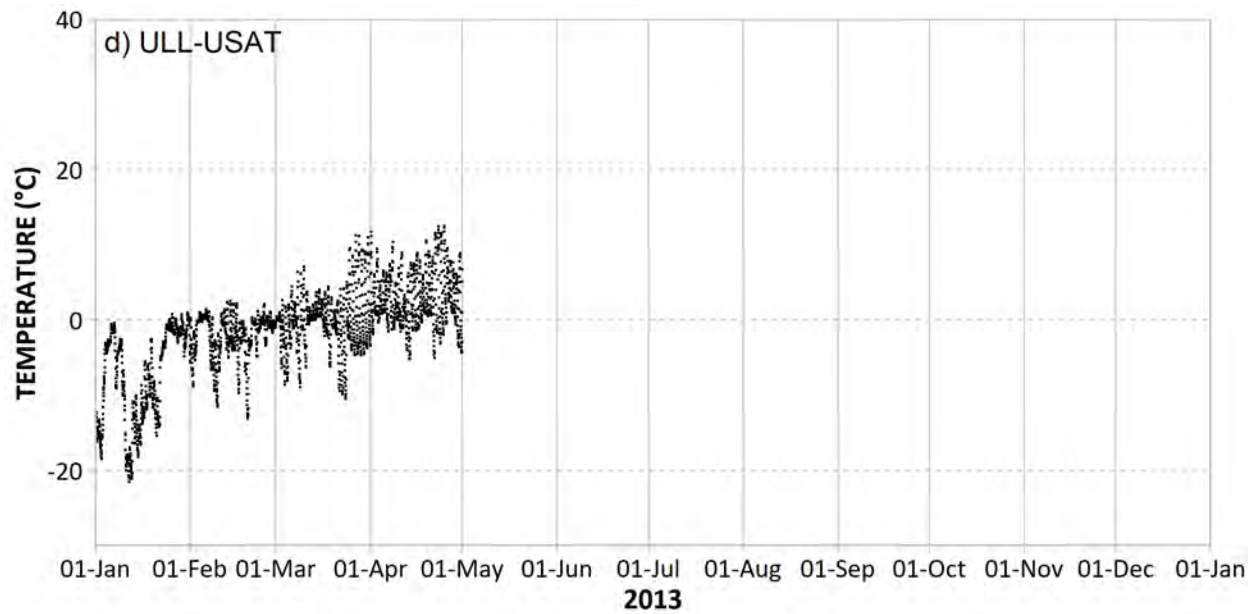
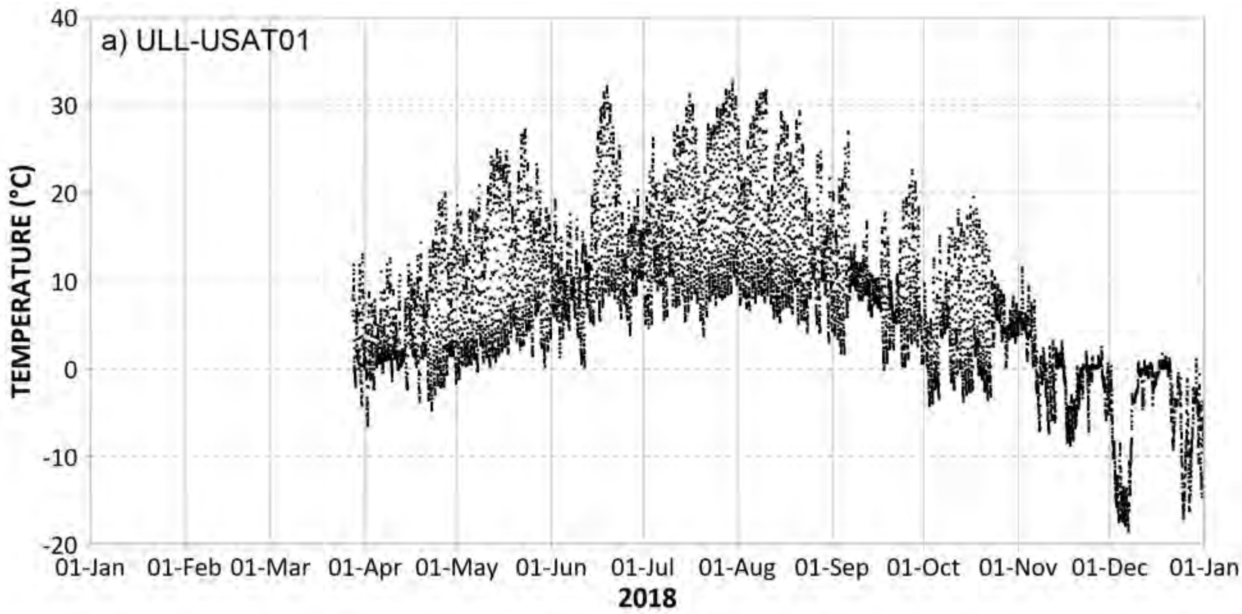


Figure 14. Operational air temperature at ULL-USAT from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.



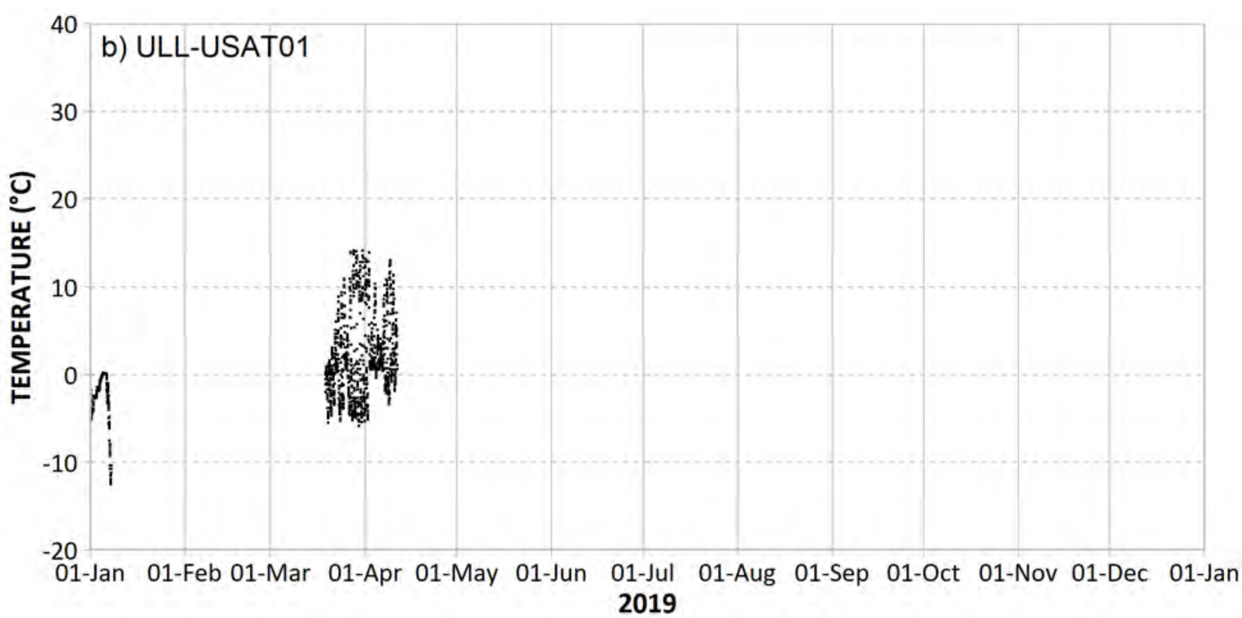
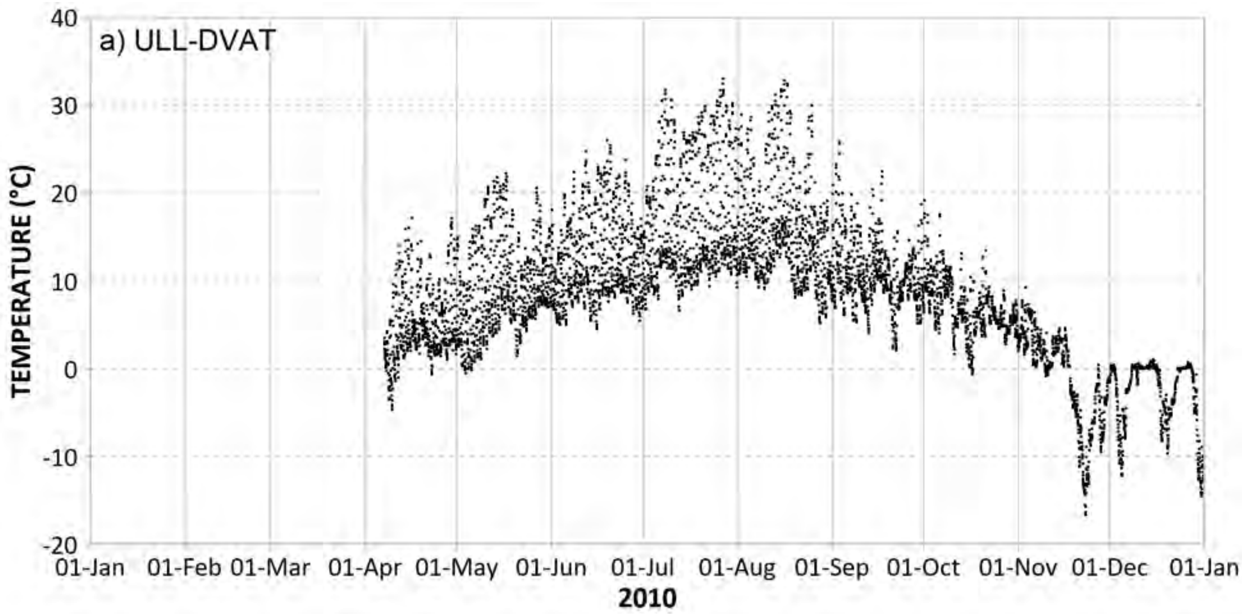
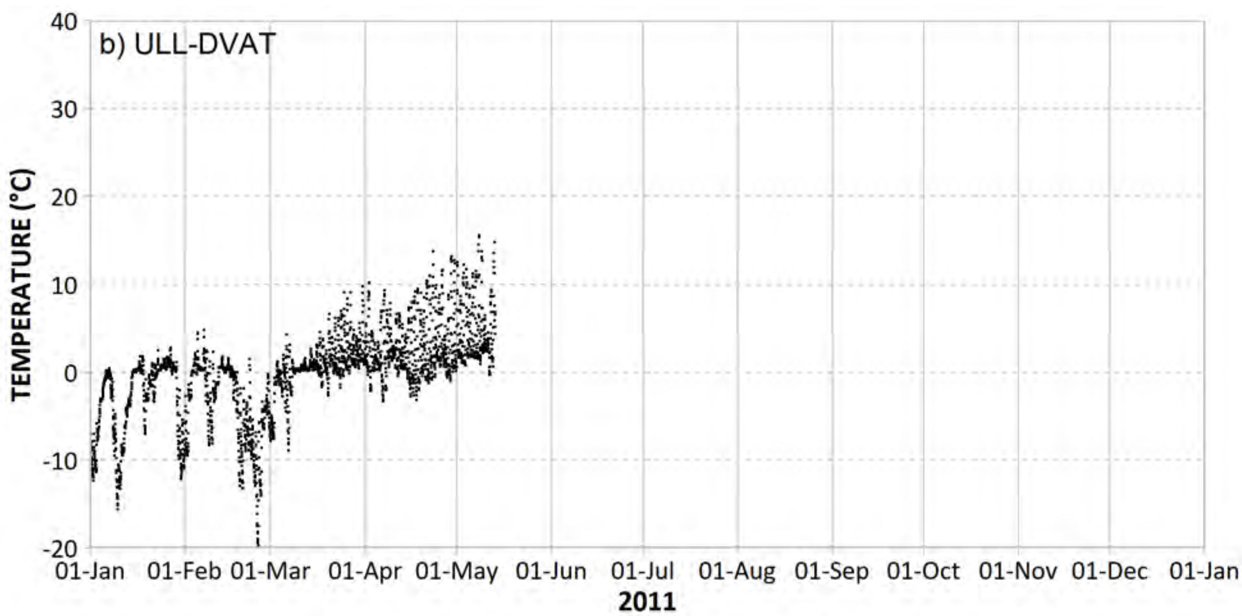


Figure 15. Baseline air temperature at ULL-DVAT from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.





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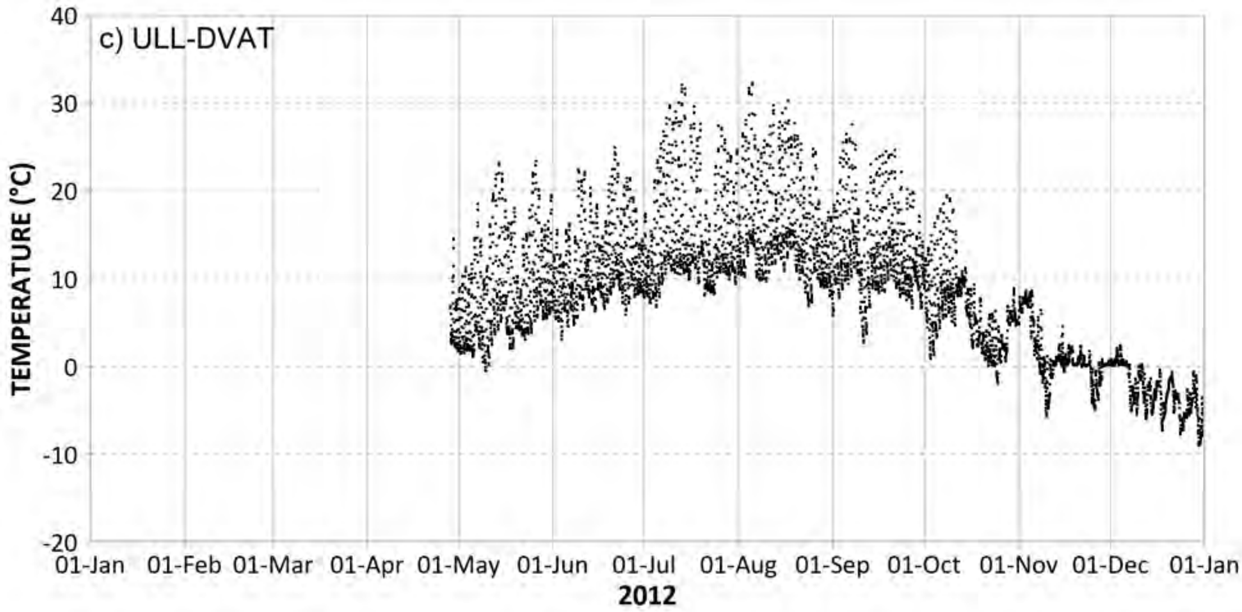


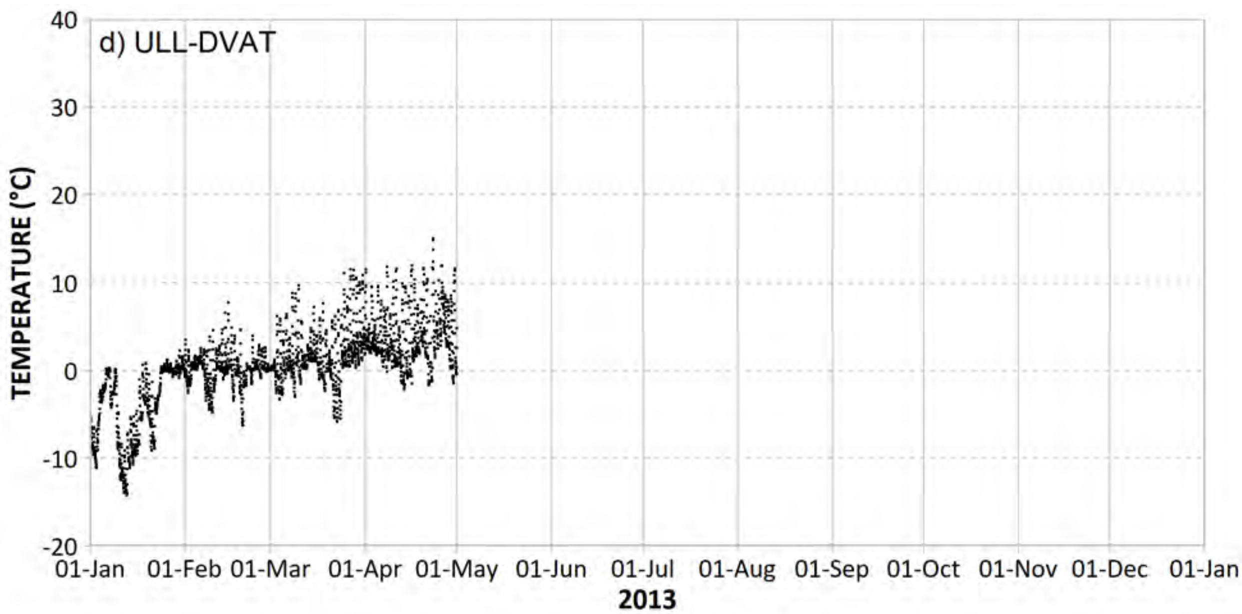
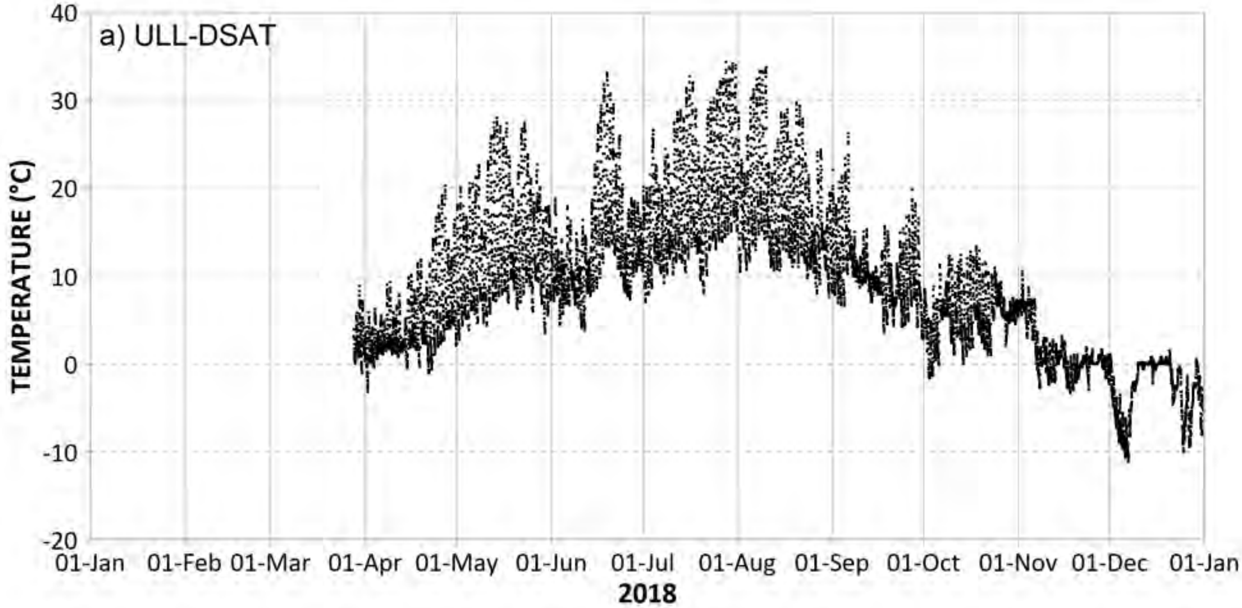
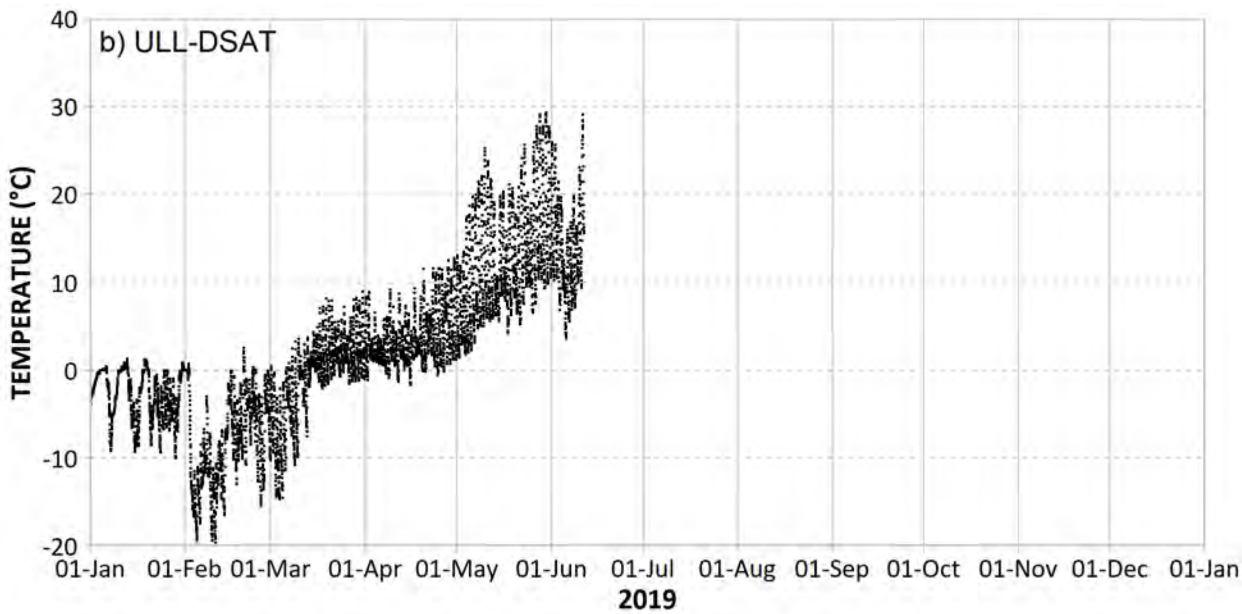


Figure 16. Operational air temperature at ULL-DSAT from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.





