Upper Lillooet Hydro Project

Operational Environmental Monitoring Year 4

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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 4 of the operational environmental monitoring program (OEMP) for the Upper Lillooet Hydro Project (ULHP) (the Project). The Project is comprised of two hydroelectric facilities (HEFs), 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 methods and results for Year 4 monitoring following the revised OEMP (Harwood *et al.* 2021). Several monitoring components have been completed in previous years. Monitoring components reported on here include those for which monitoring was conducted in Year 4 and for which results are not reported on separately.

Water Temperature and Air Temperature

The objective of monitoring water temperature is to determine Project effects on stream temperature and assess whether any 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 is being monitored continuously for the first five years of operation and will be compared to the baseline data using a Before-After-Control-Impact (BACI) design following completion of the monitoring program. Temperature metrics that were compared to BC Water Quality Guidelines (BC WQG; MECCS 2021) and species and life-history specific optimum temperature ranges included daily and monthly temperatures, length of the growing season, number of extreme temperature days, rate of temperature change, and mean weekly maximum temperature (MWMxT). Air temperature monitoring is also being conducted given its influence on water temperature and ice formation.

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. Operational monitoring for both facilities began in March 2018 and has included data from two new locations for each facility: one at the tailrace and one downstream of the tailrace. In addition, a site was established in North Creek (NTH-USWQ1) to provide replacement data for the Boulder Creek upstream site that is compromised by groundwater inflow during the late fall to early spring period, and the upstream control site in the Upper Lillooet River has been re-established twice (currently ULL-USWQ04). The current operational record for both facilities spans until October 2021.

Baseline and operational monitoring of water temperatures in the Upper Lillooet River and Boulder Creek indicate that both are cold-water streams, characterized by:

- Monthly average water temperatures of all sites in the Upper Lillooet River ranged from 0.4°C to 7.3°C and 0.8°C to 7.6°C, respectively. In Boulder Creek, the monthly average water temperature of all sites during baseline and operational monitoring ranged from 0.5°C to 7.9°C and 0.6°C to 8.8°C, respectively.
- Daily-average temperatures are frequently <1°C during the winter and remain well below 18°C throughout summer.
- The growing season in the Upper Lillooet River was similar at the upstream site during both baseline and operational monitoring (644-degree days to 861-degree days) with the diversion falling inside this range during one year of baseline monitoring (825-degree days). However, during operations there was typically more growing degree days at the diversion and downstream sites than upstream (904 to 1,121-degree days). The length of the growing season in Boulder Creek during baseline (367-degree days at the upstream site to 898-degree days in the diversion) was generally lower, than during operations (644-degree days at the upstream site to 1,185-degree days at the diversion site). Both the Upper Lillooet River and Boulder Creek experienced the longest growing season in the diversion reach in 2019.
- Mean Weekly Maximum Temperature (MWMxT) was most frequently sub-optimally cool in the Upper Lillooet River and Boulder Creek during both baseline and operations. 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 to 2021), MWMxT ranged from 0.2°C to 10.7°C in the Upper Lillooet River and from 0.0°C to 12.1°C in Boulder Creek.

We recommend that the monitoring program continue in 2022 (Year 5), based on the methodologies and schedule prescribed in the OEMP (Harwood *et al.* 2021). We recommend that water temperature data continue to be collected in the upstream reach of Boulder Creek (BDR-USWQ2) and North Creek (NTH-USWQ1) to establish a relationship between water temperatures in the two creeks, and that monitoring continues at the newly established upstream control site in the Upper Lillooet River (ULL-USWQ04) in future years.

Frazil Ice

Air temperature at Callaghan Valley and Pemberton Airport weather stations was monitored from October 2017 to February 2022. As per the frazil ice monitoring protocol, site photographs were collected by operations staff for Upper Lillooet and Boulder Creek during recorded occurrences of three consecutive days of <-5°C at both Pemberton Airport and Callaghan Valley Station. Based on a review of photographs it was determined that conditions did not warrant a site visit as frazil ice was not detected, with the exception of site visits which were conducted on December 23 and 24, 2017 and January 2, 2018. Frazil ice was identified in the margin habitat of Boulder Creek during the

December 23 and 24, 2017 survey; however, the mainstem was free of frazil ice and pool holding habitat was still available. Further the Boulder Creek facility was shut down at the time of the 2017 survey. No frazil ice was identified in the diversion reach of the Upper Lillooet River during the 2017 survey. No frazil ice was identified in the diversion reaches of the Upper Lillooet River or Boulder Creek during the January 2, 2018 survey.

The overall minimum three-day average air temperature threshold during occurrences was -16.4°C as measured at the Callaghan Valley weather station across all OEMP years to date, while the Pemberton Valley station saw a three-day average threshold of -16.0°C, both of which occurred between December 24, 2021 to January 2, 2022. Photographs of the diversion reaches of Upper Lillooet River and Boulder Creek examined during this time did not have frazil ice present. The OEMP stated that the effectiveness and suitability of the frazil ice monitoring and management protocol would be evaluated annually as there was uncertainty in conditions that may lead to frazil ice. Given observations and monitoring to date, we recommend monitoring is continued in each of the Upper Lillooet River and Boulder Creek diversions in Year 5, however the protocols should be updated to a threshold of three consecutive days of -12°C average daily temperature recorded at the Callaghan Valley and Pemberton Airport weather stations. Three periods have been monitored that met these conditions without frazil ice impacts. Revising the thresholds to these updated values will ensure detection of extreme events and monitoring will still occur, and will allow for effective mitigation of adverse effects associated with frazil ice if observed.

Fish Community

Adult Migration and Spawning

Adult fish migration and spawning was assessed within the diversion and downstream reaches of both the Upper Lillooet River HEF and Boulder Creek HEF, the tailrace of each HEF, and a section on North Creek (a reference stream) through angling surveys in 2021. These surveys were conducted to determine if access to the two diversion reaches was impacted by water diversion.

A total of sixteen Bull Trout (*Salvelinus confluentus*) were captured during angling surveys in the Upper Lillooet River (three in the diversion reach, none in the tailrace, and 13 in the downstream reach), and a total of 42 Bull Trout were captured in Boulder Creek (22 in the diversion reach, 9 in the tailrace, and 11 in the downstream reach). At both HEFs, the absence of Bull Trout holding below the powerhouse, and detection in the diversion reach, suggests that movement into the diversion reach was not inhibited by operations. All assessed lower portions of the diversion reaches (lowermost 300 m on Boulder Creek and 500 m on Upper Lillooet) were also deemed to be accessible to fish, with no barriers to migration identified.

Trends in total captures and CPUE have varied across monitoring sites. During operations, total captures and CPUE has decreased in both the Upper Lillooet diversion and tailrace but has been within the typical range, or higher than captures during baseline. Total catch and CPUE has been variable in the downstream reach of Upper Lillooet. In contrast, catch rates and CPUE within the

Boulder Creek diversion and tailrace has generally increased relative to baseline and stayed relatively stable in the downstream reach. Catch rates and CPUE within North Creek, a reference tributary in 2020 and 2021 were significantly higher than in 2019 and higher than baseline monitoring years. An increase in adult Bull Trout spawners was also observed in 2021 in 29.2 km tributary and Alena Creek compared to previous operational monitoring years.

Tributary bank walk spawner surveys were conducted in two reference streams: a tributary at km 29.2 of the Upper Lillooet River (29.2 km Tributary) and Alena Creek. The peak numbers of spawning adult Bull Trout observed in 29.2 km Tributary were higher in 2021 (three) than in previous years under operation (2018 (two), 2019 (zero), and 2020 (one)) but lower than in baseline surveys in 2011 (eight). A similar trend was observed in Alena Creek with the peak numbers of spawning adult Bull Trout in 2021 (five) being higher than in previous years under operation (2018 (two), 2019 (one), and 2020 (zero)), but lower than during baseline surveys in 2011 (nine).

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. Spot checks were conducted in Year 4 (2021) at the intake and the powerhouse on May 17, 23, and 26 ("pair surveys"), and on August 5, 10, and 23 ("brood surveys"). A zoomable surveillance camera was used to view the headpond at the intake on August 5 and 10 due to landslide risk and in person surveys were conducted at the intake on other dates and at the powerhouse on all dates. No Harlequin Ducks were observed during spot checks in Year 4 (2021) or incidentally. Evaluation of monitoring results from all the years of the monitoring program will occur in Year 5.

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. Most wildlife species incidentally observed in Year 4 have also been recorded in previous years. However, a Northern Red-legged Frog (*Rana aurora*) and Great Blue Heron (*Ardea herodias*) were seen at Alena Creek in September and November 2021, respectively. Documenting incidental wildlife observations will continue in Year 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 (*Ursus arctos*), Moose (*Alces americanus*), and Elk (*Cervus elaphus*), and particularly along the Project access roads.

Wildlife Habitat Monitoring

Habitat Restoration - Mammal Habitat

The objective of mammal habitat compliance monitoring is to confirm that habitat restoration measures prescribed to minimize sensory disturbance and visibility of the transmission line corridor from adjacent Project roads had been implemented for Grizzly Bear, Moose, and Mule Deer (*Odocoileus hemionus*) habitat. It was recommended in Year 3 that monitoring at 18 of 29 mammal restoration compliance monitoring sites (where assessment of vegetated screens is conducted) be continued in Year 5; however, the need for further monitoring was reconsidered in Year 4 based on an assessment of site-specific transmission line safety constraints for vegetated screen height, because this could have implications for the achievability of target screen heights. The assessment suggested that target heights of all vegetation screens for which continued monitoring in Year 5 was recommended are achievable; thus, all recommendations made in Year 3 are unchanged.

Mountain Goats at 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 (November 1 to June 15); 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 4 through remote infrared cameras placed along the access road and in the vicinity of the Boulder Creek HEF intake.

Access monitoring results over four years have demonstrated that the gate presents an effective physical barrier for motorized vehicles when the gate is not buried in snow during the Mountain Goat winter period. However, the gate becomes non-functional when buried by snow, and although no snowmobiles were documented accessing the intake area in Year 4 (as they were in Year 3), there is currently no physical barrier in place for snowmobiles; thus, without increasing the height of the gate, protection of Mountain Goats in the UWR during these time periods is dependent on the public noting and respecting newly installed signage. Given that recreational use of the area can be expected to continue to increase (increased winter recreational use was documented over the four years of monitoring), we have four specific recommendations related to preventing motorized public access during the Mountain Goat winter period for the life of the Project. We recommend that:

- Monitoring occur during mid- to late-winter when the gate is buried in snow through a sub-sampling design (e.g., once every five years or one month every year) to account for changing conditions in the Project area in the future (e.g., increasing recreational activity). Adaptive management will be implemented to restrict motorized public use past the gate if motorized access past the gate increases during the winter.
- Signage (two signs, one at the base of the access road and one at the gate) is inspected regularly and maintained in good condition.

- Actions are continued to be taken to ensure that Project personnel keep the gate closed.
- Project-related access of the intake area by snowmobiles (or snowcats) is minimized.

Monitoring results have detected no apparent change in predator presence or behavior in the vicinity of the UWR at the Boulder Creek HEF intake during the four years of post-construction monitoring. Based on the number of predator detections recorded during the monitoring period overall, the behaviour of potential predators in terms of road use, and the species-specific frequencies of detections, there is no evidence that predation risk to Mountain Goats using the UWR has increased since Project construction. We therefore conclude that predator monitoring is complete.

TABLE OF CONTENTS

EXECUTIVE SUMMARY .... **III**

LIST OF FIGURES .... **XII**

LIST OF TABLES .... **XV**

LIST OF MAPS .... **XIX**

LIST OF APPENDICES .... **XIX**

1. INTRODUCTION **1**

2. OBJECTIVES AND BACKGROUND **7**

2.1. INSTREAM FLOW MONITORING 7
2.2. MITIGATION AND COMPENSATION MEASURES 7
2.3. AQUATIC AND RIPARIAN HABITAT 7
2.4. WATER TEMPERATURE AND ICING 7
2.4.1. Frazil Ice 8
2.5. STREAM CHANNEL MORPHOLOGY 9
2.6. FISH COMMUNITY 9
2.7. WATER QUALITY 10
2.8. WILDLIFE SPECIES MONITORING 10
2.8.1. Harlequin Ducks 10
2.8.2. Species at Risk & Regional Concern 11
2.9. WILDLIFE HABITAT MONITORING 11
2.9.1. Habitat Restoration – Amphibian Habitat 11
2.9.2. Habitat Restoration – Mammal Habitat 11
2.9.3. Mitigation Effectiveness - Mountain Goats at Boulder Creek 14
2.10. VEGETATION MONITORING 15

3. METHODS **15**

3.1. WATER TEMPERATURE AND AIR TEMPERATURE 15
3.1.1. Study Design 15
3.1.2. Fish Species Distribution and Optimum Temperatures 19
3.1.3. Quality Assurance/Quality Control 20
3.1.4. Data Collection and Analysis 20
3.1.5. Applicable Guidelines 21
3.1.6. Frazil Ice 23
3.2. FISH COMMUNITY 24
3.2.1. Adult Migration and Spawning 24
3.3. WILDLIFE SPECIES MONITORING 25

3.3.1. Harlequin Ducks ... *25*
3.3.2. Species at Risk & Regional Concern ... *26*
3.4. WILDLIFE HABITAT MONITORING ... 26
3.4.1. Habitat Restoration – Mammal Habitat ... *26*
3.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek ... *29*

4. RESULTS ... 31

4.1. WATER TEMPERATURE AND AIR TEMPERATURE ... 31
4.1.1. Overview ... *31*
4.1.2. Monthly Summary Statistics ... *39*
4.1.3. Growing Season Degree Days ... *48*
4.1.4. Hourly Rates of Water Temperature Change ... *52*
4.1.5. Daily Temperature Extremes ... *57*
4.1.6. Bull Trout Temperature Guidelines ... *60*
4.1.7. Mean Weekly Maximum Temperature (MWMxT) ... *62*
4.1.8. Frazil Ice ... *77*
4.2. FISH COMMUNITY ... 86
4.2.1. Adult Migration and Spawning ... *86*
4.3. WILDLIFE SPECIES MONITORING ... 95
4.3.1. Harlequin Ducks ... *95*
4.3.2. Species at Risk & Regional Concern ... *95*
4.4. WILDLIFE HABITAT MONITORING ... 96
4.4.1. Habitat Restoration – Mammal Habitat ... *96*
4.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek ... *100*

5. RECOMMENDATIONS ... 113

5.1. WATER TEMPERATURE AND AIR TEMPERATURE ... 113
5.1.1. Frazil Ice ... *114*
5.2. FISH COMMUNITY ... 114
5.2.1. Adult Fish Migration and Spawning ... *114*
5.3. WILDLIFE SPECIES MONITORING ... 114
5.3.1. Harlequin Ducks ... *114*
5.3.2. Species at Risk & Regional Concern ... *115*
5.4. WILDLIFE HABITAT MONITORING ... 115
5.4.1. Habitat Restoration – Mammal Habitat ... *115*
5.5. MITIGATION EFFECTIVENESS – MOUNTAIN GOATS AT BOULDER CREEK ... 115
5.5.1. Public Access Monitoring ... *115*
5.5.2. Predator Monitoring ... *116*

6. CLOSURE ... 117

REFERENCES 118

PROJECT MAPS 124

APPENDICES 130

LIST OF FIGURES

Figure 1. Daily mean, maximum, and minimum water temperature recorded in the Upper Lillooet River during operations (2018 to 2021).......33

Figure 2. Daily mean, maximum and minimum water temperature recorded in Boulder Creek during operations (2018 to 2021).......35

Figure 3. Cumulative frequency distribution of instantaneous water temperature differences between control and impact Upper Lillooet River sites and ULL-USWQ03 (the upstream control site established in Year 2) during operations (2018 to 2021). Positive values denote that water temperature at the site of interest was warmer than the upstream control site (ULL-USWQ03).......37

Figure 4. Cumulative frequency distribution of instantaneous water temperature differences between the control and impact Boulder Creek monitoring sites and BDR-USWQ2 during operations (2019 to 2021). Positive values denote that the site of interest sites was warmer than the upstream control site (BDR-USWQ2).......38

Figure 5. Upper Lillooet River summary of the hourly rate of change (°C/hr) during operations. .55

Figure 6. Boulder Creek summary of hourly rate of change (°C/hr) for each year during operations. 56

Figure 7. Average daily air temperature data from October 2021 to February 2022 at Callaghan Valley air temperature monitoring station. Note the threshold is met when air temperature is less than -5°C for at least three consecutive days. This figure is inclusive of those three days. 78

Figure 8. Average daily air temperature data from October 2021 to February 2022 at Pemberton Airport air temperature monitoring station. Note the threshold is met when air temperature is less than -5°C for at least three consecutive days. This figure is inclusive of those three days. 78

Figure 9. Looking upstream at Boulder Creek diversion on December 28, 2021. 79

Figure 10. Looking river right to river left at Boulder Creek on December 28, 2021.......79

Figure 11. Looking downstream at Boulder Creek diversion on December 28, 2021.......80

Figure 12. Looking upstream at Upper Lillooet diversion reach from the tailrace on December 28, 2021.......80

Figure 13. Looking river left to river right at Upper Lillooet diversion on December 28, 2021.......81

Figure 14. Looking downstream at Upper Lillooet from the tailrace on December 28, 2021.......81

Figure 15. Average daily air temperature data from October 2017 to February 2022 at Callaghan Valley air temperature monitoring station. Note the threshold is met when air temperature are less

than -5°C for at least three consecutive days. This figure is inclusive of those three days. 84

Figure 16. Average daily air temperature data from October 2017 to February 2022 at Pemberton Airport air temperature monitoring station. Note the threshold is met when air temperature are less than -5°C for at least three consecutive days. This figure is inclusive of those three days. 85

Figure 17. Comparison of Bull Trout mean catch per unit effort between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on the Upper Lillooet River. Error bars shown are standard error. 90

Figure 18. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on Boulder Creek. Error bars shown are standard error. 92

Figure 19. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at monitoring sites on North Creek. Error bars shown are standard error. 93

Figure 20. Mountain Goat photographed by ULL-CAM15 on January 29, 2021. 96

Figure 21. Two skiers heading upslope photographed on December 19, 2021, at 15:00 by BDR-CAM03. 102

Figure 22. Group of skiers photographed on May 10, 2021 at 10:57 by BDR-CAM02. The same group was also photographed on the same day by BDR-CAM04 at 11:03 and by BDR-CAM08 at 11:04. 102

Figure 23. Signage posted prior to the start of the 2021/2022 winter period at base of the access road warning the public of a gate with access restrictions ahead. 103

Figure 24. Signage posted prior to the start of the 2021/2022 winter period at the location of the gate informing the public that access by motorized vehicles is prohibited during the Mountain Goat winter period. 103

Figure 25. Cougar photographed walking along the access road by BDR-CAM02 on November 3, 2021 at 07:40. A second cougar (likely the same individual) was photographed by the same camera on the same day walking along the road in the opposite direction at 17:11. 107

Figure 26. Grizzly Bear photographed walking along the access road on May 21, 2021, at 9:22 am by BDR-CAM01. A Grizzly Bear was also photographed by the same camera walking in both directions along the access road on May 20, 2021 (at 8:41 and 9:51 am). 108

Figure 27. Grizzly Bear photographed by BDR-CAM02 on January 2, 2021 at 15:49. 108

Figure 28. American Black Bear photographed along Boulder Creek HEF access road by BDR-CAM02 on June 2, 2021. 109

Figure 29. Wolverine photographed on the access road by BDR-CAM02 on December 17, 2021, at 00:14. It is evident that this wolverine is breaking though fresh snow (tracks behind but not in front of the animal). 109

Figure 30. Wolverine photographed upslope of the Boulder Creek HEF intake on the access road by BDR-CAM02 on December 17, 2021, at 12:31, travelling in an existing track. 110

Figure 31. Mountain Goat photographed upslope of the Boulder Creek HEF access road by BDR-CAM08 on October 31, 2021 at 11:37 am. Likely the same individual was also photographed along the access road by BDR-CAM02 at 11:21 on the same day. 110

LIST OF TABLES

Table 1. Summary of aquatic monitoring parameters and components specified in the updated OEMP (Harwood *et al.* 2021)........5

Table 2. Summary of terrestrial monitoring parameters and components specified in the updated OEMP (Harwood *et al.* 2021)........6

Table 3. Compliance monitoring required for mammal species (from Harwood *et al.* 2021) (see text for items previously confirmed complete). 13

Table 4. Summary of water temperature site names, location, and period of data record in the Upper Lillooet River during baseline (2008 to 2013) and operational monitoring (2018 to 2021). 17

Table 5. Summary of water temperature site names, location, and period of data record in Boulder Creek during baseline (2008 to 2013) and operational monitoring (2018 to 2021). 18

Table 6. BC WQG optimum temperature ranges and fish species distribution in the Upper Lillooet River and Boulder Creek (MECCS 2021). 19

Table 7. Description of water temperature metrics and methods of calculation. 23

Table 8. Mammal vegetated screen monitoring sites at which screens had not achieved required dimensions by Year 3 and may require reassessment in Year 5........28

Table 9. Remote infrared camera locations at the Boulder Creek HEF intake and intake access road and camera functionality during the Mountain Goat winter period during Year 4 monitoring (December 23, 2020 to June 15, 2021, and November 1, 2021 to January 26, 2022). 31

Table 10. Upper Lillooet River operational monthly water temperature summary statistics (2018 to 2021). 40

Table 11. Boulder Creek operational monthly water temperature statistics (2018 to 2021). 42

Table 12. Upper Lillooet River operational (2018 to 2021) air temperature monthly data summary statistics. 45

Table 13. Boulder Creek operational (2018 to 2021) air temperature data summary statistics. 47

Table 14. Upper Lillooet River growing season length and degree days during baseline and operational periods. 50

Table 15. Boulder Creek growing season length and degree days during baseline and operational periods. 51

Table 16. 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. 53

Table 17. 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. 54

Table 18. Upper Lillooet River summary of daily average water temperature extremes (number of days >18°C and <1°C). 58

Table 19. Boulder Creek summary of daily average water temperature extremes (number of days >18°C and <1°C). 59

Table 20. 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 (Oliver and Fidler 2001). 61

Table 21. Boulder Creek summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout BC WQG thresholds (Oliver and Fidler 2001). 62

Table 22. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ1) during baseline monitoring (2008 to 2013). 64

Table 23. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ02) during operational monitoring (2018 to 2019). 65

Table 24. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ03) during operational monitoring (2018 to 2021). 66

Table 25. MWMxTs measured during Coho Salmon life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring. 67

Table 26. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring. 68

Table 27. MWMxTs measured during Bull Trout life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring. 69

Table 28. MWMxTs measured during Coho Salmon life history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021). 70

Table 29. MWMxTs measured during Cutthroat Trout history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021). 71

Table 30. MWMxTs measured during Bull Trout life history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021). 72

Table 31. MWMxTs measured during Cutthroat Trout life history stages in the Boulder Creek diversion reach (BDR-DVWQ) during baseline (2008 to 2013) and operational (2018 to 2021) monitoring. 73

Table 32. MWMxTs measured during Bull Trout life history stages in the Boulder Creek diversion reach (BDR-DVWQ) during baseline (2008 to 2013) and operational (2018 to 2021) monitoring. 74

Table 33. MWMxTs measured during Cutthroat Trout life history stages in the Boulder Creek downstream reach (BDR-DSWQ) during operational monitoring (2018 to 2021). 75

Table 34. MWMxTs measured during Bull Trout life history stages in the Boulder Creek downstream reach (BDR-DSWQ) during operational monitoring (2018 to 2021). 76

Table 35. Summary of dates when air temperature was less than -5°C for at least three consecutive days during Year 4 (October 2021 to February 2022). 77

Table 36. Summary of dates when air temperature was less than -5°C for at least three consecutive days during years 1 through 4 (October 2017 to February 2022). 83

Table 37. Summary of Bull Trout capture data during angling surveys conducted in the Upper Lillooet River, Boulder Creek, and North Creek in fall of 2021 87

Table 38. 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 fall of 2021 88

Table 39. Summary of results from spawner surveys conducted in Alena Creek and 29.2 km Tributary in fall of 2021 89

Table 40. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on the Upper Lillooet River. 90

Table 41. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on Boulder Creek. 91

Table 42. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at monitoring sites on North Creek. 92

Table 43. Comparison of adult Bull Trout observed during tributary bank walk spawner surveys between baseline (2011) and operational years (2018 to 2021) to date on Alena Creek. 94

Table 44. Comparison of adult Bull Trout observed during tributary bank walk spawner surveys between baseline (2011) and operational years (2018 to 2021) to date on 29.2 km Tributary. 94

Table 45. Results of Harlequin Duck spot check surveys at the ULR HEF intake and powerhouse in Year 4 (2021). 95

Table 46. Mammal vegetated screen monitoring sites that had not achieved required dimensions by Year 3, associated wildlife habitat polygon assessed in Staven (2022), and conclusion regarding Year 5 monitoring needs. 98

Table 47. 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 4 monitoring period (December 23, 2020 to June 17, 2021 and October 26, 2021 to January 26, 2022). 104

Table 48. Potential predators of Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road during the Year 4 monitoring period (December 23, 2020 to June 17, 2021 and October 26, 2021 to January 26, 2022). All detections occurred in the Mountain Goat winter and spring seasons (November 1 to June 15). 111

Table 49. Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road during the Year 4 monitoring period (February 18 to June 17, 2021 and October 26, 2021 to January 26, 2022). 111

Table 50. Summary of Mountain Goat potential predators documented during baseline surveys and monitoring Years 1 to 4 in the Mountain Goat wintering period (November 1 to June 15). 112

Table 51. Numbers of predator detections during the Mountain Goat wintering period per functional camera-day for the four post-construction monitoring years. 113

LIST OF MAPS

Map 1. Project Overview 4

Map 2. Upper Lillooet River Water Temperature and Air Temperature Monitoring Sites. 125

Map 3. Boulder Creek and North Creek Water Temperature and Air Temperature Monitoring Sites. 126

Map 4. ULHP Frazil Ice Monitoring Sites 127

Map 5. Bull Trout Migration and Distribution Monitoring Sites.. 128

Map 6. Boulder Creek Mountain Goat Predator Monitoring.. 129

LIST OF APPENDICES

Appendix A. Alena Creek Fish Habitat Enhancement Project: Year 4 Monitoring Report

Appendix B. Hedberg Vegetation Monitoring Report

Appendix C. Representative Water Temperature and Air Temperature Site Photographs

Appendix D. Water Temperature Guidelines and Data Summary

Appendix E. Upper Lillooet Hydro Project Standard Operating Procedure: Harlequin Duck Spot Check Protocol

Appendix F. Water Temperature QAQC Figures

Appendix G. Angling Site Representative Photographs, Site Conditions Summary, and Individual Fish Data

Appendix H. Incidental Wildlife Observations

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 4 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 (Upper Lillooet River HEF) is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119), and the smaller (Boulder Creek HEF) 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). This original OEMP was revised, and revisions were approved in 2021 (Harwood *et al.* 2021). 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.

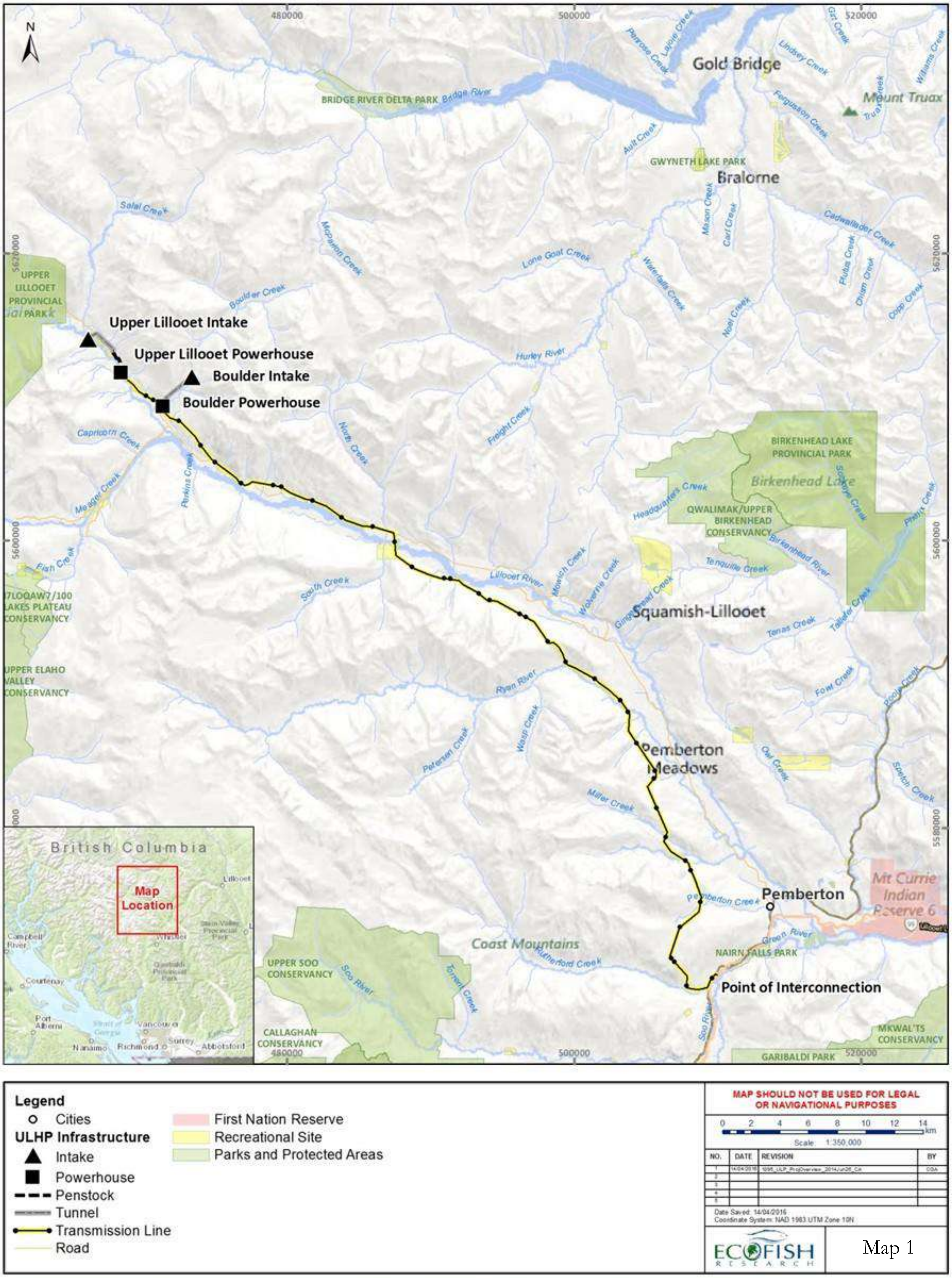
The OEMP prescribes three types of monitoring: compliance, effectiveness, and response. Compliance monitoring is conducted to ensure that conditions outlined in the EAC (EAO 2013), DFO *Fisheries Act* Authorization (09-HPAC-PA2-00303), and water licences are adhered to. Effectiveness monitoring is conducted 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 results from Year 4 (2021) of operational monitoring in accordance with requirements of the revised OEMP (Harwood *et al.* 2021). 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 and 2021)). 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). Year 4 aquatic monitoring results are presented in this report for components related to water temperature/icing, and fish community (i.e., migration and spawning), including species risk or special concern (Bull Trout (BT) and Cutthroat Trout (CT)). For other components, reporting is either being completed separately or monitoring was not conducted in Year 4. Stage and discharge monitoring for instream flow release (IFR) and ramping compliance are monitored in real time year-round and are presented in annual compliance reports submitted separately for the life of the Project. The monitoring program for the Project's fish habitat compensation project, Alena Creek, is presented in Appendix A as a standalone report. Footprint impact verification was completed in Year 1, revegetation monitoring is being conducted in years 1, 3, and 5, and stream morphology monitoring will be conducted only in Year 5 (Table 1). Water quality monitoring was removed from the OEMP after one year of monitoring following recommendations in Year 1 (Regehr et al. 2019), although alkalinity will continue to be monitored once per year in conjunction with fish sampling (Harwood *et al.* 2021).

Terrestrial monitoring parameters included in the OEMP are wildlife species, wildlife habitat, and vegetation (Table 2). Results of Year 4 monitoring components include response monitoring for Harlequin Ducks (*Histrionicus histrionicus*), species at risk, and species of regional concern, as well as effectiveness monitoring related to the Boulder Creek HEF intake area (public access and predator monitoring). Habitat restoration monitoring for mammals was conducted in Year 1 and Year 3 to confirm that vegetated screens had attained their required size; further monitoring was recommended for some monitoring sites in Year 5, but these recommendations have been re-evaluated here (in Year 4) based on an assessment of site-specific transmission line safety constraints. Habitat restoration monitoring was conducted for Coastal Tailed Frogs (*Ascaphus truei*) in Year 1 and a spot check occurred in Year 3 to confirm that all restoration prescriptions were implemented at the penstock crossing of the Upper Lillooet River HEF; an additional spot check is recommended for Year 5. Vegetation restoration monitoring is being conducted in years 1, 3, and 5 and is therefore not reported on here. All other monitoring components that were scheduled to occur only in Year 1 (Table 2) have been completed, including avian habitat restoration monitoring and mitigation effectiveness monitoring for avian collisions and Truckwash Creek portal design.

Project Overview



Map 1

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Table 1. Summary of aquatic monitoring parameters and components specified in the updated OEMP (Harwood *et al.* 2021).

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
	Ramping rates	Compliance	ULL, BDR	Continuous	Life of project	Annually
	Connectivity	Compliance	ULL, BDR	Once	Immediately post-construction	Once
Mitigation and compensation measures	Compensation projects	Compliance	ULL	Once	Immediately post-construction	Once
		Effectiveness	ULL	Anually	Years 1 through 5	Annually
Aquatic and riparian habitat	Footprint impact verification	Compliance	ULL, BDR	Once	Immediately post-construction	Once
	Revegetation assessment	Effectiveness	ULL, BDR	Anually	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	Once
Fish abundance and behavior	Compensation projects	Effectiveness	ULL	Anually	Years 1 through 5	Annually
	Resident fish density (EF)	Response	ULL	Anually	Years 1, 2, 5 and 2 more years between Year 7 and 10[4]	Annually
	Resident fish density (SN)		BDR	Anually	Years 1, 2, 5 and 2 more years between Year 7 and 10[4]	Annually
	Migration and Spawning (BT)	Response	ULL, BDR	Anually	Years 1 through 5	Annually
	Migration and Spawning (CT)		ULL	Anually	Year 1	Annually
Secondary						
Water Quality	Overall project	Response	ULL	Bi-Annual	Year 1	Annually
Species at risk or of concern[5]	BT and CT	Response	ULL, BDR	Anually	See Fish abundance and behaviour	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 rests need only be conducted once if fry are present

4: Total of five years of operational monitoring unless otherwise approved by MFLNRORD. Value of monitoring beyond Year 5 (ie. beyond 3 years of operational monitoring) will be re-assessed based on results after Year 5 sampling. Individual sampling years may be subject to change based on safety/access considerations.

5: 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 updated OEMP (Harwood *et al.* 2021).

Parameter	Project Component	Sub-component	Monitoring Type	Facility	Monitoring Requirements		
					Frequency[1]	Duration	Reporting
Wildlife Species	Harlequin Ducks	-	Response	ULL	Multiple	Years 1 to 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, 3 and 5	Annually
	Invasive Plants		Compliance/ Effectiveness	All	Annually	Years 1, 3 and 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 be 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

To measure compliance with the instream flow requirement (IFR) set out in the DFO *Fisheries Act* Authorization and conditional water license, accurate, real-time, instantaneous flow data are being collected throughout the life of the Project. Ramping rate compliance reporting is also required for the life of the Project. The IFR and ramping compliance reporting for Year 4 will be completed separately by ULHP.

2.2. Mitigation and Compensation Measures

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

2.3. Aquatic and Riparian Habitat

Footprint impact verification compliance monitoring was completed in Year 1. Effectiveness monitoring for revegetation of riparian habitat is being conducted in years 1, 3, and 5 (Table 1) and is therefore not reported on here. Objectives of the riparian revegetation effectiveness monitoring are to evaluate the early successional growth and survival of natural and planted vegetation within riparian areas disturbed by Project construction to ensure compliance criteria are met.

2.4. Water Temperature and Icing

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 and frazil ice (Section 2.4.1) is being monitored continuously in the Upper Lillooet River and Boulder Creek for the life of the project, as per the EAC (EAO 2013). The objective of monitoring water temperature is to identify any biologically significant differences (as defined in Harwood *et al.* 2021) between baseline and operational temperature regimes in the streams. To achieve this, water temperature is being monitored continuously for the first five years of operation and compared to the baseline data using a Before-After-Control-Impact (BACI) design. Potential Project effects, using a BACI analysis, will be evaluated following completion of five years of temperature monitoring.

In addition to directly assessing potential differences in water temperature between pre- and post-Project periods in control and impact sites, water temperature monitoring was conducted to assess potential effects to fish caused by Project operation; thus, water temperature is being analyzed and compared between baseline and operational periods with statistics relevant to fish. This involves producing water temperature metrics important to key life history phases of fish and relating these to established guidelines and optimum temperature ranges and thresholds for fish species occurring at the Upper Lillooet River and Boulder Creek.

Commencing in Year 1 of operations (March 2018 at most sites), water temperature was monitored at four sites (one control site and three impact sites) for each of the two HEFs (Upper Lillooet River HEF and the Boulder Creek HEF): one upstream control site, one impact site in the lower diversion, one impact site in the tailrace, and one impact site downstream of the tailrace (Map 2, Map 3). The upstream and diversion sites were established during baseline monitoring; the sites at the tailrace and downstream of the tailrace were established for operational monitoring to assist in evaluation of potential temperature effects in the downstream reach of the Project. During Year 1 monitoring (see Regehr *et al.* 2019), 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, therefore in November 2018 an additional upstream control site (ULL-USWQ03) was established to replace the original site (Map 2). This site (ULL-USWQ03) was washed out sometime between May 11, 2021, and October 2021; in 2021, another new upstream control site (ULL-USWQ04) was therefore established.

It was also identified in Year 1 that the baseline water temperature regime at the upstream control site in Boulder Creek (BDR-USWQ) was influenced by groundwater from late fall to early spring. Given that data influenced by localized groundwater inflow at BDR-USWQ can not be used as an effective baseline control record, a new upstream location was established in September 2018 for operational sampling in Boulder Creek (BDR-USWQ2) (Map 3). In addition, another reference site was established in North Creek (NTH-USWQ1) for the purpose of replacing baseline data from BDR-USWQ, which was compromised by groundwater inflow during the late fall to early spring period, following at least one year of concurrent water temperature monitoring.

This Year 4 (2021) annual monitoring data report provides a summary of baseline (2008 to 2013) and operational (March 2018 to October 2021) water and air temperature monitoring results for the Upper Lillooet River and Boulder Creek HEFs. This report is intended to be primarily a data summary report. Any changes in water temperature related to the operation of each Project will be evaluated with a BACI analysis following five years of operational water temperature data collection.

2.4.1. 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 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, which 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.

2.5. Stream Channel Morphology

Operational monitoring of stream morphology will be conducted 5 years after facility commissioning as outlined in the OEMP (Harwood *et al.* 2021).

2.6. Fish Community

The construction and operation of a run-of-river hydroelectric facility has the potential to affect the health of the fish community directly or indirectly. 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. The monitoring program assesses potential Project effects on fish communities in response to Project operations using a BACI study design. Fish community monitoring, as outlined in the OEMP, includes sub-components of juvenile density and biomass, adult migration and distribution, and entrainment at the Upper Lillooet River HEF intake (Harwood *et al.* 2021). The OEMP underwent revisions in 2021 and sampling for juveniles was determined not to be required in years 3 or 4 but will be conducted in Year 5 (Harwood *et al.* 2021).

Given that juvenile sampling was not conducted in Year 4, monitoring in Year 4 focused on the single migration and spawning fish community monitoring sub-component. The objective of this sub-component 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. Because this monitoring sub-component specifically targets Bull Trout, fieldwork was done during the Bull Trout spawning window (however, any captured Cutthroat Trout were also processed).

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, angling and bank walk surveys were used for monitoring adult migration and distribution with tagging used to help assess movement. Angling surveys were conducted at established monitoring sites (shown in Map 5) in high-grade Bull Trout habitat, that had been identified by experienced fisheries technicians. Bank walk surveys were conducted from the confluence with the Upper Lillooet River upstream to the same end point on each survey.

For the adult migration and spawning component, monitoring was conducted in the diversion and downstream reaches of both the Upper Lillooet River HEF and the Boulder Creek HEF, as well as in three reference streams (tributary at river km 29.2 of the Upper Lillooet River, Alena Creek, and North Creek). Alena Creek is also the location of the fish habitat compensation for the Project.

2.7. 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 collected at the Upper Lillooet River Hydroelectric Facility indicate that the parameters measured under operating conditions have very similar values compared to what was observed under baseline conditions. Parameter values are also within typical ranges for BC watercourses and within applicable BC Water Quality Guidelines (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.

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, Regehr (2019) recommended that that the water quality monitoring component be removed from the OEMP in years 2, 3, 4, and 5.

Alkalinity will continue to be monitored once per year in conjunction with fish sampling for use in calculations of stream productivity (Harwood *et al.* 2021).

2.8. Wildlife Species Monitoring

Project footprint and operational effects are being evaluated for select wildlife species through response monitoring with the objective of evaluating potential operational effects and providing an opportunity to adaptively manage any such identified effects. Response monitoring is prescribed in the OEMP for Harlequin Ducks (*Histrionicus histrionicus*) and for species at risk and of regional concern. 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 was completed in Year 1 with one exception (described in Section 4.6.1.1 in Regehr *et al.* (2019)). Monitoring of Grizzly Bears (*Ursus arctos*) 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. Response monitoring for Harlequin Ducks and species at risk and of regional concern was conducted in Year 4 and will continue for one more year (Table 2).

2.8.1. Harlequin Ducks

The objective of Harlequin Duck (*Histrionicus histrionicus*) monitoring is to confirm continued use by Harlequin Ducks of the Project area. These objectives are being met by conducting vantage point surveys (spot checks) (RISC 1998), along with the recording and compilation of incidental observations. Although these methods do not assess all impacted areas for occupancy by Harlequin Ducks or provide absolute abundance measures, they can be used to estimate indices of relative abundance that allow comparison among time periods. Harlequin Duck monitoring is prescribed for the first five years of Project operations (Table 2) with detailed reporting required in years 1, 3, and 5, and brief reporting, consisting of a summary table of results, provided in years 2 and 4.

2.8.2. Species at Risk & Regional Concern

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, 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 these data to the province will contribute to the provincial database.

2.9. Wildlife Habitat Monitoring

Monitoring for several wildlife habitat sub-components was completed in previous years. Avian habitat restoration prescribed for Harlequin Ducks and Peregrine Falcons (*Falco peregrinus*) were completed in Year 1 (Regehr *et al.* 2019; Table 2). Similarly, mitigation effectiveness 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; Table 2). Two wildlife cameras (ULL-CAM02 and ULL-CAM15) were left in place along the Truckwash Creek migration corridor and observations of species at risk and regional concern from these cameras are included as incidental observations.

2.9.1. 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. Due to geotextile becoming exposed at ULL-ASTR04 (Regehr *et al.* 2019), work was completed in the fall of 2019 to cover exposed geotextile and a spot check was conducted in Year 3 (2020). An additional spot check was recommended at ULL-ASTR04 for Year 5.

2.9.2. Habitat Restoration – Mammal Habitat

Mammal habitat restoration measures were prescribed for Grizzly Bear, Moose (*Alces americanus*), and Mule Deer (*Odocoileus hemionus*) owing to potential effects to habitat of these species during Project construction and to the potential for sensory disturbance that may result when vegetation is cleared and/or access is increased. The objective of mammal habitat compliance monitoring was therefore to confirm that habitat restoration measures had been implemented. For all three species, this involved: 1) confirming that vegetated screens had been maintained or restored 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 (Table 3). Additionally, for Grizzly Bears, compliance monitoring was required 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). As stated in Year 1 (Regehr *et al.* 2019) or Year 2 (Harwood *et al.* 2021) reports, access roads in WHA 2-399 were confirmed to have been deactivated, garbage and food waste were being disposed of properly, and greater than 50% planted vegetation composed of native fruit bearing shrubs was confirmed (requirements for Grizzly Bear). Further, revegetation requirements for planted vegetation for Moose and Mule Deer were adequately addressed in Year 1. Thus, these monitoring components were considered complete.

Compliance monitoring of vegetated screens for the three mammal species was conducted at a total of 29 restoration monitoring sites, which had been identified in Year 1 and where vegetated screen assessment was conducted. Some monitoring sites had been established to monitor requirements for a single mammal species and others applied to more than one species. Monitoring results from Year 1 (Regehr *et al.* 2019) indicated that many vegetation screens had not attained target dimensions (5 m height and width). Additional monitoring was therefore conducted in Year 3 (Faulkner *et al.* 2021), after which it was determined that screens remained inadequate at 18 of the 29 restoration monitoring sites. Thus, it was recommended in Year 3 that these sites be revisited in Year 5; however, it was also stated that the need for further monitoring would be reconsidered in Year 4 based on an upcoming assessment of site-specific transmission line safety constraints for vegetated screen height (Staven 2022), which may identify locations where it was not feasible for screens to reach target dimensions due to transmission line maintenance. As part of this Year 4 report, we have therefore considered results from the assessment of site-specific transmission line safety constraints (Staven 2022) and re-evaluated Year 3 recommendations accordingly.

Table 3. Compliance monitoring required for mammal species (from Harwood *et al.* 2021) (see text for items previously confirmed complete).

Species	Project Component	Facility	Location	Prescription
Grizzly Bear	Upper Lillooet River HEF	Transmission Line	WHA 2-399	• A vegetated screen is maintained or is regrowing between the transmission line RoW and WHA 2-399, following construction and vegetation maintenance.[1] • At least 50% of the planted stems within the revegetated portion of the Grizzly Bear WHA 2-399 are native fruit bearing shrubs.[4] • Temporary roads or access tracks are deactivated and non-drivable with an ATV.[4]
			South Lillooet River FSR	• A vegetated screen (5 m high and wide) is maintained or is regrowing between the transmission line RoW and the Lillooet South FSR where feasible.[2,3]
			All	• A vegetated screen (5 m high and wide) is maintained or is regrowing between field verified suitable foraging habitat (Class 1 and Class 2) and roads or transmission line RoWs, and additional clearings, wherever feasible, following construction and vegetation maintenance.[2,3]
	All	All	All	• Food waste is being disposed of in animal proof containers.
Moose	Upper Lillooet River HEF	Transmission Line	All	• Vegetated screens (5 m high) are permitted to grow where the transmission line RoW is within 10 m of active FSRs or permanent Project access roads, within the Moose ungulate winter range (UWR), where feasible.[2,3] • At least 50% of the planted stems within the revegetated portion of the Moose UWR, away from road verges, are preferred Moose forage species (Appendix A).[5]
Mule Deer	Upper Lillooet River HEF	Transmission Line	All	• Vegetated screens (5 m high and wide) are maintained or are regrowing where the transmission line RoW is within 10 m of active FSRs or permanent Project access roads, within the Deer UWR, where feasible.[2,3,5] • Revegetated portion of the Deer UWR were planted with native species.[5]

[1] Condition 12 of the Project's EA Certificate (EAO 2013) and condition of the GWM Exemption 39585-20 WHA (Berardunicci 2013b).

[2] WorkSafeBC safety constraints may prevent such a high screens as the transmission line is designed to meet the CSA Standards.

[3] Note that locations where maintaining a vegetated screen was not feasible must be documented and presented to EAO during the construction phase, as stated within Condition 12 of the Project's EA Certificate (EAO 2013).

[4] Condition of the GWM Exemption 39585-20 WHA (Berardunicci 2013b).

[5] Condition of the GWM Exemption 78700-35/06 UWR (Berardunicci 2013b).

2.9.3. Mitigation Effectiveness - Mountain Goats at Boulder Creek

Mitigation effectiveness monitoring is being conducted 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). 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 beyond the gate was accessible by ATV during the snow-free period when the gate was required to be closed and, in accordance with recommendations made in Year 1, a lock block was placed on the upslope side of the gate in 2019 to prevent potential motorized access around the gate. Also, in accordance with recommendations made in Year 1, an internal electronic reminder was set up to ensure the gate would be closed on November 1 (Katamay-Smith 2020, pers. comm.) and signage was posted at the base of the access road to inform the public of the road closure from November 1 to June 15. It was also noted in Year 1 that the gate becomes non-functional due to burial from snow and therefore will not impede snowmobile access to the intake; monitoring in Year 1 and Year 2 did not document members of the public crossing over the gate when the gate was buried in snow; however, monitoring in Year 3 (2020) documented snowmobiles accessing the intake area on February 29 by driving over the gate. In Year 3, vehicle access during the snow-free period was also documented either because Project personnel were at the intake (and had left the gate open) or because the gate was vandalized.

Monitoring from Year 1 did not identify differences in predator use or activity between pre- and post-construction; however, monitoring in Year 2 documented Grey Wolves (*Canis lupus*) and Cougars (*Puma concolor*) in the vicinity of the Boulder Creek HEF intake, both on and off the access road, and monitoring in Year 3 documented Grey Wolves off the road during the winter period (May 6) and on the road outside of the winter period (October 20); thus, there is some indication that Grey Wolf use of the intake area has increased since Project construction. These two species, which are considered main predators of Mountain Goats (Shackleton 1999), had not been detected in the vicinity of the intake during baseline or Year 1 monitoring. Four years of Mountain Goat effectiveness monitoring at the Boulder Creek HEF have now been completed and the need for additional monitoring is evaluated by a QP herein, as per requirements of the OEMP (Harwood *et al.* 2017; Table 2).

2.10. Vegetation Monitoring

Compliance and effectiveness monitoring for vegetation restoration is being conducted in years 1, 3, and 5 (Table 1) and is therefore not reported on here. 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.

3. METHODS

3.1. Water Temperature and Air 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 are summarized in Table 4 and Table 5, respectively. Detailed water and air temperature baseline methodology and data analysis are provided in the aquatic baseline report (Harwood *et al.* 2013). Representative photos for each water temperature monitoring site are provided in Appendix C and site locations in the Upper Lillooet River and Boulder Creek are shown on Map 2 and Map 3, respectively.

Baseline water temperature was monitored in the Upper Lillooet River at an upstream control site (ULL-USWQ1; November 2008 to June 2013) and at a lower diversion site (ULL-DVWQ; November 2010 to May 2013) (Table 4, Map 2). Baseline water temperature was monitored in Boulder Creek at an upstream control site (BDR-USWQ; April 2010 to May 2013) and in the diversion reach (BDR-DVWQ; November 2008 to June 2013) (Table 5, Map 3).

Operational water temperature monitoring commenced in March 2018 at three monitoring sites in the Upper Lillooet River: the upstream site (ULL-USWQ02), the tailrace site ULL-TAILWQ) and the site downstream of the tailrace (ULL-DSWQ). In November 2018, operational monitoring commenced at the lower diversion site (ULL-DVWQ01) and at a new upstream site (ULL-USWQ03), which was established due to difficult access to ULL-USWQ02 (see Section 2.4). Monitoring at the new upstream site (ULL-USWQ04), that replaced ULL-USWQ03, began in November 2021 (Table 4).

Operational water temperature monitoring in Boulder Creek commenced in March 2018 at three monitoring sites: one in the lower diversion (BDR-DVWQ), one at the tailrace (BDR-TAILWQ) and one downstream of the tailrace (BDR-DSWQ). In September 2018, temperature loggers were installed in Boulder Creek (BDR-USWQ2) and North Creek (NTH-USWQ1) to continue concurrent collection of water temperature data for at least one year of operational monitoring (Table 5). Temperature data loggers that were installed in September 2018 at the upstream site (BDR-USWQ2) were destroyed during storm events, therefore new temperature data loggers were installed on October 11, 2019, resulting in a data gap from September 2018 to October 2019 (Table 5).

Concurrent monitoring of water temperature at BDR-USWQ2 and NTH-USWQ1 was initiated in Year 3. This was continued in Year 4 to provide an additional year (October 2020 to October 2021) of data to assess the relationship between water temperatures in the two creeks, as recommended in Year 3 (Faulkner *et al.* 2021). The relationship between water 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 which is anticipated to represent baseline temperatures more reliably in the upstream reach of Boulder Creek for the BACI analysis which will be conducted at the conclusion of the operational monitoring period.

In the Upper Lillooet River, baseline air temperature was 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) (Table 4). Operational air temperature data are being recorded at two sites in the Upper Lillooet River: one in the upstream reach (ULL-USAT01; March 2018 to April 2019, ULL-USAT02; October 2019 to May 2021) and one in the downstream reach (ULL-DSAT; March 2018 to August 2021) (Table 4, Map 2). Only five complete months (November and December of 2019, November and December of 2020, and April 2021) of air temperature data are currently available for ULL-USAT02 due to damage to the sensor at this location. A new sensor was installed in October 2020; however, provided limited data because of damaged sustained during the monitoring period. The sensor appears to have been buried in snow in January 2020 collecting data reflecting this (flat around 0°C) until mid-March 2021 after which the sensor began recording a constant temperature of -95°C.

Air temperature in Boulder Creek was recorded at one site in the lower diversion (BDR-DVAT) for both baseline (April 2010 to May 2013) and operational monitoring (March 2018 to October 2021) (Table 5, Map 3).

This Year 4 report presents water and air temperature data collected up to October 30, 2021. The operational period of record spans three and a half calendar years (March 2018 to October 2021) and corresponds to Year 1, Year 2, Year 3, and Year 4 of the monitoring program (Table 4 and Table 5). Baseline water and air temperature data are provided for comparison in the report and for reference in Appendix D. 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.* 2021).

Table 4. Summary of water temperature site names, location, and period of data record in the Upper Lillooet River during baseline (2008 to 2013) and operational monitoring (2018 to 2021).

Type	Project Phase	Site	UTM Coordinates (10U)		Elevation	Periods of Record		Number of Days in Record	No. of Days with Valid Data	Data Gaps (% Complete)
			Easting	Northing	(masl)[1]	Start Date	End Date			
Water	Baseline	ULL-USWQ1	466097	5614105	666	19-Nov-08	03-Jun-13	1,658	1,653	100
		ULL-DVWQ	468283	5612234	490	12-Nov-10	01-May-13	902	632	70
	Operation	ULL-USWQ02[2]	464122	5614982	684	28-Mar-18	11-Oct-19	563	441	79
		ULL-USWQ03[3]	465530	5614484	673	01-Nov-18	11-May-21	923	919	100
		ULL-DVWQ01[4,5]	468344	5611968	481	01-Nov-18	24-Nov-20	755	546	73
		ULL-TAILWQ	468423	5611670	474	28-Mar-18	19-Oct-21	1,302	1,059	84
		ULL-DSWQ	468601	5611202	463	28-Mar-18	14-Oct-21	1,297	1,278	99
Air	Baseline	ULL-USAT	466097	5614105	666	07-Apr-10	01-May-13	1,121	1,084	97
		ULL-DVAT[6]	468375	5612158	483	07-Apr-10	01-May-13	1,121	763	69
	Operation	ULL-USAT01[7]	464141	5614996	687	28-Mar-18	11-Apr-19	380	307	81
		ULL-USAT02	468677	5611155	463	24-Oct-19	11-May-21	566	195	35
		ULL-DSAT[8]	468677	5611155	463	28-Mar-18	19-Aug-21	1,241	1,003	85

[1] Estimated from Google Earth

[2] Data gap from Nov. 14, 2018 to Mar. 13, 2019 due to low water levels and ice affecting sensors

[3] Data ends on May 11, 2021 because site was washed out. New site (ULL-USWQ04) was established in Nov. 2021

[4] Data gap from Mar. 2020 to Oct. 2020 due to damaged sensor

[5] Data gap from Dec. 2020 to May 2021 due to buried sensor under snow

[6] ULL-DVAT was relocated 1.1 km downstream to ULL-DSAT in 2018

[7] Data gap from Jan. 2020 to Mar. 2021 due to buried sensor under snow

[8] Data ends on Aug. 19, 2021 due to a sensor issue

Table 5. Summary of water temperature site names, location, and period of data record in Boulder Creek during baseline (2008 to 2013) and operational monitoring (2018 to 2021).

Type	Project Phase	Site	UTM Coordinates (10U)		Elevation	Periods of Record		Number of Days in Record	No. of Days with Valid Data	Data Gaps in Record (% Complete)
			Easting	Northing	(masl)[1]	Start Date	End Date			
Water	Baseline	BDR-USWQ[2]	474102	5614069	1,005	22-Apr-10	01-May-13	1,106	1,103	99.0
		NTH-USWQ1	484433	5605934	911	12-Sep-10	01-May-13	963	963	100
		BDR-DVWQ	471561	5609323	488	15-Nov-08	06-Jun-13	1,665	1,655	99.1
	Operation	BDR-USWQ2[3]	474580	5614356	1,030	24-Sep-18	30-Oct-21	1,133	749	66.3
		NTH-USWQ1	484433	5605934	911	24-Sep-18	30-Oct-21	1,133	1,131	100
		BDR-DVWQ[4]	471561	5609323	488	16-Mar-18	11-May-21	1,153	1,151	99.9
		BDR-TAILWQ	471326	5609383	488	16-Mar-18	19-Oct-21	1,314	960	77.1
		BDR-DSWQ	470,972	5609176	488	16-Mar-18	19-Oct-21	1,314	1,308	99.7
Air	Baseline	BDR-DVAT	471561	5609323	490	08-Apr-10	01-May-13	1,120	1,120	100
	Operation	BDR-DVAT	471561	5609323	490	16-Mar-18	05-Oct-21	1,300	1,296	99.9

[1] Estimated from Google Earth

[2] Due to groundwater inputs at BDR-USWQ, winter data during the baseline period for this site were synthesized from NTH-USWQ, including: Nov. 26, 2010 to May 21, 2011; Oct. 22, 2011 to Apr. 23, 2012; Oct. 24 to 30, 2012; and Nov. 8, 2012 to Apr. 26, 2013

[3] Data gap from Sep. 24, 2018 to Oct. 11, 2019 due to loss of temperature loggers during storm flows

[4] Data gap from May 11, 2021 to October 2021 due to loss of temperature loggers

3.1.2. Fish Species Distribution and Optimum Temperatures

The fish distribution in the Upper Lillooet River has been described in previous baseline monitoring documents and in the OEMP (Harwood *et al*. 2021) (Table 6). The fish species targeted for temperature monitoring in the Upper Lillooet River and Boulder Creek are Bull Trout and Cutthroat Trout; Coho Salmon are also targeted for the Upper Lillooet River. Cutthroat Trout may be present at all temperature monitoring site locations in the Upper Lillooet River and at the diversion and downstream locations on Boulder Creek, while Bull Trout are 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 the Upper Lillooet River and Boulder Creek and this species prefers cooler temperatures overall than other species present. The BC WQG (MECCS 2021) for water temperature specify optimum temperature ranges for rearing, spawning, incubation, and migration for these fish species (Table 6) and the applicable guideline range is defined as ± 1°C of the optimum temperature for each life stage.

Table 6. BC WQG optimum temperature ranges and fish species distribution in the Upper Lillooet River and Boulder Creek (MECCS 2021).

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 [1]	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 [1]	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.

[1] Bull Trout and Coho Salmon are only present in the lower diversion and downstream reaches of the Upper Lillooet River. They are not present above Keyhole Falls.

3.1.3. Quality Assurance/Quality Control

Prior to analysis, temperature data were carefully inspected to ensure that any suspect or unreliable data are excluded from data analysis and presentation. Excluded data include those recorded when 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 was evaluated by periodically performing *in-situ* spot temperature measurements and comparing these results to the corresponding data logged with the Tidbit sensor. Note that due to an oversight by field crews, no water temperature spot measurements were collected at the Upper Lillooet River or Boulder Creek monitoring sites in 2021.

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 ensured availability of data in case one of the loggers malfunctioned or was lost. 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 errors as part of a thorough Quality Assurance/Quality Control (QA/QC) process (see Section 3.1.3). After identifying and removing errors, 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 (i.e., >18°C and <1°C), days with exceedances of the minimum and maximum Bull Trout temperature thresholds, the length of the growing season, accumulated thermal units in the growing season (e.g., degree days), hourly rates of temperature change, and mean weekly maximum temperature (MWMxT). These statistics are defined and described in Table 7 and applicable guidelines are discussed in the following section.

After Year 2 reporting, historic data (including baseline) underwent updated cleaning to ensure it was processed according to current standards. As a result, some revisions to historic data were made to improve accuracy, and values presented herein may differ prior to those presented in Year 3. Key changes included:

- Hourly Rates of Water Temperature Change - the percentage of records calculated as the total # of valid hourly change records with a rate of change >1ºC, whereas some historical data included the total # of temperature records, rather than valid records.
- Mean Weekly Maximum Temperature (MWMxT) - changes from previous versions of this analysis include:
    - the inclusion of a cut-off whereby a day is excluded from the calculation if it does not include data during the warmest period of the day. By default, a day is excluded when it does not have at least one hourly measurement between 11:00 and 18:00.
    - for growing season, a "week" was calculated as a centred average (i.e., three days before and three days after the day for which MWMxT is being calculated). Therefore, the computed start and end date of the growing season are three days later/earlier, respectively.
- Growing Season Statistics - rules for the length of gaps that can be interpolated were applied to historic data: the maximum gap cannot exceed 14 days. In addition, start and end dates for weekly averages are defined in terms of calendar weeks (the start/end dates reported are the start of the calendar week containing the day the threshold was crossed), resulting in a change in start/end dates of ± 3 days.
- Further review of operational data collected at the upstream sites in the Upper Lillooet River has resulted in the exclusion of previously reported data collected at ULL-USWQ02 between November 14, 2018 to March 13, 2019 due to the sensors likely being buried in snow/ice.

3.1.5. Applicable Guidelines

The water temperature BC WQG for the protection of aquatic life (as per Oliver and Fidler 2001, MECCS 2021) and the water temperature metrics that were calculated (summarized in Table 7) are described below.

3.1.5.1. 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 (MECCS 2021).

3.1.5.2. 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, because these temperatures correspond to the upper bound of optimum temperature conditions for salmonids (Oliver and Fidler 2001). Since the Upper Lillooet River and Boulder Creek are cool streams where maximum temperatures recorded to date did not exceed 15°C, the number of days of water temperatures >18°C and >20°C was not reported.

Bull Trout specific water temperate guidelines (Table 7) were applied to the water temperature records by calculating the number of days of exceedance of the minimum and maximum temperature thresholds. For both Upper Lillooet River and Boulder Creek, the upstream sites were not considered as Bull Trout are not present in the upstream reaches. 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.

3.1.5.3. 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 BC WQG 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, MECCS 2021). Accordingly, MWMxT values were compared to the optimum temperature ranges for the fish species present based on the life history and periodicity (Table 6).

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

Table 7. 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 (Harwood *et al.* 2021). An automated alarm system was set up that triggers an email alert to Ecofish QPs when mean daily air temperatures of -5°C 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 -5°C 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 4), 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 to cease monitoring, continue monitoring at a defined schedule; or 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. This report includes Year 4 air temperature data, photographs, and frazil ice assessments completed in 2021/22 as well as a summary of monitoring conducted between Year 1 and 4.

3.2. Fish Community

3.2.1. Adult Migration and Spawning

The objective of this sub-component 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. Angling surveys were the preferred method on larger turbid waterbodies (i.e., Upper Lillooet, Boulder Creek, and North Creek) while bank walk visual surveys were conducted on smaller less turbid tributaries (i.e., tributary at river km 29.2 and Alena Creek). These two methodologies are outlined in further detail in the subsections below.

3.2.1.1. Bull Trout Angling Surveys

Angling surveys were conducted during the Bull Trout spawning migration window (September 15 to October 20 in 2021) in the downstream and diversion reaches, and at the tailrace, of both the Upper Lillooet River and Boulder Creek, and in a section of North Creek (which serves as a reference creek).

The angling survey area on Boulder Creek included approximately 900 m downstream and 300 m upstream from the powerhouse, and the tailrace. Angling effort upstream of the powerhouse was limited due to the safety concerns associated with accessing the entrenched canyon section. The fish bearing reach on Boulder Creek is considered to extend from the confluence with the Upper Lillooet River upstream 2.64 km, with approximately 1.7 km of the diversion reach accessible to fish. The angling survey area on the Upper Lillooet River included approximately 500 m upstream and downstream of the powerhouse, and the tailrace. The entire length of the diversion reach of Upper Lillooet River is fish bearing, but Bull Trout distribution is limited by Keyhole Falls located approximately 3 km upstream of the Upper Lillooet River HEF powerhouse. The angling survey area on North Creek included an approximately 600 m section, starting 1 km upstream from the confluence with the Upper Lillooet River.

Angling surveys were conducted at established monitoring sites (shown in Map 5), that had been identified 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 no less than 0.75 rod hours were spent per site.

Angling was conducted using roe as bait under a float as this proved to be most effective during baseline monitoring. All captured fish were anaesthetized prior to processing. During processing, fish were identified to species, weighed (±0.1 g for fish ≤ 200 g, ±1 g for fish > 200 g), measured for fork length (±1 mm), assessed for sexual maturity based on the presence of gametes, and photographed. Scale samples were collected from subsamples of any Cutthroat Trout captured during angling targeting Bull Trout, and fin ray samples were collected from all Bull Trout ≥100 mm in length and archived for future age analysis if required. Small fin clip samples were also collected from captured fish that were preserved in 95% ethanol and archived for future DNA analysis if required.

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, fish were released back into the sample site. Relevant site characteristics and conditions were also recorded during angling surveys.

Visual assessments of the potential for fish passage and upstream access were conducted during angling surveys during the spawning migration period on the lower 1.2 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 at the observed flows and connectivity was estimated for 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 River HEF powerhouse.

3.2.1.2. Tributary Bank Walk Bull Trout Spawner Surveys

Bull Trout migration, distribution, and spawning was also monitored using bank walk spawner surveys on three separate occasions (between September 15 and October 21) in fall of 2021 at two reference tributaries of the Upper Lillooet River as specified in the OEMP (Harwood *et al.* 2021): the tributary at km 29.2 of the Lillooet River (29.2 km Tributary) (three surveys) and Alena Creek (three surveys). These reference tributaries are 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 assessment of changes to 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, bank walk spawner surveys were conducted by walking along the shore during the Bull Trout spawning period and recording the number of spawning fish, any carcasses, and redds.

3.3. Wildlife Species Monitoring

3.3.1. Harlequin Ducks

Harlequin Duck monitoring was conducted at the Upper Lillooet River HEF intake and powerhouse through vantage point surveys (spot checks) (RISC 1998) along with the recording and compilation of incidental observations. According to the protocols, spot checks were conducted during two time periods when Harlequin Ducks are most likely to be observed on the breeding stream: the pre-incubation period (month of May) when Harlequin Duck pairs are on the river ("pair" survey), and the brood-rearing period (late July to late August) when males have departed from breeding streams and the female is rearing her brood ("brood" survey). In Year 4, spot checks were conducted at the intake and the powerhouse on May 17, 23, and 26, and on August 5, 10, and 23. The standardized protocols (Appendix E) were followed for most surveys, but the intake vantage point was not accessible on August 5 and 10 due to landslide risk and the surveys in this location were therefore conducted using the remote camera from inside the powerhouse (using a zoomable surveillance camera) to view the headpond on these dates. On other dates at the intake, and during all dates at the powerhouse, surveys were done in person with binoculars or spotting scope from the vantage points as specified in the protocols (Appendix E).

Data collected during spot checks included survey date, location, time, and number of individuals observed, as well as age, sex, and behaviour (e.g., feeding, flying, group or pair behaviour), if relevant (i.e., Harlequin Ducks were observed). Any comments on weather conditions or survey limitations were recorded, and photos were taken of any occurrence observations. Observations of other waterbirds seen during surveys were also recorded. Incidental Harlequin Duck observations were recorded opportunistically by plant operations staff, consulting biologists, and technicians throughout the year.

3.3.2. 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 4 were recorded and were compiled according to provincial format to facilitate data sharing. Incidental observations also include detections from 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. Incidental wildlife observations detected by the wildlife cameras in the vicinity of the Boulder Creek HEF intake installed for Mountain Goat mitigation effectiveness monitoring are summarized along with detections of predators by those cameras (in Section 4.3).

3.4. Wildlife Habitat Monitoring

3.4.1. Habitat Restoration – Mammal Habitat

Continued monitoring in Year 5 was recommended (Faulkner *et al.* 2021) for 18 mammal restoration compliance monitoring sites at which vegetated screens had not achieved required dimensions by Year 3 (Table 8). This recommendation was reconsidered in Year 4 (this report) based on the assessment of site-specific transmission line safety constraints for vegetated screen height (Staven 2022). Staven (2022) assessed the vegetated screens in nine wildlife habitat polygons in 2020 by evaluating screen status (stand description, visual screen quality) and long-term viability, given transmission line maintenance requirements, and made recommendations regarding future management. Thus, to re-evaluate the Year 3 monitoring recommendations, the mammal habitat monitoring sites that had been considered inadequate in Year 3 (Table 8) were matched to the vegetated screens in wildlife habitat polygons assessed in Staven (2022). Following this, any constraints identified by Staven (2022) in the potential for the vegetated screens to meet height and width targets, that were relevant to the mammal restoration compliance monitoring sites where screens had been identified as inadequate in Year 3, were considered to determine whether Year 5 monitoring recommendations should be revised. Locations of mammal restoration compliance monitoring sites are shown on maps 8 through 11 in the Year 3 report (Faulkner *et al.* 2021), and locations of the wildlife habitat polygons for which vegetated screens were assessed in relation to transmission line safety constraints are shown in the 15 maps of Staven (2022).

Table 8. Mammal vegetated screen monitoring sites at which screens had not achieved required dimensions by Year 3 and may require reassessment in Year 5.

Site	Species and Habitat[1]	UTM Coordinates (Zone 10U)		Comments
		Easting	Northing	
ULH-MAMCM01	Grizzly Bear - High Value	468746	5611295	Partially burnt and disturbed, some natural regeneration; slow to recover from the Boulder Creek forest fire
ULH-MAMCM02	Grizzly Bear - High Value	468915	5611147	Site is burnt; located very high above the road; slow to recover
ULH-MAMCM04B	Grizzly Bear - High Value	476857	5603920	Some natural regeneration but growth is limited on the wood chips
ULH-MAMCM06	Grizzly Bear - High Value Mule Deer - UWR	480898	5603041	Revegetation is dense and is on track for achieving height requirement; cover is high
ULH-MAMCM08	Mule Deer - UWR	481796	5602741	Abundant regeneration; on track to meet 5 m height requirement
ULH-MAMCM09	Grizzly Bear - High Value Mule Deer - UWR	482647	5602427	Some vegetation has grown tall (4 m); on track for natural regeneration reaching 5 m
ULH-MAMCM10	Mule Deer - UWR	482954	5602219	Good natural regeneration; vegetation is expected to grow taller than 5 m over time
ULH-MAMCM12	Moose - UWR	485810	5600967	Site has been disturbed; many alders and willows were cut down
ULH-MAMCM14	Grizzly Bear - WHA 2-399 Moose - UWR	487543	5599229	Abundant natural regeneration, dense bushes; vegetation growth is on track for 5 m height requirement
ULH-MAMCM17	Grizzly Bear - South Lillooet River FSR	491512	5597274	Vegetation regenerating in the areas previously disturbed by Squamish Mills; vegetation is on track for height requirement
ULH-MAMCM19	Grizzly Bear - South Lillooet River FSR	492224	5596959	Abundant natural regeneration; vegetation is well on track for 5 m height requirement
ULH-MAMCM21	Grizzly Bear - High Value Mule Deer - UWR	499872	5591204	Site is disturbed; trees that were ~2-3 m in height in 2018 were cut down and screen cover is low
ULH-MAMCM22	Grizzly Bear - High Value	500113	5591109	Site is disturbed. Shrubs that were ~2-3 m tall in 2018 were cut down
ULH-MAMCM23	Grizzly Bear - High Value	501095	5590537	Minimal screen height with vegetation composed mostly of ferns and thimbleberry; wood chips may be restricting growth; however, some alders, willows, and cottonwoods are regenerating naturally
ULH-MAMCM24	Grizzly Bear - High Value Mule Deer - UWR	501419	5590366	Moderate regeneration of abundant thimbleberry, and some willow and alder are on track for meeting height requirement; however, height will be limited by transmission line maintenance

Table 8. Continued.

Site	Species and Habitat[1]	UTM Coordinates (Zone 10U)		Comments
		Easting	Northing	
ULH-MAMCM26	Grizzly Bear - High Value Mule Deer - UWR	503208	5588834	The screen on the right side of the road has filled in with natural regeneration, but there has been some cutting on the left side; vegetation is on track for height and width requirements
ULH-MAMCM27	Grizzly Bear - High Value	507825	5577642	Abundant regeneration; good mix of conifers and deciduous trees; on track for height requirement and 100% coverage
ULH-MAMCM28	Grizzly Bear - High Value	507856	5577626	Abundant regeneration; on track for meeting height requirements

[1] High value Grizzly Bear habitat is considered as Class 1 or Class 2 as identified by habitat suitability modelling (Leigh-Spencer *et al.* 2012) and confirmed in the field (Leigh-Spencer *et al.* 2013).

3.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek

3.4.2.1. Public Access Monitoring

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 6). The first camera was placed at the gate (BDR-CAM03), and the other two cameras (BDR-CAM01 and BDR-CAM02) were installed along the access road, past the gate towards the intake (Map 6). The locations and functionality of all wildlife cameras used for Mountain Goat mitigation effectiveness monitoring are shown in Table 9 below, of which the first three cameras were installed for both public access monitoring and predator monitoring. All cameras were functional for the entire monitoring period in Year 4.

3.4.2.2. Predator Monitoring

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 monitored in Year 4, as in previous years, through the use of remote infrared cameras. Although systematic winter ground-based surveys (snow-tracking surveys along transects) were specified in the original 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, and as specified in the updated OEMP (Harwood *et al.* 2021), four remote infrared cameras were installed along the systematic winter ground-based survey transects on November 30, 2018 (Map 6, Table 9). Thus, predator monitoring was conducted through the three cameras used for gate effectiveness monitoring (BDR-CAM01, BDR-CAM02, BDR-CAM03) (note that this differs slightly from what is specified in the original OEMP because one of the previous camera locations became unsuitable), along with four additional cameras that are located along survey transects BDR-SNTR02 (BDR-CAM05 and BDR-CAM06) and BDR-SNTR03 (BDR-CAM07 and BDR-CAM08) (Table 9, Map 6). Another camera (BDR-CAM04) had also been installed near the top of transect BDR-SNTR03 since May 8, 2018, and this was also used for predator monitoring. All photographs taken by the remote infrared cameras during the Year 4 monitoring period were viewed and data were compiled.

The Year 4 post-construction monitoring period for which data are presented in this report began on December 23, 2020 (the end of the Year 3 monitoring period) and ended on January 26, 2022. Results from annual monitoring for Year 1 (conducted from December 21, 2017 to January 17, 2019), Year 2 (conducted from January 17, 2019 to February 25, 2020), and Year 3 (February 25 to June 15, 2020 and November 1 to December 23, 2020) are provided in Regehr *et al.* (2019), Harwood *et al.* (2021), and Faulkner *et al.* (2021), respectively. Baseline data from the pre-construction period (November 2010 to April 2014) are presented in the wildlife baseline monitoring report (Regehr *et al.* 2016).

To evaluate changes in predator presence and behavior within the UWR post-construction, which may increase access-related risk to Mountain Goats, numbers of predator detections documented by the wildlife cameras in the vicinity at the Boulder Creek intake post-construction were compared across monitoring years. Although the same eight cameras were employed in the four post-construction monitoring years, not all cameras were functional during all time periods. Thus, the comparison was conducted by summing the number of functional camera-days for all cameras combined and calculating and comparing the number of detections documented per camera-day by monitoring year. When cameras were semi-functional during a period of time (e.g., branch partly obscuring lens or partly buried in snow), the semi-functional days were conservatively considered non-functional. Although the comparisons did not include baseline results due to differences in methods and camera locations relative to the post-construction monitoring period, predator detections were compared between the baseline period and Year 1 in the Year 1 monitoring report (Regehr *et al.* 2019), and Year 1 results were compared to years 2, 3, and 4 herein. A qualitative assessment of the species detected (main or occasional predator) and locations of detections (e.g., on and off road) was also made to address monitoring objectives.

Table 9. Remote infrared camera locations at the Boulder Creek HEF intake and intake access road and camera functionality during the Mountain Goat winter period during Year 4 monitoring (December 23, 2020 to June 15, 2021, and November 1, 2021 to January 26, 2022).

Camera	Location	UTM Coordinates (Zone 10U)		Functionality during Monitoring Period (December 23, 2020 to June 15, 2021 and November 1, 2021 to January 26, 2022)
BDR-CAM01	Viewing the access road, approximately 300 m from the Boulder Creek HEF intake.	473222	5611166	Functional for the entire period
BDR-CAM02	Viewing the Boulder Creek HEF intake access road.	472876	5610976	Functional for the entire period
BDR-CAM03	Gate on the access road to the Boulder Creek HEF intake.	471943	5610609	Functional for the entire period
BDR-CAM04	Above the Boulder Creek HEF intake access road, along an old logging road at the top of BDR-SNTR03.	472699	5610993	Functional for the entire period.
BDR-CAM05	In an open area along transect BDR-SNTR02.	473323	5611759	Functional for the entire period
BDR-CAM06	At the top of transect BDR-SNTR02.	473198	5611474	Functional for the entire period
BDR-CAM07	Along transect BDR-SNTR03.	473092	5611314	Functional for the entire period.
BDR-CAM08	Along the upper road section of transect BDR-SNTR03.	472821	5611090	Functional for the entire period

4. RESULTS

4.1. Water Temperature and Air Temperature

4.1.1. Overview

The results of the baseline (2008 to 2013) and operational (2018 to 2021) 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 C; BC WQG for water temperature, annual water temperature figures, data summary tables, and baseline temperature records are presented in Appendix D; and QA/QC spot temperature figures are presented in Appendix F.

The period of record at Upper Lillooet River and Boulder Creek monitoring sites for years 1, 2, 3, and 4 (2018, 2019, 2020, and 2021) is from March 2018 to October 2021 (Table 4, Table 5, Map 2, Map 3). Data availability is based on the most recent download of water temperature loggers and data gaps are documented in Section 3.1.1.

Data from the upstream site located in North Creek (NTH-USWQ1), which was established because the BDR-USWQ baseline site was found to be influenced by groundwater (see Section 2.4), was successfully retrieved in Year 4 for the period spanning October 2020 to October 2021. Tidbits, which had been installed at BDR-USWQ2 in September 2018 were deemed missing during the next site visit in October 2019. Tidbits were re-installed at this site in October 2019 and data were successfully collected through to October 2021.

In Year 4, data collection continued at the upstream control site in the Upper Lillooet River (ULL-USWQ03, which replaced ULL-USWQ02; see Section 2.4). ULL-USWQ03 washed out between May 2021 and October 2021 and a new control site (ULL-USWQ04) was established in November 2021; however, no data have been downloaded from this site to date due to lack of winter site access (Table 4).

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 1 and Figure 2, respectively).

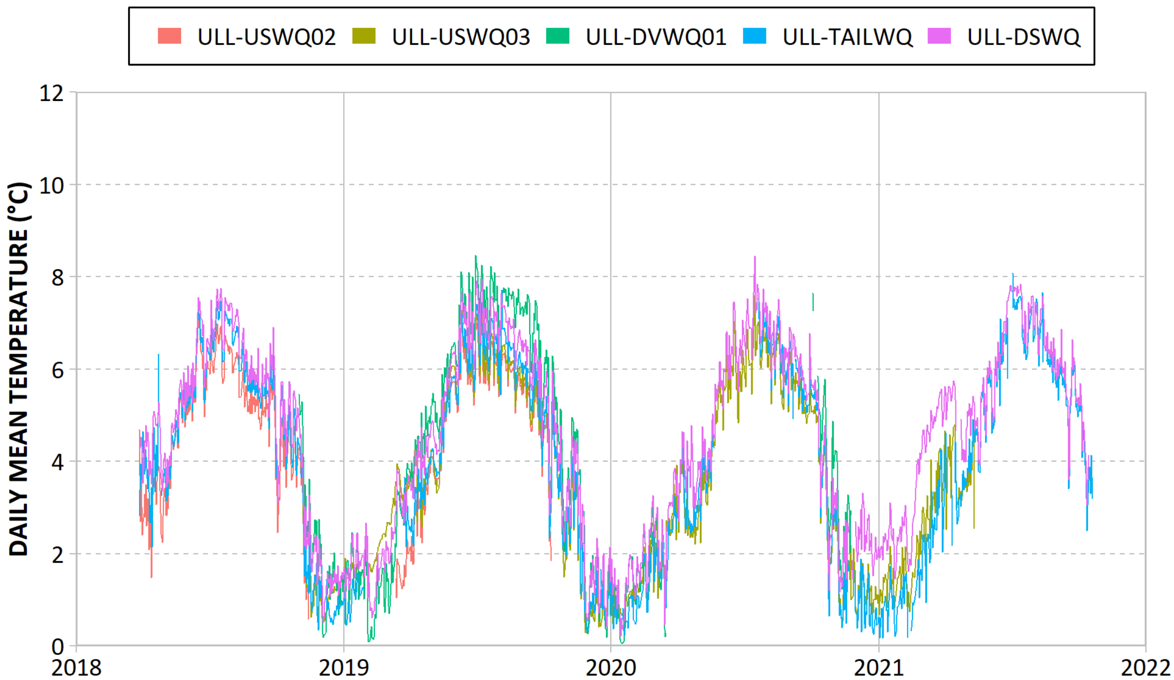
Differences in water temperature between the main control site relative to other control and impact sites are displayed graphically in Section 7 of Appendix D for baseline conditions, and for operational conditions this is shown in Figure 3 (Upper Lillooet) and Figure 4 (Boulder Creek). Temperature loggers at USWQ02 were removed on October 11, 2019, therefore ULL-USWQ03 data are presented for Year 4.

The water temperature at the three impact sites, the Upper Lillooet River downstream site (ULL-DSWQ), diversion site (ULL-DVWQ01), and the tailrace site (ULL-TAILWQ), was warmer than the water temperature at the upstream control site (ULL-USWQ03) for the majority of the data record (Figure 3). A similar difference was also observed during the baseline period, when water temperature at the diversion site (ULL-DVWQ) was warmer than at the upstream site (ULL-USWQ1) (Section 7, Appendix D); however, the difference was small (<1°C for the majority of the time) both during baseline and operational periods. Comparison between operational water temperatures between ULL-USWQ02 and ULL-USWQ03 show that temperatures were similar between the two control sites (Figure 3).

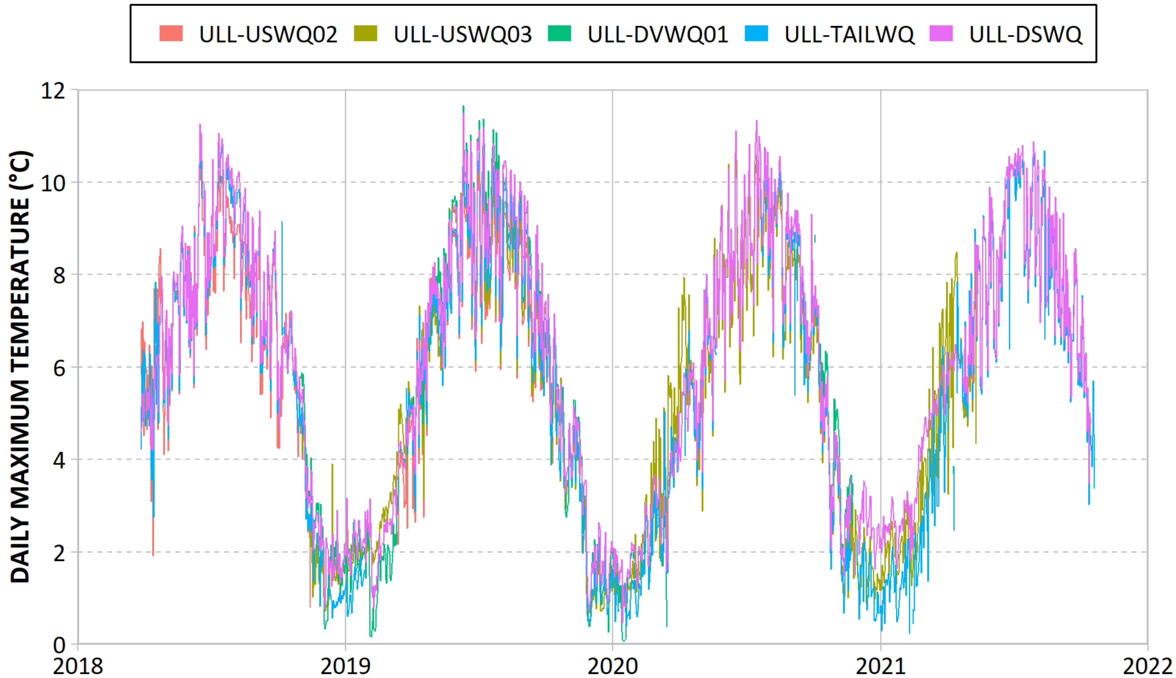
In Boulder Creek during operations, water temperature at the three impact sites, the downstream site (BDR-DSWQ), diversion site (BDR-DVWQ), and the tailrace site (BDR-TAILWQ), was warmer than the water temperature at the upstream control site (BDR-USWQ2) for the vast majority of the data record (Figure 4). Based on the operational data available at the end of Year 4, inter-site differences in water temperature suggests that the temperature at impact diversion site (BDR-DVWQ) is generally warmer than that at the upstream control site under baseline conditions (Section 7, Appendix D). Comparison between operational water temperatures between NTH-USWQ1 and BDR-USWQ2 indicated that temperatures are slightly warmer at NTH-USWQ1 than at BDR-USWQ2 for most of the period of record; however, the difference is <1°C for the majority of the dataset (Figure 4).

Figure 1. Daily mean, maximum, and minimum water temperature recorded in the Upper Lillooet River during operations (2018 to 2021).

(a) Daily Average



(b) Daily Maximum



(c) Daily Minimum

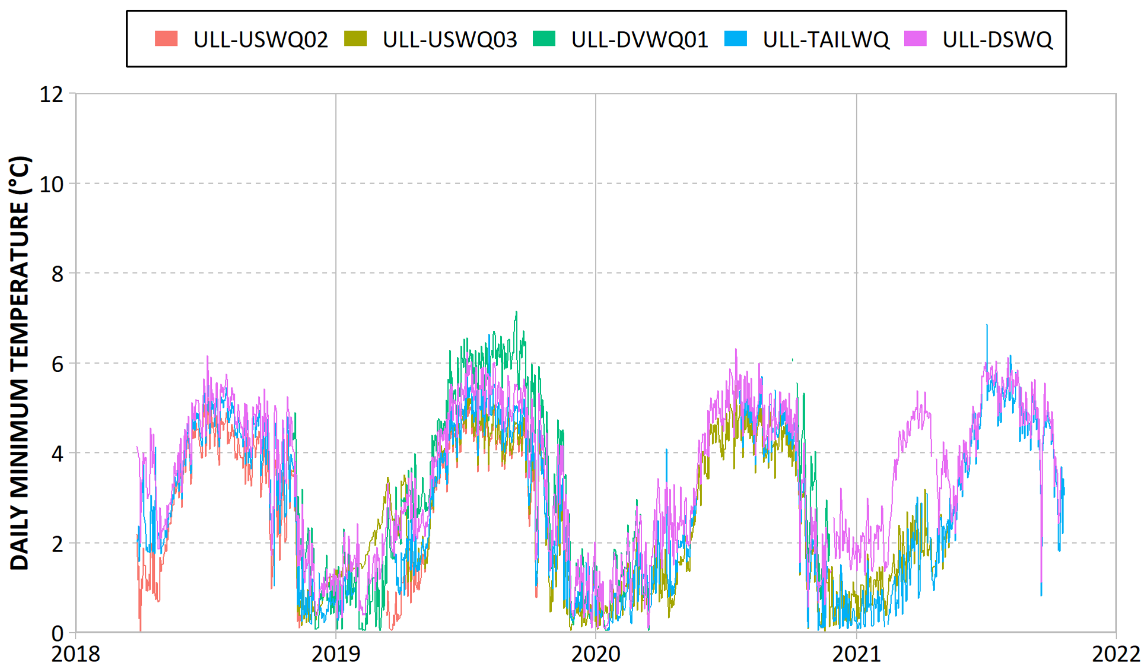
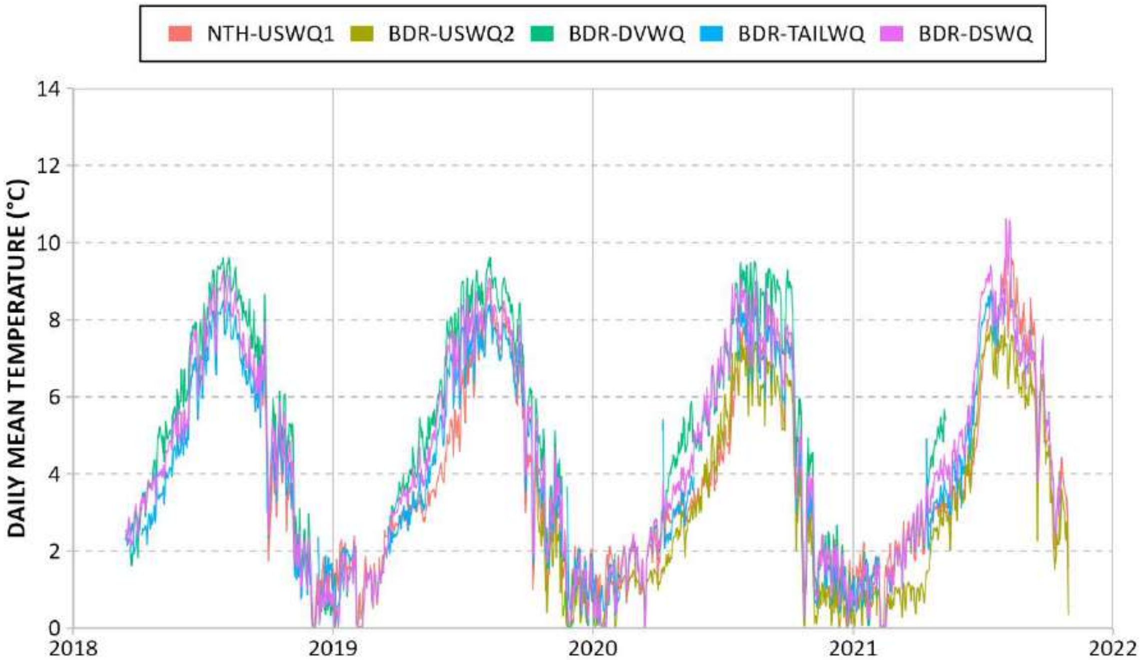
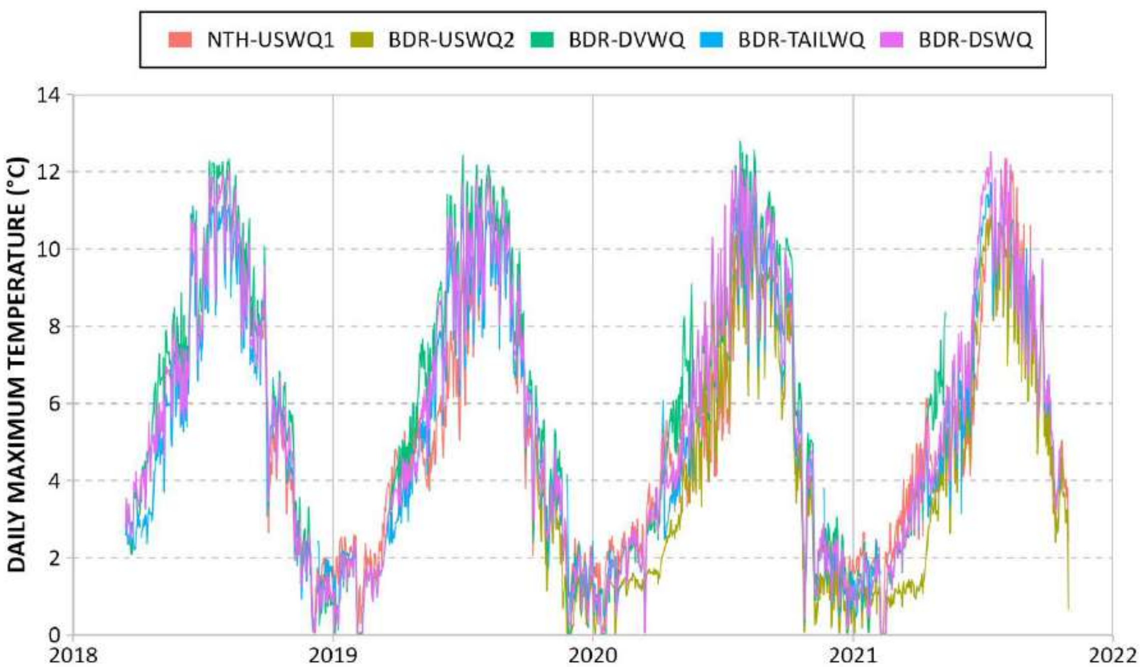


Figure 2. Daily mean, maximum and minimum water temperature recorded in Boulder Creek during operations (2018 to 2021).

(a) Daily Average



(b) Daily Maximum



(c) Daily Minimum

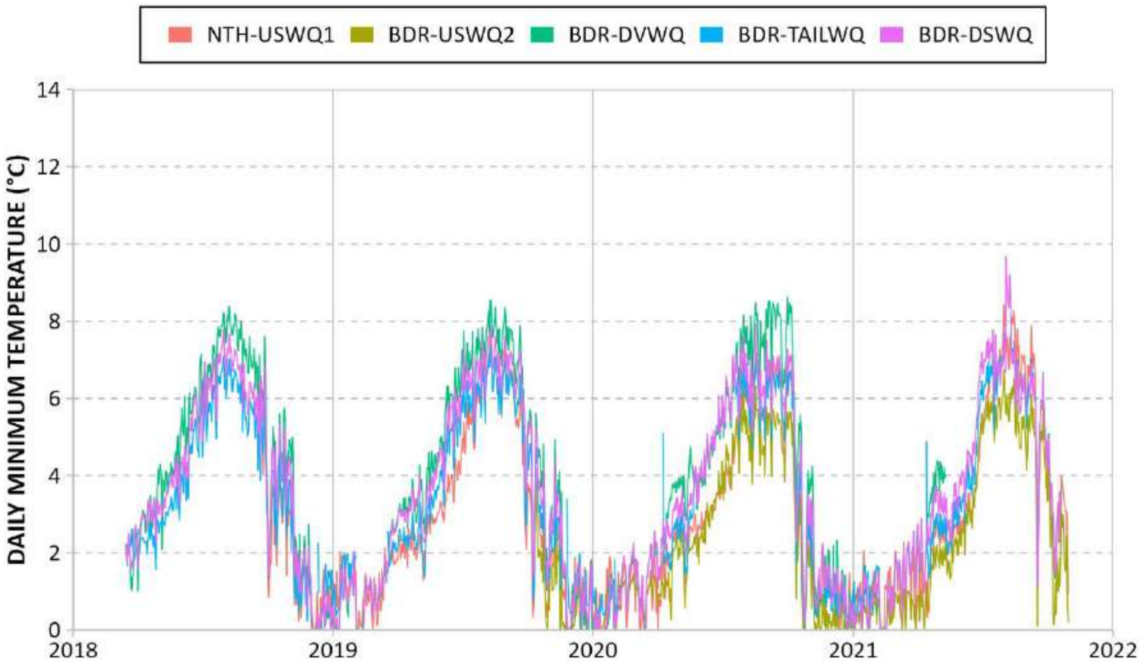


Figure 3. **Cumulative frequency distribution of instantaneous water temperature differences between control and impact Upper Lillooet River sites and ULL-USWQ03 (the upstream control site established in Year 2) during operations (2018 to 2021). Positive values denote that water temperature at the site of interest was warmer than the upstream control site (ULL-USWQ03).**

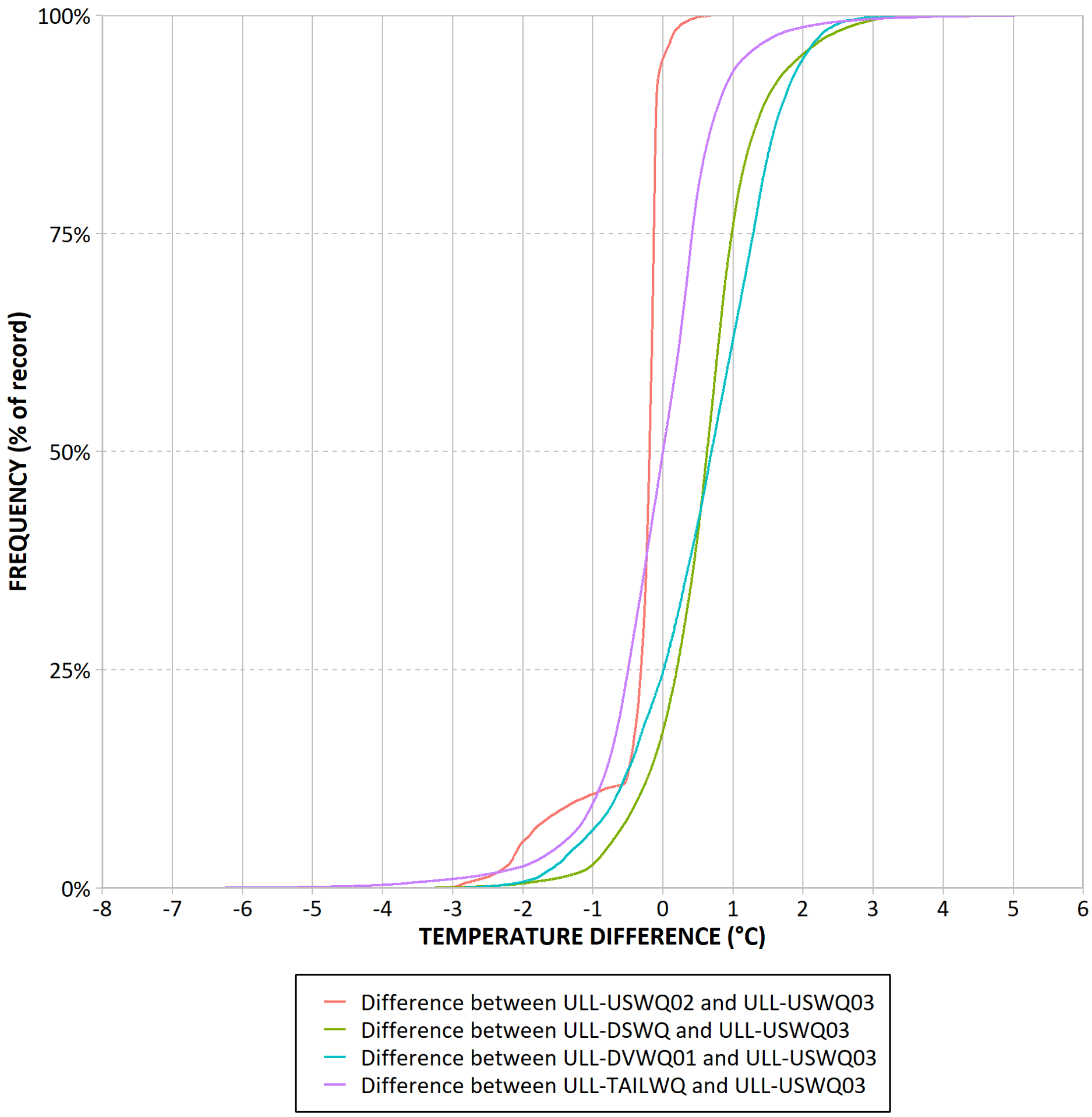
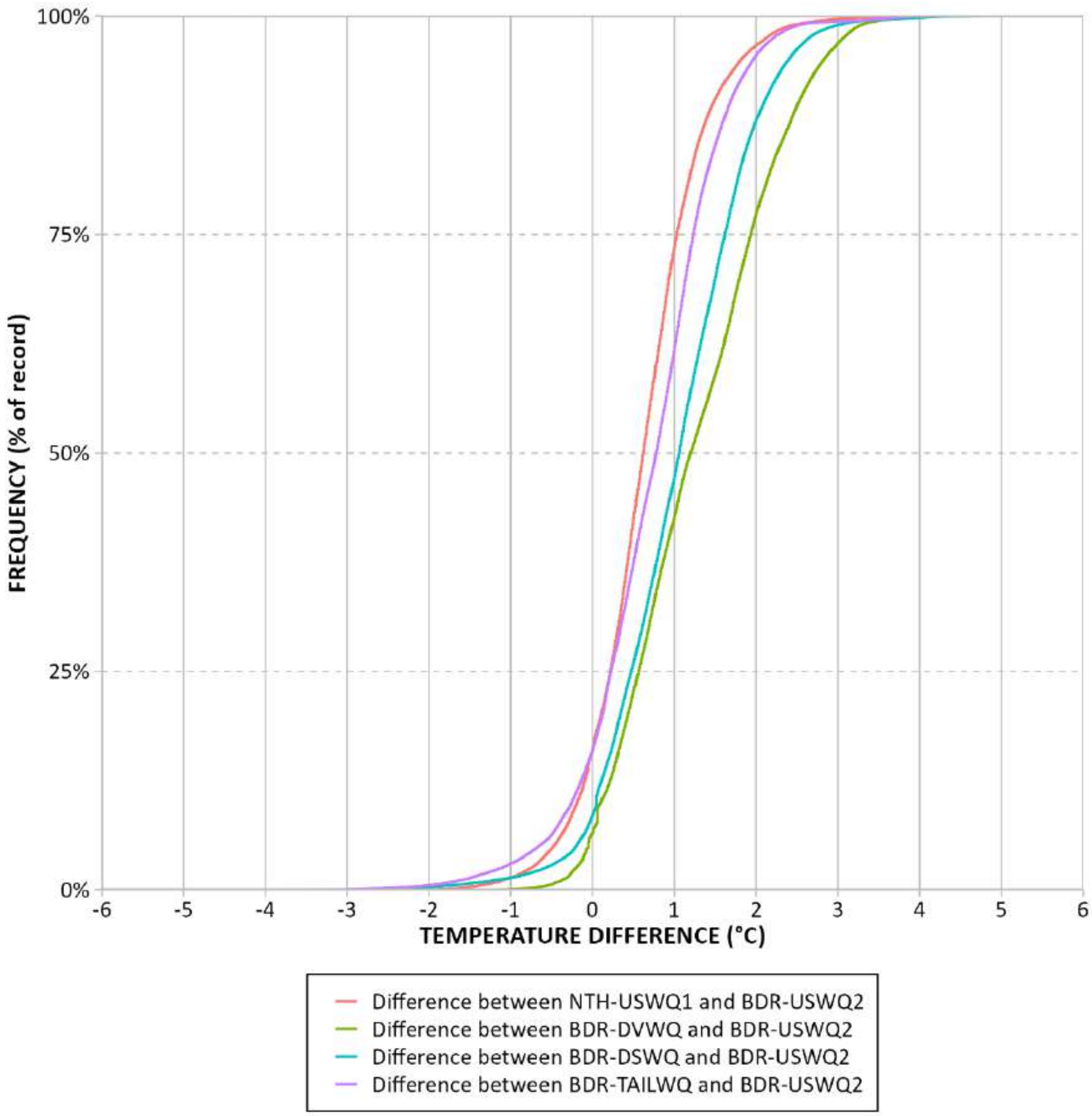


Figure 4. Cumulative frequency distribution of instantaneous water temperature differences between the control and impact Boulder Creek monitoring sites and BDR-USWQ2 during operations (2019 to 2021). Positive values denote that the site of interest sites was warmer than the upstream control site (BDR-USWQ2).



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 D and operational period (upstream, diversion, tailrace and downstream) in Section 4.1.2.1.

The Upper Lillooet River and Boulder Creek mean/average, instantaneous minimum, instantaneous maximum, and standard deviation for air temperature for each month of the record are summarized for the baseline period (upstream and diversion) in Appendix D and operational period (upstream, diversion, and downstream) in Section 4.1.2.2.

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 (Section 4 of Appendix D) and was 0.8°C to 6.4°C during operational monitoring to date (Table 10). The warmest average monthly water temperature to date in the Upper Lillooet River was at the diversion site during operations in July 2019 (7.6°C, Table 10) and the coolest average monthly water temperature to date in the Upper Lillooet River occurred during baseline at the upstream site ULL-USWQ1 in December 2009 (0.4°C) (Section 4 of Appendix D).

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 (Table 11, Section 4 of Appendix D). In the Boulder Creek diversion reach during operations, the coldest average monthly water temperature occurred in December 2018 and January 2020 (0.6°C) and the warmest occurred in August 2018 and August 2019 (8.8°C). At the Boulder Creek downstream site (BDR-DSWQ), the range in monthly average water temperature was 0.7°C to 8.6°C during operations. The coldest average monthly water temperature at BDR-DSWQ occurred in December 2018 and January 2020, and the warmest average monthly water temperature was recorded in July 2021 (Table 11).

Table 10. Upper Lillooet River operational monthly water temperature summary statistics (2018 to 2021).

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	-	-	-	-	1.8	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	-	-	-	-	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	-	-	-	-	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	-	-	-	-	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	-	-	-	-	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	4.0	2.0	8.1	1.3
	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	5.2	2.1	9.5	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	6.8	3.7	11.5	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	7.2	4.4	11.2	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	6.9	4.5	10.5	1.5
	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	6.0	3.4	9.7	1.1
	Oct	-	-	-	-	3.8	0.5	7.4	1.4	4.8	1.4	7.1	1.4	4.0	1.0	7.2	1.3	4.3	1.4	7.6	1.4
	Nov	-	-	-	-	2.1	0.1	4.8	1.2	3.1	0.2	5.3	1.3	2.3	0.3	4.8	1.2	2.9	0.4	5.2	1.2
	Dec	-	-	-	-	0.8	0.1	2.3	0.4	1.2	0.1	2.5	0.6	1.0	0.3	2.3	0.4	1.4	0.1	2.6	0.5
2020	Jan	-	-	-	-	0.9	0.1	1.8	0.3	1.0	0.0	2.1	0.6	-	-	-	-	1.2	0.1	2.2	0.6
	Feb	-	-	-	-	1.6	0.4	4.9	0.7	1.8	0.6	3.3	0.7	1.3	0.2	3.3	0.7	2.0	0.4	3.7	0.7
	Mar	-	-	-	-	2.3	0.4	7.3	1.3	-	-	-	-	2.2	0.5	5.1	0.9	2.6	0.1	5.1	1.0
	Apr	-	-	-	-	2.9	0.3	7.9	1.7	-	-	-	-	-	-	-	-	3.8	1.4	6.1	1.0
	May	-	-	-	-	4.2	1.4	9.5	1.9	-	-	-	-	-	-	-	-	4.7	1.9	9.5	1.7
	Jun	-	-	-	-	5.8	3.4	10.9	1.5	-	-	-	-	-	-	-	-	6.3	3.9	11.1	1.5
	Jul	-	-	-	-	6.4	3.6	10.6	1.5	-	-	-	-	-	-	-	-	7.1	4.4	11.3	1.6
	Aug	-	-	-	-	6.0	3.6	9.9	1.5	-	-	-	-	6.3	3.7	10.2	1.5	6.6	3.9	10.6	1.5
	Sep	-	-	-	-	5.5	3.4	8.9	1.2	-	-	-	-	5.7	4.0	9.2	1.1	6.1	4.3	9.4	1.2
	Oct	-	-	-	-	3.6	0.1	7.2	1.5	4.5	0.6	8.9	1.5	3.8	0.1	7.6	1.6	4.0	0.6	7.8	1.5
	Nov	-	-	-	-	1.5	0.0	4.2	0.9	2.7	0.5	5.1	1.0	-	-	-	-	-	-	-	-
	Dec	-	-	-	-	1.1	0.2	2.5	0.5	-	-	-	-	0.8	0.1	2.2	0.5	2.3	1.4	3.5	0.5

[1] Statistics based on continuous data logged at 15 minute intervals. Statistics were not generated for months with less than three weeks of data.
Minimum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in red.

Table 10. Continued.

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
2021	Jan	-	-	-	-	1.4	0.2	2.7	0.5	-	-	-	-	0.8	0.1	2.1	0.4	2.2	1.3	3.2	0.4
	Feb	-	-	-	-	1.7	0.4	4.2	0.7	-	-	-	-	1.2	0.1	2.8	0.5	2.9	1.4	4.5	0.8
	Mar	-	-	-	-	3.2	1.1	7.3	1.3	-	-	-	-	2.7	0.4	6.5	1.1	4.9	4.0	6.1	0.4
	Apr	-	-	-	-	3.8	1.2	8.5	1.7	-	-	-	-	-	-	-	-	-	-	-	-
	May	-	-	-	-	-	-	-	-	-	-	-	-	4.7	1.6	9.9	1.9	5.1	2.2	9.9	1.6
	Jun	-	-	-	-	-	-	-	-	-	-	-	-	6.0	3.4	10.1	1.7	6.5	3.6	10.6	1.7
	Jul	-	-	-	-	-	-	-	-	-	-	-	-	7.1	4.6	10.6	1.5	7.4	4.8	10.9	1.6
	Aug	-	-	-	-	-	-	-	-	-	-	-	-	6.5	4.3	10.7	1.4	6.7	4.6	10.5	1.4
	Sep	-	-	-	-	-	-	-	-	-	-	-	-	5.5	0.8	9.1	1.2	5.7	1.1	9.3	1.2
	Oct	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Nov	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Dec	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Statistics based on continuous data logged at 15 minute intervals. Statistics were not generated for months with less than three weeks of data.
Minimum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in red.

Table 11. Boulder Creek operational monthly water temperature statistics (2018 to 2021).

Year	Month	Water Temperature[1] (°C)																			
		BDR-USWQ2				NTH-USWQ1				BDR-DVWQ				BDR-DSWQ				BDR-TAILWQ			
		Avg	Min	Max	SD	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	3.4	1.6	6.0	0.6	2.8	1.6	5.5	0.5
	May	-	-	-	-	-	-	-	-	5.2	2.1	8.5	1.2	4.7	2.9	8.1	1.1	4.1	2.5	7.3	1.1
	Jun	-	-	-	-	-	-	-	-	6.9	4.6	11.1	1.3	6.3	3.9	10.8	1.4	5.8	3.4	10.9	1.4
	Jul	-	-	-	-	-	-	-	-	8.6	5.5	12.3	1.6	8.2	4.9	11.9	1.6	7.6	4.5	11.2	1.6
	Aug	-	-	-	-	-	-	-	-	8.8	6.7	12.3	1.2	8.1	5.7	12.0	1.3	7.6	5.1	11.2	1.3
	Sep	-	-	-	-	-	-	-	-	7.5	4.5	10.8	0.9	6.7	3.6	10.2	1.0	6.3	3.1	9.6	1.0
	Oct	-	-	-	-	3.7	0.8	6.3	1.1	4.9	1.3	6.8	1.1	4.5	1.4	6.7	0.9	4.3	2.2	6.5	0.9
	Nov	-	-	-	-	2.1	0.2	4.5	0.9	2.8	0.2	5.8	1.3	2.4	0.5	5.4	1.1	2.0	0.3	4.8	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	1.2	0.0	2.5	0.6	1.5	0.4	2.2	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	3.5	2.7	4.7	0.4	3.0	2.1	4.8	0.5
	May	-	-	-	-	3.4	1.3	6.0	0.9	5.2	2.5	9.0	1.3	4.6	2.3	8.6	1.2	4.0	1.4	7.9	1.2
	Jun	-	-	-	-	4.8	2.8	7.9	1.1	7.2	4.2	11.4	1.5	6.7	3.7	10.8	1.5	6.2	3.2	10.2	1.5
	Jul	-	-	-	-	6.9	4.6	10.8	1.3	8.5	5.8	12.4	1.4	7.9	5.4	11.8	1.3	7.3	4.9	11.1	1.3
	Aug	-	-	-	-	7.9	5.4	11.9	1.3	8.8	6.3	12.2	1.2	8.2	5.9	11.8	1.2	7.6	5.4	11.0	1.2
	Sep	-	-	-	-	6.4	2.1	11.2	1.5	7.5	3.5	11.3	1.4	7.0	3.6	10.7	1.3	6.5	2.7	10.2	1.3
	Oct	-	-	-	-	3.1	0.3	5.7	1.3	4.4	1.0	6.8	1.5	4.0	1.1	6.5	1.4	3.7	0.7	6.4	1.2
	Nov	1.5	0.0	3.9	1.1	2.1	0.0	4.3	1.2	2.8	0.0	5.3	1.5	2.6	0.0	4.8	1.2	-	-	-	-
	Dec	0.6	0.1	1.5	0.4	1.2	0.0	2.5	0.6	1.0	0.0	2.4	0.7	1.0	0.1	2.2	0.5	1.2	0.4	2.1	0.5
2020	Jan	0.6	0.1	1.4	0.4	1.1	0.0	2.6	0.8	0.6	0.0	1.9	0.6	0.7	0.0	1.9	0.6	0.9	0.4	2.4	0.4
	Feb	1.1	0.1	1.6	0.4	1.6	0.0	2.9	0.6	1.5	0.0	2.6	0.6	1.5	0.1	2.8	0.6	-	-	-	-
	Mar	1.2	0.2	1.7	0.3	1.7	0.0	3.9	0.9	1.8	0.0	3.6	0.8	1.8	0.0	3.8	0.8	-	-	-	-
	Apr	1.8	0.3	3.0	0.6	2.6	0.0	5.6	1.0	3.5	1.1	6.1	1.0	3.1	1.1	5.2	0.7	-	-	-	-
	May	2.9	0.6	5.9	0.9	3.2	1.3	5.7	0.7	5.0	2.9	9.1	1.1	4.3	2.3	7.9	1.0	-	-	-	-
	Jun	4.3	2.2	8.6	1.3	4.0	2.6	7.0	0.9	5.9	3.7	10.1	1.3	6.0	3.9	10.3	1.3	-	-	-	-
	Jul	6.2	3.4	11.1	1.6	5.9	3.6	10.7	1.6	8.0	5.0	12.8	1.7	7.9	5.1	12.3	1.6	-	-	-	-
	Aug	6.5	3.8	10.6	1.5	7.3	4.6	11.4	1.4	8.7	6.3	12.6	1.3	7.8	5.1	12.0	1.4	7.3	4.7	11.4	1.4
	Sep	6.2	3.9	9.5	1.2	7.3	3.8	11.2	1.4	8.5	6.3	11.5	1.0	7.5	5.4	11.1	1.2	7.1	4.9	10.4	1.1
	Oct	3.5	0.1	8.4	2.1	4.0	0.0	9.1	2.3	5.3	0.1	10.1	2.6	4.6	0.2	9.5	2.3	4.2	0.2	9.1	2.2
	Nov	1.1	0.0	4.0	0.8	1.8	0.4	4.1	0.7	2.3	0.6	5.1	1.1	2.0	0.5	4.8	0.9	-	-	-	-
	Dec	0.5	0.1	1.8	0.5	1.4	0.0	2.8	0.7	1.3	0.1	3.1	0.8	1.2	0.0	2.5	0.6	1.0	0.3	2.3	0.5

[1] Statistics based on continuous data logged at 15 minute intervals. Statistics were not generated for months with less than three weeks of data.

Minimum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in red.

Table 11. Continued.

Year	Month	Water Temperature[1] (°C)																			
		BDR-USWQ2				NTH-USWQ1				BDR-DVWQ				BDR-DSWQ				BDR-TAILWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2021	Jan	0.6	0.1	1.3	0.4	1.4	0.0	2.7	0.6	1.0	0.0	2.4	0.5	1.0	0.1	2.2	0.4	1.1	0.4	1.9	0.4
	Feb	0.5	0.0	1.5	0.4	1.2	0.0	2.9	0.7	0.9	0.0	2.1	0.6	0.9	0.0	2.0	0.7	-	-	-	-
	Mar	0.9	0.0	1.4	0.3	2.2	0.0	5.0	0.8	2.1	0.3	4.0	0.5	2.1	0.3	4.2	0.6	-	-	-	-
	Apr	1.6	0.0	3.8	0.8	2.7	0.1	6.1	1.1	3.6	1.0	6.9	1.2	3.3	1.0	5.6	0.8	-	-	-	-
	May	3.0	1.3	6.9	1.1	3.3	1.9	6.3	0.8	-	-	-	-	4.2	2.3	7.8	1.0	3.7	2.0	7.4	1.0
	Jun	4.6	1.9	9.8	1.6	4.4	2.4	8.6	1.2	-	-	-	-	6.1	3.1	11.4	1.7	5.5	2.7	10.6	1.6
	Jul	7.3	4.9	10.9	1.5	7.9	5.2	11.6	1.5	-	-	-	-	8.6	5.8	12.5	1.5	8.1	5.1	11.7	1.5
	Aug	6.8	4.7	10.4	1.2	8.5	6.3	12.3	1.2	-	-	-	-	8.1	5.6	12.3	1.5	7.6	5.6	11.5	1.2
	Sep	5.5	0.1	9.5	1.4	6.7	2.8	10.6	1.4	-	-	-	-	6.3	1.1	9.9	1.3	6.4	1.1	10.0	1.3
	Oct	2.9	0.1	6.3	1.1	3.6	1.0	6.1	0.9	-	-	-	-	-	-	-	-	-	-	-	-

[1] Statistics based on continuous data logged at 15 minute intervals. Statistics were not generated for months with less than three weeks of data.
Minimum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the operational monitoring period are shaded in red.

4.1.2.2. Air Temperature

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 (Section 5 of Appendix D) and was -5.8°C to 15.9°C during operational monitoring to date (Table 12). The warmest month occurred in July 2018 and the coolest in January 2013 (large data gaps occurred in winter 2019, 2020, and 2021).

In the Upper Lillooet River lower diversion, monthly average air temperature ranged from -4.4°C to 16.7°C during baseline monitoring (Section 5 of Appendix D), and at ULL-DSAT (1.1 km downstream of the baseline diversion reach site in the downstream reach), the monthly average air temperature during operations ranged from -8.2°C to 18.5°C (Table 12). Considering both sites, the warmest month occurred in July 2018 and the coolest in February 2019.

Air temperature was recorded at the same location along the lower diversion reach of Boulder Creek in baseline and operational monitoring (BDR-DVAT). 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 (Section 5 of Appendix D), and -7.2°C to 20.2°C during operational monitoring to date (Table 13).The coldest average monthly air temperatures occurred in February 2019 (-7.2°C) and the warmest average monthly air temperatures occurred in July 2021 (20.2°C).

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). Since air temperature is one of the primary drivers of water temperature, the air temperature data suggest that the water temperature trends observed during operations are likely largely reflective of natural inter annual variation in climate conditions.

Table 12. Upper Lillooet River operational (2018 to 2021) air temperature monthly data summary statistics.

Year	Month	Air Temperature[1] (°C)											
		ULL-USAT01				ULL-USAT02				ULL-DSAT			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2018	Mar	-	-	-	-	-	-	-	-	-	-	-	-
	Apr	3.8	-6.5	20.0	4.7	-	-	-	-	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	6.1
	Aug	14.7	3.0	31.6	6.8	-	-	-	-	17.5	7.6	33.7	5.4
	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
	Jun	-	-	-	-	-	-	-	-	-	-	-	-
	Jul	-	-	-	-	-	-	-	-	-	-	-	-
	Aug	-	-	-	-	-	-	-	-	-	-	-	-
	Sep	-	-	-	-	-	-	-	-	-	-	-	-
	Oct	-	-	-	-	-	-	-	-	-	-	-	-
	Nov	-	-	-	-	-0.9	-16.3	9.2	5.0	1.1	-10.5	8.4	3.8
	Dec	-	-	-	-	-4.3	-18.7	2.3	4.9	-2.2	-10.2	2.1	2.8
2020	Jan	-	-	-	-	-	-	-	-	-3.9	-21.3	2.4	6.1
	Feb	-	-	-	-	-	-	-	-	-1.8	-9.9	4.5	2.8
	Mar	-	-	-	-	-	-	-	-	-0.8	-13.4	8.7	3.6
	Apr	-	-	-	-	-	-	-	-	3.0	-6.3	12.4	3.2
	May	-	-	-	-	-	-	-	-	10.2	0.0	26.5	5.3
	Jun	-	-	-	-	-	-	-	-	12.9	4.2	26.3	4.4
	Jul	-	-	-	-	-	-	-	-	16.3	6.5	32.4	5.4
	Aug	-	-	-	-	-	-	-	-	15.6	6.4	31.1	5.0
	Sep	-	-	-	-	-	-	-	-	13.6	5.3	26.3	4.2
	Oct	-	-	-	-	-	-	-	-	5.8	-7.0	17.8	4.9
	Nov	-	-	-	-	-0.9	-12.7	8.1	2.9	0.4	-7.3	8.8	2.3
	Dec	-	-	-	-	-4.2	-16.7	1.1	4.6	-1.8	-9.8	3.1	2.6

[1] Statistics based on data logged at 30-minute intervals and were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 12. Continued.

Year	Month	Air Temperature[1] (°C)											
		ULL-USAT01				ULL-USAT02				ULL-DSAT			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2021	Jan	-	-	-	-	-	-	-	-	-1.6	-11.7	2.2	2.4
	Feb	-	-	-	-	-	-	-	-	-3.9	-20.8	4.7	5.2
	Mar	-	-	-	-	-	-	-	-	1.0	-7.1	8.9	2.2
	Apr	-	-	-	-	3.3	-9.0	23.0	6.3	4.6	-4.4	18.7	4.2
	May	-	-	-	-	-	-	-	-	-	-	-	-
	Jun	-	-	-	-	-	-	-	-	-	-	-	-
	Jul	-	-	-	-	-	-	-	-	-	-	-	-
	Aug	-	-	-	-	-	-	-	-	-	-	-	-
	Sep	-	-	-	-	-	-	-	-	-	-	-	-
	Oct	-	-	-	-	-	-	-	-	-	-	-	-
	Nov	-	-	-	-	-	-	-	-	-	-	-	-
	Dec					-	-	-	-				

[1] Statistics based on data logged at 30-minute intervals and were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 13. Boulder Creek operational (2018 to 2021) air temperature data summary statistics.

Year	Month	Air Temperature[1] (°C)			
		BDR-DVAT			
		Avg	Min	Max	SD
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
	Apr	5.3	-0.8	17.2	3.8
	May	13.8	2.6	30.0	6.4
	Jun	15.6	4.2	31.5	5.7
	Jul	16.2	7.2	29.9	5.0
	Aug	17.1	8.4	32.2	5.4
	Sep	12.3	2.1	30.2	4.3
	Oct	4.8	-2.5	14.5	3.0
	Nov	1.5	-10.4	8.4	3.9
	Dec	-1.9	-9.2	2.8	2.5
2020	Jan	-3.6	-19.9	3.0	6.1
	Feb	-1.1	-8.8	5.9	2.8
	Mar	-0.1	-13.1	11.2	3.7
	Apr	5.1	-5.8	18.3	4.4
	May	11.8	1.3	27.5	5.4
	Jun	12.5	4.9	26.9	4.9
	Jul	16.4	6.6	35.6	6.1
	Aug	16.5	7.1	34.6	5.6
	Sep	14.3	5.6	30.4	4.8
	Oct	6.2	-7.3	20.8	5.1
	Nov	0.6	-6.3	8.9	2.3
	Dec	-1.4	-8.9	2.8	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. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 13. Continued.

Year	Month	Air Temperature[1] (°C)			
		BDR-DVAT			
		Avg	Min	Max	SD
2021	Jan	-1.2	-10.7	5.2	2.3
	Feb	-3.4	-19.8	6.3	5.0
	Mar	1.6	-7.4	11.2	2.6
	Apr	6.3	-4.0	21.2	5.1
	May	11.6	1.3	25.6	5.5
	Jun	15.6	4.8	38.8	7.4
	Jul	20.2	10.5	36.1	6.3
	Aug	17.3	8.5	36.3	5.9
	Sep	11.5	0.4	27.6	4.1
	Oct	-	-	-	-

[1] Statistics based on continuous data logged at 30 minute intervals. Statistics were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

4.1.3. Growing Season Degree Days

In both the Upper Lillooet River (Table 14) and Boulder Creek (Table 15), the upstream sites generally have had shorter growing seasons than the diversion and downstream sites, as would be expected due to cooler water temperatures at higher elevations.

The start of the growing season based on the water temperature record has been variable in the Upper Lillooet River (Table 14). During baseline monitoring, the growing season start dates at the upstream and diversion sites varied from late-May to early-July. During operations, the start date occurred in mid- to late-May in all years (2018 to 2021) (Table 14). The growing season end dates occurred in October during baseline and operational years for most sites, except in the downstream reach (ULL-DSWQ) and tailrace (ULL-TAILWQ) during operations in 2018, when the growing season ended in early November. A notable exception was at ULL-USWQ02 in 2018 when the growing season ended on September 30. This was coincident with cooler air temperatures (Figure 20, Appendix D); however, the cooling was not enough to end the growing season at the tailrace and downstream sites where the growing season continued until early November. The length of the growing season in the Upper Lillooet River during baseline monitoring ranged from 644-degree days to 861-degree days at the upstream site and was 825-degree days at the diversion site. During operations, the growing season ranged from 746 to 839-degree days at the upstream sites, from 904 to 1,121-degree days at the diversion and downstream sites, and from 854 to 963-degree days in the tailrace (Table 14). The longest growing season occurred in the diversion during operations (ULL-DVWQ01) in 2019.

In Boulder Creek during the baseline period, the growing season start dates and end dates were variable (Table 15). During baseline, start dates occurred between late-May and mid-August (North Creek), with end dates occurring from early October to early November. The operational growing season start date occurred from late April to mid-July and ended from late-September (North Creek) to late-October (Boulder Creek). 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 Boulder Creek ranged from 644-degree days (upstream site) to 1,185-degree days, with the longest growing season recorded in 2019 in the diversion reach at BDR-DVWQ (Table 15).

Table 14. Upper Lillooet River growing season length and degree days during baseline and operational periods.

Project Phase	Site	Year	No. of days with valid data	Growing Season[1,3]				
				Start Date	End Date	Length (day)	Gap (day)	Degree Days[2]
Baseline	ULL-USWQ1	2008	41	-	-	-	-	-
		2009	365	22-May-09	8-Oct-09	141	0	861
		2010	365	28-Jun-10	13-Oct-10	109	0	644
		2011	365	2-Jul-11	23-Oct-11	114	0	693
		2012	364	20-Jun-12	17-Oct-12	119	2	707
		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	230	23-May-18	30-Sep-18	132	0	746
		2019	211	20-May-19	6-Oct-19	141	0	798
	ULL-USWQ03	2018	60	-	-	-	-	-
		2019	364	18-May-19	7-Oct-19	143	0	839
		2020	365	24-May-20	11-Oct-20	142	0	817
		2021	130	-	-	-	-	-
	ULL-DVWQ01	2018	60	-	-	-	-	-
		2019	365	13-May-19	25-Oct-19	167	0	1,121
		2020	121	-	21-Oct-20	-	-	-
	ULL-TAILWQ	2018	259	21-May-18	3-Nov-18	167	6	963
		2019	293	20-May-19	7-Oct-19	142	0	854
		2020	250	-	12-Oct-20	-	-	-
		2021	257	21-May-21	8-Oct-21	141	18	865
	ULL-DSWQ	2018	278	19-May-18	4-Nov-18	171	0	1,020
		2019	365	16-May-19	23-Oct-19	161	0	1,016
		2020	356	21-May-20	13-Oct-20	147	0	922
		2021	279	21-May-21	10-Oct-21	143	0	904

[1] "-" denote periods where insufficient data were available to accurately assess the entire length of the growing season.

[2] Degree days are accumulated thermal units.

[3] We defined the start of the growing season as the beginning of the first week that average stream temperatures exceeded and remained above 5°C for the season; the end of the growing season was defined as the last day of the first week that average stream temperature dropped below 4°C as per Coleman and Fausch (2007).

Table 15. Boulder Creek growing season length and degree days during baseline and operational periods.

Project Phase	Site	Year	No. of days with valid data	Growing Season[1,3]				
				Start Date	End Date	Length (day)	Gap (day)	Degree Days[2]
Baseline	BDR-USWQ	2010	235	6-Jul-10	2-Nov-10	119	11	634
		2011	364	2-Aug-11	12-Oct-11	71	0	367
		2012	365	23-Jul-12	16-Oct-12	86	1	479
		2013	118	-	-	-	-	-
	NTH-USWQ1	2010	111	-	17-Oct-10	-	-	-
		2011	365	18-Aug-11	10-Oct-11	55	0	280
		2012	366	26-Jul-12	16-Oct-12	83	0	474
		2013	121	-	-	-	-	-
	BDR-DVWQ	2008	45	-	-	-	-	-
		2009	365	31-May-09	8-Oct-09	131	0	898
		2010	351	13-Jun-10	29-Oct-10	139	11	895
		2011	354	7-Jul-11	14-Oct-11	100	2	617
		2012	366	3-Jul-12	19-Oct-12	109	0	726
		2013	156	23-May-13	-	-	-	-
Operation	BDR-USWQ2	2019	81	-	-	-	-	-
		2020	366	30-Jun-20	11-Oct-20	104	0	644
		2021	302	20-Jun-21	4-Oct-21	107	0	677
	NTH-USWQ1	2018	98	-	25-Oct-18	-	-	-
		2019	283	17-Jun-19	30-Sep-19	106	0	721
		2020	366	11-Jul-20	12-Oct-20	93	0	651
		2021	302	24-Jun-21	6-Oct-21	104	0	770
	BDR-DVWQ	2018	290	17-May-18	3-Oct-18	140	0	1,062
		2019	296	15-May-19	24-Oct-19	164	0	1,185
		2020	366	2-Jun-20	21-Oct-20	142	0	1,077
		2021	130	30-Apr-21	-	-	-	-
	BDR-TAILWQ	2018	255	9-Jun-18	29-Oct-18	143	8	919
		2019	235	29-May-19	7-Oct-19	132	2	887
		2020	222	-	13-Oct-20	-	40	-
		2021	196	15-Jun-21	7-Oct-21	115	12	813
	BDR-DSWQ	2018	290	20-May-18	2-Oct-18	136	0	959
		2019	296	23-May-19	8-Oct-19	138	0	997
		2020	366	30-May-20	20-Oct-20	144	0	1,013
		2021	287	8-Jun-21	7-Oct-21	122	4	886

[1] "-" denote periods where insufficient data were available to accurately assess the entire length of the growing season.

[2] Degree days are accumulated thermal units.

[3] We defined the start of the growing season as the beginning of the first week that average stream temperatures exceeded and remained above 5°C for the season; the end of the growing season was defined as the last day of the first week that average stream temperature dropped below 4°C as per Coleman and Fausch (2007).

4.1.4. Hourly Rates of Water Temperature Change

During baseline, the percentage (%) of record where exceedances of the ±1.0°C/hr rate of change threshold were observed was low (≤0.51%) in the Upper Lillooet River and Boulder Creek monitoring sites (Figure 5, Figure 6,Table 16, Table 17, and Section 8 of Appendix D). Exceedances occurred more often during operations, particularly at the upstream site ULL-USWQ02 in the Upper Lillooet River (Table 16) and at the tailrace and downstream sites for Boulder Creek; however, exceedances as a percentage of the record were still relatively infrequent (≤1.2%, Table 17). Based on Ecofish's experience collecting baseline temperature data on numerous other streams with run of river hydroelectric development in British Columbia, it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1.0°C/hr.

Table 16. 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		Number of Datapoints	Occurrence of rates >1°C/hr.		Min -ve	Percentile				Max+ve
		Start	End		No.	% of Record		1st	5th	95th	99th	
Baseline	ULL-USWQ1	19-Nov-08	03-Jun-13	158,955	803	0.51	-1.344	-0.734	-0.499	0.642	0.921	1.97
	ULL-DVWQ	12-Nov-10	01-May-13	60,846	25	0.04	-1.02	-0.668	-0.407	0.5101	0.792	1.12
Operation	ULL-USWQ02	28-Mar-18	11-Oct-19	42,503	661	1.56	-1.42	-0.88	-0.65	0.80	1.03	2.42
	ULL-USWQ03	01-Nov-18	11-May-21	88,504	619	0.70	-2.73	-0.80	-0.52	0.65	0.94	2.07
	ULL-DVWQ01	01-Nov-18	24-Nov-20	52,704	100	0.19	-1.53	-0.66	-0.34	0.41	0.79	1.53
	ULL-TAILWQ	28-Mar-18	19-Oct-21	105,301	873	0.83	-4.56	-0.82	-0.55	0.70	0.93	5.05
	ULL-DSWQ	28-Mar-18	14-Oct-21	122,963	493	0.40	-2.44	-0.77	-0.52	0.63	0.88	2.78

Table 17. 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		Number of Datapoints	Occurrence of rates >1°C/hr.		Min-ve	Percentile				Max+ve
		Start	End		No.	% of Record		1st	5th	95th	99th	
Baseline	BDR-USWQ	22-Apr-10	01-May-13	26,274	157	0.15	-1.91	-0.543	-0.314	0.395	0.791	1.22
	NTH-USWQ1	12-Sep-10	01-May-13	92,298	10	0.01	-1.56	-0.43	-0.26	0.33	0.67	1.11
	BDR-DVWQ	15-Nov-08	06-Jun-13	39,576	471	0.30	-1.37	-0.499	-0.30	0.36	0.82	1.58
Operation	BDR-USWQ2	24-Sep-18	30-Oct-21	72,012	518	0.72	-2.71	-0.63	-0.38	0.45	0.94	2.13
	NTH-USWQ1	24-Sep-18	30-Oct-21	108,681	489	0.45	-3.50	-0.56	-0.35	0.47	0.88	1.38
	BDR-DVWQ	16-Mar-18	11-May-21	110,601	730	0.66	-3.20	-0.57	-0.35	0.43	0.90	1.78
	BDR-TAILWQ	16-Mar-18	19-Oct-21	97,118	1,131	1.17	-5.79	-0.61	-0.39	0.53	1.03	4.13
	BDR-DSWQ	16-Mar-18	19-Oct-21	125,707	1,241	0.99	-2.96	-0.58	-0.37	0.45	0.99	2.71

Figure 5. Upper Lillooet River summary of the hourly rate of change (°C/hr) during operations.

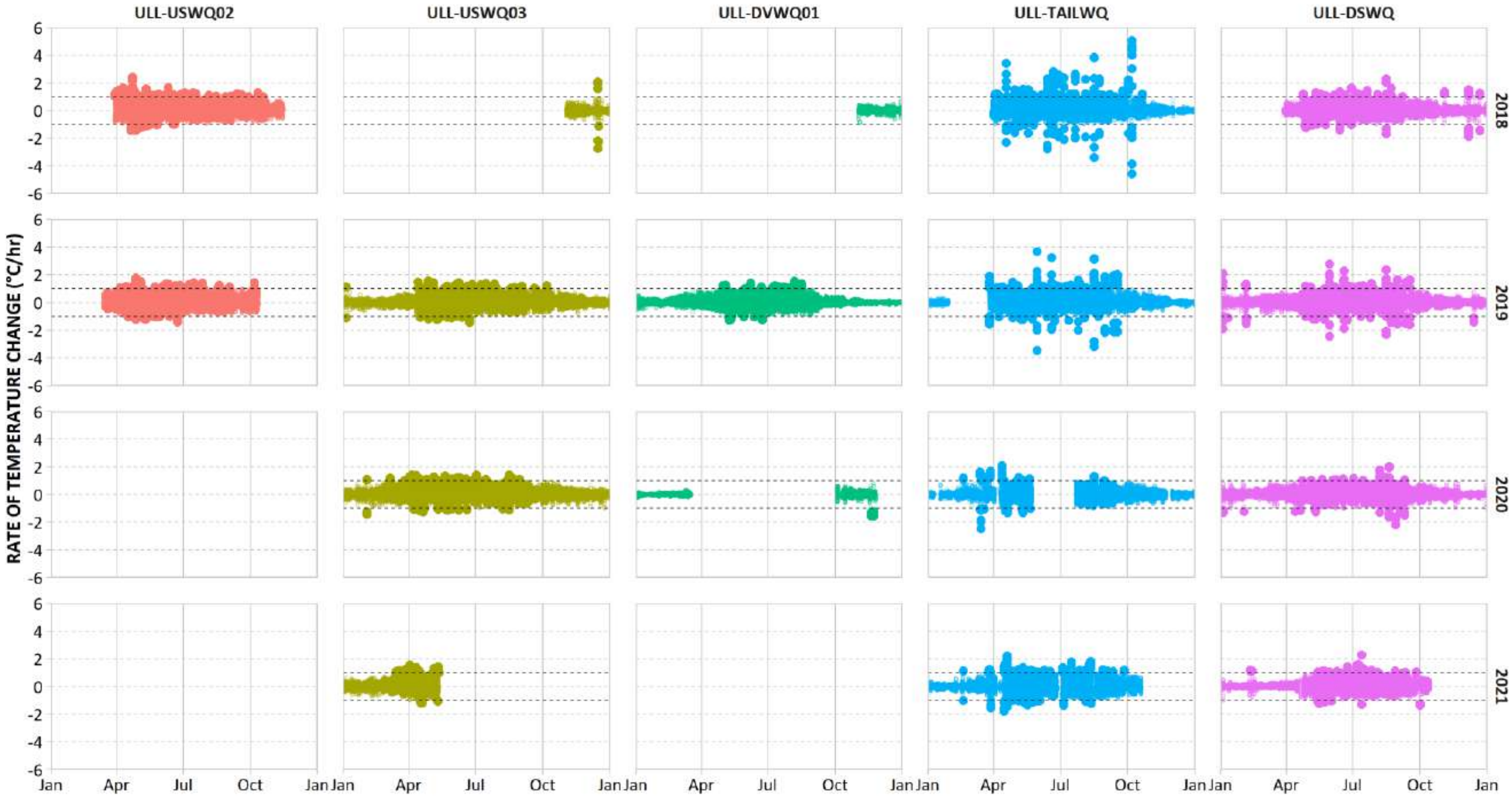
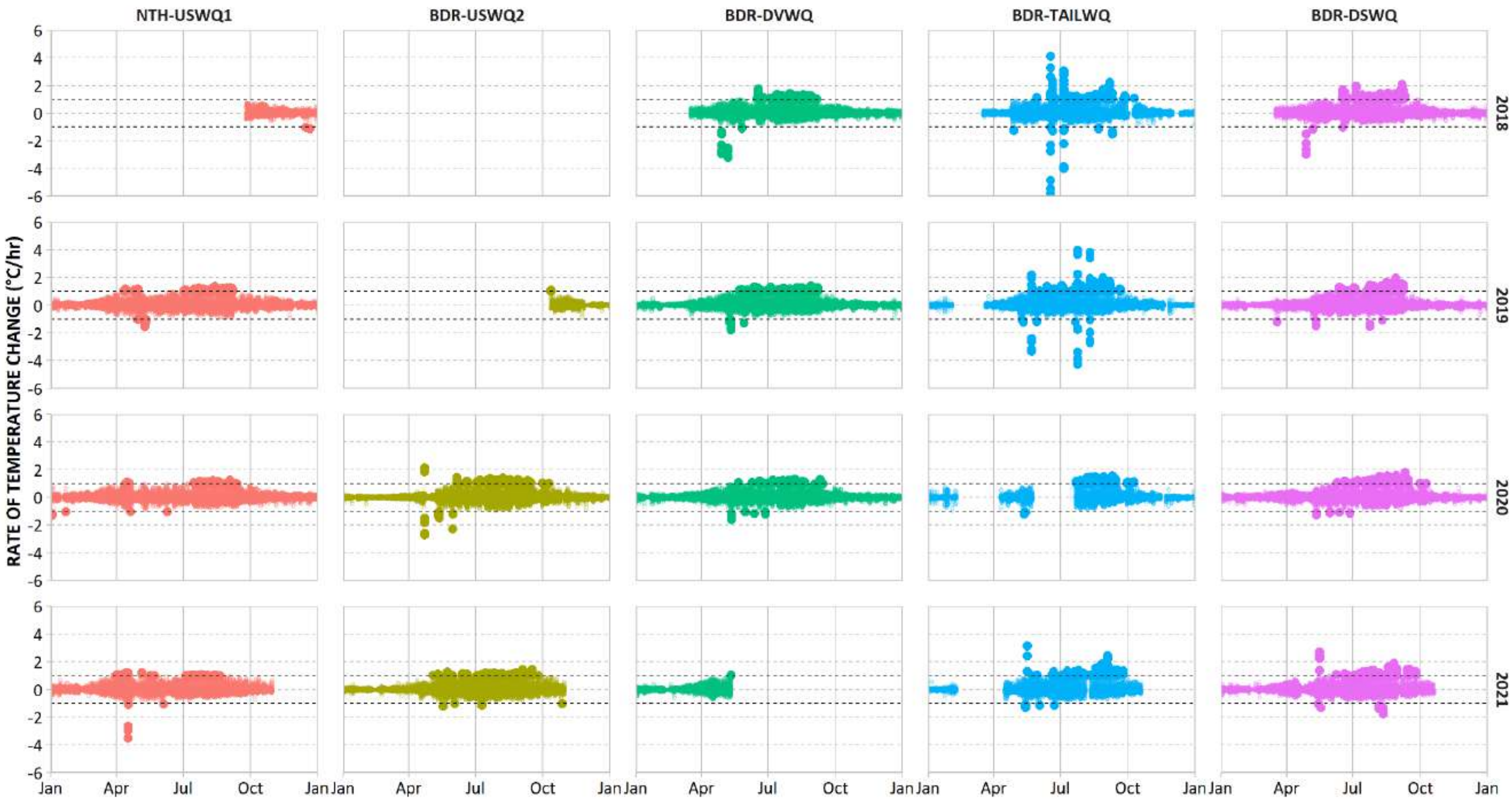


Figure 6. Boulder Creek summary of hourly rate of change (°C/hr) for each year during operations.



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 18 and Table 19). Considering all sites and dates in the Upper Lillooet River, the maximum instantaneous water temperature during baseline monitoring was 11.8°C at the upstream site in July 2009[1]; during operations it was 11.7°C at the diversion site in June 2019 (Table 10). Considering all sites and dates in Boulder Creek, the maximum instantaneous water temperature during baseline monitoring was 11.4°C at the diversion site in July 2009, and during operations it was 12.8°C at the diversion site in July 2020 (Table 11).

The number of days in a calendar year with daily average temperatures <1°C in Upper Lillooet River during baseline ranged from 32 to 95, and during operations, ranged from 12 to 56 (Table 16).

The number of days with daily average temperatures <1°C in Boulder Creek during baseline ranged from 33 to 83, and during operations, ranged from 19 to 89 (Table 19).

[1] The lower diversion site in July 2009 was likely warmer than the maximum instantaneous water temperature observed at the upstream site, however there is no data for the lower diversion site during this period as temperature sensors did not survive the 2009 freshet.

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

Project Phase	Site	Year	n (days)[1]	Days T_{water} > 18°C	Days T_{water} > 20°C	Days T_{water} < 1°C
Baseline	ULL-USWQ1	2008	41	-	0	-
		2009	365	0	0	95
		2010	365	0	0	58
		2011	365	0	0	86
		2012	365	0	0	74
		2013	153	-	-	33
	ULL-DVWQ	2010	49	-	-	-
		2011	97	-	-	-
		2012	366	0	0	32
		2013	120	-	-	-
Operation	ULL-USWQ02	2018	230	0	0	-
		2019	211	0	0	-
	ULL-USWQ03	2018	60	-	-	-
		2019	364	0	0	28
		2020	365	0	0	43
		2021	130	-	-	-
	ULL-DVWQ01	2018	60	-	-	-
		2019	365	0	0	36
		2020	121	-	-	-
	ULL-DSWQ	2018	278	0	0	-
		2019	365	0	0	21
		2020	356	0	0	12
		2021	279	0	0	-
	ULL-TAILWQ	2018	259	0	0	-
		2019	293	-	-	-
		2020	250	-	-	56
		2021	257	0	0	-

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

"-" denotes periods when insufficient data were available

Table 19. Boulder Creek summary of daily average water temperature extremes (number of days >18°C and <1°C).

Project Phase	Site	Year	n (days)[1]	Days T_{water} > 18°C	Days T_{water} > 20°C	Days T_{water} < 1°C
Baseline	BDR-USWQ	2010	235	0	0	-
		2011	364	0	0	42
		2012	365	0	0	47
		2013	118	-	-	-
	NTH-USWQ1	2010	98	-	-	-
		2011	365	0	0	43
		2012	366	0	0	48
		2013	121	-	-	-
	BDR-DVWQ	2008	45	-	-	-
		2009	365	0	0	66
		2010	351	0	0	33
		2011	354	0	0	83
		2012	366	0	0	58
		2013	156	-	-	-
Operation[2]	BDR-USWQ2	2019	81	-	-	-
		2020	366	0	0	89
		2021	302	0	0	-
	NTH-USWQ1	2018	98	-	-	-
		2019	365	0	0	36
		2020	366	0	0	35
		2021	302	0	0	-
	BDR-DVWQ	2018	290	0	0	-
		2019	365	0	0	49
		2020	366	0	0	48
		2021	130	-	-	-
	BDR-TAILWQ	2018	255	0	0	-
		2019	287	0	0	19
		2020	222	0	0	44
		2021	196	0	0	-
	BDR-DSWQ	2018	290	0	0	-
		2019	365	0	0	48
		2020	366	0	0	54
		2021	287	0	0	-

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

[2] Operational water temperature Tidbit monitoring commenced on March 16, 2018

"-" denotes periods when insufficient data were available

4.1.6. Bull Trout Temperature Guidelines

During baseline and operational monitoring periods, the highest maximum daily temperatures did not exceed the prescribed thresholds for Bull Trout rearing (15°C) in Upper Lillooet River or Boulder Creek (Oliver and Fidler, 2001; Table 20 and Table 21).

The number of days where daily maximum water temperatures were above the Bull Trout thresholds for spawning and incubation (i.e., >10°C) in a calendar year during baseline monitoring are only available for 2012 in the diversion reach of the Upper Lillooet River (six days, Table 20). During operations, considering the diversion, tailrace, and downstream sites, this number ranged from zero to nine (Table 20). In Boulder Creek, the number of days in a calendar year where daily maximum water temperatures were above the thresholds for spawning and incubation (i.e., >10°C) ranged from two to 16 during in the baseline record at the diversion site, and from 12 to 38 during operations considering data from the diversion, tailrace, and downstream sites (Table 21).

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 20 and Table 21) due to cooler temperatures during the winter months (Table 10 and Table 11). Overall, the number of exceedances of the lower temperature threshold of 2°C were on average less during operations to date (2018 to 2021) than during the baseline period.

Table 20. 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 (Oliver and Fidler 2001).

Project Phase	Site	Year	n (days)[1]	Rearing (Year Round)	Spawning (Aug. 1 - Dec. 8)	Incubation[2] (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
Baseline	ULL-DVWQ	2010	49	-	-	-	-
		2011	97	-	-	-	-
		2012	366	0	6	110	6
		2013	120	-	-	-	-
Operation	ULL-DVWQ01	2018	60	-	-	102	-
		2019	365	0	5	92	5
		2020	121	-	-	-	-
	ULL-TAILWQ	2018	259	-	-	-	-
		2019	293	0	0	90	0
		2020	250	0	3	113	3
		2021	257	0	4	-	4
	ULL-DSWQ	2018	278	0	4	105	4
		2019	365	0	9	101	9
		2020	356	0	7	60	7
		2021	279	0	7	-	7

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

[2] 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).

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.

Table 21. Boulder Creek summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout BC WQG thresholds (Oliver and Fidler 2001).

Project Phase	Site	Year	n (days)[1]	Rearing (Year Round)	Spawning (Aug. 1 - Dec. 8)	Incubation[2] (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
Baseline	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	365	0	32	108	32
		2020	366	0	38	117	38
		2021	130	-	-	-	-
	BDR-TAILWQ	2018	255	0	12	-	-
		2019	287	0	14	62	14
		2020	222	0	19	81	19
		2021	196	0	-	-	-
	BDR-DSWQ	2018	290	0	15	52	21
		2019	365	0	25	110	25
		2020	366	0	27	121	27
		2021	287	0	-	-	-

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

[2] 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).

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.

4.1.7. Mean Weekly Maximum Temperature (MWMxT)

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 6) in the upstream (Table 22, Table 23, Table 24), diversion (Table 25, Table 26, and Table 27) and downstream (Table 28, Table 29, and Table 30) reaches of the Upper Lillooet River, and the diversion (Table 31 and Table 32) and downstream (Table 33 and Table 34) reaches of Boulder Creek. The upstream reach of Boulder Creek is non fish bearing.

Each of the MWMxT tables shows the completeness of the data record (in percent) 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 temperature range for each fish species life stage. Exceedance of the BC WQG range (MECCS 2021, greater than ±1°C outside the optimum ranges) are highlighted in each summary table where blue indicates MWMxTs are cooler than the lower guidelines by more than 1°C and red indicates temperatures are higher than the upper guidelines by more than 1°C. MWMxT results were not calculated for the tailrace sites.

The rearing life stage for all the fish species is year-round, and therefore corresponds to the annual MWMxT range. 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 to 2021), MWMxT ranged from 0.2°C to 10.7°C in the Upper Lillooet River and from 0.0°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 27, Table 30, Table 32, and Table 34).

Table 22. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ1) during baseline monitoring (2008 to 2013).

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	-	-	-	-	-
			92	2009	100	4.7	9.5	64.1	17.4	0.0
			92	2010	100	4.1	8.1	96.7	0.0	0.0
			92	2011	100	3.8	7.0	100.0	0.0	0.0
			92	2012	100	3.1	7.6	100.0	0.0	0.0
			92	2013	69.6	4.4	7.8	100.0	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2008	0.0	-	-	-	-	-
			124	2009	100	6.5	10.8	26.6	46.0	0.0
			124	2010	100	5.7	9.9	52.4	25.0	0.0
			124	2011	100	3.8	10.1	67.7	17.7	0.0
			124	2012	99.2	4.0	10.0	57.7	22.8	0.0
			124	2013	27.4	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	366	2008	9.8	-	-	-	-	-
			366	2009	100	0.1	10.8	52.3	40.3	0.0
			366	2010	100	0.3	9.9	57.0	30.4	0.0
			366	2011	100	0.4	10.1	61.4	24.1	0.0
			366	2012	99.5	0.1	10.0	58.2	26.9	0.0
			366	2013	42.2	-	-	-	-	-

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. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ02) during operational monitoring (2018 to 2019).

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	97.8	4.6	9.9	84.4	6.7	0.0
			92	2019	100	4.0	9.8	60.9	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
			124	2019	100	6.5	9.8	33.1	8.9	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	61.6	2.8	9.9	22.7	58.2	0.0
			365	2019	58.4	2.6	9.8	23.0	59.6	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 24. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River upstream reach (ULL-USWQ03) during operational monitoring (2018 to 2021).

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	0.0	-	-	-	-	-
			92	2019	100	4.7	10.1	57.6	19.6	0.0
			92	2020	100	4.3	9.1	77.2	1.1	0.0
			92	2021	43.5	-	-	-	-	-
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	0.0	-	-	-	-	-
			124	2019	100	6.3	10.1	21.8	21.0	0.0
			124	2020	100	4.3	9.5	41.9	18.5	0.0
			124	2021	8.1	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	15.1	-	-	-	-	-
			365	2019	99.7	0.7	10.1	54.7	35.2	0.0
			365	2020	100	0.9	9.5	54.4	34.4	0.0
			365	2021	35.6	-	-	-	-	-

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. MWMxTs measured during Coho Salmon life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring.

Species	Life Stage Data			Year[1]	% Complete[2]	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	1.1	9.5	63.1	25.4	0.0
			122	2018	45.1	-	-	-	-	-
			122	2019	100	0.8	9.1	68.9	21.3	0.0
			122	2020	40.2	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2012	100	1.1	6.3	65.8	22.8	0.0
			79	2018	70.9	0.7	5.5	82.1	7.1	0.0
			79	2019	100	0.8	6.2	53.2	30.4	0.0
			79	2020	51.9	2.2	5.9	39.0	39.0	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2012	100	0.5	6.3	66.3	18.9	0.0
			169	2018	86.4	0.4	5.5	79.5	12.3	0.0
			169	2019	90.0	0.2	6.2	68.6	19.6	0.0
			169	2020	24.3	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2012	100	0.4	10.1	74.6	12.6	0.0
			365	2018	15.1	-	-	-	-	-
			365	2019	100	0.4	10.7	68.8	23.8	0.0
			365	2020	33.9	-	-	-	-	-

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] 2012 data were collected at ULL-DVWQ; 2018 to 2020 data were collected at ULL-DVWQ01.

[2] 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. MWMxTs measured during Cutthroat Trout life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring.

Species	Life Stage Data			Year[1]	% Complete[2]	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	3.6	8.5	90.2	0.0	0.0
			92	2018	0.0	-	-	-	-	-
			92	2019	100	4.7	10.7	55.4	28.3	0.0
			92	2020	0.0	-	-	-	-	-
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2012	100	4.5	10.1	46.0	31.5	0.0
			124	2018	0.0	-	-	-	-	-
			124	2019	100	7.0	10.7	16.9	67.7	0.0
			124	2020	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2012	100	0.4	10.1	54.9	35.8	0.0
			365	2018	15.1	-	-	-	-	-
			365	2019	100	0.4	10.7	52.6	41.1	0.0
			365	2020	33.9	-	-	-	-	-

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] 2012 data were collected at ULL-DVWQ; 2018 to 2020 data were collected at ULL-DVWQ01.