3.2. Boulder Creek

4. MONTHLY STATISTICS – BASELINE CONDITIONS

4.1. Upper Lillooet River

Table 2. Baseline monthly summary statistics at the upstream (ULL-USWQ1) and diversion (ULL-DVWQ) sites in the Upper Lillooet River from 2008 to 2013.

Year	Month	Water Temperature[1] (°C)							
		ULL-USWQ1				ULL-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2008	Dec	0.7	0.0	2.8	0.6	-	-	-	-
2009	Jan	0.7	0.0	1.6	0.3	-	-	-	-
	Feb	0.9	0.0	3.0	0.6	-	-	-	-
	Mar	1.6	0.0	6.2	1.2	-	-	-	-
	Apr	3.4	0.5	8.1	1.8	-	-	-	-
	May	4.7	1.1	10.1	2.0	-	-	-	-
	Jun	6.2	3.6	10.5	1.7	-	-	-	-
	Jul	7.3	4.1	11.8	1.8	-	-	-	-
	Aug	6.4	3.9	9.9	1.5	-	-	-	-
	Sep	5.6	2.4	9.4	1.3	-	-	-	-
	Oct	3.6	0.6	6.9	1.4	-	-	-	-
	Nov	1.2	0.0	4.0	1.0	-	-	-	-
	Dec	0.4	0.0	1.2	0.3	-	-	-	-
2010	Jan	1.0	0.0	2.8	0.5	-	-	-	-
	Feb	1.8	0.0	4.1	0.7	-	-	-	-
	Mar	2.4	0.0	6.5	1.2	-	-	-	-
	Apr	3.2	0.3	8.0	1.6	-	-	-	-
	May	4.0	0.9	8.5	1.6	-	-	-	-
	Jun	4.9	2.8	8.9	1.4	-	-	-	-
	Jul	6.4	3.7	10.1	1.7	-	-	-	-
	Aug	6.4	3.7	10.1	1.5	-	-	-	-
	Sep	5.7	2.8	9.9	1.2	-	-	-	-
	Oct	4.5	1.7	7.4	1.0	-	-	-	-
	Nov	1.6	0.0	4.6	1.3	-	-	-	-
	Dec	0.7	0.0	1.8	0.4	1.2	0.0	2.4	0.6

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

Table 2. Continued.

Year	Month	Water Temperature[1] (°C)							
		ULL-USWQ1				ULL-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2011	Jan	0.9	0.0	2.5	0.6	1.3	0.0	3.1	0.9
	Feb	0.8	0.0	2.7	0.6	1.2	0.0	3.3	0.8
	Mar	1.9	0.0	5.7	1.2	-	-	-	-
	Apr	3.2	0.8	7.4	1.6	-	-	-	-
	May	3.1	1.1	7.3	1.2	-	-	-	-
	Jun	4.4	2.2	8.5	1.3	-	-	-	-
	Jul	5.8	3.3	10.0	1.4	-	-	-	-
	Aug	6.8	4.0	10.4	1.6	-	-	-	-
	Sep	6.4	3.9	10.1	1.4	-	-	-	-
	Oct	4.6	0.0	8.5	1.5	-	-	-	-
	Nov	0.9	0.0	3.5	0.7	-	-	-	-
	Dec	0.7	0.0	1.7	0.4	1.1	0.1	2.2	0.5
2012	Jan	0.6	0.0	2.2	0.5	1.1	0.0	2.8	0.7
	Feb	1.4	0.0	3.7	0.7	2.1	0.0	4.0	0.8
	Mar	1.8	0.0	5.7	1.2	2.5	0.1	5.1	1.1
	Apr	2.8	0.5	6.9	1.4	3.4	1.3	7.0	1.3
	May	3.7	1.5	7.7	1.5	4.3	1.9	8.5	1.7
	Jun	4.8	2.6	9.0	1.4	5.4	2.9	9.9	1.5
	Jul	6.2	3.5	10.0	1.6	6.6	3.9	10.4	1.6
	Aug	6.7	4.0	10.7	1.6	6.9	4.2	10.7	1.5
	Sep	6.0	2.7	9.9	1.6	6.2	3.1	9.9	1.5
	Oct	3.9	0.8	7.4	1.3	4.3	1.4	7.7	1.2
	Nov	1.8	0.0	5.6	1.4	2.3	0.0	5.9	1.4
	Dec	0.6	0.0	1.9	0.4	1.1	0.1	2.5	0.5
2013	Jan	0.6	0.0	1.7	0.5	1.0	0.0	2.5	0.7
	Feb	1.4	0.0	3.3	0.8	2.1	0.3	3.6	0.6
	Mar	2.1	0.0	7.0	1.5	2.8	0.4	6.2	1.2
	Apr	3.4	0.0	8.2	1.8	3.9	1.0	8.0	1.5
	May	4.4	1.1	9.5	1.8	-	-	-	-

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

4.2. Boulder Creek

Table 3. Baseline monthly summary statistics at the upstream (BDR-USWQ) and diversion (BDR-DVWQ) sites in the Boulder Creek from 2008 to 2013.

Year	Month	Water Temperature[1] (°C)							
		BDR-USWQ				BDR-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2008	Dec	-	-	-	-	0.8	0.0	3.5	0.9
2009	Jan	-	-	-	-	1.1	0.0	2.0	0.6
	Feb	-	-	-	-	1.2	0.0	2.2	0.6
	Mar	-	-	-	-	1.1	0.0	2.3	0.6
	Apr	-	-	-	-	2.6	1.4	4.8	0.6
	May	-	-	-	-	4.1	2.4	8.5	1.1
	Jun	-	-	-	-	6.2	3.6	10.0	1.4
	Jul	-	-	-	-	7.9	4.6	11.4	1.6
	Aug	-	-	-	-	7.5	5.2	10.7	1.2
	Sep	-	-	-	-	6.7	3.3	10.0	1.2
	Oct	-	-	-	-	3.7	0.6	6.4	1.4
	Nov	-	-	-	-	1.6	0.0	4.0	0.9
	Dec	-	-	-	-	0.5	0.0	1.8	0.5
2010	Jan	-	-	-	-	1.4	0.0	2.7	0.6
	Feb	-	-	-	-	2.1	0.9	3.2	0.4
	Mar	-	-	-	-	2.3	0.0	4.2	0.8
	Apr	-	-	-	-	3.2	0.5	5.9	0.9
	May	2.8	0.8	5.6	0.9	4.2	1.8	7.1	1.0
	Jun	3.6	2.1	7.4	1.1	5.1	3.4	8.9	1.1
	Jul	5.5	2.9	9.4	1.6	7.0	4.3	11.0	1.6
	Aug	6.0	3.1	9.7	1.4	7.5	4.6	11.1	1.4
	Sep	5.2	2.2	9.2	1.2	6.7	3.5	10.7	1.2
	Oct	4.7	2.8	6.8	0.6	4.7	2.1	7.2	1.0
	Nov	2.0	0.0	4.3	1.4	1.8	0.0	4.8	1.5
	Dec	1.4	0.0	2.3	0.5	1.1	0.0	2.0	0.6

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

Table 3. Continued.

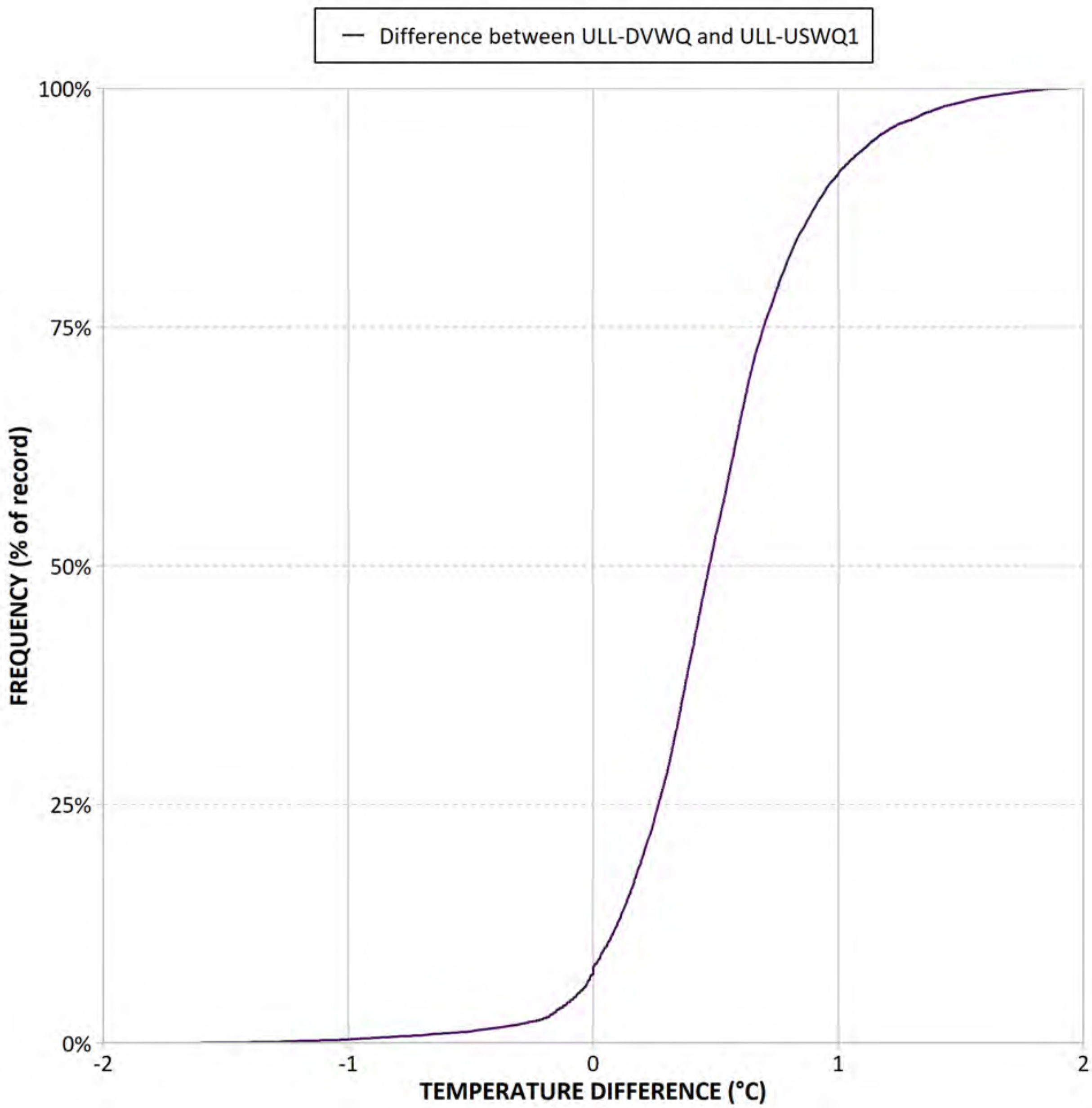
Year	Month	Water Temperature[1] (°C)							
		BDR-USWQ				BDR-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2011	Jan	1.4	0.0	2.7	0.7	0.8	0.0	2.4	0.8
	Feb	1.2	0.0	2.5	0.6	0.7	0.0	2.3	0.7
	Mar	2.0	0.1	3.7	0.5	1.7	0.0	3.2	0.6
	Apr	2.5	1.2	4.9	0.7	2.6	1.5	4.5	0.5
	May	2.7	1.3	5.2	0.7	3.3	2.4	6.1	0.6
	Jun	2.9	1.2	3.9	0.5	4.1	2.3	6.9	0.7
	Jul	4.1	2.2	7.6	1.0	5.5	3.3	9.0	1.1
	Aug	5.4	3.0	8.8	1.2	6.8	4.1	10.0	1.3
	Sep	5.2	3.0	8.4	1.1	6.6	3.9	10.1	1.3
	Oct	3.6	0.2	6.0	1.2	4.2	0.7	7.1	1.5
	Nov	0.9	0.0	2.5	0.6	0.8	0.0	2.5	0.7
	Dec	1.2	0.0	2.3	0.5	0.9	0.0	2.0	0.5
2012	Jan	1.0	0.0	2.3	0.7	0.6	0.0	1.7	0.5
	Feb	1.7	0.0	2.9	0.6	1.5	0.0	2.3	0.5
	Mar	1.7	0.0	3.4	0.7	1.5	0.0	2.6	0.5
	Apr	2.7	0.9	5.0	0.7	2.6	1.4	4.4	0.5
	May	3.0	0.7	4.7	0.9	3.7	2.3	6.2	0.7
	Jun	2.9	0.4	5.1	0.7	4.3	2.2	6.7	0.8
	Jul	4.7	1.2	8.4	1.3	6.3	3.2	9.8	1.4
	Aug	6.0	3.8	9.5	1.4	7.6	5.3	10.7	1.3
	Sep	5.9	2.6	9.2	1.3	7.0	3.6	10.2	1.3
	Oct	3.5	0.6	6.7	1.4	4.4	1.3	8.1	1.6
	Nov	1.8	0.1	4.4	1.1	2.3	0.5	5.4	1.3
	Dec	0.9	0.1	2.2	0.4	0.8	0.1	2.2	0.5
2013	Jan	1.0	0.0	2.2	0.6	0.7	0.0	1.9	0.5
	Feb	1.5	0.1	2.6	0.5	1.4	0.3	2.1	0.4
	Mar	1.6	0.1	3.4	0.6	1.7	0.2	3.5	0.7
	Apr	2.6	0.9	5.4	0.7	3.2	1.7	5.4	0.6
	May	-	-	-	-	4.5	1.8	7.3	1.1

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Blue shading indicates minimum temperatures and red shading indicates maximum temperatures within each Project phase.

5. INTER-STATION COMPARISON – BASELINE CONDITIONS

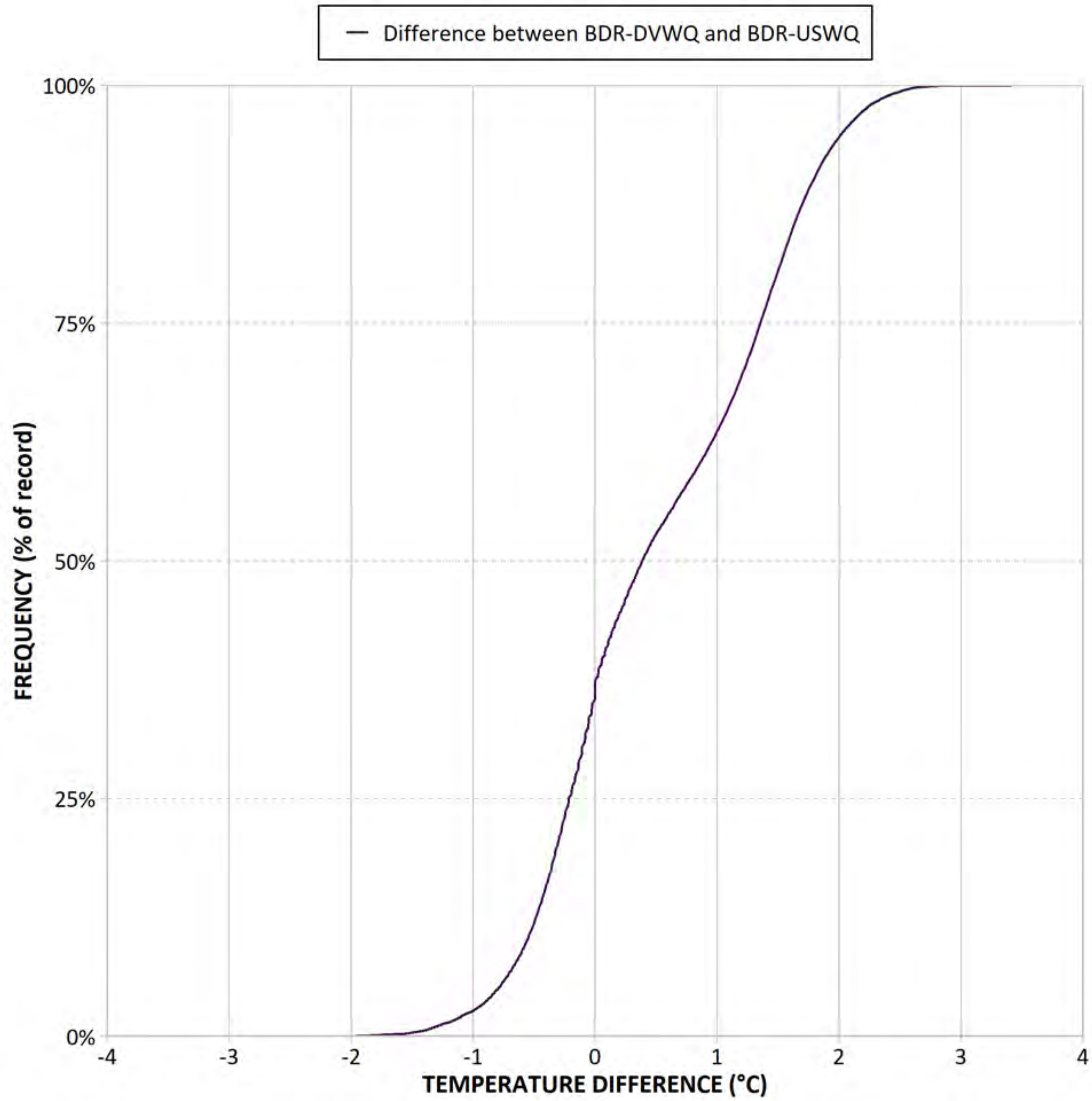
5.1. Upper Lillooet River

Figure 17. Cumulative frequency distribution of differences in baseline instantaneous water temperature between the diversion (ULL-DVWQ) and upstream control (ULL-USWQ1) site in the Upper Lillooet River.