[2] 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 27. MWMxTs measured during Bull Trout life history stages in the Upper Lillooet River diversion reach (ULL-DVWQ01) during baseline (2012) and operational (2018 to 2020) monitoring.

Species	Life Stage Data			Year[1]	% Complete[2]	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	2012	100	1.6	10.1	23.1	42.3	0.8
			130	2018	24.6	-	-	-	-	-
			130	2019	100	0.8	9.9	19.2	43.1	0.0
			130	2020	37.7	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2012	100	0.5	10.1	5.6	34.3	30.0
			213	2018	54.0	0.4	5.5	11.3	36.5	0.0
			213	2019	100	0.2	9.9	6.5	30.8	27.6
			213	2020	23.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2012	100	0.4	10.1	46.7	45.1	0.0
			365	2018	15.1	-	-	-	-	-
			365	2019	100	0.4	10.7	44.9	47.4	0.0
			365	2020	33.9	-	-	-	-	-

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] 2012 data were collected at ULL-DVWQ; 2018 to 2020 data were collected at ULL-DVWQ01.

[2] 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 28. MWMxTs measured during Coho Salmon life history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021).

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	59.8	21.3	0.0
			122	2019	100	1.1	9.2	68.9	17.2	0.0
			122	2020	92.6	2.0	9.2	63.7	27.4	0.0
			122	2021	36.1	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2018	100	1.6	6.7	63.3	32.9	0.0
			79	2019	100	1.1	6.2	48.1	26.6	0.0
			79	2020	88.6	2.0	5.3	71.4	12.9	0.0
			79	2021	0.0	-	-	-	-	-
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2018	100	1.1	6.7	66.9	24.3	0.0
			169	2019	100	1.0	6.2	62.4	21.2	0.0
			169	2020	94.7	2.0	5.8	56.9	30.0	0.0
			169	2021	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2018	74.8	1.6	10.7	67.0	19.8	0.0
			365	2019	100	1.1	10.5	69.0	19.7	0.0
			365	2020	97.5	1.0	10.3	71.7	15.1	0.0
			365	2021	76.4	2.2	10.5	67.0	19.4	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 29. MWMxTs measured during Cutthroat Trout history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021).

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	97.8	4.8	10.4	77.8	8.9	0.0
			92	2019	100	4.6	10.5	56.5	23.9	0.0
			92	2020	100	4.2	9.4	72.8	5.4	0.0
			92	2021	91.3	5.7	10.3	67.9	13.1	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	100	6.0	10.7	33.9	43.5	0.0
			124	2019	100	7.0	10.5	17.7	57.3	0.0
			124	2020	100	5.1	10.3	30.6	37.9	0.0
			124	2021	100	6.0	10.5	28.2	43.5	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	74.8	1.6	10.7	33.7	52.4	0.0
			365	2019	100	1.1	10.5	51.0	41.1	0.0
			365	2020	97.5	1.0	10.3	55.5	39.5	0.0
			365	2021	76.4	2.2	10.5	37.3	48.7	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 30. MWMxTs measured during Bull Trout life history stages in the Upper Lillooet River downstream reach (ULL-DSWQ) during operational monitoring (2018 to 2021).

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	10.1	21.5	58.5	1.5
			130	2019	100	1.1	10.2	17.7	47.7	2.3
			130	2020	93.1	2.0	10.1	27.3	47.9	1.7
			130	2021	57.7	5.0	10.0	0.0	78.7	0.0
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2018	100	1.1	10.1	0.0	39.9	28.2
			213	2019	100	1.0	10.2	0.0	32.7	26.2
			213	2020	95.8	2.0	10.1	0.0	63.7	31.4
			213	2021	35.2	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2018	74.8	1.6	10.7	22.0	66.3	0.0
			365	2019	100	1.1	10.5	45.8	49.0	0.0
			365	2020	97.5	1.0	10.3	44.8	44.5	0.0
			365	2021	76.4	2.2	10.5	25.8	62.7	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 31. MWMxTs measured during Cutthroat Trout life history stages in the Boulder Creek diversion reach (BDR-DVWQ) during baseline (2008 to 2013) and operational (2018 to 2021) 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
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2008	0.0	-	-	-	-	-
			92	2009	100	2.5	10.3	76.1	4.3	0.0
			92	2010	97.8	3.2	7.8	100	0.0	0.0
			92	2011	92.4	2.8	5.7	100	0.0	0.0
			92	2012	100	2.6	6.1	100	0.0	0.0
			92	2013	68.5	3.4	7.8	100	0.0	0.0
			92	2018	100	3.2	10.6	79.3	12.0	0.0
			92	2019	100	4.2	10.8	60.9	23.9	0.0
			92	2020	100	3.0	8.6	92.4	0.0	0.0
			92	2021	44.6	-	-	-	-	-
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2008	0.0	-	-	-	-	-
			124	2009	100	4.5	11.0	32.3	45.2	0.0
			124	2010	99.2	5.1	10.8	50.4	42.3	0.0
			124	2011	92.7	3.6	9.4	72.2	7.8	0.0
			124	2012	100	4.0	10.5	57.3	22.6	0.0
			124	2013	26.6	-	-	-	-	-
			124	2018	100	6.3	12.1	34.7	57.3	0.0
			124	2019	100	6.4	11.9	21.0	67.7	0.0
			124	2020	100	5.4	11.8	44.4	39.5	0.0
			124	2021	8.9	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	366	2008	11.7	-	-	-	-	-
			365	2009	100	0.1	11.0	63.8	33.2	0.0
			365	2010	96.7	0.0	10.8	64.0	26.9	0.0
			365	2011	97.5	0.1	9.9	72.8	18.0	0.0
			366	2012	100	0.0	10.5	69.9	25.4	0.0
			365	2013	41.9	-	-	-	-	-
			365	2018	78.9	0.3	12.1	42.7	48.6	0.0
			365	2019	100	0.1	11.9	57.0	37.5	0.0
			366	2020	100	0.0	11.8	55.2	38.0	0.0
			365	2021	35.9	-	-	-	-	-

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 32. MWMxTs measured during Bull Trout life history stages in the Boulder Creek diversion reach (BDR-DVWQ) during baseline (2008 to 2013) and operational (2018 to 2021) 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
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2008	15.4	-	-	-	-	-
			130	2009	100	0.2	10.4	38.5	36.2	4.6
			130	2010	92.3	0.0	10.8	26.7	34.2	8.3
			130	2011	100	0.2	9.9	35.4	43.8	0.0
			130	2012	100	1.3	10.5	31.5	35.4	6.2
			130	2013	0.0	-	-	-	-	-
			130	2018	100	0.3	12.0	23.8	43.1	19.2
			130	2019	100	0.3	11.9	20.8	27.7	31.5
			130	2020	100	1.7	11.8	29.2	15.4	34.6
			130	2021	0.0	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	214	2008	48.4	-	-	-	-	-
			213	2009	100	0.1	10.4	11.7	36.2	27.2
			213	2010	95.3	0.0	10.8	20.7	20.2	27.1
			213	2011	100	0.0	9.9	18.2	12.6	24.8
			214	2012	100	0.1	10.5	18.8	16.9	31.0
			213	2013	0.0	-	-	-	-	-
			213	2018	100	0.1	12.0	17.8	24.9	28.2
			213	2019	100	0.0	11.9	13.6	28.5	27.6
			214	2020	100	0.1	11.8	8.9	24.9	34.7
			213	2021	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	366	2008	11.7	-	-	-	-	-
			365	2009	100	0.1	11.0	56.4	36.2	0.0
			365	2010	96.7	0.0	10.8	53.0	36.0	0.0
			365	2011	97.5	0.1	9.9	66.9	27.2	0.0
			366	2012	100	0.0	10.5	61.2	30.1	0.0
			365	2013	41.9	-	-	-	-	-
			365	2018	78.9	0.3	12.1	31.9	57.3	0.0
			365	2019	100	0.1	11.9	51.0	43.0	0.0
			366	2020	100	0.0	11.8	48.6	44.8	0.0
			365	2021	35.9	-	-	-	-	-

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 33. MWMxTs measured during Cutthroat Trout life history stages in the Boulder Creek downstream reach (BDR-DSWQ) during operational monitoring (2018 to 2021).

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
			92	2019	100	3.6	10.3	70.7	17.4	0.0
			92	2020	100	0.8	5.5	77.2	13.9	0.0
			92	2021	5.1	-	-	-	-	-
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2018	100	5.2	11.6	37.9	50.0	0.0
			124	2019	100	4.7	11.5	28.2	62.9	0.0
			124	2020	100	0.1	5.5	82.8	8.9	0.0
			124	2021	2.4	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2018	78.9	0.4	11.6	49.7	40.3	0.0
			365	2019	100	0.1	11.5	62.5	34.2	0.0
			366	2020	100	0.1	11.4	71.6	20.2	0.0
			365	2021	78.6	0.1	12.0	69.7	22.6	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 34. MWMxTs measured during Bull Trout life history stages in the Boulder Creek downstream reach (BDR-DSWQ) during operational monitoring (2018 to 2021).

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	0.4	11.6	24.6	45.4	16.2
			130	2019	100	0.6	11.5	30.0	24.6	20.8
			130	2020	100	0.8	5.5	77.2	13.9	0.0
			130	2021	5.1	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2018	100	0.1	11.6	14.1	27.2	28.2
			213	2019	100	0.1	11.5	12.6	30.8	27.6
			214	2020	100	0.1	5.5	82.8	8.9	0.0
			213	2021	2.4	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2018	78.9	0.4	11.6	34.7	50.3	0.0
			365	2019	100	0.1	11.5	55.9	37.5	0.0
			366	2020	100	0.1	11.4	71.6	20.2	0.0
			365	2021	78.6	0.1	12.0	69.7	22.6	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.

4.1.8. Frazil Ice

Air temperature recorded at Callaghan Valley and Pemberton Airport weather stations was monitored from October 2021 to March 2022. The lowest monthly average and instantaneous air temperatures in Year 4 at Callaghan Valley and Pemberton airport weather stations were recorded in December 2021 (averages of -6.4°C and -5.6°C with instantaneous minimums of -21.1°C and -18.5°C respectively, Table 35).

Analysis of air temperature data from Pemberton Airport weather station confirmed there were three occurrences of six, sixteen and four consecutive days of temperatures averaging <-5°C in December 2021, January 2022 and February 2022 (Table 35, Figure 7). In addition, two occurrences of ten and five consecutive days of temperatures averaging <-5°C in December 2021 and February 2021 respectfully was observed at the Callaghan Valley Station (Table 35, Figure 8). When air temperatures were less than -5°C for at least three consecutive days, Callaghan Valley and Pemberton airport had minimum average daily temperatures of -14.1 °C which occurred between December 24, 2021, and January 2, 2022 (Table 35)

As per the frazil ice monitoring protocol, site photographs were collected by operations staff for Upper Lillooet and Boulder Creek during recorded occurrences of three consecutive days of <-5°C at both Pemberton Airport and Callaghan Valley Station. Representative photos of the ice conditions during the period of the coldest recorded conditions on Boulder Creek in Year 4 are shown in Figure 9 to Figure 11. Extensive ice cover is present in Figure 9 looking upstream on Boulder Creek, however Figure 10 and Figure 11 show clear flowing water, free of frazil ice. Representative photos of the ice conditions during the coldest recorded conditions on Upper Lillooet in Year 4 are shown in Figure 12 to Figure 14. Additional photographs were reviewed for both facilities during all periods identified in Table 35 and it was determined that conditions did not warrant a site visit as frazil ice was not detected.

Table 35. Summary of dates when air temperature was less than -5°C for at least three consecutive days during Year 4 (October 2021 to February 2022).

Weather Station Air Temperature	Year	Start Date	End Date	Length (days)	Average Daily Temperature (°C)	Minimum Daily Temperature (°C)
Callaghan Valley	2021	19-Dec	21-Dec	3	-9.3	-12.8
		24-Dec	1-Jan	9	-14.1	-21.1
	2022	4-Jan	6-Jan	3	-9.6	-13.4
		21-Feb	25-Feb	5	-7.7	-11.0
Pemberton Airport	2021	17-Dec	22-Dec	6	-8.3	-14.0
	2022	25-Dec	2-Jan	9	-14.1	-18.5
		4-Jan	10-Jan	7	-10.4	-12.4
		27-Jan	29-Jan	3	-7.1	-8.4
		23-Feb	25-Feb	3	-5.8	-6.1

Figure 7. Average daily air temperature data from October 2021 to February 2022 at Callaghan Valley air temperature monitoring station. Note the threshold is met when air temperature is less than -5°C for at least three consecutive days. This figure is inclusive of those three days.

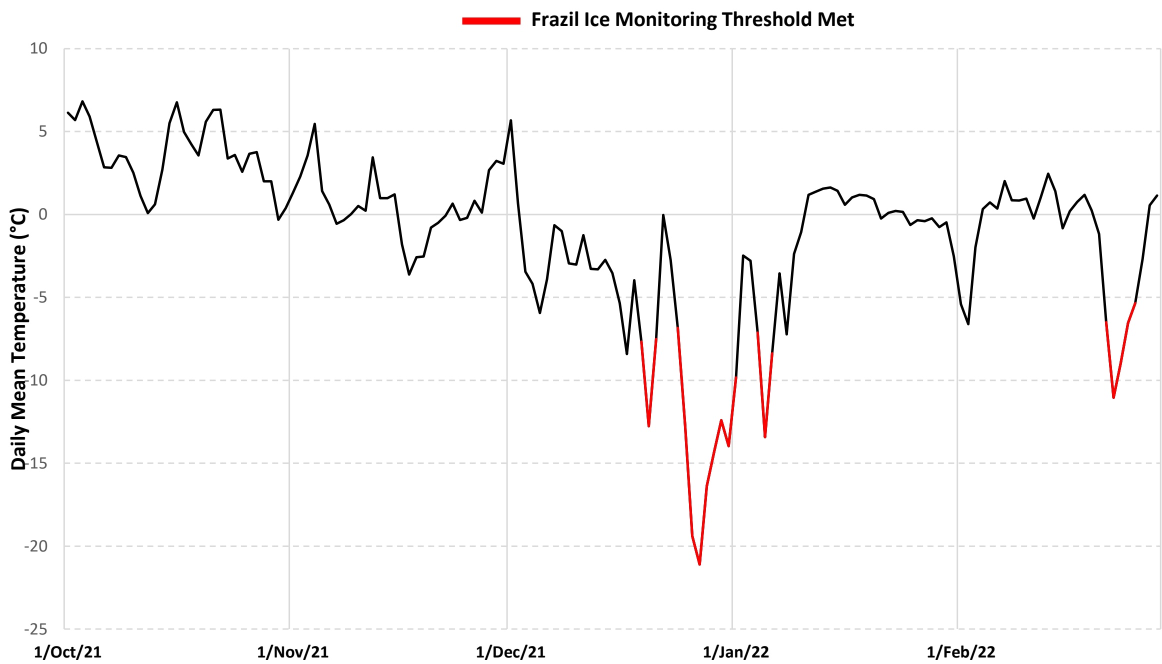


Figure 8. Average daily air temperature data from October 2021 to February 2022 at Pemberton Airport air temperature monitoring station. Note the threshold is met when air temperature is less than -5°C for at least three consecutive days. This figure is inclusive of those three days.

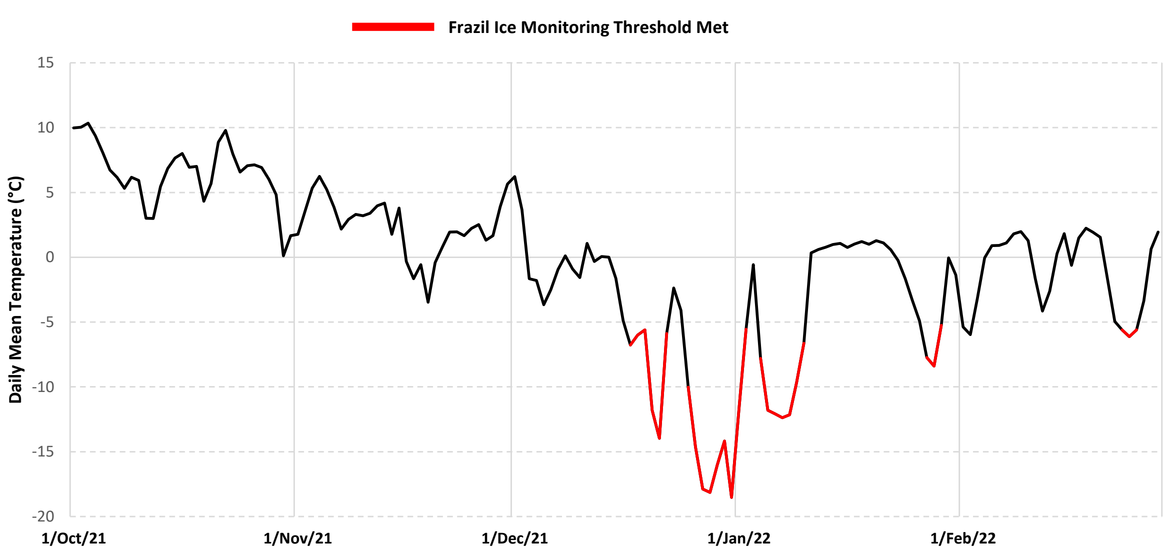


Figure 9. Looking upstream at Boulder Creek diversion on December 28, 2021.

Figure 10. Looking river right to river left at Boulder Creek on December 28, 2021.

Figure 11. Looking downstream at Boulder Creek diversion on December 28, 2021.

Figure 12. Looking upstream at Upper Lillooet diversion reach from the tailrace on December 28, 2021.

Figure 13. Looking river left to river right at Upper Lillooet diversion on December 28, 2021.

Figure 14. Looking downstream at Upper Lillooet from the tailrace on December 28, 2021.

4.1.8.1. Frazil Ice Summary (Year 1 through 4)

Air temperature at Callaghan Valley and Pemberton Airport weather stations was monitored from October 2017 to February 2022. Analysis of air temperature data from Callaghan Valley Station confirmed there was ten occurrences ranging from three to twelve consecutive days of temperatures averaging <-5°C between October 2017 to February 2022 (Table 36). Pemberton Airport weather station confirmed there was eight events of ranging from four to sixteen consecutive days of temperatures averaging <-5°C during October 2017 to February 2022. (Table 36, Figure 16). Ten occurrences ranging from three and twelve consecutive days of temperatures averaging <-5°C from October 2017 to February 2022 respectively were observed at the Callaghan Valley Station (Table 36, Figure 8).

As per the frazil ice monitoring protocol, site photographs were collected by operations staff for Upper Lillooet and Boulder Creek during recorded occurrences of three consecutive days of <-5°C at both Pemberton Airport and Callaghan Valley Station. Photographs were reviewed for both facilities during periods identified in Table 36. Based on a review of photographs it was determined that conditions did not warrant a site visit as frazil ice was not detected, with the exception of site visits conducted on December 23 and 24, 2017 and January 2, 2018. Frazil ice was identified in the margin habitat of Boulder Creek during the December 23 and 24, 2017 survey however, the mainstem was free of frazil ice and pool holding habitat was still available. Further, the Boulder Creek facility was shut down at the time of survey. No frazil ice was identified in Upper Lillooet during this survey. No frazil ice was identified on Upper Lillooet or Boulder Creek during the January 2, 2018 survey.

The overall minimum three-day average air temperature threshold during occurrences was -16.4°C as measured at the Callaghan Valley weather station across all years, while the Pemberton Valley station saw a three-day average threshold of -16.0°C, both of which occurred between December 24, 2021 to January 2, 2022 (Table 36). Conditions on Boulder Creek during this period are shown in Figure 9 to Figure 11 above. Extensive ice cover is present in Figure 9 looking upstream on Boulder Creek, however, Figure 10 and Figure 11 show clear flowing water, free of frazil ice. Conditions on the Upper Lillooet River during this period are shown in Figure 12 to Figure 14, with the river flowing clear and free of frazil ice. Results from the first four years of operational monitoring have supported that frazil ice does not appear to be an issue in the diversion reaches of the Upper Lillooet River or Boulder Creek.

Table 36. Summary of dates when air temperature was less than -5°C for at least three consecutive days during years 1 through 4 (October 2017 to February 2022).

Weather Station Air Temperature	Year	Start Date	End Date	Length (days)	Average Daily Air Temperature (°C)	Minimum Daily Air Temperature (°C)	Minimum 3-Day Threshold Air Temperature (°C)[2]
Callaghan Valley	2017	03-Nov	06-Nov	4	-7.9	-8.6	-7.8
		20-Dec	31-Dec	12	-7.4	-10.7	-8.2
	2018	18-Feb	23-Feb	6	-10.0	-11.2	-10.8
	2019	03-Feb	14-Feb	12	-11.2	-14.4	-11.5
		24-Feb	26-Feb	3	-8.5	-9.8	-6.5
		28-Feb	05-Mar	6	-7.6	-9.5	-7.3
		28-Nov	30-Nov	3	-6.9	-7.8	-6.3
	2020	12-Jan	18-Jan	7	-11.5	-17.9	-16.0
	2021	08-Feb	14-Feb	7	-10.7	-15.3	-11.0
		19-Dec	21-Dec	3	-9.3	-12.8	-7.5
		24-Dec	01-Jan	9	-14.1	-21.1	-16.4
	2022	04-Jan	06-Jan	3	-9.6	-13.4	-7.1
		21-Feb	25-Feb	5	-7.7	-11.0	-6.5
Pemberton Airport	2018	23-Dec	04-Jan	13	-7.7	-12.5	-9.0
		19-Feb	23-Feb	5	-8.8	-10.6	-9.2
	2019	03-Feb	14-Feb	12	-9.5	-14.2	-10.7
	2020	13-Jan	18-Jan	6	-13.2	-15.1	-14.0
	2021	09-Feb	14-Feb	6	-8.8	-11.2	-9.0
		17-Dec	22-Dec	6	-8.3	-14.0	-5.9
	2022	25-Dec	02-Jan	9	-14.1	-18.5	-16.0
		04-Jan	10-Jan	7	-10.4	-12.4	-12.1
		27-Jan	29-Jan	3	-7.1	-8.4	-5.2
		23-Feb	25-Feb	3	-5.8	-6.1	-5.6

[1] Occurrence start date is in the previous year, or ends in the following year.

[2] Minimum 3-day Thresholds are based on maximum daily temperuture during the coldest 3 day period.

Figure 15. Average daily air temperature data from October 2017 to February 2022 at Callaghan Valley air temperature monitoring station. Note the threshold is met when air temperature are less than -5°C for at least three consecutive days. This figure is inclusive of those three days.

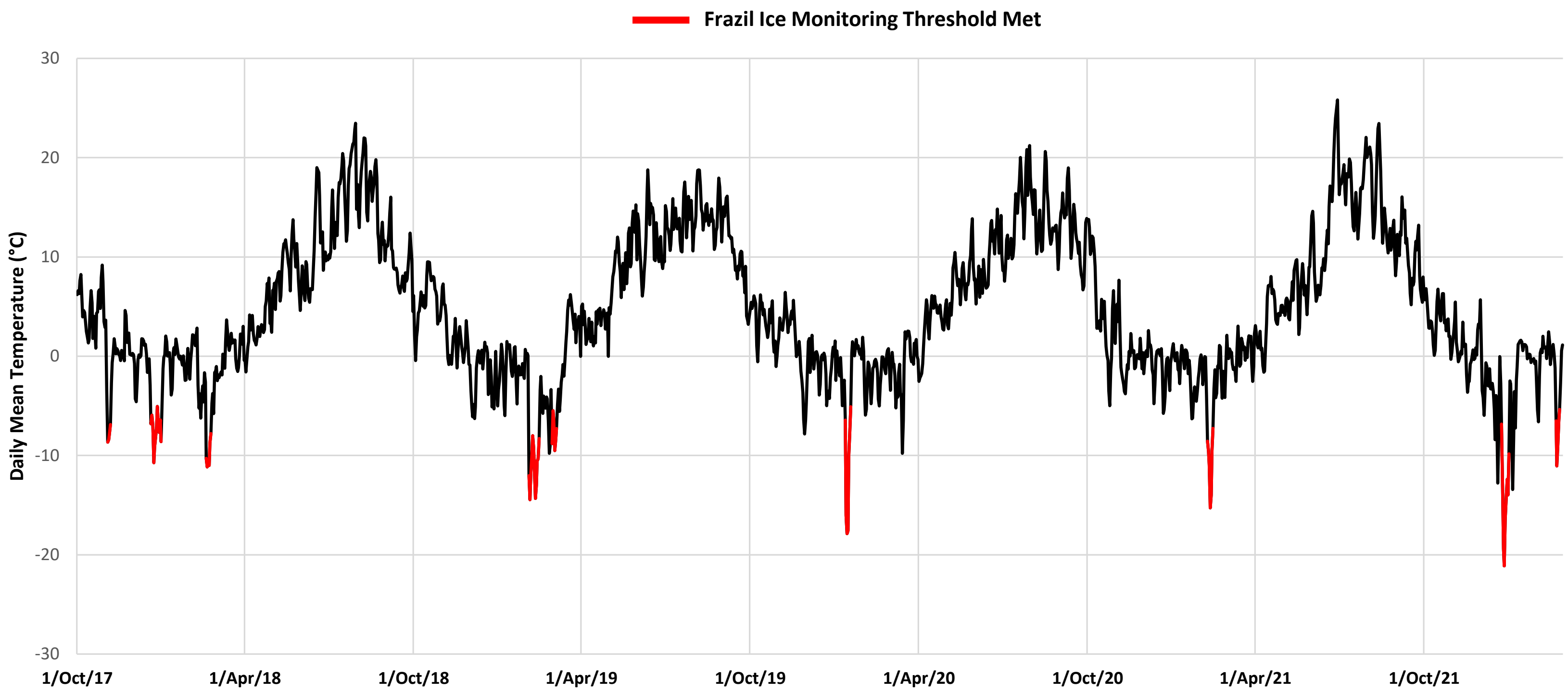
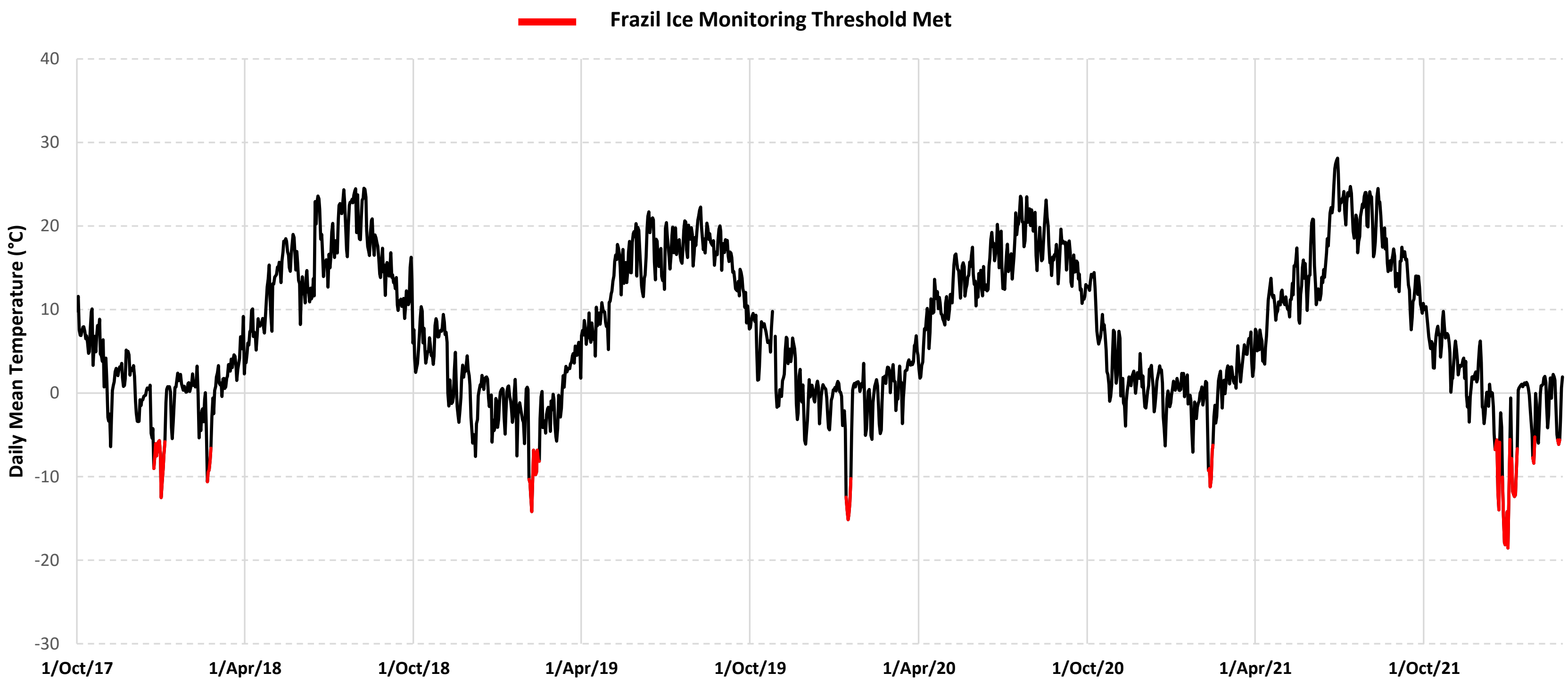


Figure 16. Average daily air temperature data from October 2017 to February 2022 at Pemberton Airport air temperature monitoring station. Note the threshold is met when air temperature are less than -5°C for at least three consecutive days. This figure is inclusive of those three days.



4.2. Fish Community

4.2.1. Adult Migration and Spawning

4.2.1.1. Bull Trout Angling Surveys

Habitat summaries and representative photographs of angling sites in the Upper Lillooet River, Boulder Creek, and North Creek are presented in Appendix G. Capture results from Year 4 (2021) angling surveys are presented in Table 37 and site-specific results, individual fish data, and monitoring site locations are provided in Appendix G and Map 5.

Upper Lillooet River

A total of sixteen Bull Trout were captured during angling surveys in Year 4, three in the diversion reach and thirteen in the downstream reach (Table 37). No Bull Trout were captured within the tailrace. Captured Bull Trout ranged from 173 mm to 566 mm fork length, with the largest fish captured in the downstream reach (Table 38). None of the captured Bull Trout were classified as sexually mature. As in previous years, 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 powerhouse and presence of Bull Trout detections in the diversion reach suggest that movement into the diversion reach was not inhibited by operations in 2021.

A single Bull Trout was recaptured during the 2021 sampling effort. The individual was originally captured and tagged at ULL-DSAG05 on September 15, 2021 and recaptured at the same site on October 7, 2021 (Map 5). There were no Bull Trout recaptures of fish tagged in previous years.

In addition to Bull Trout, two Cutthroat Trout were captured during surveys (220 mm at ULL-DVAG05 and 261 mm at ULL-TRAG01; see Map 5 for locations of monitoring sites). These fish were not included in catch per unit effort (CPUE) calculations.

Boulder Creek

A total of 42 Bull Trout were captured during angling surveys in Year 4, 22 in the diversion reach, nine in the tailrace, and 11 in the downstream reach (Table 37). Of these, 5% were sexually mature in the diversion, 0% were sexually mature in the tailrace, and 9% were sexually mature in the downstream reach. Captured Bull Trout ranged from 163 mm to 470 mm fork length, with the largest fish captured in the diversion reach (Table 38). As in previous years, no barriers to migration were observed during assessment of fish passage and upstream access conducted during angling surveys within the lower 1.3 km of Boulder Creek. Absence of Bull Trout holding below the powerhouse and Bull Trout presence in the diversion reach suggest movement into the diversion reach was not inhibited by operations in 2021. No previously captured Bull Trout were recaptured in Boulder Creek in 2021.

North Creek

A total of 20 Bull Trout were captured in North Creek, of which 0-12% were sexually mature depending on the capture date (Table 37). Captured Bull Trout ranged from 183 mm to 511 mm in fork length (Table 38). No previously captured Bull Trout were recaptured in North Creek in 2021.

Table 37. Summary of Bull Trout capture data during angling surveys conducted in the Upper Lillooet River, Boulder Creek, and North Creek in fall of 2021.

Stream	Date	Project Area	Project Area	# of Sites	Effort (rod hrs)	Bull Trout Captures	CPUE [1] (Bull Trout/hr)	% Sexually Mature [2]
Upper Lillooet River	15-Sep	Diversion	Diversion	2	2.3	2	0.9	0%
		Tailrace	Tailrace	1	1.1	0	0.0	n/a
		Downstream	Downstream	3	3.4	8	2.4	0%
	07-Oct	Diversion	Diversion	2	2.0	0	0.0	n/a
		Tailrace	Tailrace	1	1.0	0	0.0	n/a
		Downstream	Downstream	3	3.0	3	1.0	0%
	19-Oct and 21-Oct	Diversion	Diversion	2	2.1	1	0.5	0%
		Tailrace	Tailrace	1	1.0	0	0.0	n/a
		Downstream	Downstream	3	3.0	2	0.7	0%
2021 Total:		**Diversion**	**Diversion**	**6**	**6.4**	**3**	**0.5**	**0%**
		Tailrace	**Tailrace**	**3**	**3.1**	**0**	**0.0**	**n/a**
		Downstream	**Downstream**	**9**	**9.4**	**13**	**1.4**	**0%**
Boulder Creek	13-Sep	Diversion	Diversion	3	3.6	9	2.5	11%
		Tailrace	Tailrace	1	1.2	5	4.3	0%
		Downstream	Downstream	3	3.2	2	0.6	50%
	05-Oct	Diversion	Diversion	3	3.9	11	2.8	0%
		Tailrace	Tailrace	1	1.0	3	3.0	0%
		Downstream	Downstream	3	3.0	5	1.7	0%
	19-Oct and 20-Oct	Diversion	Diversion	3	2.9	2	0.7	0%
		Tailrace	Tailrace	1	1	1	1.0	0%
		Downstream	Downstream	3	3	4	1.3	0%
2021 Total:		**Diversion**	**Diversion**	**9**	**10.4**	**22**	**2.1**	**5%**
		Tailrace	**Tailrace**	**3**	**3.2**	**9**	**2.8**	**0%**
		Downstream	**Downstream**	**9**	**9.2**	**11**	**1.2**	**9%**
North Creek	14-Sep	Diversion	N/A	6	6.9	17	2.5	12%
	06-Oct	Downstream	N/A	6	5.2	7	1.4	0%
	20-Oct	Downstream	N/A	4	3.8	10	2.6	0%
2021 Total:		**Downstream**	**N/A**	**16**	**15.9**	**34**	**2.1**	**0%**

[1] Two Cutthroat Trout were captured during surveys. The first Cutthroat Trout was captured on October 2, 2020 at ULL-DVAG19 (251 mm, 120 grams). The second Cutthroat Trout was captured October 21, 2020 at ULL-DSAG09 (116 mm, 9.8 grams). These fish were not included in catch per unit effort calculations.

[2] Sexually maturity was determined based on the presence of gametes upon examination.

Table 38. 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 fall of 2021.

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	3	217	210	229	3	92	60	122	3	0.88	0.65	1.02
	Tailrace	0	-	-	-	0	-	-	-	0	-	-	-
	Downstream	13	319	173	566	13	435	56	1,650	13	0.98	0.83	1.08
	Total:	16	300	173	566	16	371	56	1,650	16	0.96	0.65	1.08
Boulder Creek	Diversion	21	266	163	470	21	235	50	1,000	21	1.03	0.90	1.15
	Tailrace	9	299	195	419	9	344	81	723	9	1.08	0.92	1.54
	Downstream	11	341	207	450	11	459	93	952	11	0.98	0.41	1.16
	Total:	41	294	163	470	41	319	50	1,000	41	1.03	0.41	1.54
North Creek	N/A	34	360	183	511	33	562	61	1,226	33	0.99	0.72	1.20
	Total:	34	360	183	511	33	562	61	1,226	33	0.99	0.72	1.20

4.2.1.1. Tributary Bank Walk Bull Trout Spawner Surveys

A summary of effort and fish observations during bank walk spawner surveys in Alena Creek and 29.2 km Tributary in the fall of 2021 are presented in Table 39. As in 2020, surveyed distances ranged from 1,750 m to 2,300 m in Alena Creek and were 724 m in 29.2 km Tributary. It should be noted that the change in survey distance on Alena Creek is not expected to have a significant effect on total observations as a small percentage of fish are observed in this section due to the high turbidity influence from the Upper Lillooet and lack of holding habitat. Live Bull Trout were observed in both Alena Creek and 29.2 km Tributary (five Bull Trout were counted in Alena Creek on October 21, 2021 and three were counted in 29.2 km Tributary on October 6, 2021). No Bull Trout carcasses or redds were observed in either Alena Creek or 29.2 km. Four Cutthroat Trout were observed in 29.2 km Tributary during one survey in 29.2 km Tributary (Table 39).

Table 39. Summary of results from spawner surveys conducted in Alena Creek and 29.2 km Tributary in fall of 2021.

Stream	Date	Survey Time (hh:mm)	Survey Distance (m)	Number Observed[1]					
				Live Adults		Adult Carcasses		Redds	
				BT	CT	BT	CT	BT	CT
Alena Creek	15-Sep-21	01:40	1,750	0	0	0	0	0	0
	7-Oct-21	01:35	2,300	0	0	0	0	0	0
	21-Oct-21	02:38	2,300	5	0	0	0	0	0
	Total:	**13:34**	**13,250**	**5**	**0**	**0**	**0**	**0**	**0**
29.2 km Tributary	14-Sep-21	01:12	724	0	0	0	0	0	0
	6-Oct-21	01:25	724	0	0	0	0	0	0
	22-Oct-21	01:09	724	3	4	0	0	0	0
	Total:	**03:46**	**2,172**	**3**	**4**	**0**	**0**	**0**	**0**

[1] BT = Bull Trout, CT = Cutthroat Trout

4.2.1.2. Comparison Among Years

Angling Catch per Unit Effort (CPUE)

Upper Lillooet River

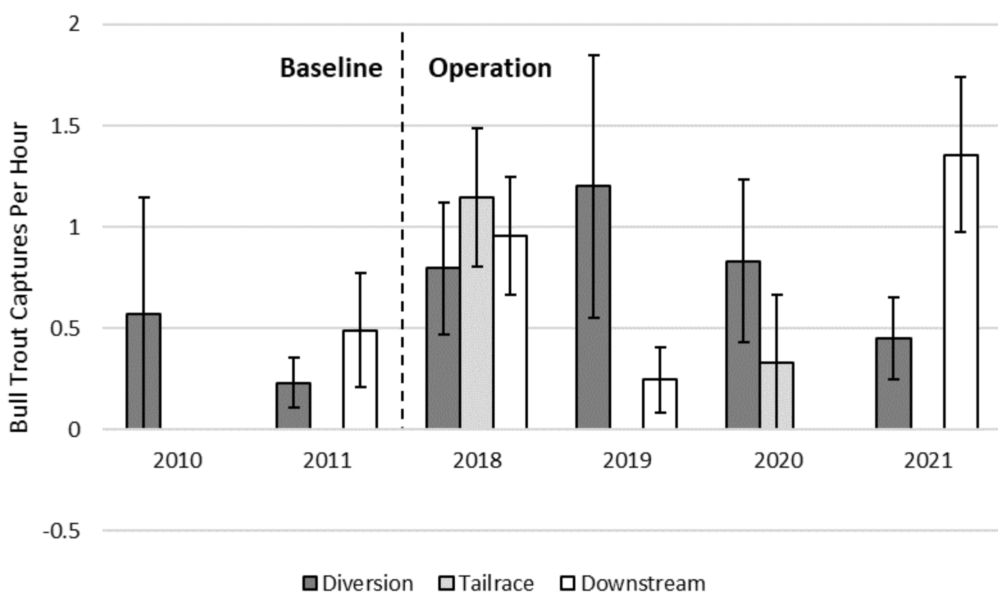
Average CPUE in the diversion reach has remained relatively consistent during operations (ranging 0.45 – 1.20 fish per hour within Year 1 to Year 4) and has generally been higher than during baseline surveys (0.23 – 0.57 fish per hour) to date (Table 40, Figure 17). Average CPUE in the tailrace ranged from zero to 1.15 fish per hour during operations. Average CPUE in the downstream reach was variable in both baseline (0 – 0.49 fish per hour) and operational years (0 – 1.36 fish per hour) and was higher in Year 4 than in previous years (1.36 fish per hour verse 0 – 0.96 fish per hour). There is no observable trend in CPUE during operational monitoring between Project reaches or over time.

The continued captures of Bull Trout in the diversion reach and lack of congregation below the tailrace during the spawning period throughout the operational monitoring period provides evidence that movement into the reach has not been inhibited by operations. It should be noted that a facility shutdown occurred during the expected peak spawning migration period in 2018. Thus, the relatively high number of captures in the downstream reach in 2018 did not represent a Project effect on movement into the diversion reach as river flows were natural (unaffected by operations). The relatively high number of captures in the downstream reach in 2021 was due primarily to captures during the first of three surveys (8 of 13 total captures) (Appendix G). Given that high captures in the downstream reach did not continue on subsequent surveys (3 on October 7, 2021, and 2 on October 17, 2021) this suggests that these fish moved into alternate habitats.

Table 40. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on the Upper Lillooet River.

Metric	Reach	Baseline		Operational			
		2010	2011	2018	2019	2020	2021
Sites Sampled	Diversion	3	10	6	6	6	6
	Tailrace	-	-	3	3	3	3
	Downstream	2	4	9	8	9	9
Captures	Diversion	4	3	6	7	5	3
	Tailrace	-	-	4	0	1	0
	Downstream	0	2	10	2	0	13
Effort (hr)	Diversion	3.9	11.2	8.0	7.1	6.0	6.4
	Tailrace	-	-	3.6	3.4	3.0	3.1
	Downstream	2.1	4.0	11.0	8.0	9.0	9.4
Mean CPUE (fish/hr)	Diversion	0.57	0.23	0.80	1.20	0.83	0.45
	Tailrace	-	-	1.15	0.00	0.33	0.00
	Downstream	0.00	0.49	0.96	0.25	0.00	1.36

Figure 17. Comparison of Bull Trout mean catch per unit effort between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on the Upper Lillooet River. Error bars shown are standard error.



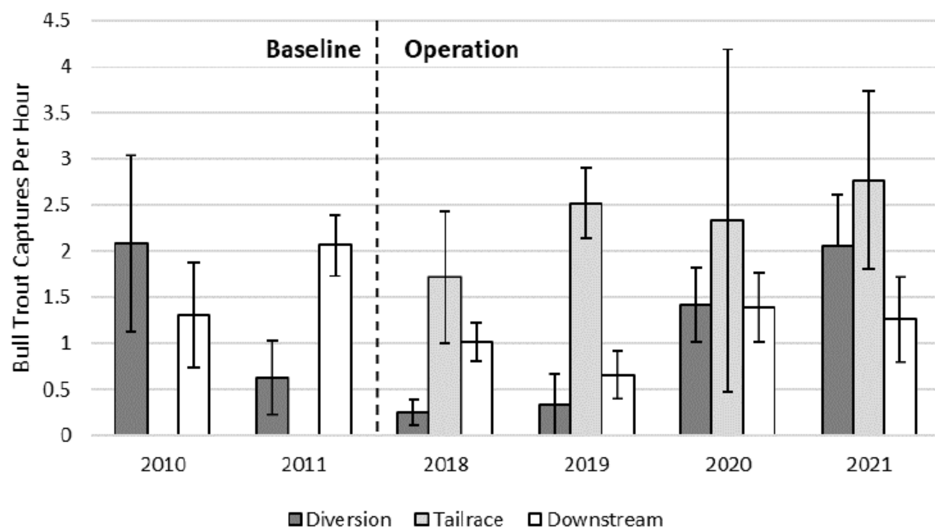
Boulder Creek

Average CPUE in the Boulder Creek diversion reach fluctuated throughout the monitoring period. During the operational monitoring years (years 1 to 4), CPUE in the diversion ranged between 0.25 and 2.06 and was similar to that during the baseline period (0.63 – 2.08 fish per hour) (Table 41, Figure 18). In the diversion, there has been an increasing trend in average CPUE annually during the operational period, with a maximum obtained during 2021 sampling (2.06 fish per hour) being consistent with the highest baseline year (2.08 fish per hour in 2010). CPUE in the tailrace ranged from 1.72 to 2.77 fish per hour during operations. CPUE in the downstream reach was similar during baseline (1.30 to 2.06 fish per hour) and operational (0.65 to 1.26 fish per hour) monitoring to date. Similar to observations in the Upper Lillooet River, captures in the diversion reach during the operational monitoring years suggests that access to the diversion was not inhibited.

Table 41. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on Boulder Creek.

Metric	Reach	Baseline		Operational			
		2010	2011	2018	2019	2020	2021
Sites Sampled	Diversion	2	6	11	9	12	9
	Tailrace	-	-	3	3	3	3
	Downstream	4	7	12	11	10	9
Captures	Diversion	8	4	4	3	17	22
	Tailrace	-	-	6	8	7	9
	Downstream	5	17	16	8	14	11
Effort (hr)	Diversion	6.6	7.8	12.9	9.1	12.0	10.4
	Tailrace	-	-	3.3	3.2	3.3	3.2
	Downstream	4.1	8.9	15.5	11.6	9.9	9.2
Mean CPUE (fish/hr)	Diversion	2.08	0.63	0.25	0.33	1.42	2.06
	Tailrace	-	-	1.72	2.52	2.33	2.77
	Downstream	1.30	2.06	1.02	0.65	1.39	1.26

Figure 18. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at diversion, tailrace, and downstream monitoring sites on Boulder Creek. Error bars shown are standard error.



North Creek

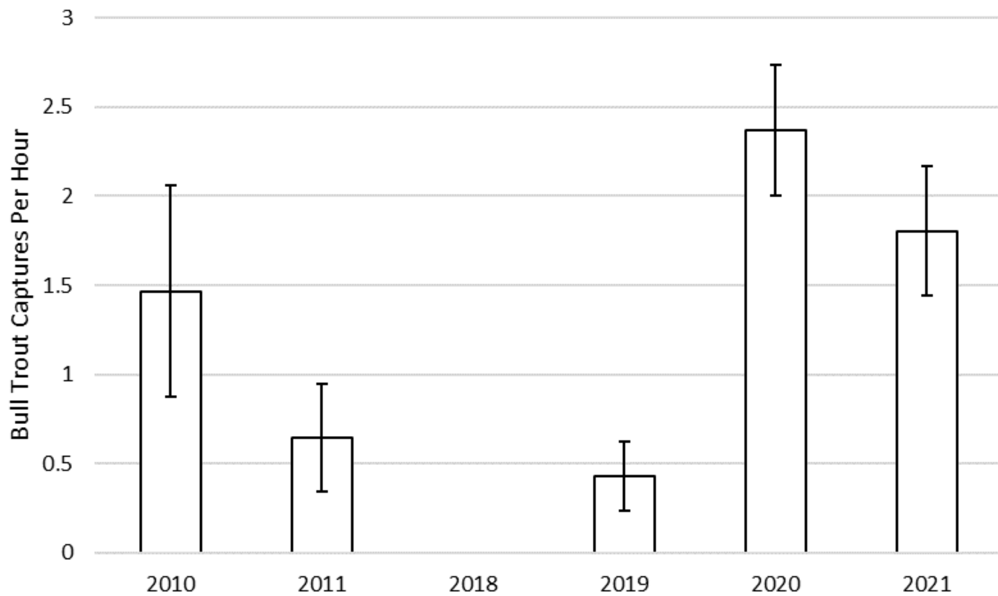
Angling in North Creek was conducted in both years of the baseline sampling period (i.e., 2010 and 2011) and in years 2, 3, and 4 of operations (i.e., 2019, 2020, and 2021[2]). CPUE in Year 4 (2021) was 1.80 fish per hour, which was notably higher than all previous monitoring years except 2020 (Table 42, Figure 19). Average CPUE was lowest in 2019 and intermediate during the two baseline years (1.47 and 0.64 fish per hour in 2010 and 2011, respectively).

Table 42. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at monitoring sites on North Creek.

Metric	Reach	Baseline		Operational			
		2010	2011	2018	2019	2020	2021
Sites Sampled	N/A	5	7	-	12	18	16
Captures	N/A	9	5	-	4	43	34
Effort (hr)	N/A	10.9	7.7	-	11.1	18.1	18.1
Mean CPUE (fish/hr)	N/A	1.47	0.64	-	0.43	2.37	1.80

[2] Angling in North Creek was included following recommendations in Year 1 to avoid confusion on sampling requirements due to discrepancy in the OEMP text and tables (Harwood *et al.* 2017).

Figure 19. Comparison of Bull Trout captures and mean catch per unit effort (CPUE) between baseline years and operational years to date, at monitoring sites on North Creek. Error bars shown are standard error.



Tributary Bank Walk Spawner Surveys

Tributary bank walk spawner surveys were conducted on Alena Creek and on the 29.2 km Tributary in September and October during the Bull Trout spawning period in one baseline year (2011) and four operational years (2018 to 2021). Nine Bull Trout were observed over 700 m during a single survey on Alena Creek in 2011 (Table 43). Two surveys were conducted in Year 1 (2018), three surveys were conducted in years 2 and 3 (2019, 2020), and six surveys were conducted in Year 4 (2021) of operations. Peak counts in these years were two, one, zero, and five Bull Trout, respectively. Survey distances were notably longer during operational years than during the single baseline survey (700 m), ranging from 1,631 m to 2,300 m in years 1 through 4.

A single spawner survey was conducted on 29.2 km Tributary in 2011 during which eight Bull Trout were observed over 560 m (Table 44). Three surveys were completed in each year from Year 1 through Year 4 of operations. Peak counts in these years were two, zero, one, and three Bull Trout, respectively. Survey distance in years 1 through 4 was 724 m, which is slightly greater than the 560 m survey distance during baseline.

Peak counts observed in operational years 1 through 4 on Alena Creek and 29.2 km Tributary were lower than baseline counts, even though the distances surveyed during baseline surveys were shorter. It should be noted that the change in survey distance on Alena Creek is not expected to have a significant effect on total observations as a small percentage of fish are observed in this section due to the high turbidity influence from the Upper Lillooet and lack of holding habitat.

Table 43. Comparison of adult Bull Trout observed during tributary bank walk spawner surveys between baseline (2011) and operational years (2018 to 2021) to date on Alena Creek.

Date	Survey Time (hh:mm) [1]	Survey Distance (m)	Adult Bull Trout Observed		
			Live	Carcasses	Redds
04-Oct-11	n/c	700	9	0	0
14-Sep-18	01:28	1,631	0	0	0
11-Oct-18	04:07	1,719	2	0	0
17-Sep-19	01:30	1,750	0	0	0
01-Oct-19	01:53	2,300	1	0	1
22-Oct-19	02:00	2,300	0	0	0
16-Sep-20	01:30	1,750	0	0	0
02-Oct-20	01:27	2,300	0	0	0
21-Oct-20	01:31	2,300	0	0	0
15-Sep-21	01:40	1,750	0	0	0
07-Oct-21	01:35	2,300	0	0	0
21-Oct-21	02:38	2,300	5	0	0

[1] n/c = not collected

Table 44. Comparison of adult Bull Trout observed during tributary bank walk spawner surveys between baseline (2011) and operational years (2018 to 2021) to date on 29.2 km Tributary.

Date	Survey Time (hrs:mm) [1]	Survey Distance (m)	Adult Bull Trout Observed		
			Live	Carcasses	Redds
04-Oct-11	n/c	560	8	0	0
13-Sep-18	01:19	724	0	0	0
28-Sep-18	00:45	724	0	0	0
09-Oct-18	00:45	724	2	0	0
18-Sep-19	00:56	724	0	0	0
29-Sep-19	00:58	724	0	0	0
23-Oct-19	00:55	724	0	0	0
17-Sep-20	01:03	724	0	0	0
30-Sep-20	00:55	724	1	0	1
19-Oct-20	00:55	724	0	0	0
14-Sep-21	01:12	724	0	0	0
06-Oct-21	01:25	724	0	0	0
22-Oct-21	01:09	724	3	0	0

[1] n/c = not collected

4.3. Wildlife Species Monitoring

4.3.1. Harlequin Ducks

No Harlequin Ducks were observed during spot checks in 2021 (Table 45), similar to results in 2020 (Faulkner *et al.* 2021). Harlequin Ducks were also not incidentally observed in the Project area in 2021 (see below). According to the OEMP (Table 2), detailed reporting including evaluation of monitoring results from all the years of the monitoring program will occur in Year 5.

Table 45. Results of Harlequin Duck spot check surveys at the ULR HEF intake and powerhouse in Year 4 (2021).

Survey Type	Date	Infrastructure	Spot Check Vantage Point UTM Coordinates (Zone 10U)		Harlequin Ducks Observed	Other Waterbirds Observed
			Easting	Northing		
pair	17-May-2021	intake	466156	5614170	0	0
		powerhouse	468416	5611634	0	0
	23-May-2021	intake	466156	5614170	0	0
		powerhouse	468416	5611634	0	0
	26-May-2021	intake	466156	5614170	0	0
		powerhouse	468416	5611634	0	0
brood	5-Aug-2021	intake[1]	466156	5614170	0	0
		powerhouse	468416	5611634	0	0
	10-Aug-2021	intake[1]	466156	5614170	0	0
		powerhouse	468416	5611634	0	0
	23-Aug-2021	intake	466156	5614170	0	0
		powerhouse	468416	5611634	0	0

[1]The intake vantage point was not accessible on August 5 and 10 due to landslide risk. The surveys were conducted using the remote camera from inside the powerhouse to view the headpond on these dates.

4.3.2. Species at Risk & Regional Concern

Species at risk and of regional concern incidentally observed and recorded by Ecofish personnel and Project operators in the Project area in Year 4 are summarized in Appendix H (note that observations of species at risk and regional concern detected by the wildlife cameras in the vicinity of the Boulder Creek HEF intake installed for Mountain Goat mitigation effectiveness monitoring are summarized in Section 4.4.2). Most of the wildlife species observed incidentally in Year 4 have also been recorded in previous years (e.g., Moose, Mule Deer, Grizzly Bear, American Black Bear (*Ursus americanus*), Mountain Goat (Figure 20), American Marten (*Martes americana*), Cougar, Canada Lynx (*Lynx canadensis*), Grey Wolf, Bald Eagle (*Haliaeetus leucocephalus*), and Barrow's Goldeneye

(*Bucephala islandica*)), either incidentally or as part of a the predator monitoring program at the Boulder Creek HEF (Section 4.4.2). Of particular interest, a Northern Red-legged Frog (*Rana aurora*) was seen at Alena Creek in September 2021. This is a significant sighting because the Project area is located outside of the current official species range (CDC 2022). The species, which is blue-listed in BC and of Special Concern federally, has previously been detected in the Project area and the Pemberton area by Ecofish crews and other professionals. A Great Blue Heron (*Ardea herodias*) (blue-listed in BC; CDC 2022) was also detected at Alena Creek in November 2021.

As discussed in Year 2 and Year 3, to reduce the potential for human-wildlife conflict, observations of large mammals, especially Grizzly Bears and Moose along the Lillooet River FSR, and Elk (also sighted along the FSR in Year 3), are given special consideration by Project operations (i.e., sightings are recorded and shared among Project operators to raise awareness of where these large mammal species are more likely to be encountered when working outdoors and driving).

Figure 20. Mountain Goat photographed by ULL-CAM15 on January 29, 2021.

4.4. Wildlife Habitat Monitoring

4.4.1. Habitat Restoration – Mammal Habitat

Of the 18 mammal restoration compliance monitoring sites at which vegetated screens had not achieved required dimensions by Year 3 (Table 8; see maps 8 through 11 in Faulkner *et al.* 2021 for site locations), 12 could be matched to vegetated screens in the wildlife habitat polygons assessed by Staven (2022) (the monitoring sites were within, or close to, the polygon screen management area) (Table 46). All of the vegetated screens at the wildlife habitat polygons that were matched to the compliance monitoring sites were assessed, by Staven (2022), to be achievable: at all of these screens, conductor clearance was judged sufficient to retain trees at < 5 m (Table 46; see also Table 4 in Staven 2022). Only in one wildlife habitat polygon assessed by Staven (2022) (polygon ULH-GB15), was the vegetated screen height assessed to be not achievable (conductor clearance not sufficient to retain trees < 5 m in height). However, none of the monitoring sites evaluated in Year 3 for mammal restoration compliance monitoring were located within this polygon. Where Staven (2022) evaluated the potential for heights to be achievable adjacent to the FSR, heights of < 5 m could be attained within 10 m of the FSR (Table 46).

Given that the Staven (2022) assessment suggests that target heights (and widths) of all vegetation screens for which continued monitoring in Year 5 was recommended (Table 8) are achievable in relation to transmission line maintenance constraints, the screens at these mammal restoration compliance monitoring sites should be able to attain heights of near 5 m and recommendations made in Year 3 related to sites that should be revisited in Year 5 are unchanged. However, heights slightly less than 5 m may occur during vegetation maintenance (i.e., Staven (2022) assessed if heights are attainable < 5 m). Further, in several wildlife habitat polygons assessed by Staven (2022), vegetation removal by other road users was noted, which, if this continues to occur, may limit the ability of the screen to attain target dimensions by Year 5. Thus, vegetation removal should be noted at the sites reassessed in Year 5 and heights slightly lower than 5 m should be considered adequate where transmission line maintenance has recently occurred.

The Staven (2022) assessment also noted that in several wildlife habitat polygons, the screen location was not ideal, and it was recommended that the screens be moved to be more effective. These results are noted in Table 46 but will not affect monitoring results or recommendations related to OEMP requirements.

Table 46. Mammal vegetated screen monitoring sites that had not achieved required dimensions by Year 3, associated wildlife habitat polygon assessed in Staven (2022), and conclusion regarding Year 5 monitoring needs.

<table>
<tr><th colspan="6">OEMP Mammal Restoration Compliance Monitoring</th><th colspan="2">Transmission Line Safety Constraint Assessment[2]</th><th rowspan="3">Year 5 OEM Monitoring[4]</th></tr>
<tr><th rowspan="2">Site</th><th rowspan="2">Species and Habitat[1]</th><th colspan="3">Vegetated Screen Metrics[2] in Year 3</th><th rowspan="2">Year 3 Comments</th><th rowspan="2">Wildlife Habitat Polygon[3]</th><th rowspan="2">2020 Status and Long-term Viability</th></tr>
<tr><th>Average Width</th><th>Average Height</th><th>Average % Cover</th></tr>
<tr><td>ULH-MAMCM01</td><td>Grizzly Bear - High Value</td><td>7</td><td>4</td><td>17</td><td>Partially burnt and disturbed, some natural regeneration; slow to recover from the Boulder Creek forest fire</td><td rowspan="2">ULH-GB01</td><td rowspan="2">Affected by wildfire; vegetation regenerating
Screen achievable: conductor clearance is sufficient to retain trees <5 m; manage to < 5 m tall within 10 m of the FSR
Recommend adjusting location to improve results</td><td rowspan="2">Screen can reach required dimensions</td></tr>
<tr><td>ULH-MAMCM02</td><td>Grizzly Bear - High Value</td><td>–</td><td>–</td><td>–</td><td>Site is burnt; located very high above the road; slow to recover</td></tr>
<tr><td>ULH-MAMCM04B</td><td>Grizzly Bear - High Value</td><td>3</td><td>2</td><td>12</td><td>Some natural regeneration but growth is limited on the wood chips</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>ULH-MAMCM06</td><td>Grizzly Bear - High Value
Mule Deer - UWR</td><td>18</td><td>4</td><td>70</td><td>Revegetation is dense and is on track for achieving height requirement; cover is high</td><td>UWR-J054-79</td><td rowspan="4">One to 4 m deciduous trees, minimal shrubs and herbs; vegetation regenerating
Subject to vegetation removal by road users
Screen achievable: conductor clearance is sufficient to retain trees <5 m; manage to < 5 m tall within 10 m of the FSR
Recommend adjusting location to improve results</td><td rowspan="4">Screen can reach required dimensions
Document any vegetation removal by road users as this may limit the potential for screen to achieve targets</td></tr>
<tr><td>ULH-MAMCM08</td><td>Mule Deer - UWR</td><td>17</td><td>4</td><td>50</td><td>Abundant regeneration; on track to meet 5 m height requirement</td><td>UWR-J054-79</td></tr>
<tr><td>ULH-MAMCM09</td><td>Grizzly Bear - High Value
Mule Deer - UWR</td><td>4</td><td>2</td><td>6</td><td>Some vegetation has grown tall (4 m); on track for natural regeneration reaching 5 m</td><td>UWR-J054-79</td></tr>
<tr><td>ULH-MAMCM10</td><td>Mule Deer - UWR</td><td>11</td><td>2</td><td>15</td><td>Good natural regeneration; vegetation is expected to grow taller than 5 m over time</td><td>UWR-J054-79</td></tr>
<tr><td>ULH-MAMCM12</td><td>Moose - UWR</td><td>7</td><td>2</td><td>10</td><td>Site has been disturbed; many alders and willows were cut down</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>ULH-MAMCM14</td><td>Grizzly Bear - WHA 2-399
Moose - UWR</td><td>10</td><td>4</td><td>100</td><td>Abundant natural regeneration, dense bushes; vegetation growth is on track for 5 m height requirement</td><td>ULH-GB25</td><td>Two to 4 m deciduous trees and dense shrubs and herbs
Screen achievable: conductor clearance is sufficient to retain trees <5 m</td><td>Screen can reach required dimensions</td></tr>
<tr><td>ULH-MAMCM17</td><td>Grizzly Bear - South Lillooet River FSR</td><td>8</td><td>4</td><td>90</td><td>Vegetation regenerating in the areas previously disturbed by Squamish Mills; vegetation is on track for height requirement</td><td>–</td><td>–</td><td>–</td></tr>
</table>

Table 46. Continued (2 of 2).

OEMP Mammal Restoration Compliance Monitoring						Transmission Line Safety Constraint Assessment[2]		Year 5 OEM Monitoring[4]
Site	Species and Habitat[1]	Vegetated Screen Metrics[2] in Year 3			Year 3 Comments	Wildlife Habitat Polygon[3]	2020 Status and Long-term Viability	
		Average Width	Average Height	Average % Cover				
ULH-MAMCM19	Grizzly Bear - South Lillooet River FSR	25	4	35	Abundant natural regeneration; vegetation is well on track for 5 m height requirement	–	–	–
ULH-MAMCM21	Grizzly Bear - High Value Mule Deer - UWR	4	1	4	Site is disturbed; trees that were ~2-3 m in height in 2018 were cut down and screen cover is low	UWR-J046-74	One to 4 m deciduous trees, dense shrubs and herbs; vegetation regenerating Subject to vegetation removal by road users Screen achievable: conductor clearance is sufficient to retain trees to <5 m; manage to < 5 m tall within 10 m of the FSR Recommend adjusting location to improve results	Screen can reach required dimensions Document any vegetation removal by road users as this may limit the potential for screen to achieve targets
ULH-MAMCM22	Grizzly Bear - High Value	7	1	3	Site is disturbed. Shrubs that were ~2-3 m tall in 2018 were cut down	UWR-J046-74		
ULH-MAMCM23	Grizzly Bear - High Value	8	1	4	Minimal screen height with vegetation composed mostly of ferns and thimbleberry; wood chips may be restricting growth; however, some alders, willows, and cottonwoods are regenerating naturally	likely segment of UWR-J046-74		
ULH-MAMCM24	Grizzly Bear - High Value Mule Deer - UWR	8	1	7	Moderate regeneration of abundant thimbleberry, and some willow and alder are on track for meeting height requirement; however, height will be limited by transmission line maintenance	UWR-J046-74		
ULH-MAMCM26	Grizzly Bear - High Value Mule Deer - UWR	42	3	52	The screen on the right side of the road has filled in with natural regeneration, but there has been some cutting on the left side; vegetation is on track for height and width requirements	UWR-J046-75	One to 4 m deciduous trees, dense shrubs and herbs Screen achievable: conductor clearance is sufficient to retain trees to <5 m	Screen can reach required dimensions
ULH-MAMCM27	Grizzly Bear - High Value	47	4	90	Abundant regeneration; good mix of conifers and deciduous trees; on track for height requirement and 100% coverage	–	–	–
ULH-MAMCM28	Grizzly Bear - High Value	40	3	25	Abundant regeneration; on track for meeting height requirements	–	–	–

[1] High value Grizzly Bear habitat is considered as Class 1 or Class 2 as identified by habitat suitability modelling (Leigh-Spencer *et al.* 2012) and confirmed in the field (Leigh-Spencer *et al.* 2013).

[2] From Staven (2022).

[3] Wildlife habitat polygon associated with OEMP mammal restoration compliance monitoring sites; dashes indicate the monitoring site was not matched to a wildlife habitat polygon.

[4] Vegetated screen height may be slightly less than 5 m following transmission line maintenance.

4.4.2. Mitigation Effectiveness – Mountain Goats at Boulder Creek

4.4.2.1. Public Access Monitoring

Public access monitoring in Year 4 detected no motorized vehicles that were not Project related traveling past the gate during the monitoring period in Year 4; all vehicles photographed on the access road past the gate were Project-related. BDR-CAM03 photographed two non-Project related vehicles, but both were parked outside the gate (Table 47). Two snowmobiles were detected passing the gate by BDR-CAM02 and BDR-CAM03 on November 24, 2021, but these were also Project-related.

Although skiers were seen on several occasions, they were coming past the gate on foot. Groups of skiers were detected between May 10 and December 19, 2021 (by BDR-CAM02, BDR-CAM03, BDR-CAM04, and BDR-CAM08; Table 47). On three occasions, groups were heading upslope by the gate (at BDR-CAM03) (e.g., Figure 21) and on one occasion a group walked into the area (past three cameras), carrying skis (Figure 22). Several groups of hikers were also documented walking along the access road (photographed by BDR-CAM02 and BDR-CAM03) between May 10 and December 3.

In most cases, monitoring over four years post-construction to date has demonstrated functioning of the gate in preventing public motorized access during the Mountain Goat winter period. However, specific situations have been identified over the monitoring period during which the gate did not prevent public motorized access; these were:

- Motorized vehicles drove around the gate in Year 1;
- The gate was vandalized followed by vehicle passage (Year 3);
- The gate was left open for several hours on one occasion by Project workers while at the intake (Year 3); and
- Snowmobiles passed over the gate because it becomes non-functional when buried in snow >1.5 m deep (issue noted in all years, snowmobiles detected passing over the gate in Year 3).

Several recommendations were made to address these issues, and a number of actions have been taken. Specifically, a barricade (cement block) was installed on the upslope side of the gate to prevent small vehicles from driving around the gate after Year 1, and this has been effective in preventing motorized vehicle access during the snow-free period. Project workers have been instructed to keep the gate closed at all times, and no incidents of the gate left open were detected in Year 4. Further, signage was posted in Year 2 (small sign located at the base of the access road) which was improved upon after Year 3: two large and highly visible signs were posted in fall 2021, one at access road base (Figure 23) and one at the gate (Figure 24). Given that no snowmobiles passed over the gate in Year 4, the signage may have been an effective deterrent, although the test period was short (i.e., only about one month - the gate became snow covered in mid-December 2021 and monitoring ended January 26, 2022). The skiers that came into the area on foot in Year 4 (and could potentially have arrived in the general area on snowmobile) were photographed before the signage had been installed.

Although no snowmobiles were observed passing over the snow-covered gate in Year 4, this issue remains a potential issue of concern because public use of the Upper Lillooet River area is anticipated to increase over time (owing to ever increasing population growth and recreational use in the area) and snowmobiles have substantial potential for disturbing Mountain Goats in the UWR. Only one snowmobile incident has been documented in four years of monitoring; however, it is difficult to predict how this risk may change in the future, given that conditions continue to change, and it often takes some time for new recreational opportunities to become exploited. For example, detections of skiers have increased over the monitoring period, likely reflecting either communication among recreational users or the increasing number of recreational users in the area. No skiers were detected in years 1 and 2, one group was detected (on snowmobiles) in Year 3, and four groups were detected (on foot) in Year 4. Although snowmobile access to the Boulder Creek intake area was considered unlikely in Year 2 due to the travel distance involved (and no incidents had been observed at that time; Faulkner *et al.* 2020), observations in Year 3 indicated that snowmobiles do come into the area and can pass over the gate. Further, documentation of several groups of skiers in Year 4 indicates that the public is accessing the general area in mid-winter. Thus, if snowmobiles are accessing the general area when the gate is buried by snow, protection of Mountain Goats in the UWR is dependent on signage being an effective deterrent.

Overall, four years of monitoring have demonstrated that the gate (with cement block added) provides an effective physical barrier for motorized vehicles when it is not buried in snow provided that Project personnel keep it closed at all times. When the gate is buried in snow, there is currently no effective physical barrier in place to prevent snowmobile access of the intake area, and without modification of the gate (as recommended in Year 3), protection of Mountain Goats in the UWR during these time periods is dependent on the public noting and respecting signage.

Figure 21. **Two skiers heading upslope photographed on December 19, 2021, at 15:00 by BDR-CAM03.**

Figure 22. **Group of skiers photographed on May 10, 2021 at 10:57 by BDR-CAM02. The same group was also photographed on the same day by BDR-CAM04 at 11:03 and by BDR-CAM08 at 11:04.**

Figure 23. Signage posted prior to the start of the 2021/2022 winter period at base of the access road warning the public of a gate with access restrictions ahead.

Figure 24. Signage posted prior to the start of the 2021/2022 winter period at the location of the gate informing the public that access by motorized vehicles is prohibited during the Mountain Goat winter period.

Table 47. 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 4 monitoring period (December 23, 2020 to June 17, 2021 and October 26, 2021 to January 26, 2022).

Non-Project Human Activity	Date	Time	Camera	Comments
Hiker	10-May-2021	13:46	BDR-CAM02	two hikers, entering the area; not project related
		14:12	BDR-CAM02	same hikers leaving the area; not project related
Hiker	24-May-2021	15:51	BDR-CAM02	entering the area; not project related
Hiker	03-Dec-2021	16:04	BDR-CAM03	group of four, walking up past gate; some wearing hi-vis vests/workers
		16:42	BDR-CAM02	group of four, wearing vis vest and carrying EQ
		18:20	BDR-CAM02	crew walking back
		18:31	BDR-CAM03	crew of four, heading back out down road
Skier	10-May-2021	10:57	BDR-CAM02	group of four, carrying skis; not project related
		11:03	BDR-CAM04	same group of four carrying skis; not project related
		11:04	BDR-CAM08	same group of four carrying skis; not project related
Skier	21-May-2021	4:26	BDR-CAM03	Three skiers heading upslope, not project related
Skier	19-Dec-2021	12:22	BDR-CAM03	Two skiers, heading upslope; not project related
		15:00	BDR-CAM03	Two skiers, heading upslope; not project related
Vehicle	11-May-2021	13:08	BDR-CAM03	ATV driving up to gate; car parked outside the gate until May 14
Vehicle	20-May-2021	7:05	BDR-CAM03	Parked outside the gate

4.4.2.2. Predator Monitoring

Results from predator monitoring identified four potential Mountain Goat predators within the survey area in the vicinity of the Boulder Creek HEF intake during the Mountain Goat winter and spring period (November 1 to June 15) in Year 4 (Table 48, Map 6). Remote infrared cameras photographed American Black Bear, Cougar, Grizzly Bear, and Wolverine along the Boulder Creek HEF access road (by BDR-CAM01 and/or BDR-CAM02); some species were additionally detected off the road in the vicinity of the intake (other cameras). No Grey Wolves were photographed during Year 4 monitoring. Species other than predators and Mountain Goats recorded by the eight wildlife cameras included Mule Deer, Snowshoe Hare (*Lepus americanus*), and Red Squirrel (*Tamiasciurus hudsonicus*).

Each of the predator species detected in Year 4 were photographed along the access road at least once, but most were also photographed off the road. A Cougar was photographed along the road by BDR-CAM02 on November 3, 2021, first heading away from the intake at 7:40 am (Figure 25), then (likely the same animal) heading towards the intake ~12 hours later (at 17:11) (Table 48, Map 6). Grizzly Bears were photographed on three occasions in spring, twice in May 2021 travelling along the access road past BDR-CAM01 (located at the gate; Figure 26), and once in May 2020 upslope of the access road past BDR-CAM04. A Grizzly Bear was also photographed along the access road by BDR-CAM02 in deep snow in January (Figure 27), which is a very unusual time of year to detect a Grizzly Bear. American Black Bears were also photographed on three occasions: twice along the access road by BDR-CAM02 (on June 2 and 12, 2021; Figure 28) and once upslope of the access road by BDR-CAM06 (in May). Wolverines were photographed by three cameras, two were photographed along the access road (by BDR-CAM02) on December 17, 2021 (Figure 29), and two were photographed upslope of the access road (by BDR-CAM08 and BDR-CAM06) on December 17, 2021 and January 11, 2022, respectively (Map 6). It is likely that the wolverines photographed on the access road (by BDR-CAM02) on December 17, 2021 were two different animals (one at 00:14 and the second one at 12:31) because both were moving in the same direction (the first wolverine (Figure 29) was breaking through fresh snow and the second (Figure 30) was travelling in the tracks created by the first wolverine, 12 hours previously). It is likely that the two wolverines photographed by BDR-CAM08 at similar times as the ones photographed by BDR-CAM02 were the same two individuals.

Although all potential predators were photographed travelling along the access road, all were photographed by only one of the three wildlife cameras along the road. This suggests that the individuals photographed on the road only travelled along a relatively short portion of the road. In some cases (Cougar and Grizzly Bear), the same portion of the road was used by an individual travelling in both directions. For the Cougar photographed by BDR-CAM02 on November 3, 2021 (Figure 25), ten hours had passed between photographs, suggesting that the same route taken in the morning had also been taken, in the opposite direction, ten hours later. Nevertheless, Cougars were only documented on this one day, suggesting that travelling along this route was not a repeated event.

Mountain Goats were photographed twice by the cameras used for predator monitoring (Table 49): one individual was photographed walking along the access road by BDR-CAM02 on October 31, 2021 at 11:21. Likely the same individual was also photographed upslope of the Boulder Creek HEF access road by BDR CAM08 on the same day at 11:37 am (Figure 31). On May 2, 2021, a Mountain Goat was photographed upslope of the intake by BDR-CAM06 on May 2, 2021.

As discussed in the Year 3 report (Faulkner *et al.* 2021), monitoring results provide some evidence of increased use of the Boulder Creek HEF intake area by main predators of Mountain Goats since Project construction. During baseline (Regehr *et al.* 2016) and Year 1 (Regehr *et al.* 2019) monitoring, the only potential Mountain Goat predators detected were Wolverine, bear, and Bobcat, all of which are considered occasional predators of Mountain Goats (Shackleton 1999). Grey Wolves and Cougars, which are considered main predators of Mountain Goats, were not detected during baseline and Year 1 monitoring (Table 50). However, Grey Wolves were detected in both Year 2 and Year 3 and Cougars were detected in Year 2 (and have now been detected again in Year 4) which could suggest that the use of the area by these two main Mountain Goat predators has increased since access road construction and that some time was required (one year) to discover the road and begin to use it. However, during the past four monitoring years, both species have been detected rarely and periodically (not in every year), and there has been no indication of an increasing trend in numbers of observations by species with time over the four post-construction monitoring years (see also below). Cougars were detected in Year 2 and Year 4 but were not detected in Year 3 (Table 50). Similarly, Grey Wolves were detected in both Year 2 and Year 3, but not in Year 4. Further, Grey Wolves detected in Year 3 were recorded off the road during the Mountain Goat winter/spring period (wolves seen travelling along the access road were seen outside of the winter period, on October 20, 2020), and, as discussed in previous reports, there is likely little benefit for wolves in travelling along the road when covered in snow unless the snow has been compacted by snowmobile traffic. Most occasional predator species detected during the post-construction monitoring period were also detected prior to construction (Grizzly Bears are the exception; Table 50), and other occasional predators have been detected in some years but not others (e.g., Bobcat (*Lynx rufus*) and Coyote (*Canis latrans*); Table 50). Such irregular and infrequent detections of predator species using the area is expected, given typically low frequency of predator occurrences, unless they are tuning in to a consistently available resource.

A comparison across years of the numbers of detections per functional camera-day supported the qualitative assessment that numbers of predator detections have not increased during the monitoring period (Table 51). Numbers of detections per camera-day ranged between roughly 0.01 and 0.02 for all years (i.e., for all cameras combined, there were between one and two detections in all years for every 100 camera-days). The lowest numbers of detections per camera-day were observed in Year 4 and the highest were observed in Year 2 (largely due to multiple detections of American Black Bear in this year; Table 50). Thus, the rate of detections has been low during all years and there has been no indication of a trend over time. In addition, although the baseline monitoring period was not included in the comparison (see Section 3.4.2.2), Year 1 results were compared to baseline results in the Year 1 monitoring report (Regehr *et al.* 2019), and little difference was noted: during the baseline period, predators had been detected on four occasions during 21 aerial and ground-based surveys combined (an average of 0.19 individuals per survey; Regehr *et al.* 2016); during Year 1, predators were detected on two occasions during eight surveys (an average of 0.25 individuals per survey).

Based on all monitoring results combined, there is therefore no evidence that either main predator (Grey Wolves or Cougars) or occasional predator numbers have increased in the intake area post-construction. Although main predators have only been detected post-construction, no trend in their use of the road is apparent in the numbers of all detections combined when standardized by functional camera recording period. Further, although potential predators have been photographed along the road in every year, individuals were not generally photographed by more than one or two cameras, which suggests that when the access road is used, it is not being used as a direct route to the intake.

Figure 25. Cougar photographed walking along the access road by BDR-CAM02 on November 3, 2021 at 07:40. A second cougar (likely the same individual) was photographed by the same camera on the same day walking along the road in the opposite direction at 17:11.

Figure 26. Grizzly Bear photographed walking along the access road on May 21, 2021, at 9:22 am by BDR-CAM01. A Grizzly Bear was also photographed by the same camera walking in both directions along the access road on May 20, 2021 (at 8:41 and 9:51 am).

Figure 27. Grizzly Bear photographed by BDR-CAM02 on January 2, 2021 at 15:49.

Figure 28. American Black Bear photographed along Boulder Creek HEF access road by BDR-CAM02 on June 2, 2021.

Figure 29. Wolverine photographed on the access road by BDR-CAM02 on December 17, 2021, at 00:14. It is evident that this wolverine is breaking though fresh snow (tracks behind but not in front of the animal).

Figure 30. Wolverine photographed upslope of the Boulder Creek HEF intake on the access road by BDR-CAM02 on December 17, 2021, at 12:31, travelling in an existing track.

Figure 31. Mountain Goat photographed upslope of the Boulder Creek HEF access road by BDR-CAM08 on October 31, 2021 at 11:37 am. Likely the same individual was also photographed along the access road by BDR-CAM02 at 11:21 on the same day.

Table 48. Potential predators of Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road during the Year 4 monitoring period (December 23, 2020 to June 17, 2021 and October 26, 2021 to January 26, 2022). All detections occurred in the Mountain Goat winter and spring seasons (November 1 to June 15).

Species		Camera	Date	Time	Number of Individuals
Common Name	Scientific Name				
American Black Bear	*Ursus americanus*	BDR-CAM02	02-Jun-2021	08:38:00	1
			12-Jun-2021	11:07:00	1
		BDR-CAM06	14-May-2021	14:52:00	1
Cougar	*Puma concolor*	BDR-CAM02	03-Nov-2021	07:40:00	1
				17:11:00	1
Grizzly Bear	*Ursus arctos*	BDR-CAM01	20-May-2021	08:41:00	1[1]
			21-May-2021	09:22:00	1
		BDR-CAM02	02-Jan-2021	15:49:07	1
		BDR-CAM04	20-May-2020	17:20:00	1
Wolverine	*Gulo gulo*	BDR-CAM02	17-Dec-2021	00:14:00	1
				12:31:00	1
		BDR-CAM06	11-Jan-2022	19:51:00	1
		BDR-CAM08	17-Dec-2021	00:07:00	1
				12:24:00	1

[1] The individual was photographed travelling in one direction at 8:41 and in the opposite direction at 09:51.

Table 49. Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road during the Year 4 monitoring period (February 18 to June 17, 2021 and October 26, 2021 to January 26, 2022).

Date	Camera	Time	Number of Individuals
31-Oct-2021	BDR-CAM02	11:21:00	1
	BDR-CAM08	11:37:00	1
02-May-2021	BDR-CAM06	21:46:00	1

Table 50. Summary of Mountain Goat potential predators documented during baseline surveys and monitoring Years 1 to 4 in the Mountain Goat wintering period (November 1 to June 15).

Species		Type of Predator[1]	Years Detected	Number of Detections	Camera(s)
Common Name	Scientific Name				
Grey Wolf	*Canis lupus*	Main	Year 2	4[2]	BDR-CAM01, 02, 04, 06
			Year 3	3[3]	BDR-CAM01, 02, 08
Cougar	*Puma concolor*	Main	Year 2	3	BDR-CAM01, 06
			Year 4	2	BDR-CAM02
Grizzly Bear	*Ursus arctos*	Occasional	Year 1	1	BDR-CAM02
			Year 2	3	BDR-CAM02, 03, 05
			Year 3	2	BDR-CAM01, 02
			Year 4	4	BDR-CAM01, 02, 04
American Black Bear	*Ursus americanus*	Occasional	Baseline	1	BDR-CAM D[4]
			Year 1	8	BDR-CAM01, 02
			Year 2	18[5]	BDR-CAM01, 02, 04, 07, 08
			Year 3	11	BDR-CAM02, 06, 08
			Year 4	3	BDR-CAM02, 06
Wolverine	*Gulo gulo*	Occasional	Baseline	5	–[6]
			Year 1	1	BDR-CAM02
			Year 2	6	BDR-CAM01, 03, 04, 07, 08
			Year 4	5	BDR-CAM02, 06, 08
Bobcat	*Lynx rufus*	Occasional	Baseline	–[7]	–
			Year 1	1	BDR-CAM02[8]
Coyote	*Canis latrans*	Occasional	Year 1	–	–[9]
			Year 2	2[10]	BDR-CAM04, 08

[1] Shackleton 1999.

[2] Two detections with 6 individuals, one detection with 5 individuals; three detections from same group on same day.

[3] One detection with 2 individuals; two detections on same day.

[4] BDR-CAM D was functional during baseline studies (see Regehr *et al.* 2016 for camera location).

[5] One with detection with two individuals; two detections of undetermined bear species (assumed American Black Bear).

[6] Detections during ground-based transect surveys.

[7] Detected during summer only (September 2011).

[8] Also detected during ground-based transect surveys.

[9] Detected during ground-based transect surveys.

[10] One detection with two individuals.

Table 51. Numbers of predator detections during the Mountain Goat wintering period per functional camera-day for the four post-construction monitoring years.

Monitoring Year	Length of Monitoring Period (days)[1]	Functional Camera-days[2]	Total Number of Detections[3]	Detections per Camera-day
Year 1	255	1,048	11	0.0105
Year 2	267	1,860	36	0.0194
Year 3	165	1,168	14	0.0120
Year 4	262	2,096	14	0.0067

[1] Includes only the Mountain Goat wintering period (November 1 to June 15).

[2] For all cameras combined; sum of all functional camera days.

[3] Detections as defined in monitoring reports (a single camera trigger event); does not consider number of individuals per detection or the potential for the same individual to occur within separate detections.

5. RECOMMENDATIONS

5.1. Water Temperature and Air Temperature

Temperature metrics recorded during Year 1 to Year 4 were not substantially different from the baseline monitoring results. However, the warmest months on record, to date, considering both water and air temperature occurred in July/August of 2018, 2019, and 2021. Of note, in late June and early July 2021, BC experienced a prolonged period of unusually high pressure that was associated with an unprecedented heat wave (Environment and Climate Change Canada 2021). Similarly, some of the coolest periods on record were observed during winter 2019 in both the water and air temperature data sets. For Year 5 (2022/23), we recommend that:

- Monitoring is continued in 2022 (Year 5) based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017).
- Water temperature monitoring is continued at the newly established upstream control site, ULL-USWQ04, in the Upper Lillooet River.
- The collection of water temperature data in the upstream reach of Boulder Creek (BDR-USWQ2) and North Creek (NTH-USWQ1) is continued to provide additional concurrent data sets that can be used to establish a relationship between water temperatures in the two creeks.

5.1.1. Frazil Ice

The frazil ice assessment protocol has been implemented since December 2017 and crews have responded to two alarms (prolonged cold periods) 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 now informed by data collected from four operational years. The OEMP stated that the effectiveness and suitability of the frazil ice monitoring and management protocol would be evaluated annually as there was uncertainty in conditions that may lead to frazil ice. Following Year 4 of monitoring we recommend updating the protocols to reflect current knowledge and also ensure that detection of extreme events will still occur, and allow for effective mitigation of adverse effects associated with frazil ice if it occurs.

Year 5 (2022/23) Monitoring Recommendations:

- Monitoring is continued in each of the Upper Lillooet River and Boulder Creek diversions, however the protocols used in Years 1 through 4 should be updated to have a higher threshold trigger. Based on data collected to date and observations in 2021/22 we recommend updating the threshold to three consecutive days of -12°C average daily temperature at Callaghan Valley and Pemberton Airport weather stations as these conditions have been monitored on three separate occasions as measured at Pemberton Airport. Three events have been monitored with conditions that exceeded this trigger to date. To further support this recommendation, fish abundance data collected at Upper Lillooet and Boulder Creek in Spring 2022 will be examined during summer 2022 to look at potential temperature effects on fish as winter 2021/22 was the coldest on record during operational years.

5.2. Fish Community

5.2.1. Adult Fish Migration and Spawning

Adult Bull Trout migration and spawning monitoring was successfully implemented in Year 4 through a combination of angling surveys conducted in the diversion and downstream reaches of the Upper Lillooet River and Boulder Creek, and in North Creek (a reference stream), and tributary bank walk spawner surveys conducted in 29.2 km Tributary and Alena Creek (both are reference streams). For Year 5 (2022/23), we recommend that:

- Monitoring is continued using the same methods used in Year 4, as specified in the OEMP.

5.3. Wildlife Species Monitoring

5.3.1. Harlequin Ducks

No Harlequin Ducks were observed in Year 4, either during spot checks or incidentally. Evaluation of monitoring results from all the years of the monitoring program will occur in Year 5 when all results will be considered and discussed in relation to monitoring objectives. For Year 5 (2022/23), we recommend that:

- Harlequin Duck monitoring is continued as specified in the OEMP.

5.3.2. Species at Risk & Regional Concern

Incidental wildlife observations have provided valuable information on the timing and locations of species at risk and of regional concern within the Project area. For Year 5 (2022/23), we recommend that:

- Incidental wildlife observations will continue in Year 5, as specified in the OEMP.
- Project personnel continue to record and share wildlife sightings with other Project personnel, especially of Grizzly Bear, Moose, and Elk, to raise awareness of the locations where these species are more likely to be encountered when working outdoors and driving and to thereby reduce the potential for human-wildlife conflict.

5.4. Wildlife Habitat Monitoring

5.4.1. Habitat Restoration – Mammal Habitat

The target vegetated screen heights within wildlife habitat polygons assessed by Staven (2022) for transmission line safety constraints that could be matched to the 18 mammal restoration compliance monitoring sites where vegetated screens had not reached the target dimensions by Year 3 were considered achievable (Table 46), although in some locations vegetation removal within screens by other road users was identified. For Year 5 (2022/23), we therefore recommend that:

- Monitoring is conducted at the 18 monitoring sites identified for additional monitoring in Year 3 to assess ongoing vegetated screen growth and determine if measures to enhance vegetation growth are needed (i.e., recommendations made in Year 3 are unchanged).
- Other recommendations made in Year 3 (e.g., as planting at ULH-MAMCM4B in areas where wood chips are preventing the natural establishment of vegetation) are also implemented.
- Vegetation removal within screens by other road users is noted during monitoring because this may limit the ability of the screen to attain target dimensions by Year 5.
- Screen heights slightly lower than 5 m are considered adequate where transmission line maintenance has recently occurred.

5.5. Mitigation Effectiveness – Mountain Goats at Boulder Creek

5.5.1. Public Access Monitoring

Monitoring over four years post-construction has demonstrated that the gate, following modifications made in Year 1, provides an effective physical barrier for motorized vehicles when not buried in snow provided that Project personnel keep it closed at all times. When the gate is buried in snow, there is currently no physical barrier in place for snowmobiles, and protection of Mountain Goats in the UWR during these time periods is therefore dependent on the public noting and respecting signage. Given this documented gate limitation and that recreational use of the area can be expected to continue to increase (and increased winter use has been documented over the four years of monitoring), and given the high risk of disturbance to Mountain Goats in the UWR that could be caused by snowmobiles entering the UWR (or operating in the vicinity), we recommend the following for the life of the Project:

- Monitoring occur for snowmobiles entering the intake area by driving over the gate during the mid- to late-winter period when the gate is buried in snow through a sub-sampling design (e.g., one winter every five years or one month every year) for the life of the Project (unless the gate becomes modified to prevent snowmobile passage), to account for changing conditions (e.g., increasing recreational activity) in the Project area in the future and allow continued identification and evaluation of risks to Mountain Goats. Adaptive management will be implemented to restrict motorized public use past the gate during the winter if motorized access past the locked gate increases.
- Signage is inspected each year and maintained in good condition (where signage includes two large and highly visible signs, one at access road base and one at the gate, informing the public that the road is gated and impassable from November 1 to June 15 and that entry to the site is prohibited to protect Mountain Goats on their winter range during this sensitive time period).
- Actions are continued to be taken to ensure that Project personnel close the gate behind them when entering the intake area (even when only planning to be at the intake for a short period of time).
- Access of the intake area by snowmobiles (or snowcats) is minimized for Project-related activities. Creating a compacted track to and beyond the gate should be minimized because such a track may encourage snowmobilers to enter the area (increasing the risk of their passing over the gate, if not increased in height (see above) and driving into the UWR), and provides an efficient predator travel route which may encourage use of the road by predators.

5.5.2. Predator Monitoring

Monitoring results have detected no apparent change in predator presence or behavior in the vicinity of the UWR during four years of post-construction monitoring. Based on the number of predator detections recorded during the monitoring period overall, the behaviour of potential predators in terms of road use, and the species-specific frequencies of detections, there is no evidence that predation risk to Mountain Goats using the UWR has increased since Project construction. No increasing trend in use of the intake area or the road was documented over the entire monitoring period by any species, predators appeared to be using the road for short stretches rather than as a direct path to the intake, and predators were detected both on and off the road. Predator monitoring at the Boulder Creek HEF intake was required to occur for a minimum of three years (Table 2). Given these results after four years of monitoring, we conclude that predator monitoring is now complete. We nevertheless recommend that:

- Access of the intake area by snowmobiles (or snowcats) is minimized for Project-related activities for the life of the Project to minimize the potential use of the access road by Mountain Goat predators during winter (as described for public access monitoring above).

6. CLOSURE

The monitoring objectives for Year 4 were achieved in accordance with requirements of the Project's OEMP, which was revised in 2021 (Harwood *et al.* 2021).

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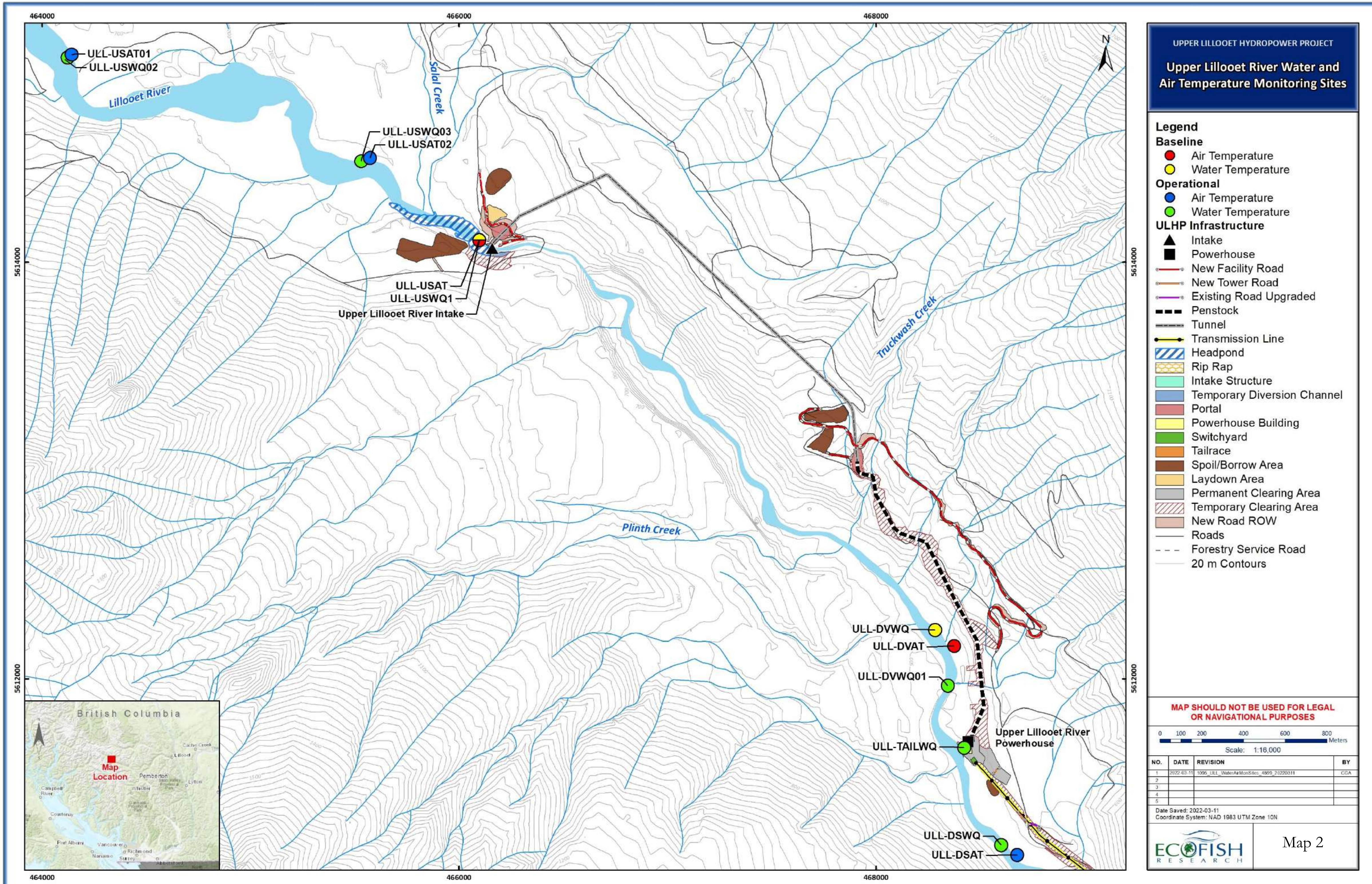

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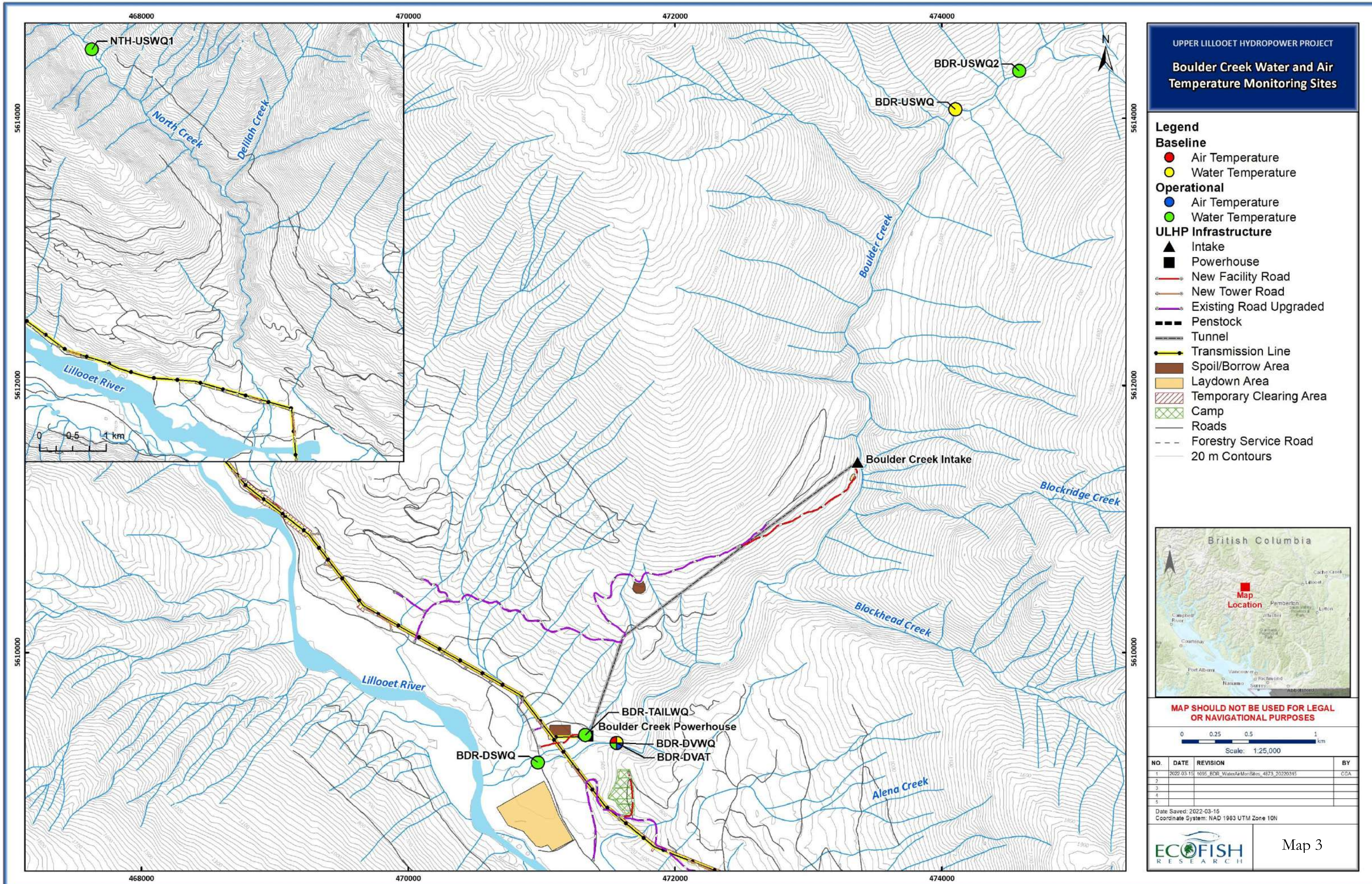

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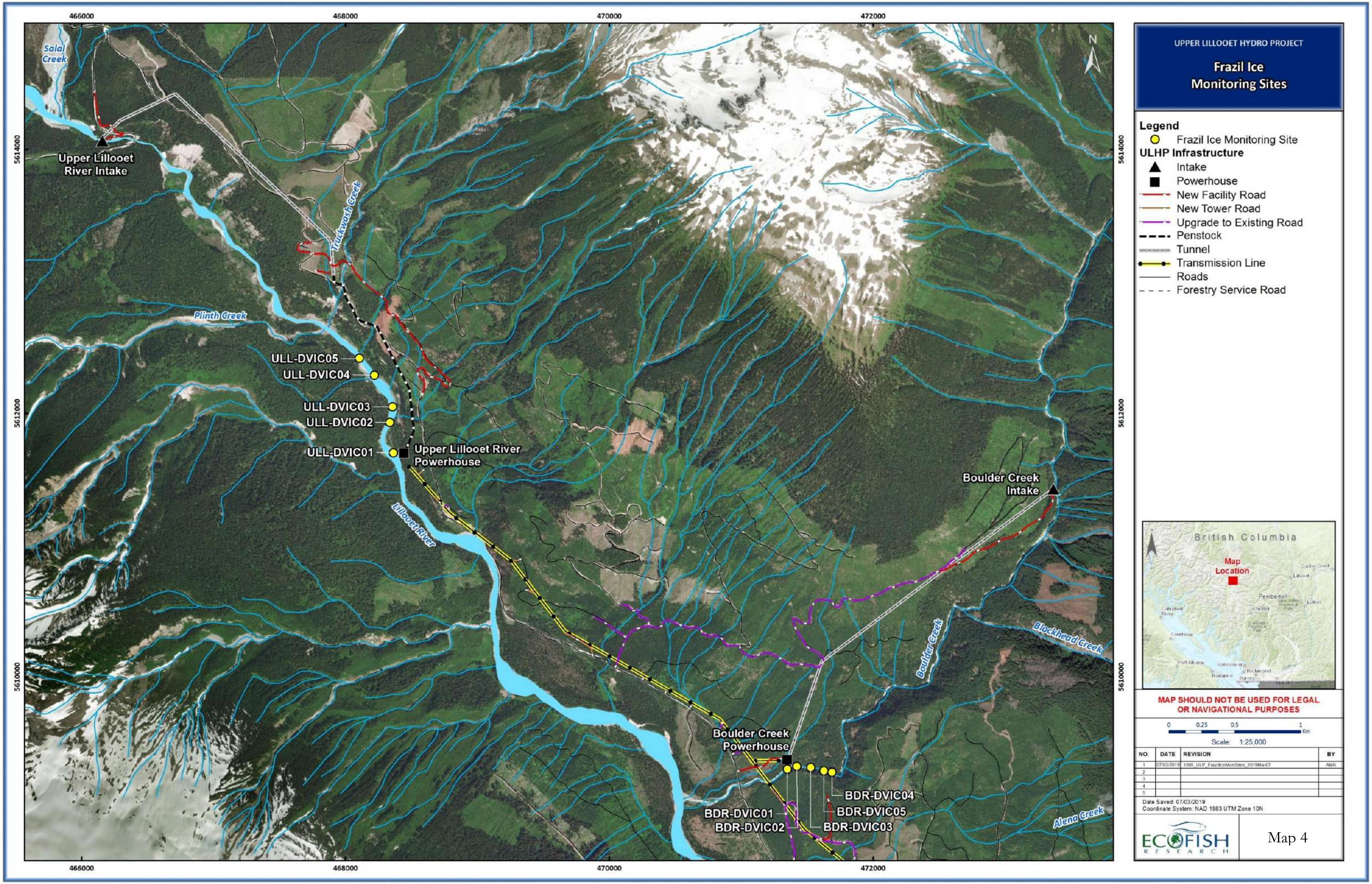

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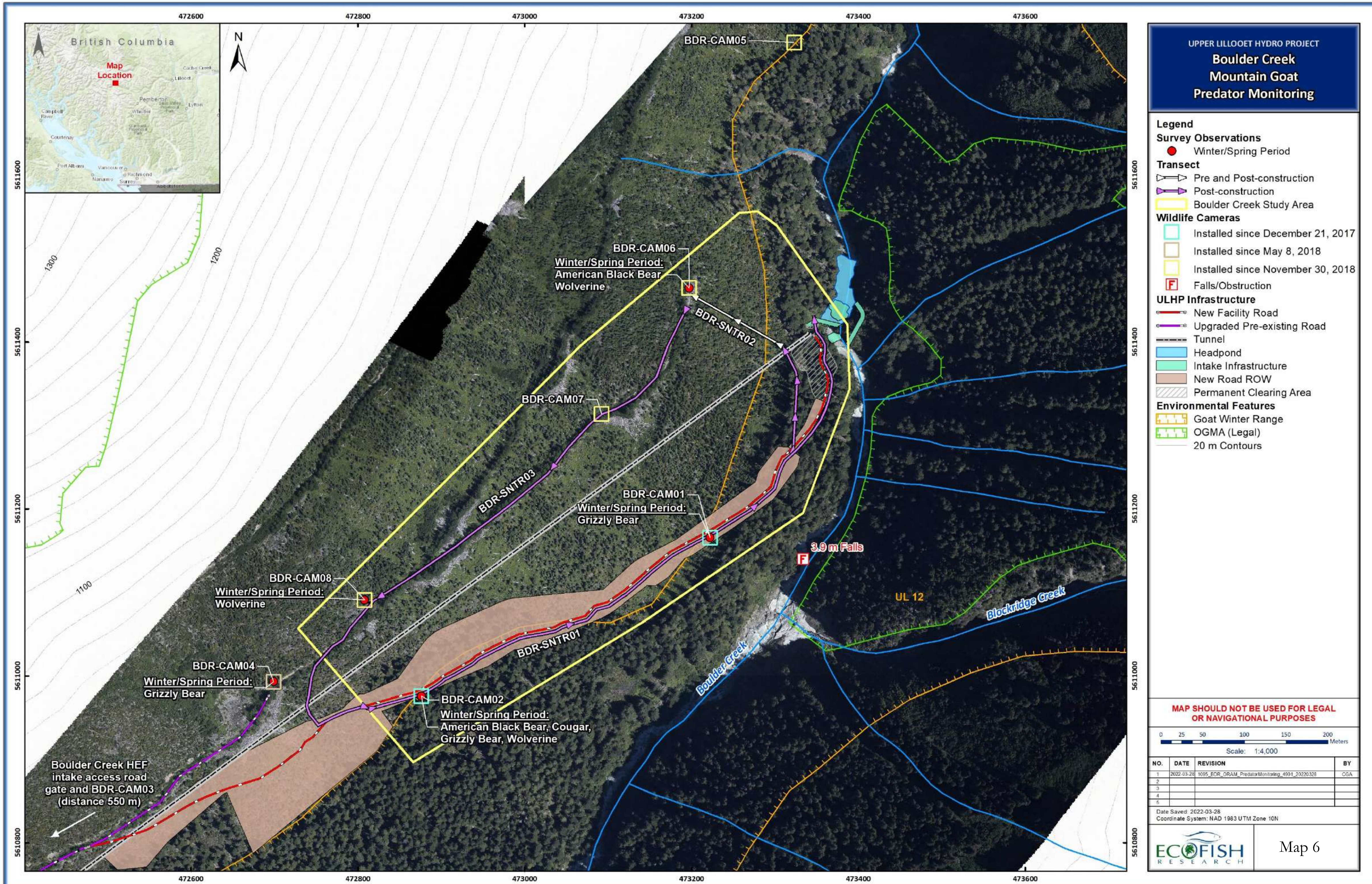

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APPENDICES

Appendix A. Alena Creek Fish Habitat Enhancement – Year 5 Monitoring Report

Alena Creek Fish Habitat Enhancement Project

Year 5 Monitoring Report

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April 29, 2022

Prepared by:

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EXECUTIVE SUMMARY

This report provides the Year 5 (2021) results of the long-term monitoring program implemented 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 (09-HPAC-PA2-00303) issued for the Upper Lillooet Hydro Project (the Project). The FHEP was designed to offset the footprint and operational habitat losses incurred by the Project and monitoring requirements were integrated into the Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2021). 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), 2019 (Year 3), 2020 (Year 4), and 2021 (Year 5).

Also, note that a second offset project was completed on Alena Creek in September 2021 (Faulkner *et al.* 2021a) for *Fisheries Act* Authorization 19-HPAC-00331 to offset the predicted residual effects of an operational sediment management procedure (Flush Procedure) for the Upper Lillooet Hydro Project (ULHP) (Faulkner *et al.* 2019). Monitoring of this new offset habitat is not part of this report, although observations of the newly constructed habitat were made during on-going monitoring activities.

Fish Habitat

FHEP habitat features (riffles and woody debris) were installed in reaches 1 and 3 in 2016 to enhance fish habitat. A stability assessment was conducted to monitor the stability and functionality of each of the FHEP habitat features and ensure that any remedial action required to maintain their effectiveness is promptly identified and implemented. Excessive erosion that reduces the quality of the constructed habitat has not occurred to date. The channel adjustments that occurred after a peak flow event in November 2016 were modest and have largely stabilized due to vegetation establishment and natural sorting of sediment. However, in Year 3 (2019), multiple locations were identified where remediation was recommended, and instream repairs were conducted during the least risk timing window on August 6, 2020. Repairs were done by hand using gravel, cobble, small boulder, and large wood pieces found on site to improve functionality and limit erosion through bank revetments, flow deflector installation, riffle repairs, and gravel redistribution. Upon inspection in 2021, the repairs appeared to be stable and functioning as intended.

A beaver dam complex located immediately upstream of Reach 3 was causing partial flow bypass and formation of newly cut channels that increased fine sediment deposition within the reach; therefore, the dam height was lowered to prevent further channel erosion. No new beaver activity was observed above Reach 3 in 2021, and the dam was considered inactive in 2021. A newly constructed beaver dam in the lower end of Reach 3, which was previously removed in 2020, had been reconstructed and continued to create moderate backwatering in ALE-XS5, ALE-X06, and ALE-XS7. Beavers were removed from the Alena Creek enhancement area in the fall of 2021 by a licensed trapper from EBB Environmental Consulting Inc. with the objective of ensuring salmon spawner access and spawning riffle functionality.

In Reach 1, a log jam just upstream of ALE-XS1 has formed. However, no backwatering was observed during the stability assessment on October 27, 2021. Associated bank erosion issues from this log jam were partially addressed in 2020 by placing cobble along the head of a cut-off channel that has formed and largely stabilized. During the stability assessment on October 27, 2021, the cobble placement appeared to be stable and functioning as intended.

After 5 years of monitoring, the habitat appears to be physically stable and functioning as intended however, beaver activity has continued to pose a risk to habitat functionality. Recommendations for Year 5 included continued management of beaver activity.

Fish Community

The adult fish community in Alena Creek was assessed by bank walk spawner surveys focused on Bull Trout and Coho Salmon, the latter of which is the dominant species within Alena Creek. Three Bull Trout spawner surveys were completed between September and October 2021, and three Coho Salmon spawners surveys were conducted between November and December 2021. A total of five Bull Trout were observed on one of the three spawning surveys, the highest observed to date apart from 2011. In contrast, Coho Salmon were present in all Coho Salmon spawning surveys and were observed spawning and holding in enhanced habitat in Alena Creek, demonstrating their continued use of this habitat. Within the survey area (which contains enhanced and unenhanced habitat), a peak of 371 live Coho Salmon was observed on December 6, 2021, which was the highest annual peak observed during monitoring to date (previous peak counts ranged from 109 to 218, in 2017 and 2019 respectively). Peak counts provide a general indication of continued and increased use of Alena Creek post-enhancement compared to baseline, although among-year variability in spawner abundance is high.

Minnow trapping surveys were conducted at eight sites (five in the enhanced reaches) on September 27, 2021 to measure catch-per-unit-effort (CPUE) by species and life history stage. Across all sites, the average Cutthroat Trout CPUE in 2021 (1.9 fish per 100 trap hours) was similar to that in previous sampling years excluding 2014 and 2020 when average CPUE was 4.1 and 7.2 fish per 100 trap hours, respectively, noting 2014 CPUE results are biased high due to short set times. The average Coho Salmon CPUE in 2021 was 81.1 fish per 100 trap hours, which is the second highest recorded across monitoring years. Three Bull Trout were captured in minnow traps in Alena Creek in 2021, compared to zero captures in all previous monitoring years. The average Bull Trout CPUE in 2021 was 0.3 fish per 100 trap hours.

Enhancements in Alena Creek were designed to create habitat and increase productivity of the entire system. Overall juvenile and adult abundance appear to be improving over time, particularly juvenile Coho Salmon. These results support that the offset habitat is functioning as intended and is supporting greater fish use relative to pre-project conditions.

Hydrology

Seasonal trends in the Alena Creek hydrograph in the winter and spring of 2021 were consistent with a coastal, snow-dominated watershed. Stage levels remained low in the winter until the beginning of snowmelt early March, reaching peak values on April 18.

On June 28, steady high temperatures in the region increased discharge in the Lillooet River to extreme levels for the summer, inducing an upstream shift in the confluence between a secondary channel of Lillooet River and Alena Creek. The secondary channel also increased in size, causing backwatering from the Lillooet River into Alena Creek. This caused a rise in the recorded stage, from 0.25 m to 1.24 m, along with greater amplitude of daily variation (from < 0.04 m to < 0.2 m, Figure 24). Stage remained very high and under the influence of the Lillooet River for the rest of the summer.

A precipitation event shifted hydrological controls again on December 1, 2021, decreasing base stage level from 0.66 m prior to the event to 0.36 m post event. This event likely disconnected Alena Creek from backwatering by the Lillooet, as indicated by a return to smaller daily oscillations, but low flow stage levels remain higher than in previous years, indicating a shift in creek morphology and making the comparison with previous levels difficult without redefining the stage offset from a local benchmark.

Water Temperature

The objective of water temperature monitoring is to confirm that conditions in the FHEP are suitable for spawning, incubation, and rearing by the target fish species. Water temperature has been monitored continuously since 2013 at two sites: the upstream site (ALE-USWQ1, upstream of all FHEP works) and the downstream site (ALE-BDGWQ, located at the downstream extent of the reaches enhanced by the FHEP). Some data gaps occurred pre-construction in 2014 at the upstream site in winter/early spring 2014. No data gaps were recorded post-construction, with monitoring starting at both sites on November 23, 2016. To inform this report, Year 5 data were available up to September 27, 2021 for both sites.

Alena Creek is a relatively cool stream. In 2021, instantaneous temperature measurements at the upstream (2.8°C to 10.2°C) and downstream sites (0.1°C to 14.2°C) were within the post-construction ranges. Measurements in 2021 were generally consistent with the baseline ranges, although maximum water temperatures measured at each site were 0.2°C greater than those measured during baseline monitoring. Despite the small elevation (11 m) difference and short distance (~1 km) between the two sites, the downstream site exhibits greater seasonal variability in water temperature and is generally warmer than the upstream site in the summer and cooler in the winter, likely due to the influences of groundwater inflow and a tributary that enters Alena Creek between the two sites. The seasonal pattern of differences in water temperature between the two sites is similar between the pre- and post-construction, indicating that there has not been a clear change in seasonal variability in water temperature due to the FHEP construction.

Results to date indicate that the FHEP provides water temperatures typical of stream habitats in the area. Conditions for Coho Salmon and Cutthroat Trout were generally more suitable at the site at the downstream end of the enhanced reach than at the upstream site, although conditions were frequently sub-optimally cool for these species. Temperatures were more suitable for Bull Trout than Coho Salmon and Cutthroat Trout due to the generally cooler optimum temperature ranges preferred by Bull Trout.

Riparian Habitat

The objective of the riparian restoration effectiveness monitoring program is to evaluate revegetation and planting success as specified by the OEMP, including specific stem density targets. In Year 5, the density of trees (35,350 ± 22,275) and the density of shrubs (26,650 ± 12,573) met the stem density targets. Percent vegetation cover was high, and no invasive species were found. Soils appeared stable and no erosion was observed. Photopoint monitoring supported these results and demonstrated that vegetation was healthy and continued to increase in size. Conifer species abundance declined relative to monitoring after restoration in 2016; red alder and black cottonwood were dominant, and vegetation composition was similar to what was found in 2014, prior to instream habitat enhancement activities.

Vegetation in the Alena Creek FHEP area is establishing well and this component of the OEMP program is considered complete. A second offset project was completed on Alena Creek in September 2021 (Faulkner *et al.* 2021a), including a newly planted area. This area will be monitored under a separate monitoring program.

Conclusion

The success of the FHEP was evaluated 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. The new channel construction and enhancement of existing channels has provided 3,194 m^2 of high-quality instream fish habitat (West *et al.* 2017). Restoration of riparian habitat yielded a further 4,060 m^2 of habitat directly enhanced by the FHEP. The FHEP created further ancillary benefits by providing improved passage to upstream spawning areas while retaining good quality rearing habitat provided by the beaver pond and woody debris jam (West *et al.* 2017). Although some repairs were required for a high flow event that occurred soon after construction, the five-year monitoring period has shown that the habitat is physically stable, provides suitable flows and that fish use is generally higher than pre-project conditions. CPUE for all captured species combined was 0.93 fish per 100 trap hours in 2021 compared to 0.52 fish per 100 trap hours during baseline. Beaver activity continues to pose a risk to habitat functionality and management of this species is recommended to continue to ensure the habitat remains to be function as intended.

TABLE OF CONTENTS

EXECUTIVE SUMMARY .... **III**

LIST OF FIGURES .... **IX**

LIST OF TABLES .... **XI**

LIST OF MAPS .... **XII**

LIST OF APPENDICES .... **XIII**

1. INTRODUCTION **1**

2. OBJECTIVES AND BACKGROUND **4**

2.1. Fish Habitat 4
2.2. Fish Community 5
2.3. Hydrology 5
2.4. Water Quality 5
2.5. Water Temperature 5
2.6. Riparian Habitat 6

3. METHODS **7**

3.1. Fish Habitat 7
3.2. Fish Community 7
3.2.1. Adult Spawner Abundance 7
3.2.2. Juvenile Abundance 8
3.3. Hydrology 9
3.4. Water Temperature 10
3.4.1. Study Design 10
3.4.2. Quality Assurance/Quality Control 12
3.4.3. Data Collection and Analysis 12
3.4.4. Applicable Guidelines 13
3.5. Riparian Habitat 15
3.5.1. Permanent Revegetation Monitoring Plots 15
3.5.2. Percent Vegetation Cover Estimates 16
3.5.3. Photopoint Comparison 16

4. RESULTS **17**

4.1. Fish Habitat 17
4.1.1. Overview 17
4.1.2. Reach 1 17
4.1.3. Reach 3 21

4.2. FISH COMMUNITY 23
4.2.1. Adult Spawner Abundance *23*
4.2.2. Juvenile Abundance *27*
4.3. HYDROLOGY 41
4.4. WATER TEMPERATURE 42
4.4.1. Spatiotemporal Variability *42*
4.4.2. Mean Weekly Maximum Temperatures (MWMxT) *48*
4.4.3. Bull Trout Temperature Guidelines *56*
4.5. RIPARIAN HABITAT 58
4.5.1. Permanent Revegetation Density Monitoring Plots *58*
4.5.2. Percent Vegetation Cover Estimates *62*
4.5.3. Photopoint Comparison *62*

5. SUMMARY AND RECOMMENDATIONS 65

5.1. FISH HABITAT 65
5.2. FISH COMMUNITY 66
5.3. HYDROLOGY 66
5.4. WATER TEMPERATURE 66
5.5. RIPARIAN HABITAT 67

6. CLOSURE 67

REFERENCES 68

PROJECT MAPS 72

APPENDICES 75

LIST OF FIGURES

Figure 1. Looking from river left to river right at ALE-XS1 on September 19, 2016, showing a single channel....19

Figure 2. Looking from river left to river right at ALE-XS1 on November 10, 2017, showing the beginnings of a secondary channel forming on the river left floodplain....19

Figure 3. Looking from river left to river right at ALE-XS1 on November 5, 2018, showing further development of a secondary channel on the river left floodplain. 19

Figure 4. Looking from river left to river right at ALE-XS1 on November 13, 2019; the secondary channel on the river left floodplain is partly obscured by growing vegetation....19

Figure 5. Looking from river left to river right at ALE-XS1 on November 7, 2020; the secondary channel on the river left floodplain is partly obscured by growing vegetation....19

Figure 6. Looking from river left to river right at ALE-XS1 on October 27, 2021; the secondary channel on the river left floodplain is partly obscured by growing vegetation....19

Figure 7. Cobble placement at the head of the side channel upstream of ALE-XS1 on August 06, 2020....20

Figure 8. Log jam that has formed at a collapsed channel spanning log approximately 10 m upstream of at ALE-XS2. Photo taken on June 20, 2019....20

Figure 9. Confluence of overflow channel that formed during 2019 as a result of beaver activity upstream of Reach 3. Photo shows uppermost 20 m of Reach 3 (right) and overflow channel (left). Photo taken on November 13, 2019. 22

Figure 10. New reconstructed Beaver dam at the lower end of Reach 3 that was identified during fall 2021 and subsequently removed. 23

Figure 11. Coho Salmon observed holding in enhanced habitat on November 5, 2021. 25

Figure 12. Spawning Coho Salmon observed in unenhanced habitat on December 6, 2021. 26

Figure 13. Spawning Coho Salmon observed in new offset habitat on December 6, 2021. 26

Figure 14. Fork length frequency for juvenile Cutthroat Trout captured (by minnow trapping) in Alena Creek in 2021. 31

Figure 15. Fork length by age for juvenile Cutthroat Trout captured in Alena Creek in 2021....32

Figure 16. Fork length frequency for juvenile Coho Salmon captured (minnow trapping) in Alena Creek in 2021. 34

Figure 17. Fork length by age for Coho Salmon captured in Alena Creek in 2021....35

Figure 18. Fork length frequency for juvenile Bull Trout captured (minnow trapping) in Alena Creek in 2021. 37

Figure 19. Fork length by age for Bull Trout captured in Alena Creek in 2021. 37

Figure 20. Comparison of minnow trap CPUE for Cutthroat Trout during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years. 39

Figure 21. Comparison of minnow trap CPUE for Cutthroat Trout at each site during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years...39

Figure 22. Comparison of minnow trap CPUE for Coho Salmon during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years. 40

Figure 23. Comparison of minnow trap CPUE for Coho Salmon at each site during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years...41

Figure 24. Stage in Alena Creek at the Lillooet River FSR bridge during baseline (April 2013 to November 2014), and post-construction monitoring (November 2016 to March 2022)..42

Figure 25. Daily average (a), maximum (b), and minimum (c) temperature in Alena Creek pre-construction (April 17, 2013 to December 30, 2014) and post-construction (November 23, 2016 to September 27, 2021) recorded at the upstream control (ALE-USWQ1) and downstream impact (ALE-BDGWQ) sites...44

Figure 26. Cumulative frequency distribution of differences in pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) instantaneous water temperature between the downstream site (ALE-BDGWQ) and the upstream site (ALE USWQ1) (positive values indicate warmer temperatures at ALE-BDGWQ). 47

Figure 27. Western redcedar approximately 1 m in height at ALE-PRM05, on September 01, 2021. 63

Figure 28. Diversity of woody species observed at ALE-PRM06, with red-osier dogwood in foreground. Western redcedar visible in right of photograph. Photograph taken on September 01, 2021. 64

Figure 29. Abundant black cottonwood and red alder at ALE-PRM07 on September 01, 2021........64

Figure 30. Tall vegetation at ALE-PRM03 on September 01, 2021. 65

LIST OF TABLES

Table 1. Summary of water temperature site names, logging details, and periods of data records in Alena Creek pre-construction (2013, 2014) and post-construction (November 2016 through 2021). 11

Table 2. Water temperature metrics and method of calculation. 13

Table 3. Optimum water temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout during spawning, incubation, rearing, and migration (MECCS 2021). 14

Table 4. Periodicity of fish species in Alena Creek. 15

Table 5. Summary of adult fish observed during fall spawner surveys in 2021. 24

Table 6. Peak Live Coho Salmon spawner counts during baseline (2010-2011) and post-construction monitoring (2016 - 2021). 24

Table 7. Peak Live Bull Trout spawner counts during baseline (2011) and post-construction monitoring (2018 - 2021). 25

Table 8. Summary of minnow trapping habitat characteristics and fish captures in Alena Creek on September 27, 2021. 28

Table 9. Catch and CPUE for Cutthroat Trout captured by minnow trapping in Alena Creek on September 27, 2021. 30

Table 10. Summary of fork length, weight, and condition for juvenile Cutthroat Trout captured in Alena Creek in 2021. 31

Table 11. Size bins by age class for juvenile Cutthroat Trout captured in Alena Creek in 2021........31

Table 12. Catch and CPUE for Coho Salmon captured in Alena Creek on September 27, 2021. 33

Table 13. Summary of fork length, weight, and condition for Coho Salmon captured in Alena Creek in 2021. 33

Table 14. Size bins by age class for Coho Salmon captured in Alena Creek in 2021. 34

Table 15. Catch and CPUE for Bull Trout captured in Alena Creek on September 27, 2021. 36

Table 16. Summary of fork length, weight, and condition for Bull Trout captured in Alena Creek in 2021........36

Table 17. Size bins by age class for Bull Trout captured in Alena Creek in 2021. 36

Table 18. Coho Salmon periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE-USWQ1. 50

Table 19. Coho Salmon periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE BDGWQ. 51

Table 20. Cutthroat Trout periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE-USWQ1. 52

Table 21. Cutthroat Trout periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE-BDGWQ. 53

Table 22. Bull Trout periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE-USWQ1. 54

Table 23. Bull Trout periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek at ALE-BDGWQ. 55

Table 24. Summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout thresholds BC WQG (MECCS 2021) in Alena Creek at the upstream site (ALE USWQ1) and downstream site (ALE-BDGWQ)................................57

Table 25. Summary of riparian habitat data collected for the Alena Creek FHEP from Year 1 (2017) to Year 5 (2021) of effectiveness monitoring; in 2016 (baseline), immediately after riparian restoration works; and in 2014, four years after the Meager Creek slide. 60

Table 26. Live species counted within each of the permanent revegetation monitoring plots in Year 5 (2021). Stem density summaries are included for Year 3 (2019), Year 1 (2017), and 2016 (baseline). 61

Table 27. Dead tree species counted within each of the permanent revegetation monitoring plots in Year 5 (2021). Summaries of dead trees are included for Year 1 (2017), Year 3 (2019), and baseline (2016). 62

LIST OF MAPS

Map 1. Overview of the location of Alena Creek relative to Project infrastructure. 3

Map 2. Alena Creek water temperature monitoring sites. 73

Map 3. Alena Creek fish abundance sampling and riparian monitoring sites. 74

LIST OF APPENDICES

Appendix A. **Final Design Drawings of the Alena Creek Fish Habitat Enhancement Project**

Appendix B. **Water Temperature Guidelines, Data Summary, and Site Photographs**

Appendix C. **Photographs of Alena Creek Fish Habitat Enhancement Project Stability Assessment Year 5 Monitoring**

Appendix D. **Raw Data Tables and Representative Photographs from Fish Community Surveys**

Appendix E. **Revegetation Assessment – Riparian Revegetation Monitoring Photographs for the Compensation Channel 2021**

1. INTRODUCTION

This report provides the Year 5 (2021) results of the long-term monitoring program implemented 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 (09-HPAC-PA2-00303) 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, located 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).

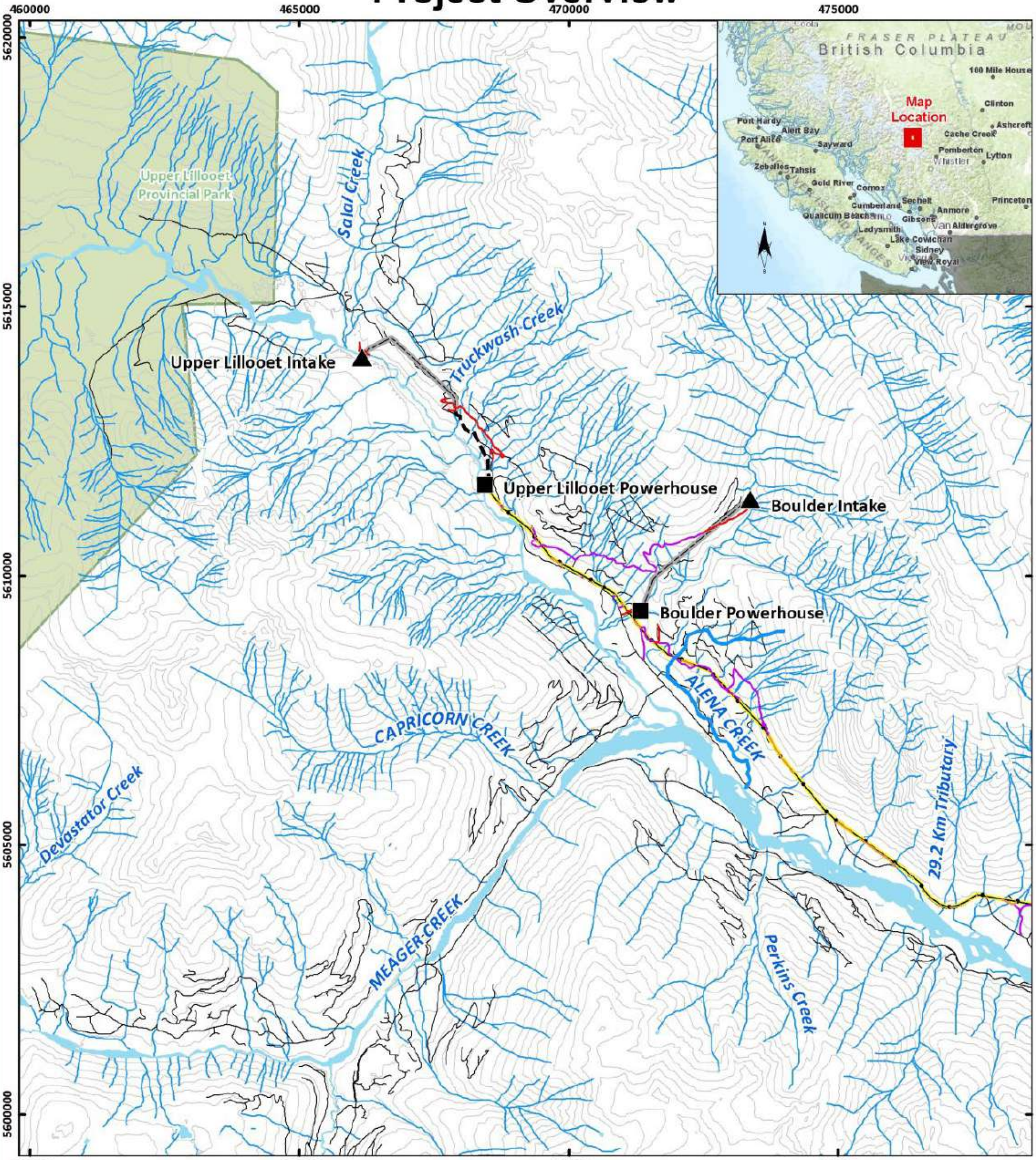
Details of the predicted habitat losses incurred by Project construction and operation are provided in the aquatic and riparian footprint reports for the HEFs and the transmission line (Buchanan *et al.* 2013a, 2013b). These habitat losses were authorized by Fisheries and Oceans Canada (DFO) through 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). The Meager Creek slide was 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 by uprooting trees and smothering root systems with a thick layer of sediment. The FHEP, which was constructed in the summer of 2016, created a new section of channel and enhanced both the aquatic and riparian habitat of Alena Creek. It 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.* 2021). Monitoring of the FHEP involves monitoring of six components relevant to assessing the effectiveness of the offset habitat: fish habitat, fish community, hydrology, water quality, water temperature, and riparian habitat (Harwood *et al.* 2021). Among these, water quality monitoring was discontinued after Year 1 due to improvements observed and lack of anticipated adverse effects (Harwood *et al.* 2018). Results of Years 1 and 2 of Alena Creek pre-construction (pre-enhancement) monitoring are documented in Harwood *et al.* (2016). Results of Year 1 through 4 (2017-2020) of post-construction monitoring are presented in Harwood *et al.* (2019a, 2019b) and Thornton *et al.* (2020) and Thornton *et al.* (2021). Results from Year 5 (2021) the fifth and final year of monitoring are summarized below.

In addition to Year 5 monitoring, a second offset project was completed on Alena Creek in September 2021 (Faulkner *et al.* 2021a). The project was required to offset the predicted residual effects of an operational sediment management procedure (Flush Procedure) for the Upper Lillooet Hydro Project (ULHP) (Faulkner *et al.* 2019). The total amount of instream habitat required for this second offset project was 123 m^2 which included spawning and rearing habitat for Coho Salmon (*Oncorhynchus kisutch*), Bull Trout (*Salvelinus confluentus*), and Cutthroat Trout (*O. clarkii*) as per *Fisheries Act* Authorization (19-HPAC-00331). The completed offset habitat spans 197 m^2 and consists of a downstream extension of the existing FHEP offset channel that was constructed in Reach 3 of Alena Creek in 2016. Monitoring of this new offset habitat is not part of this report, although observations of the newly constructed habitat were made during on-going monitoring activities.

Project Overview



Legend

ULHP Infrastructure

- Intake
- Powerhouse
- Proposed Facility Road (New)
- Proposed Tower Road (New)
- Upgrade Required to Existing Road
- Penstock
- Tunnel
- First Nation Reserve
- Parks and Protected Areas
- Roads
- Contours (100 m)

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 3 4 km

Scale: 1:100,000

NO.	DATE	REVISION	BY
1	07/04/2015	1095_ULP_Overview_AlenaCreek_2015Apr07_ADN	EF
2			
3			
4			
5			

Date Saved: 07/04/2015
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

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 Habitat

FHEP habitat features (riffles and woody debris) were installed in reaches 1 and 3 in 2016 to enhance fish habitat. In Reach 1, 13 riffles and more than 120 pieces of large wood were installed to create 1,387 m^2 of enhanced fish habitat. In Reach 3, a total of 668 m^2 of new instream habitat and 1,139 m^2 of floodplain were created and 12 cobble riffles and over 100 pieces of large woody debris were installed.

A stability assessment has been conducted annually since the construction occurred to monitor the establishment and functionality of each of the FHEP habitat features and promptly identify whether any remedial action is required to maintain their effectiveness. The assessment has been conducted throughout the enhanced reaches and at eight marked transects (transects ALE-XS1 through ALE-XS4 in Reach 1 and transects ALE-XS5 through ALE-XS8 in Reach 3; Map 3) that are revisited each year and where photographs have been taken at photo-points to track changes over time. Details of the habitat features installed are provided in West *et al.* (2017).

A high flow event occurred shortly after construction in 2016 that affected habitat features constructed for the FHEP, which was monitored until 2019 (Year 3), when repairs were proposed to address stability issues in Reach 3. On August 6, 2020, during the least risk timing window (MOE 2006), a crew of four staff from Ecofish and Lil'wat First Nation completed the repairs by hand as recommended in 2019. The repairs were distributed throughout the reach: conditions were enhanced, and erosion protection was installed at roughly every other habitat unit (pool or riffle). Specifically, the repairs included the following actions:

1. Eroding banks were stabilized by creating a revetment composed of cobble, small boulder, and large wood.
2. Flow deflectors were installed to direct flow energy away from banks and towards root wad complexes in pools that have partially infilled with fines. Flow deflectors were composed of a matrix of materials ranging in size from sand to small boulders and large wood.
3. Riffles that had been outflanked were rebuilt and contoured to prevent further bank erosion and keep flow energy focused on gravel deposits for cleaning purposes.
4. Gravel was redistributed from pools and slack water areas into pool tail-outs and riffles where spawning might occur.

Photos of the repairs are included in the Year 4 report (Thornton *et al.* 2021). Inspection of these repairs was included in fish habitat monitoring in the following year (Year 5).

Reach 1 was generally found to be stable after the high flow event except for one location where a channel spanning log had collapsed, creating a wood jam and minor avulsion of the channel around the jam. The channel at this location had largely stabilized and was not expected to continue eroding at an unnatural rate. Some repairs were made in 2020 at this location, but they were restricted to placement of cobble along portion of the avulsed channel that would direct flow energy away from the channel bank and back towards the original channel alignment.

2.2. Fish Community

The goal of enhancing aquatic and riparian habitat in Alena Creek was to provide spawning and rearing habitat for Coho Salmon, Cutthroat Trout, and Bull Trout, and to support equivalent or greater fish use (based on fish abundance) in Alena Creek relative to pre-construction conditions. Fish habitat use in Alena Creek was assessed by comparing adult Coho Salmon spawner abundance and juvenile Cutthroat Trout and Coho Salmon abundance under baseline and post-construction conditions. Bull Trout spawner abundance monitoring on Alena Creek was primarily conducted to be used as a reference against Project streams (i.e., Upper Lillooet River and Boulder Creek). Adults were surveyed by counting fish during bank walks (spawner surveys) during Bull Trout and Coho Salmon spawning seasons in September and October, and early November to early December, respectively. Juvenile fish were sampled using minnow traps deployed at eight sites in Alena Creek (five enhanced, three unenhanced). The objective of minnow trapping was to monitor interannual variation in the relative abundance of juvenile fish, based on catch per unit effort (CPUE), for individual species and life stages in the enhanced and unenhanced reaches of Alena Creek (Map 3) and thereby assess changes in fish abundance over time and before and after construction.

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). Hydrological monitoring in Alena Creek was undertaken by ULRPLP.

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.* 2019a). Furthermore, 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.* 2019a).

2.5. Water Temperature

Changes in water temperature can potentially affect stream biota, including fish. Tolerance to water temperature changes varies among species and life-history stages and according to existing conditions. The objective of water temperature monitoring is to confirm that conditions within the Alena Creek FHEP support migration, spawning, incubation, and rearing by the fish species present. Monitoring entails collecting continuous water temperature data to allow comparison of pre- and post-construction temperature data and monitor changes within the FHEP over time. Water temperature may be influenced by factors that include shading or hydraulic changes by the instream enhancement features, and changes to shade conditions due to maturation of riparian vegetation planted during the habitat restoration.

Water temperature in Alena Creek is being monitored continuously at two sites (Map 2) for the first five years post-construction. One site is located upstream of the restoration works and serves as a control site, and the other site is in the downstream end of the FHEP and serves as an impact site. This Year 5 (2021) annual monitoring data report provides a summary of pre-construction (2013-2014) and post-construction (2016–2021) water temperature monitoring results and providing qualitative assessment of temperature in relation to the fish community monitoring data.

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). The overall objective of the riparian restoration effectiveness monitoring program, as per the OEMP, is to describe natural revegetation and planting success in riparian areas, 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.* 2021).

In the OEMP, successful revegetation is defined by two specific targets: 1) survival of at least 80% of planted vegetation within the first year of planting (DFO and MELP 1998, Harwood *et al.* 2013, Harwood *et al.* 2021); and 2) stem densities equal to or more than 1,200 tree stems/ha and 2,000 shrub stems/ha (Harwood *et al.* 2021). Conifer establishment and riparian species diversity is measured to assess the overall objectives stated in the OEMP and FHEP (Harwood *et al.* 2021, Hemmera 2015).

To evaluate regeneration and planting success, results from the fifth year of monitoring are compared with three benchmarks: 1) data collected post-construction (this includes as-built surveys conducted immediately following instream habitat enhancement and subsequent restoration work in 2016 (Harwood *et al.* 2019a), Year 1 monitoring in 2017 (Harwood *et al.* 2019a), and Year 3 monitoring in 2019 (Thornton *et al.* 2020)); 2) data collected four years after the slide prior to restoration work, in 2014 (Harwood *et al.* 2016); and 3) conditions 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

Fish habitat was assessed in Year 5 by taking and comparing photographs taken in the same locations (transect repeat photos) throughout the monitoring period. In addition, the repairs completed in Reach 1 and Reach 3 in 2020 were inspected for functionality and long-term stability. Fish habitat monitoring in Year 5 was conducted on October 27, 2021.

Reaches 1 and 3 of Alena Creek were enhanced as a part of the FHEP. To assess the stability of the habitat enhancements, initial photos were taken at photo-points established during the as-built survey (completed shortly following FHEP construction in 2016). A total of eight transects were established (four in each reach) and surveyed at that time. At each transect, a panorama of photos was taken to support evaluation of changes in habitat conditions over time. Photos were taken looking downstream, upstream, from river left to river right, and from river right to river left. The photo aspects were oriented to provide a full view of the bankfull channel and floodplain, with the transect tape included in the photos to provide a visual reference that would aid with analysis of the topographic transect surveys. The transect photos have been repeated during each year since construction, including Year 5, to allow for detection of changes in channel conditions. Additional photos were also taken throughout reaches 1 and 3 at key points.

3.2. Fish Community

3.2.1. Adult Spawner Abundance

Spawner surveys in Alena Creek focused on Coho Salmon; however, Bull Trout were also monitored to provide additional information on Project streams (i.e., Upper Lillooet and Boulder Creek). Spawner surveys for Bull Trout were done through bank walks conducted approximately every two weeks between September 15 and October 21, 2021 (a total of three surveys). Coho Salmon spawner surveys were conducted every two weeks between November 5 and December 6, 2021 (a total of three surveys). Consistent with previous years, bank walks extended from the downstream confluence with the Upper Lillooet River to the upstream end of Alena Creek at the groundwater spring at the Lillooet River Forest Service Road (FSR) crossing at kilometer 36.5. During bank walks, live fish and carcasses were counted. Due to the meandering nature of the Upper Lillooet River, the downstream confluence with Alena Creek has varied over the monitoring years by up to ~1 km. Although survey distance can vary on Alena Creek, it is not expected to have a significant effect on total observations as a small percentage of fish are observed in this section due to the high turbidity influence from the Upper Lillooet and lack of holding habitat.

It is important to note that the carcasses in Alena Creek are quickly consumed by wildlife in the area, as evident by observations that they are not often whole and show signs of being eaten. Often only the pyloric caeca, which animals prefer not to eat, are left behind. Thus, combined counts of spawners and carcass counts may be biased low and not accurately reflect true abundance.

3.2.2. Juvenile Abundance

3.2.2.1. Minnow Trapping

Minnow trapping surveys in Alena Creek for Year 5 monitoring occurred on September 27, 2021. Eight sites were sampled in 2021 (five enhanced, three unenhanced; Map 3), which were also sampled in 2018, 2019, 2020, and 2021; six were sampled in years prior to 2018. In 2021 (as in previous years as of 2018), five traps were installed at each site, except at ALE-MT06, where 10 traps were used because a large pool present at this site required a higher level of sampling effort. Sampling was conducted in five of the six sites sampled in years prior to 2018 (ALE-MT01, ALE-MT02, ALE-MT03, ALE-MT05 and ALE-MT06). Due to American Beaver (*Castor canadensis*) (hereafter, beaver) activity in these years, sampling at ALE-MT04 was discontinued in 2018 through 2021 as recommended in the Year 1 report (Harwood *et al.* 2019a). Additionally, three new sites established in 2018 in FHEP habitat were sampled, one site in Reach 1 (ALE-MT07) and two sites in Reach 3 (ALE-MT08 and ALE-09) (Map 3). The Year 1 OEMP report 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). Although more sites were sampled in 2018 to 2021 (eight sites) than in the years before that (six sites), this difference does not affect comparability of CPUE among years since it is a standardized metric.

Minnow traps were baited using salmon roe and left overnight in most years; an exception was 2014 when minnow traps at some sites were left only during the daytime due to bear activity. When the traps were retrieved, captured fish were identified and measured (discussed below), then released.

3.2.2.2. Biological Information

All captured fish were enumerated and identified to species level using standard field keys. Due to the volume of fish captured, only a subset of fish captured at each site were measured and weighed (i.e., approximately 10 of each species and age class per site). The sub-sampled fish were measured for fork length using a measuring board (±1.0 mm) and weighed using a field scale (±0.1 g).

Scale samples to be used for aging analysis were collected from a sub-sample of captured fish and aged at the Ecofish laboratory in Campbell River (i.e., approximately 10 of each species and age class from all sites combined). Three representative scales for each fish included in the sub-sample were examined under a dissecting microscope, photographed, and apparent annuli were 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 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 age classes were defined for fry (0+), parr (1+), parr (2+), and adults (3+). These discrete classes allowed measured fish to be assigned an age class based on fork length.

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, for this monitoring program, the condition of fish was calculated separately for each age class, so violations of this assumption were not expected. The condition of fish was 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

Water level monitoring began 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 2). Baseline monitoring at these two stations occurred from approximately 2013 to 2015. Post-construction monitoring started in 2016 and is ongoing. Pos-construction water level data has been collected at the Alena Bridge site in every monitoring year. The gauge was reinstalled and moved slightly on November 26, 2019. An offset was applied to data collected after that point to ensure stage data collected before and after removal was comparable.

In addition, a second gauge (R1) was installed based on recommendation by Harwood *et al.* (2018), at approximately 125 m upstream from the Alena Bridge gauge. This gauge was deployed from August 23, 2018, until fall 2019. The purpose of the second gauge was 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 were representative of Alena Creek water levels. Results from the Year 3 report (Thornton *et al.* 2020) indicated that backwatering from Upper Lillooet River to the FSR bridge was no longer occurring, and the gauge was removed in November 2019.

3.4. Water Temperature

3.4.1. Study Design

Pre-construction and post-construction water temperature monitoring occurred 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 2, Appendix B). Pre-construction water temperature monitoring occurred from April 17, 2013 to December 31, 2014 at the upstream control site (ALE-USWQ1) and from August 27, 2013 to December 31, 2014 at the downstream impact site (ALE-BDGWQ) (Map 2). Post-construction monitoring commenced at both sites on November 23, 2016. Year 5 data are available up to September 27, 2021 for the upstream site and downstream site (Table 1).

Table 1. Summary of water temperature site names, logging details, and periods of data records in Alena Creek pre-construction (2013, 2014) and post-construction (November 2016 through 2021).

Type	Site	UTM Coordinates (10U)		Elevation (masl)[1]	Project Phase[2]	Periods of Record		Number of Data Records	Logging Interval (min.)	No. of Days with Valid Data	% Complete[3]
		Easting	Northing			Start Date	End Date				
Upstream	ALE-USWQ1	472,976	5,606,870	391	Pre-construction	17-Apr-13	30-Dec-14	623	60	561	91
					Post-construction	23-Nov-16	27-Sep-21	1,770	15	1,766	100
Downstream	ALE-BDGWQ	473,336	5,606,095	382	Pre-construction	27-Aug-13	30-Dec-14	491	60	453	94
					Post-construction	23-Nov-16	27-Sep-21	1,770	15	1,767	100

[1] Estimated from Google Earth.

[2] Pre-construction (2013-2014) water temperature was monitored via hydrometric gauges maintained by Knight Piésold Ltd. Post-construction Tidbit temperature loggers were installed.

[3] The pre-construction data gap at the upstream site occurred between mid January and mid March 2014 due to icing concerns. 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. Quality Assurance/Quality Control

Processing of water temperature data was conducted by first identifying and removing outliers and then compiling data into a timeseries 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 suspect or unreliable data were excluded from analysis and presentation. Excluded data included, for example, data collected when the sensor was suspected of being out of the water, affected by snow or ice, or buried in sediment.

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). There have been no data gaps post-construction to date (i.e., data set is 100 % complete; Table 1).

3.4.3. Data Collection and Analysis

Pre-construction temperature data were recorded at 60-minute intervals using hydrometric gauges maintained by Knight Piésold Ltd. The temperature sensors incorporated into the gauges were installed in aluminum standpipes and had an accuracy of ±0.3°C and 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 record data with precision of 0.02°C. Water temperature at ALE-BDGWQ was concurrently logged with 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.

After identifying and removing outliers, the records from duplicate loggers were averaged and records from different download dates were combined into a single timeseries for each monitoring site. The timeseries for all sites were then interpolated to a regular interval of 15-minutes (for instances whereby data were not already logged at a 15-minute interval), starting at the full hour. Data are presented in plots that were generated from the resultant 15-minute interval temperature data.

Analysis of the data involved computing mean, minimum, and maximum water temperatures as well as differences in water temperature among sites and mean weekly maximum temperature (MWMxT). Table 2 defines these statistics and describes how they were calculated. MWMxT values were compared to optimum ranges for priority fish species, and daily minimum and maximum temperatures were compared to temperature thresholds for Bull Trout.

After Year 3 reporting, data were subject to further analysis to ensure they were processed according to current standards. As a result, some revisions were made to improve accuracy, and the values presented herein may differ from those presented in previous reports during Year 1 to Year 3. Key changes were:

- Mean Weekly Maximum Temperature (MWMxT) – changes from previous versions of this analysis were:
  - The inclusion of a cut-off whereby a day is excluded from the calculation if it does not include data during the warmest period of the day. By default, a day is excluded when it does not have at least one hourly measurement between 11:00 and 18:00.
  - For growing season, a "week" was calculated as a centred average (i.e., three days before and three days after the day for which MWMxT is being calculated). Therefore, the revised start and end dates of the growing season are three days later/earlier, respectively.

Table 2. 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.
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.

3.4.4. Applicable Guidelines

3.4.4.1. Overview

The water temperature BC Water Quality Guidelines (BC WQG) for the protection of aquatic life define water temperature thresholds and optimum temperature ranges specific to fish species and life stages (Oliver and Fidler 2001, MECCS 2021). The target fish species expected to benefit from enhancement in Alena Creek are Coho Salmon, Cutthroat Trout, and Bull Trout. The relevant water temperature BC WQGs for the protection of aquatic life is summarized in the sub-sections below. Optimum water temperature ranges, as defined by the BC WQG for rearing, spawning, incubation, are provided for the fish species present in Alena Creek in Table 3. The timing of life history stages in Alena Creek (Harwood *et al.* 2016) that were used to define the start and end dates for each of the applicable life stages for Coho Salmon, Cutthroat Trout, and Bull Trout are shown in Table 4.

3.4.4.2. 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 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, MECCS 2021). Accordingly, MWMxT values were compared to the optimum temperature ranges for the fish species present in Alena Creek based on the life history and periodicity (Table 3, Table 4).

Within each life history period, the completeness of the temperature data record (% complete) was calculated and results are only included if at least 50% of the data for the period was available. The minimum and maximum MWMxT values, percentage of data within the optimum range, and percentage of data that exceeded ±1.0°C of the optimal temperature range were 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.

3.4.4.3. Bull Trout Temperature Guidelines

Additional water temperature BC WQG (MECCS 2021) are specified for streams with Bull Trout and Dolly Varden (Oliver and Fidler 2001; Table 1 in Appendix B). 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 when these thresholds were exceeded were calculated using the appropriate daily maximum or minimum temperature values for each site.

Table 3. Optimum water temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout during spawning, incubation, rearing, and migration (MECCS 2021).

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	-

Table 4. Periodicity of fish species in Alena Creek.

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)	Undefined	Undefined

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 due to a revised design. 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), and 2017 (Year 1) to 2021 (Year 5). These four permanent revegetation monitoring plots were assessed for the duration of the monitoring program (Map 3). A direct comparison between plots established in 2016 and plots monitored in 2014 is not possible. However, they were all intended to be representative of the riparian zone of Alena Creek, and the 2014 monitoring plots still provide a useful benchmark.

Surveyors counted the number of stems of all native perennial woody plants and conducted health and mortality checks. Perennial woody vegetation includes long-lived species such as trees and shrubs, but excludes forbs, grasses, and mosses. 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 at least the size or length of a quarter 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 (Harwood *et al.* 2021). 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. Planted vegetation was not tracked beyond the first year, so it was not possible to assess survival, but the proportion of dead stems was used to give a general measure of vegetation health.

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. 80% cover has been adopted as a general indicator of functioning riparian habitat for the monitoring program but is not a monitoring target in the OEMP and is not used to evaluate success (DFO and MELP 1998, Harwood *et al.* 2013, Harwood *et al.* 2021). 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 haphazardly placed in the vicinity of each permanent revegetation monitoring plot (not necessarily within the plot), 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

The as-built survey was completed following construction in Year 1 (West *et al.* 2017). The new channel construction and enhancement of existing channels has provided 3,194 m^2 of high-quality instream fish habitat. Restoration of riparian habitat yielded a further 4,060 m^2 of habitat directly enhanced by the FHEP. The FHEP created further ancillary benefits not included in these totals by providing improved passage to upstream spawning areas while retaining good quality rearing habitat provided by the beaver pond and woody debris jam (West *et al.* 2017). This exceeded the target of 2,310 m^2 set out in the *Fisheries Act* Authorization (09-HPAC-PA2-00303); however, monitoring was required to ensure this habitat remained to be functioning as intended over a five-year period.

In Year 5, photos were taken at established photo-point locations (transects) in the enhanced reaches (Reach 1 and Reach 3) of Alena Creek on October 27, 2021. A comparison of all photos taken during the five years of monitoring by transect is available in Appendix C. Transects are shown in Map 3.

Overall, it has been evident during monitoring that the riparian vegetation has increased since 2016 and the channel has remained stable over this time. Grasses, shrubs, and herbaceous vegetation have become established, and are continuing to establish, throughout the reaches. This vegetation is protecting 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.

New beaver activity was observed in the lower end of Reach 3. Previous beaver activity upstream of Reach 3 had ceased, but flow was still being partially diverted around the upper portion of Reach 3. Beavers were trapped within the Alena Creek enhancement area and the dams were removed in the fall of 2021 by a licensed trapper from EBB Environmental Consulting Inc. A description of channel condition, geomorphic processes, and instream repair inspection is provided for the two reaches in the following sections. Instream repairs completed on August 6, 2020, are also described. Details of the habitat features installed by transect are provided in West *et al.* (2017).

4.1.2. Reach 1

Reach 1 is the most downstream reach of Alena Creek; it extends from the Lillooet River FSR bridge to approximately 200 m upstream (Map 3). Photos of each transect from each year of monitoring are provided in Appendix C. The following bullets summarize observations of constructed features by transect, including repairs made in 2020 where a channel spanning log had collapsed (near ALE-XS1):

- **ALE-XS1** – The channel had previously avulsed onto the river left floodplain and created a secondary channel less than 10 m long (Figure 1 through Figure 6). This secondary channel remains active in 2021. Following repairs made in 2020, which involved placing cobble upstream of ALE-XS1 along a portion of the avulsed channel, the riffle is still composed of gravel and is relatively free of fines but has some algae growth. Inspection of repairs in 2021 indicated that these repairs were effective in directing flows back to the original channel alignment and reducing bank erosion (Figure 7). There are no concerns for long term stability.

- **ALE-XS2** – The channel is backwatered in this location due to the collapse of one of the channel-spanning logs downstream, and the accumulation of small wood pieces have created a minor log jam (Figure 8). The collapse was identified during the 2019 assessment (Thornton *et al*. 2020). Some undercutting has occurred on river left under a longitudinally aligned log, which appears to be stable and has created good cover. The root wads on river right continue to provide good cover habitat. The log jam has not grown and 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. The center log has shifted slightly. There are 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. There are no concerns for long term stability.

Figure 1. Looking from river left to river right at ALE-XS1 on September 19, 2016, showing a single channel.