5.2. Boulder Creek

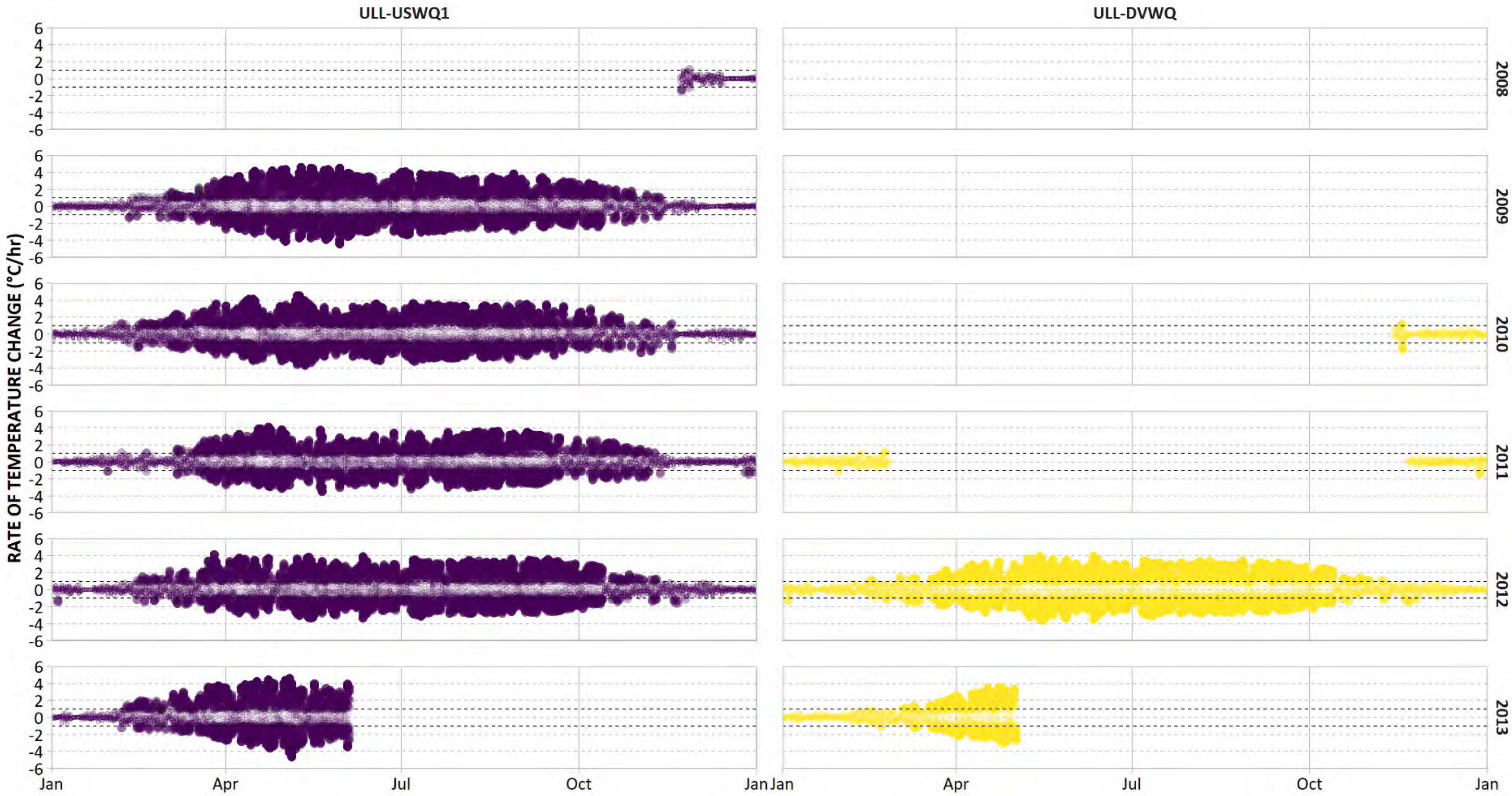
Figure 18. Cumulative frequency distribution of differences in baseline instantaneous water temperature between the diversion (BDR-DVWQ) and upstream control (BDR-USWQ) site in Boulder Creek. Note that BDR-USWQ is influenced by localized groundwater inflow during late fall and winter months.



6. HOURLY RATE OF WATER TEMPERATURE CHANGE

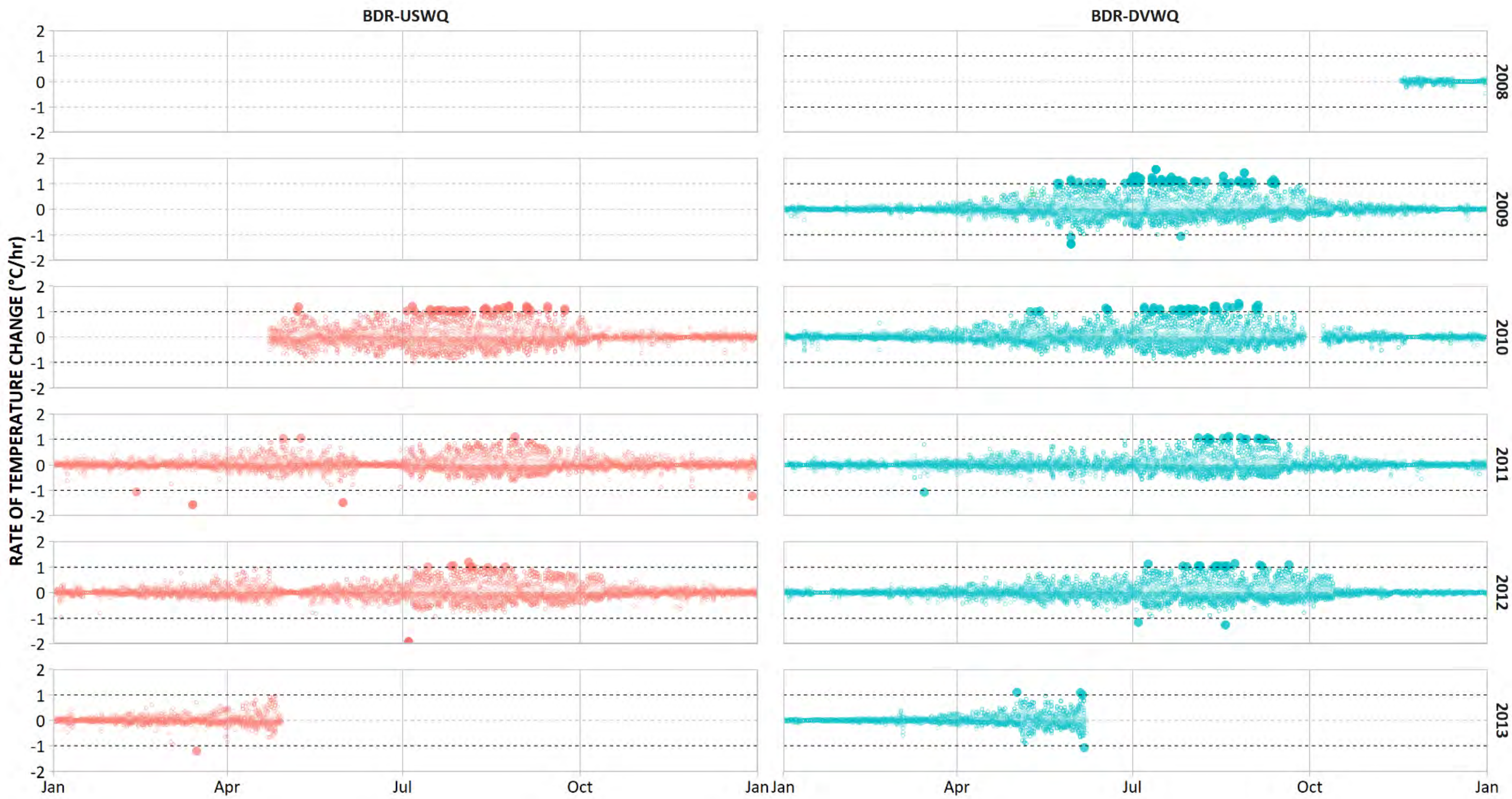
6.1. Upper Lillooet River

Figure 19. Baseline hourly rate of change in water temperature at the upstream (ULL-USWQ1) and diversion (ULL-DVWQ) water temperature monitoring sites from 2008 to 2013.



6.1. Boulder Creek

Figure 20. Baseline hourly rate of change in water temperature at the upstream (BDR-USWQ) and diversion (BDR-DVWQ) water temperature monitoring sites from 2008 to 2013.



REFERENCES

MOE (BC Ministry of Environment and Climate Change). 2019. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture. Available online at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/wqg_summary_aquaticlife_wildlife_agri.pdf. Accessed on April 24, 2019.

Oliver, G.G. and L.E. Fidler. 2001. Towards a water quality guideline for temperature in the Province of British Columbia. Prepared for Ministry of Environment, Lands and Parks, Water Management Branch, Water Quality Section, Victoria, B.C. Prepared by Aspen Applied Sciences Ltd., Cranbrook, B.C., 53 pp + appnds. Available online at: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/wqgs-wqos/approved-wqgs/temperature-or.pdf. Accessed on April 24, 2019.

Appendix G. Water Temperature QA/QC Figures, 2019

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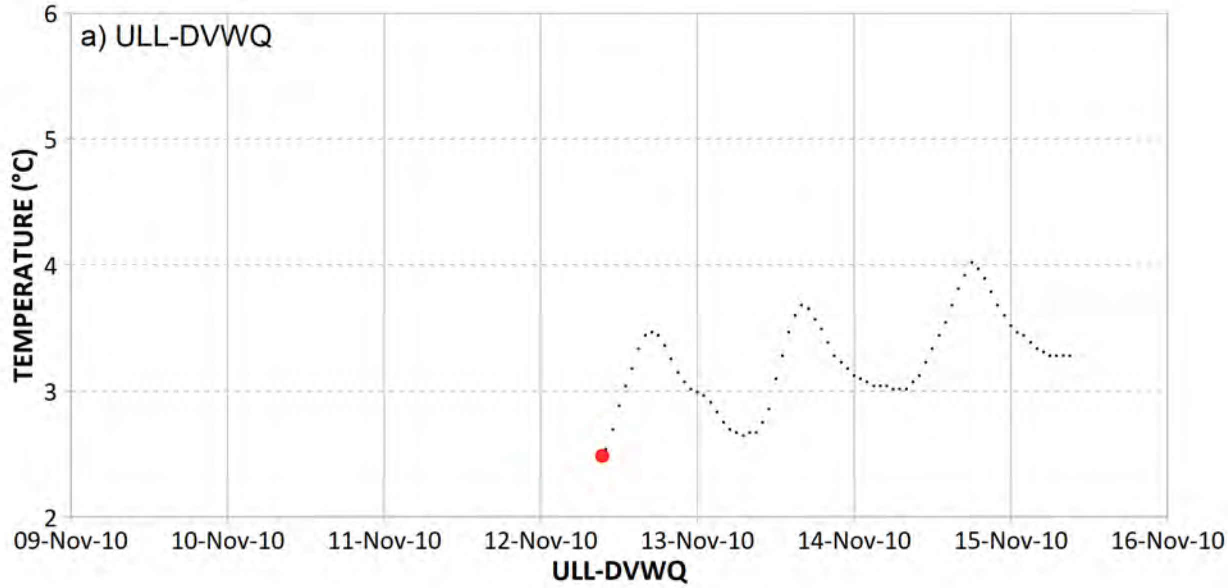
1. QA/QC SPOT TEMPERATURE MEASUREMENTS

1.1. Upper Lillooet River

Figure 1. Spot temperature QA/QC plots for ULL-DVWQ.



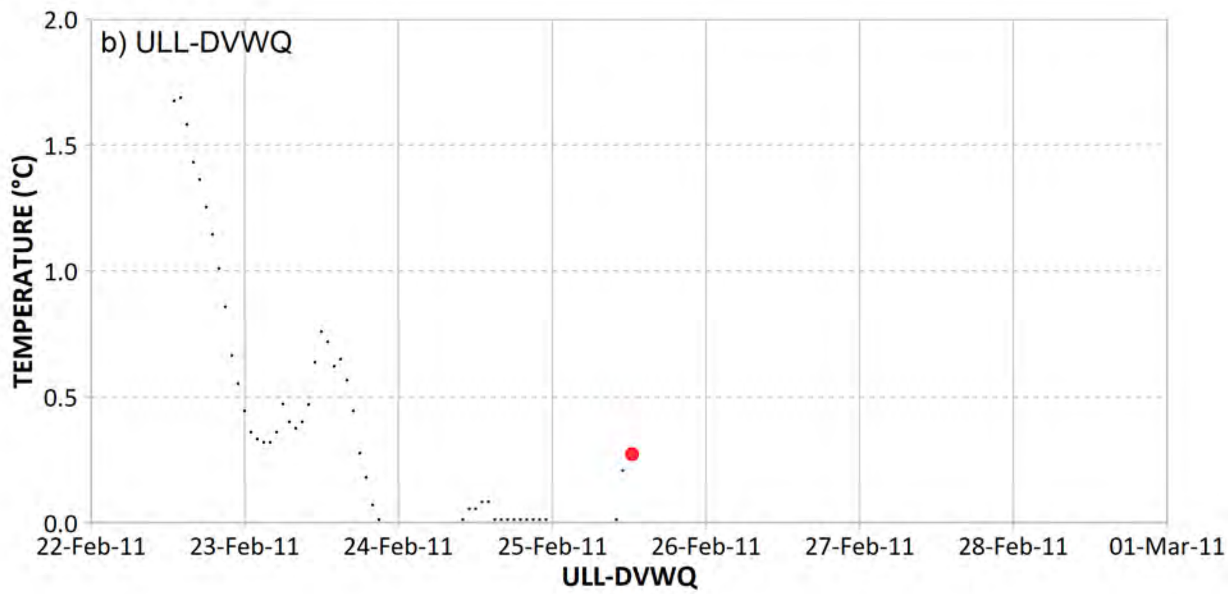
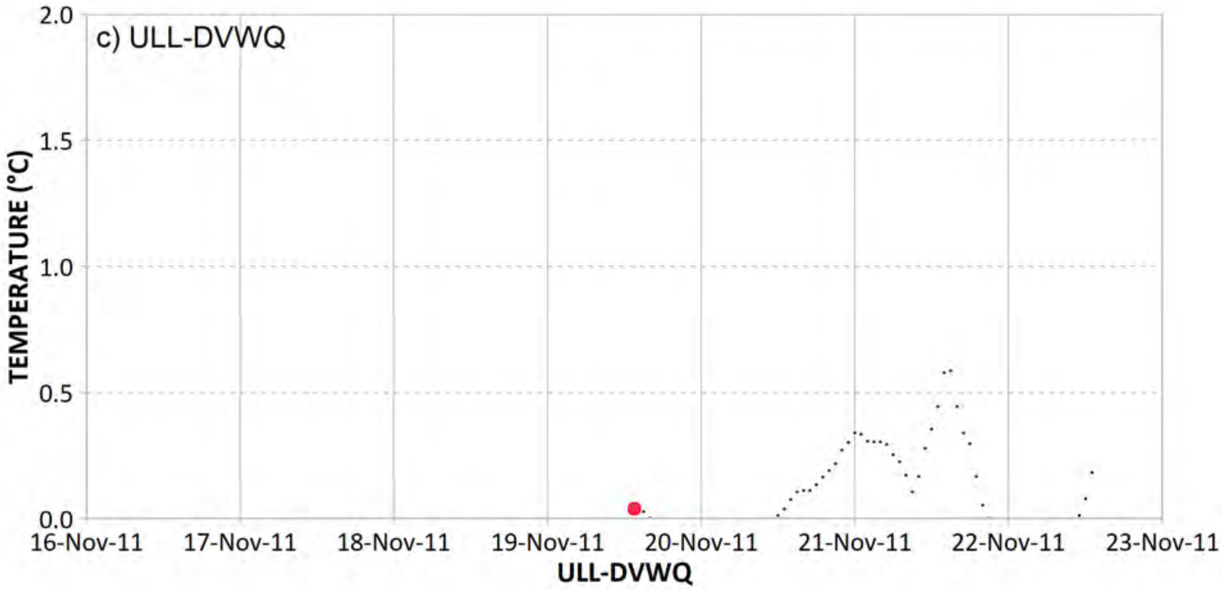


Figure 1. Continued.



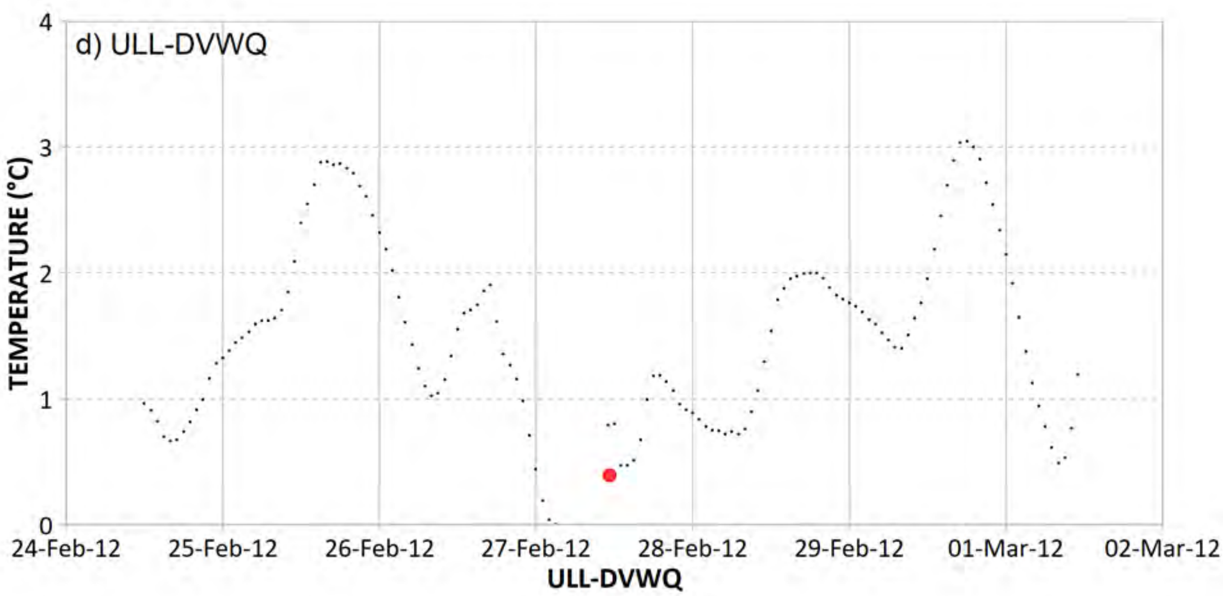


Figure 1. Continued.

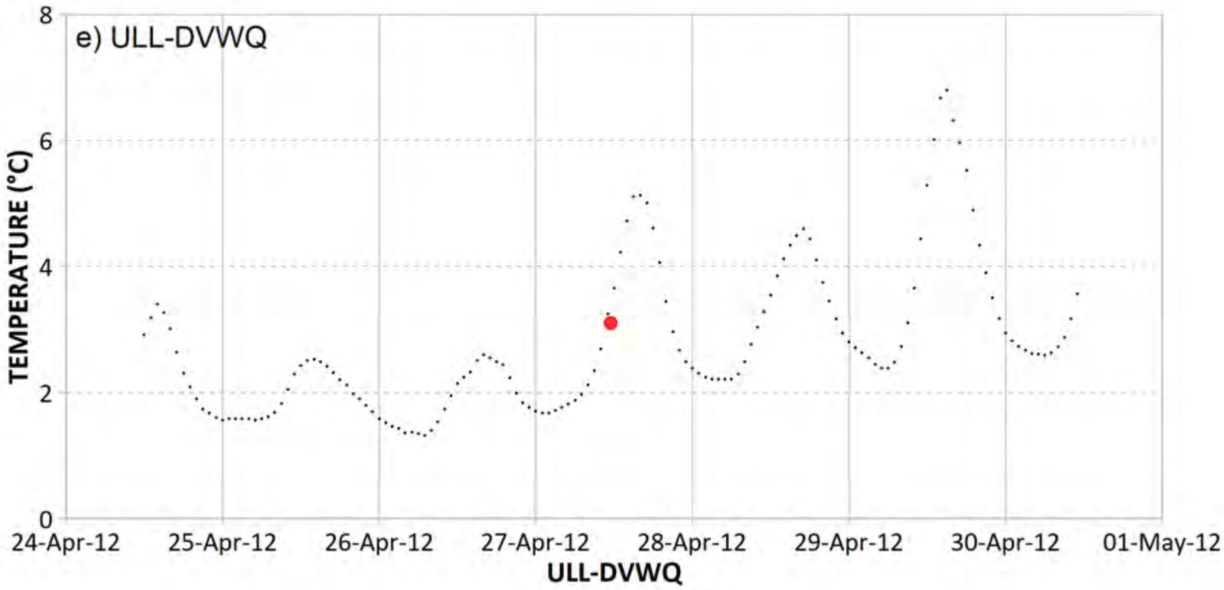


Figure 2. Spot temperature QA/QC plots for ULL-USWQ02 and ULL-USWQ03.