Figure 2. Looking from river left to river right at ALE-XS1 on November 10, 2017, showing the beginnings of a secondary channel forming on the river left floodplain.

Figure 3. Looking from river left to river right at ALE-XS1 on November 5, 2018, showing further development of a secondary channel on the river left floodplain.

Figure 4. Looking from river left to river right at ALE-XS1 on November 13, 2019; the secondary channel on the river left floodplain is partly obscured by growing vegetation.

Figure 5. Looking from river left to river right at ALE-XS1 on November 7, 2020; the secondary channel on the river left floodplain is partly obscured by growing vegetation.

Figure 6. Looking from river left to river right at ALE-XS1 on October 27, 2021; the secondary channel on the river left floodplain is partly obscured by growing vegetation.

Figure 7. Cobble placement at the head of the side channel upstream of ALE-XS1 on August 06, 2020.

Figure 8. Log jam that has formed at a collapsed channel spanning log approximately 10 m upstream of at ALE-XS2. Photo taken on June 20, 2019.

4.1.3. Reach 3

4.1.3.1. Transect Repeat Photos

Reach 3 extends from approximately 600 m to 800 m upstream of the Lillooet River FSR bridge. A brief description of changes that have occurred to constructed features at each of the monitoring transects is provided in the bullets below, followed by an overview description of changes occurring in the channel. Photos at each transect from each year of monitoring are provided in Appendix C.

- **ALE-XS5** - Due to reoccurring beaver activity in 2021 at the lower end of Reach 3, this section is slightly backwatered. Wetted widths and wetted depths have increased relative to 2019. 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 slightly affecting hydraulics. Rootwads upstream of the riffle continue to provide good cover for juvenile salmonids. There are no concerns for long term stability.
- **ALE-XS6** - A new beaver dam was constructed in this section, causing some moderate backwatering and sand deposition in 2020. Although the beaver dam was dismantled in the fall of 2021, wetted widths and wetted depths have increased relative to 2019. Some sand deposition has occurred on riffle material, with sand likely originating partially from upstream supply and from bank erosion that largely occurred during the November 2016 high flow event and due to an avulsion of the channel around a beaver dam above Reach 3. Grass and herbaceous bank vegetation have established that should prevent excessive erosion in the future. There are no concerns for long term stability.
- **ALE-XS7** – The pool has aggregated with sand to some extent and may now be at an equilibrium depth with the upstream sand supply. There has been an increase in deposition of sand mid channel since 2019. 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. Deposition of fines has occurred on the glide that is unavoidable given upstream sediment supply and the newly cut side channel flowing into the top of Reach 3. There are no concerns for long term stability.

During Year 3 (2019), two channels were identified that 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. The channel that enters Reach 3 approximately 40 m downstream from the head of Reach 3 was flowing throughout 2020 (Figure 9). The other channel that entered Reach 3 further downstream had ceased flowing during 2020, likely due to changes in upstream beaver activity. The beaver dam complex upstream of Reach 3 was considered inactive in 2021. The dams 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. The dams were managed through 2018, 2019, and 2020 in accordance with best management practices for dam removal provided by a licensed trapper from EBB Environmental Consulting Inc. As recommended in 2019, the dam that is blocking flow to the mainstem was lowered in 2020 to prevent excessive flow diversion.

New beaver activity was observed in the lower end of Reach 3: two reconstructed beaver dams created moderate backwatering at ALE-XS5, ALE-XS6 and ALE-XS7 (Figure 10). Beavers were trapped within the Alena Creek enhancement area and dams were removed in the fall of 2021 by a licensed trapper from EBB Environmental Consulting Inc.

Figure 9. Confluence of overflow channel that formed during 2019 as a result of beaver activity upstream of Reach 3. Photo shows uppermost 20 m of Reach 3 (right) and overflow channel (left). Photo taken on November 13, 2019.

Figure 10. New reconstructed Beaver dam at the lower end of Reach 3 that was identified during fall 2021 and subsequently removed.

4.1.3.2. Instream Repairs

During the stability assessment on October 27, 2021, the repairs in Reach 3 from 2020 were inspected and appeared to be intact, stable, and functioning as intended. The large wood pieces placed along the banks to deflect flow and prevent erosion, have not shifted, and remain intact, thus alleviating previous erosion issues.

4.2. Fish Community

4.2.1. Adult Spawner Abundance

The peak counts of live Coho Salmon spawners observed in 2021 was 371 live fish on December 6, 2021 (Table 5). The peak count of live adult spawning Coho Salmon in 2021 was the highest observed during monitoring to date. Variability in peak counts of live adult spawning Coho Salmon during the last eight years, which ranged from 109 to 218 (in 2017 and 2020 respectively), is evident in Table 6. This comparison of observations among years also highlights the variability in run timing, with the annual peak live count recorded between early November and early December. Peak counts of live spawners provide a general indication of habitat use and demonstrate that Alena Creek supports potentially greater use by Coho Salmon spawners currently than it did pre-construction, although among-year variability in spawner abundance is strongly affected by factors other than spawning habitat quality, such as marine survival. Example photos of adult Coho Salmon holding in enhanced habitat and unenhanced habitat are provided in Figure 11 and Figure 12 respectively. Adult

Coho Salmon were also observed spawning in the newly constructed offset habitat (*Fisheries Act* Authorization 19-HPAC-00331) on December 6, 2021 (Figure 13).

Five Bull Trout were observed in 2021. Counts in previous years ranged from zero to nine individuals (Table 5, Table 7). Bull Trout numbers have been low in small tributaries of Upper Lillooet River since 2011 with an increasing trend in recent years including 29.2 km Tributary (Faulkner *et al.* 2022).

Table 5. Summary of adult fish observed during fall spawner surveys in 2021.

Stream	Date	Survey Time (hh:mm)	Survey Distance (m)	Live Adults[1]		Adult Carcasses[1]	
				BT	CO	BT	CO
Alena Creek	2021-Sep-15	16:00	1,750	0	0	0	0
	2021-Oct-07	14:00	2,300	0	0	0	0
	2021-Oct-21	15:12	2,300	5	37	0	0
	2021-Nov-05	17:36	2,300	0	185	0	21
	2021-Nov-17	04:00	2,300	0	339	0	66
	2021-Dec-06	18:48	2,300	0	371	0	4
Alena Creek Total:		**13:36**	**13,250**	**5**	**932**	**0**	**91**

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

Table 6. Peak Live Coho Salmon spawner counts during baseline (2010-2011) and post-construction monitoring (2016 - 2021).

Year	Date [1]	Adult Spawning Coho		
		Live	Dead	Total
2010	Nov-05	127	0	127
2011	Dec-02	110	1	111
2016	Nov-14	174	18	192
2017	Nov-26	109	22	131
2018	Nov-05	126	4	130
2019	Dec-09	153	20	173
2020	Nov-19	218	51	269
2021	Dec-06	371	4	375

[1] Date of adult spawning Coho Salmon peak count

Table 7. Peak Live Bull Trout spawner counts during baseline (2011) and post-construction monitoring (2018 - 2021).

Year	Date [1]	Adult Spawning Bull Trout		
		Live	Dead	Total
2011	Oct-04	9	0	9
2018	Oct-11	2	0	2
2019	Oct-01	1	0	1
2020	N/A	0	0	0
2021	Oct-21	5	0	5

[1] Date of adult spawning Bull Trout peak count

Figure 11. Coho Salmon observed holding in enhanced habitat on November 5, 2021.

Figure 12. Spawning Coho Salmon observed in unenhanced habitat on December 6, 2021.

Figure 13. Spawning Coho Salmon observed in new offset habitat on December 6, 2021.

4.2.2. Juvenile Abundance

4.2.2.1. Overview

On September 27, 2021, 45 minnow traps were set overnight in riffle, pool, and glide habitats ranging in depth from 0.2 to 1.4 m (Table 8) at eight sites (Map 3). A total of 1,045 fish (1,017 Coho Salmon and 28 Cutthroat Trout) were captured during minnow trap sampling (Table 8). Three juvenile Bull Trout were captured in 2021. Raw data tables and representative photos of minnow trapping sites are presented in Appendix D.

Table 8. Summary of minnow trapping habitat characteristics and fish captures in Alena Creek on September 27, 2021.

Site	Enhancement Status	# of Traps	Total Soak Time (hrs)	Mesh Size (mm)	Habitat Type	Trap Depth Range (m)	Total Captures [1]		
							BT	CO	CT
ALE-MT01	Enhanced	5	112.6	6.3	Glide, Riffle	0.6 - 1.0	2	29	0
ALE-MT02	Enhanced	5	115.7	3.2 - 6.3	Pool, Riffle	0.3 - 0.9	0	50	1
ALE-MT07	Enhanced	5	119.1	3.2 - 6.3	Pool	0.4 - 0.9	1	60	1
ALE-MT03	Unenhanced	5	121.6	3.2 - 6.3	Pool, Glide	0.3 - 0.9	0	94	3
ALE-MT08	Unenhanced	5	130.3	3.2 - 6.3	Pool	0.2 - 0.7	0	106	1
ALE-MT09	Enhanced	5	134.4	3.2 - 6.3	Pool, Riffle	0.3 - 1.0	0	103	2
ALE-MT05	Enhanced	5	136.2	3.2 - 6.3	Pool, Riffle	0.4 - 1.0	0	189	3
ALE-MT06	Unenhanced	10	248.4	3.2 - 6.3	Pool	0.3 - 1.4	0	386	17
Grand Total:		**45**	**1,118**				**3**	**1,017**	**28**
Grand Average:		**5.6**	**139.8**				**0**	**127**	**4**

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

4.2.2.2. Cutthroat Trout

A total of 28 Cutthroat Trout, ranging in length from 52 mm to 128 mm, were captured during the 2021 sampling program at all sites combined (Table 9, Table 10). CPUE ranged from 0.0 fish per 100 trap hours at ALE-MT01 to 6.8 fish per 100 trap hours in ALE-MT06 (Table 9). The average CPUE was 1.9 fish per 100 trap hours (± 2.1 Standard Deviation (SD)) (Table 9). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 10. Discrete fork length ranges were defined for each age class (Table 11), based on a review of the length-frequency histogram (Figure 14) and aging data from scale analysis (Figure 15).

Cutthroat Trout Fry (0+)

Two Cutthroat Trout fry (0+) were captured in 2021 at ALE-MT06 (unenhanced) (Table 9).

Cutthroat Trout Parr (1+)

Cutthroat Trout parr (1+) were distributed throughout Alena Creek and were captured at all sites except for ALE-MT01 (enhanced) and ALE-MT08 (unenhanced) (Table 9). A total of 18 Cutthroat Trout 1+ parr were captured, with the largest number of fish captured in ALE-MT06 (unenhanced).

Cutthroat Trout Parr (2+)

Eight Cutthroat Trout 2+ parr were captured in 2021. Fish were captured in ALE-MT06 (7) and ALE-MT08 (1) (Table 9).

Cutthroat Trout Adults (≥3+)

No adult Cutthroat Trout were captured in 2021 (Table 9).

Table 9. Catch and CPUE for Cutthroat Trout captured by minnow trapping in Alena Creek on September 27, 2021.

Site	Enhancement Status	# of Traps	Total Soak Time (hrs)	Total CT Catch (# of Fish) [1]	CPUE (# of Fish/100 Trap hrs) [1]	CT Catch (# of Fish)[2]				
						0+	1+	2+	3+	All
ALE-MT01	Enhanced	5	112.6	0	0.0	0	0	0	0	**0**
ALE-MT02	Enhanced	5	115.7	1	0.9	0	1	0	0	**1**
ALE-MT07	Enhanced	5	119.1	1	0.8	0	1	0	0	**1**
ALE-MT03	Unenhanced	5	121.6	3	2.5	0	3	0	0	**3**
ALE-MT08	Unenhanced	5	130.3	1	0.8	0	0	1	0	**1**
ALE-MT09	Enhanced	5	134.4	2	1.5	0	2	0	0	**2**
ALE-MT05	Enhanced	5	136.2	3	2.2	0	3	0	0	**3**
ALE-MT06	Unenhanced	10	248.4	17	6.8	2	8	7	0	**17**
Total:		**45**	**1118.4**	**28**	**15.5**	**2**	**18**	**8**	**0**	**28**
Average:		**5.6**	**139.8**	**3.5**	**1.9**	**0**	**2**	**1**	**0**	**4**
Standard Deviation:				**5.6**	**2.1**	**1**	**3**	**2**	**0**	**6**

[1] Includes all captured fish in the minnow traps

[2] CT = Cutthroat Trout. Only includes fish measured for fork length and assigned an age

Table 10. Summary of fork length, weight, and condition for juvenile Cutthroat Trout captured in Alena Creek in 2021.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	52	2	52	50	1	1.70	1.70	1.70	1	1.14	1.14	1.14
Parr (1+)	101	18	101	56	17	12.26	2.40	20.70	17	1.06	0.91	1.37
Parr (2+)	134	8	134	128	8	23.95	20.60	29.20	8	0.99	0.94	1.07
Adult (≥3+)	0	-	-	-	0	-	-	-	0	-	-	-
All	**287**	**9**	**52**	**128**	**26**	**12.64**	**1.70**	**29.20**	**26**	**1.06**	**0.91**	**1.37**

Table 11. Size bins by age class for juvenile Cutthroat Trout captured in Alena Creek in 2021.

Age Class	Fork Length Range (mm)
Fry (0+)	0-53
Parr (1+)	73-126
Parr (2+)	≤ 130

Figure 14. Fork length frequency for juvenile Cutthroat Trout captured (by minnow trapping) in Alena Creek in 2021.

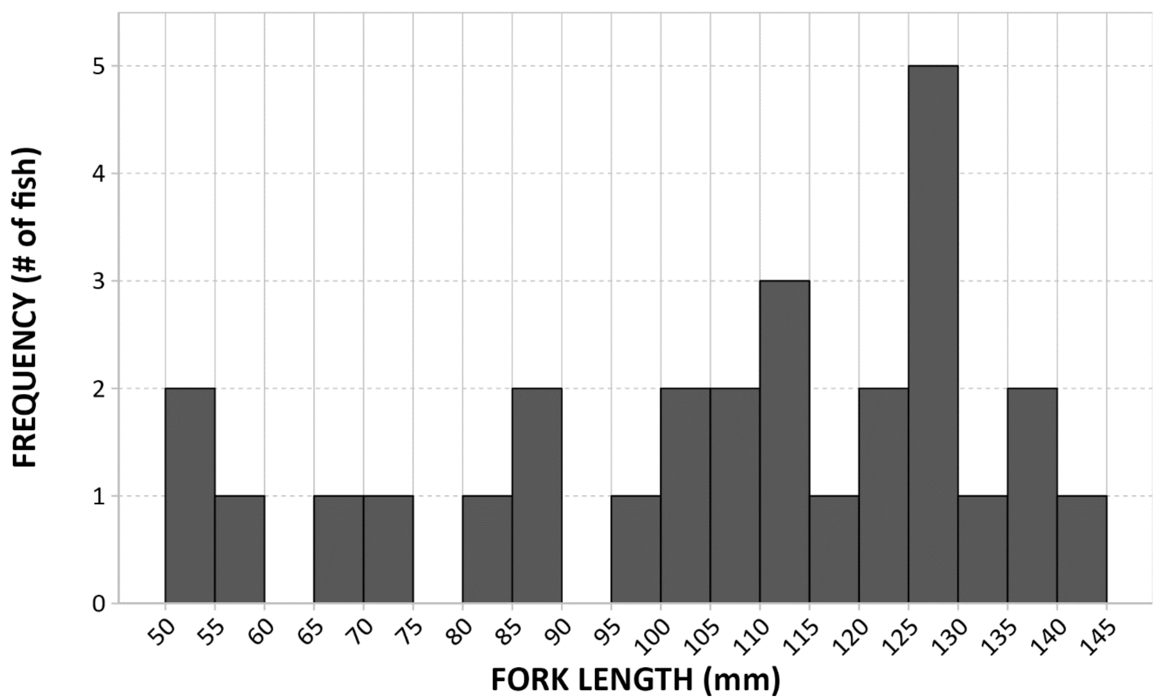
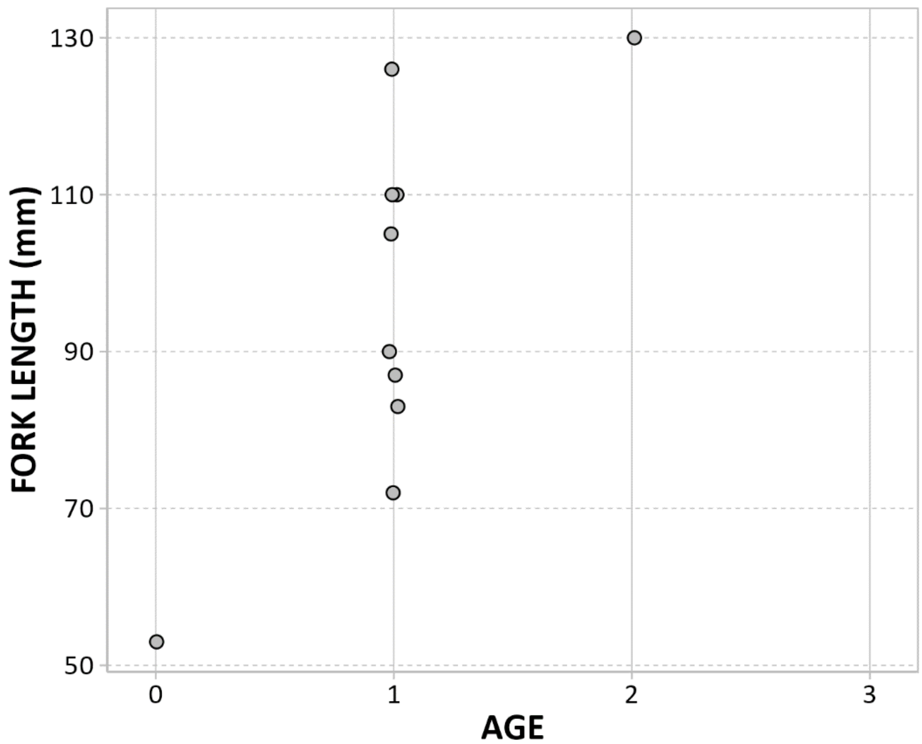


Figure 15. Fork length by age for juvenile Cutthroat Trout captured in Alena Creek in 2021.



4.2.2.3. Coho Salmon

A total of 1,017 juvenile Coho Salmon were captured during minnow trap sampling in Alena Creek on September 27, 2021 (Table 12). CPUE ranged from 25.7 fish per 100 trap hours at ALE-MT01 (enhanced) to 155.4 fish per 100 trap hours in ALE-MT06 (unenhanced) (Table 12). The total average CPUE was 127.1 fish per 100 trap hours (± 115.3 SD) (Table 12). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 13. Discrete fork length ranges were defined for each age class (Table 13), based on a review of the length-frequency histogram (Figure 16) and aging data from scale analysis (Figure 17).

Coho Salmon Fry (0+)

Coho Salmon fry (0+) were captured at all sampling sites in 2021 and are distributed throughout the sampled reaches of Alena Creek (Table 12). Due to the large volume of Coho Salmon juveniles captured, not all fish were measured for fork length, and therefore not all Coho Salmon could be assigned an age class. Based on total captures, 0+ fry was likely most abundant at ALE-MT03 (unenhanced), ALE-MT06 (unenhanced), and ALE-MT07 (enhanced) (Reach 4).

Coho Salmon Parr (1+)

Coho Salmon 1+ parr were captured at all sites in 2021 (Table 12). Based on total captures, 1+ parr were likely most abundant at ALE-MT03 and ALE-MT06 in the unenhanced reach (Reach 2). The high proportion of 1+ parr could be due to size range selectively, where larger fish access the trap faster and have more difficulty escaping. This has been documented for Coho Salmon juveniles in previous studies (Bloom 1976).

Table 12. Catch and CPUE for Coho Salmon captured in Alena Creek on September 27, 2021.

Site	Enhancement Status	# of Traps	Total Soak Time (hrs)	Total CO Catch (# of Fish) [1]	CPUE (# of Fish/100 Trap hrs) [1]	CO Catch (# of Fish)[2]				
						0+	1+	2+	3+	All
ALE-MT01	Enhanced	5	112.6	29	25.7	8	21	0	0	**29**
ALE-MT02	Enhanced	5	115.7	50	43.2	29	21	0	0	**50**
ALE-MT07	Enhanced	5	119.1	60	50.4	45	15	0	0	**60**
ALE-MT03	Unenhanced	5	121.6	94	77.3	56	38	0	0	**94**
ALE-MT08	Unenhanced	5	130.3	106	81.4	17	11	0	0	**28**
ALE-MT09	Enhanced	5	134.4	103	76.6	16	10	0	0	**26**
ALE-MT05	Enhanced	5	136.2	189	138.8	13	20	0	0	**33**
ALE-MT06	Unenhanced	10	248.4	386	155.4	68	43	0	0	**111**
Total:		**45.0**	**1,118.4**	**1017.0**	**648.8**	**252**	**179**	**0**	**0**	**431**
Average:			**139.8**	**127.1**	**81.1**	**32**	**22**	**0**	**0**	**54**
Standard Deviation:				**115.3**	**45.2**	**22**	**12**	**0**	**0**	**33**

[1] Includes all captured fish in the minnow traps

[2] CO = Coho Salmon. Only includes fish measured for fork length and assigned an age.

Table 13. Summary of fork length, weight, and condition for Coho Salmon captured in Alena Creek in 2021.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	252	56	38	74	169	2.43	0.08	5.70	169	1.25	0.09	1.97
Parr (1+)	179	82	75	99	123	6.19	3.70	10.10	123	1.11	0.78	1.37
All	**431**	**69**	**38**	**99**	**292**	**4.31**	**0.08**	**10.10**	**292**	**1.18**	**0.09**	**1.97**

Table 14. Size bins by age class for Coho Salmon captured in Alena Creek in 2021.

Age Class	Fork Length Range (mm)
Fry (0+)	46-74
Parr (1+)	75-99

Figure 16. Fork length frequency for juvenile Coho Salmon captured (minnow trapping) in Alena Creek in 2021.

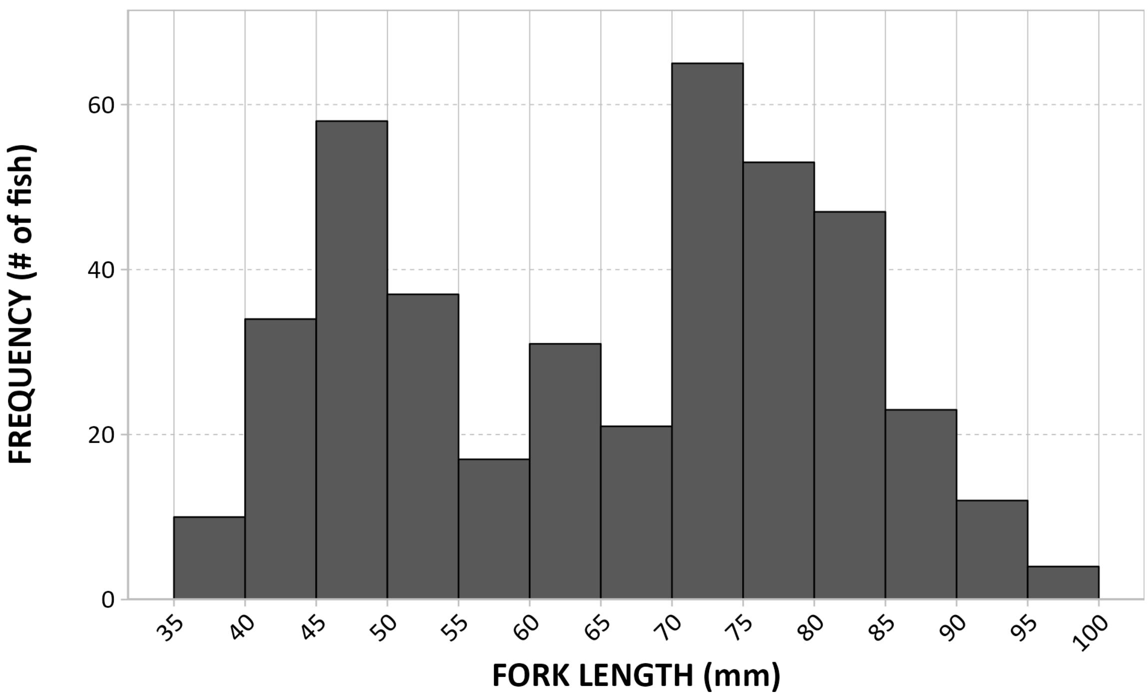
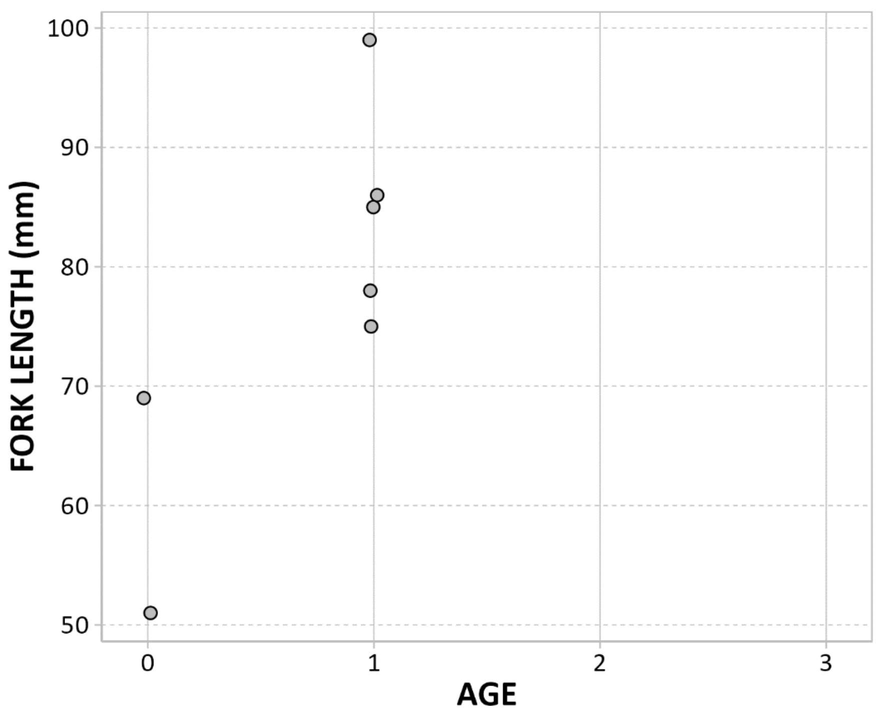


Figure 17. Fork length by age for Coho Salmon captured in Alena Creek in 2021.



4.2.2.4. Bull Trout

A total of three Bull Trout, ranging in length from 120 mm to 196 mm, were captured during the 2021 sampling program at all sites combined (Table 15, Table 10). CPUE ranged from 0.0 fish per 100 trap hours at ALE-MT02, ALE-MT03, ALE-MT05, ALE-MT06, ALE-MT08, AND ALE-MT09 to 1.8 fish per 100 trap hours in ALE-MT01 (Table 9). The average CPUE was 0.3 fish per 100 trap hours (± 0.7 Standard Deviation (SD)) (Table 9). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 16. Discrete fork length ranges were defined for each age class (Table 17), based on a review of the length-frequency histogram (7) and aging data from scale analysis (Figure 15).

Bull Trout Fry (0+)

No Bull Trout fry (0+) were captured in 2021 (Table 15).

Bull Trout Parr (1+)

Two Bull Trout parr (1+) were captured in 2021. One individual was captured at ALE-MT01 and one at ALE-MT07 (Table 15).

Bull Trout Parr (2+)

One Bull Trout parr (1+) was captured in 2021 at ALE-MT01 (Table 15).

Bull Trout Adults (≥3+)

No adult Bull Trout were captured in 2021 (Table 9).

Table 15. Catch and CPUE for Bull Trout captured in Alena Creek on September 27, 2021.

Site	Enhancement Status	# of Traps	Total Soak Time (hrs)	Total BT Catch (# of Fish) [1]	CPUE (# of Fish/100 Trap hrs) [1]	BT Catch 0+	1+	2+	3+	All
ALE-MT01	Enhanced	5	112.6	2	1.8	0	1	1	0	2
ALE-MT02	Enhanced	5	115.7	0	0.0	0	0	0	0	0
ALE-MT07	Enhanced	5	119.1	1	1.0	0	1	0	0	1
ALE-MT03	Unenhanced	5	121.6	0	0.0	0	0	0	0	0
ALE-MT08	Unenhanced	5	130.3	0	0.0	0	0	0	0	0
ALE-MT09	Enhanced	5	134.4	0	0.0	0	0	0	0	0
ALE-MT05	Enhanced	5	136.2	0	0.0	0	0	0	0	0
ALE-MT06	Unenhanced	10	248.4	0	0.0	0	0	0	0	0
Total:		**45.0**	**1,118.4**	**3.0**	**2.8**	**0**	**2**	**1**	**0**	**3**
Average:			**139.8**	**0.4**	**0.3**	**0**	**0**	**0**	**0**	**0**
Standard Deviation:				**0.7**	**0.7**	**0**	**0**	**0**	**0**	**1**

[1] Includes all captured fish in the minnow traps

[2] BT = Bull Trout. Only includes fish measured for fork length and assigned an age.

Table 16. Summary of fork length, weight, and condition for Bull Trout captured in Alena Creek in 2021.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	0	-	-	-	0	-	-	-	0	-	-	-
Parr (1+)	2	129	120	138	2	18.1	16.8	19.4	2	0.86	0.74	0.97
Parr (2+)	1	196	196	196	1	67.6	67.6	67.6	1	0.90	0.90	0.90
Adult (≥3+)	0	-	-	-	0	-	-	-	0	-	-	-
All	**3**	**163**	**120**	**196**	**3**	**42.85**	**16.80**	**67.60**	**3**	**0.88**	**0.74**	**0.97**

Table 17. Size bins by age class for Bull Trout captured in Alena Creek in 2021.

Age Class	Fork Length Range (mm)
Fry (0+)	N/A
Parr (1+)	120-138
Parr (2+)	≤ 139

Figure 18. Fork length frequency for juvenile Bull Trout captured (minnow trapping) in Alena Creek in 2021.

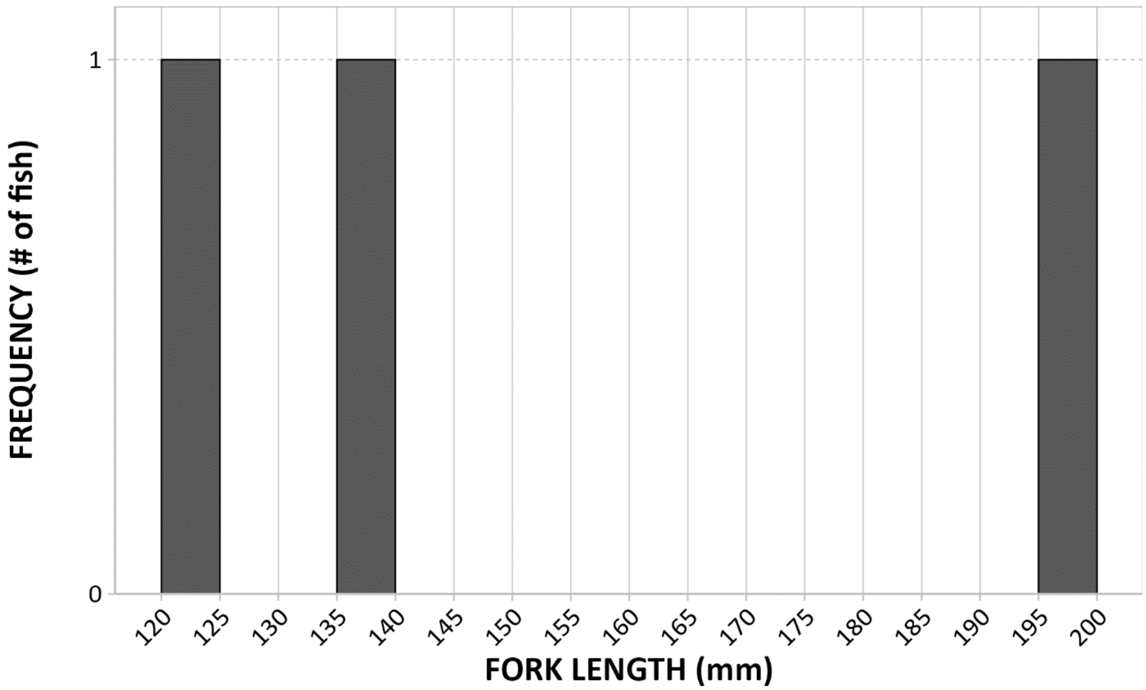
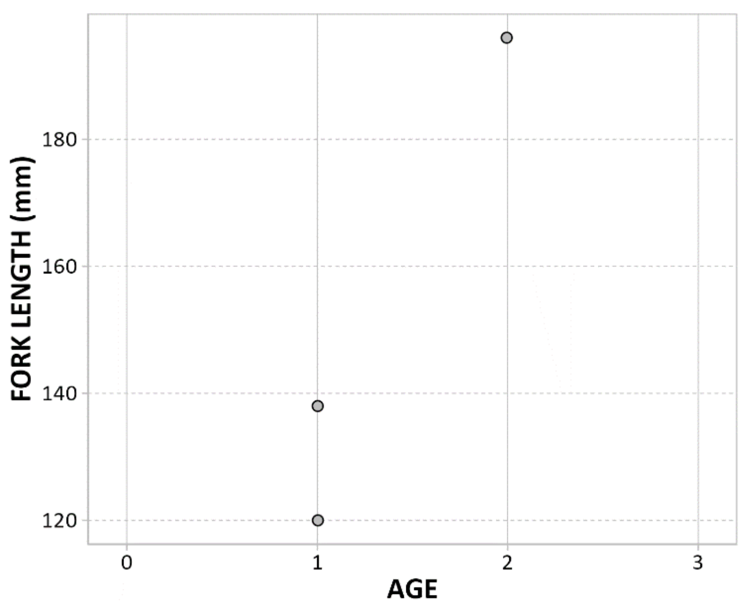


Figure 19. Fork length by age for Bull Trout captured in Alena Creek in 2021.



4.2.2.5. Comparison Among Years

Cutthroat Trout

The average Cutthroat Trout CPUE in 2021 (1.9 fish per 100 trap hours) was similar to that in previous sampling years excluding 2014 and 2020 (Figure 24), when average CPUE was 4.1 and 7.2 fish per 100 trap hours, respectively. The 2014 CPUE results are, however, biased high because the minnow traps were left only during the daytime in this year at some sites (due to bear activity) and soak times were therefore shorter than in other years (Harwood *et al.* 2016). Given that catchability is not likely constant throughout the trap soak time, and that there is likely a high initial catch rate that diminishes over time (Harwood *et al.* 2016), a shorter soak time would result in an apparent higher CPUE. Between 2018 and 2021 there were more sites sampled than in previous years (eight sites versus six sites), although this should not affect comparability of CPUE among years since it is a standardized metric.

A comparison of CPUE by sampling site and year suggests Cutthroat Trout were relatively evenly distributed in relatively low abundances throughout Alena Creek in 2021 (Figure 21). In 2021, CPUE ranged from 0 to 2.5 fish per 100 trap hours across sites excluding ALE-MT06 (unenhanced), where CPUE was more than two times higher than all other sites (6.8 fish per 100 trap hours). The distribution of CPUE across sites was similar in 2021 to previous years, except in 2014 and 2020 when higher CPUE was recorded.

The capture of Cutthroat Trout in the enhanced sites in 2021 (average CPUE 1.1 Cutthroat/100 trap hours) provides evidence of use and suggests that habitat in the enhanced sites is high quality. Higher CPUE in unenhanced verse unenhanced sites (average CPUE 3.4 Cutthroat/100 trap hours) could be due to the presence of proportionally more pool type habitat in unenhanced compared to enhanced sites.

Figure 20. Comparison of minnow trap CPUE for Cutthroat Trout during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years.

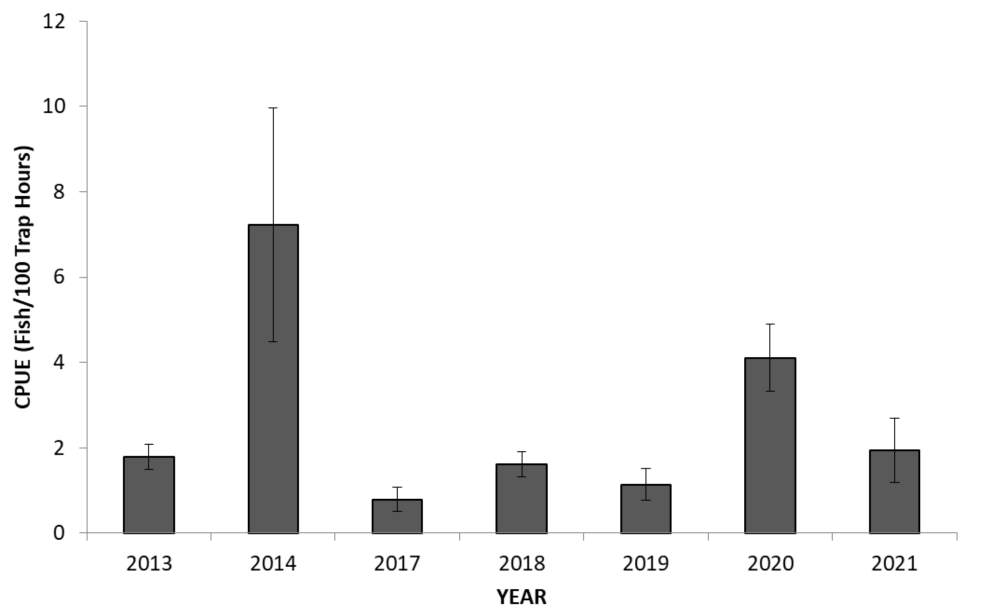
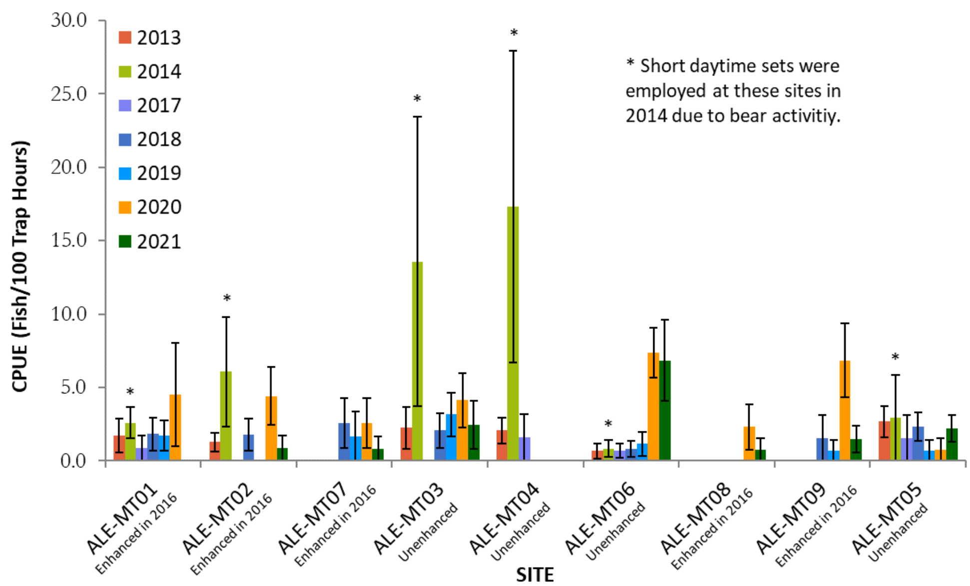


Figure 21. Comparison of minnow trap CPUE for Cutthroat Trout at each site during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years.



Coho Salmon

The average Coho Salmon CPUE in 2021 was 81.1 fish per 100 trap hours, which is the second highest recorded across monitoring years (Figure 22). CPUE in 2021 was similar to that in 2020 and 2018 and higher than in baseline years. It is important to note that 2014 CPUE results are biased high by the short daytime sets (as described for Cutthroat Trout above). It should be noted, that CPUE of Coho Salmon is around 80 fish per hour for multiple years, suggesting this may be near trap capacity.

In 2021, Coho Salmon fry and parr were captured at all sites. CPUE of Coho Salmon at individual sites in 2021 was generally similar to that in more than one previous year of sampling, with the exception of ALE-MT02 (enhanced), where CPUE was notably higher in 2021 than in all previous years except 2018 (Figure 23).

The capture of Coho in the enhanced sites in 2021 (average CPUE 66.9 Coho/100 trap hours) provides evidence of use and suggests that habitat in the enhanced sites is high quality. Higher CPUE in unenhanced verse enhanced sites (average CPUE 104.7 Coho/100 trap hours) could be due to the presence of proportionally more pool type habitat in unenhanced compared to enhanced sites.

Figure 22. Comparison of minnow trap CPUE for Coho Salmon during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years.

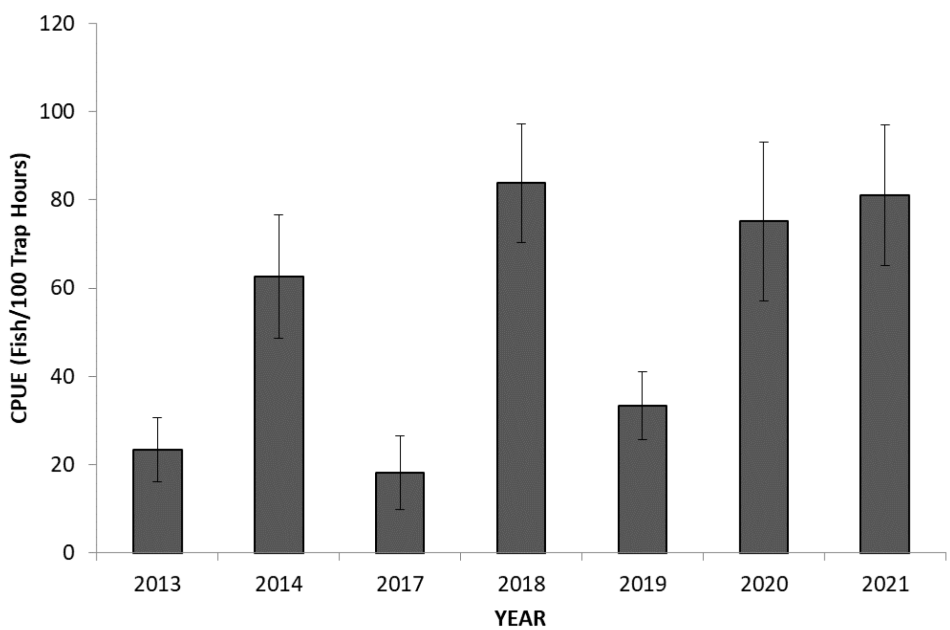
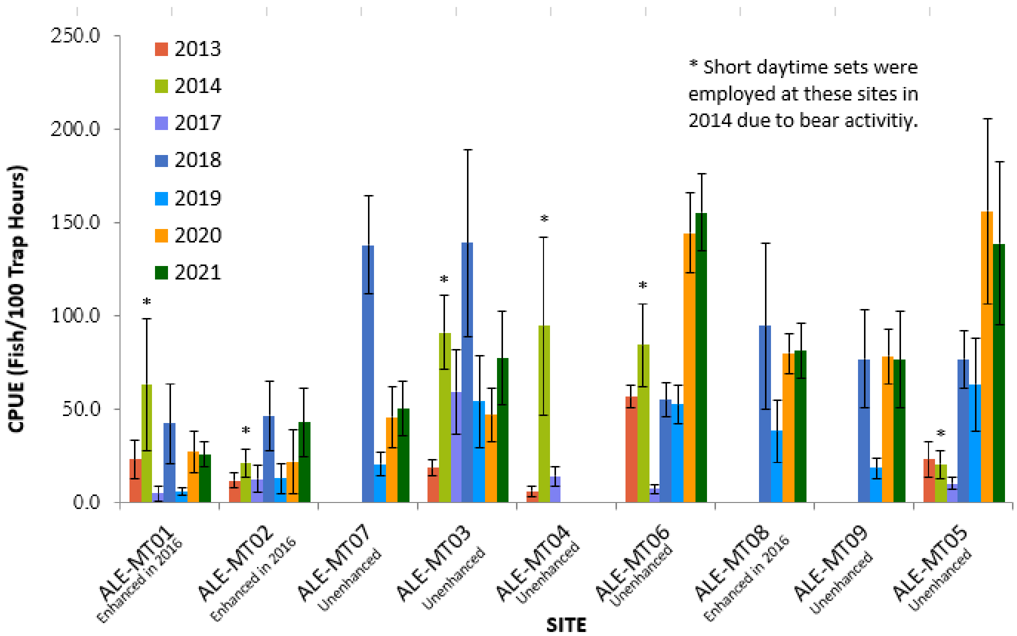


Figure 23. Comparison of minnow trap CPUE for Coho Salmon at each site during baseline (2013 and 2014) and post-construction (2017-2021) sampling. Error bars represent standard error. Note that in 2014 trap soak times were shorter than in other years; thus, CPUE is biased high relative to other years



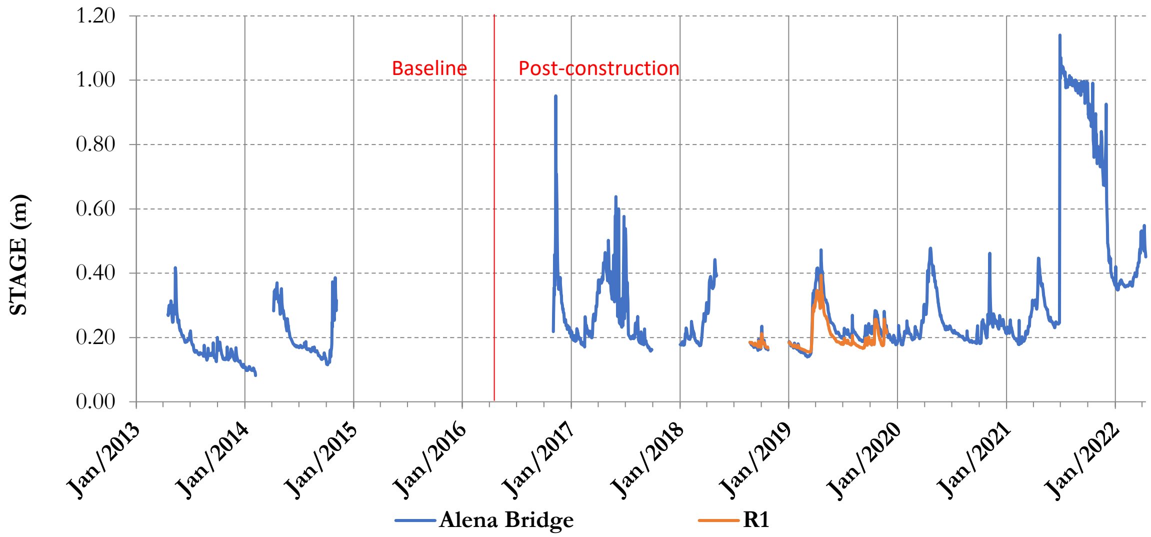
4.3. Hydrology

Seasonal trends in the Alena Creek hydrograph in the winter and spring of 2021 were consistent with a coastal, snow-dominated watershed. Stage levels remained low in the winter until the beginning of snowmelt early March, reaching peak values on April 18.

On June 28, steady high temperatures in the region increased discharge in the Lillooet River to extreme levels for the summer, inducing an upstream shift in the confluence between a secondary channel of Lillooet River and Alena Creek. The secondary channel also increased in size, causing backwatering from the Lillooet River into Alena Creek. This caused a rise in the recorded stage, from 0.25 m to 1.24 m, along with greater amplitude of daily variation (from < 0.04 m to < 0.2 m, Figure 24). Stage remained very high and under the influence of the Lillooet River for the rest of the summer.

A precipitation event shifted hydrological controls again on December 1, 2021, decreasing base stage level from 0.66 m prior to the event to 0.36 m post event. This event likely disconnected Alena Creek from backwatering by the Lillooet, as indicated by a return to smaller daily oscillations, but low flow stage levels remain higher than in previous years, indicating a shift in creek morphology and making the comparison with previous levels difficult without redefining the stage offset from a local benchmark.

Figure 24. Stage in Alena Creek at the Lillooet River FSR bridge during baseline (April 2013 to November 2014), and post-construction monitoring (November 2016 to March 2022).



4.4. Water Temperature

4.4.1. Spatiotemporal Variability

The current post-construction period of record is from November 23, 2016 to September 27, 2021 (Table 1, Map 2). Monitoring in Years 1–5 (2017– 2021) complete nearly five full years of post-construction water temperature data collection at the upstream (control; ALE-USWQ1) and downstream (impact; ALE-BDGWQ) sites. Data availability is based on the most recent date when data were downloaded from water temperature loggers.

Daily average, maximum, and minimum water temperature at ALE-USWQ1 and ALE-BDGWQ are shown in Figure 25. 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 (Figure 25). Post-construction (December 2016 to September 2021), 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 and 2020) to 14.5°C (August 2019) at the downstream site (Figure 25). In 2021, instantaneous temperatures at the upstream (2.8°C to 10.2°C) and downstream sites (0.1°C to 14.2°C) were within the post-construction ranges.

In general, seasonal variability in water temperature upstream (ALE-USWQ1) was less variable than observed downstream (ALE-BDGWQ) (Figure 25). The seasonal pattern of differences in water temperature between the two sites is largely the same pre- and post-construction, as evident from comparison of the cumulative frequency distributions between the sites, which show similar differences in temperature between the two sites during the two periods (Figure 26). Despite the small difference in elevation (11 m) and short distance (~1 km) between the sites, the downstream site has generally been warmer than the upstream site in the summer and cooler in the winter (Figure 25). These differences are considered to be at least partly due to the temperature-regulating influence of groundwater at the upstream site, and to the influence of 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 25, Figure 26, Map 2). The daily average temperatures recorded at both sites were higher post-construction (November 2016 to September 2021) than pre-construction (April 2013 to December 2014) in the warmer months and the increase is more pronounced at the downstream site.

Water temperature site photos, annual water temperature figures, and BC WQG for water temperature are presented in Appendix B.

Figure 25. Daily average (a), maximum (b), and minimum (c) temperature in Alena Creek pre-construction (April 17, 2013 to December 30, 2014) and post-construction (November 23, 2016 to September 27, 2021) recorded at the upstream control (ALE-USWQ1) and downstream impact (ALE-BDGWQ) sites.

a) Daily Average

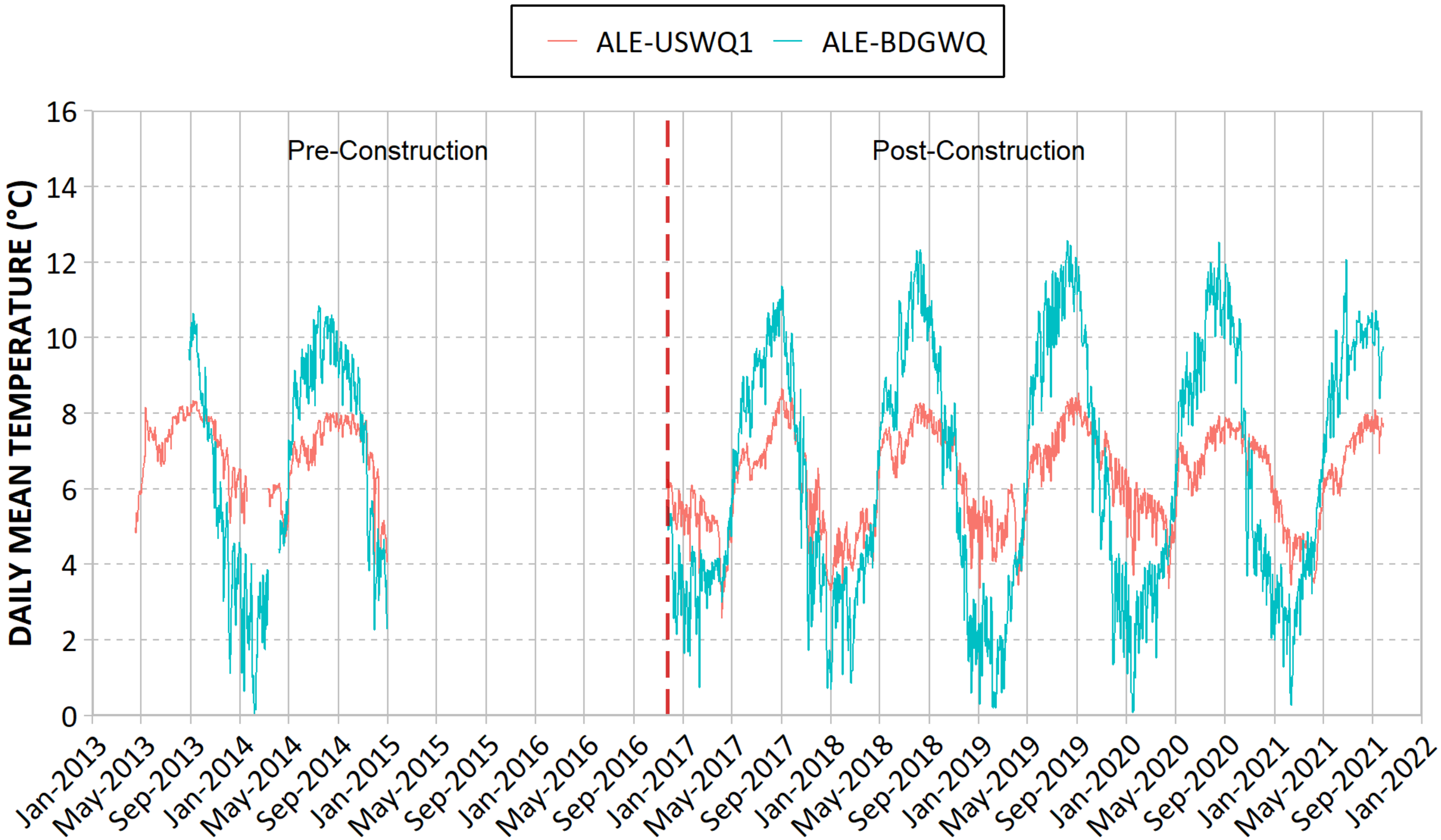


Figure 25. Continued (2 of 3).

b) Daily Maximum

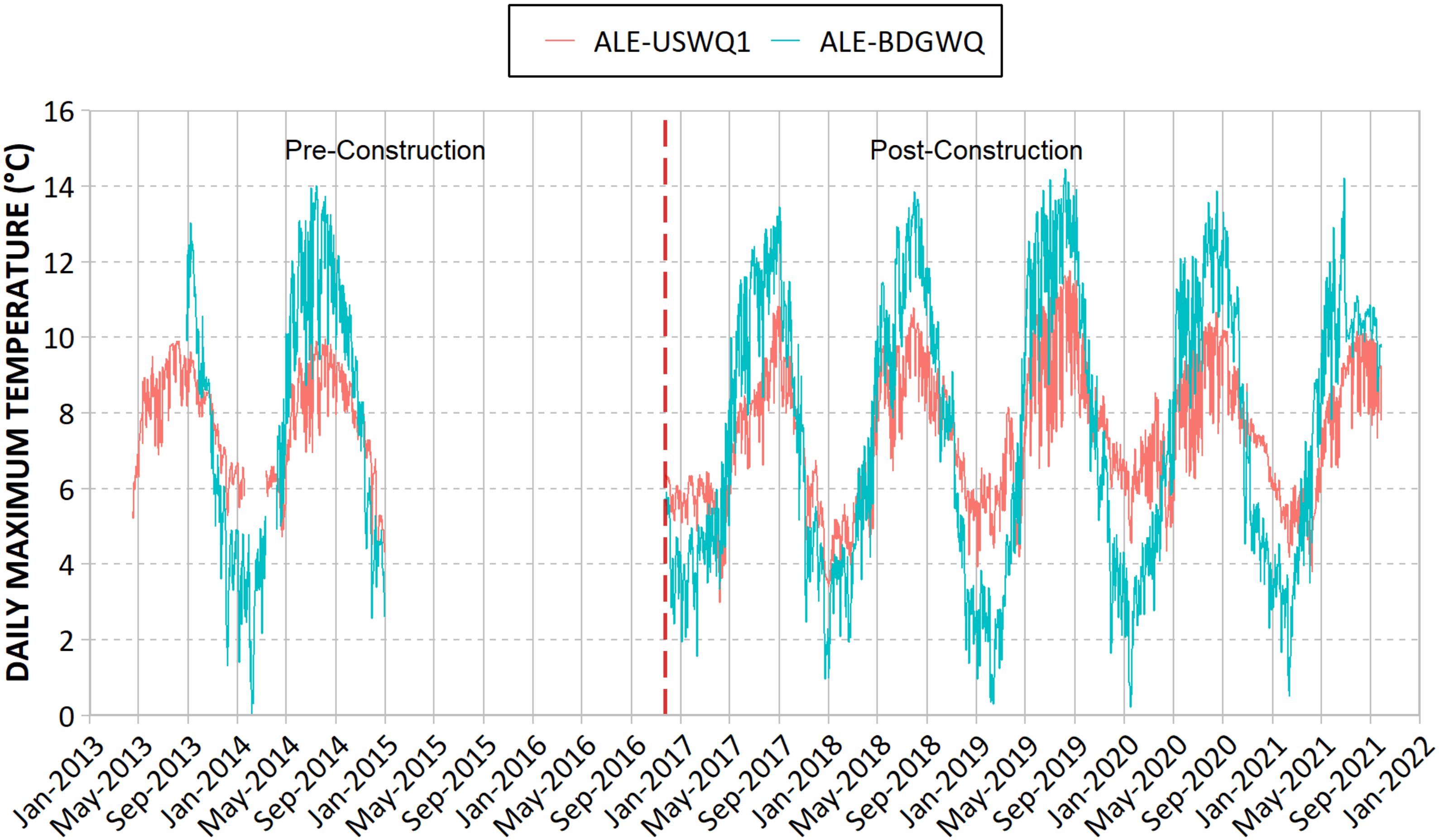


Figure 25. Continued (3 of 3).

c) Daily Minimum

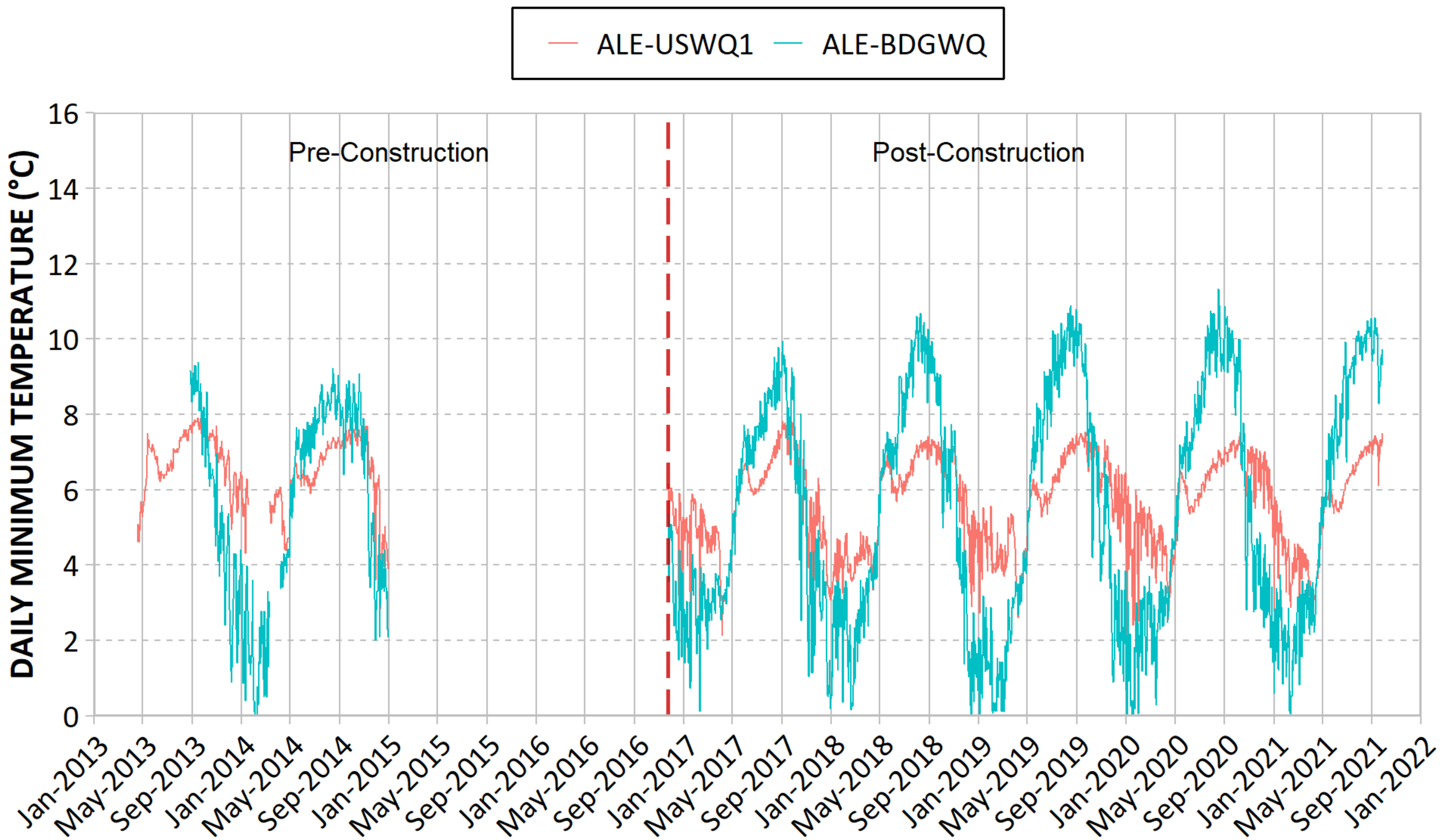
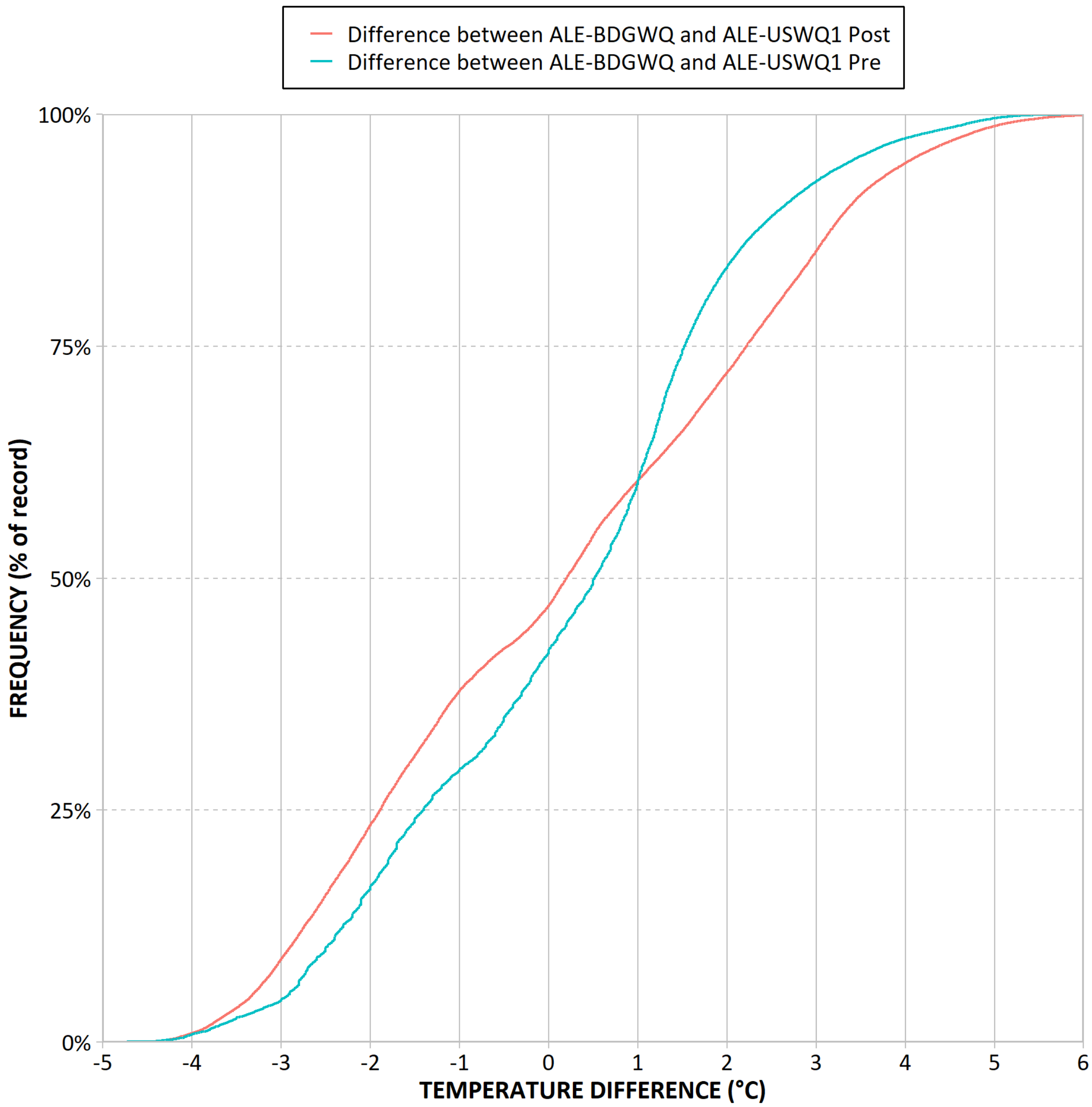


Figure 26. **Cumulative frequency distribution of differences in pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) instantaneous water temperature between the downstream site (ALE-BDGWQ) and the upstream site (ALE USWQ1) (positive values indicate warmer temperatures at ALE-BDGWQ).**



4.4.2. Mean Weekly Maximum Temperatures (MWMxT)

4.4.2.1. Overview

MWMxT temperature data collected at the upstream site and the downstream site were compared to optimum temperature ranges for Coho Salmon (Table 18, Table 19), Cutthroat Trout (Table 20, Table 21), and Bull Trout (Table 22, Table 23) using pre- and post-construction data.

Each of the tables provides the percent complete of the data record for each life stage, along with the minimum and maximum optimum MWMxT in each period. The percentage of data within each optimum temperature range is provided to evaluate the overall suitability of the observed temperatures for each fish species life stage. Data outside 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. In 2021, MWMxT values were within the range observed in previous post-construction monitoring years.

At the upstream site, post-construction, MWMxT ranged from 3.5°C to 11.5°C, while pre-construction MWMxTs ranged from 4.4°C to 9.9°C (Table 18, Table 20, Table 22). 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. The highest MWMxT value of 11.5°C was recorded in 2019.

At the downstream site, post-construction, MWMxT ranged from 0.6°C to 14.0°C, while pre-construction MWMxTs ranged from 1.7°C to 13.7°C. The lowest value at the downstream site was recorded in 2018, 2019, and 2020, whereas the highest MWMxT was recorded in 2019 (0.6°C to 14.0°C) (Table 19, Table 21, Table 23).

The correspondence of MWMxT values 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 3), therefore fewer values below the cooler temperature limits were observed for this species. In general, values below 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.

4.4.2.2. 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 Table 18). During pre- and post-construction periods at the downstream site, values >1°C below the lower bounds of the optimum ranges (blue shading) were observed during all life stages, while no exceedances of the upper temperature limits were observed (Table 19).

4.4.2.3. 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 in Table 20). During pre- and post-construction periods at the downstream site, values >1°C below the lower bounds of the optimum ranges were observed during all life stages; however, sub-optimally cool water temperatures were generally observed less frequently during incubation than for other life stages and occasional exceedances of the higher temperature limits (red shading) were observed during incubation and spawning (post-construction only; Table 21). MWMxT values were generally within the optimum range for Cutthroat Trout rearing for the majority of each year, including 54% (upstream site) and 62% (downstream site) of the time in 2021.

4.4.2.4. 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, values >1°C below the lower bounds of the optimum ranges were observed during rearing (Table 22). During pre- and post-construction periods at the downstream site, values >1°C below the lower bounds of the optimum ranges were observed during all life stages; however, this was observed less frequently during incubation (none during pre-construction) and exceedances of the higher temperature limits (red shading) were observed during incubation and spawning (Table 23).

The occurrence of 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 potential redds during the warmer months at the start of the incubation period (Table 22).

Warmer MWMxTs occurred in 2019 than in previous years; however, in 2021 MWMxT data available to date were within the post-construction range. Evaluation of any increased heating or cooling attributable to the FHEP will be completed following final data collection. Overall, no substantial change in the ranges of MWMxTs were observed between pre- and post-construction phases recognizing that there were data gaps during the cooler months in the pre-construction dataset.

Table 18. Coho Salmon periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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 (ALE-USWQ1)	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	100.0	5.6	9.4	6.6	63.1	0.0
			122	2014	95.1	4.4	9.3	21.6	62.9	0.0
			122	2016	28.7	-	-	-	-	-
			122	2017	100.0	3.5	10.5	43.4	44.3	0.0
			122	2018	100.0	5.3	9.3	23.8	55.7	0.0
			122	2019	100.0	6.4	10.4	0.0	68.0	0.0
			122	2020	100.0	6.1	10.1	1.6	82.8	0.0
			122	2021	19.7	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	100.0	5.6	8.5	0.0	100.0	0.0
			79	2014	91.1	4.4	7.9	0.0	98.6	0.0
			79	2016	45.6	-	-	-	-	-
			79	2017	100.0	3.5	7.8	0.0	84.8	0.0
			79	2018	100.0	5.2	8.6	0.0	100.0	0.0
			79	2019	100.0	6.4	8.2	0.0	100.0	0.0
			79	2020	100.0	6.1	8.0	0.0	100.0	0.0
			79	2021	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
			169	2014	42.6	-	-	-	-	-
			169	2016	74.6	4.6	6.3	0.0	100.0	0.0
			169	2017	100.0	3.5	7.8	0.0	91.1	0.0
			169	2018	99.4	4.8	8.6	0.0	100.0	0.0
			170	2019	100.0	4.9	8.2	0.0	100.0	0.0
			169	2020	100.0	4.6	8.0	0.0	100.0	0.0
			169	2021	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	70.1	5.6	9.9	35.9	23.4	0.0
			365	2014	83.0	4.4	9.7	53.5	18.5	0.0
			366	2016	9.6	-	-	-	-	-
			365	2017	99.7	3.5	10.6	70.3	11.0	0.0
			365	2018	100.0	3.5	10.5	56.7	20.8	0.0
			365	2019	99.7	4.7	11.5	54.4	27.7	0.0
			366	2020	100.0	4.9	10.3	59.6	16.1	0.0
			365	2021	73.2	4.3	9.9	58.4	26.2	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 19. Coho Salmon periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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 (ALE-BDGWQ)	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	99.2	2.1	12.5	43.0	49.6	0.0
			122	2014	96.7	3.5	11.7	39.0	59.3	0.0
			122	2016	29.5	-	-	-	-	-
			122	2017	100.0	1.6	12.9	50.0	44.3	0.0
			122	2018	100.0	2.3	11.5	43.4	54.9	0.0
			122	2019	100.0	2.6	12.8	42.6	45.1	0.0
			122	2020	100.0	3.2	12.8	50.0	41.8	0.0
			122	2021	18.9	-	-	-	-	-
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	98.7	2.1	8.8	9.0	70.5	0.0
			79	2014	93.7	3.5	9.1	0.0	75.7	0.0
			79	2016	46.8	-	-	-	-	-
			79	2017	100.0	1.6	8.1	19.0	45.6	0.0
			79	2018	100.0	2.2	8.1	38.0	59.5	0.0
			79	2019	100.0	2.6	8.1	21.5	51.9	0.0
			79	2020	100.0	3.2	8.4	7.6	77.2	0.0
			79	2021	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
			169	2014	43.8	3.5	9.1	0.0	90.5	0.0
			169	2016	75.1	2.8	5.7	1.6	58.3	0.0
			169	2017	100.0	1.6	8.1	14.2	53.3	0.0
			169	2018	100.0	0.6	8.1	50.9	38.5	0.0
			169	2019	100.0	0.6	8.1	15.9	47.6	0.0
			170	2020	100.0	1.2	8.4	15.4	58.0	0.0
			169	2021	0.0	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	33.7	-	-	-	-	-
			365	2014	89.6	1.7	13.7	44.6	49.8	0.0
			366	2016	9.8	-	-	-	-	-
			365	2017	99.7	1.6	13.1	56.3	37.6	0.0
			365	2018	100.0	1.8	13.4	53.2	41.9	0.0
			365	2019	100.0	0.6	14.0	53.7	43.0	0.0
			366	2020	100.0	0.6	13.0	53.6	43.4	0.0
			365	2021	72.9	1.2	13.2	39.8	53.4	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 20. Cutthroat Trout periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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
Cutthroat Trout (ALE-USWQ1)	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	79.3	5.9	8.9	42.5	0.0	0.0
			92	2014	98.9	5.0	9.3	58.2	6.6	0.0
			92	2016	0.0	-	-	-	-	-
			92	2017	98.9	3.5	8.4	87.9	0.0	0.0
			92	2018	100.0	5.3	9.7	44.6	26.1	0.0
			92	2019	100.0	4.7	10.4	35.9	35.9	0.0
			92	2020	100.0	5.0	8.8	55.4	0.0	0.0
			92	2021	100.0	4.3	9.2	71.7	9.8	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	100.0	6.9	9.9	16.1	35.5	0.0
			124	2014	99.2	6.3	9.7	18.7	37.4	0.0
			124	2016	0.0	-	-	-	-	-
			124	2017	99.2	6.3	10.6	40.7	22.8	0.0
			124	2018	100.0	7.3	10.5	10.5	58.9	0.0
			124	2019	100.0	7.6	11.5	2.4	73.4	0.0
			124	2020	100.0	6.3	10.3	16.9	37.9	0.0
			124	2021	100.0	6.7	9.9	29.0	52.4	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
			365	2014	83.0	4.4	9.7	13.9	66.0	0.0
			366	2016	9.6	-	-	-	-	-
			365	2017	99.7	3.5	10.6	40.4	46.7	0.0
			365	2018	100.0	3.5	10.5	33.7	55.1	0.0
			365	2019	99.7	4.7	11.5	21.7	62.9	0.0
			366	2020	100.0	4.9	10.3	8.2	67.5	0.0
			365	2021	73.2	4.3	9.9	37.1	53.9	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. Cutthroat Trout periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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
Cutthroat Trout (ALE-BDGWQ)	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	0.0	-	-	-	-	-
			92	2014	92.4	5.8	12.7	24.7	60.0	0.0
			92	2016	0.0	-	-	-	-	-
			92	2017	98.9	4.4	12.2	38.5	41.8	0.0
			92	2018	100.0	5.7	12.6	23.9	60.9	0.0
			92	2019	100.0	5.1	13.1	26.1	45.7	4.3
			92	2020	100.0	5.5	11.3	34.8	62.0	0.0
			92	2021	100.0	5.8	13.2	17.4	51.1	2.2
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	2.4	-	-	-	-	-
			124	2014	99.2	8.5	13.7	0.0	61.0	13.8
			124	2016	0.0	-	-	-	-	-
			124	2017	99.2	7.5	13.1	4.1	58.5	0.8
			124	2018	100.0	8.8	13.4	0.0	59.7	12.1
			124	2019	100.0	9.8	14.0	0.0	35.5	18.5
			124	2020	100.0	7.4	13.0	1.6	65.3	0.0
			124	2021	100.0	8.5	13.2	0.0	87.9	1.6
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	33.7	-	-	-	-	-
			365	2014	89.6	1.7	13.7	34.3	59.9	0.0
			366	2016	9.8	-	-	-	-	-
			365	2017	99.7	1.6	13.1	46.4	50.5	0.0
			365	2018	100.0	1.8	13.4	40.0	55.6	0.0
			365	2019	100.0	0.6	14.0	41.9	51.8	0.0
			366	2020	100.0	0.6	13.0	41.5	50.3	0.0
			365	2021	72.9	1.2	13.2	33.1	62.4	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. Bull Trout periodicity and life stage MWMxT ranges during pre-construction (April 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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
Bull Trout (ALE-USWQ1)	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	100.0	5.6	9.9	0.0	73.8	0.0
			130	2014	98.5	5.8	9.7	0.0	71.1	0.0
			130	2016	9.2	-	-	-	-	-
			130	2017	100.0	5.2	10.6	0.0	71.5	9.2
			130	2018	100.0	5.7	10.3	0.0	76.9	1.5
			130	2019	100.0	6.4	11.5	0.0	67.7	27.7
			130	2020	100.0	7.2	10.3	0.0	68.5	8.5
			130	2021	42.3	-	-	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	79.3	5.6	9.9	0.0	5.9	64.5
			213	2014	69.0	4.4	9.7	0.0	14.3	78.2
			213	2016	44.6	-	-	-	-	-
			213	2017	100.0	3.5	10.6	0.0	50.7	41.3
			213	2018	99.5	4.8	10.3	0.0	41.0	47.6
			213	2019	100.0	4.9	11.5	0.0	5.1	54.2
			213	2020	100.0	4.6	10.3	0.0	23.5	64.8
			213	2021	25.8	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	70.1	5.6	9.9	0.0	96.9	0.0
			365	2014	83.0	4.4	9.7	3.0	86.1	0.0
			366	2016	9.6	-	-	-	-	-
			365	2017	99.7	3.5	10.6	9.9	59.6	0.0
			365	2018	100.0	3.5	10.5	15.1	66.3	0.0
			365	2019	99.7	4.7	11.5	3.8	78.3	0.0
			366	2020	100.0	4.9	10.3	0.3	91.8	0.0
			365	2021	73.2	4.3	9.9	8.6	62.9	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. Bull Trout periodicity and life stage MWMxT ranges during pre-construction (August 2013 to December 2014) and post-construction (November 2016 to September 2021) water temperature monitoring in Alena Creek 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
Bull Trout (ALE-BDGWQ)	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	76.9	2.1	12.5	6.0	47.0	25.0
			130	2014	99.2	3.5	13.3	3.9	29.5	48.1
			130	2016	10.0	-	-	-	-	-
			130	2017	100.0	3.3	13.1	6.2	26.9	43.8
			130	2018	100.0	2.4	13.4	5.4	36.9	34.6
			130	2019	100.0	2.6	14.0	10.0	39.2	43.1
			130	2020	100.0	4.3	13.0	0.0	32.3	53.8
			130	2021	41.5	-	- -	-	-	-
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	83.1	1.7	12.5	0.0	54.2	36.2
			213	2014	69.5	3.5	13.3	0.0	31.1	67.6
			213	2016	45.1	-	-	-	-	-
			213	2017	100.0	1.6	13.1	0.0	51.6	40.8
			213	2018	100.0	0.6	13.4	3.3	45.5	46.0
			214	2019	100.0	0.6	14.0	1.9	46.7	40.7
			213	2020	100.0	1.2	13.0	0.0	52.6	39.4
			213	2021	25.4	-	- -	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	33.7	-	-	-	-	-
			365	2014	89.6	1.7	13.7	30.0	65.4	0.0
			366	2016	9.8	-	-	-	-	-
			365	2017	99.7	1.6	13.1	42.3	53.6	0.0
			365	2018	100.0	1.8	13.4	30.7	59.7	0.0
			365	2019	100.0	0.6	14.0	34.2	57.5	0.0
			366	2020	100.0	0.6	13.0	32.8	58.5	0.0
			365	2021	72.9	1.2	13.2	26.7	66.9	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.

4.4.3. Bull Trout Temperature Guidelines

Water temperate guidelines for Bull Trout (see Section 3.4.4) were compared 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 24). In BC, Bull Trout are considered to have the highest thermal sensitivity of the native salmonids evaluated in Oliver and Fidler (2001); therefore, more restrictive guidelines are applied to streams with this species. In 2021, the numbers of days when measurements were outside of the ranges bounded by the minimum and maximum temperature thresholds were within the ranges observed in previous post-construction years.

During both pre- and post-construction monitoring periods, the highest maximum daily temperatures did not exceed the prescribed threshold for rearing (15°C) at either site (Table 24).

The number of days when daily maximum water temperatures were outside the Bull Trout thresholds for spawning and incubation (i.e., >10°C) were higher at the downstream site (ALE-BDGWQ) than at the upstream site (ALE-USWQ1) during both pre- and post-construction monitoring periods. This is due to warmer temperatures in August and September at the downstream site (Table 24, Figure 25), which is likely before the main spawning period for Bull Trout on Alena Creek based on data collected to date (Thornton *et al.* 2021).

The number of days when 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 in comparison to the upstream site which exhibits a warmer temperature regime in the winter likely due to the groundwater input (Figure 25). These results suggest that the temperature regime may be more suitable for Bull Trout at the upper end of the FHEP during spawning and incubation where there were fewer days with temperatures >10°C and <2°C. (Table 24).

Table 24. Summary of the number of days where the daily minimum or maximum water temperature (°C) exceeds the Bull Trout thresholds BC WQG (MECCS 2021) in Alena Creek at the upstream site (ALE USWQ1) and downstream site (ALE-BDGWQ).

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[2]	Pre-construction	2013	256	0	0	0	0
		2014	305	0	0	0	0
	Post-construction	2016	38	-	-	-	-
		2017	364	0	14	0	14
		2018	365	0	9	0	9
		2019	364	0	28	1	28
		2020	366	0	18	0	18
		2021	269	0	8	0	8
ALE-BDGWQ	Pre-construction	2013	125	0	28	44	28
		2014	328	0	57	0	57
	Post-construction	2016	38	-	-	-	-
		2017	364	0	52	48	52
		2018	365	0	46	76	46
		2019	365	0	54	46	54
		2020	366	0	69	36	69
		2021	269	0	43	0	43

[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 (MECCS 2021) for the Bull Trout incubation period: August 1 to March 1, spawning period: August 1 to December 8, and rearing period: January 1 to December 31.

[2] Pre-construction data collected at the upstream site excludes February 2014 data based on suspected ice/frozen temperature loggers.

"-" indicates that there were not enough data to calculate the metric.

[3] To date, post-construction water temperature Tidbit monitoring commenced on November 23, 2016 and ended on January 30, 2019.

4.5. Riparian Habitat

The Year 5 monitoring results indicate that revegetation is progressing well, and resemble conditions seen prior to instream habitat enhancement and subsequent riparian restoration in 2016. Estimated stem densities met the targets for shrubs and trees in all individual plots. The vegetation cover and photopoint monitoring results further demonstrate that riparian vegetation is healthy and continues to develop. No erosion was noted, and no invasive species were observed.

4.5.1. Permanent Revegetation Density Monitoring Plots

In Year 5, the mean estimated stem density of woody vegetation for all four monitoring plots was 62,000 ± 24,951 stems/ha (Table 25). Stem densities in individual plots ranged from 35,000 stems/ha to 85,200 stems/ha. The overall estimated stem density is a slight drop from Year 3 of monitoring, when it was 79,900 ± 48,103 stems/ha (Thornton *et al.* 2020). However, this is not a source of concern, as current stem density remains above the targets, and is higher than would be expected in a more mature stand, which is the goal of revegetation. Furthermore, mean estimated stem density remains higher than in 2014, prior to instream habitat enhancement work, when it was estimated as 46,250 ± 32,469 stems/ha (Harwood *et al.* 2016). Stem density is expected to decrease as vegetation matures and increases in size, and competition for resources results in thinning. 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).

The mean estimated density of trees was 35,350 ± 22,275 stems/ha, which exceeded the target for mature trees of 1,200 stems/ha (Table 26). Similarly, the overall density of shrubs in the FHEP area was 26,650 ± 12,573 stems/ha, which exceeded the shrub specific target of 2,000 stems/ ha (Table 26). The density of trees decreased slightly from Year 3 monitoring, primarily due to decreases in red alder (*Alnus rubra*) and black cottonwood (*Populus balsamifera*) stem counts. Shrub density increased from Year 3 monitoring, due to increases in species such as thimbleberry (*Rubus parviflorus*), red raspberry (*Rubus ideaus*), black raspberry (*Rubus leucodermis*), willow(s) (*Salix* spp.), and red-osier dogwood (*Cornus stolonifera*). No dead stems were observed (Table 27).

The abundance of coniferous tree species declined from Year 3 of monitoring: no Douglas-fir (*Pseudotsuga menziesii*) was detected during monitoring in Year 5, and estimated western redcedar (*Thuja plicata)* stem density dropped from 1,600 stems/ha to 500 stems/ha (Table 26; Figure 27). This was primarily due to a decrease in western redcedar stem counts at ALE-PRM06, which dropped from 21 stems to 4 stems. Immediately after instream habitat enhancement efforts in 2016, estimated stem densities of all three coniferous species were higher than in Year 5, and the overall proportion of coniferous trees was greater: for example, western redcedar had an estimated stem density of 800 stems/ha in 2016, whereas black cottonwood was just 250 stems/ha. This was likely due to planting prescriptions that favoured coniferous species, particularly western redcedar (West *et al.* 2017), in an attempt to hasten succession as per the recommendations of FHEP (Hemmera 2015). Although a direct comparison to 2014 is not possible as only one plot remained in the same position after enhancement, just one Douglas-fir stem and one western redcedar stem were observed in all 4 plots in 2014.

In Year 5, the number of woody tree and shrub species remained similar to previous monitoring years, both before and after instream habitat enhancement and restoration. Four tree species and 10 shrub species were observed in Year 5, including willow shrubs which were identified to the genus level. Two new shrub species were observed in 2021: red raspberry and western mountain-ash (*Sorbus scopulina*; Table 26). In 2016, immediately after instream habitat enhancement and subsequent restoration, there were five tree species and eight shrub species (Harwood *et al.* 2019). In 2014, prior to instream habitat enhancement, four tree species and 11 woody shrub species were present in the original monitoring plots (Harwood *et al.* 2016). In Year 5, black cottonwood was the most abundant tree species in the monitoring plots, with a mean estimated stem density of 25,500 stems/ha, followed by red alder at 9,300 stems/ha. The willow species were the most abundant shrub(s), with a mean estimated density of 15,500 stems/ha, followed by thimbleberry with 4,600 stems/ha (Figure 28). These species were the most abundant in Year 3 monitoring as well. In comparison, in 2016 after instream habitat enhancement and restoration, red alder was the most abundant tree species and western redcedar was the second-most abundant tree species. Devil's club (*Oploplanax horridus*) and red-osier dogwood were in the most abundant shrub species. In 2014, red alder and black cottonwood were the most abundant tree species, and willow species and red-osier dogwood were the most abundant shrub species. No invasive species were observed in Year 5 monitoring. The potential invasive thistle species (*Cirsium* sp.) that was present at ALE-PRM03 in 2019 was not observed and was therefore not identified to species level in Year 5 (Thornton *et al.* 2020).

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 high-bench and mid-bench riparian habitats in this zone, stands of red alder and black cottonwood contain small amounts of western redcedar or Sitka spruce (*Picea sitchensis*; 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) and post-slide, the area remained dominated by red alder and black cottonwood. Riparian vegetation composition in Year 5 monitoring appears to resemble most closely the 2014 or pre-slide conditions and has revegetated since enhancement and subsequent restoration in 2016 (Figure 29).

Table 25. Summary of riparian habitat data collected for the Alena Creek FHEP from Year 1 (2017) to Year 5 (2021) 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) Easting	UTM (Zone 10U) Northing	Year[1]	Woody Vegetation Density: Live Stems/Plot	Woody Vegetation Density: Dead Stems/Plot	Woody Vegetation Density: Estimated Live Vegetation Density (stems/ha)	Estimated Vegetation Cover (%)	Revegetation Area (Site) Comments
ALE-PRM03	473335	5606225	2021	175	0	35,000	98	Dense natural regeneration ~3-4.5 m high with red alder and cottonwood. Abundant grasses, fireweed, horsetail, ferns and sedges.
			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	2021	350	0	70,000	62	Excellent natural revegetation: alder, willow, cottonwood, horsetail, fireweed, thimbleberry. Excellent survival of planted stock ~1.0-1.5m high.
			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	2021	426	0	85,200	78	Excellent dense revegetation ~2.0-3.0 m height: alder, willow, fireweed, grasses, blackberry, fireweed. Planted stock is healthy and thriving. New beaver dam at this site.
			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	2021	289	0	57,800	87	Dense revegetation ~3-4 m in height, lots of fireweed. Planted stock is thriving with excellent survival rate.
			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	-
2021 Expected Density (stems/ha)						**62,000**		
Confidence Interval (±stems/ha)						**24,951**		
2019 Expected Density (stems/ha)						**79,900**		
Confidence Interval (±stems/ha)						**48,103**		
2017 Expected Density (stems/ha)						**43,200**		
Confidence Interval (±stems/ha)						**36,210**		
2016 Expected Density (stems/ha)						**5,700**		
Confidence Interval (±stems/ha)						**5,002**		

[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. A baseline survey was also 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 from 2016 - 2021.

Table 26. Live species counted within each of the permanent revegetation monitoring plots in Year 5 (2021). Stem density summaries are included for Year 3 (2019), Year 1 (2017), and 2016 (baseline).

Permanent Revegetation Monitoring Plot	Trees						Shrubs														Total
	black cottonwood (*Populus balsamifera ssp. trichocarpa*)	Douglas-fir (*Pseudotsuga menziesii*)	red alder (*Alnus rubra*)	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	*Trees Subtotal*	black raspberry (*Rubus leucodermis*)	devil's club (*Oplopanax horridus*)	falsebox (*Paxistima myrsinites*)	hardhack (*Spiraea douglasii*)	red elderberry (*Sambucus racemosa*)	red raspberry (*Rubus idaeus*)	red-osier dogwood (*Cornus stolonifera*)	salmonberry (*Rubus spectabilis*)	Sitka willow (*Salix sitchensis*)	thimbleberry (*Rubus parviflorus*)	trailing blackberry (*Rubus ursinus*)	western mountain-ash (*Sorbus scopulina*)	willow (unknown species) (*Salix* sp.)	*Shrubs Subtotal*	
ALE-PRM03	10	0	24	0	1	*35*	20	19	0	0	1	0	0	12	0	62	0	0	26	*140*	**175**
ALE-PRM05	197	0	30	0	3	*230*	0	0	0	0	0	1	8	0	0	16	0	1	94	*120*	**350**
ALE-PRM06	177	0	43	1	4	*225*	1	0	0	1	0	21	37	0	0	12	0	0	129	*201*	**426**
ALE-PRM07	126	0	89	0	2	*217*	2	0	0	1	0	0	6	0	0	2	0	0	61	*72*	**289**
Mean (stems/plot)	127.50	0.00	46.50	0.25	2.50	*176.75*	5.75	4.75	0.00	0.50	0.25	5.50	12.75	3.00	0.00	23.00	0.00	0.25	77.50	*133.25*	**310.00**
Confidence Interval (stems/plot)	98.66	0.00	34.62	0.59	1.52	*111.38*	11.22	11.18	0.00	0.68	0.59	12.17	19.44	7.06	0.00	31.37	0.00	0.59	51.96	*62.87*	**124.76**
2021 Expected Density (stems/ha)	**25,500**	**0**	**9,300**	**50**	**500**	***35,350***	**1,150**	**950**	**0**	**100**	**50**	**1,100**	**2,550**	**600**	**0**	**4,600**	**0**	**50**	**15,500**	***26,650***	**62,000**
Confidence Interval (± stems/ha)	**19,732**	**0**	**6,924**	**118**	**304**	***22,275***	**2,244**	**2,236**	**0**	**136**	**118**	**2,434**	**3,888**	**1,412**	**0**	**6,274**	**0**	**118**	**10,391**	***12,573***	**24,951**
2019 Expected Density (stems/ha)	**33,700**	**50**	**23,950**	**50**	**1,600**	***59,350***	**0**	**1,000**	**50**	**650**	**50**	**0**	**1,650**	**550**	**0**	**1,750**	**850**	**0**	**14,000**	***20,550***	**79,900**
Confidence Interval (± stems/ha)	**26,356**	**118**	**25,831**	**118**	**2,078**	***45,222***	**0**	**2,353**	**118**	**1,110**	**118**	**0**	**2,967**	**824**	**0**	**2,616**	**2,000**	**0**	**10,657**	***11,491***	**48,103**
2017 Expected Density (stems/ha)	**23,100**	**0**	**15,800**	**50**	**700**	***39,650***	**0**	**650**	**0**	**0**	**350**	**0**	**650**	**450**	**0**	**1,100**	**250**	**0**	**100**	***3,550***	**43,200**
Confidence Interval (± stems/ha)	**20,115**	**0**	**17,600**	**118**	**781**	-	**0**	**1,377**	**0**	**0**	**353**	**0**	**703**	**778**	**0**	**1,129**	**588**	**0**	**235**	-	**36,210**
2016 Expected Density (stems/ha)[1]	**250**	**100**	**1,350**	**150**	**800**	***2,650***	**200**	**850**	**0**	**0**	**50**	**0**	**700**	**350**	**500**	**250**	**0**	**0**	**150**	***3,050***	**5,700**
Confidence Interval (± stems/ha)	**445**	**235**	**3,177**	**225**	**508**	-	**471**	**1,542**	**0**	**0**	**118**	**0**	**804**	**556**	**891**	**353**	**0**	**0**	**353**	-	**5,002**

[1] 2016 is the baseline, measured immediately after restoration work

Table 27. Dead tree species counted within each of the permanent revegetation monitoring plots in Year 5 (2021). Summaries of dead trees are included for Year 1 (2017), Year 3 (2019), and baseline (2016).

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
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**
2021 Expected Density (stems/ha)	**0**	**0**	**0**	**0**	**0**	**0**
Confidence Interval (± stems/ha)	**0**	**0**	**0**	**0**	**0**	**0**
2019 Expected Density (stems/ha)	**0**	**0**	**0**	**0**	**0**	**0**
Confidence Interval (± stems/ha)	**0**	**0**	**0**	**0**	**0**	**0**
2017 Expected Density (stems/ha)	**0**	**150**	**50**	**0**	**50**	**250**
Confidence Interval (± stems/ha)	**0**	**225**	**118**	**0**	**118**	**353**
2016 Expected Density (stems/ha)[1]	**0**	**0**	**0**	**0**	**0**	**0**
Confidence Interval (± stems/ha)	**0**	**0**	**0**	**0**	**0**	**0**

[1] 2016 is the baseline, measured immediately after restoration work

4.5.2. Percent Vegetation Cover Estimates

In Year 5, the percent cover of vegetation ranged from 62% at ALE-PRM05 to 98% at ALE-PRM03 (Table 25). This is similar to 2014, when cover ranged from 64% to 98 (albeit in different plots), and higher than immediately after enhancement and restoration in 2016, when cover ranged from 8% to 30% (Table 25). Herbaceous and woody ground cover is primarily monitored because it stabilizes soil and provides sediment interception and erosion control early in the revegetation process. Woody shrubs or trees also contribute to these functions. The combination of high percent cover values and lack or erosion in the revegetation areas, along with high stem densities, means that there are no concerns regarding vegetation ground cover and associated riparian functions.

4.5.3. Photopoint Comparison

Standard photographs taken in 2016, 2017, 2019 and 2021 from 1.3 m above the plot centre, facing 0 degrees (north) are presented in Appendix E 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.

In Year 5, sampling occurred in early September, whereas in previous years sampling occurred in early to late October. It is therefore difficult to compare growth directly, as many leaves had senesced by late October. Regardless, the replicate standard photographs appear to show an increase in vegetation abundance and cover since 2016, as well as increases in the size of individual plants (Figure 30). Therefore, photographic monitoring supports the stem density results (Section 4.5.1) and vegetation cover results (Section 4.5.2) that demonstrate an increase in stem density and ground cover since instream habitat enhancement and restoration in 2016.

Figure 27. Western redcedar approximately 1 m in height at ALE-PRM05, on September 01, 2021.

Figure 28. Diversity of woody species observed at ALE-PRM06, with red-osier dogwood in foreground. Western redcedar visible in right of photograph. Photograph taken on September 01, 2021.

Figure 29. Abundant black cottonwood and red alder at ALE-PRM07 on September 01, 2021.

Figure 30. Tall vegetation at ALE-PRM03 on September 01, 2021.

5. SUMMARY AND RECOMMENDATIONS

The success of the FHEP was evaluated 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. Year 5 monitoring results suggest the FHEP is meeting criteria outlined in the *Fisheries Act* Authorization.

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. Instream repairs completed on August 6, 2020 have enhanced the stream conditions and increased erosion protection.

Continuous beaver activity was observed in the lower end of Reach 3 near ALE-XS5 and upstream of ALE-XS6 and ALE-XS7. The newly formed dams created moderate backwatering in the lower portion of 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. Although the beaver complex upstream of Reach 3 was considered to be inactive in 2020, we recommend ongoing management of beaver dams; in particular, we recommend ensuring that the beaver dam complex above Reach 3 does not grow or further redirect flows around the constructed channel, and monitoring of the dams in the lower section of Reach 3. We also recommend removing or lowering any dams that cause backwatering of habitat that would otherwise be suitable for spawning.

Establishment of herbaceous plants along the constructed channel banks has been successful in protecting the channel banks. Installing additional live stakes was considered but is not recommended at this time because it could increase local beaver activity.

5.2. Fish Community

The fish community component of the Alena Creek FHEP monitoring was successfully implemented in 2021. The 2021 monitoring documented the highest abundance of adult Coho Salmon to date and CPUE of juvenile Coho Salmon during minnow trapping was high. Minnow trapping CPUE of juvenile Cutthroat Trout was similar to previous years monitoring. Comparison of CPUE for all captured species combined (i.e., Bull Trout, Coho Salmon, and Cutthroat Trout) demonstrates that CPUE was higher in 2021 relative to in baseline sampling. In baseline monitoring, CPUE across captured species was 0.3 fish per 100 trap hours and 0.75 fish per 100 trap hours in 2013 and 2014, respectively. It is important to note that CPUE estimates for 2014 are biased high due to reduced set length as a result of safety concerns surrounding bear activity in the sampling areas. Despite this bias, CPUE in 2021 was higher than the average CPUE across baseline monitoring years (0.93 fish per 100 trap hours in 2021, 0.52 fish per 100 trap hours during baseline). A total of five adult Bull Trout were observed in 2021 during spawner bank walks compared to counts in previous years which ranged from zero to nine individuals. Three juvenile Bull Trout were captured during minnow trapping compared to zero in all previous years, except 2013 where one was captured.

5.3. Hydrology

The hydrology monitoring program has reached the five years length post-construction recommended by the OEMP (Harwood *et al.* 2021).

5.4. Water Temperature

The 2021 water temperature regime was within the temperature ranges observed in previous post-construction monitoring (2016 to 2020) and 2019 remains the year with the highest (11.7°C) and lowest (1.2°C) monthly average temperatures on record, both occurring at the downstream water temperature monitoring site. To date, the instantaneous temperature ranges observed at both sites were similar between 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.

5.5. Riparian Habitat

Year 5 monitoring indicates that vegetation is healthy and dense, although the abundance of conifers has declined since restoration in 2016. Therefore, further restoration as proposed by the FHEP does not appear to be necessary for riparian functioning and this component of the OEMP program is considered complete. A second offset project was completed on Alena Creek in September 2021 (Faulkner *et al.* 2021a), including a newly planted area. This area will be monitored under a separate monitoring plan.

6. CLOSURE

The monitoring objectives for Year 5 monitoring of the Alena Creek FHEP were achieved, as described in the OEMP (Harwood *et al.* 2021). The success of the FHEP was evaluated 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. The new channel construction and enhancement of existing channels has provided 3,194 m^2 of high-quality instream fish habitat exceeding the requirement (West *et al.* 2017). Although some repairs were required for a high flow event that occurred soon after construction, the five-year monitoring period has shown that the habitat is physically stable, provides suitable flows and that fish use is generally higher than pre-project conditions. Beaver activity continues to pose a risk to habitat functionality and management of this species is recommended to continue to ensure the habitat remains to be function as intended.

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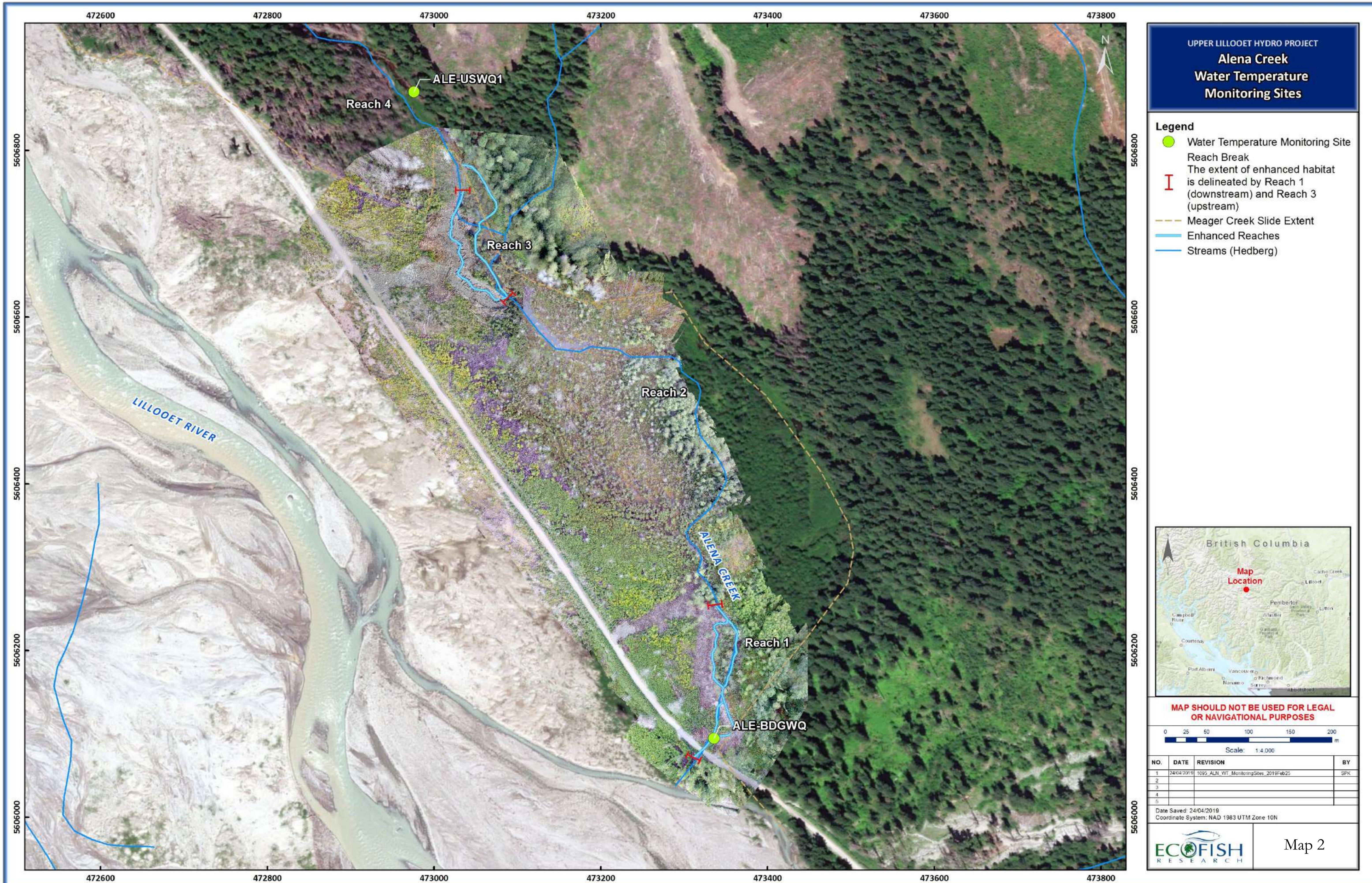
PROJECT MAPS



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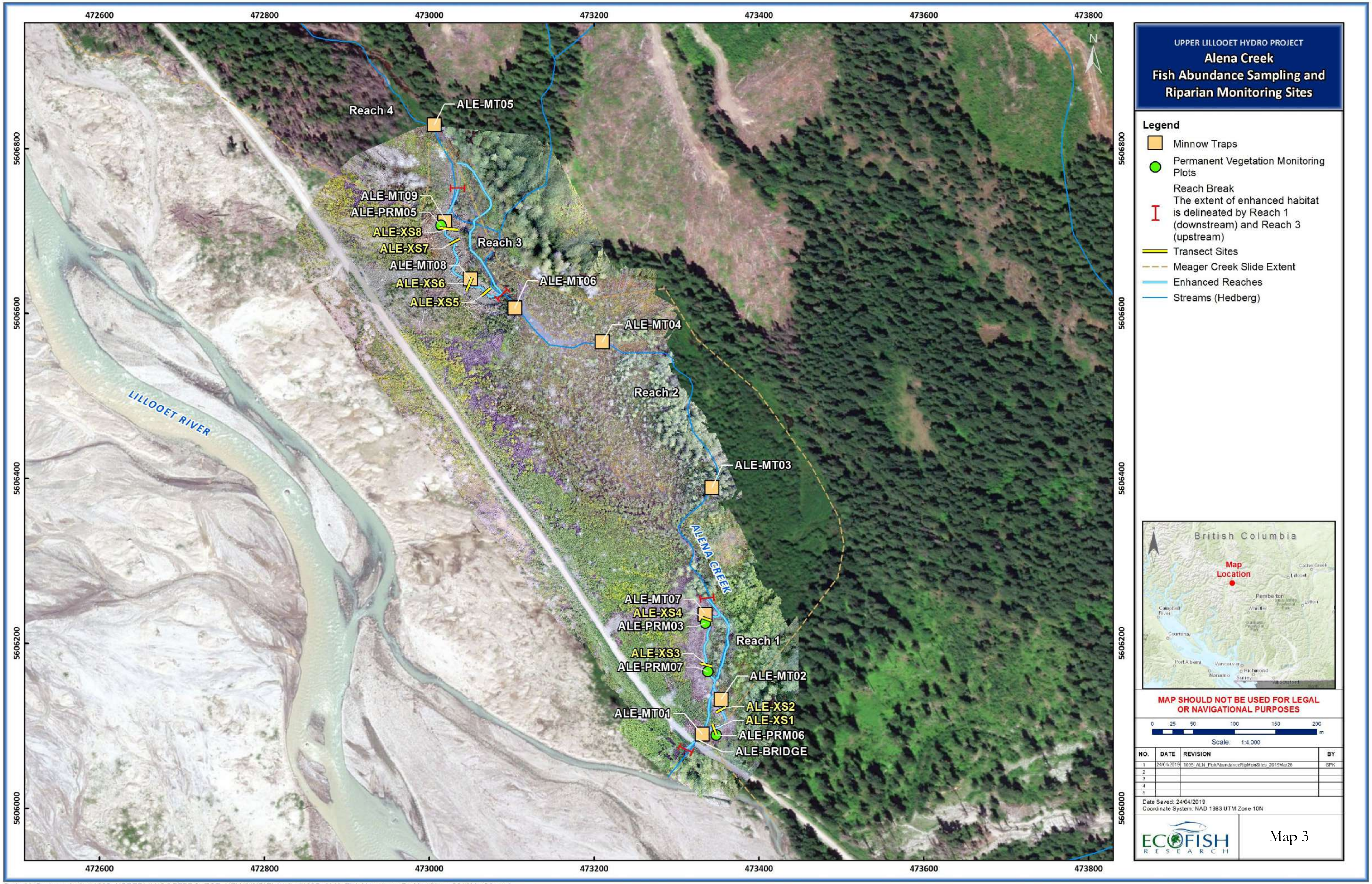

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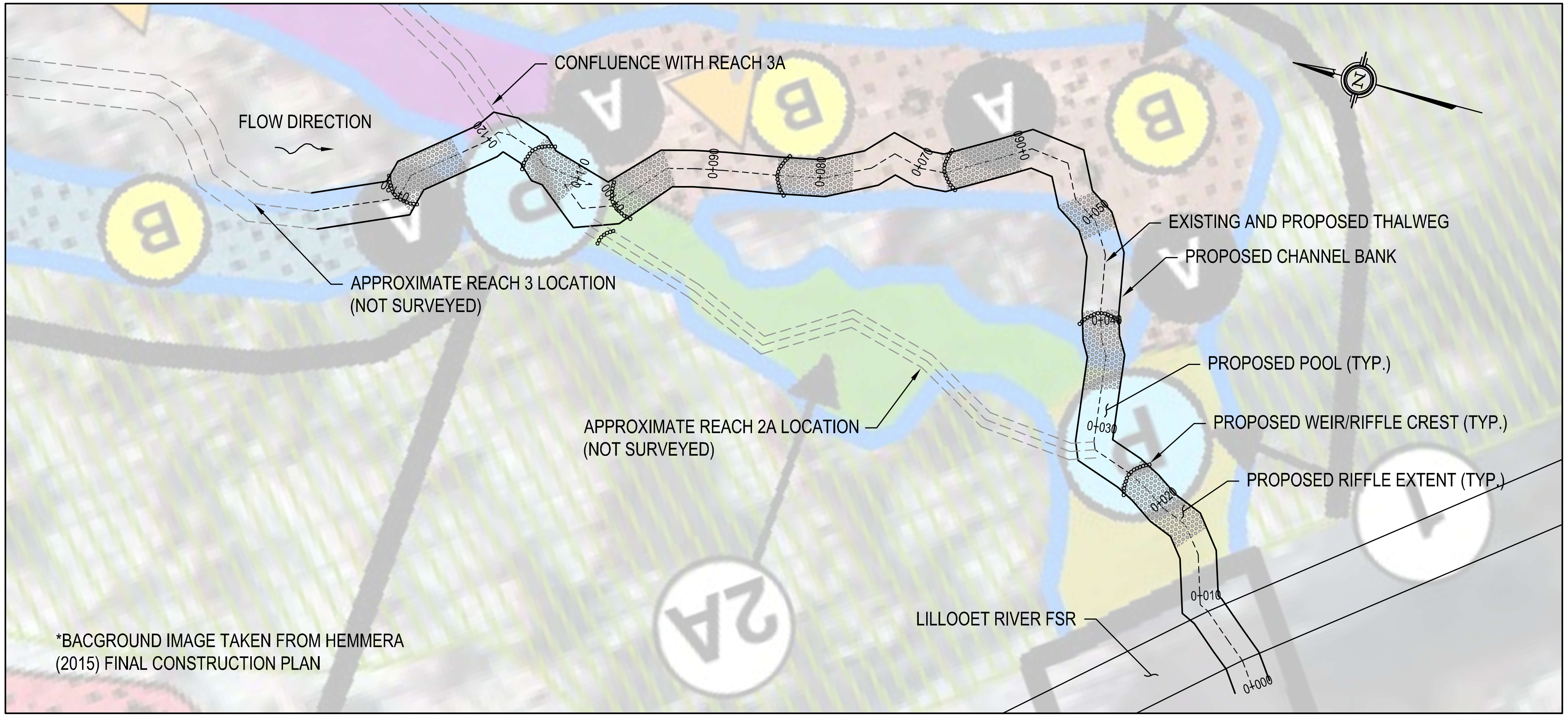
APPENDICES

Appendix A. Final Design Drawings of the Alena Creek Fish Habitat Enhancement Project



REACH 1, 2, & 2A PLANVIEW

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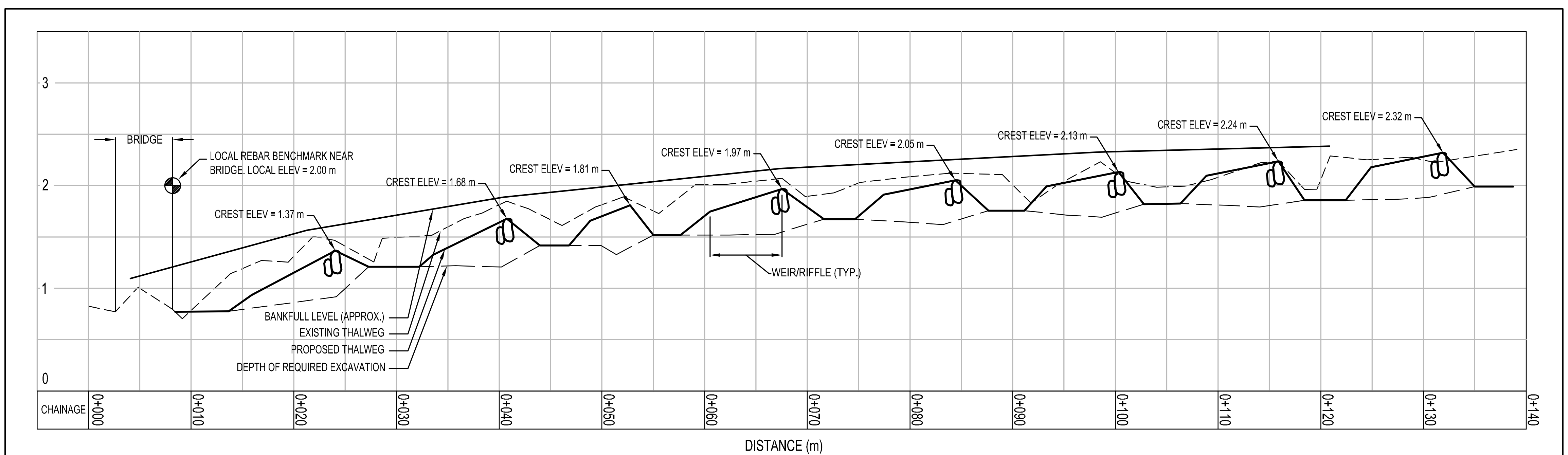

REACH 1, 2, & 2A PROFILE

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GENERAL NOTES

1. THE CONTRACTOR SHALL PROVIDE THE CONSULTING ENGINEER OR GEOMORPHOLOGIST 48 HOURS NOTICE PRIOR TO COMMENCING WORK.
2. THIS SET OF DRAWINGS SHALL BE READ IN CONJUNCTION WITH ACCOMPANYING FINAL CONSTRUCTION PLAN (HEMMERA, 2015).
3. ALL DRAWINGS SHALL BE USED FOR CONSTRUCTION. DO NOT SCALE FROM PLANFORM DRAWING.
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WATERCOURSE PROTECTION

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7. THE WEATHER FORECAST SHALL BE CONTINUALLY MONITORED TO ENSURE THAT CONSTRUCTION ACTIVITIES MAY PROCEED UNDER FAVOURABLE CONDITIONS.
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12. CONSTRUCTION MATERIAL, EXCESS MATERIAL, CONSTRUCTION DEBRIS AND EMPTY CONTAINERS SHALL BE STORED AWAY FROM WATERCOURSES AND WATERCOURSE BANKS.

DATE	BY	REVISIONS
07-10-16	D.W.	ISSUED FOR CONSTRUCTION

DESIGNED BY:	D.W.	CHECKED BY:	D.W.
DRAWN BY:	D.W.	DATE:	AUGUST 10, 2015

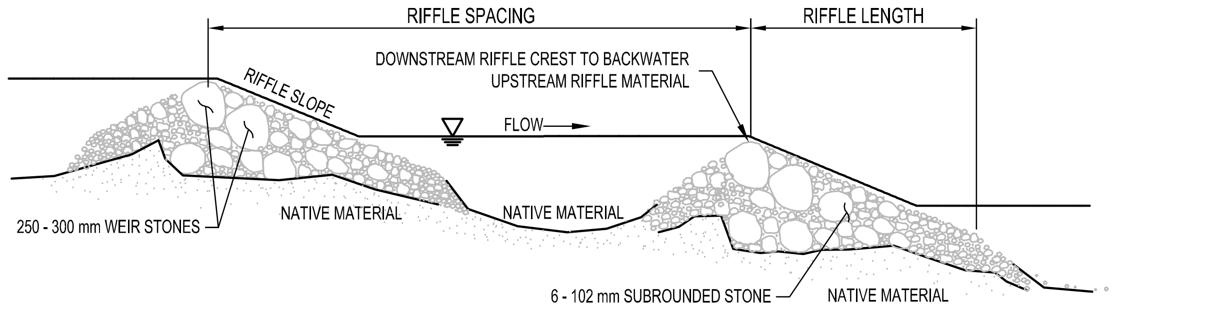
PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — D. T. WEST # 41242 — July 10, 2016

ECOFISH RESEARCH

ALENA CREEK FHEP DETAILED CONSTRUCTION PLAN

REACH 1 AND 2 PLANFORM AND PROFILE

PROJECT No.:	1095.16	DRAWING No.:	GEO-1
SCALE:	AS SHOWN	SHEET 1 OF 3	

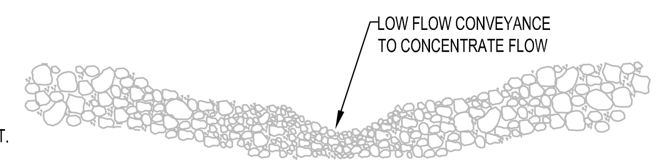


TYPICAL RIFFLE SEQUENCE PROFILE

N.T.S.

CONSTRUCTION NOTES

1. CREST TO CREST CHANNEL GRADIENT IN REACHES 3 TO 6 TO MATCH EXISTING UNLESS OTHERWISE INSTRUCTED BY ENVIRONMENTAL MONITOR.
2. DIG DEPRESSIONS INTO THE BED TO STABILIZE RIFFLE MATERIALS.
3. PLACE LARGEST MATERIAL (KEY STONE) AT RIFFLE CREST (HIGHEST POINT).
4. ENSURE THAT LARGEST ROCKS PROTRUDE INTO FLOW.
5. THICKNESS OF RIFFLE SUBSTRATE AT CREST IS APPROXIMATELY 400 mm.
6. FILL VOIDS IN RIFFLE WITH NATIVE MATERIALS.
7. TAPER GRAIN SIZE AND BED THICKNESS DOWNSTREAM AND UPSTREAM OF CREST.
8. RIFFLE MATERIALS SHOULD EXTEND OVER LIP OF THE DEPRESSION.
9. SPREAD REMAINING ROCK ON RIFFLE TO ATTAIN RIFFLE ANGLE.
10. RIFFLE LENGTH IS DETERMINED FROM PROFILE WHERE SHOWN.
11. SUBSTRATE TO BE MECHANICALLY COMPACTED WITH EXCAVATOR BUCKET TO MINIMIZE INTERSTITIAL SPACING.

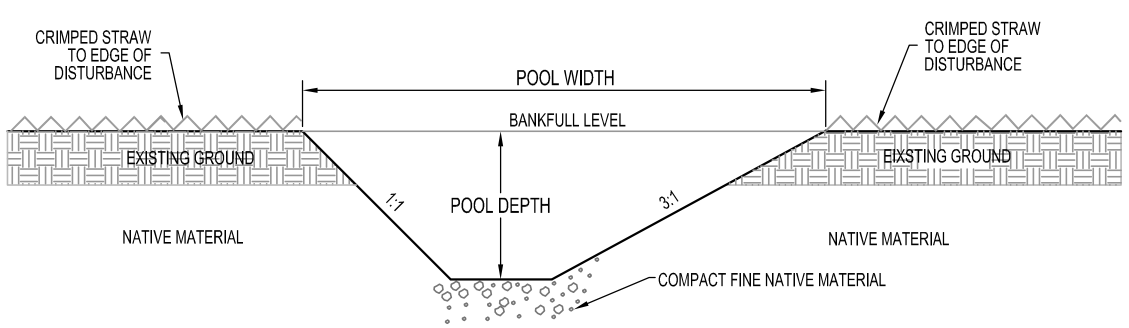


CROSS-SECTION

N.T.S.

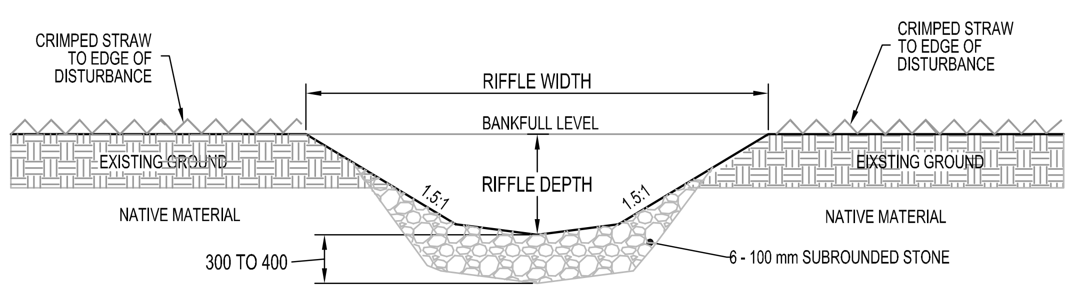
WEIR/RIFFLE CONSTRUCTION DETAILS

N.T.S.



TYPICAL POOL CROSS SECTION

N.T.S.



TYPICAL RIFFLE CROSS SECTION

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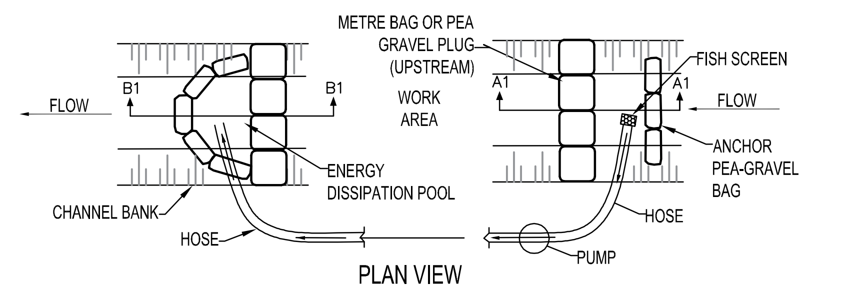
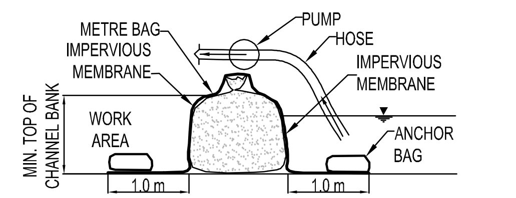
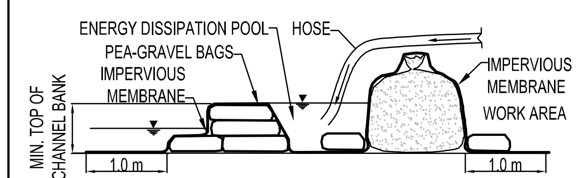


PLAN VIEW



SECTION A1-A1



SECTION B1-B1

NOTES

1. COFFERDAM BARRIER BAGS TO BE FILLED WITH PEA GRAVEL OR SAND IF PEA GRAVEL IS UNAVAILABLE.
2. IMPERVIOUS MEMBRANE SHALL COVER THE METRE BAGS TO LIMIT WATER ENTRY INTO WORK AREA.
3. PUMPING CAPACITY TO BE A MINIMUM OF 2 - 75 mm (3 in) DIAMETER PUMPS.
4. SCREEN TO BE INSTALLED AT INTAKE END OF HOSE TO LIMIT FISH MORTALITY. FISH SCREEN TO BE 1.25 m^2 WITH A 15 mm MESH SIZE/OPENING.
5. PUMPED WATER SHALL BE DISCHARGED INTO THE ENERGY DISSIPATION POOL.
6. A BACKUP PUMP AND HOSE SHALL BE KEPT ONSITE IN THE EVENT THAT INCREASED FLOWS CANNOT BE PUMPED IN THE PRIMARY SYSTEM.
7. THE CONTRACTOR SHALL MONITOR WEATHER CONDITIONS AND WILL NOT PROCEED WITH WORKS IN THE EVENT OF A STORM EVENT, OR IF IT IS ANTICIPATED THAT FLOWS CANNOT BE PUMPED AROUND AS REQUIRED.

COFFERDAM BARRIER

N.T.S.

CHANNEL GEOMETRY FOR EACH REACH

REACH	RIFFLE SLOPE	RIFFLE LENGTH	RIFFLE SPACING	RIFFLE WIDTH (m)	MAX. RIFFLE DEPTH (m)	POOL WIDTH (m)	MAX. POOL DEPTH (m)
1	SEE GEO-1	SEE GEO-1	SEE GEO-1	2.7	0.35	4.1	0.7
2	SEE GEO-1	SEE GEO-1	SEE GEO-1	2.7	0.35	4.1	0.7
3	2 TO 3 %	5 - 10 m	15 - 18 m	2.7	0.35	4.1	0.7
4	2 TO 3 %	5 - 10 m	15 - 18 m	2.7	0.35	4.1	0.7
5	2 TO 3%	3 - 6 m	10 - 14 m	2.0	0.30	2.9	0.6
6	2 TO 3 %	4 - 8 m	13 - 16 m	2.5	0.35	3.6	0.7

GENERAL NOTES

1. THE CONTRACTOR SHALL PROVIDE THE CONSULTING ENGINEER OR GEOMORPHOLOGIST 48 HOURS NOTICE PRIOR TO COMMENCING WORK.
2. THIS SET OF DRAWINGS SHALL BE READ IN CONJUNCTION WITH ACCOMPANYING FINAL CONSTRUCTION PLAN (HEMMERA, 2015).
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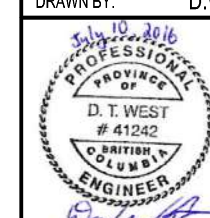
DATE	BY	REVISIONS

DESIGNED BY: D.W. CHECKED BY: D.W.

DRAWN BY: D.W. DATE: AUGUST 10, 2015



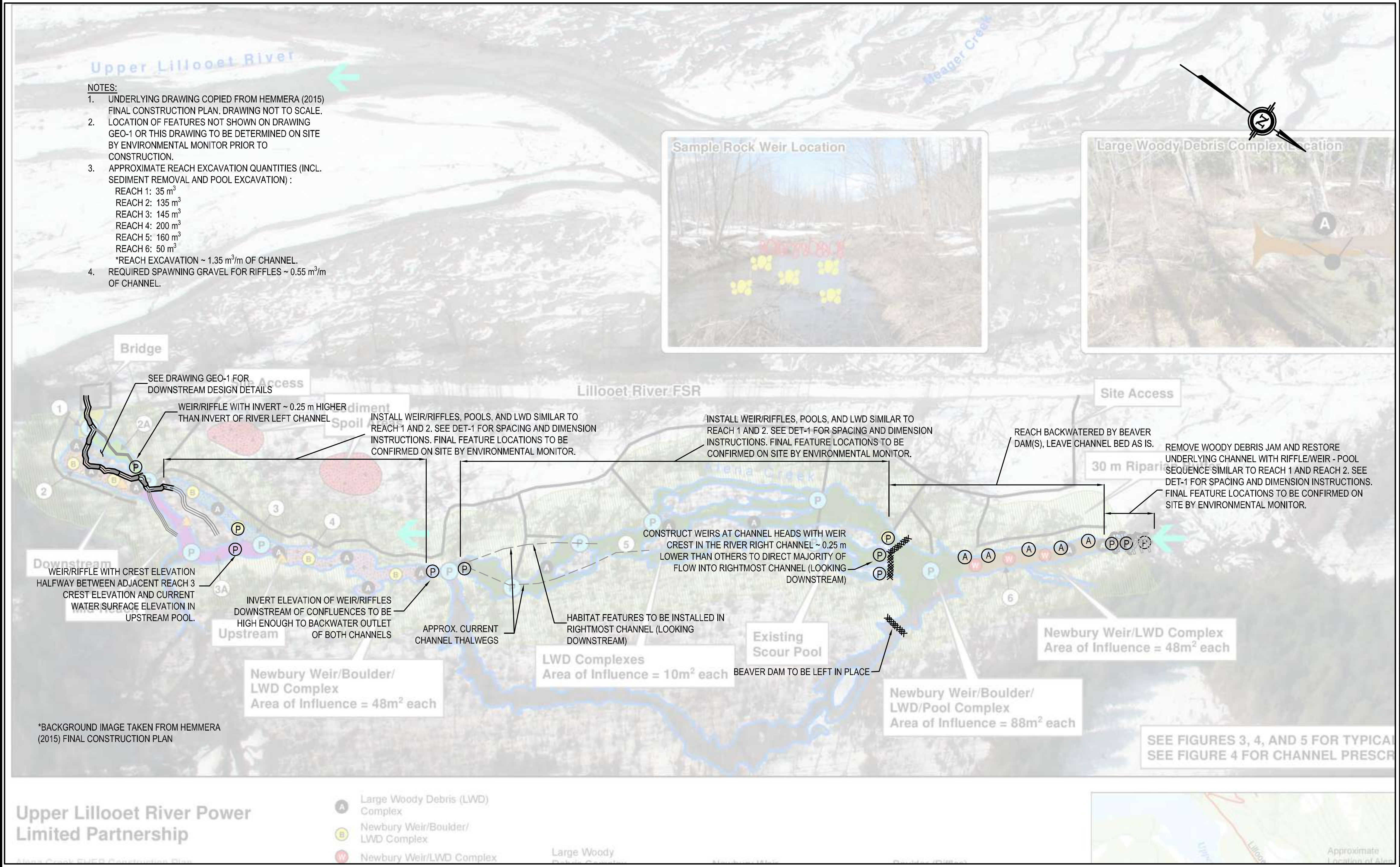
ECOFISH RESEARCH

ALENA CREEK FHEP DETAILED CONSTRUCTION PLAN

CHANNEL GEOMETRY DETAILS

PROJECT No.: 1095.16 DRAWING No.: DET-1

SCALE: AS SHOWN SHEET 2 OF 3



PLANVIEW

N.T.S.

RECOMMENDED CONSTRUCTION SEQUENCE

* MITIGATION MEASURES SECTION OF HEMMERA (2015) FINAL CONSTRUCTION PLAN TO BE ADHERED TO. IF AN APPARENT INCONSISTENCY IS IDENTIFIED, THE ENVIRONMENTAL MONITOR IS TO BE CONSULTED.

PHASE 1 (REACH 1):

1. ISOLATE REACH 1 BY INSTALLING COFFERDAM AND PUMPING OR FLUMING FLOW AROUND SITE.
2. FISH RESCUE OF REACH 1 TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
3. COMPLETE CHANNEL WORKS IN REACH 1 AND REACTIVATE FLOW BY DISMANTLING COFFERDAM.

PHASE 2 (REACH 2 & 2A):

4. ISOLATE REACH 2 BY INSTALLING COFFERDAM AT UPSTREAM EXTENT TO DIVERT FLOW THROUGH REACH 2A.
5. FISH RESCUE OF REACH 1 TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
6. COMPLETE CHANNEL WORKS IN REACH 2 AND REACTIVATE CHANNEL BY SLOWLY DISMANTLING COFFERDAM.
7. ISOLATE REACH 2A BY INSTALLING COFFERDAM AT UPSTREAM EXTENT TO DIVERT FLOW THROUGH REACH 2.
8. CONSTRUCT RIFFLE/WEIR AT HEAD OF REACH 2A WITH CREST ~ 0.25 m HIGHER THAN ADJACENT REACH 2 CREST.

PHASE 3 (REACH 3 & 3A):

9. FEATURE LOCATIONS TO BE ESTABLISHED ON SITE BY ENVIRONMENTAL MONITOR.
10. ISOLATE REACH 3 BY INSTALLING COFFERDAM AT UPSTREAM EXTENT TO DIVERT FLOW THROUGH REACH 3A.
11. FISH RESCUE OF REACH 3 TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
12. COMPLETE CHANNEL WORKS IN REACH 3 BY FOLLOWING INSTALLATION INSTRUCTIONS ON DRAWING DET-1 IN CONSULTATION WITH ECOFISH TECHNICIAN.
13. REACTIVATE REACH 3 BY SLOWLY DISMANTLING COFFERDAM.
14. ISOLATE HEAD OF REACH 3A BY INSTALLING COFFERDAMS ABOVE AND BELOW PROPOSED WEIR LOCATION.
15. FISH RESCUE OF ISOLATED AREA TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
16. PUMP FLOW FROM REACH 4 FORK INTO REACH 3A AT A NATURAL RATE.
17. CONSTRUCT RIFFLE/WEIR AT HEAD OF REACH 3A WITH CREST ELEVATION HALFWAY BETWEEN ADJACENT REACH 3 CREST ELEVATION AND CURRENT WATER SURFACE ELEVATION IN UPSTREAM POOL.
18. REACTIVATE ISOLATED AREA BY DISMANTLING COFFERDAM.

PHASE 4 (REACH 4):

19. FEATURE LOCATIONS TO BE ESTABLISHED ON SITE BY ENVIRONMENTAL MONITOR.
20. ISOLATE FEATURE LOCATIONS ONE AT A TIME BEGINNING AT DOWNSTREAM BY INSTALLING COFFERDAM ABOVE AND BELOW EXTENTS OF FEATURE AND PUMPING OR FLUMING FLOW AROUND ISOLATED AREA.
21. FISH RESCUE OF ISOLATED AREAS TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.

22. PHASE 5 (REACH 5):
23. FEATURE LOCATIONS TO BE ESTABLISHED ON SITE BY ENVIRONMENTAL MONITOR.
24. ISOLATE FEATURE LOCATIONS ONE AT A TIME BEGINNING AT DOWNSTREAM BY INSTALLING COFFERDAM ABOVE AND BELOW EXTENTS AND PUMPING OR FLUMING FLOW AROUND. DIVERSION OF FLOWS INTO ADJACENT CUTOFF CHANNELS MAY ALSO BE FEASIBLE AND WILL BE DISCUSSED WITH ENVIRONMENTAL MONITOR PRIOR TO DIVERSION.
25. FISH RESCUE OF ISOLATED AREAS TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
26. FOR EACH CUTOFF CHANNEL OF REACH 5, COMPLETE STEPS 28 TRHOUGH 32.
27. ISOLATE HEAD OF CUTOFF CHANNEL BY INSTALLING COFFERDAMS ABOVE AND BELOW PROPOSED WEIR LOCATIONS ONE BY ONE.
28. PUMP FLOW AROUND ISOLATED AREA AT A NATURAL RATE.
29. FISH RESCUE OF ISOLATED AREA TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
30. INSTALL RIFFLE/WEIR NEAR HEAD OF CUTOFF CHANNEL DOWNSTREAM OF BEAVERDAM. CREST ELEVATION OF RIGHTMOST CHANNEL TO BE LOWEST. CREST ELEVATIONS TO BE DETERMINED IN FIELD BY ENVIRONMENTAL MONITOR.
31. REACTIVATE ISOLATED AREA BY DISMANTLING COFFERDAM.

PHASE 6 (REACH 6):

32. ISOLATE WOODY DEBRIS JAM BY INSTALLING COFFERDAM ABOVE AND BELOW EXTENTS AND PUMPING OR FLUMIING AROUND.
33. FISH RESCUE OF ISOLATED AREAS TO BE COMPLETED BY A QUALIFIED PROFESSIONAL.
34. REMOVE WOODY DEBRIS PIECES AND DEPOSIT IN SPOIL AREA APPROVED BY ENVIRONMENTAL MONITOR.
35. FEATURES TO BE INSTALLED AT LOCATIONS SPECIFIED BY ENVIRONMENTAL MONITOR ON SITE.
36. REACTIVATE ISOLATED AREA BY DISMANTLING COFFERDAM.

	07-10-16	D.W.	ISSUED FOR CONSTRUCTION
	DATE	BY	REVISIONS

DESIGNED BY:	D.W.	CHECKED BY:	D.W.
DRAWN BY:	D.W.	DATE:	AUGUST 10, 2015

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — D. T. WEST # 41242 — July 10, 2016

ECOFISH RESEARCH

ALENA CREEK FHEP DETAILED CONSTRUCTION PLAN

FULL SITE PLANFORM AND PHASING

PROJECT No.:	1095.16	DRAWING No.:	PESC-1
SCALE:	AS SHOWN	SHEET 3 OF 3	

Appendix B. Water Temperature Guidelines, Data Summary, and Site Photographs

LIST OF FIGURES

Figure 1. ALE-USWQ1 pre-construction annual plots (2013 to 2014). 2

Figure 2. ALE-USWQ1 post-construction annual plots (2016 to 2021). 3

Figure 3. ALE-BDGWQ pre-construction annual plots (2013 to 2014). 6

Figure 4. ALE-BDGWQ post-construction annual plots (2016 to 2021). 7

Figure 5. Looking downstream at ALE-BDGWQ on September 27, 2021 10

Figure 6. Looking upstream at ALE-BDGWQ on September 27, 2021. 10

Figure 7. Looking RR-RL at ALE-USWQ1 on September 27, 2021. 11

Figure 8. Looking at ALE-USWQ1 Tidbits on September 27, 2021. 11

LIST OF TABLES

Table 1. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001). 1

1. WATER TEMPERATURE GUIDELINES

Table 1. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001).

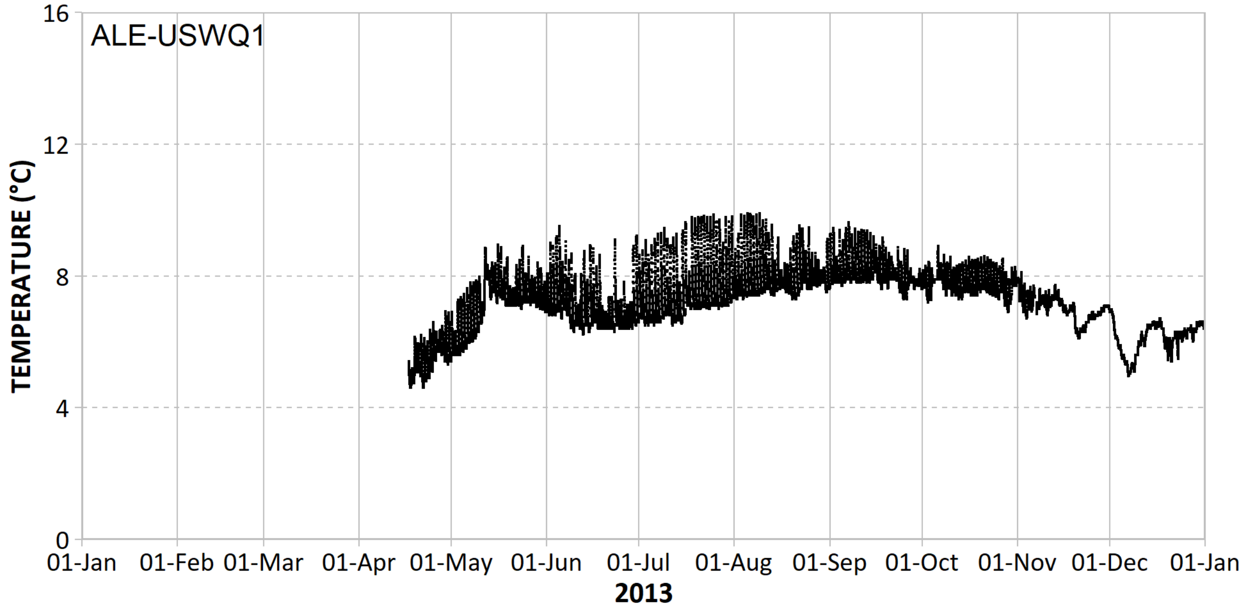
Category	Guideline[1]
All Streams	the rate of temperature change in natural water bodies not to exceed 1°C/hr
	temperature metrics to be described by the mean weekly maximum temperature (MWMxT)
Streams with Known Fish Presence	mean weekly maximum water temperatures should not exceed ±1°C beyond the optimum 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. ANNUAL WATER TEMPERTURE PLOTS

2.1. ALE-USWQ1

Figure 1. ALE-USWQ1 pre-construction annual plots (2013 to 2014).



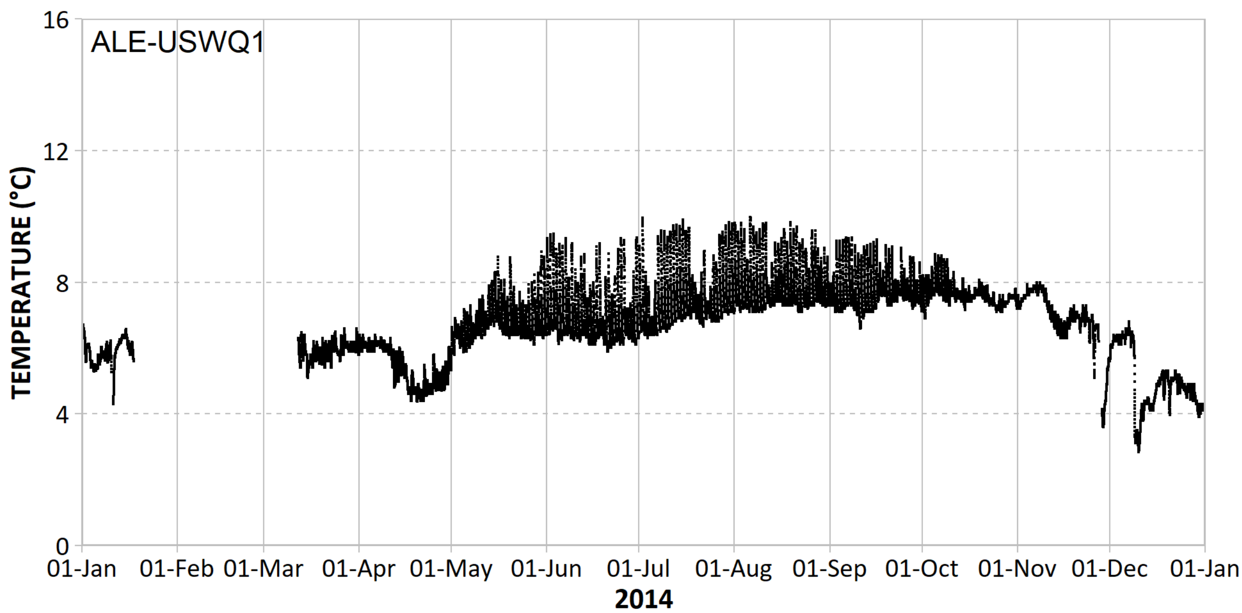
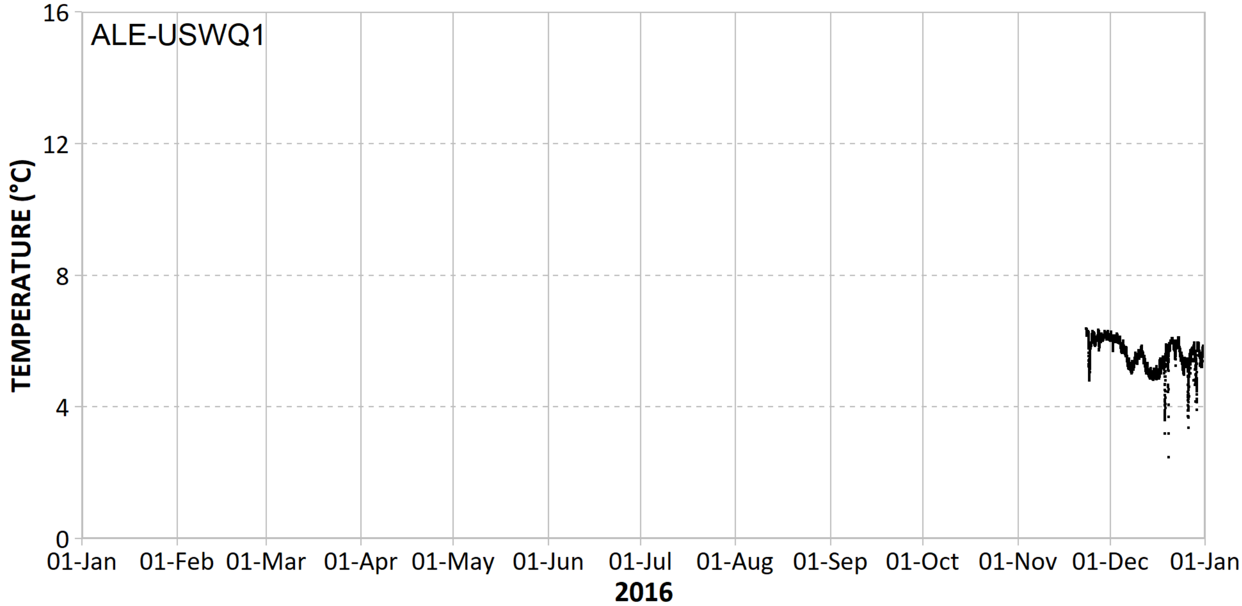


Figure 2. ALE-USWQ1 post-construction annual plots (2016 to 2021).



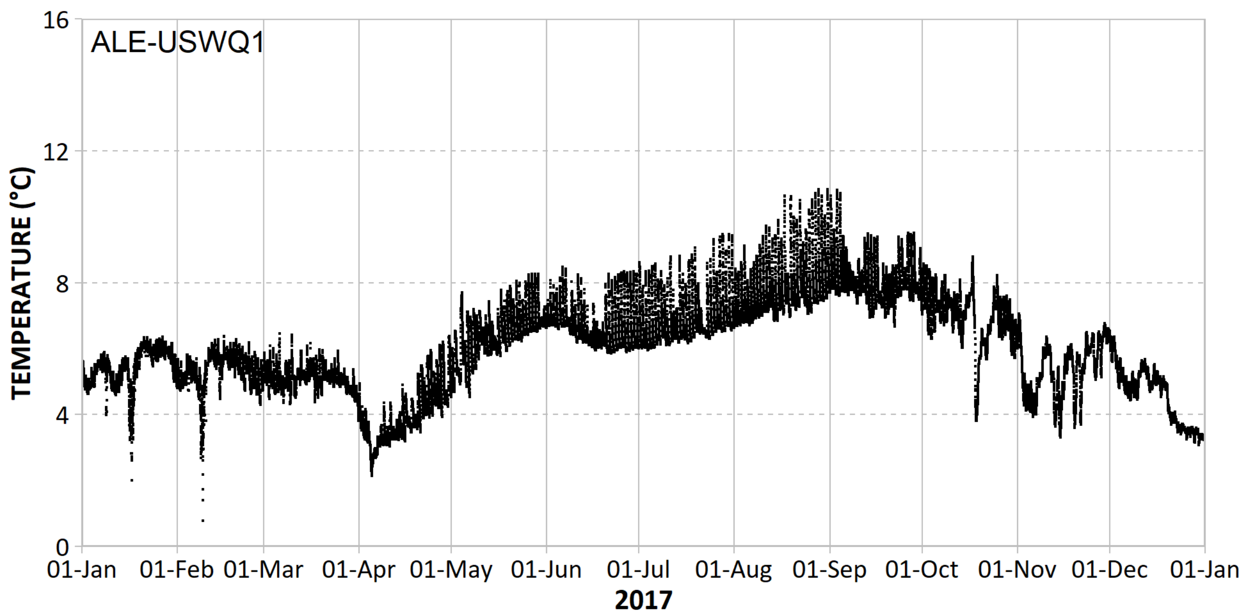
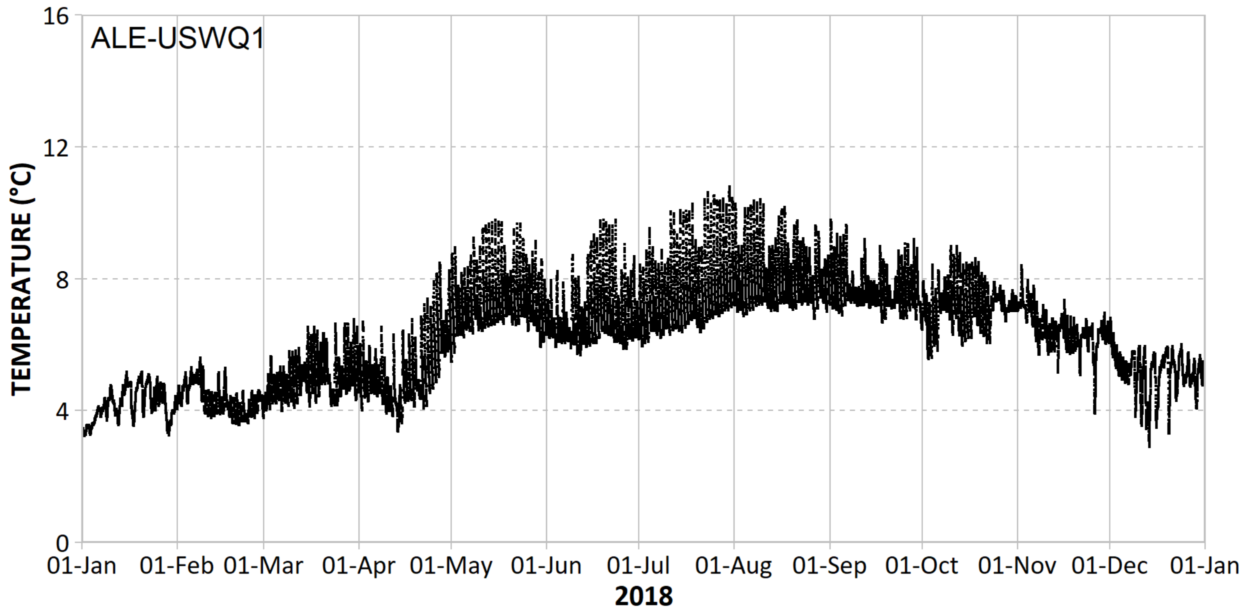


Figure 2. Continued.