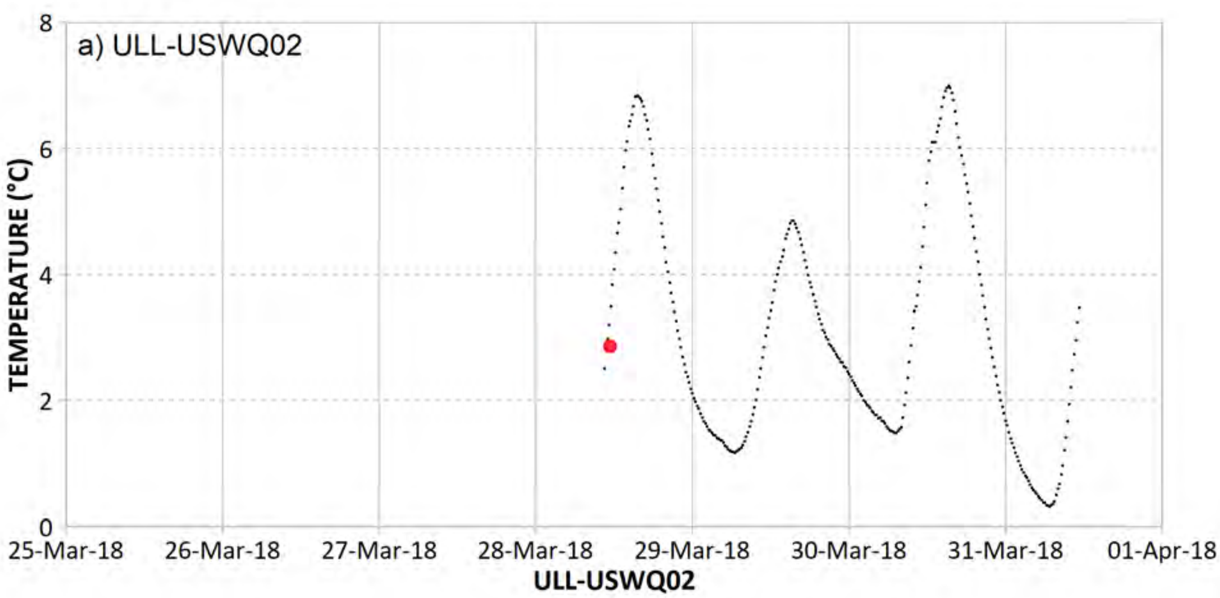


Figure 2. Continued.

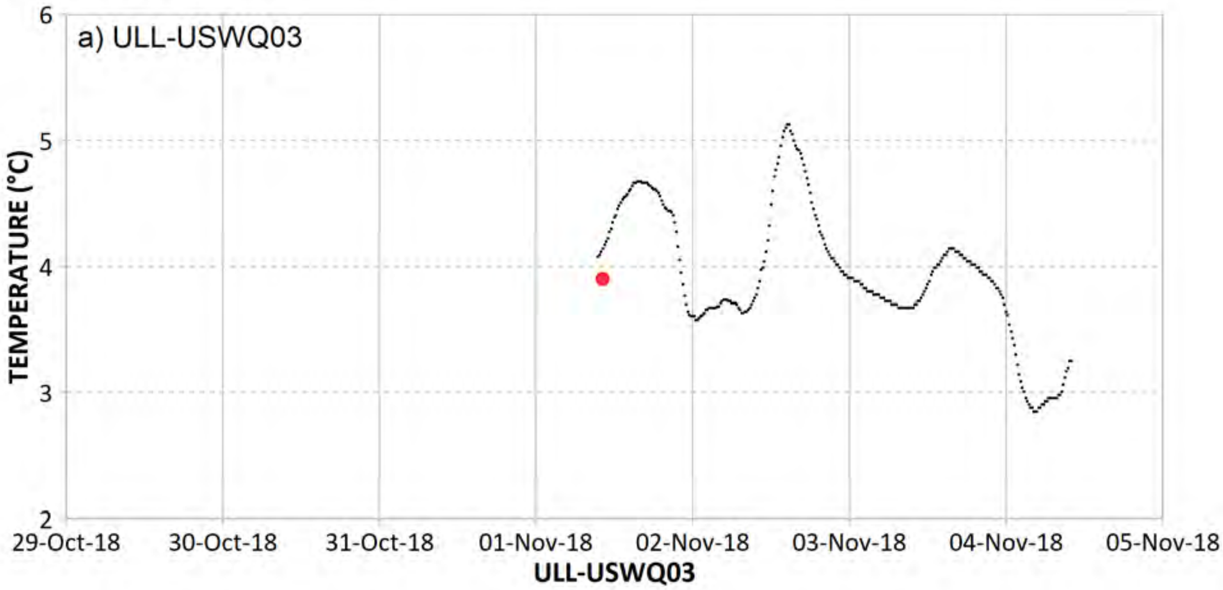
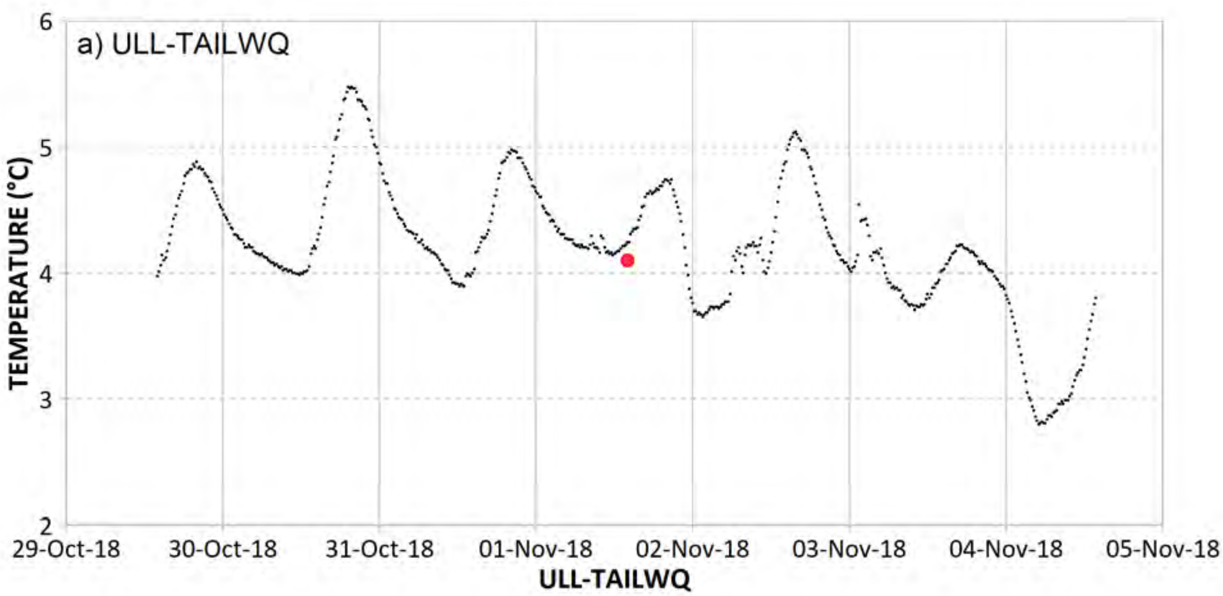
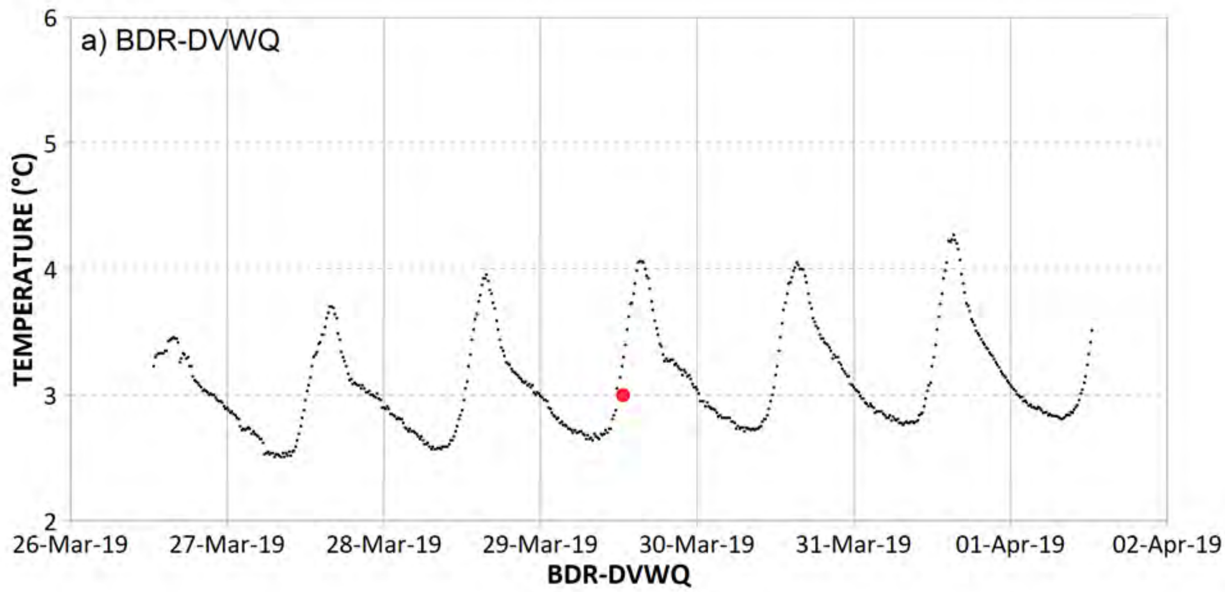


Figure 3. Spot temperature QA/QC plots for ULL-TAILWQ.



1.2. Boulder Creek

Figure 4. Spot temperature QA/QC plots for BDR-DVWQ.



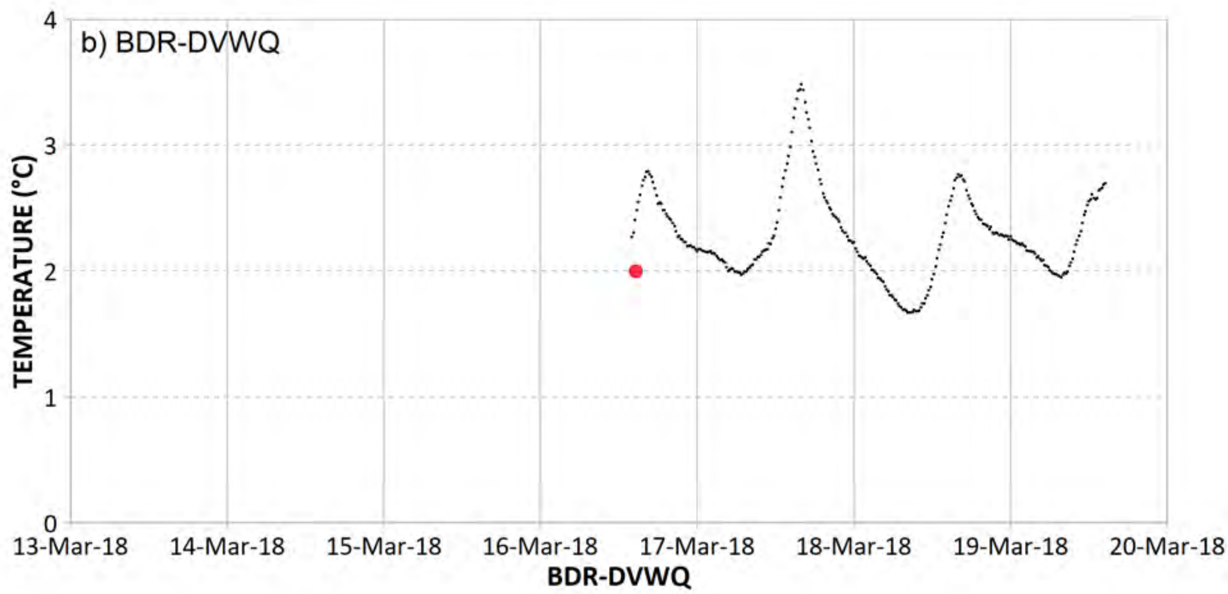


Figure 5. Spot temperature QA/QC plots for BDR-TAILWQ.

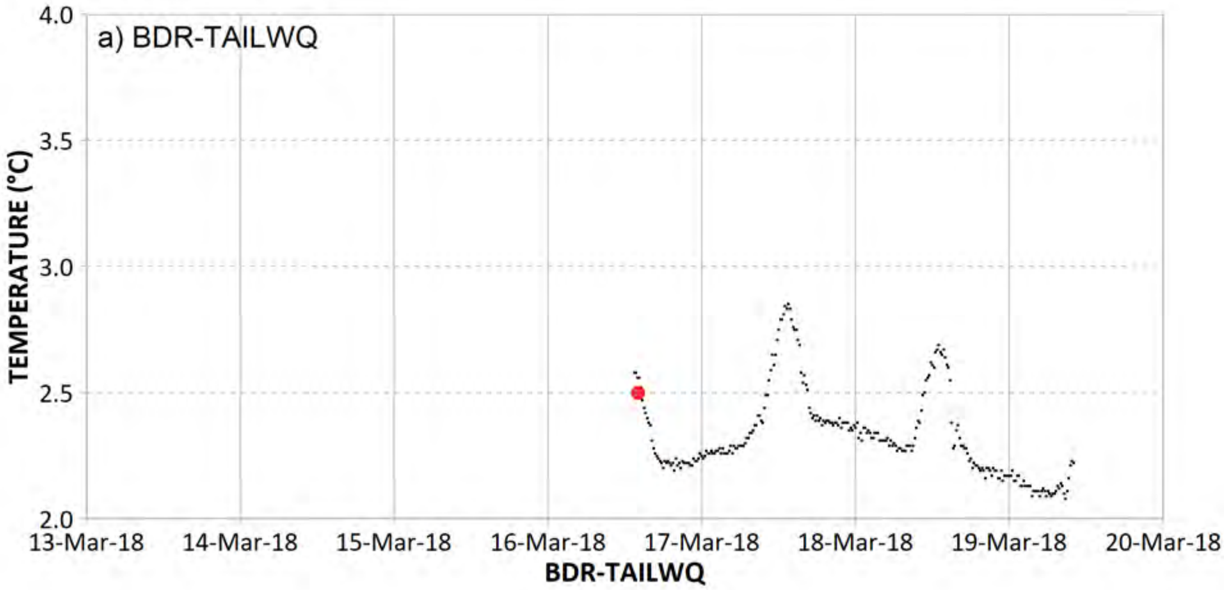
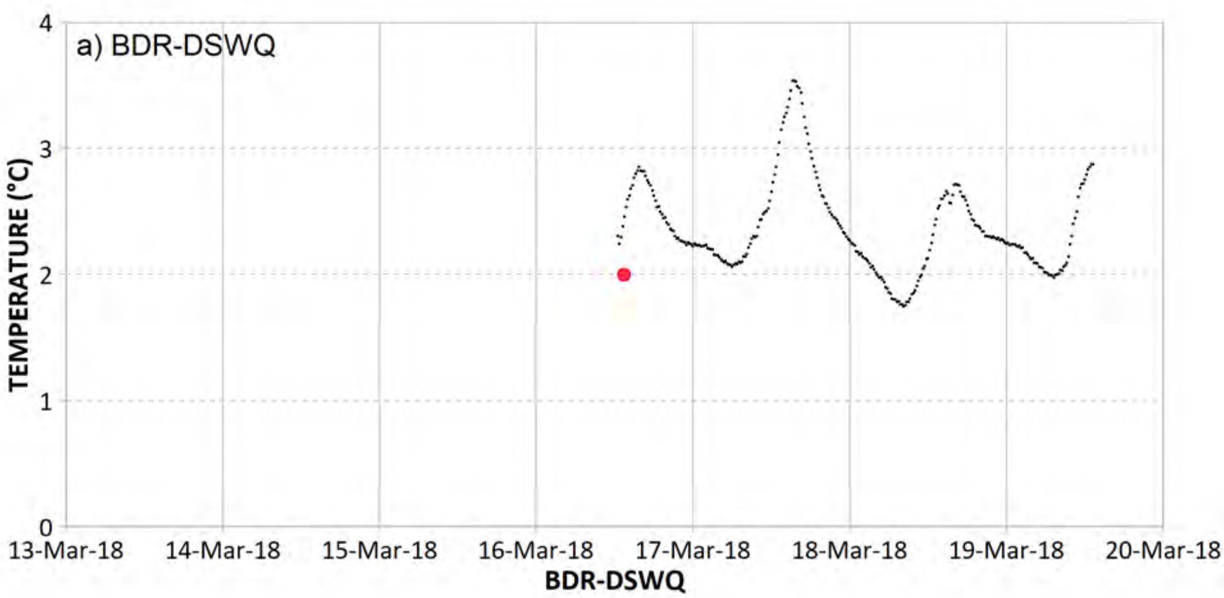


Figure 6. Spot temperature QA/QC plots for BDR-DSWQ.



Appendix H. Habitat Summaries and Representative Photographs of Closed-Site Electrofishing Sites

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Table 1. Summary of habitat, cover, and substrate at closed-site electrofishing sites in the diversion and upstream reaches of the Upper Lillooet River in 2019.

Reach	Site	Habitat	Cover[1]		Substrate (%)[2]						Gradient (%)
			Dom.	Sub. Dom.	BR	BO	CO	LG	SG	F	
Diversion	ULL-DVEF02b	Riffle	BO	CO/DP	0	35	10	5	10	40	2.5
	ULL-DVEF04	Run	BO	CO	5	25	15	2	23	30	1.0
	ULL-DVEF06	Riffle	BO	CO	0	40	10	5	5	40	3.0
	ULL-DVEF07b	Riffle	BO	CO	0	25	5	5	15	50	0.8
	ULL-DVEF09	Riffle	BO	CO	0	10	10	10	50	20	1.5
Upstream	ULL-USEF01	Riffle	BO	CO	0	20	35	5	5	35	1.0
	ULL-USEF02b	Riffle	CO	BO	0	0	45	15	10	30	1.0
	ULL-USEF03	Riffle	CO	None	0	5	40	20	5	30	1.0
	ULL-USEF10	Run	CO	BO/UC	0	25	40	10	5	20	1.0
	ULL-USEF13	Riffle	CO	BO	0	5	40	40	5	10	1.0
	ULL-USEF08	Riffle	CO	BO	0	20	30	20	20	10	0.8
	ULL-USEF16	Riffle	CO	BO	0	5	20	25	25	25	1.0
	ULL-USEF15	Run	BO	CO/LWD	0	40	15	5	5	35	0.5
	ULL-USEF11b	Run	CO	BO/UC	0	15	40	10	5	30	1.0
	ULL-USEF06b	Run	CO	LWD	0	2	8	15	25	50	0.5

[1] Cover Codes: Dom. = Dominant, Sub-Dom. = sub-dominant, BO = boulder, CO = cobble, LWD = Large woody debris.

[2] F = fine (<2 mm), SG = small gravel (2 - 16 mm), LG = large gravel (16 - 64 mm), CO = cobble (64 - 256 mm), BO = boulder (256-4,000 mm), and BR = bedrock (>4,000 mm).

Figure 1. Looking upstream at ULL-DVEF02b on April 13, 2019.

Figure 2. Looking downstream at ULL-DVEF02b on April 13, 2019.

Figure 3. Looking upstream at ULL-DVEF04 on April 13, 2019.

Figure 4. Looking downstream at ULL-DVEF04 on April 13, 2019.

Figure 5. Looking upstream at ULL-DVEF06 on April 13, 2019.

Figure 6. Looking downstream at ULL-DVEF06 on April 13, 2019.

Figure 7. Looking upstream at ULL-DVEF07b on April 13, 2019

Figure 8. Looking downstream at ULL-DVEF07b on April 13, 2019.

Figure 9. Looking upstream at ULL-DVEF09 on April 13, 2019.

Figure 10. Looking downstream at ULL-DVEF09 on April 13, 2019.

Figure 11. Looking upstream at ULL-USEF01 on April 10, 2019.

Figure 12. Looking downstream at ULL-USEF01 on April 10, 2019.

Figure 13. Looking upstream at ULL-USEF02b on April 10, 2019.

Figure 14. Looking downstream at ULL-USEF02b on April 10, 2019.

Figure 15. Looking upstream at ULL-USEF03 on April 10, 2019.

Figure 16. Looking downstream at ULL-USEF03 on April 10, 2019.

Figure 17. Looking upstream at ULL-USEF06B on April 10, 2019.

Figure 18. Looking downstream at ULL-USEF06B on April 10, 2019.

Figure 19. Looking upstream at ULL-USEF08 on April 10, 2019.

Figure 20. Looking downstream at ULL-USEF08 on April 10, 2019.

Figure 21. Looking upstream at ULL-USEF10 on April 11, 2019.

Figure 22. Looking downstream at ULL-USEF10 on April 11, 2019.

Figure 23. Looking upstream at ULL-USEF11B on April 11, 2019.

Figure 24. Looking downstream at ULL-USEF11B on April 11, 2019.

Figure 25. Looking upstream at ULL-USEF13 on April 11, 2019.

Figure 26. Looking downstream at ULL-USEF13 on April 11, 2019.

Figure 27. Looking upstream at ULL-USEF15 on April 11, 2019.

Figure 28. Looking downstream at ULL-USEF15 on April 11, 2019.

Figure 29. Looking upstream at ULL-USEF16 on April 11, 2019.

Figure 30. Looking downstream at ULL-USEF16 on April 11, 2019.

Figure 31. Looking upstream at ULL-HPTB87.0EF01 on October 19, 2019.

Figure 32. Looking downstream at ULL-HPTB87.0EF01 on October 19, 2019.

Figure 33. Looking upstream at ULL-HPTB87.0EF02 on October 19, 2019.

Figure 34. Looking downstream at ULL-HPTB87.0EF02 on October 19, 2019.

Figure 35. Looking upstream at ULL-HPTB87.0EF03 on October 20, 2019.

Figure 36. Looking downstream at ULL-HPTB87.0EF03 on October 20, 2019.

Appendix I. Closed-Site Electrofishing Fish Aging Figures and Individual Fish Data

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Figure 1. **Length-frequency of Bull Trout captured during closed-site electrofishing within the Upper Lillooet River in 2019.**

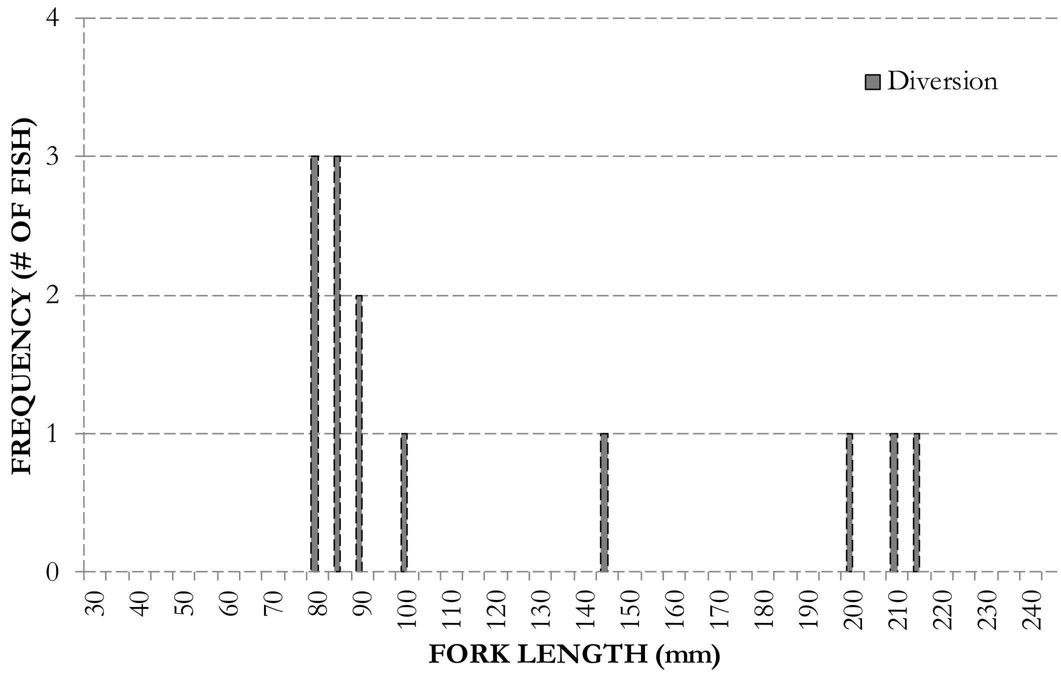

Figure 2. **Length-weight regression of Bull Trout captured during closed-site electrofishing in the Upper Lillooet River in 2019.**

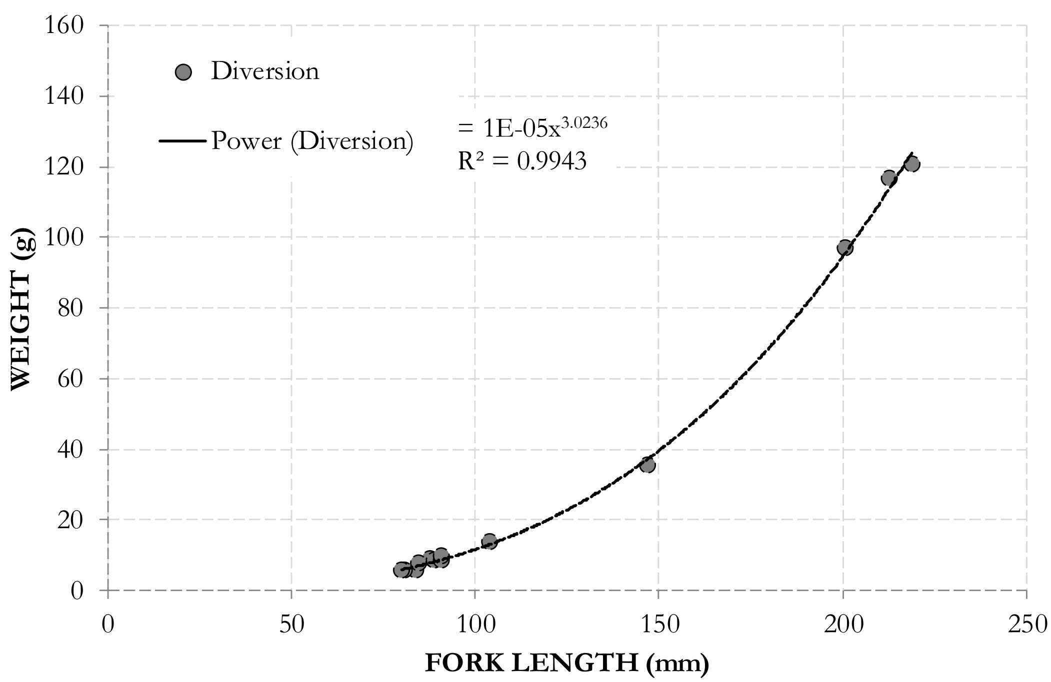

Figure 3. Length-frequency of Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2019.

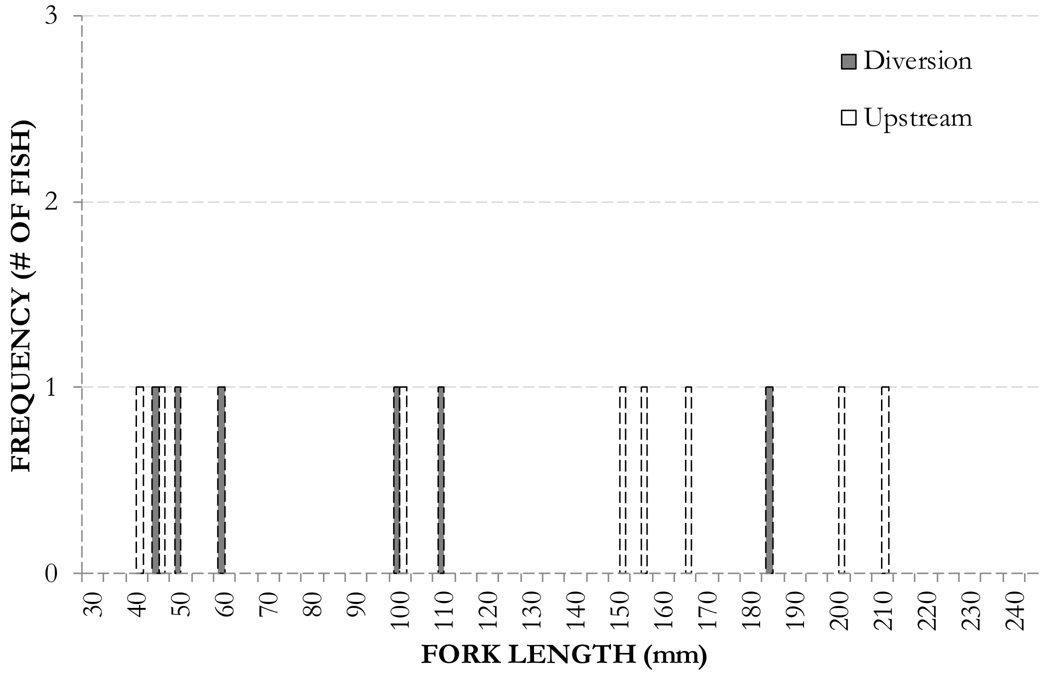

Figure 4. Length-weight regression of Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2019.

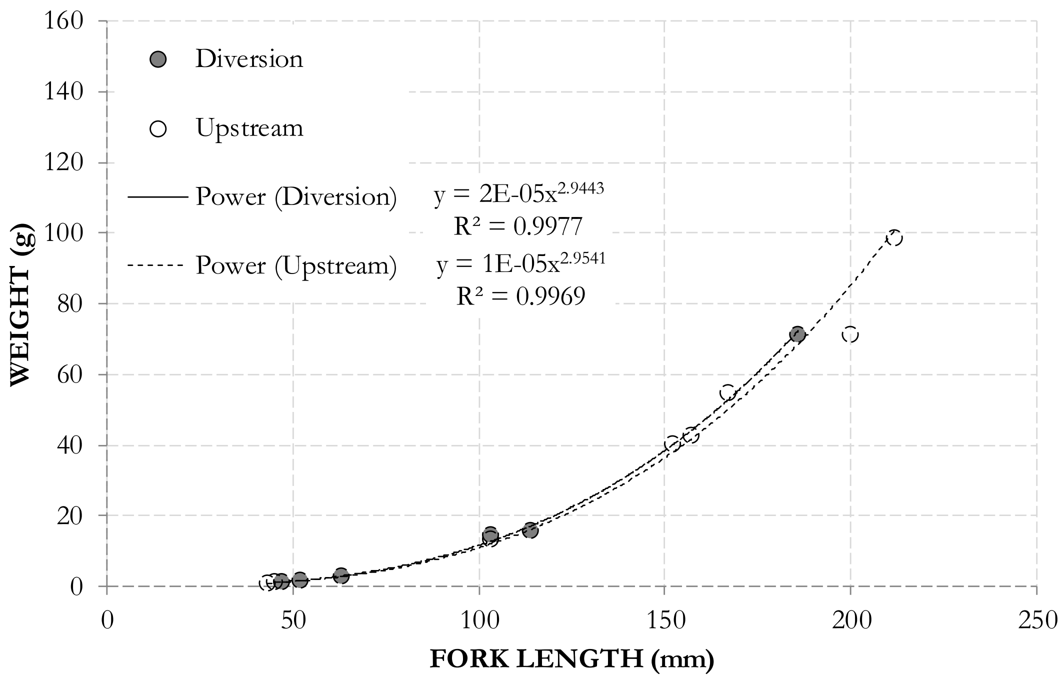

Figure 5. **Length at age relationship for Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2019.**

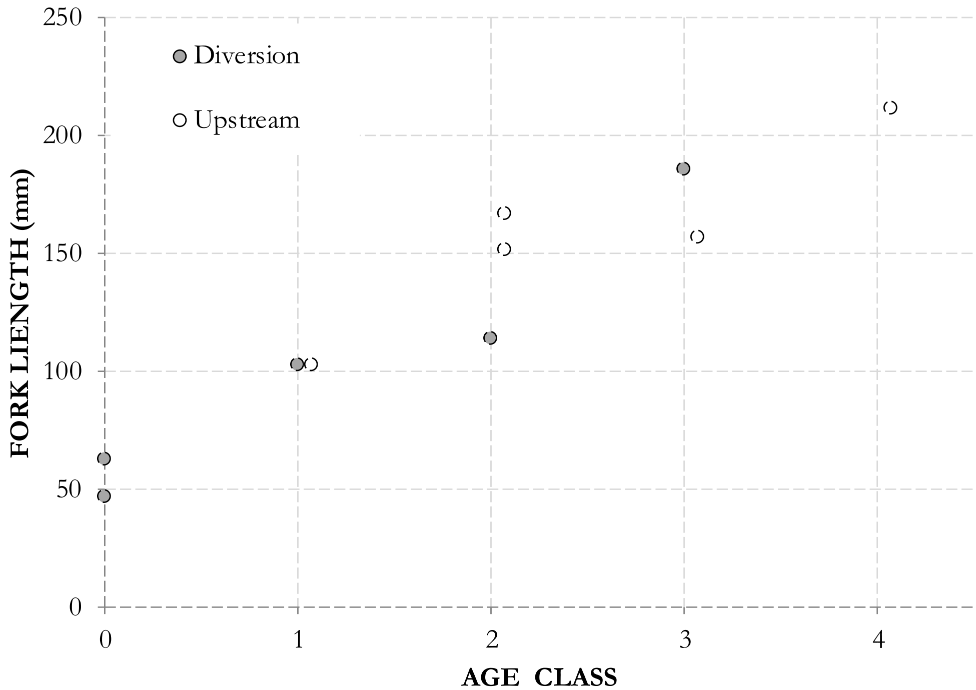

Figure 6. **Length-frequency of Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2019.**

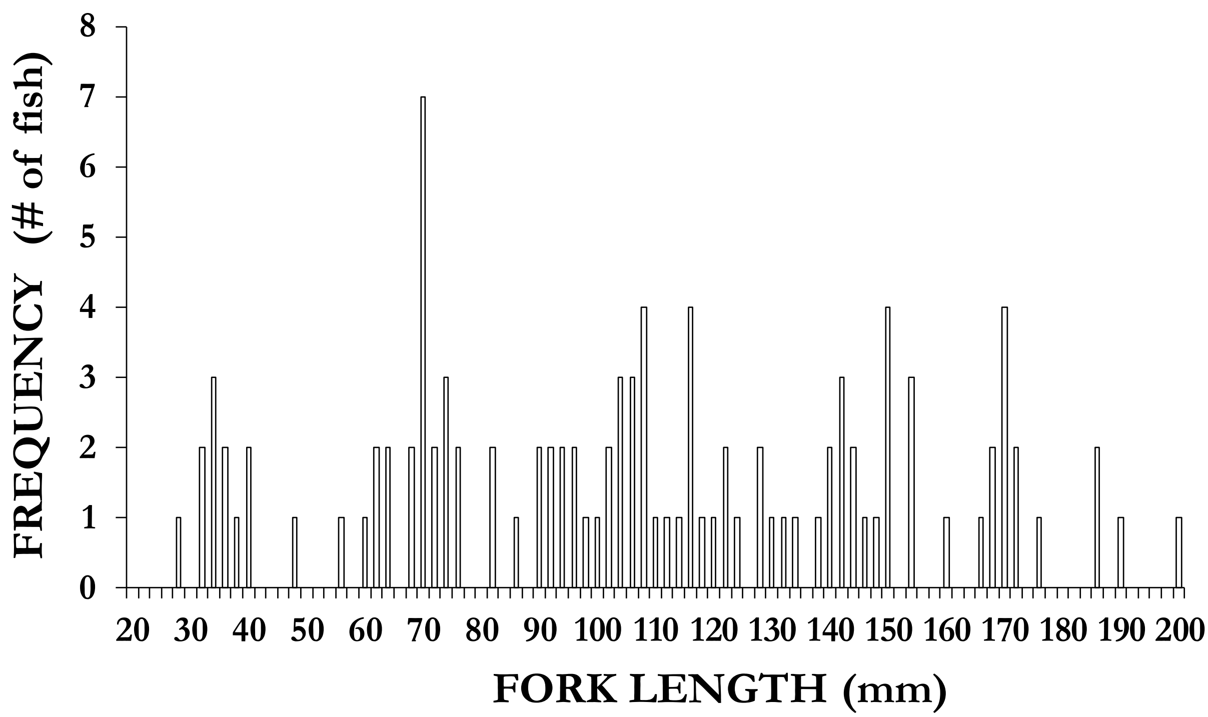

Figure 7. Length-weight regression for Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2019.

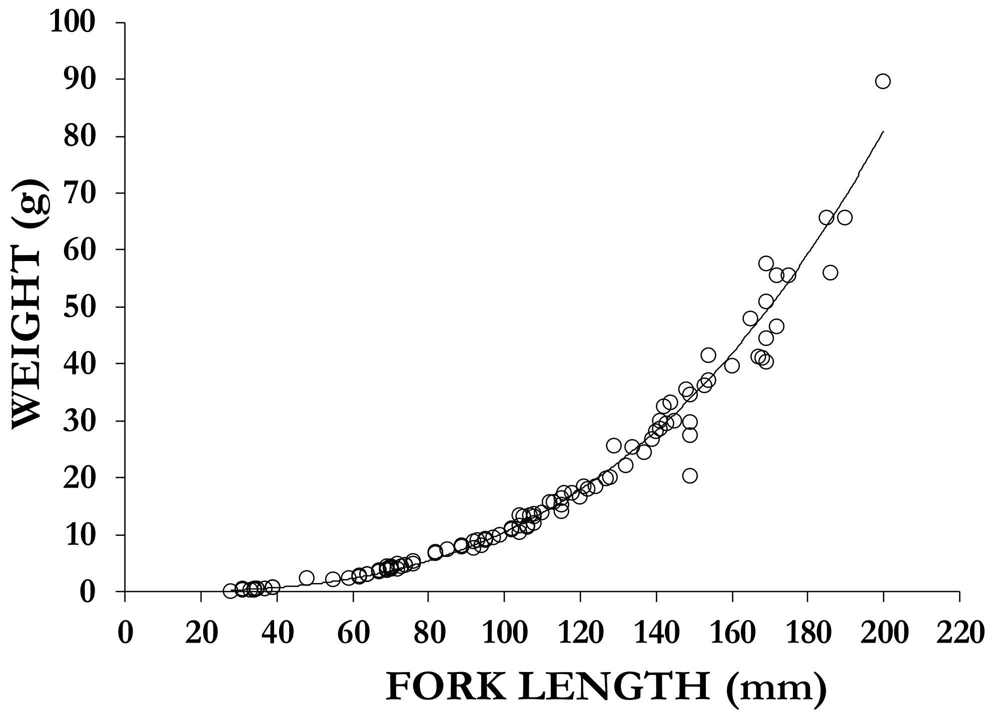

Figure 8. Length at age relationship for Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2019.

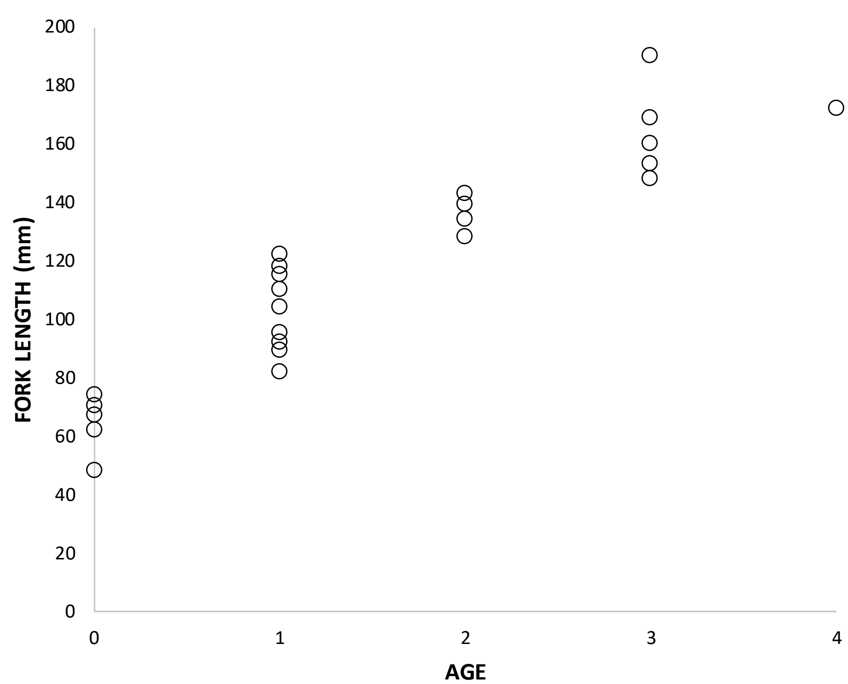

Table 1. Summary of all fish captured during closed-site electrofishing in the Upper Lillooet River in 2019.