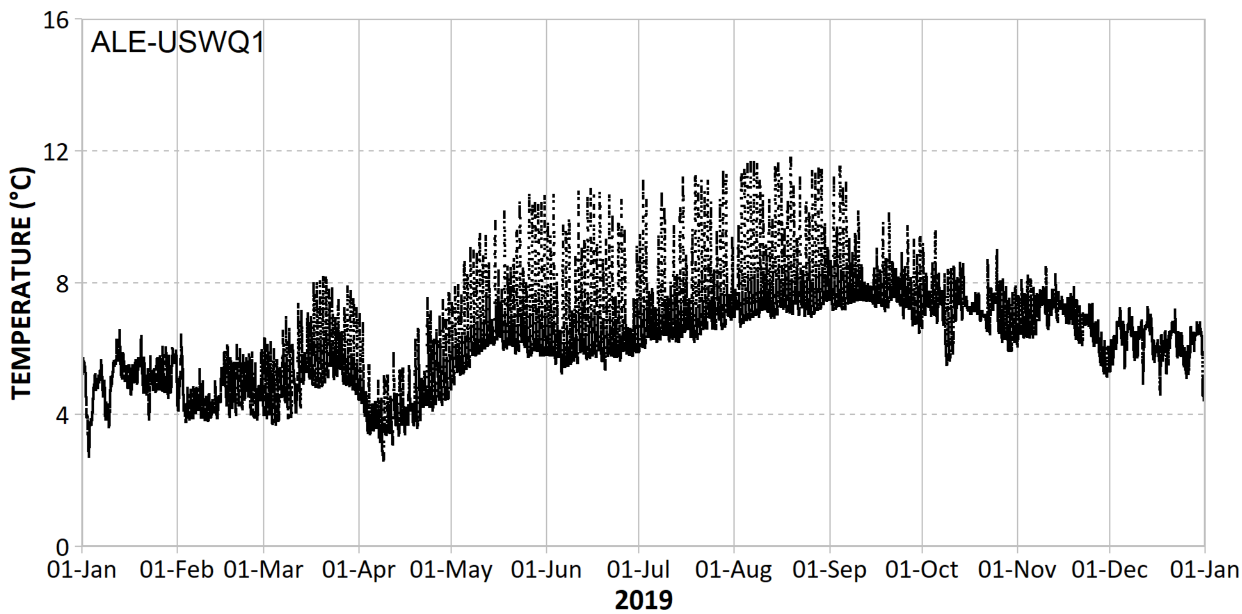
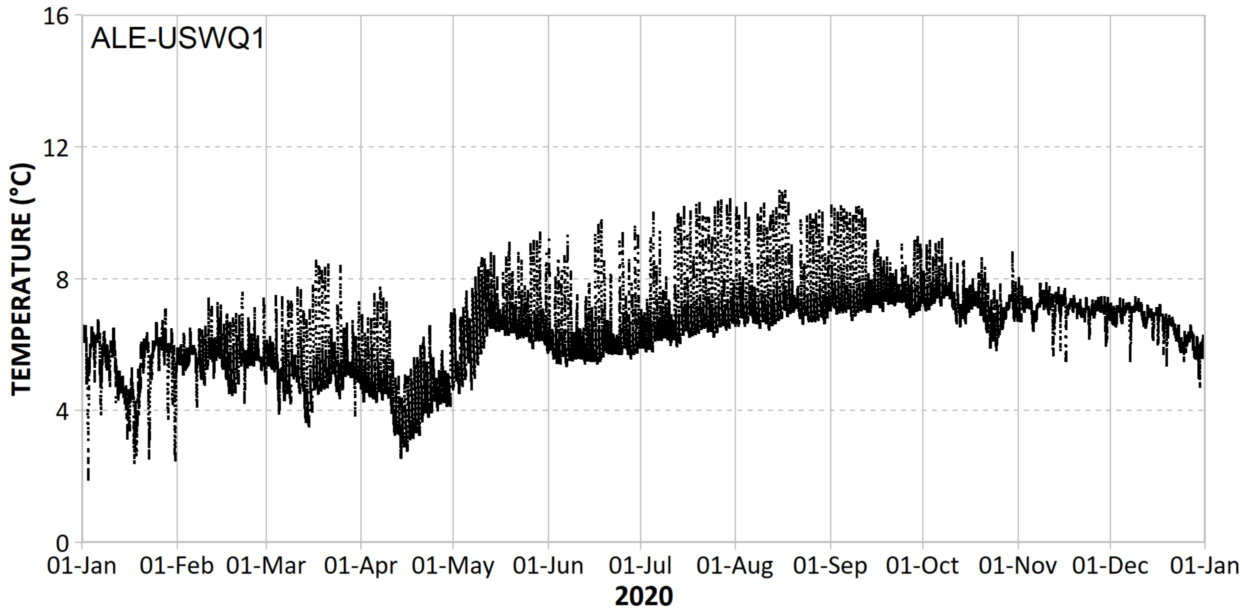
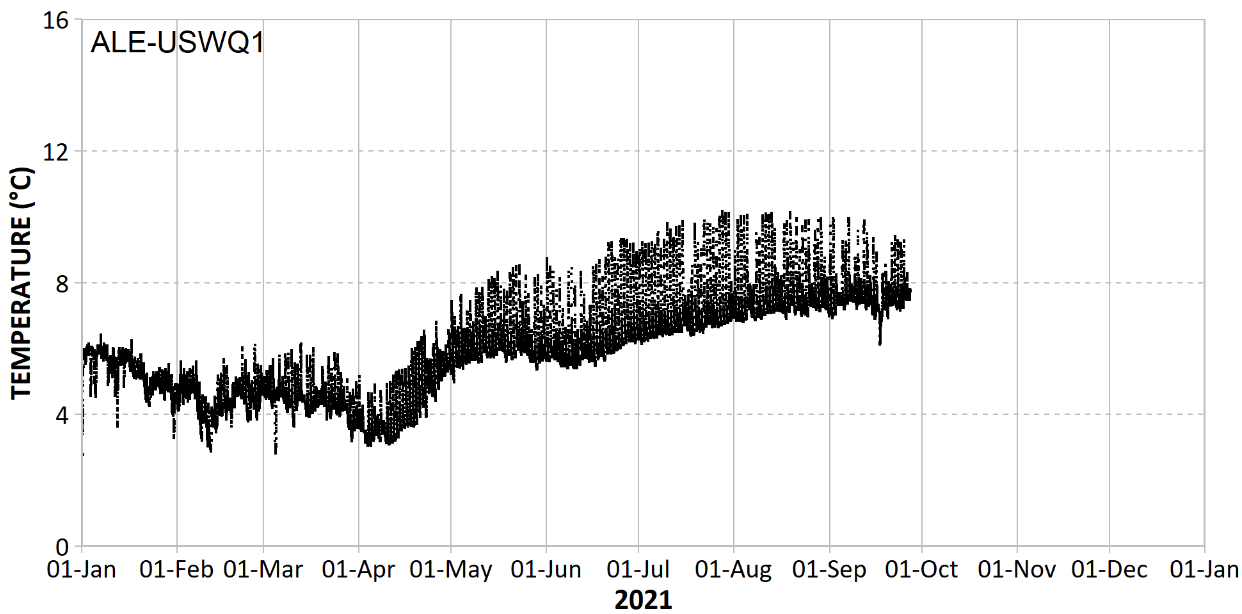


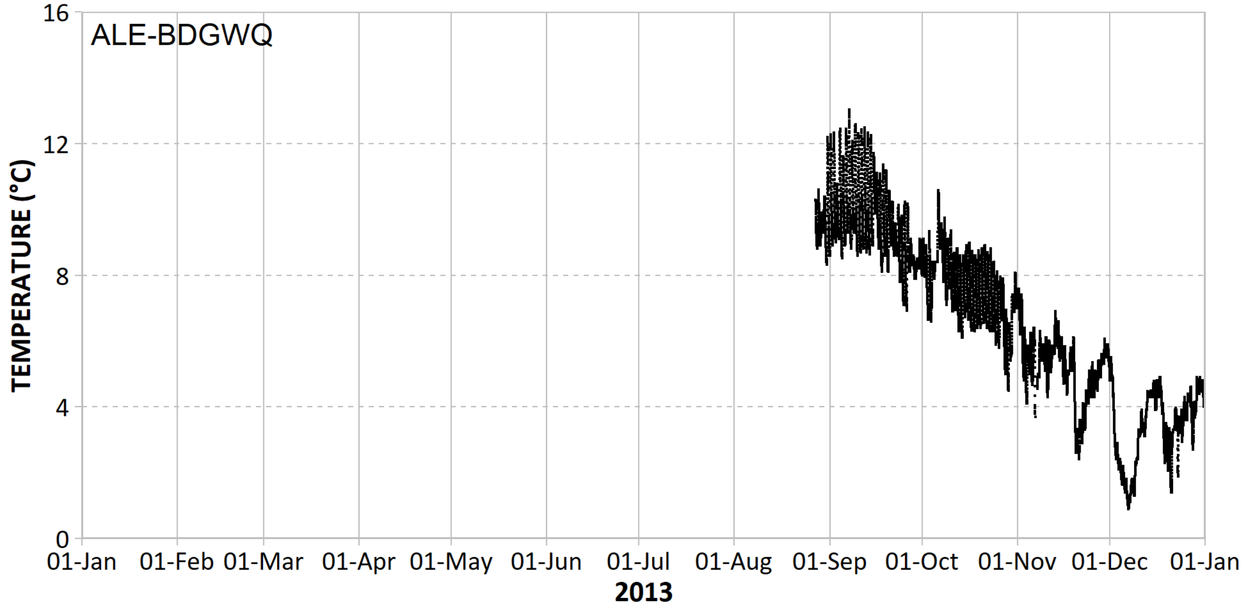
Figure 2. Continued.





2.2. ALE-BDGWQ

Figure 3. ALE-BDGWQ pre-construction annual plots (2013 to 2014).



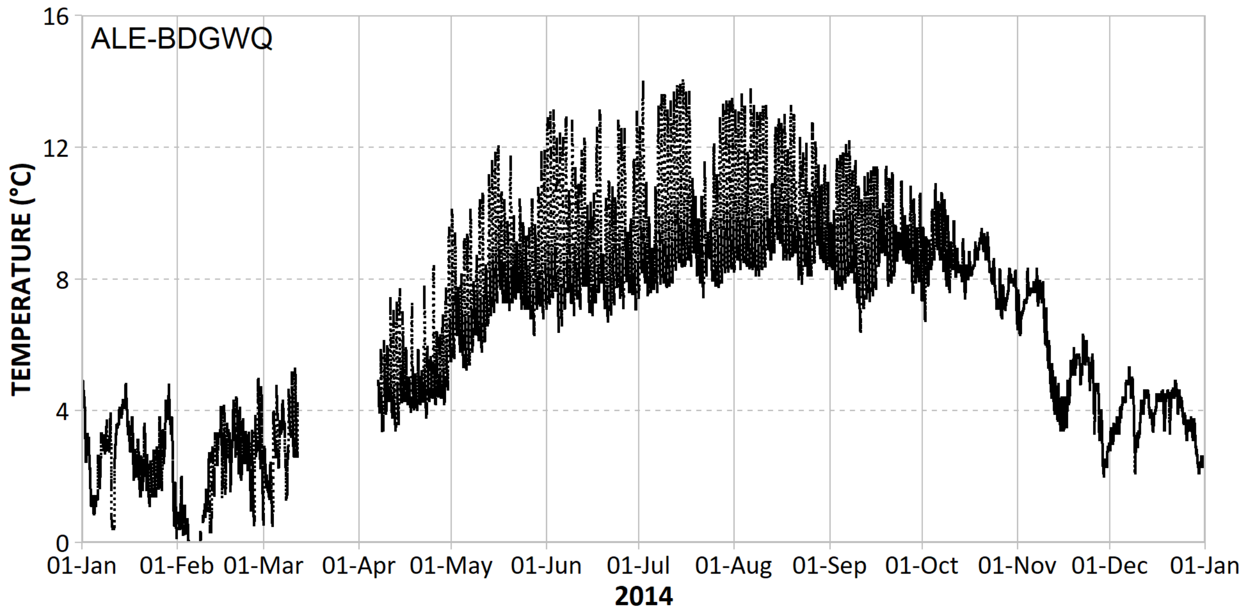
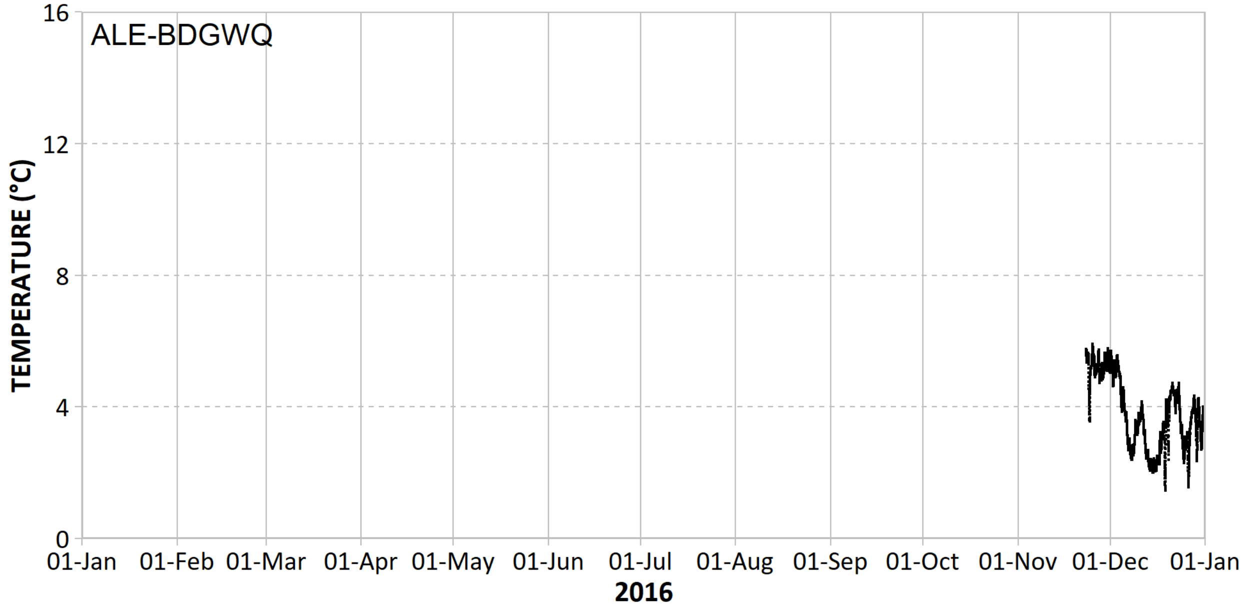


Figure 4. ALE-BDGWQ post-construction annual plots (2016 to 2021).



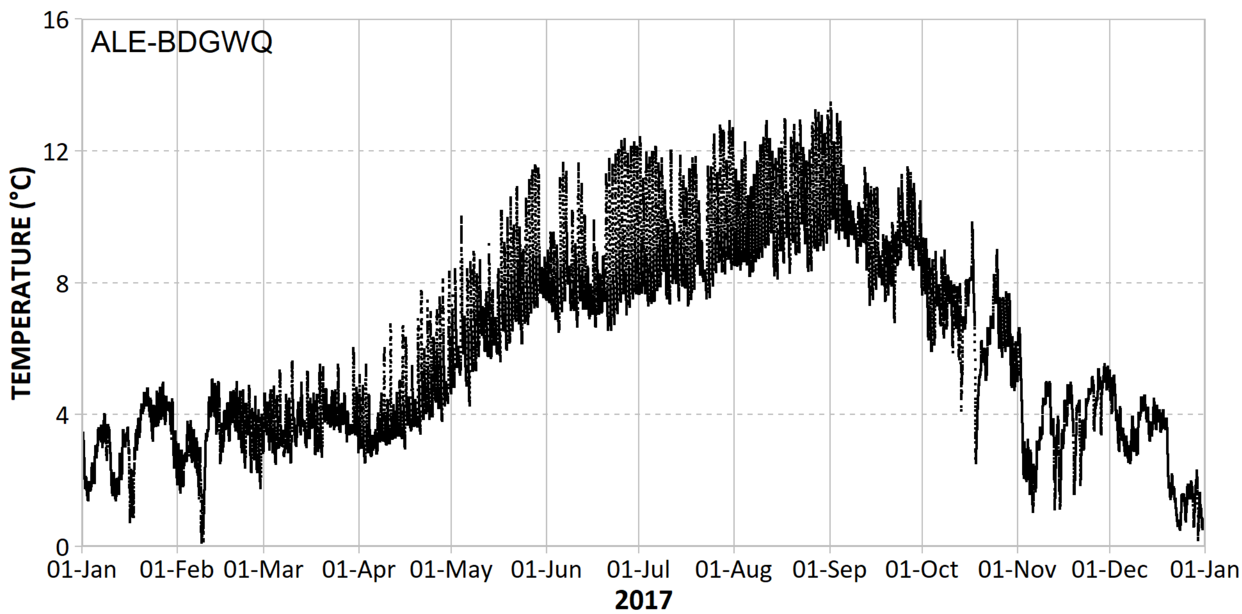
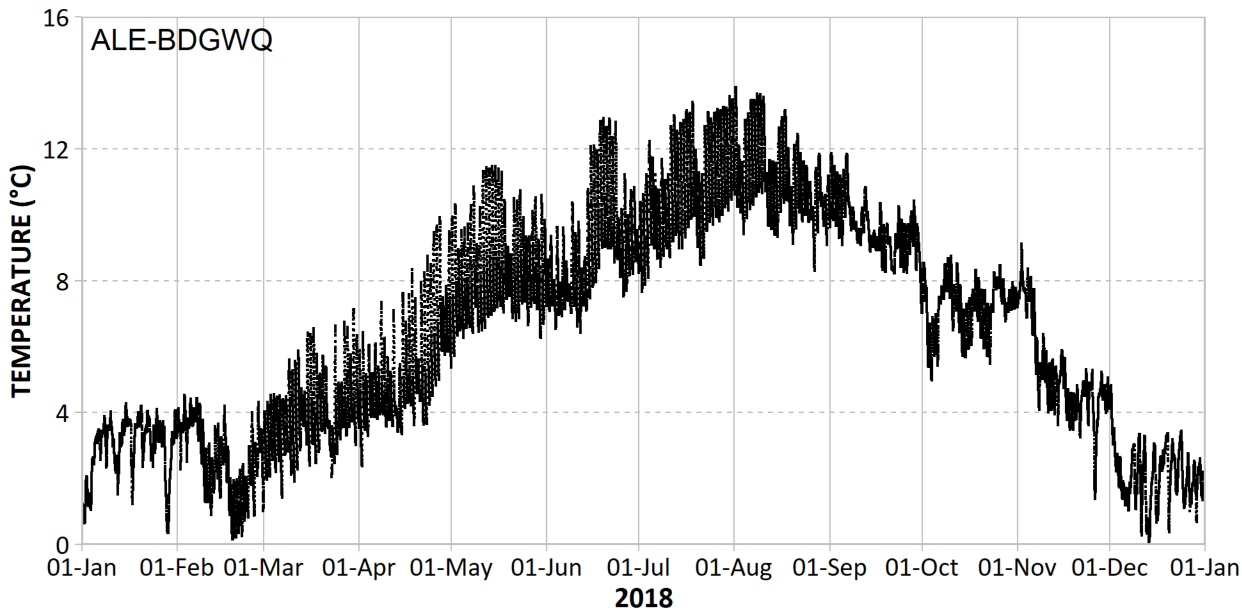


Figure 4. Continued.



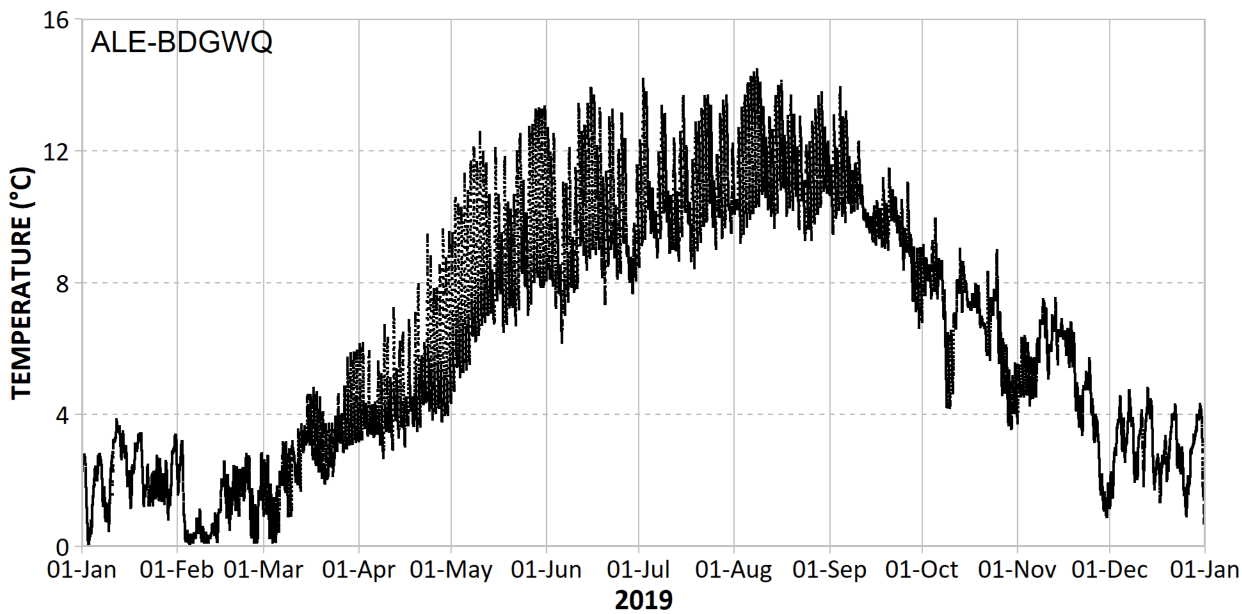
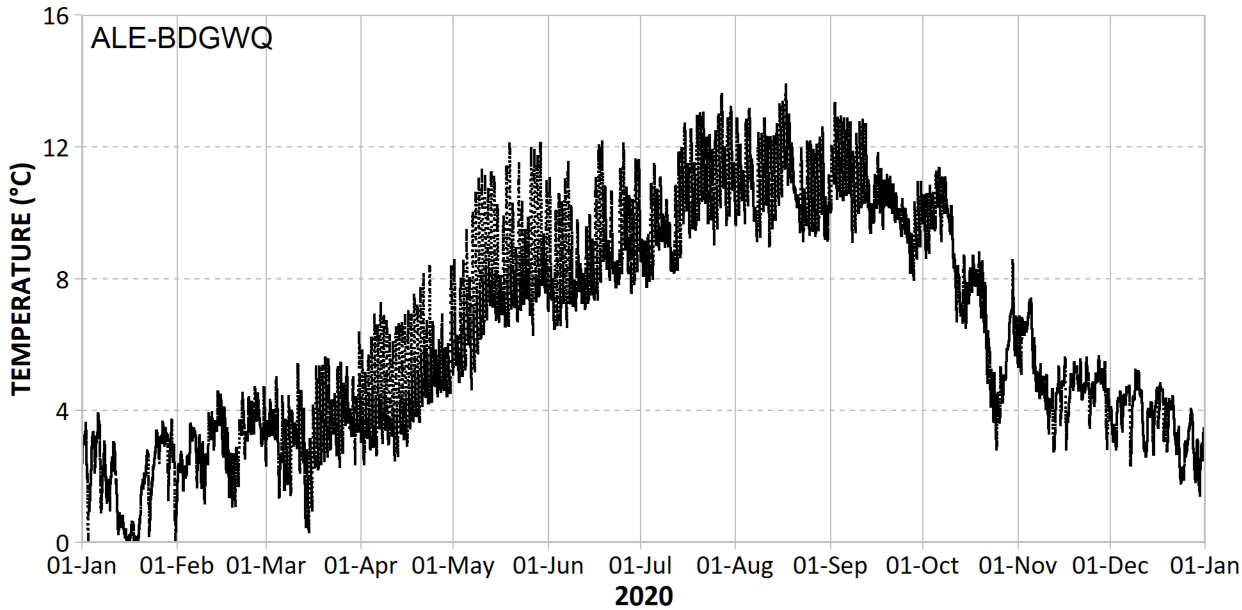
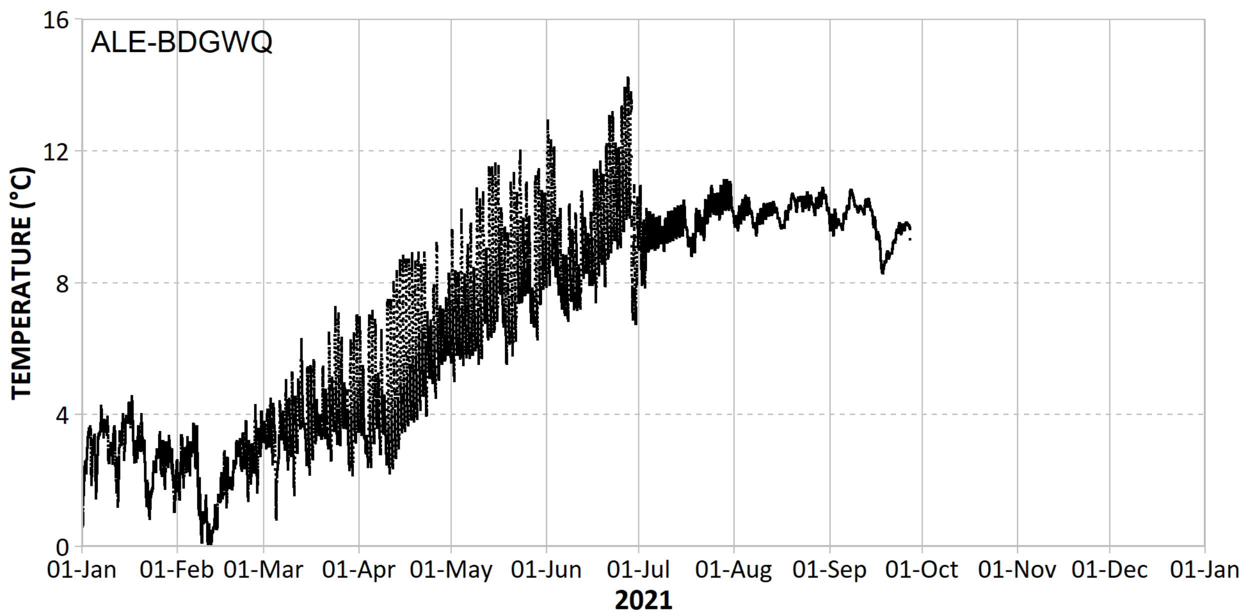


Figure 4. Continued.





3. REPRESENTATIVE WATER TEMPERATURE SITE PHOTOGRAPHS

Figure 5. Looking downstream at ALE-BDGWQ on September 27, 2021.

Figure 6. Looking upstream at ALE-BDGWQ on September 27, 2021.

Figure 7. Looking RR-RL at ALE-USWQ1 on September 27, 2021.

Figure 8. Looking at ALE-USWQ1 Tidbits on September 27, 2021.

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Appendix C. Photographs of Alena Creek Fish Habitat Enhancement Project Stability Assessment Year 5 Monitoring

LIST OF FIGURES

Figure 1. ALE-XS1 on September 19, 2016. 1

Figure 2. ALE-XS1 on November 10, 2017. 2

Figure 3. ALE-XS1 on November 05, 2018. 3

Figure 4. ALE-XS1 on November 13, 2019. 4

Figure 5. ALE-XS1 on November 07, 2020. 5

Figure 6. ALE-XS1 on October 27, 2021. 6

Figure 7. ALE-XS2 on September 19, 2016. 7

Figure 8. ALE-XS2 on November 10, 2017. 8

Figure 9. ALE-XS2 on November 05, 2018. 9

Figure 10. ALE-XS2 on November 13, 2019. 10

Figure 11. ALE-XS2 on November 07, 2020. 11

Figure 12. ALE-XS2 on October 27, 2021. 12

Figure 13. ALE-XS3 on September 19, 2016. 13

Figure 14. ALE-XS3 on November 10, 2017. 14

Figure 15. ALE-XS3 on November 05, 2018. 15

Figure 16. ALE-XS3 on November 13, 2019. 16

Figure 17. ALE-XS3 on November 07, 2020. 17

Figure 18. ALE-XS3 on October 27,2021. 18

Figure 19. ALE-XS4 on September 19, 2016. 19

Figure 20. ALE-XS4 on November 10, 2017. 20

Figure 21. ALE-XS4 on November 05, 2018. 21

Figure 22. ALE-XS4 on November 13, 2019. 22

Figure 23. ALE-XS4 on November 07, 2020. 23

Figure 24. ALE-XS4 on October 27, 2021. 24

Figure 25. ALE-XS5 on September 19, 2016. 25

Figure 26. ALE-XS5 on November 10, 2017. 26

Figure 27. ALE-XS5 on November 05, 2018. 27

Figure 28. ALE-XS5 on November 13, 2019. 28

Figure 29. ALE-XS5 on November 07, 2020. 29
Figure 30. ALE-XS5 on October 27, 2021. 30
Figure 31. ALE-XS6 on September 19, 2016. 31
Figure 32. ALE-XS6 on November 10, 2017. 32
Figure 33. ALE-XS6 on November 05, 2018. 33
Figure 34. ALE-XS6 on November 13, 2019. 34
Figure 35. ALE-XS6 on November 07, 2020. 35
Figure 36. ALE-XS6 on October 27, 2021. 36
Figure 37. ALE-XS7 on September 19, 2016. 37
Figure 38. ALE-XS7 on November 10, 2017. 38
Figure 39. ALE-XS7 on November 05, 2018. 39
Figure 40. ALE-XS7 on November 13, 2019. 40
Figure 41. ALE-XS7 on November 07, 2020. 41
Figure 42. ALE-XS7 on October 27, 2021. 42
Figure 43. ALE-XS8 on September 19, 2016. 43
Figure 44. ALE-XS8 on November 10, 2017. 44
Figure 45. ALE-XS8 on November 05, 2018. 45
Figure 46. ALE-XS8 on November 13, 2019. 46
Figure 47. ALE-XS8 on November 07, 2020 47
Figure 48. ALE-XS8 on October 27, 2021 48

Figure 1. ALE-XS1 on September 19, 2016.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 2. ALE-XS1 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 3. ALE-XS1 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 4. ALE-XS1 on November 13, 2019.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 5. ALE-XS1 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 6. ALE-XS1 on October 27, 2021.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 7. ALE-XS2 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 8. ALE-XS2 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 9. ALE-XS2 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 10. ALE-XS2 on November 13, 2019.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 11. ALE-XS2 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 12. ALE-XS2 on October 27, 2021.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 13. ALE-XS3 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 14. ALE-XS3 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 15. ALE-XS3 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 16. ALE-XS3 on November 13, 2019.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 17. ALE-XS3 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 18. ALE-XS3 on October 27,2021.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 19. ALE-XS4 on September 19, 2016.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 20. ALE-XS4 on November 10, 2017.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 21. ALE-XS4 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 22. ALE-XS4 on November 13, 2019.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 23. ALE-XS4 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 24. ALE-XS4 on October 27, 2021.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 25. ALE-XS5 on September 19, 2016.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 26. ALE-XS5 on November 10, 2017.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 27. ALE-XS5 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 28. ALE-XS5 on November 13, 2019.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 29. ALE-XS5 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 30. ALE-XS5 on October 27, 2021.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 31. ALE-XS6 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 32. ALE-XS6 on November 10, 2017.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 33. ALE-XS6 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 34. ALE-XS6 on November 13, 2019.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 35. ALE-XS6 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 36. ALE-XS6 on October 27, 2021.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 37. ALE-XS7 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 38. ALE-XS7 on November 10, 2017.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 39. ALE-XS7 on November 05, 2018.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 40. ALE-XS7 on November 13, 2019.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 41. ALE-XS7 on November 07, 2020.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 42. ALE-XS7 on October 27, 2021.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 43. ALE-XS8 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 44. ALE-XS8 on November 10, 2017.

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 45. ALE-XS8 on November 05, 2018.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 46. ALE-XS8 on November 13, 2019.

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Figure 47. ALE-XS8 on November 07, 2020

a) Looking upstream.

c) Looking from river right to river left.

b) Looking downstream.

d) Looking from river left to river right.

Figure 48. ALE-XS8 on October 27, 2021

a) Looking upstream.

b) Looking downstream.

c) Looking from river right to river left.

d) Looking from river left to river right.

Appendix D. Raw Data Tables and Representative Photographs from Fish Community Surveys

LIST OF FIGURES

Figure 1. Minnow trap #1 at sampling site ALE-MT01 on September 27, 2021. 1

Figure 2. Minnow trap #3 at sampling site ALE-MT02 on September 27, 2021. 1

Figure 3. Minnow trap #2 at sampling site ALE-MT03 on September 27, 2021. 2

Figure 4. Minnow trap #3 at sampling site ALE-MT05 on September 27, 2021. 2

Figure 5. Minnow trap #10 at sampling site ALE-MT06 on September 27, 2021. 3

Figure 6. Minnow trap #1 at sampling site ALE-MT07 on September 27, 2021. 3

Figure 7. Minnow trap #2 at sampling site ALE-MT08 on September 27, 2021. 4

Figure 8. Minnow trap #4 at sampling site ALE-MT09 on September 27, 2021. 4

LIST OF TABLES

Table 1. Summary of minnow traps soak times and capture data at each site. 5

Table 2. Detailed fish capture, fork length and age assigned data..6

Figure 1. Minnow trap #1 at sampling site ALE-MT01 on September 27, 2021.

Figure 2. Minnow trap #3 at sampling site ALE-MT02 on September 27, 2021.

Figure 3. Minnow trap #2 at sampling site ALE-MT03 on September 27, 2021.

Figure 4. Minnow trap #3 at sampling site ALE-MT05 on September 27, 2021.

Figure 5. Minnow trap #10 at sampling site ALE-MT06 on September 27, 2021.

Figure 6. Minnow trap #1 at sampling site ALE-MT07 on September 27, 2021.

Figure 7. Minnow trap #2 at sampling site ALE-MT08 on September 27, 2021.

Figure 8. Minnow trap #4 at sampling site ALE-MT09 on September 27, 2021.

Table 1. Summary of minnow traps soak times and capture data at each site.

Site	Trap #	Mesh Size (mm)	Date In	Time In	Date Out	Time Out	Trap Depth	Soak Time (hrs)	Catch[1]	
									CO	CT
ALE-MT01	1	6.4	27/Sep/21	10:24	28/Sep/21	09:00	0.57	22.60	7	0
ALE-MT01	2	6.4	27/Sep/21	10:26	28/Sep/21	09:00	0.68	22.57	2	0
ALE-MT01	3	6.4	27/Sep/21	10:28	28/Sep/21	09:00	0.90	22.53	4	0
ALE-MT01	4	6.4	27/Sep/21	10:29	28/Sep/21	09:00	0.97	22.52	5	0
ALE-MT01	5	6.4	27/Sep/21	10:32	28/Sep/21	09:00	0.60	22.47	11	0
ALE-MT02	1	6.4	27/Sep/21	11:11	28/Sep/21	10:23	0.30	23.20	12	1
ALE-MT02	2	6.4	27/Sep/21	11:14	28/Sep/21	10:23	0.50	23.15	5	0
ALE-MT02	3	3.2	27/Sep/21	11:15	28/Sep/21	10:23	0.75	23.13	25	0
ALE-MT02	4	6.4	27/Sep/21	11:16	28/Sep/21	10:23	0.90	23.12	8	0
ALE-MT02	5	3.2	27/Sep/21	11:16	28/Sep/21	10:23	0.50	23.12	0	0
ALE-MT07	1	3.2	27/Sep/21	11:29	28/Sep/21	11:19	0.45	23.83	14	0
ALE-MT07	2	6.4	27/Sep/21	11:30	28/Sep/21	11:20	0.90	23.83	10	1
ALE-MT07	3	6.4	27/Sep/21	11:32	28/Sep/21	11:21	0.90	23.82	23	0
ALE-MT07	4	3.2	27/Sep/21	11:33	28/Sep/21	11:22	0.45	23.82	1	0
ALE-MT07	5	3.2	27/Sep/21	11:35	28/Sep/21	11:22	0.55	23.78	12	0
ALE-MT03	1	6.4	27/Sep/21	11:53	28/Sep/21	12:14	0.43	24.35	32	2
ALE-MT03	2	6.4	27/Sep/21	11:54	28/Sep/21	12:14	0.45	24.33	10	1
ALE-MT03	3	3.2	27/Sep/21	11:55	28/Sep/21	12:14	0.70	24.32	35	0
ALE-MT03	4	3.2	27/Sep/21	11:56	28/Sep/21	12:14	0.35	24.30	5	0
ALE-MT03	5	3.2	27/Sep/21	11:57	28/Sep/21	12:14	0.90	24.28	12	0
ALE-MT06	1	3.2	27/Sep/21	13:01	28/Sep/21	13:54	0.30	24.88	24	0
ALE-MT06	2	6.4	27/Sep/21	13:03	28/Sep/21	13:55	0.50	24.87	40	5
ALE-MT06	3	3.2	27/Sep/21	13:03	28/Sep/21	13:56	0.80	24.88	62	0
ALE-MT06	4	3.2	27/Sep/21	13:05	28/Sep/21	13:56	0.95	24.85	72	0
ALE-MT06	5	6.4	27/Sep/21	13:06	28/Sep/21	13:57	1.20	24.85	28	1
ALE-MT06	6	6.4	27/Sep/21	13:08	28/Sep/21	13:57	1.00	24.82	33	4
ALE-MT06	7	3.2	27/Sep/21	13:09	28/Sep/21	13:58	0.45	24.82	34	0
ALE-MT06	8	3.2	27/Sep/21	13:10	28/Sep/21	13:58	1.40	24.80	38	2
ALE-MT06	9	6.4	27/Sep/21	13:10	28/Sep/21	13:58	1.00	24.80	22	5
ALE-MT06	10	6.4	27/Sep/21	13:12	28/Sep/21	13:58	0.45	24.77	33	0
ALE-MT08	1	6.4	27/Sep/21	13:40	28/Sep/21	15:45	0.45	26.08	20	0
ALE-MT08	2	3.2	27/Sep/21	13:40	28/Sep/21	15:45	0.65	26.08	24	0
ALE-MT08	3	6.4	27/Sep/21	13:41	28/Sep/21	15:45	0.30	26.07	25	1
ALE-MT08	4	3.2	27/Sep/21	13:43	28/Sep/21	15:45	0.45	26.03	30	0
ALE-MT08	5	6.4	27/Sep/21	13:45	28/Sep/21	15:45	0.23	26.00	7	0
ALE-MT09	1	6.4	27/Sep/21	13:26	28/Sep/21	16:20	0.75	26.90	16	0
ALE-MT09	2	3.2	27/Sep/21	13:27	28/Sep/21	16:20	0.30	26.88	7	1
ALE-MT09	3	6.4	27/Sep/21	13:28	28/Sep/21	16:21	1.00	26.88	6	0
ALE-MT09	4	6.4	27/Sep/21	13:29	28/Sep/21	16:22	0.45	26.88	34	1
ALE-MT09	5	3.2	27/Sep/21	13:30	28/Sep/21	16:23	0.40	26.88	40	0
ALE-MT05	1	3.2	27/Sep/21	14:00	28/Sep/21	17:15	0.45	27.25	79	0
ALE-MT05	2	3.2	27/Sep/21	14:00	28/Sep/21	17:15	1.00	27.25	35	1
ALE-MT05	3	3.2	27/Sep/21	14:01	28/Sep/21	17:15	0.50	27.23	24	1
ALE-MT05	4	3.2	27/Sep/21	14:02	28/Sep/21	17:15	0.45	27.22	43	1
ALE-MT05	5	6.4	27/Sep/21	14:03	28/Sep/21	17:15	0.36	27.20	8	0

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

ECOFISH RESEARCH

Table 2. Detailed fish capture, fork length and age assigned data.

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT01	2021-Sep-27	1	CO	61		2.2	0.97					0
ALE-MT01	2021-Sep-27	1	CO	69		3.4	1.03	SC	1	FC	1	0
ALE-MT01	2021-Sep-27	1	CO	72		4.4	1.18					1
ALE-MT01	2021-Sep-27	1	CO	75		5.8	1.37					1
ALE-MT01	2021-Sep-27	1	CO	78		3.7	0.78					1
ALE-MT01	2021-Sep-27	1	CO	80		4.2	0.82					1
ALE-MT01	2021-Sep-27	1	CO	85		5.2	0.85					1
ALE-MT01	2021-Sep-27	2	CO	74		5.3	1.31					1
ALE-MT01	2021-Sep-27	2	CO	99		8.6	0.89	SC	3	FC	3	1
ALE-MT01	2021-Sep-27	3	CO	54		3.1	1.97					0
ALE-MT01	2021-Sep-27	3	CO	54		3.1	1.97	SC	5	FC	5	0
ALE-MT01	2021-Sep-27	3	CO	94		7.3	0.88					1
ALE-MT01	2021-Sep-27	3	CO	95		8.9	1.04					1
ALE-MT01	2021-Sep-27	4	CO	52		2.5	1.78					0
ALE-MT01	2021-Sep-27	4	CO	83		7.0	1.22					1
ALE-MT01	2021-Sep-27	4	CO	85		6.2	1.01	SC	6	FC	6	1
ALE-MT01	2021-Sep-27	4	CO	89		7.5	1.06					1
ALE-MT01	2021-Sep-27	4	CO	92		9.3	1.19					1
ALE-MT01	2021-Sep-27	5	CO	65		3.6	1.31					0
ALE-MT01	2021-Sep-27	5	CO	75		4.9	1.16					1
ALE-MT01	2021-Sep-27	5	CO	78		4.7	0.99					1
ALE-MT01	2021-Sep-27	5	CO	80		6.4	1.25					1
ALE-MT01	2021-Sep-27	5	CO	82		5.9	1.07					1
ALE-MT01	2021-Sep-27	5	CO	84		5.1	0.86					1
ALE-MT01	2021-Sep-27	5	CO	85		5.6	0.91					1
ALE-MT01	2021-Sep-27	5	CO	89		7.5	1.06					1
ALE-MT01	2021-Sep-27	5	CO	90		6.7	0.92					1
ALE-MT01	2021-Sep-27	5	CO	93		8.3	1.03					1
ALE-MT01	2021-Sep-27	5	CO	95		8.3	0.97					1
ALE-MT02	2021-Sep-27	1	CO	42		1.0	1.35					0
ALE-MT02	2021-Sep-27	1	CO	45		1.0	1.10					0
ALE-MT02	2021-Sep-27	1	CO	54		1.8	1.14					0
ALE-MT02	2021-Sep-27	1	CO	54		2.3	1.46					0
ALE-MT02	2021-Sep-27	1	CO	56		1.9	1.08					0
ALE-MT02	2021-Sep-27	1	CO	65		3.4	1.24					0
ALE-MT02	2021-Sep-27	1	CO	67		4.6	1.53					0
ALE-MT02	2021-Sep-27	1	CO	73		4.2	1.08					1
ALE-MT02	2021-Sep-27	1	CO	75		4.7	1.11					1
ALE-MT02	2021-Sep-27	1	CO	82		6.8	1.23					1
ALE-MT02	2021-Sep-27	1	CO	83		6.0	1.05					1
ALE-MT02	2021-Sep-27	1	CO	86		7.3	1.15	SC	2	FC	2	1
ALE-MT02	2021-Sep-27	1	CT	83		5.6	0.98	SC	1	FC	1	1
ALE-MT02	2021-Sep-27	2	CO	59		2.3	1.12					0
ALE-MT02	2021-Sep-27	2	CO	70		3.8	1.11					1
ALE-MT02	2021-Sep-27	2	CO	86		7.8	1.23					1
ALE-MT02	2021-Sep-27	2	CO	92		8.3	1.07					1
ALE-MT02	2021-Sep-27	2	CO	97		9.8	1.07	SC	3	FC	3	1

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (2 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT02	2021-Sep-27	3	CO	43		1.2	1.51					0
ALE-MT02	2021-Sep-27	3	CO	47		1.2	1.16					0
ALE-MT02	2021-Sep-27	3	CO	49		1.6	1.36					0
ALE-MT02	2021-Sep-27	3	CO	50		1.5	1.20					0
ALE-MT02	2021-Sep-27	3	CO	54		2.3	1.46					0
ALE-MT02	2021-Sep-27	3	CO	55		1.9	1.14					0
ALE-MT02	2021-Sep-27	3	CO	55		1.9	1.14					0
ALE-MT02	2021-Sep-27	3	CO	59		2.4	1.17					0
ALE-MT02	2021-Sep-27	3	CO	60		2.3	1.06					0
ALE-MT02	2021-Sep-27	3	CO	63		2.9	1.16					0
ALE-MT02	2021-Sep-27	3	CO	65		3.0	1.09					0
ALE-MT02	2021-Sep-27	3	CO	65		3.1	1.13					0
ALE-MT02	2021-Sep-27	3	CO	73		4.1	1.05					1
ALE-MT02	2021-Sep-27	3	CO	75		4.4	1.04					1
ALE-MT02	2021-Sep-27	3	CO	78		6.1	1.29					1
ALE-MT02	2021-Sep-27	3	CO	80		5.4	1.05					1
ALE-MT02	2021-Sep-27	3	CO	81		5.9	1.11					1
ALE-MT02	2021-Sep-27	3	CO	81		6.2	1.17					1
ALE-MT02	2021-Sep-27	3	CO	82		6.3	1.14					1
ALE-MT02	2021-Sep-27	3	CO	82		6.5	1.18					1
ALE-MT02	2021-Sep-27	3	CO	85		7.1	1.16					1
ALE-MT02	2021-Sep-27	3	CO	88		7.3	1.07					1
ALE-MT02	2021-Sep-27	3	CO	88		8.1	1.19					1
ALE-MT02	2021-Sep-27	3	CO	90		8.4	1.15					1
ALE-MT02	2021-Sep-27	3	CO	97		9.7	1.06					1
ALE-MT02	2021-Sep-27	4	CO	51		1.6	1.21	SC	4	FC	4	0
ALE-MT02	2021-Sep-27	4	CO	65		3.1	1.13					0
ALE-MT02	2021-Sep-27	4	CO	68		3.9	1.24					0
ALE-MT02	2021-Sep-27	4	CO	69		3.9	1.19					0
ALE-MT02	2021-Sep-27	4	CO	73		4.3	1.11					1
ALE-MT02	2021-Sep-27	4	CO	74		4.6	1.14					1
ALE-MT02	2021-Sep-27	4	CO	86		7.8	1.23					1
ALE-MT02	2021-Sep-27	4	CO	88		8.0	1.17					1
ALE-MT02	2021-Sep-27	5	NFC									
ALE-MT07	2021-Sep-27	1	CO	44		1.0	1.17					0
ALE-MT07	2021-Sep-27	1	CO	45								0
ALE-MT07	2021-Sep-27	1	CO	47		1.4	1.35					0
ALE-MT07	2021-Sep-27	1	CO	50		1.5	1.20					0
ALE-MT07	2021-Sep-27	1	CO	50								0
ALE-MT07	2021-Sep-27	1	CO	50								0
ALE-MT07	2021-Sep-27	1	CO	53								0
ALE-MT07	2021-Sep-27	1	CO	54		1.7	1.08					0
ALE-MT07	2021-Sep-27	1	CO	68		3.1	0.99	SC	1	FC	1	0
ALE-MT07	2021-Sep-27	1	CO	75		4.7	1.11					1
ALE-MT07	2021-Sep-27	1	CO	77		5.1	1.12					1
ALE-MT07	2021-Sep-27	1	CO	80		5.7	1.11					1
ALE-MT07	2021-Sep-27	1	CO	83		7.5	1.31	SC	2	FC	2	1
ALE-MT07	2021-Sep-27	1	CO	85								1

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (3 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT07	2021-Sep-27	2	CO	50								0
ALE-MT07	2021-Sep-27	2	CO	55								0
ALE-MT07	2021-Sep-27	2	CO	60								0
ALE-MT07	2021-Sep-27	2	CO	65								0
ALE-MT07	2021-Sep-27	2	CO	70								1
ALE-MT07	2021-Sep-27	2	CO	75								1
ALE-MT07	2021-Sep-27	2	CO	75								1
ALE-MT07	2021-Sep-27	2	CO	85								1
ALE-MT07	2021-Sep-27	2	CO	86								1
ALE-MT07	2021-Sep-27	2	CO	90								1
ALE-MT07	2021-Sep-27	2	CT	110		16.5	1.24	SC	3	FC	3	1
ALE-MT07	2021-Sep-27	3	CO	45								0
ALE-MT07	2021-Sep-27	3	CO	45								0
ALE-MT07	2021-Sep-27	3	CO	46		1.4	1.44					0
ALE-MT07	2021-Sep-27	3	CO	50		1.6	1.28					0
ALE-MT07	2021-Sep-27	3	CO	50		1.6	1.28					0
ALE-MT07	2021-Sep-27	3	CO	50								0
ALE-MT07	2021-Sep-27	3	CO	50								0
ALE-MT07	2021-Sep-27	3	CO	50								0
ALE-MT07	2021-Sep-27	3	CO	52		1.8	1.28					0
ALE-MT07	2021-Sep-27	3	CO	52								0
ALE-MT07	2021-Sep-27	3	CO	56		2.4	1.37					0
ALE-MT07	2021-Sep-27	3	CO	60		2.5	1.16					0
ALE-MT07	2021-Sep-27	3	CO	60								0
ALE-MT07	2021-Sep-27	3	CO	65		3.5	1.27					0
ALE-MT07	2021-Sep-27	3	CO	67		3.5	1.16					0
ALE-MT07	2021-Sep-27	3	CO	68								0
ALE-MT07	2021-Sep-27	3	CO	70								1
ALE-MT07	2021-Sep-27	3	CO	72								1
ALE-MT07	2021-Sep-27	3	CO	78								1
ALE-MT07	2021-Sep-27	3	CO	80		5.6	1.09					1
ALE-MT07	2021-Sep-27	3	CO	80		5.7	1.11					1
ALE-MT07	2021-Sep-27	3	CO	80								1
ALE-MT07	2021-Sep-27	4	CO	50								0
ALE-MT07	2021-Sep-27	5	CO	47		1.2	1.16					0
ALE-MT07	2021-Sep-27	5	CO	47		1.5	1.44					0
ALE-MT07	2021-Sep-27	5	CO	49		1.9	1.61					0
ALE-MT07	2021-Sep-27	5	CO	50		1.7	1.36					0
ALE-MT07	2021-Sep-27	5	CO	55		2.0	1.20					0
ALE-MT07	2021-Sep-27	5	CO	55		2.1	1.26					0
ALE-MT07	2021-Sep-27	5	CO	55		2.1	1.26					0
ALE-MT07	2021-Sep-27	5	CO	62		2.7	1.13					0
ALE-MT07	2021-Sep-27	5	CO	67		3.6	1.20					0
ALE-MT07	2021-Sep-27	5	CO	70		3.6	1.05					1
ALE-MT07	2021-Sep-27	5	CO	74		4.9	1.21					1
ALE-MT07	2021-Sep-27	5	CO	77		4.7	1.03	SC	5	FC	5	1
ALE-MT03	2021-Sep-27	1	CO	45		1.4	1.54					0
ALE-MT03	2021-Sep-27	1	CO	50		1.3	1.04					0

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (4 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT03	2021-Sep-27	1	CO	50								0
ALE-MT03	2021-Sep-27	1	CO	50								0
ALE-MT03	2021-Sep-27	1	CO	52		1.4	1.00					0
ALE-MT03	2021-Sep-27	1	CO	54		1.7	1.08					0
ALE-MT03	2021-Sep-27	1	CO	54		1.8	1.14					0
ALE-MT03	2021-Sep-27	1	CO	55		1.8	1.08					0
ALE-MT03	2021-Sep-27	1	CO	60		3.1	1.44					0
ALE-MT03	2021-Sep-27	1	CO	62								0
ALE-MT03	2021-Sep-27	1	CO	62								0
ALE-MT03	2021-Sep-27	1	CO	64								0
ALE-MT03	2021-Sep-27	1	CO	65		3.7	1.35					0
ALE-MT03	2021-Sep-27	1	CO	70								1
ALE-MT03	2021-Sep-27	1	CO	73		4.2	1.08					1
ALE-MT03	2021-Sep-27	1	CO	73								1
ALE-MT03	2021-Sep-27	1	CO	73								1
ALE-MT03	2021-Sep-27	1	CO	75		4.8	1.14					1
ALE-MT03	2021-Sep-27	1	CO	75		5.0	1.19					1
ALE-MT03	2021-Sep-27	1	CO	75								1
ALE-MT03	2021-Sep-27	1	CO	75								1
ALE-MT03	2021-Sep-27	1	CO	77								1
ALE-MT03	2021-Sep-27	1	CO	78								1
ALE-MT03	2021-Sep-27	1	CO	80								1
ALE-MT03	2021-Sep-27	1	CO	80								1
ALE-MT03	2021-Sep-27	1	CO	80								1
ALE-MT03	2021-Sep-27	1	CO	82		6.5	1.18					1
ALE-MT03	2021-Sep-27	1	CO	82								1
ALE-MT03	2021-Sep-27	1	CO	84		5.9	1.00					1
ALE-MT03	2021-Sep-27	1	CO	84								1
ALE-MT03	2021-Sep-27	1	CO	86		7.3	1.15					1
ALE-MT03	2021-Sep-27	1	CO	92		9.1	1.17	SC	1	FC	1	1
ALE-MT03	2021-Sep-27	1	CT	72		4.8	1.29	SC	2	FC	2	1
ALE-MT03	2021-Sep-27	1	CT	87		6.3	0.96	SC	3	FC	3	1
ALE-MT03	2021-Sep-27	2	CO	40								0
ALE-MT03	2021-Sep-27	2	CO	40								0
ALE-MT03	2021-Sep-27	2	CO	41								0
ALE-MT03	2021-Sep-27	2	CO	43								0
ALE-MT03	2021-Sep-27	2	CO	45								0
ALE-MT03	2021-Sep-27	2	CO	45								0
ALE-MT03	2021-Sep-27	2	CO	50								0
ALE-MT03	2021-Sep-27	2	CO	50								0
ALE-MT03	2021-Sep-27	2	CO	52								0
ALE-MT03	2021-Sep-27	2	CO	83								1
ALE-MT03	2021-Sep-27	2	CT	110		14.4	1.08	SC	4	FC	4	1
ALE-MT03	2021-Sep-27	3	CO	45								0
ALE-MT03	2021-Sep-27	3	CO	47								0
ALE-MT03	2021-Sep-27	3	CO	50		1.5	1.20					0
ALE-MT03	2021-Sep-27	3	CO	50								0
ALE-MT03	2021-Sep-27	3	CO	50								0

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (5 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT03	2021-Sep-27	3	CO	50								0
ALE-MT03	2021-Sep-27	3	CO	52		1.6	1.14					0
ALE-MT03	2021-Sep-27	3	CO	55								0
ALE-MT03	2021-Sep-27	3	CO	59								0
ALE-MT03	2021-Sep-27	3	CO	60		2.3	1.06					0
ALE-MT03	2021-Sep-27	3	CO	61								0
ALE-MT03	2021-Sep-27	3	CO	65								0
ALE-MT03	2021-Sep-27	3	CO	65								0
ALE-MT03	2021-Sep-27	3	CO	65								0
ALE-MT03	2021-Sep-27	3	CO	65								0
ALE-MT03	2021-Sep-27	3	CO	67								0
ALE-MT03	2021-Sep-27	3	CO	70		4.1	1.20					1
ALE-MT03	2021-Sep-27	3	CO	70								1
ALE-MT03	2021-Sep-27	3	CO	70								1
ALE-MT03	2021-Sep-27	3	CO	72		3.9	1.04					1
ALE-MT03	2021-Sep-27	3	CO	72								1
ALE-MT03	2021-Sep-27	3	CO	73		5.7	1.47					1
ALE-MT03	2021-Sep-27	3	CO	73								1
ALE-MT03	2021-Sep-27	3	CO	75								1
ALE-MT03	2021-Sep-27	3	CO	78		5.9	1.24					1
ALE-MT03	2021-Sep-27	3	CO	80								1
ALE-MT03	2021-Sep-27	3	CO	80								1
ALE-MT03	2021-Sep-27	3	CO	81								1
ALE-MT03	2021-Sep-27	3	CO	82								1
ALE-MT03	2021-Sep-27	3	CO	83								1
ALE-MT03	2021-Sep-27	3	CO	85								1
ALE-MT03	2021-Sep-27	3	CO	85								1
ALE-MT03	2021-Sep-27	3	CO	87								1
ALE-MT03	2021-Sep-27	3	CO	92								1
ALE-MT03	2021-Sep-27	3	CO	95								1
ALE-MT03	2021-Sep-27	4	CO	58		2.0	1.03					0
ALE-MT03	2021-Sep-27	4	CO	58		2.8	1.44					0
ALE-MT03	2021-Sep-27	4	CO	65		3.2	1.17					0
ALE-MT03	2021-Sep-27	4	CO	79		5.6	1.14					1
ALE-MT03	2021-Sep-27	4	CO	80		5.4	1.05					1
ALE-MT03	2021-Sep-27	5	CO	61		3.0	1.32					0
ALE-MT03	2021-Sep-27	5	CO	65		3.0	1.09					0
ALE-MT03	2021-Sep-27	5	CO	66		3.7	1.29					0
ALE-MT03	2021-Sep-27	5	CO	71		4.1	1.15					1
ALE-MT03	2021-Sep-27	5	CO	75		4.5	1.07					1
ALE-MT03	2021-Sep-27	5	CO	75		5.0	1.19					1
ALE-MT03	2021-Sep-27	5	CO	75		5.1	1.21					1
ALE-MT03	2021-Sep-27	5	CO	78		5.3	1.12					1
ALE-MT03	2021-Sep-27	5	CO	78		5.7	1.20					1
ALE-MT03	2021-Sep-27	5	CO	79		5.3	1.07	SC	5	FC	5	1
ALE-MT03	2021-Sep-27	5	CO	80		5.6	1.09					1
ALE-MT03	2021-Sep-27	5	CO	85		6.6	1.07					1
ALE-MT08	2021-Sep-27	1	CO	38		0.7	1.28					0

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (6 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT08	2021-Sep-27	1	CO	38		0.9	1.64					0
ALE-MT08	2021-Sep-27	1	CO	42		1.0	1.35					0
ALE-MT08	2021-Sep-27	1	CO	42		1.1	1.48					0
ALE-MT08	2021-Sep-27	1	CO	45		1.1	1.21					0
ALE-MT08	2021-Sep-27	1	CO	45		1.2	1.32					0
ALE-MT08	2021-Sep-27	1	CO	47		1.6	1.54	SC	1	FC	1	0
ALE-MT08	2021-Sep-27	1	CO	50		1.9	1.52					0
ALE-MT08	2021-Sep-27	1	CO	51		1.9	1.43					0
ALE-MT08	2021-Sep-27	1	CO	75		5.1	1.21					1
ALE-MT08	2021-Sep-27	1	CO	82		6.8	1.23					1
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	1	CO									
ALE-MT08	2021-Sep-27	2	CO	50		1.8	1.44					0
ALE-MT08	2021-Sep-27	2	CO	52		1.9	1.35					0
ALE-MT08	2021-Sep-27	2	CO	72		5.2	1.39					1
ALE-MT08	2021-Sep-27	2	CO	73		4.2	1.08					1
ALE-MT08	2021-Sep-27	2	CO	74		4.5	1.11					1
ALE-MT08	2021-Sep-27	2	CO	78		6.0	1.26	SC	2	FC	2	1
ALE-MT08	2021-Sep-27	2	CO	80		6.0	1.17					1
ALE-MT08	2021-Sep-27	2	CO	85		7.1	1.16					1
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	2	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (7 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CO									
ALE-MT08	2021-Sep-27	3	CT	132		21.8	0.95					2
ALE-MT08	2021-Sep-27	4	CO	54		2.3	1.46					0
ALE-MT08	2021-Sep-27	4	CO	56		3.1	1.77					0
ALE-MT08	2021-Sep-27	4	CO	61		3.0	1.32					0
ALE-MT08	2021-Sep-27	4	CO	76		4.7	1.07					1
ALE-MT08	2021-Sep-27	4	CO	77		5.7	1.25					1
ALE-MT08	2021-Sep-27	4	CO	80		5.5	1.07					1
ALE-MT08	2021-Sep-27	4	CO	80		5.8	1.13					1
ALE-MT08	2021-Sep-27	4	CO	85		6.8	1.11					1
ALE-MT08	2021-Sep-27	4	CO	85		6.9	1.12					1
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (8 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	4	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT08	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	1	CO	76		5.6	1.28					1
ALE-MT09	2021-Sep-27	1	CO	84		7.1	1.20					1
ALE-MT09	2021-Sep-27	1	CO	85		6.8	1.11	SC	1	FC	1	1
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	1	CO									
ALE-MT09	2021-Sep-27	2	CO	45		1.1	1.21					0
ALE-MT09	2021-Sep-27	2	CO	70		4.4	1.28					1
ALE-MT09	2021-Sep-27	2	CO	73		4.7	1.21					1
ALE-MT09	2021-Sep-27	2	CO	92		8.7	1.12					1
ALE-MT09	2021-Sep-27	2	CO									
ALE-MT09	2021-Sep-27	2	CO									
ALE-MT09	2021-Sep-27	2	CO									
ALE-MT09	2021-Sep-27	2	CT	121		18.2	1.03					1
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	3	CO									
ALE-MT09	2021-Sep-27	4	CO	48		1.2	1.09					0
ALE-MT09	2021-Sep-27	4	CO	50		1.8	1.44					0
ALE-MT09	2021-Sep-27	4	CO	69		3.5	1.07					0
ALE-MT09	2021-Sep-27	4	CO	75		4.6	1.09					1
ALE-MT09	2021-Sep-27	4	CO	75		4.9	1.16					1
ALE-MT09	2021-Sep-27	4	CO	79		5.9	1.20					1
ALE-MT09	2021-Sep-27	4	CO	80		5.6	1.09					1
ALE-MT09	2021-Sep-27	4	CO	81		5.9	1.11					1

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (9 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CO									
ALE-MT09	2021-Sep-27	4	CT	56		2.4	1.37					1
ALE-MT09	2021-Sep-27	5	CO	40		0.6	0.94					0
ALE-MT09	2021-Sep-27	5	CO	40		0.9	1.41					0
ALE-MT09	2021-Sep-27	5	CO	45		1.2	1.32					0
ALE-MT09	2021-Sep-27	5	CO	46		1.4	1.44					0
ALE-MT09	2021-Sep-27	5	CO	50		1.7	1.36					0
ALE-MT09	2021-Sep-27	5	CO	50		1.7	1.36					0
ALE-MT09	2021-Sep-27	5	CO	54		1.6	1.02					0
ALE-MT09	2021-Sep-27	5	CO	55		2.0	1.20					0
ALE-MT09	2021-Sep-27	5	CO	65		2.9	1.06					0
ALE-MT09	2021-Sep-27	5	CO	73		4.6	1.18					1
ALE-MT09	2021-Sep-27	5	CO	75		4.6	1.09	SC	2	FC	2	1
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (10 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT09	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	1	CO	43		1.2	1.51					0
ALE-MT06	2021-Sep-27	1	CO	45								0
ALE-MT06	2021-Sep-27	1	CO	48		1.5	1.36					0
ALE-MT06	2021-Sep-27	1	CO	49		1.1	0.93					0
ALE-MT06	2021-Sep-27	1	CO	50								0
ALE-MT06	2021-Sep-27	1	CO	50								0
ALE-MT06	2021-Sep-27	1	CO	50								0
ALE-MT06	2021-Sep-27	1	CO	52		2.1	1.49					0
ALE-MT06	2021-Sep-27	1	CO	60								0
ALE-MT06	2021-Sep-27	1	CO	72								1
ALE-MT06	2021-Sep-27	1	CO	73								1
ALE-MT06	2021-Sep-27	1	CO	74								1
ALE-MT06	2021-Sep-27	1	CO	75								1
ALE-MT06	2021-Sep-27	1	CO	75								1
ALE-MT06	2021-Sep-27	1	CO	78								1
ALE-MT06	2021-Sep-27	1	CO	85								1
ALE-MT06	2021-Sep-27	1	CO	85								1
ALE-MT06	2021-Sep-27	1	CO	88								1
ALE-MT06	2021-Sep-27	1	CO	88								1
ALE-MT06	2021-Sep-27	1	CO	90								1
ALE-MT06	2021-Sep-27	1	CO	90								1
ALE-MT06	2021-Sep-27	1	CO	90								1
ALE-MT06	2021-Sep-27	1	CO	91								1
ALE-MT06	2021-Sep-27	1	CO	94		9.1	1.10					1
ALE-MT06	2021-Sep-27	2	CO	43		0.1	0.11					0
ALE-MT06	2021-Sep-27	2	CO	44		0.1	0.09					0
ALE-MT06	2021-Sep-27	2	CO	44		1.1	1.29					0
ALE-MT06	2021-Sep-27	2	CO	44		1.5	1.76					0
ALE-MT06	2021-Sep-27	2	CO	45		1.0	1.10					0

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (11 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	2	CO	45		1.3	1.43					0
ALE-MT06	2021-Sep-27	2	CO	45		1.3	1.43					0
ALE-MT06	2021-Sep-27	2	CO	46		1.3	1.34					0
ALE-MT06	2021-Sep-27	2	CO	49		1.3	1.10					0
ALE-MT06	2021-Sep-27	2	CO	49		1.8	1.53					0
ALE-MT06	2021-Sep-27	2	CO	50		1.5	1.20					0
ALE-MT06	2021-Sep-27	2	CO	50		1.9	1.52					0
ALE-MT06	2021-Sep-27	2	CO	50								0
ALE-MT06	2021-Sep-27	2	CO	51		2.1	1.58					0
ALE-MT06	2021-Sep-27	2	CO	52		1.3	0.92					0
ALE-MT06	2021-Sep-27	2	CO	53		1.6	1.07					0
ALE-MT06	2021-Sep-27	2	CO	65		2.9	1.06					0
ALE-MT06	2021-Sep-27	2	CO	72		4.2	1.13					1
ALE-MT06	2021-Sep-27	2	CO	72		4.8	1.29					1
ALE-MT06	2021-Sep-27	2	CO	77		5.2	1.14					1
ALE-MT06	2021-Sep-27	2	CO	80								1
ALE-MT06	2021-Sep-27	2	CO		50							0
ALE-MT06	2021-Sep-27	2	CO		50							0
ALE-MT06	2021-Sep-27	2	CO		60							0
ALE-MT06	2021-Sep-27	2	CO		60							0
ALE-MT06	2021-Sep-27	2	CO		60							0
ALE-MT06	2021-Sep-27	2	CO		60							0
ALE-MT06	2021-Sep-27	2	CO		60							0
ALE-MT06	2021-Sep-27	2	CO		70							1
ALE-MT06	2021-Sep-27	2	CO		70							1
ALE-MT06	2021-Sep-27	2	CO		70							1
ALE-MT06	2021-Sep-27	2	CO		80							1
ALE-MT06	2021-Sep-27	2	CO		80							1
ALE-MT06	2021-Sep-27	2	CO		80							1
ALE-MT06	2021-Sep-27	2	CO		80							1
ALE-MT06	2021-Sep-27	2	CO		90							1
ALE-MT06	2021-Sep-27	2	CO		90							1
ALE-MT06	2021-Sep-27	2	CO		90							1
ALE-MT06	2021-Sep-27	2	CO		90							1
ALE-MT06	2021-Sep-27	2	CO		90							1
ALE-MT06	2021-Sep-27	2	CT	53		1.7	1.14	SC	2	FC	2	0
ALE-MT06	2021-Sep-27	2	CT	105		11.9	1.03	SC	3	FC	3	1
ALE-MT06	2021-Sep-27	2	CT	122		18.6	1.02					1
ALE-MT06	2021-Sep-27	2	CT	126		20.7	1.03	SC	4	FC	4	1
ALE-MT06	2021-Sep-27	2	CT	130		22.2	1.01	SC	1	FC	1	2
ALE-MT06	2021-Sep-27	3	CO	40		1.1	1.72					0
ALE-MT06	2021-Sep-27	3	CO	40								0
ALE-MT06	2021-Sep-27	3	CO	40								0
ALE-MT06	2021-Sep-27	3	CO	40								0
ALE-MT06	2021-Sep-27	3	CO	45		1.1	1.21					0
ALE-MT06	2021-Sep-27	3	CO	45		1.4	1.54					0
ALE-MT06	2021-Sep-27	3	CO	45		1.4	1.54					0
ALE-MT06	2021-Sep-27	3	CO	45								0

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (12 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	3	CO	46		1.6	1.64	SC	5	FC	5	0
ALE-MT06	2021-Sep-27	3	CO	48								0
ALE-MT06	2021-Sep-27	3	CO	50								0
ALE-MT06	2021-Sep-27	3	CO	50								0
ALE-MT06	2021-Sep-27	3	CO	52								0
ALE-MT06	2021-Sep-27	3	CO	60								0
ALE-MT06	2021-Sep-27	3	CO	65								0
ALE-MT06	2021-Sep-27	3	CO	71		3.8	1.06					1
ALE-MT06	2021-Sep-27	3	CO	72		4.2	1.13					1
ALE-MT06	2021-Sep-27	3	CO	75								1
ALE-MT06	2021-Sep-27	3	CO	78								1
ALE-MT06	2021-Sep-27	3	CO	80		5.2	1.02					1
ALE-MT06	2021-Sep-27	3	CO	80								1
ALE-MT06	2021-Sep-27	3	CO	80								1
ALE-MT06	2021-Sep-27	3	CO	83								1
ALE-MT06	2021-Sep-27	3	CO	85		6.7	1.09					1
ALE-MT06	2021-Sep-27	3	CO	90								1
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (13 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	3	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (14 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	4	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (15 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CO									
ALE-MT06	2021-Sep-27	5	CT	115		15.6	1.03	SC	6	FC	6	1
ALE-MT06	2021-Sep-27	6	CO	42		0.9	1.21					0
ALE-MT06	2021-Sep-27	6	CO	55		1.8	1.08					0
ALE-MT06	2021-Sep-27	6	CO	65		3.2	1.17					0
ALE-MT06	2021-Sep-27	6	CO	72		4.0	1.07					1
ALE-MT06	2021-Sep-27	6	CO	75		3.8	0.90					1
ALE-MT06	2021-Sep-27	6	CO	75		4.4	1.04					1
ALE-MT06	2021-Sep-27	6	CO	79		5.6	1.14					1
ALE-MT06	2021-Sep-27	6	CO	80		5.7	1.11					1
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CO									
ALE-MT06	2021-Sep-27	6	CT	100		10.9	1.09					1
ALE-MT06	2021-Sep-27	6	CT	112		13.3	0.95					1
ALE-MT06	2021-Sep-27	6	CT	128		20.7	0.99					2
ALE-MT06	2021-Sep-27	6	CT	130		20.6	0.94					2

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (16 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	7	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

ECOFISH RESEARCH

Table 2. Continued (17 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CO									
ALE-MT06	2021-Sep-27	8	CT	50								0
ALE-MT06	2021-Sep-27	8	CT	70								1
ALE-MT06	2021-Sep-27	9	CO	64		3.0	1.14					0
ALE-MT06	2021-Sep-27	9	CO	73		4.7	1.21					1
ALE-MT06	2021-Sep-27	9	CO	75		4.6	1.09					1
ALE-MT06	2021-Sep-27	9	CO	79		5.1	1.03					1
ALE-MT06	2021-Sep-27	9	CO	82		6.5	1.18					1
ALE-MT06	2021-Sep-27	9	CO	85		7.1	1.16					1
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									
ALE-MT06	2021-Sep-27	9	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (18 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT06	2021-Sep-27	9	CT	120		16.1	0.93					1
ALE-MT06	2021-Sep-27	9	CT	130		23.5	1.07					2
ALE-MT06	2021-Sep-27	9	CT	140		26.1	0.95					2
ALE-MT06	2021-Sep-27	9	CT	140		27.5	1.00					2
ALE-MT06	2021-Sep-27	9	CT	143		29.2	1.00					2
ALE-MT06	2021-Sep-27	10	CO	50		1.5	1.20					0
ALE-MT06	2021-Sep-27	10	CO	55		2.7	1.62					0
ALE-MT06	2021-Sep-27	10	CO	59		2.3	1.12					0
ALE-MT06	2021-Sep-27	10	CO	65		3.7	1.35					0
ALE-MT06	2021-Sep-27	10	CO	79		5.2	1.05					1
ALE-MT06	2021-Sep-27	10	CO	81		6.8	1.28					1
ALE-MT06	2021-Sep-27	10	CO	84		6.4	1.08					1
ALE-MT06	2021-Sep-27	10	CO	85		7.2	1.17					1
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT06	2021-Sep-27	10	CO									
ALE-MT05	2021-Sep-27	1	CO	45		1.4	1.54					0
ALE-MT05	2021-Sep-27	1	CO	49		1.3	1.10	SC	2	FC	2	0
ALE-MT05	2021-Sep-27	1	CO	50		1.2	0.96					0
ALE-MT05	2021-Sep-27	1	CO	53		2.0	1.34					0
ALE-MT05	2021-Sep-27	1	CO	63		2.5	1.00					0
ALE-MT05	2021-Sep-27	1	CO	75		4.4	1.04					1
ALE-MT05	2021-Sep-27	1	CO	75		5.4	1.28					1
ALE-MT05	2021-Sep-27	1	CO	82		6.0	1.09					1
ALE-MT05	2021-Sep-27	1	CO	90		7.6	1.04	SC	1	FC	1	1
ALE-MT06	2021-Sep-27	10	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (19 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (20 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	1	CO									
ALE-MT05	2021-Sep-27	2	CO	71		4.6	1.29					1
ALE-MT05	2021-Sep-27	2	CO	72		4.4	1.18					1
ALE-MT05	2021-Sep-27	2	CO	73		4.0	1.03					1
ALE-MT05	2021-Sep-27	2	CO	75		4.8	1.14					1
ALE-MT05	2021-Sep-27	2	CO	75		4.8	1.14					1
ALE-MT05	2021-Sep-27	2	CO	76		5.1	1.16					1
ALE-MT05	2021-Sep-27	2	CO	80		6.0	1.17					1
ALE-MT05	2021-Sep-27	2	CO	85		6.9	1.12					1
ALE-MT05	2021-Sep-27	2	CO	89		7.4	1.05					1
ALE-MT05	2021-Sep-27	2	CO	96		10.1	1.14					1
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (21 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CO									
ALE-MT05	2021-Sep-27	2	CT	105		11.9	1.03	SC	3	FC	3	1
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CO									
ALE-MT05	2021-Sep-27	3	CT	90		7.3	1.00	SC	4	FC	4	1
ALE-MT05	2021-Sep-27	4	CO	46		1.3	1.34					0
ALE-MT05	2021-Sep-27	4	CO	50		1.4	1.12					0
ALE-MT05	2021-Sep-27	4	CO	50		1.6	1.28					0
ALE-MT05	2021-Sep-27	4	CO	70		3.6	1.05					1
ALE-MT05	2021-Sep-27	4	CO	78		5.3	1.12					1
ALE-MT05	2021-Sep-27	4	CO	81		6.5	1.22					1
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Table 2. Continued (22 of 22).

Site	Date	Trap #	Species[1]	Measured Fork Length (mm)	Estimated Fork Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Number	Age Assigned
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CO									
ALE-MT05	2021-Sep-27	4	CT	115		13.9	0.91					1
ALE-MT05	2021-Sep-27	5	CO	74		5.1	1.26					1
ALE-MT05	2021-Sep-27	5	CO	75		4.6	1.09					1
ALE-MT05	2021-Sep-27	5	CO	75		5.1	1.21					1
ALE-MT05	2021-Sep-27	5	CO	76		4.6	1.05					1
ALE-MT05	2021-Sep-27	5	CO	79		5.4	1.10					1
ALE-MT05	2021-Sep-27	5	CO	80		5.3	1.04					1
ALE-MT05	2021-Sep-27	5	CO	81		5.8	1.09					1
ALE-MT05	2021-Sep-27	5	CO	87		7.5	1.14					1

[1] CO = Coho Salmon, CT = Cutthroat Trout, NFC = No Fish Captured.

Appendix E. Revegetation Assessment – Riparian Revegetation Monitoring Photographs for the Compensation Channel 2021

LIST OF FIGURES

Figure 1. ALE-PRM03, taken from plot centre at 0º. 1
Figure 2. Representative photo of ALE-PRM03....3
Figure 3. ALE-PRM05, taken from plot centre at 0º. 5
Figure 4. Representative photo of ALE-PRM05....7
Figure 5. ALE-PRM06 taken from plot centre at 0º. 9
Figure 6. Representative photo of ALE-PRM06....11
Figure 7. ALE-PRM07 taken from plot centre at 0º. 13
Figure 8. Representative photo of ALE-PRM07....15

1. ALE-PRM03

Figure 1. ALE-PRM03, taken from plot centre at 0º.

a) On October 25, 2016.

b) On October 5, 2017.

c) On October 29, 2019.

d) On September 01, 2021.

Figure 2. Representative photo of ALE-PRM03.

a) On October 5, 2017.

b) On October 29, 2019.

c) On September 1, 2021.

2. ALE-PRM05

Figure 3. ALE-PRM05, taken from plot centre at 0º.

a) On October 25, 2016.

b) On October 5, 2017.

c) On October 29, 2019.

d) On September 01, 2021.

Figure 4. Representative photo of ALE-PRM05.

a) On October 5, 2017.

b) On October 29, 2019.

c) On September 1, 2021.

3. ALE-PRM06

Figure 5. ALE-PRM06 taken from plot centre at 0º.

a) On October 25, 2016.

b) On October 5, 2017.

c) On October 29, 2019.

d) On September 1, 2021.

Figure 6. Representative photo of ALE-PRM06.

a) On October 5, 2017.

b) On October 29, 2019.

c) On September 1, 2021.

4. ALE-PRM07

Figure 7. ALE-PRM07 taken from plot centre at 0º.

a) On October 25, 2016.

b) On October 5, 2017.

c) On October 29, 2019.

d) On September 1, 2021.

Figure 8. Representative photo of ALE-PRM07.

a) On October 5, 2017.

b) On October 29, 2019.

c) On September 1, 2021.