Reach	Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	Mean Fat %	PIT Tag #
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	BT	80	5.7	1.11			03		Tag: 9891006335416
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	BT	91	8.5	1.13			05		Tag: 9891006335271
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	BT	91	9.9	1.31			04		Tag: 9891006335268
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	CT	52	1.6	1.14			01		
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	CT	103	4.5	0.41	SC-02	1	02		Tag: 9891006696340
Diversion	ULL-DVEF02b	13-Apr-2019	EF	1	MW	225	105.1	0.92	SC-06	5	06		
Diversion	ULL-DVEF02b	13-Apr-2019	EF	2	CT	186	71.3	1.11	SC-07	3	07	2.1	Tag: 9891006335248
Diversion	ULL-DVEF04	13-Apr-2019	EF	1	BT	213	116.6	1.21	FR-01		01		Tag: 9891006335405
Diversion	ULL-DVEF04	13-Apr-2019	EF	1	BT	201	96.8	1.19	FR-02		02		Tag: 9891006335428
Diversion	ULL-DVEF04	13-Apr-2019	EF	1	CT	47	1.3	1.25	SC-03	0	03		
Diversion	ULL-DVEF04	13-Apr-2019	EF	2	NFO								
Diversion	ULL-DVEF06	13-Apr-2019	EF	1	BT	219	120.8	1.15	FR-01		01	3.5	Tag: 9891006118722
Diversion	ULL-DVEF06	13-Apr-2019	EF	1	BT	81	5.6	1.05			02		Tag: 9891006118704
Diversion	ULL-DVEF06	13-Apr-2019	EF	1	MW	228	138.9	1.17	SC-03		03		
Diversion	ULL-DVEF06	13-Apr-2019	EF	1	MW	264	229	1.24	SC-04		04		
Diversion	ULL-DVEF06	13-Apr-2019	EF	1	MW	260	221	1.26	SC-05		05		
Diversion	ULL-DVEF06	13-Apr-2019	EF	2	BT	104	13.6	1.21			06		Tag: 9891006646971
Diversion	ULL-DVEF06	13-Apr-2019	EF	2	BT	85	7.8	1.27			07		Tag: 9891006647191
Diversion	ULL-DVEF06	13-Apr-2019	EF	3	NFO								
Diversion	ULL-DVEF07b	13-Apr-2019	EF	1	BT	147	35.5	1.12	FR-02		02		Tag: 9891006696844
Diversion	ULL-DVEF07b	13-Apr-2019	EF	1	BT	84	5.6	0.94	FR-03		03		Tag: 9891006335417
Diversion	ULL-DVEF07b	13-Apr-2019	EF	1	BT	88	8.9	1.31	FR-04		04		Tag: 9891006335267
Diversion	ULL-DVEF07b	13-Apr-2019	EF	1	BT	89	8.5	1.21	FR-05		05		Tag: 9891006696366
Diversion	ULL-DVEF07b	13-Apr-2019	EF	2	CT	63	3	1.20	SC-01	0	01		
Diversion	ULL-DVEF07b	13-Apr-2019	EF	3	NFO								
Diversion	ULL-DVEF09	13-Apr-2019	EF	1	CT	114	15.8	1.07	SC-01	2	01		Tag: 9891006696836
Diversion	ULL-DVEF09	13-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF01	10-Apr-2019	EF	1	NFO								
Upstream	ULL-USEF01	10-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF02b	10-Apr-2019	EF	1	NFO								
Upstream	ULL-USEF02b	10-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF03	10-Apr-2019	EF	1	CT	167	54.7	1.17	SC-01	2	01		Tag: 9891006335284
Upstream	ULL-USEF03	10-Apr-2019	EF	2	NFO								

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] FR = fin ray, SC = scale.

Table 1. Continued.

Reach	Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	Mean Fat %	PIT Tag #
Upstream	ULL-USEF10	11-Apr-2019	EF	1	NFO								
Upstream	ULL-USEF10	11-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF13	11-Apr-2019	EF	1	NFO								
Upstream	ULL-USEF13	11-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF08	10-Apr-2019	EF	1	CT	43	0.8	1.01					
Upstream	ULL-USEF08	10-Apr-2019	EF	1	CT	45	1.1	1.21					
Upstream	ULL-USEF08	10-Apr-2019	EF	2	NFO								
Upstream	ULL-USEF16	11-Apr-2019	EF	1	NFO								
Upstream	ULL-USEF16	11-Apr-2019	EF	2	NFO								

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] FR = fin ray, SC = scale.

Table 2. Summary of all fish captured during closed-site electrofishing in 87.0 km Tributary in 2019.

Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	PIT Tag #
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	37	0.4	0.79				
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	48	2.2	1.99	SC-13	0	13	
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	59	2.4	1.17				
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	67	3.4	1.13	SC-11	0	11	
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	67	3.6	1.20	SC-3		3	
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	70	4.3	1.25				
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	70	4.2	1.22	SC-8		8	
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	74	4.6	1.14	SC-6	0	6	
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	82	6.9	1.25	SC-12		12	Tag: 9891031378501
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	102	11	1.04				Tag: 9891031378472
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	108	13.2	1.05	SC-10		10	Tag: 9891031378491
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	112	15.7	1.12	SC-7		7	Tag: 9891031378500
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	115	16.4	1.08	SC-9	1	9	Tag: 9891031378534
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	118	17.3	1.05	SC-5	1	5	Tag: 9891031378571
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	140	28	1.02	SC-1		1	Tag: 9891031378483
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	148	35.4	1.09	SC-4	3	4	Tag: 9891031378481
ULL-HPTB87.0EF01	2019-Oct-19	EF	1	CT	172	46.5	0.91	SC-2	4	2	Tag: 9891031378482
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	153	36.2	1.01	SC-14	3	14	Tag: 9891031378512
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	39	0.7	1.18				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	64	2.9	1.11				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	74	4.7	1.16				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	76	5.3	1.21				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	CT	115	15.3	1.01				Tag: 9891031378542
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	TR	33	0.3	0.83				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	TR	34	0.4	1.02				
ULL-HPTB87.0EF01	2019-Oct-19	EF	2	TR	39	0.6	1.01				

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] SC = scale.

Table 2. Continued.

Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	PIT Tag #
ULL-HPTB87.0EF01	2019-Oct-19	EF	3	CT	149	27.3	0.83	SC-15		15	Tag: 9891031378527
ULL-HPTB87.0EF01	2019-Oct-19	EF	3	CT	76	4.9	1.12				
ULL-HPTB87.0EF01	2019-Oct-19	EF	3	TR	35	0.5	1.17				
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	149	20.2	0.61				Tag: 9891031378598
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	89	8.1	1.15	SC-11	1	11	Tag: 9891031378588
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	104	13.3	1.18	SC-8	1	8	Tag: 9891006647050
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	104	11.6	1.03				Tag: 9891031378524
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	186	55.9	0.87	SC-6		6	Tag: 9891031378496
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	28	0.1	0.46				
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	34	0.3	0.76				
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	64	2.9	1.11	SC-4		4	
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	82	6.6	1.20	SC-7	1	7	Tag: 9891031378611
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	92	8.8	1.13				Tag: 9891031378498
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	93	8.9	1.11				Tag: 9891031378493
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	106	11.5	0.97	SC-9		9	Tag: 9891031378551
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	113	15.6	1.08				Tag: 9891031378478
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	121	18.5	1.04				Tag: 9891031378614
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	134	25.3	1.05	SC-2	2	2	Tag: 9891031378536
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	137	24.4	0.95	SC-3		3	Tag: 9891006646798
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	139	26.6	0.99	SC-5	2	5	Tag: 9891031378606
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	141	30	1.07				Tag: 9891031378479
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	141	28.6	1.02				Tag: 9891006646668
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	143	29.4	1.01	SC-10	2	10	Tag: 9891031378509
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	CT	169	57.5	1.19	SC-1		1	Tag: 9891002803483
ULL-HPTB87.0EF02	2019-Oct-19	EF	1	TR	31	0.3	1.01				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	69	4.3	1.31				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	149	34.6	1.05				Tag: 9891031378633
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	89	7.8	1.11				Tag: 9891031378564

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] SC = scale.

Table 2. Continued.

Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	PIT Tag #
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	55	2.1	1.26				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	62	2.8	1.17				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	70	4.2	1.22				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	72	4	1.07				
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	102	10.8	1.02				Tag: 9891031378578
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	127	19.7	0.96				Tag: 9891031378585
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	132	22	0.96				Tag: 9891031378610
ULL-HPTB87.0EF02	2019-Oct-19	EF	2	CT	154	37	1.01				Tag: 9891031378608
ULL-HPTB87.0EF02	2019-Oct-19	EF	3	CT	105	13.2	1.14				Tag: 9891031378569
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	69	3.7	1.13				
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	69	3.8	1.16				
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	95	9	1.05	SC-5	1	5	Tag: 9891031378581
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	116	17.3	1.11				Tag: 9891031378565
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	120	16.5	0.95	SC-8		8	Tag: 9891031378582
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	175	55.4	1.03				Tag: 9891006646862
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	190	65.7	0.96	SC-10	3	10	Tag: 9891031378602
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	104	10.3	0.92				Tag: 9891031378604
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	200	89.5	1.12	SC-16		16	Tag: 9891031378658
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	167	41.2	0.88				Tag: 9891031378609
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	62	2.6	1.09	SC-15	0	15	
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	70	3.9	1.14	SC-9	0	9	
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	72	4.9	1.31	SC-1		1	
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	73	4.3	1.11				
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	92	7.6	0.98	SC-6	1	6	Tag: 9891031378594
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	94	8	0.96	SC-11		11	Tag: 9891031378595
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	97	9.5	1.04				Tag: 9891031378656
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	99	9.8	1.01				Tag: 9891031378613
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	110	13.7	1.03	SC-12	1	12	Tag: 9891031378571
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	115	14	0.92				Tag: 9891031378586
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	122	17.9	0.99	SC-7	1	7	Tag: 9891031378575

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] SC = scale.

Table 2. Continued.

Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Measured Age	DNA Sample Number	PIT Tag #
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	124	18.4	0.97				Tag: 9891031378627
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	128	20.1	0.96	SC-13	2	13	Tag: 9891031378590
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	129	25.6	1.19				Tag: 9891031378630
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	142	32.4	1.13				Tag: 9891006647036
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	145	29.9	0.98				Tag: 9891031378624
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	154	41.4	1.13				Tag: 9891031378644
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	160	39.5	0.96	SC-4	3	4	Tag: 9891031378628
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	169	40.4	0.84	SC-2	3	2	Tag: 9891006646827
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	169	50.9	1.05				Tag: 9891031378648
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	169	44.5	0.92				Tag: 9891031378583
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	172	55.4	1.09	SC-3		3	Tag: 9891031378577
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	CT	185	65.7	1.04	SC-14		14	Tag: 9891031378599
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	TR	31	0.5	1.68				
ULL-HPTB87.0EF03	2019-Oct-20	EF	1	TR	35	0.4	0.93				
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	95	9.2	1.07				Tag: 9891031378636
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	144	33.1	1.11				Tag: 9891031378593
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	149	29.6	0.89				Tag: 9891031378626
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	106	11.3	0.95				Tag: 9891031378631
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	107	13.3	1.09				Tag: 9891031378625
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	165	48	1.07				Tag: 9891031378641
ULL-HPTB87.0EF03	2019-Oct-20	EF	2	CT	168	41	0.86				Tag: 9891031378659
ULL-HPTB87.0EF03	2019-Oct-20	EF	3	CT	85	7.4	1.20				Tag: 9891031378580
ULL-HPTB87.0EF03	2019-Oct-20	EF	3	CT	108	13.5	1.07				Tag: 9891031378573
ULL-HPTB87.0EF03	2019-Oct-20	EF	3	CT	108	12	0.95				Tag: 9891031378632

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, NFO = No Fish Observed.

[3] SC = scale.

Appendix J. Habitat Summaries and Representative Photographs of Snorkel Mark Re-sight Sites

LIST OF FIGURES

LIST OF TABLES

Table 1. Summary of site conditions at mark re-sight sites in Boulder Creek, 2019.

Reach	Sampling Event	Site	Date	Estimated Visibility (m)	Water Temp. (°C)	Air Temp. (°C)	Daily Average Flow (m^3/s)[1]
Diversion	Mark	BDR-DVSN01	28-Mar-2019	2.0	3.3	5.0	2.13
		BDR-DVSN02	28-Mar-2019	1.5	2.0	2.0	2.13
		BDR-DVSN03	28-Mar-2019	1.5	2.0	1.8	2.13
		BDR-DVSN04	28-Mar-2019	2.0	0.0	2.0	2.13
		BDR-DVSN05	28-Mar-2019	1.5	2.0	1.0	2.13
	Re-Sight Index	BDR-DVSN01	29-Mar-2019	1.5	3.5	1.5	2.13
		BDR-DVSN02	29-Mar-2019	1.5	0.0	1.0	2.13
		BDR-DVSN03	29-Mar-2019	1.5	3.5	1.0	2.13
		BDR-DVSN04	29-Mar-2019	1.5	0.0	0.0	2.13
		BDR-DVSN05	29-Mar-2019	1.5	3.0	1.0	2.13
Downstream	Mark	BDR-DSSN01B	30-Mar-2019	0.8	2.0	0.0	2.95
		BDR-DSSN02B	30-Mar-2019	1.0	2.0	3.0	2.95
		BDR-DSSN03	30-Mar-2019	1.0	2.0	0.5	2.95
		BDR-DSSN04	30-Mar-2019	0.8	2.0	1.0	2.95
		BDR-DSSN05	30-Mar-2019	0.8	3.0	1.0	2.95
	Re-Sight Index	BDR-DSSN01B	31-Mar-2019	1.3	3.0	1.0	3.18
		BDR-DSSN02B	31-Mar-2019	1.3	0.0	1.0	3.18
		BDR-DSSN03	31-Mar-2019	1.5	0.0	0.0	3.18
		BDR-DSSN04	31-Mar-2019	1.5	2.5	0.5	3.18
		BDR-DSSN05	31-Mar-2019	1.5	2.5	0.5	3.18

[1] Diversion flow was calculated by subtracting powerhouse flows from downstream flows as measured at BDR-DSLG02.

Table 2. Summary of habitat data at mark re-sight sites in Boulder Creek, 2019

Reach	Site	Habitat	Complete Site			Surveyed Area		Max. Depth (m)	Cover[1]		Substrate (%)[2]							Gradient (%)
			Length (m)	Width (m)	Area (m²)	% of Total	Area (m²)		Dom.	Sub-dom.	BR	BO	LC	SC	LG	SG	F	
Diversion	BDR-DVSN01	Cascade/Pool	100	14.3	1,430	65	930	1.1	BO	CO	0	35	15	20	10	10	10	8.0
	BDR-DVSN02	Cascade	98	12.6	1,238	80	988	1.6	BO	DP	10	25	15	20	10	10	10	5.5
	BDR-DVSN03	Cascade	124	11.6	1,435	88	1,265	1.2	BO	CO	5	25	20	20	10	10	10	4.0
	BDR-DVSN04	Cascade	87	11.6	1,007	60	606	1.1	BO	DP	10	25	10	15	10	20	10	6.0
	BDR-DVSN05	Cascade	92	11.9	1,098	65	712	1.4	BO	DP	5	25	15	15	15	15	10	5.5
Downstream	BDR-DSSN01B	Riffle	95	9.3	886	60	530	0.8	CO	BO	0	25	30	20	10	10	5	3.0
	BDR-DSSN02B	Riffle	107	9.5	1,020	60	610	1.1	BO	CO	0	40	25	15	5	5	10	4.0
	BDR-DSSN03	Cascade	104	12.4	1,286	60	774	1.5	BO	CO	0	45	20	10	10	10	5	5.0
	BDR-DSSN04	Cascade	115	11.8	1,354	45	611	1.8	BO	CO	0	40	20	15	10	10	5	6.0
	BDR-DSSN05	Cascade	99	14.1	1,396	55	768	1.8	BO	CO	0	40	25	10	15	5	5	6.0

[1] Cover codes: Dom. = dominant, Sub-Dom. = sub-dominant, BO = boulder, CO = cobble, DP = deep pool

[2] F = fine (<2 mm), SG = small gravel (2 - 16 mm), LG = large gravel (16 - 64 mm), SC = small cobble (64 - 128 mm), LC = large cobble (128 - 256 mm), BO = boulder (256-4,000 mm), and BR = bedrock (>4,000 mm)

Figure 1. Looking upstream at BDR-DSSN01B on March 30, 2019.

Figure 2. Looking downstream at BDR-DSSN01B on March 30, 2019.

Figure 3. Looking upstream at BDR-DSSN02B on March 30, 2019.

Figure 4. Looking downstream at BDR-DSSN02B on March 30, 2019.

Figure 5. Looking upstream at BDR-DSSN03 on March 30, 2019.

Figure 6. Looking downstream at BDR-DSSN03 on March 30, 2019.

Figure 7. Looking upstream at BDR-DSSN04 on March 30, 2019.

Figure 8. Looking downstream at BDR-DSSN04 on March 30, 2019.

Figure 9. Looking upstream at BDR-DSSN05 on March 30, 2019.

Figure 10. Looking downstream at BDR-DSSN05 on March 30, 2019.

Figure 11. Looking upstream at BDR-DVSN01 on March 29, 2019.

Figure 12. Looking downstream at BDR-DVSN01 on March 29, 2019.

Figure 13. Looking upstream at BDR-DVSN02 on March 29, 2019.

Figure 14. Looking downstream at BDR-DVSN02 on March 29, 2019.

Figure 15. Looking upstream at BDR-DVSN03 on March 29, 2019.

Figure 16. Looking downstream at BDR-DVSN03 on March 29, 2019.

Figure 17. Looking upstream at BDR-DVSN04 on March 29, 2019.

Figure 18. Looking downstream at BDR-DVSN04 on March 29, 2019.

Figure 19. Looking upstream at BDR-DVSN05 on March 29, 2019.

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Appendix K. Snorkel Mark Re-sight Fish Aging Figures and Individual Fish Data

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Figure 1. Length-frequency of Bull Trout captured during mark re-sight snorkelling in Boulder Creek in 2019.

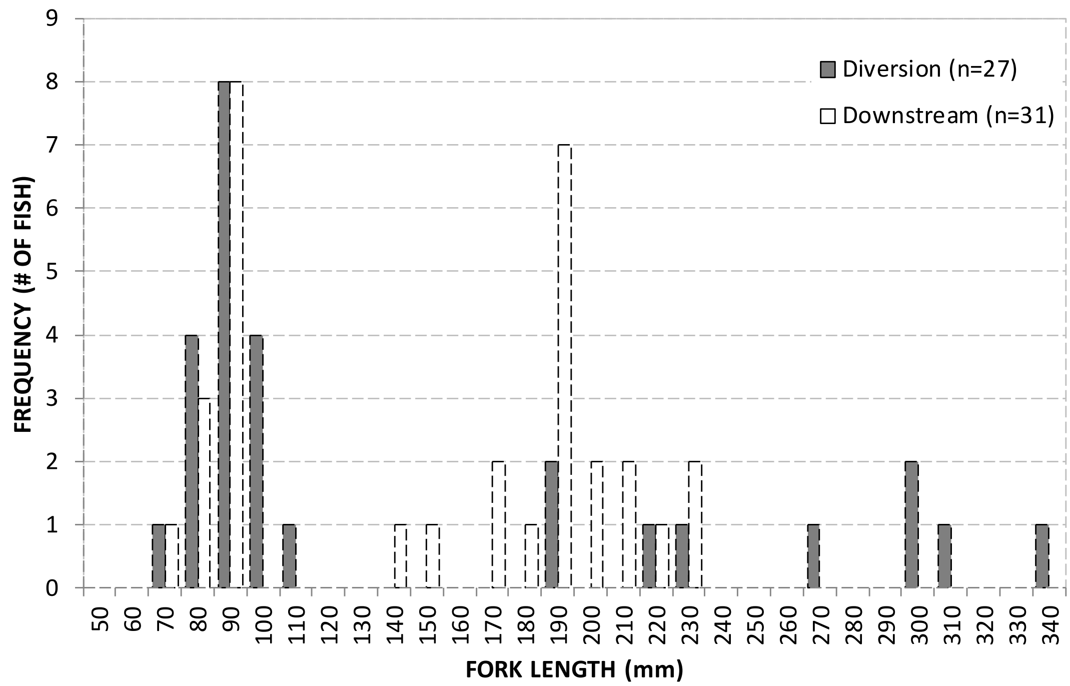

Figure 2. Length-weight regression for Bull Trout captured during mark re-sight snorkelling in Boulder Creek in 2019.

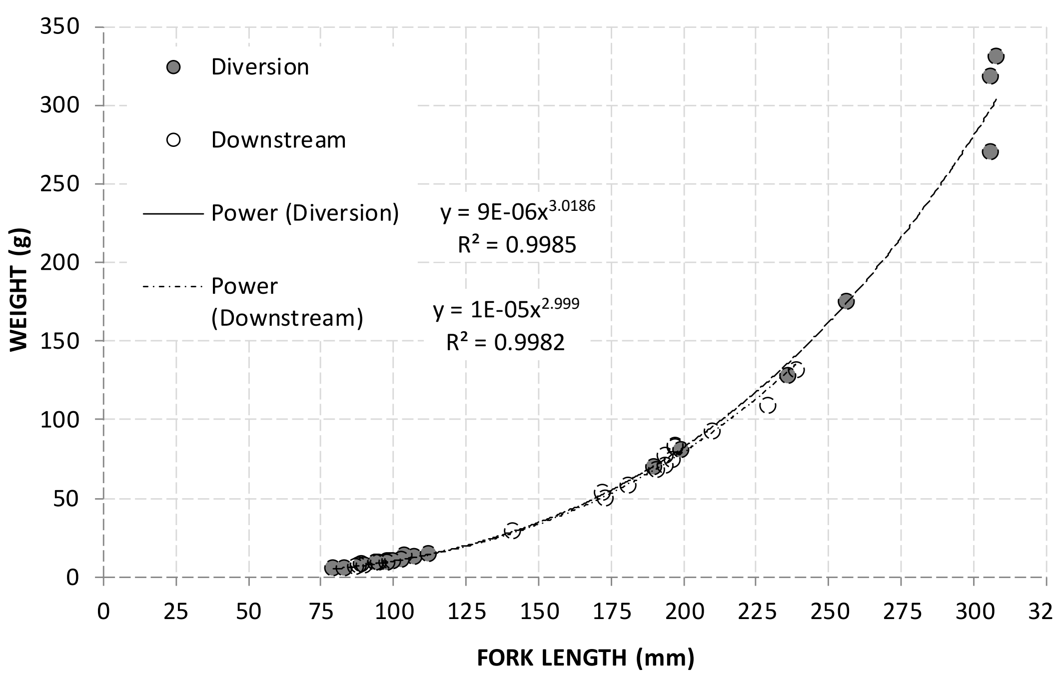

Figure 3. **Length-frequency of Cutthroat Trout captured during mark re-sight snorkelling in Boulder Creek in 2018.**

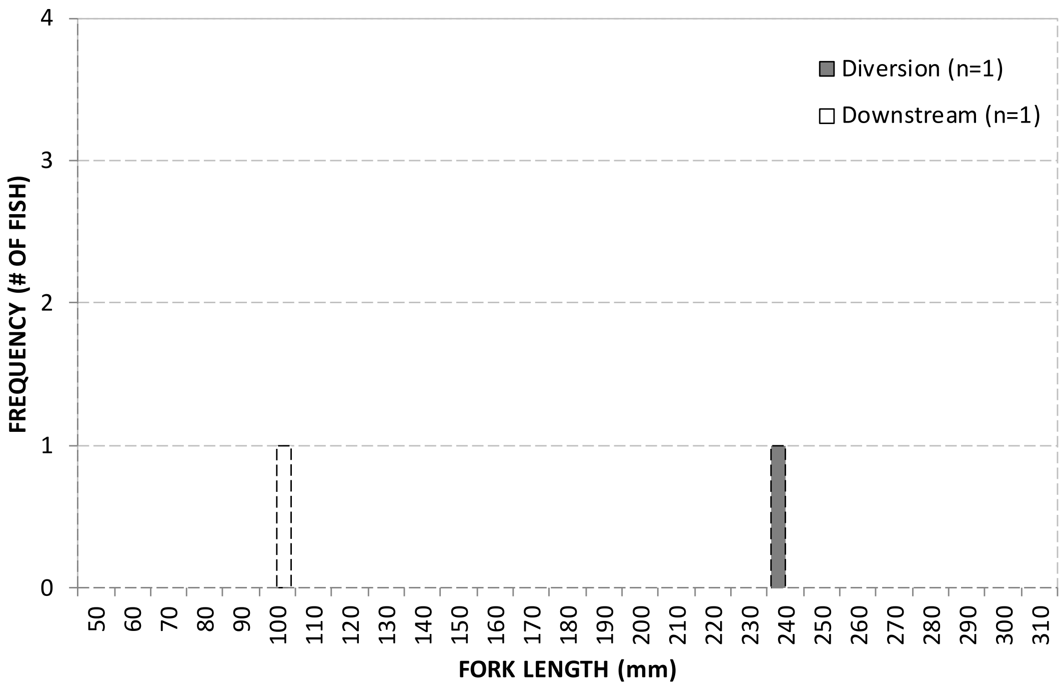

Figure 4. **Length-weight regression for Cutthroat Trout captured during mark re-sight snorkelling in Boulder Creek in 2019.**

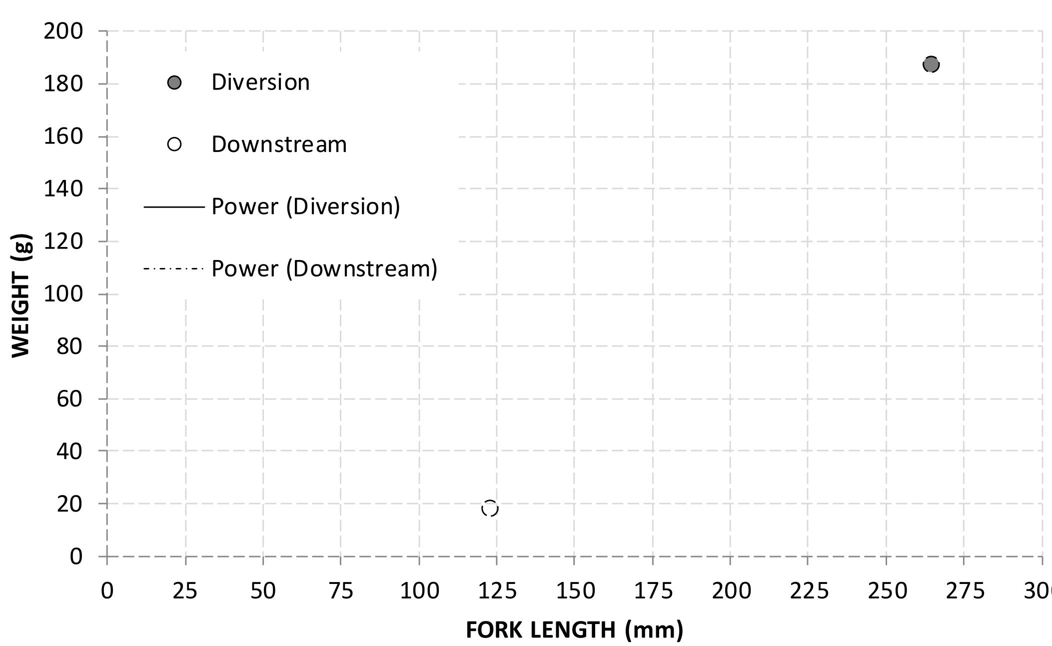

Table 1. Summary of all fish captured during mark-resight sampling in Boulder Creek, 2019.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Tag Colour	Recapture	PIT Tag #
BDR-DSSN01B	31/Mar/19	Downstream	SN	CT	130	123	18.1	0.97	SC01		No	9891006696279
BDR-DSSN01B	31/Mar/19	Downstream	SN	BT	150						No	
BDR-DSSN01B	31/Mar/19	Downstream	SN	MW	300						No	
BDR-DSSN01B	30/Mar/19	Downstream	SN	CT	130						No	
BDR-DSSN01B	30/Mar/19	Downstream	SN	CT	260						No	
BDR-DSSN01B	30/Mar/19	Downstream	SN	BT	200	197				SP GR	No	
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	80	90	7.2	0.99			No	9891006335412
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	200	194	70.4	0.96	FR03		No	9891006646976
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	220	197	82.2	1.08	FR02	SP YE	Yes	9891006647246
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	310						No	
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	90	87	6.4	0.97		RE	Yes	9891006335249
BDR-DSSN02B	31/Mar/19	Downstream	SN	BT	100	94	8.5	1.02		RE	Yes	9891006335414
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	80	84				RE	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	220						No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	300						No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	210	200				SP YE	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	90					RE	Yes	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	90	95				PI	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	90	90				RE	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	95	96				RE	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	BT	70	78				RE	No	
BDR-DSSN02B	30/Mar/19	Downstream	SN	TR	100						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	130	141	28.5	1.02	FR01		No	9891006335282
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	140						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	150						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	170	172	53.1	1.04			No	9891006335253
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	170	181	57.4	0.97		SP OR	Yes	9891006335279
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	180	173	49.7	0.96	FR04		No	9891006335327

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, TR = Unknown Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Tag Colour	Recapture	PIT Tag #
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	190					SP OR	Yes	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	200						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	200	191	67.7	0.97	FR02		No	9891006696289
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	200	210	92.6	1.00			No	9891006696354
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	200	196	74.5	0.99			No	9891006335313
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	230	229	108.6	0.90	FR05		No	9891006647011
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	240	239	131.1	0.96	FR09		No	9891006696818
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	90	95	8.8	1.03			No	9891006696280
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	100						No	
BDR-DSSN03	31/Mar/19	Downstream	SN	BT	235	197	83.4	1.09	FR03		No	9891006335354
BDR-DSSN03	30/Mar/19	Downstream	SN	CT	150						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	CT	200						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	120						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	130						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	140						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	140	155				SP OR	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	150						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	160						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	160	183				SP OR	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	200						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	210	233				PI	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	210	210				PI	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	210	196				SP OR	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	210	201				SP YE	No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN03	30/Mar/19	Downstream	SN	BT	110						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	130						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	170						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	190	194	77	1.05			No	: 989106696358

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, TR = Unknown Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Tag Colour	Recapture	PIT Tag #
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	200						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	100						No	
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	85	88	6.7	0.98			No	9891006696269
BDR-DSSN04	31/Mar/19	Downstream	SN	BT	110						No	
BDR-DSSN04	30/Mar/19	Downstream	SN	BT	150						No	
BDR-DSSN04	30/Mar/19	Downstream	SN	BT	205						No	
BDR-DSSN04	30/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN05	31/Mar/19	Downstream	SN	BT	180						No	
BDR-DSSN05	31/Mar/19	Downstream	SN	BT	210						No	
BDR-DSSN05	31/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN05	31/Mar/19	Downstream	SN	BT	90					RE	Yes	
BDR-DSSN05	31/Mar/19	Downstream	SN	BT	90	98	9	0.96		RE	Yes	9891006696482
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	80	85				PI	No	
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	130						No	
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	150						No	
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	90						No	
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	90	95				PI	No	
BDR-DSSN05	30/Mar/19	Downstream	SN	BT	90	93				PI	No	
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	80	83	5.6	0.98			No	9891006335289
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	130					YE	Yes	
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	300	306	270	0.94		SP GR	Yes	9891006335241
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	90						No	
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	90	89	7.6	1.08		RE	Yes	9891006696539
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	100						No	
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	85						No	
BDR-DVSN01	29/Mar/19	Diversion	SN	BT	110						No	
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	130						No	
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	270	310				GR SP	Yes	9891006335241
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	90	95				RE	No	

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, TR = Unknown Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Tag Colour	Recapture	PIT Tag #
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	90	89				RE	No	
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	110	101				YE	No	
BDR-DVSN01	28/Mar/19	Diversion	SN	BT	70						No	
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	80	79	4.9	0.99			No	9891006646975
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	150	199	80.2	1.02	FR04		No	9891006696274
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	160	190	69.6	1.01	FR05		No	9891006696282
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	300					SP PI	Yes	
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	320	308	331	1.13		SP PI	Yes	9891006696631
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	90	98	9.5	1.01			No	9891006335261
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	90	103	10.9	1.00			No	9891006335399
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	90	100	9.9	0.99			No	9891006646978
BDR-DVSN02	29/Mar/19	Diversion	SN	BT	100						No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	130						No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	210	229				SP YE	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	350	350				SP PI	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	330	300				SP PI	Yes	98910060696631
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	290	274				SP PI	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	90	98				PI	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	90	95				PI	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	90	83				PI	No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	100						No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	110						No	
BDR-DVSN02	28/Mar/19	Diversion	SN	BT	110	94				PI	No	
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	80	98	8.9	0.95			No	9891006647000
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	80	99	9.8	1.01			No	9891006647009
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	120						No	
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	130	112	14.2	1.01			No	9891006647205
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	220	256	175	1.04		SP PI	Yes	9891006335232
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	90						No	
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	90	107	12.7	1.04		SP GR	Yes	9891006696326

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, TR = Unknown Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample Number[3]	Tag Colour	Recapture	PIT Tag #
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	85	94	8.6	1.04			No	9891006647064
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	85	104	13.4	1.19			No	9891006335383
BDR-DVSN03	29/Mar/19	Diversion	SN	BT	110					RE	Yes	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	210						No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	350						No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	290	260				SP PI	No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	90					PI	No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	90	95				PI	No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	90	86				PI	No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	100					SP GR	No	
BDR-DVSN03	28/Mar/19	Diversion	SN	BT	100	102				SP GR	No	
BDR-DVSN04	29/Mar/19	Diversion	SN	CT	270	265	187.3	1.01	SC01	SP GR	Yes	9891006335278
BDR-DVSN04	28/Mar/19	Diversion	SN	CT	270	268				SP GR	No	
BDR-DVSN05	29/Mar/19	Diversion	SN	BT	150	236	128	0.97	FR02		No	9891006696357
BDR-DVSN05	29/Mar/19	Diversion	SN	BT	260	306	318	1.11	FR01	SP PI	Yes	9891006335400
BDR-DVSN05	28/Mar/19	Diversion	SN	BT	280	305				SP PI	No	
BDR-DVSN05	28/Mar/19	Diversion	SN	BT	305						No	

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout, MW = Mountain Whitefish, TR = Unknown Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Appendix L. Angling Site Representative Photographs, Site Conditions Summary, and Individual Fish Data

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Figure 2. Looking downstream at BDR-DVAG04 on September 30, 2019.

Figure 3. Looking upstream at BDR-DVAG05 on September 30, 2019.

Figure 4. Looking downstream from river right at BDR-TRAG01 on September 30, 2019.

Figure 5. Looking downstream at BDR-DSAG01 on October 22, 2019.

Figure 6. Looking upstream at BDR-DSAG02 on September 30, 2019.

Figure 7. Looking upstream at BDR-DSAG06 on September 30, 2019.

Figure 8. Looking downstream at BDR-DSAG07 on September 30, 2019.

Figure 9. Looking upstream at ULL-DVAG15 on September 29, 2019.

Figure 10. Looking upstream at ULL-DVAG16 on September 29, 2019.

Figure 11. Looking from river right to river left at ULL-TRAG01 on September 29, 2019.

Figure 12. Looking downstream at ULL-DSAG08 on September 29, 2019.

Figure 13. Looking upstream from river left at ULL-DSAG09 on September 29, 2019.

Figure 14. Looking downstream at ULL-DSAG10 on September 29, 2019.

Figure 15. Looking downstream at NTH-DSAG01 on October 1, 2019.

Figure 16. Looking river right to river left at NTH-DSAG05 on October 1, 2019.

Figure 17. Looking downstream at NTH-DSAG06 on October 1, 2019.

Figure 18. Looking upstream at NTH-DVAG04 on October 1, 2019.

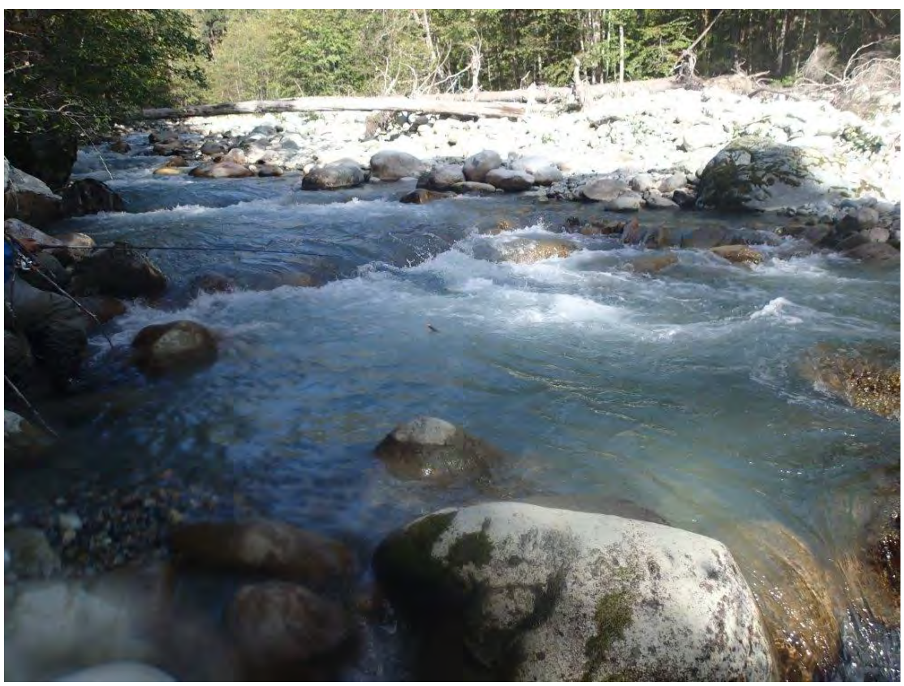

Figure 19. Looking upstream at NTH-DVAG05 on October 1, 2019.

Figure 20. Looking river right to river left at NTH-DVAG06 on October 1, 2019.

Table 1. Summary of angling sites in Boulder Creek in fall 2019.

Site [1]	Habitat Type	Date	Water Temp. (°C)	Site Length (m)	Stream Wetted Width (m)	Average Angled Width (m)	Overall Site Area (m²)	Fished Area (m²)	Estimated Fishable Area (%)
BDR-DSAG01	Cascade	18-Sep	7.1	32.0	12.0	3.0	384	96	20
		22-Oct	4.4	32.0	12.0	3.0	384	192	25
BDR-DSAG02	Cascade	18-Sep	7.0	21.0	18.0	4.0	378	84	20
		30-Sep	4.2	18.0	15.6	5.0	280.8	90	30
		22-Oct	3.6	18.0	15.0	5.0	270	90	30
BDR-DSAG06	Cascade	18-Sep	7.1	21.0	15.0	4.0	315	84	25
		30-Sep	3.9	23.0	12.0	6.0	276	414	40
		22-Oct	4.4	23.0	12.0	6.0	276	138	40
BDR-DSAG07	Riffle	18-Sep	7.0	55.0	20.0	4.0	1100	220	50
		30-Sep	4.5	69.0	28.0	6.0	1932	414	20
		22-Oct	3.4	69.0	28.0	6.0	1932	414	20
BDR-DVAG01	Cascade/Pool	18-Sep	9.5	13.0	10.0	4.0	130	52	45
		30-Sep	3.6	22.0	8.0	8.0	176	176	60
		22-Oct	4.9	22.0	8.0	8.0	176	176	60
BDR-DVAG04	Cascade/Pool	18-Sep	9.5	12.0	9.0	4.0	108	48	50
		30-Sep	3.7	24.0	4.8	2.0	115.2	144	40
		22-Oct	5.0	24.0	5.0	3.0	120	72	40
BDR-DVAG05	Cascade	18-Sep	8.9	30.0	9.0	3.0	270	900	25
		30-Sep	3.7	23.0	9.0	5.0	207	115	50
		22-Oct	5.4	23.0	9.0	5.0	207	115	50
BDR-TRAG01	Run	18-Sep	6.4	52.0	8.0	4.0	416	416	60
		30-Sep	3.3	33.0	9.0	5.0	297	495	40
		22-Oct	3.4	33.0	9.0	5.0	297	495	40

[1] Sites labels for North Creek are historic. No downstream or diversion exist.

Table 2. Summary of angling sites in Lillooet River in fall 2019.

Site [1]	Habitat Type	Date	Water Temp. (°C)	Site Length (m)	Stream Wetted Width (m)	Average Angled Width (m)	Overall Site Area (m²)	Fished Area (m²)	Estimated Fishable Area (%)
ULL-DSAG08	Riffle/Pool	17-Sep	6.6	24.0	30.0	5.0	720	120	20
		21-Oct	3.4	75.0	18.0	3.0	1350	225	15
ULL-DSAG09	Riffle/Pool	17-Sep	6.2	30.0	29.0	5.0	870	150	20
		29-Sep	4.8	37.0	25.0	3.0	925	111	20
		21-Oct	2.8	37.0	25.0	3.0	925	111	20
ULL-DSAG10	Riffle/Pool	17-Sep	5.7	15.0	25.0	4.0	375	60	15
		29-Sep	3.3	31.0	25.0	4.0	775	124	20
		21-Oct	3.4	31.0	25.0	4.0	775	124	20
ULL-DVAG15	Cascade	17-Sep	6.8	46.0	15.0	4.0	690	184	40
		29-Sep	4.6	32.0	13.0	3.0	416	96	20
		21-Oct	3.8	32.0	13.0	3.0	416	96	20
ULL-DVAG16	Step/Pool	17-Sep	7.4	45.0	16.0	10.0	720	450	60
		29-Sep	5.6	28.0	18.0	4.0	504	448	30
		21-Oct	3.9	28.0	18.0	4.0	504	112	30
ULL-TRAG01	Step/Pool	17-Sep	5.6	15.0	30.0	6.0	450	90	10
		29-Sep	3.1	15.0	40.0	4.0	600	60	30
		21-Oct	3.4	15.0	40.0	4.0	600	60	30

[1] Sites labels for North Creek are historic. No downstream or diversion exist.

Table 3. Summary of angling sites in North Creek in fall 2019.

Site [1]	Habitat Type	Date	Water Temp. (°C)	Site Length (m)	Stream Wetted Width (m)	Average Angled Width (m)	Overall Site Area (m²)	Fished Area (m²)	Estimated Fishable Area (%)
NTH-DSAG01	Riffle/Pool	1-Oct	5.4	15.0	8.0	8.0	120	120	60
		23-Oct	3.3	15.0	8.0	8.0	120	120	60
NTH-DSAG05	Cascade/Pool	1-Oct	5.4	9.0	10.0	10.0	90	90	80
		23-Oct	3.3	9.0	10.0	10.0	90	90	80
NTH-DSAG06	Run	1-Oct	5.1	24.0	8.0	4.0	192	96	50
		23-Oct	3.4	24.0	8.0	4.0	192	96	50
NTH-DVAG04	Cascade/Pool	1-Oct	5.1	26.0	13.0	3.0	338	78	15
		23-Oct	3.5	26.0	13.0	3.0	338	78	15
NTH-DVAG05	Cascade/Pool	1-Oct	5.5	31.0	7.0	4.0	217	124	30
		23-Oct	3.8	31.0	7.0	4.0	217	124	30
NTH-DVAG06	Cascade/Pool	1-Oct	5.8	55.0	14.0	3.0	770	165	20
		23-Oct	4.2	55.0	14.0	3.0	770	165	20

[1] Sites labels for North Creek are historic. No downstream or diversion exist.

Table 4. Summary of all fish captured during angling in Boulder Creek in 2019.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Diversion	18-Sep	BDR-DVAG01	NFC							
Diversion	18-Sep	BDR-DVAG04	NFC							
Diversion	18-Sep	BDR-DVAG05	NFC							
Tailrace	18-Sep	BDR-TRAG01	BT	266	191	1.01481869	FR	2	2	989001031378544
Tailrace	18-Sep	BDR-TRAG01	BT	276	228	1.08444518	FR	1	1	989001006335250
Downstream	18-Sep	BDR-DSAG01	NFC							
Downstream	18-Sep	BDR-DSAG02	NFC							
Downstream	18-Sep	BDR-DSAG06	NFC							
Downstream	18-Sep	BDR-DSAG07	NFC							
Diversion	30-Sep	BDR-DVAG01	NFC							
Diversion	30-Sep	BDR-DVAG04	BT	180	62	1.06310014	FR	5	5	989001031378539
Diversion	30-Sep	BDR-DVAG04	BT	161	45	1.07828828	FR	4	4	989001031378531
Diversion	30-Sep	BDR-DVAG04	BT	325	329	0.95839782	FR	6	6	989001031378523
Diversion	30-Sep	BDR-DVAG05	NFC							
Tailrace	30-Sep	BDR-TRAG01	BT	266	194	1.03075825	FR	2	2	989001031378544
Tailrace	30-Sep	BDR-TRAG01	BT	278	220	1.0239725	FR	1	1	989001006335250
Tailrace	30-Sep	BDR-TRAG01	BT	226	113	0.97893335	FR	3	3	989001031378548
Downstream	30-Sep	BDR-DSAG02	NFC							

[1] Sites labels are historic. No downstream or diversion exist for North Creek

[2] BT = Bull Trout, NFC = No fish caught.

Table 4. Continued.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Downstream	30-Sep	BDR-DSAG06	BT	235	124	0.95547229	FR	7	7	989001031378488
Downstream	30-Sep	BDR-DSAG06	BT	300	243	0.9				989001006696285
Downstream	30-Sep	BDR-DSAG06	BT	284	212	0.92550941	FR	8	8	989001031378518
Downstream	30-Sep	BDR-DSAG07	BT	412	626	0.89512294	FR	9	9	989001031378519
Diversion	22-Oct	BDR-DVAG01	NFC							
Diversion	22-Oct	BDR-DVAG04	NFC							
Diversion	22-Oct	BDR-DVAG05	NFC							
Tailrace	22-Oct	BDR-TRAG01	BT	205	91	1.05628183	FR	1	1	989001031378634
Tailrace	22-Oct	BDR-TRAG01	BT	225	106	0.93058985				989001031378548
Tailrace	22-Oct	BDR-TRAG01	BT	225	113	0.9920439	FR	2	2	989001031378563
Downstream	22-Oct	BDR-DSAG01	BT	207	87	0.98086269				989001006335354
Downstream	22-Oct	BDR-DSAG01	BT	351	429	0.99205544	FR	1	1	989001031378567
Downstream	22-Oct	BDR-DSAG02	BT	220	103	0.96731781				989001006696289
Downstream	22-Oct	BDR-DSAG06	NFC							
Downstream	22-Oct	BDR-DSAG07	BT	301	266	0.97539865	FR	1	1	989001031378645

[1] Sites labels are historic. No downstream or diversion exist for North Creek

[2] BT = Bull Trout, NFC = No fish caught.

Table 5. Summary of all fish captured during angling in Lillooet River in 2019.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Diversion	17-Sep	ULL-DVAG15	NFC							
Diversion	17-Sep	ULL-DVAG16	NFC							
Tailrace	17-Sep	ULL-TRAG01	NFC							
Downstream	17-Sep	ULL-DSAG08	NFC							
Downstream	17-Sep	ULL-DSAG09	NFC							
Downstream	17-Sep	ULL-DSAG10	NFC							
Diversion	29-Sep	ULL-DVAG15	BT	279	211	0.97156049	FR	2	2	989001031378546
Diversion	29-Sep	ULL-DVAG16	BT	242	147	1.03722085	FR	4	4	989001031378541
Diversion	29-Sep	ULL-DVAG16	BT	305	286	1.00801389	FR	3	3	989001031378552
Diversion	29-Sep	ULL-DVAG16	BT	320	298	0.90942383	FR	5	5	989001031378554
Diversion	29-Sep	ULL-DVAG16	BT	237	143	1.07421447	FR	6	6	989001031378529
Tailrace	29-Sep	ULL-TRAG01	NFC							
Downstream	29-Sep	ULL-DSAG09	NFC							
Downstream	29-Sep	ULL-DSAG10	BT	410	707	1.02581216	FR	1	1	989001031378557
Diversion	21-Oct	ULL-DVAG15	BT	261	161	0.90553315	FR	1	1	989001031378603
Diversion	21-Oct	ULL-DVAG16	BT	273	194	0.95348483	FR	1	1	989001031378654
Tailrace	21-Oct	ULL-TRAG01	NFC							
Downstream	21-Oct	ULL-DSAG08	NFC							
Downstream	21-Oct	ULL-DSAG09	NFC							
Downstream	21-Oct	ULL-DSAG10	BT	168	51	1.07557904	FR	1	1	989001031378484

[1] Sites labels are historic. No downstream or diversion exist for North Creek

[2] BT = Bull Trout, NFC = No fish caught.

Table 6. Summary of all fish captured during angling in North Creek in 2019.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
N/A	1-Oct	NTH-DVAG06	NFC							
N/A	1-Oct	NTH-DVAG05	BT	385	536	0.93925302	FR	3	3	989001031378549
N/A	1-Oct	NTH-DVAG04	BT	328	340	0.96351257	FR	2	2	989001000524272
N/A	1-Oct	NTH-DSAG06	BT	292	237	0.95191855	FR	1	1	989001031378538
N/A	1-Oct	NTH-DSAG05	NFC							
N/A	1-Oct	NTH-DSAG01	NFC							
N/A	23-Oct	NTH-DVAG06	BT	244	147	1.01192391	FR	1	1	989001031378649
N/A	23-Oct	NTH-DVAG05	NFC							
N/A	23-Oct	NTH-DVAG04	NFC							
N/A	23-Oct	NTH-DSAG06	NFC							
N/A	23-Oct	NTH-DSAG05	NFC							
N/A	23-Oct	NTH-DSAG01	NFC							

[1] Sites labels are historic. No downstream or diversion exist for North Creek

[2] BT = Bull Trout, NFC = No fish caught.

Appendix M. Incidental Wildlife Observations, 2019

LIST OF TABLES

Table 1. Incidental wildlife sightings: Mammals.

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
American Beaver	*Castor canadensis*	9-Dec-2019		473126	5606575	Alena Creek	Sign	Activity near the lodge	1	FD	U	Unknown
American Black Bear	*Ursus americanus*	23-Apr-2019		501209	5595156	2.5 km ULR FSR	Sighting	Black bear, standing.	1	LI	U	Unknown
		24-Apr-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Unknown
		11-May-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Unknown
		11-Aug-2019	07:00:00	493290	5598096	12 km ULR FSR	Sighting	Adult female and 2 young of year (listed separately), Normal behavior avoids people.	1	TF	F	Adult
		11-Aug-2019	07:00:00	493290	5598096	12 km ULR FSR	Sighting	2 Yearlings with a female (listed separately); black colouring	2	TF	U	Cub (Yearling)
		11-Aug-2019	12:00:00	470955	5609332	39 km ULR FSR	Sighting	Normal behavior, avoids people	1	TF	M	Adult
		5-Sep-2019	14:00:00	471316	5609412	Boulder Compound	Sighting	Normal behavior, avoids people, black coloring.	1	FL	M	Adult
		7-Sep-2019	12:00:00	471316	5609412	Boulder Compound	Sighting	Normal behavior, avoids people.	1	TF	U	Cub (COY)
		15-Sep-2019	13:45:00	469348	5610404	41 km	Sighting	Staring at operator.	1	AL	U	Unknown
		18-Sep-2019	16:00:00	476290	5604458	31 km ULR FSR	Sighting	Normal behavior, avoids people	1	TF	U	Cub (COY)
		20-Sep-2019	07:00:00	468623	5611389	ULR Powerhouse Road	Sighting	Normal behavior, avoids people, black colouring.	1	TF	U	Cub (COY)
		13-Nov-2019	10:23:00	473581	5605580	Alena Creek	Sign	Tracks all through the site	2	TF	U	Adult
American Marten	*Martes americana*	14-Mar-2019		471335	5609410	Boulder Powerhouse and Camp	Sighting	Pine Martin, multiple sightings over a few days.	1	LI	U	Unknown
		22-Mar-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Unknown
Cougar	*Puma concolor*	18-Aug-2019		471165	5609500	Boulder Camp	Sighting	Walking across camp driveway, heading for the river.	1	TF	U	Adult
Coyote	*Canis latrans*	9-Dec-2019		473022	5606675	Alena Creek	Sign	Tracks all along the creek	1	TF	U	Unknown
Ermine	*Mustela erminea*	10-Jan-2020	11:32:00	472819	5611087	Boulder Creek HEF intake	Sighting	BDR-CAM08	1	LI	U	Unknown
Grey Wolf	*Canis lupus*	22-Aug-2019	09:30:00	470955	5609332	39 km	Sighting	Black wolf crossing road.	1	TF	U	Unknown
		13-Nov-2019	11:48:00	473333	5606196	Alena Creek	Sign	Tracks beside the creek	1	TF	U	Unknown
		9-Dec-2019		473494	5605342	Alena Creek	Sign	Tracks in the sand along the creek	1	TF	U	Unknown
Grizzly Bear	*Ursus arctos*	26-Apr-2019	13:30:00	469754	5610204	40.5 km ULR FSR	Sighting	Sub adult, normal behavior - avoids people	1	TF	U	Cub (Yearling)
		25-Oct-2019		466631	5614362	46 km ULR FSR	Sighting	normal behaviour, avoids people, light brown colouring.	1	TF	F	Adult
		29-Oct-2019	12:00:00	466094	5614459	ULR Intake Road	Sighting	Normal behaviour, avoids people, light brown colouring	1	TF	F	Adult

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating

Table 1. Continued.

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
mammal		30-Jan-2019	10:33:00	466419	5614087	Upstream; ULL Intake	Sign	Possible cat or coyote. there was ~5 cm of hoar frost.	1	LI	U	Unknown
		8-May-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15, possibly Mule Deer	1	LI	U	Unknown
		9-May-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15, possibly Mule Deer	1	LI	U	Unknown
		10-May-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15, possibly Mule Deer	1	LI	U	Unknown
Moose	*Alces americanus*	12-Mar-2019	06:30:00	476292	5604452	31 km	Sighting	Crossing road	1	TF	M	Adult
		12-Mar-2019	07:00:00	492310	5598281	13 km	Sighting	Pregnant Cow moose	1	LI	F	Adult
		23-Apr-2019		493289	5598097	12 km ULR FSR	Sighting		1	LI	F	Unknown
		23-Apr-2019	07:00:00	490112	5599407	14 - 17 km	Sighting	Cow with calf (listed separately)	1	RR	F	Adult
		23-Apr-2019	07:00:00	490112	5599407	14 - 17 km	Sighting	Health calf seen with cow (listed separately)	1	RR	U	Juvenile
		24-Apr-2019	07:10:00	490112	5599407	14 - 17 km	Sighting		1	FD	F	Adult
		13-May-2019	10:30:00	468471	5611667	ULR Powerhouse Driveway	Sighting		1	TF	U	Juvenile
		23-May-2019	09:00:00	469198	5610521	41.2 km	Sighting		1	LI	M	Adult
		28-Aug-2019	07:30:00	494273	5597916	11 km	Sighting	Cow and calf (listed separately)	1	TF	F	Adult
		28-Aug-2019	07:30:00	494273	5597916	11 km	Sighting	Calf with cow (listed separately)	1	TF	U	Juvenile
		10-Dec-2019	12:00:00	468548	5612078	43 km	Sighting	Crossing penstock	1	TF	F	Adult
		15-Dec-2019	15:00:00	471121	5608837	38.5 km	Sighting		1	TF	M	Adult
Mountain Goat	*Oreamnos americanus*	Sensitive timing and location information has been redacted to protect this species.										
Mule Deer	*Odocoileus hemionus*	18-Jun-2019	11:39:21	470496	5609210	Gravel bar at ULL-DSSD01	Sighting		1	LI	F	
rodent		21-Jan-2019		467946	5613055	Truckwash Creek	Sighting	ULL-CAM02, likely same rodent photographed repeatedly in January	1	TF	U	Adult
		24-Jan-2019		467946	5613055	Truckwash Creek	Sighting	ULL-CAM02	1	TF	U	Adult
		27-Jan-2019		467946	5613055	Truckwash Creek	Sighting	ULL-CAM02	1	TF	U	Adult
		29-Jan-2019		467946	5613055	Truckwash Creek	Sighting	ULL-CAM02	1	TF	U	Adult

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating

Table 1. Continued.

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
shrew		21-Aug-2019	15:04:35	472932	5606254	ULL River DS (ULL-DSSD05)	Sighting	Ran/swam across side channel to woody debris	1	TF		
Snowshoe Hare	*Lepus americanus*	15-Jan-2019		467903	5612901	Truckwash Creek	Sighting	ULL-CAM08	1	TF	U	Adult
		17-Jan-2019	13:18:00	472893	5611123	Boulder Creek Intake	Sign		1	LI	U	Unknown
squirrel		21-Jan-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15, likely Douglas Squirrel	1	TF	U	Adult
		7-Feb-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	FD	U	Adult
		17-Feb-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	2	LI	U	Adult
		28-Feb-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Adult
		10-Mar-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Adult
		18-Mar-2019		467982	5612841	Truckwash Creek	Sighting	ULL-CAM15	1	TF	U	Adult
Wolverine	*Gulo gulo*	17-Jan-2019	11:37:00	473321	5611348	Boulder Creek Intake	Sign	Tracks were heading down to the Intake road	1	LI	U	Unknown
		26-Feb-2019	07:49:00	470974	5609317	ULL transmission line	Sign	Tracks to the west of Boulder Creek Powerhouse along the transmission line around 39KM crossing the right of way a couple of times.	1	LI	U	Unknown
		26-Feb-2019		471377	5608973	38 - 39.7 km	Sign	ID uncertain; Travelling under transmission lines	1	TF	U	Unknown

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating

Table 2. Incidental wildlife sightings: Avian.

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Accipiter		29-Mar-2019	11:50:00	472882	5611120	Boulder Creek intake	Sign	large unknown tracks	1	LI	U	Unknown
		18-Apr-2019	08:00:00	466114	5614066	ULR Headpond	Sighting	Hunting Ducks	1	HU	U	Unknown
Bald Eagle	*Haliaeetus leucocephalus*	13-Nov-2019	10:23:00	473581	5605580	Alena Creek	Sighting		3	LI	U	Adult
		24-Nov-2019	09:59:00	473591	5605645	Alena Creek	Sighting	Sitting in a tree	1	LI	U	Adult
		24-Nov-2019	10:40:00	473089	5606628	Alena Creek	Sighting	In the trees near the creek	5	LI	U	Unknown
		5-Dec-2019	15:15:00	472686	5606939	36 km	Sighting	Watching from tree tops	2	LI	U	Unknown
		9-Dec-2019		473545	5605443	Alena Creek	Sighting	Feeding on fish carcasses	6	FD	U	Unknown
		9-Dec-2019		473008	5606793	Alena Creek	Sighting		4	LI	U	Adult
Bufflehead	*Bucephala albeola*	10-Apr-2019	09:00:00	466114	5614066	ULR Headpond	Sighting	Avoiding rain, males and females.	3	FD		Adult
		15-Apr-2019	13:00:00	466114	5614066	ULR Headpond	Sighting	Swimming, male and female; number not specified (at least 2)	2	FD		Adult
		15-May-2019	08:00:00	466114	5614066	ULR Headpond	Sighting	2 male and 1 female (listed separately)	2	LI	M	Adult
		15-May-2019	08:00:00	466114	5614066	ULR Headpond	Sighting	1 female with 2 males (listed separately)	1	LI	F	Adult
Chukar	*Alectoris chukar*	20-Nov-2019	16:45:00	470240	5609979	40 km	Sighting	Chukar, on side of the road.	15	TF	U	Unknown
Eagle	*unidentified species*	5-Dec-2019	15:15:00	472686	5606939	36 km	Sighting	Watching from tree tops	2	LI	U	Unknown
Harlequin Duck	*Histrionicus histrionicus*	10-May-2019	11:30:00	473370	5611436	Boulder Intake	Sighting	Adult male and female (entered separately), swimming together.	1	FD	M	Adult
		10-May-2019	11:30:00	473370	5611436	Boulder Intake	Sighting	Swimming with adult male (listed separately)	1	FD	F	Adult
		11-May-2019		473463	5611770	BDR Head Pond	Sighting		1	LI	M	Adult
		11-May-2019		473463	5611770	BDR Head Pond	Sighting		1	LI	F	Adult
		29-May-2019	13:17:28	470503	5609197	Sighting	Sighting	Flying downstream	1	TF	F	
		18-Jun-2019	14:17:22	470496	5609210	Mainstem	Sighting	Harlequin duck female in mainstem adjacent to ULL-DSSD01	1	LI	F	

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating

Table 2. Continued.

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Mallard	*Anas platyrhynchos*	10-Apr-2019	09:00:00	466114	5614066	ULR Headpond	Sighting	Males and females, avoiding rain	6-8	FD		Adult
		15-Apr-2019	13:00:00	466114	5614066	ULR Headpond	Sighting	At least 10; Swimming, males and females	10	FD		Adult
		16-Sep-2019	12:00:00	466114	5614066	ULR Headpond	Sighting	3 female with 2 males (listed separately) swimming.	2	FD	M	Adult
		16-Sep-2019	12:00:00	466114	5614066	ULR Headpond	Sighting	3 females swimming with 2 males (listed separately)	3	FD	F	Adult

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating

Table 3. Incidental wildlife sightings: Reptiles.

Species		Date	Time	UTM Coordinates		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Northwestern Alligator Lizard	*Elgaria coerulea principis*	23-May-2019	15:30:00	468473	5611629	ULR Powerhouse	Sighting		2	FL	U	Unknown

[1]Activity Codes - AL: alert, BA: basking, BE: bedding, BI: birthing, BP: body parts, BU: building nest, CO: courtship, CR: carcass, DE: denning, DI: disturbed, FD: feeding, EX: excreting, FL: fleeing, GR: grooming, HI: hibernating, HU: hunting, IN: incubating, LI: unspecified, RR: rearing, ST: security/thermal, TE: territoriality (singing), TF: traveling, flying, UR: urinating