Appendix B. Hedberg Vegetation Monitoring Report

UPPER LILLOOET HYDRO PROJECT
REVEGETATION ASSESSMENT REPORT FOR THE OPERATIONAL ENVIRONMENTAL MONITORING PLAN (OEMP)
YEAR 3 - 2020 MONITORING YEAR

PREPARED FOR:

UPPER LILLOOET RIVER POWER LIMITED PARTNERSHIP AND BOULDER CREEK LIMITED PARTNERSHIP

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Senior Review

Disclaimer:

Hedberg and Associates Consulting Ltd. (Hedberg and Associates) prepared this report for Upper Lillooet River Power Limited Partnership and Boulder Creek Limited Partnership. The material in it reflects the professional judgment of Hedberg and Associates in light of the information available to Hedberg and Associates at the time of report preparation. Judgment has been applied in developing the recommendations in this report. No other warranty is made, either expressed or implied to our clients, third parties, and any regulatory agencies that may be impacted by the recommendations. Any use, which a Third Party makes of this report, or any reliance on decisions based on it, is the responsibility of such Third Parties. Hedberg and Associates accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

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Table of Contents

List of Appendices 7

Appendix A: Maps of Project Revegetation Sites 7

Appendix B: Civil Works Sites Permanent Monitoring Plot Data for Sites Established in 2018. 7

Appendix C: Civil Works Sites Permanent Monitoring Plot Data for Sites Established in 2020. 7

Appendix D: Transmission Line Permanent Monitoring Plot Data for Sites Established in 2018. 7

1. Introduction 8

2. Scope of the Revegetation Monitoring Program 8

3. Revegetation/ Restoration Works Source Documents 9

4. Objectives of Revegetation Program 10

4.1 Long-term Revegetation Goals 10

4.2 Short-term Revegetation Goals 11

4.3 Site-specific Revegetation Goals 11

5. 2020 Revegetation Monitoring Program and Data Collection Methods 11

5.1 Permanent Vegetation Density Monitoring Plots 13

5.1.1 Success Targets for Stem Densities 13

5.1.1.1 Shrubs and Deciduous Trees (Density Targets) 14

5.1.1.2 Conifer Tree Species (Density Targets) 14

5.2 Percentage of Vegetation Cover Estimate (Quadrat monitoring) 14

5.2.1 Success Targets for Percent Vegetation Cover 15

5.3 Inspection Points 15

5.3.1 Success Targets for Inspection Points 15

5.4 Wildlife Specific Revegetation Requirements 16

5.4.1 Success Targets within Grizzly Bear Wildlife Habitat Areas (WHA) 16

5.4.2 Success Targets within Moose Ungulate Winter Range (UWR) 16

5.4.3 Success Targets within Deer Ungulate Winter Range (UWR) 16

6. Results 17

6.1 Results for Civil Works Sites with 2018 and 2020 Data 17

6.1.1 Zone 1 Results Summary 17
6.1.2 Zone 2 Results Summary 21
6.1.3 Zone 3 Results Summary 26
6.1.4 Zone 4 Results Summary 32
6.1.5 Zone 5 Results Summary 34
6.1.6 Zone 6 Results Summary 39
6.2. Results for Civil Work Sites Plots Established in 2019 and 2020 51
6.3. Results for Transmission Line Sites 65
6.3. Transmission Line Road Site 53.1/56.1 Summary 66
6.3.1 Transmission Line Road 73.1 Summary 68
6.3.2 Transmission Line Road 129.1 Summary 70
6.3.3 Transmission Line Road 130.1 Summary 72
6.3.4 Transmission Line Road 133.1 Summary 74
6.3.5 Transmission Line Road 140.1 Summary 76
6.3.6 Transmission Line Road 163.1 Summary 78
6.3.7 Transmission Line Road 237.1 Summary 79
6.3.8 Transmission Line Road 238.1 Summary 81
6.3.9 Transmission Line Road 239.1 Summary 83
6.3.11 Transmission Line Road 245.1 Summary 85
6.3.12 Transmission Line Road 247.1/249.1 Summary 87
6.3.13 Transmission Line Road 250.1 Summary 89
6.3.14 Transmission Line Road 255.1 Summary 91
6.3.15 Transmission Line Road 260.1 Summary 93
6.3.16 Ryan Crossing Summary 95
6.4. Quadrat Survey Results 97
6.4.1 Civil Works Sites Quadrat Survey Results 97
6.4.2 Transmission Line Quadrat Survey Results 99
6.5. Invasive Plants Monitoring Results 101
6.6. Species Diversity Results 102
7. Conclusions 104
8. Recommendations 104
References 104

Appendices..106

List of Figures

Figure 1. Zone 1 Plot Photos from 2018 and 2020 19
Figure 3. Zone 3 Plot Photos from 2018 and 2020.. 27
Figure 4. Zone 4 Plot Photos from 2018 and 2020 32
Figure 5. Zone 5 Plot Photos from 2018 and 2020 35
Figure 6. Zone 6 Plot Photos from 2018 and 2020 41
Figure 7. 38 Km Laydown Plot Photos from 2020.. 53
Figure 8. 41.7 Km Laydown Plot Photo from 2020 59
Figure 9. Boulder Spoil #4 and #7 Plot Photos from 2020 60
Figure 10. Camp Photos from 2020 61
Figure 11. Upper Spoil #5 Plot Photos from 2020.. 64
Figure 12. Upper Spoil #7 Plot Photos from 2020.. 65
Figure 13. 53.1/56.1 Plot Photos from 2018 and 2020.. 66
Figure 14. 73.1 Plot Photos from 2018 and 2020 68
Figure 15. 29.1 Plot Photos from 2018 and 2020 70
Figure 16. 130.1 Plot Photos from 2018 and 2020 72
Figure 17. 133.1 Plot Photos from 2018 and 2020 74
Figure 18. 140.1 Plot Photos from 2018 and 2020 76
Figure 19. 163.1 Plot Photos from 2018 and 2020 78
Figure 20. 237.1 Plot Photos from 2018 and 2020 79
Figure 21. 238.1 Plot Photos from 2018 and 2020 81
Figure 22. 239.1 Plot Photos from 2018 and 2020 83
Figure 23. 245.1 Plot Photos from 2018 and 2020 85
Figure 24. 247./249.1 Plot Photos from 2018 and 2020... 87
Figure 25. 250.1 Plot Photos from 2018 to 2020 89
Figure 26. 255.1 Plot Photos from 2018 and 2020 91
Figure 27. 260.1 Plot Photos from 2018 and 2020 93
Figure 28. Ryan Crossing Photos from 2018 and 2020 95

List of Tables

Table 1. Zone 1 - Species Diversity from 2018 to 2020……………………………………………………………………20
Table 2. Zone 2 - Species Diversity from 2018 to 2020……………………………………………………………………25
Table 3. Zone 3 - Species Diversity from 2018 to 2020……………………………………………………………………31
Table 4. Zone 4 - Species Diversity from 2018 to 2020……………………………………………………………………33
Table 5. Zone 5 - Species Diversity from 2018 to 2020……………………………………………………………………38
Table 6. Zone 6- Species Diversity from 2018 to 2020……………………………………………………………………49
Table 7. 53.1/56.1 Species Diversity from 2018 to 2020…………………………………………………………………67
Table 8. 73.1 Species Diversity from 2018 to 2020…………………………………………………………………………69
Table 9. 129.1 Species Diversity from 2018 and 2020……………………………………………………………………..71
Table 10. 130.1 Species Diversity from 2018 to 2020……………………………………………………………………..73
Table 11. 133.1 Species Diversity from 2018 to 2020……………………………………………………………………..75
Table 12. 140.1 Species Diversity from 2018 to 2020……………………………………………………………………..77
Table 13. Species Diversity from 2018 and 2020……………………………………………………………………………..80
Table 14. 238.1 Species Diversity from 2018 to 2020……………………………………………………………………..82
Table 15. 239.1 Species Diversity from 2018 and 2020…………………………………………………………………..84
Table 16. 245.1 Species Diversity from 2018 to 2020……………………………………………………………………..86
Table 17. 247./249.1 Species Diversity from 2018 to 2020……………………………………………………………..88
Table 18. 250.1 Species Diversity from 2018 to 2020……………………………………………………………………..90
Table 19. 255.1 Species Diversity from 2018 to 2020……………………………………………………………………..92
Table 20. 260.1 Species Diversity from 2018 to 2020……………………………………………………………………..94
Table 21. Ryan Crossing Species Diversity from 2018 to 2020………………………………………………………..96
Table 22. Civil Works Sites - Percent Cover of Herbaceous Layer from Quadrat Plot Data …………………97
Table 23. Civil Works Sites - Percent Cover of Shrub Layer from Quadrat Plot Data……………………………98
Table 24. Civil Works Sites - Percent Cover of Tree Layer from Quadrat Plot Data………………………………98
Table 25. Transmission Line Sites - Percent Cover of Herbaceous Layer from Quadrat Plot Data………..99
Table 26. Transmission Line Sites - Percent Cover of Shrub Layer from Quadrat Plot Data………………..100
Table 27. Transmission Line Sites - Percent Cover of Tree Layer from Quadrat Plot Data…………………100
Table 28. Invasive Species Occurrences by Site……………………………………………………………………………101
Table 29. List of Tree and Shrub Species Identified in the Revegetation Monitoring Plots ………………103

List of Appendices

Appendix A: Maps of Project Revegetation Sites

Appendix B: Civil Works Sites Permanent Monitoring Plot Data for Sites Established in 2018.

Appendix C: Civil Works Sites Permanent Monitoring Plot Data for Sites Established in 2020.

Appendix D: Transmission Line Permanent Monitoring Plot Data for Sites Established in 2018.

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). One of the requirements within the OEMP was to complete long-term vegetation monitoring of sites that were disturbed and rehabilitated following project construction.

Hedberg and Associates Consulting Ltd. (HAC) is being retained by the Partnerships to complete the vegetation monitoring requirements of the OEMP. The requirements pertaining to revegetation works are described in Section 3.3 of the OEMP and are the basis for the works described in this report (see also Section 0 below).

This report summarizes the results of the revegetation assessment program for the 2020 monitoring year (Year 3 - 2020).

This report contains the following sections:

- the scope of the revegetation monitoring program (Section 0);
- a summary of source documents pertaining to restoration works (Section 0);
- the objectives of the revegetation program (Section 0);
- the 2020 data collection methods and field program details (Section 0);
- the results of the data collection from the 2020 monitoring program (Section 0); and
- the conclusions and recommendations regarding Year 3 (2020) monitoring (Section 7).

2. Scope of the Revegetation Monitoring Program

The scope of work for the year 3 revegetation monitoring program has followed the requirements of the OEMP (Harwood *et al.*, 2017). This includes the data collection, analysis and reporting of Section 3.3 "Vegetation Monitoring Requirements" of the OEMP. This report summarizes and compares the data collected in 2018 (Year 1 of the OEMP program) and 2020 (Year 3 of the OEMP program).

Monitoring for the 2018 and 2020 programs was carried out on two types of revegetation sites: transmission line sites and civil works sites. This will be discussed in greater detail below. The scope of work for this report includes the data collection, analysis and reporting of the following components outlined in Section 3.2.1 Habitat Restoration and Section 3.3 Vegetation Monitoring Requirement of the ULHP OEMP (Harwood et al, 2017):

- Section 3.3 - Vegetation Monitoring Requirements (including Table 27 and 28)
    - o Vegetation Restoration Monitoring
    - o Invasive Plant Monitoring
- Subcomponent of Section 3.2.1.3 - Wildlife Habitat Restoration, specifically the requirement to ensure the following:
    - o Grizzly Bear habitat (subcomponent of Table 14 & 20)

- At least 50% of the planted stems within the revegetated portion of the Grizzly Bear WHA 2-399 are native fruit bearing shrubs (Appendix A of the OEMP);
- temporary roads or access tracks within WHA 2-399 are deactivated and non-drivable with an ATV.

o Moose habitat (subcomponent of Table 14 & 21)

- At least 50% of the planted stems within the revegetated portion of the Moose UWR, away from road verges, are preferred Moose forage species (Appendix A of the OEMP).

o Mule Deer habitat (subcomponent of Table 14 & 22)

- Revegetated portion of the Deer UWR were planted with native species.

Note: Other vegetation and/or habitat restoration assessments such as Aquatic and Riparian Habitat (Revegetation Assessment) (Section 2.3 of the OEMP) and the larger Wildlife Habitat Restoration (Section 3.2 of the OEMP) except for what is noted above are outside the scope of this report.

The OEMP (Harwood *et al*., 2017) requires that vegetation and invasive plants be monitored annually for the first five years of the Project, except for riparian vegetation monitoring, which is only required in Years 1, 3 and 5. A revised OEMP recommended reducing the frequency of the non-riparian vegetation monitoring and invasive plants to match the frequency of the riparian vegetation monitoring (i.e. Years 1, 3 and 5 instead of Years 1 through 5) in their letter titled "Upper Lillooet Hydro Project Updated Operational Environmental Monitoring Plan" (Faulkner *et al*. 2018). Specifically, the letter states the following regarding the proposed change to vegetation monitoring frequency:

"This change is recommended based on our monitoring of revegetation succession on similar projects and the observation that progress does not change substantially in a single year. Monitoring revegetation success can therefore be effectively determined by monitoring in the beginning, middle and end of a monitoring program." Furthermore, "frequency and/or duration of vegetation restoration monitoring will vary depending on revegetation success. Hence, if concerns are identified additional monitoring and/or management actions may be required" (Faulkner *et al.* 2018, p 10-11). Similar to the vegetation restoration component, Ecofish also recommends changing the frequency of "the invasive plants monitoring program [to] years 1,3, and 5 concurrent with the vegetation restoration component" (Faulkner *et al.* 2018, p. 11).

The letter along with a revised version of the OEMP (dated February 8, 2018) was submitted to MFLNRORD for review in February, 2018 and approval to reduce the frequency of monitoring was received by MFLNRORD on Sept 26, 2019 (T Katamay-Smith, pers comms). It is our recommendation at HAC that the program proceed with Year 5 of monitoring for both the vegetation and invasive plant monitoring as previously detailed in Ecofish's letter (Faulkner *et al.* 2018).

3. Revegetation/ Restoration Works Source Documents

Revegetation and restoration work for the ULHP were completed between 2016 and 2018 by the subcontractors for the ULHP (Westpark Electric Ltd. and CRT-ebc) as well as by the Partnerships. The restoration works for the civil works sites were completed by CRT-ebc and the Partnerships. The transmission line sites were rehabilitated by Westpark Electric Ltd. In general, restoration works consisted of a variety of treatments including soil rehabilitation/ decompaction, topsoil replacement, slope re-contouring, coarse woody debris placement, grass seeding and replanting with a variety of shrub and/or trees. This report does not detail the restoration measures that have been implemented, but for reference, restoration works and post-revegetation inspections can be found in the following reports:

- Upper Lillooet Hydro Master Reclamation Work Plan, BC unpublished report prepared for Ian McKeachie, Environmental Manager, CRT-EBC Construction, Upper Lillooet Hydro Project (McKeachie, 2016)
- Restoration Progress at Upper Lillooet Power Project (Polster, 2016)
- Works Plan for Transmission Line Access Roads Deactivation and Rehabilitation - North Zone, March 10, 2016 (Barker & Guilbride 2016)
- Works Plan for Transmission Line Access Roads Deactivation and Rehabilitation - South Zone (Barker & Guilbride 2016)
- Memorandum prepared for Robert Taylor, Westpark Electric Ltd. October 13, 2017 Re: Inspection of completed deactivation and rehabilitation works, Upper Lillooet Power Project transmission line, North Zone (Guilbride 2017)
- Memorandum prepared for Robert Taylor, Westpark Electric Ltd. August 7, 2017 Re: Inspection of completed deactivation and rehabilitation works, Upper Lillooet Power Project transmission line, North Zone (Guilbride 2017)
- Memorandum prepared for Robert Taylor, Westpark Electric Ltd. October 3, 2017 Re: Inspection of completed deactivation and rehabilitation works, Upper Lillooet Power Project transmission line, South Zone (Guilbride 2017)
- Memorandum prepared for Tanya Katamay-Smith, the Partnerships. March 26, 2019 Re: Reforestation summary of October 2018 tree planting for civil works sites at the Upper Lillooet Hydroelectric Project (Barker 2019)

4. Objectives of Revegetation Program

4.1 Long-term Revegetation Goals

As per Section 3.3 of the OEMP, the objectives of the long-term vegetation monitoring program are to "qualify and quantify the re-growth of vegetation in terrestrial and riparian areas to mitigate the short-term habitat loss and to prevent the introduction of invasive species that may occur through site disturbance" (Harwood et al. 2017).

An additional project objective is:

"to assist the recovery of disturbed areas towards reaching a desired future condition that is self-sustaining and capable of supporting soils, soil function and vegetation communities and processes similar to the adjacent undeveloped areas with no subsequent management inputs required" (Soil Salvage, Site Reclamation and Landscape Restoration Plan, Barker 2012).

Lastly, during the Environmental Assessment process, it was identified that the ULHP will affect forest resource values, and in this case, the Timber Harvesting Land Base (Hedberg Associates, 2011). In order to minimize these effects, it was identified in the forestry baseline assessment that reforestation plans would be developed to return the land base, wherever practicable, "*similar to the adjacent undeveloped areas*" by replanting with coniferous species or mixed forests to achieve forest objectives.

This monitoring program is part of the overall plan to achieve these revegetation/ reforestation goals and is designed in accordance with the OEMP and all ULHP related documentation.

4.2 Short-term Revegetation Goals

In the first 5 years following planting and during the OEMP monitoring period, the goal is to have strong survival of a diversity of natural and planted herb, shrub and tree species. The community begins with relatively few pioneering plant species and develops through increasing complexity until it becomes stable or self-sustaining over time.

A restored site would consist of vigorous and healthy plant communities, with a diversity of herbs, shrubs, and trees that have become established and are growing well. Additional site indicators for a successful site would include a stable slope shape, coarse woody debris of various sizes present on the landscape, and no siltation or major erosion issues.

Following the implementation of the revegetation treatment in combination with natural recovery processes, it is expected that the following will occur over the next decade:

- Continued growth and infill of planted and naturally seeded vegetation;
- Soil development processes and improved soil moisture holding capacity will continue to occur over time;
- Restoration of wildlife habitat providing wildlife forage areas, security and thermal cover areas; and
- Increased habitat connectivity between adjacent undisturbed areas and treated areas.

4.3 Site-specific Revegetation Goals

As mentioned above, there are some additional project specific OEMP requirements (Harwood et al. 2017) and they include:

1. At least 50% of the planted stems within the revegetated portion of the grizzly bear Wildlife Habitat Area (WHA) 2-399 are native fruit bearing shrubs.
2. Temporary roads or access tracks within WHA 2-399 are deactivated and non-drivable with an ATV.
3. At least 50% of the planted stems within the revegetated portion of the moose Ungulate Winter Range (UWR), away from road verges, are preferred moose forage species.
4. That the revegetated portion of the deer UWR are planted with native species.

5. 2020 Revegetation Monitoring Program and Data Collection Methods

The 2020 monitoring program was carried out by team lead Codie Johnston RFT. Codie Johnston is a BC Certified Accredited Silviculture Surveyor #AA2006008 with 17 years of plant identification experience. Other staff members of Hedberg and Associates who worked on the data collection phase of the project are Rachel Amundsen FIT and Nick Seymour RPF. Rachel Amundsen is a Certified Accredited Silviculture Surveyor #AA2020036 and has 3 years of plant identification experience. Nick Seymour has 1 year of plant identification experience. Both Rachel and Nick's roles included the identification of conifer, deciduous, shrub and herbaceous species as well as collecting percent cover of trees, shrubs and herbs in the quadrat surveys. When Rachel and Nick were available to collect field data they worked as a team with Codie Johnston. The fieldwork for the 2020 monitoring program was carried out in July and October of 2020.

To evaluate the areas that were revegetated and or restored by the Partnerships or their subcontractors, revegetation monitoring plots were permanently established throughout the treated areas. Treated areas consist of both civil works sites and the transmission line sites. On the transmission line sites, the post-construction revegetation works were completed prior to the 2018 survey; however, on the civil works sites, the majority of sites were planted with additional conifers in October 2018.

Plot data collection and success reporting followed a methodology similar to the process used for assessing commercial tree stocking on harvested areas (BC silviculture stocking survey procedure – FS658). Plot information collected includes the number of planted/ natural woody stems present within the plot area and the density (% cover) and average heights of existing natural non-commercial and brush species that are contributing to revegetation of the sites. Professional judgement and quantifiable results of data collected in the fixed radius plots were utilized to determine if revegetation objectives are being met in Year 3 and are trending towards being met in Year 5 (the final monitoring year). The details of the revegetation success results will be described in Sections 6 of this document.

A minimum of one plot per site was established on sites smaller than one hectare (ha). For areas greater than one ha, one plot/ha was used to evaluate a given site (also called stratum on the data collection cards in Appendix B, C and D). Each fixed radius plot measured 3.99 m in radius or 50 m^2 in area. Plots were established at sites that will not be subject to future vegetation management efforts (i.e. areas outside of the limits of approach of the powerline) to represent areas that will remain stable throughout all of the monitoring years.

For very small road spurs (less than 0.4 hectares) that had high levels of early revegetation success, inspection points were taken as opposed to setting up permanent monitoring plots. Typically, inspection points were along spur roads where no major clearing efforts occurred, but rather a low impact machine (small excavator with wheels as opposed to tracks) was used to access the power pole. This resulted in very low overall impacts to soils and/or existing plants on those areas. The inspection sites were revisited in 2020 and are all continue to increase in diversity and stems per hectare. Many of the sites have completely recovered and are no longer identifiable as access points.

The monitoring used to evaluate the growth and survivorship of the natural and planted vegetation was achieved through three approaches:

1. sampling of permanent revegetation monitoring plots to quantify the stem densities of trees and shrubs.
2. placing quadrats to assess the percentage of vegetation ground cover in each layer (herb, shrub and tree layer); and
3. comparison of photographs taken at a similar angle and location to qualitatively document changes in vegetation and site conditions over time.

Additional information collected at each monitoring plot and inspection site included describing:

- erosion or siltation issues;
- coarse woody debris presence;
- whether wildlife-specific requirements were being met;
- evidence of disease or damage to plants;
- evidence of moss growth as an indicator of soil development processes; and
- invasive species presence.

5.1 Permanent Vegetation Density Monitoring Plots

In Year 1 (2018) of the overall monitoring program, circular permanent vegetation monitoring plots were established in the revegetation areas using a methodology similar to the process used to assess commercial tree stocking on harvested areas (BC silviculture stocking survey procedure – FS658). Each permanent plot area that was surveyed measured 3.99 m in radius, representing a total area of 50 m^2. Plots were pre-selected using a random GPS grid to avoid surveyor bias. See the maps in Appendix A for permanent monitoring plot locations. Each site had a minimum of 1 plot per hectare.

Within each plot, the surveyors counted the number of stems of each species of native perennial woody plant species. Perennially woody plant species include both shrubs and trees but excludes herbs and mosses. Each plant was identified and input into a computer program called "SNAP". Shrub and tree density values are then calculated in the office based on the number of live stems counted for each species multiplied over the given area.

No division was made between trees and/ or shrubs that were planted as opposed to those regenerated naturally; all planted and naturally regenerated species were counted in the same tally to measure overall vegetation growth. For accuracy and for repeatability of the process between years, stems were counted, as opposed to individual plants. Only stems that were rooted immediately adjacent to the soil surface were counted, as opposed to counting individual plants species with multiple stems. Individual shrubs are difficult to identify in the early phases of growth, as many shrubs have multiple stems from the soil surface interface (e.g. falsebox (*Paxistima myrsinites)*, salal *(Gaultheria shallon),* and many shrubs in the raspberry family (*Rubus spp.*)). Only live stems were counted in each plot in Year 1 (2018) and Year 3 (2020), this method will be replicated in Year 5 (2022). Where present invasive species were identified and recorded at each plot. Invasive species and treatments are discussed in Section 6.5 of this report.

5.1.1 Success Targets for Stem Densities

Stem density measurements will be collected as per the revised frequency proposed by Faulkner et al. (2018): Years 1, 3 and 5. The data collected regarding the density of each perennial woody species found will contribute the following critical information to the program:

1. Whether perennial woody species (shrubs and trees) are becoming denser or less dense over time. In a typical site, similar to one found at the ULHP, in the very early years, it is typical that shrub growth will increase rapidly over the first few years, but may decrease once the later successional species start to take hold at the site. Tree growth increases typically somewhat slower than shrubs and typically increases in density are on the order of 5-20 years for the sites/ typical species mixes that are found at the ULHP. In the first few years, it would be unlikely to see a high rate of conifer natural regeneration but typically by the end of the program, small conifer seedlings will be starting to establish. Measuring the densities will enable monitoring of any significant decreases, which may be indicative of a struggling site. Conversely, significant increases may indicate a need for thinning to reduce vegetation competing with conifer regeneration.
2. A list of the number and types of species found at each site. Knowing which species are found and how many different species are found at each site gives the assessor an understanding of the types of species being found (e.g. early colonizers versus climax species) and is an indicator of overall site diversity and resilience. The number of different species found is an important indicator of whether the diversity of the site is increasing or decreasing over time. For example,

an alder dominated site may become less diverse over time and a berry shrub type habitat may become more diverse over time. It is ideal to see a variety of species at a given site as this contributes to the natural resilience of each site.

Regarding the stem densities, the following comparisons will be included in subsequent monitoring years (Year 3 and 5):

1. A comparison of the density increases or decreases of shrubs and deciduous tree species
2. A comparison of the density increases or decreases of conifer tree species
3. A comparison the total number of species found
4. A comparison of the types of species found in each year (seral stage and climax species)

5.1.1.1 Shrubs and Deciduous Trees (Density Targets)

Due to the fact that a range of densities are desirable depending on the monitoring year, no quantitative stem density targets are recommended for shrubs and deciduous trees other than to monitor their increases or decreases over time. This is because the desired end goal for this variable is not linear, and sites can be healthy at a variety of stem densities as observed in the natural environment. In some stages of site regeneration, it may be desirable for areas to become denser, while at later stages, less dense sites are preferred to mimic natural succession processes. In addition, quantitative targets do not account for site specific biotic and abiotic variables. Instead, it is recommended that a site-specific approach be applied to each site to account for critical biotic and abiotic environmental factors. Each site will be assessed on a site-by-site basis to understand site trends and dynamics. Using this information, the Qualified Professional will determine on a site species basic whether treatments are required to meet overall project goals. Results from previous long-term vegetation monitoring programs have shown that using professional judgement is a valuable method incorporate a broad range of health factors that contribute to site vegetation establishment. Evidence over the past seven years on monitoring projects of a similar nature done by HAC showed that ecosystems can be healthy at a variety of densities and requires interpretation of the results as opposed to meeting pre-determined goal.

5.1.1.2 Conifer Tree Species (Density Targets)

For the conifer tree component, the recommended density target will be 1000 stems per hectare (sph) depending on the site. These densities have been recommended by the Registered Professional Forester (Wes Staven, RPF) assigned to this project. He has based this target on the ecology of the area, the biogeoclimatic zone, similar project success rates and other site-specific variables.

5.2 Percentage of Vegetation Cover Estimate (Quadrat monitoring)

For this project, total percentage of ground cover will be measured by layer (tree, shrub, and herb layer). To collect this metric, the surveyor placed a quadrat (a square frame with measured gradations) on the ground surface to measure the percentage of ground cover that is occupied by a given plant layer (herb, shrub and tree layer). Herb is a general term that includes forb (non woody plants with broader leaves and distinct flowers), ferns and fern allies, grasses, and sedges. The quadrat used for these surveys measured 1 m by 1 m. The quadrat is marked at regular intervals; each square of the quadrat represented 1% of the total area. In this case, each 10cm by 10cm of marked off area represented 1% of the total quadrat. For example, if there were five squares covered by shrub species

(3% of ground covered by thimbleberry and 2% of falsebox), then the surveyor would note that there was 5% cover in the shrub layer. This data was then input into the “SNAP” program on the iPad.

In total, two quadrat surveys were taken at each site. Each quadrat was placed on the north and east axis of the plot, 2.0 m away from the plot centre to avoid bias and increase repeatability between years. Each plant layer was grouped and measured as one unit. The layers are identified as 1) the herb layer, 2) the shrub layer and 3) the tree layer.

Determination of the average height for each species within each layer was completed through in-plot measurements of identified species.

Where present, total ground cover occupancy by moss species also was noted. For the moss layer an ocular estimate of total ground cover was completed. The cover attributed to moss does not contribute to the total cover calculations, rather it’s provided to present evidence of ongoing soil development processes.

5.2.1 Success Targets for Percent Vegetation Cover

The target for success being measured is whether the percentage of ground cover for the later successional species (shrubs and trees) in each quadrat survey are increasing steadily throughout the monitoring period or reaching a steady state (i.e. not declining over time). Collecting percentage vegetation cover by layer will provide valuable data as to whether ecological succession processes are initiating. Using growth trends for the later successional species as the target is a good indicator to show whether succession is taking place or if mortality is occurring.

Targets for this measure will be met if the trend in each subsequent monitoring year for the shrub and tree layer is greater or equal to the previous monitoring year’s percentage cover. If the trend is that the percent cover for the later successional species amounts are declining, then additional remedial measures will be considered.

5.3 Inspection Points

As explained in Section 5, for very small road spurs (less than 0.4 hectares) that had high levels of early revegetation success, inspection points were taken as opposed to setting up permanent monitoring plots. At each inspection point, the following data was collected:

- health and vigour of plant communities;
- erosion or siltation issues;
- coarse woody debris presence;
- notes on whether wildlife specific requirements were being met;
- evidence disease or damage to plants;
- evidence of moss growth as an indicator of soil development processes; and
- invasive species presence.

5.3.1 Success Targets for Inspection Points

Successful rehabilitation for each inspection point is defined in this report as a site that requires no further treatment to sustain plant growth and meet the long-term objectives of the OEMP and all project documentation. This will be based on qualitative observations of the data collected at each site (Section 5.3 above) and professional judgement of the surveyor.

5.4 Wildlife Specific Revegetation Requirements

As part of this monitoring program, there were additional wildlife-specific requirements associated with the revegetation program. The method used to evaluate compliance with the wildlife specific requirements included a field visit to each site located within designated Wildlife Habitat Areas (WHAs) and Ungulate Winter Ranges (UWR) and consisted of at least 1 visual plot per hectare. The visual plot entailed an ocular estimate that evaluated compliance within an area the size of a 3.99 m fixed radius plot. The plot was then assessed for compliance with the wildlife specific targets discussed below.

It is important to note that for the deer and moose UWRs, the majority of sites were under the transmission line and will be subject to future vegetation management efforts. Those sites were visited even if they were under the transmission line to evaluate compliance, however to maintain line security, those sites will be subject to alterations (e.g. thinning, pruning, tree felling, etc.) in the future. The sites found within grizzly bear WHA 2-399 were located adjacent to the forest service road (Upper Lillooet FSR South) and were evaluated for compliance with OEMP requirements; although, the berry shrub planting requirement is not recommended for areas within close proximity to road verges and is therefore considered not applicable to the sites studied within this report. This will be discussed further in Results: Section 0 below.

5.4.1 Success Targets within Grizzly Bear Wildlife Habitat Areas (WHA)

Within Grizzly Bear Wildlife Habitat Area (WHA 2-399), as mentioned above, the requirement is as follows: “at least 50% of the planted stems within the revegetated portion of the Grizzly Bear WHA 2-399 are native fruit bearing shrubs” (Appendix A of the Long Term Monitoring Program Report (LTMP)). This will be measured in each monitoring year (years 1, 3 and 5) to ensure that the fruit-bearing shrub component for each revegetated portion on any upland areas meets or exceeds this requirement. Additionally, temporary roads or access tracks within WHA 2-399 are required to be deactivated and non-drivable with an ATV. See Section 6.3.5 for the 2020 results.

5.4.2 Success Targets within Moose Ungulate Winter Range (UWR)

Within moose UWR, as per the OEMP, the following success target will be used within government established moose habitat: that “at least 50% of the planted stems within the revegetated portion of the Moose Ungulate Winter Range (UWR) away from road verges, are preferred moose forage species” (Appendix A of the LTMP). This requirement was field verified by the Surveyor in Year 1 and does not require future monitoring because it is a planting requirement not a long-term monitoring requirement.

5.4.3 Success Targets within Deer Ungulate Winter Range (UWR)

Within deer UWR, any revegetated portions of Deer Ungulate Winter Range will be measured for the following success target, that “the revegetated portion of the Deer UWR were planted with native species” (Appendix A of the LTMP). This was an ocular estimate carried out in the initial monitoring year (Year 1) to determine if this target has been met. This requirement was field verified by the Surveyor in Year 1 and does not require future monitoring because it is a planting requirement not a long-term monitoring requirement.

6. Results

The civil works site plot data collected in Year 3 (2020) has been separated into two categories to make it easier to summarize and compare the information. The first category includes all the sites that had permanent sample plots established in 2018 and for which data was collected in both Year 1 (2018) and Year 3 (2020). This data set is further separated by zones (see Appendix A: Maps of Project Revegetation Sites). At the end of each zone summary there are photos from 2018 and 2020 taken at each plot to show visual vegetation changes on the site. Plot data tables are also included. The tables compare the vegetation density (by stems per hectare) that was onsite in 2018 with the vegetation found in 2020. The tables display coniferous, deciduous and shrub diversity as well as the number of species present in 2018 and 2020.

The second category includes all the sites that were planted in the fall of 2018. Permanent sample plots were established on these sites in 2019 and 2020. These sites are summarized separately as a complete data set was only collected in 2020. The survey data collected in 2019 was to assess seedling survival one year after planting.

6.1 Results for Civil Works Sites with 2018 and 2020 Data

6.1.1 Zone 1 Results Summary

Zone 1 includes two sites - the 36 Km Borrow Pit and the Boulder Powerhouse, Spoil and Operators Residence. The 36 Km Borrow Pit and part of the Boulder Powerhouse sites were planted in 2017 with a mix of conifers and shrubs. The Boulder Powerhouse Spoil area in front of the operator’s residence was planted in the fall of 2018. A second plot was established here in 2020 and is summarized with the civil works sites that were established in 2020.

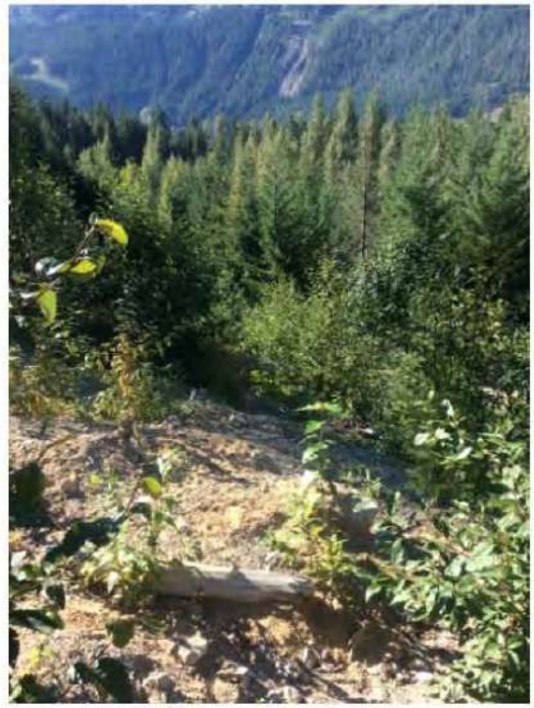
The 36 km Borrow Pit is located on a gentle slope with sandy soils that are not too compact. The soils were fluffed up and coarse woody debris was scattered across the site. The area was planted with a mix of conifers in 2017. In 2018 there were 800 sph of Douglas fir growing onsite. There are other conifer species present but they were not picked up in our long-term monitoring plot. The number of Douglas fir has increased to 1200 sph in 2020. The increase in sph is due to natural ingress of Douglas fir seed from adjacent mature conifers. The planted and natural conifers are of good form and vigour and are free from any forest health concerns. The naturals are still quite small, ranging from 3 to 15 cm. The planted conifers have an average height of 35 cm. The number of deciduous sph has increased significantly from 2200 sph in 2018 to 9600 sph in 2020. The deciduous trees are growing vigorously onsite but are not impeding conifer growth at this time. In 2018 200 sph of shrub species were found in the plot. In 2020 this number increased to 600. This site is meeting the target of 1000 sph of conifers and increases in sph of both deciduous and shrub species indicates the site is successfully recovering. Moss cover is developing and is dependent on microtopography but will likely continue to increase. No evidence of erosion or siltation was noted.

The Boulder Powerhouse, Spoil and Operators Residence site has coarse gravel soils and is well drained. The original area adjacent to the powerhouse was planted with a mix of berry shrubs and conifers in 2017. When the operator's residence was built in 2018 further excavations were required and the size of the site was increased to accommodate the building activities. Both areas were planted with conifers in 2018. The number of conifers has increased from 600 sph in 2018 to 6000 in 2020. There has been lots of natural conifer ingress on this site from the adjacent mature stands. The number of black cottonwoods sph has increased from zero in 2018 to 24,000 in 2020. Many of these trees are still very small at less than 10 cm in height. The cottonwoods are not impeding conifer establishment at this time. The number of sph of shrubs and species diversity has increased significantly on this site. In 2018 there were 1000 sph and three species of shrubs present. In 2020 there were 11,400 sph and six species of shrubs. Red raspberry and thimbleberry had the greatest increase in number of sph. Moss cover is developing and is dependent on microtopography but will likely continue to increase. No evidence of erosion or siltation was noted.

Figure 1. Zone 1 Plot Photos from 2018 and 2020

Card: Civil Work
Stratum: 2018 36Km Borrow Pit/Plot: S/Comments
Overview photo looks South towards plot center. Oct 16, 2018 11.58.04 AM.jpg

Card: Civil Work
Stratum: 2020 36 Km Borrow Pit/Plot: S/Comments
Overview photo looks South from plot S.jpg



Card: Civil Work
Stratum: 2018 Boulder Powerhouse and Spoil/Plot: Q/Comments
Overview photo looks South towards plot center. Oct 15, 2018 12.07.35 PM.jpg

Card: Civil Work
Stratum: 2020 Boulder Powerhouse and Spoil/Plot: Q/Comments
Overview photo looks South from plot Q.jpg

Table 1. Zone 1 – Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Douglas Fir		Lodgepole Pine		Western Hemlock		Western Red Cedar		Western White Pine		Target SPH	**Total SPH Conifers**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020		**2018**	**2020**
36 Km Borrow Pit	0.5	1	800	1,200	0	0	0	0	0	0	0	0	1000	**800**	**1,200**
Boulder Powerhouse and Spoil/ Operators Residence	1.4	1	0	5,200	0	600	200	600	400	400	0	200	1000	**600**	**7,000**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Black Cottonwood		Red Alder		**Total SPH Deciduous**	
			2018	2020	2018	2020	**2018**	**2020**
36 Km Borrow Pit	0.5	1	1,800	9,200	400	400	**2,200**	**9,600**
Boulder Powerhouse and Spoil/ Operators Residence	1.4	1	0	24,000	0	0	**0**	**24,000**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Falsebox		Kinnikinnick		Red Osier Dogwood		Red Raspberry		Sitka Mountain-Ash		Thimbleberry		Vaccinium Species		Willow		**Total SPH Shrubs**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
36 Km Borrow Pit	0.5	1	0	400	0	0	0	0	0	0	0	200	0	0	200	0	0	0	**200**	**600**
Boulder Powerhouse and Spoil/ Operators Residence	1.4	1	0	800	0	200	200	200	400	7,200	0	0	400	2,800	0	0	0	200	**1,000**	**11,400**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
36 Km Borrow Pit	1	1	2	2	1	2	**4**	**5**
Boulder Powerhouse and Spoil/ Operators Residence	2	5	0	1	3	6	**5**	**12**

6.1.2 Zone 2 Results Summary

Zone 2 includes two sites - Boulder Spoil #2 and the Explosive Magazine. Boulder Spoil #2 is located on a steep slope with compact soils and numerous rocky patches. This site is marginally reforestable due to compact soils. The site was planted in 2017 and had poor survival of the planted conifers and shrubs. The target of 1000 sph target for conifers has not been attained on this site. The number of conifers has increased slightly since 2017, from zero to 100 conifer sph. The number of shrubs per ha has increased and diversity has also increased with vaccinium infilling naturally. The falsebox and thimbleberry have grown in size and the grass cover has increased. Replanting this site is not recommended due to site limiting factors. It is the only area in the Civil Works sites that is not meeting the minimum conifer criteria. Conifer ingress may increase over time as the shrub and herbaceous species add more biomass to the soils and shade to the site. Adjacent to the site there are live mature Douglas-fir and Western hemlock that will provide a viable seed source. Despite steep slopes and compact soils no erosion or siltation was noted on this site. Moss cover has increased overall but there is still minimal cover on this site.

The Explosive Magazine site is one of the more natural looking sites. A good mix of mineral soil and organics has created an ideal growing medium for all the species on site. This area was planted at a lower density of 600 sph in 2018 as it was accidentally planted in 2017 by the Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD) during their reforestation project of the Boulder Creek fire. Species diversity has not increased on this site but the number of sph has increased for all species except red alder. Douglas- fir and western redcedar have continued to infill from natural seed sources. All conifers are growing well and are free of any forest health concerns or pests. The deciduous component will add to the seral stage diversity of the stand. Shrub cover in the Explosive Magazine area is high and will remain high until the conifers emerge from the shrub cover and begin to shade them out. Moss cover has increased significantly on this site since 2018. Overall, this site exceeds the revegetation targets for the project. No erosion or siltation was noted while on site.

Figure 2. Zone 2 Plot Photos from 2018 and 2020

Card: Civil Works
Stratum: 2018 Boulder Spoil #2/Plot: K/Comments
Overview photo looks South towards plot center. Sep 26, 2018 12.53.38 PM.jpg

Card: Civil Works
Stratum: 2020 Boulder Spoil #2/Plot: K/Comments
Overview photo looks South from plot K.jpg

Card: Civil Works
Stratum: 2018 Boulder Spoil #2/Plot: L/Comments
Overview photo looks South towards plot center. Sep 26, 2018 01.10.41 PM.jpg

Card: Civil Works
Stratum: 2020 Boulder Spoil #2/Plot: L/Comments
Overview photo looks South from plot L.jpg

Card: Civil Works
Stratum: 2018 Explosive Magazine/Plot: 001/Comments
Overview photo looks North towards plot center. Sep 05, 2018 11.22.20 AM.jpg

Card: Civil Works
Stratum: 2020 Explosive Magazine/Plot: 001/Comments
Overview photo looks South from plot 001.jpg

Card: Civil Works
Stratum: 2018 Explosive Magazine/Plot: 002/Comments
Overview photo looks North towards plot center. Sep 05, 2018 12.20.55 PM.jpg

Card: Civil Works
Stratum: 2020 Explosive Magazine/Plot: 002/Comments
Overview photo looks South from plot 002.jpg

Card: Civil Works
Stratum: 2018 Explosive Magazine/Plot: 003/Comments Overview photo looks North toward plot center. Sep 05, 2018 11.47.35 AM.jpg

Card: Civil Works
Stratum: 2020 Explosive Magazine/Plot: 003/Comments Overview photo looks South from plot 003.jpg

Card: Civil Works
Stratum: 2018 Explosive Magazine/Plot: 004/Comments Sep 05, 2018 12.02.37 PM.jpg

Card: Civil Works
Stratum: 2020 Explosive Magazine/Plot: 004/Comments Overview photo looks South from plot 004.jpg

Table 2. Zone 2 – Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Douglas Fir		Lodgepole Pine		Western Red Cedar		Target SPH	**Total SPH Conifers**	
			2018	2020	2018	2020	2018	2020		**2018**	**2020**
Boulder Spoil #2	1.25	2	0	100	0	0	0	0	1000	**0**	**100**
Explosive Magazine	2.5	4	400	1,300	50	100	50	250	1000	**500**	**1,650**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Bigleaf Maple		Black Cottonwood		Red Alder		**Total SPH Deciduous**	
			2018	2020	2018	2020	2018	2020	**2018**	**2020**
Boulder Spoil #2	1.25	2	0	0	0	0	0	0	**0**	**0**
Explosive Magazine	2.5	4	50	150	250	500	100	100	**400**	**750**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Ceanothus		Falsebox		Red Raspberry		Rose Species		Thimbleberry		Vaccinium Species		Willow		**Total SPH Shrubs**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Boulder Spoil #2	1.25	2	0	0	700	900	0	0	100	200	1,400	2,000	0	300	0	0	**2,200**	**3,400**
Explosive Magazine	2.5	4	50	100	0	0	3,900	11,650	0	0	2,250	2,150	0	0	8,650	9,050	**14,850**	**22,950**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Boulder Spoil #2	0	1	0	0	3	4	**3**	**5**
Explosive Magazine	3	3	3	3	4	4	**10**	**10**

6.1.3 Zone 3 Results Summary

Zone 3 includes two sites - the 41.7 Km Laydown and the Upper Lillooet Penstock. The 41.7 Km Laydown has been divided into two data sets. The portion of the laydown located on the West side of the Lillooet River forest service road (FSR) was planted in 2017 with berry shrubs to meet the requirements of the grizzly bear management strategy and was subsequently planted in 2018 with a mix of conifer species. The portion of the laydown site located on the East side of the FSR was planted in 2018 and is described in Section 6.2 of this document. The terrain in this site is mainly flat and was mounded when the site was reclaimed. Soils contain a good mix of mineral and organics. The area currently exceeds the conifer density target of 1000 sph with a total of 1900 sph. The planted conifers are of good form and vigour with strong leader growth. Natural ingress of Douglas-fir continues on site with naturals ranging from 5 to 25 cm in height. Cottonwood numbers continue to increase. The cottonwoods are not out competing the conifers and are adding biomass to the site annually. The number of shrub species on site has not increased but the number of sph has increased, which indicates the site is continuing to recover. This increase in number of species is due to the conifer planting treatment in 2018. No soil erosion or siltation was noted at the time of the survey. Moss cover continues to increase and is dependent on microtopography at this time. Moss cover will continue to increase as more shading is created by the growing herbs, shrubs and trees onsite.

The Upper Lillooet Penstock is a long linear site that follows the buried penstock. This area was not planted and has no wildlife specific planting requirements. Four plots were established in 2018. The plot at the north end of the penstock was partially disturbed since plot data was collected in 2018 (Year 1). The disturbance involved approximately a quarter of the plot area being machine bladed. The disturbed area has started to recover and it was determined that the disturbance was not significant enough to drop the plot from the data set. The penstock has good distribution of coarse woody debris and soils are not compacted. Natural ingress of conifers has increased significantly between 2018 and 2020 and this site exceeds the conifer target of 1000 sph with 3150 coniferous sph. The conifers range from 10 to 35 cm in height and have patchy distribution. The penstock has also had significant infilling of deciduous species with over 8000 sph of cottonwood and red alder. The conifer and deciduous species will eventually need to be manually brushed to protect the integrity of the penstock. Brushing will not likely be required for another 5 to 8 years. Shrub diversity has increased significantly from three species to seven species. Minor ungulate browse was noted on the ceanothus and willow. No erosion or siltation issues were noted during the survey. The moss cover is increasing slowly and is dependent on microtopgraphy. No forest health issues were noted on any of the species.

Figure 3. Zone 3 Plot Photos from 2018 and 2020

Card: Civil Works
Stratum: 2018 41.7km Laydown/Plot: M/Comments Overview photo looks South towards plot center. Sep 26, 2018 02.04.09 PM.jpg

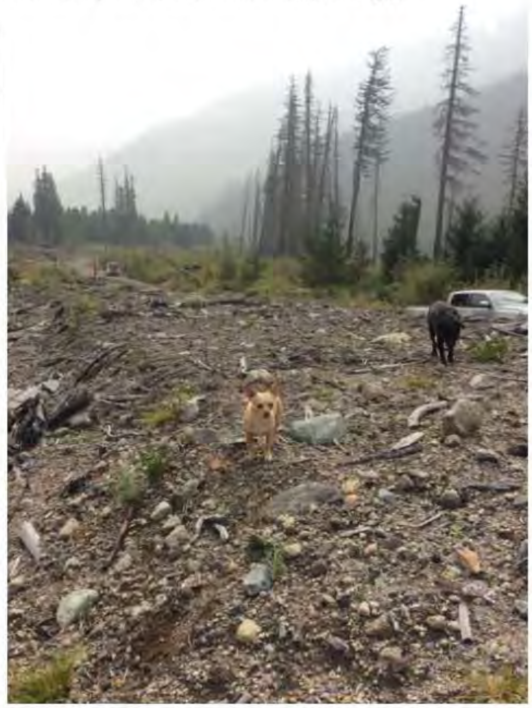
Card: Civil Works
Stratum: 2020 41.7 Km Borrow Pit/Plot: M/Comments Overview photo looks South from plot M.jpg

Card: Civil Works
Stratum: 2018 41.7km Laydown/Plot: N/Comments Overview photo looks South towards plot center. Sep 26, 2018 02.15.33 PM.jpg

Card: Civil Works
Stratum: 2020 41.7 Km Borrow Pit/Plot: N/Comments Overview photo looks South from plot N.jpg

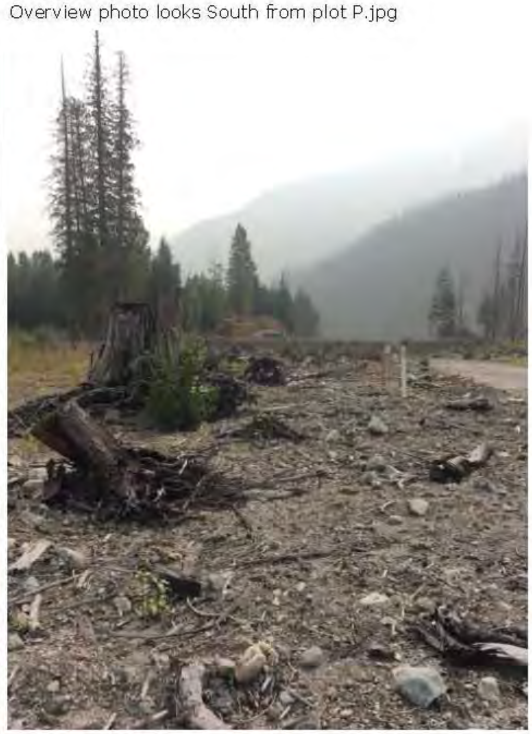
Card: Civil Works
Stratum: 2018 Upper Lillooet Penstock/Plot: O/Comments
Overview photo looks South towards plot center. Sep 26, 2018 02.48.28 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Lillooet Penstock/Plot: O/Comments
Overview photo looks South from plot O.jpg



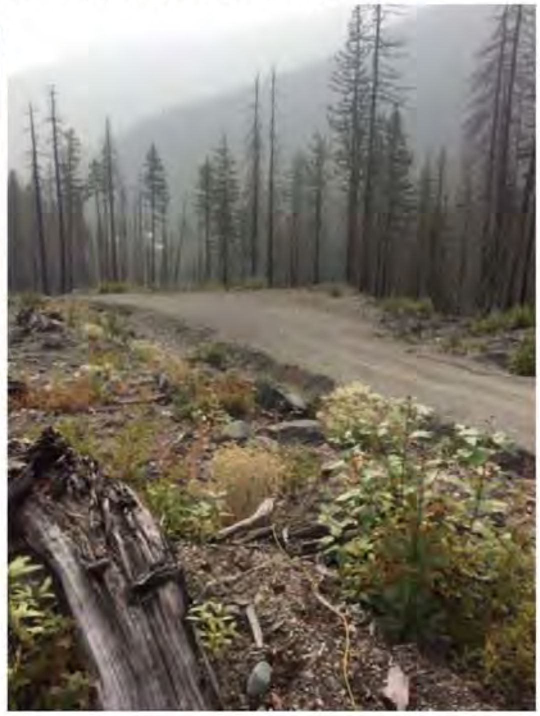
Card: Civil Works
Stratum: 2018 Upper Lillooet Penstock/Plot: P/Comments
Overview photo looks South towards plot center. Sep 26, 2018 02.59.52 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Lillooet Penstock/Plot: P/Comments
Overview photo looks South from plot P.jpg



Card: Civil Works
Stratum: 2018 Upper Lillooet Penstock/Plot: I/Comments
Overview photo looks South towards plot center. Sep 18, 2018 02.11.15 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Lillooet Penstock/Plot: I/Comments
Overview photo looks South from plot I.jpg



Card: Civil Works
Stratum: 2018 Upper Lillooet Penstock/Plot: H/Comments
Overview photo looks South towards plot center. Sep 18, 2018 01.15.06 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Lillooet Penstock/Plot: H/Comments
Overview photo looks South from plot H.jpg

Card: Civil Works
Stratum: 2020 Upper Lillooet Penstock/Plot:
H/Comments
Site has been partially disturbed since 2018.jpg

Table 3. Zone 3 - Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Douglas Fir		Spruce		Western Red Cedar		Western White Pine		Target SPH	Total SPH Conifers	
			2018	2020	2018	2020	2018	2020	2018	2020		**2018**	**2020**
41.7 Km Laydown	1.1	2	0	1,300	0	600	0	0	0	0	1000	**0**	**1,900**
Upper Lillooet Penstock	4.6	4	250	2,900	0	0	0	200	0	50	1000	**250**	**3,150**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Black Cottonwood		Red Alder		Total SPH Deciduous	
			2018	2020	2018	2020	**2018**	**2020**
41.7 Km Laydown	1.1	2	800	3,400	0	0	**800**	**3,400**
Upper Lillooet Penstock	4.6	4	450	7,800	0	450	**450**	**8,250**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Ceanothus		Douglas Maple		Falsebox		Oregon Grape		Red Osier Dogwood		Red Raspberry		Thimbleberry		Willow		Total SPH Shrubs	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
41.7 Km Borrow Pit	1.1	2	0	0	0	0	0	0	300	200	0	0	600	3,800	500	1,400	0	0	**1,400**	**5,400**
Upper Lillooet Penstock	4.6	4	0	50	0	50	0	50	0	0	50	50	900	7,850	250	650	550	150	**1,750**	**8,850**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		Total Number of Species	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
41.7 Km Borrow Pit	0	2	1	1	3	3	**4**	**6**
Upper Lillooet Penstock	1	3	1	2	4	7	**6**	**12**

6.1.4 Zone 4 Results Summary

Zone 4 is composed of one site - Upper Spoil #6. This site has gentle slopes and was mounded when the site was reclaimed. The soils are gravelly but have moderate amounts of organics mixed in and are not too compacted. The site was planted in the fall of 2018 with a mix of coniferous species. Douglas-fir naturals were already infilling prior to planting. This site exceeds the target of 1000 sph with 4000 sph of conifers. The planted and natural conifers are well established on site and have excellent leader growth. The density of black cottonwoods has increased significantly from 400 sph to 7400 sph. Many of these stems are still quite short (< 5 cm) but will grow quickly to occupy the site. The shrub layer, although not very diverse, is greening up nicely. Shrub diversity is not expected to increase much as the fast growing alder and willow will shade out other shrub species trying to establish onsite. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal.

Figure 4. Zone 4 Plot Photos from 2018 and 2020

Card: Civil Works
Stratum: 2018 Upper Spoil #6/Plot: J/Comments
Overview photo looks South towards plot center. Sep 18, 2018 02.23.18 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #6/Plot: J/Comments
Overview photo looks South from plot J.jpg

Table 4. Zone 4 - Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Douglas Fir		Spruce		Western Red Cedar		Target SPH	**Total SPH Conifers**	
			2018	2020	2018	2020	2018	2020		**2018**	**2020**
Upper Spoil #6	1	1	1,200	2,800	0	400	0	800	1000	**1,200**	**4,000**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Black Cottonwood		**Total SPH Deciduous**	
			2018	2020	**2018**	**2020**
Upper Spoil #6	1	1	400	7,400	**400**	**7,400**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Sitka Alder		Willow		**Total SPH Shrubs**	
			2018	2020	2018	2020	**2018**	**2020**
Upper Spoil #6	1	1	200	200	0	200	**200**	**400**

Number of Species From Plot Data (SPH)

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Upper Spoil #6	1	3	1	1	1	2	**3**	**6**

6.1.5 Zone 5 Results Summary

Zone 5 is composed of three sites - Upper Spoil #3, Upper Spoil #4 and Upper Spoil #8. All three of these spoil sites were planted in 2017 with berry shrubs to meet the requirements of the grizzly bear management strategy and were subsequently planted in 2018 with a mix of conifer species. Upper Spoil #3 has mostly flat terrain with steeper slopes on the south side of the polygon. The steeper area was contoured to keep the spoil site from raveling onto the mainline. The flatter portion of the site was mounded prior to planting. Soils are mostly coarse and although they are quite compact the planted and natural vegetation has been successful in establishing on site. This site exceeds the target of 1000 sph with 1800 sph of conifers. In general, the conifers are of good form and vigour with some stems exhibiting minor drought stress in the form of chlorotic or dead needles on the lower half of the tree. The drought damage is minimal and the affected trees are expected to make a full recovery. Cottonwoods continue to infill on site and will add biomass to the coarse soils over time. The shrub complex has not increased in diversity or stem density but the plants are getting larger and are well established. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal.

Spoil #4 has moderate to gentle slopes and was mounded prior to planting. Soils are mostly gravelly with some organics and sand mixed in. This site had good survival of the planted trees with Douglas-fir and amablis fir continuing to infill. The planted and natural conifers are of good form and vigour with moderate to strong leader growth. This site exceeds the target of 1000 sph with 1900 sph of conifers. There are fewer cottonwoods on this site but their numbers continue to increase. The planted and natural shrubs are also growing well and although species diversity has not increased the number of sph has increased from 1200 sph to 4100 sph. The increase in the number of sph ensures biomass will be added to the soils annually, thus increasing the organic component of the soils over time. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal.

Spoil #8 has concave terrain and is partially mounded. Soils are relatively sandy with a minor component of pumice, making them well drained. The area of Spoil #8 was increased after the berry shrubs were planted and the permanent plots were established. The additional area was not planted with berry shrubs but was planted with conifers. The conifer planting treatment was successful and planted and natural conifers are growing well onsite with nice foliage and good leader growth. Douglas-fir, amabilis fir and Western hemlock continue to infill across the site. This site exceeds the target of 1000 sph with 6800 sph. Many of the conifers are still germinants and their survival is not guaranteed. Cottonwood numbers have exploded onsite – increasing from 200 sph to 4000 sph. The majority of the cottonwoods are significantly shorter than the planted conifers and are not expected to out compete the conifers. The shrub complex on site is diverse with a ceanothus and Sitka alder infilling naturally. The planted shrubs continue to grow in size and are well established. In 2018 there was some erosion and settling on the site. This was likely due to the sandy nature of the site. No new erosion or settling was noted in 2020. Moss cover is increasing slowly but cover is still quite minimal and dependent on microtopography.

Figure 5. Zone 5 Plot Photos from 2018 and 2020

Card: Civil Works
Stratum: 2018 Upper Spoil #3/Plot: D/Comments Overview photo looks South towards plot center. Sep 18, 2018 10.54.28 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #3/Plot: D/Comments Overview photo looks South from plot D.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #3/Plot: E/Comments Overview photo looks South towards plot center. Sep 18, 2018 11.08.44 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #3/Plot: E/Comments Overview photo looks South from plot E.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #4/Plot: F/Comments
Overview photo looks South towards plot center. Sep 18, 2018 12.00.57 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #4/Plot: F/Comments
Overview photo looks South from plot F.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #4/Plot: G/Comments
Overview photo looks South towards plot center. Sep 18, 2018 12.20.59 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #4/Plot: G/Comments
Overview photo looks South from plot G.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #8/Plot: 005/Comments
Overview photo looks North towards plot center. Sep 05, 2018 02.03.09 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #8/Plot: 005/Comments
Overview photo looks South from plot 005.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #8/Plot: 006/Comments
Overview photo looks North towards plot center. Sep 05, 2018 02.13.28 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #8/Plot: 006/Comments
Overview photo looks South from plot 006.jpg

Table 5. Zone 5 - Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Amabalis Fir		Douglas Fir		Mountain Hemlock		Spruce		Western Hemlock		Western Red Cedar		Western White Pine		Target SPH	**Total SPH Conifers**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020		**2018**	**2020**
Upper Spoil #3	1.1	2	0	300	0	1,300	0	0	0	200	0	0	0	0	0	0	1000	**0**	**1,800**
Upper Spoil #4	1.6	2	0	100	0	1,100	0	0	0	700	0	0	0	0	0	0	1000	**0**	**1,900**
Upper Spoil #8	2.2	2	0	1,100	100	4,600	0	200	0	100	0	400	0	300	0	100	1000	**100**	**6,800**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Black Cottonwood		**Total SPH Deciduous**	
			2018	2020	**2018**	**2020**
Upper Spoil #3	1.1	2	1,300	2,900	**1,300**	**2,900**
Upper Spoil #4	1.6	2	300	500	**300**	**500**
Upper Spoil #8	2.2	2	200	4,000	**200**	**4,000**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Falsebox		Ceanothus		Red Osier Dogwood		Red Raspberry		Sitka Alder		Thimbleberry		Willow		**Total SPH Shrubs**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Upper Spoil #3	1.1	2	0	0	0	0	0	0	1,300	1,300	0	0	300	300	100	100	**1,700**	**1,700**
Upper Spoil #4	1.6	2	0	0	0	0	100	100	800	3,200	0	0	300	800	0	0	**1,200**	**4,100**
Upper Spoil #8	2.2	2	400	500	0	100	100	100	1,600	12,700	0	100	0	0	200	500	**1,900**	**13,300**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Upper Spoil #3	0	3	1	1	3	3	**4**	**7**
Upper Spoil #4	0	3	1	1	3	3	**4**	**7**
Upper Spoil #8	1	7	1	1	4	6	**6**	**14**

6.1.6 Zone 6 Results Summary

Zone 6 is the largest area surveyed and consists of five sites - the Diversion Channel and Slopes, Keyhole Laydown, Upper Intake and Laydown, Upper Spoil #1 and Upper Spoil #2 and Settling Basin. All the sites in Zone 6 except the Keyhole Laydown site were planted with berry shrubs in 2017. The Diversion Channel and Slopes appear to have been grass seeded with a fall rye seed mix. This site has moderate slopes and was roughed up with a machine prior to berry planting, grass seeding and conifer planting. In 2018 a mix of high elevation conifers were planted. Despite having coarse soils and a shorter growing season this site has had good conifer survival. Amabilis fir and Western hemlock were already infilling in 2018 and continue to seed in. Some of the naturals are still in the germinant stage and were a bit chlorotic. The planted conifers have moderate to strong leader growth. Some drought stress was noted but generally the trees look good. This site exceeds the target of 1000 sph with 2666 sph. Cottonwood numbers have increased significantly from 133 sph in 2018 to 1933 sph in 2020. A minor amount of red alder has also infilled. The cottonwood and red alder will add biomass to the site, increasing organic matter in the coarse soils. Red alder will also increase nitrogen levels in the soil, improving growing conditions for other species. The shrub complex on this site is growing well and has increased in diversity and number of sph since 2018. Red Elderberry numbers have decreased slightly since 2018. This is likely due to the dieback of one or two plants in the plots. Overall, this site is well on its way to meeting revegetation targets.

Keyhole Laydown is a small site that had minimal soil disturbance and looks very natural. This site was planted in 2018 with conifers. The planted and natural amabilis fir are of fair to good form and vigour with moderate leader growth. They are growing a bit slower than some of the adjacent sites, likely due to increased competition from the well-developed shrub complex on site. This site exceeds the target of 1000 sph with 1400 sph. The shrub community has not increased in diversity but there are more sph of most species and all species have grown taller since 2018. Highbrush cranberry and vaccinium stem numbers decreased since 2018.This could be due to an error in stem counts as it was difficult to accurately count the plants due to high site occupancy. Overall, this site continues to meet the revegetation targets of a recovering site. No erosion or siltation was noted during the survey. Moss cover has started to fill in where there is exposed mineral soil.

The Upper Intake and Laydown is a large site that was mounded prior to reforestation activities. The portion of the site located above the Lillooet River FSR was contoured and grass seeded to increase slope stability and decrease raveling down to the FSR. Soils are variable on this site, the area above the FSR are slightly compact despite the site prep that was completed. Below the FSR there is an increased component of sand in the soil making them less compact and well drained. In 2017 the site was planted with a mix of berry shrubs and larger conifers grown in five-gallon pots, in 2018 conifers were planted to increase stem density to meet the stocking target of 1000 sph. Conifer diversity is good on this site with six different species, some planted and some occurring naturally. Density of the conifers has increased from 600 sph to 3100 sph. Below the FSR many of the conifers have chlorotic needles and moderate leader growth. Despite the rapidly draining site conditions very little mortality was noted. Above the FSR chlorosis of the needles is less noticeable, and the planted and natural conifers are exhibiting moderate to strong leader growth. The conifers range from 3 cm germinants to 85 cm planted conifers. The average height is 35 cm. Deciduous stem counts have increased significantly from 533 sph in 2018 to 5601 sph in 2020. Black Cottonwood makes almost all of the deciduous component. Many of the cottonwoods are still quite small but are expected to start to grow faster as they become more established onsite. The shrub complex has decreased in diversity since 2018 with the loss of kinnikinnick and thimbleberry. Both of these species were planted and may have succumbed to drought stress. The shrub count has increased from 800 sph to 1290 sph. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal and dependent on microtopography.

Upper Spoil #1 is the highest elevation site in the civil works areas. This site was mostly mounded the sides of the spoil were contoured for stability and are rockier. Soils are coarse with some boulders mixed in. There is scattered coarse woody debris. The spur road into the site was rehabbed and mounded in 2018 but has since been reactivated since then, one of the plots was partially disturbed by the reactivation. This plot was not removed from the data set as less than 50% of the plot was disturbed and there were signs that the herbs and shrubs were starting to grow back. Berry shrubs were planted in 2017 and a mix of high elevation conifers were planted in 2018. The tree planting treatment was successful and the site is stocked with 1866 sph exceeding the reforestation target of 1000 sph. Some natural ingress of conifers was noted, the naturals range from 3 to 10 cm in height. The planted conifers have an average height of 30 cm. The conifers are growing well onsite and are free from any forest health issues. The number of deciduous trees has increased significantly from 533 sph in 2018 to 5601 sph in 2020. The deciduous sph will increase steadily increase the organic component of the soils with annual leaf fall. The shrub complex emerging has increased in diversity and sph. In 2018 there were 934 sph of shrubs in 2020 this had increased to 6400. Salal numbers have decreased slightly since 2018. This is likely due to the dieback of one or two plants in the plots. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal and dependent on microtopography.

The Upper Spoil #2 and Settling Basin site had a large amount of overburden placed on the site creating a large mound with a flat top. The coarse gravel soils were fluffed up by mounding and there is some scattered coarse woody debris. The Southeast portion of the site has more sand mixed into the soil and is a bit less compact than the rest of the site. There is a small area (0.06 ha) area that had a couple of dump truck loads of soil dropped onto the site. This newly disturbed area is not stocked. To replant this area approximately 100 trees would need to be planted. Spoil #2 was planted with berry shrubs in 2017 and was planted with a mix of conifers in 2018. The conifers had good survival rates and is currently stocked with 1550 sph exceeding the target stocking levels of 1000 sph. The conifers are of good form and vigour with moderate to strong leader growth. The deciduous component has increased significantly from 50 sph to 5300 sph, the majority of the deciduous sph are cottonwood. The planted shrubs are growing well onsite with moderate increases in the number of sph. In 2018 there were 500 sph, in 2020 that number had increased to 700 sph. No erosion or siltation was noted during the survey. Moss cover is increasing slowly but cover is still quite minimal and dependent on microtopography.

Figure 6. Zone 6 Plot Photos from 2018 and 2020

Card: Civil Works
Stratum: 2018 Diversion Channel Slopes/Plot: 008/Comments
Overview photo looks towards plot center from the North side of the plot. Sep 06, 2018 02.54.31 PM.jpg

Card: Civil Works
Stratum: 2020 Diversion Channel and Slopes/Plot: 008/Comments
Overview photo looks South from plot 0p8.jpg

Card: Civil Works
Stratum: 2018 Diversion Channel Slopes/Plot: 009/Comments
Overview photo looks at plot from the North side. Sep 06, 2018 03.00.48 PM.jpg

Card: Civil Works
Stratum: 2020 Diversion Channel and Slopes/Plot: 009/Comments
Overview photo looking South from plot 009.jpg

Card: Civil Works
Stratum: 2018 Diversion Channel Slopes/Plot: 013/Comments
Overview photo looks South towards plot center. Sep 07, 2018 12.01.34 PM.jpg

Card: Civil Works
Stratum: 2020 Diversion Channel and Slopes/Plot: 013/Comments
Overview looking South plot 013.jpg

Card: Civil Works
Stratum: 2018 Keyhole Laydown/Plot: 00/Comments
Overview photo looks towards plot center from North side of plot. Sep 06, 2018 02.13.30 PM.jpg

Card: Civil Works
Stratum: 2020 Keyhole Laydown/Plot: 007/Comments
Looking South plot center 007.jpg

Card: Civil Works
Stratum: 2018 Upper Intake and Laydown/Plot: B/Comments
Overview photo looks South towards plot center. Sep 18, 2018 09.12.42 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Intake and Laydown/Plot: B/Comments
Overview photo looks South from plot B.jpg

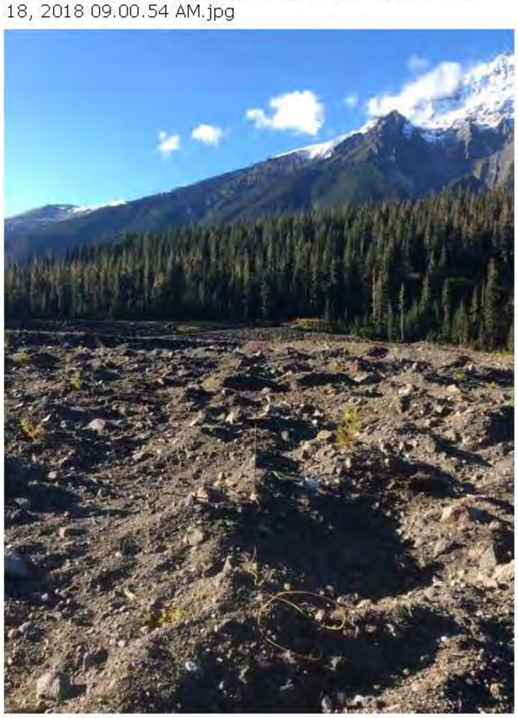
Card: Civil Works
Stratum: 2018 Upper Intake and Laydown/Plot: C/Comments
Overview photo looks South towards plot center. Sep 18, 2018 09.24.35 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Intake and Laydown/Plot: C/Comments
Overview photo looks South from plot C.jpg

Card: Civil Works
Stratum: 2018 Upper Intake and Laydown/Plot: 014/Comments
Overview photo looks South towards plot center. Sep 07, 2018 02.43.28 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Intake and Laydown/Plot: 014/Comments
Overview photo looks South from plot 014.jpg

Card: Civil Works
Stratum: 2018 Upper Intake and Laydown/Plot: A/Comments
Overview photo looks South towards plot center. Sep 18, 2018 09.00.54 AM.jpg



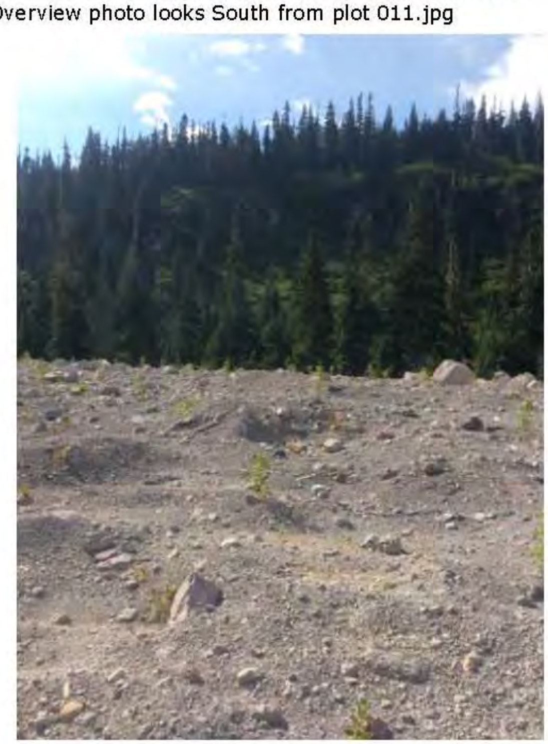
Card: Civil Works
Stratum: 2020 Upper Intake and Laydown/Plot: A/Comments
Overview looking South from c plot b.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #1/Plot: 010/Comments
Overview photo looks South towards plot center. Sep 07, 2018 09.44.26 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #1/Plot: 010/Comments
OV looking South.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #1/Plot: 011/Comments
Overview photo looks South towards plot center. Sep 07, 2018 09.55.49 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #1/Plot: 011/Comments
Overview photo looks South from plot 011.jpg

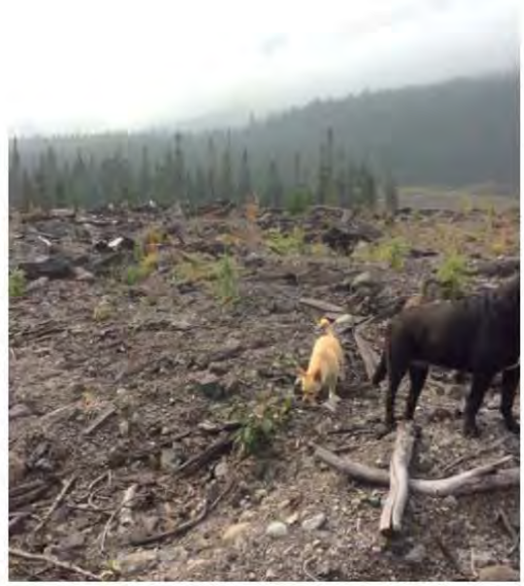


Card: Civil Works
Stratum: 2018 Upper Spoil #1/Plot: 012/Comments
Overview photo looks South towards plot center. Sep 07, 2018 10.17.17 AM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #1/Plot: 012/Comments
Overview photo looks South from plot 012.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #2 & Settling Basin/Plot: 017/Comments
Overview photo looks South towards plot center. Sep 07, 2018 03.27.45 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #2 and Settling Basin/Plot: 017/Comments
Overview photo looks South from plot 017.jpg



Card: Civil Works
Stratum: 2018 Upper Spoil #2 & Settling Basin/Plot: 018/Comments
Overview photo looks South towards plot center. Sep 07, 2018 03.37.08 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #2 and Settling Basin/Plot: 018/Comments
Overview photo looks South from plot 018.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #2 & Settling Basin/Plot: 015/Comments
Overview photo looks South towards plot center. Sep 07, 2018 03.03.11 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #2 and Settling Basin/Plot: 015/Comments
Overview photo looks South from plot 015.jpg

Card: Civil Works
Stratum: 2018 Upper Spoil #2 & Settling Basin/Plot: 016/Comments
Overview photo looks South towards plot center. Sep 07, 2018 03.18.21 PM.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #2 and Settling Basin/Plot: 016/Comments
Overview photo looks South from plot 016.jpg

Table 6. Zone 6- Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Amabalis Fir		Douglas Fir		Lodgepole Pine		Mountain Hemlock		Spruce		Western Hemlock		Western Red Cedar		Target SPH	Total SPH Conifers	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020		**2018**	**2020**
Diversion Channel and Slopes	2.5	3	267	2,133	0	133	0	0	0	67	0	333	0	0	0	0	1000	**267**	**2,666**
Keyhole Laydown	0.1	1	200	1,400	0	0	0	0	0	0	0	0	0	0	0	0	1000	**200**	**1,400**
Upper Intake and Laydown	2.4	4	300	2,100	100	300	0	50	0	0	0	350	50	50	150	250	1000	**600**	**3,100**
Upper Spoil #1	2.4	3	0	533	0	200	0	0	0	0	0	1,000	0	0	0	133	1000	**0**	**1,866**
Upper Spoil #2 and Settling Basin	2.8	4	0	650	0	600	0	0	0	0	0	300	0	0	0	0	1000	**0**	**1,550**

Deciduous Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Black Cottonwood		Red Alder		Trembling Aspen		Total SPH Deciduous	
			2018	2020	2018	2020	2018	2020	**2018**	**2020**
Diversion Channel and Slopes	2.5	3	133	1,933	0	400	0	0	**133**	**2,333**
Keyhole Laydown	0.1	1	0	0	0	0	0	0	**0**	**0**
Upper Intake and Laydown	2.4	4	1,700	16,400	0	200	0	0	**1,700**	**16,600**
Upper Spoil #1	2.4	3	533	5,467	0	67	0	67	**533**	**5,601**
Upper Spoil #2 and Settling Basin	2.8	4	50	5,050	0	250	0	0	**50**	**5,300**

Shrub Diversity From Plot Data (SPH)

Site	Area (Ha)	# Plots	Hardhack Spirea		Highbrush Cranberry		Kinnikinnick		Oregon Grape		Red Elderberry		Red Osier Dogwood		Red Raspberry		Rose Species	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020
Diversion Channel and Slopes	2.5	3	0	0	67	67	0	0	0	0	133	67	0	67	0	133	0	0
Keyhole Laydown	0.1	1	0	0	800	600	0	0	0	0	600	800	0	0	14,800	46,400	0	0
Upper Intake and Laydown	2.4	4	0	0	0	0	50	0	50	50	50	40	0	0	0	0	100	100
Upper Spoil #1	2.4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Spoil #2 and Settling Basin	2.8	4	50	0	0	0	0	0	0	0	0	0	0	0	250	350	0	0

Shrub Diversity From Plot Data Continued (SPH)

Site	Area (Ha)	# Plots	Salal		Salmonberry		Sitka Alder		Sitka Mountain-Ash		Thimbleberry		Vaccinium Species		Willow		**Total SPH Shrubs**	
			2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Diversion Channel and Slopes	2.5	3	133	133	67	133	267	1,000	0	133	67	67	200	267	0	933	**934**	**3,000**
Keyhole Laydown	0.1	1	0	0	0	0	0	0	0	0	0	0	7,200	4,800	400	400	**23,800**	**53,000**
Upper Intake and Laydown	2.4	4	0	0	0	0	200	50	0	0	50	0	0	0	300	1,050	**800**	**1,290**
Upper Spoil #1	2.4	3	67	0	0	0	800	2,667	0	0	67	133	0	0	0	3,600	**934**	**6,400**
Upper Spoil #2 and Settling Basin	2.8	4	50	50	0	0	100	0	0	0	50	50	0	0	0	250	**500**	**700**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Diversion Channel and Slopes	1	4	1	2	7	11	**9**	**17**
Keyhole Laydown	1	1	0	0	5	5	**6**	**6**
Upper Intake and Laydown	4	6	1	2	7	5	**12**	**13**
Upper Spoil #1	0	4	1	3	3	3	**4**	**10**
Upper Spoil #2 and Settling Basin	0	3	1	2	5	4	**6**	**9**

6.2. Results for Civil Work Sites Plots Established in 2019 and 2020

Within the civil works areas, 26 permanent plots were established on 8 sites in 2019 and 2020. For these sites there is only one year of monitoring data available. These sites include the 38 Km Laydown, 41.7 Km Laydown, Camp, Boulder Spoil #4, Boulder Spoil #7, Upper Spoil #5 and Upper Spoil #7. The 41.7 Km Laydown site had one new plot established on the east side of the Lillooet River FSR. The second site that had an additional plot established was the Boulder Powerhouse and Spoil. These civil works sites are not within riparian areas, Ungulate Winter Ranges or Wildlife Habitat Areas and were not planted until the fall of 2018. All sites were planted with a mix of site appropriate conifers. Shrubs and deciduous species have infilled naturally since the sites were reclaimed. A target of 1000 stems per hectare (sph) of conifers has been set for successful reforestation of the sites.

All seedlings were planted with fertilizer teabags to increase available nutrients to seedlings during their first year of growth. Fertilizer teabags are commonly used on nutrient poor sites in conventional forestry. Three types of fertilizer were used on the civil works sites. The first is a 20-gram Chilcotin Worm Blend teabag with a 15-4-4 nitrogen/phosphate/potash mix. The second is a 10-gram Chilcotin PHP teabag with a 17-5-7 mix. The third is recommended for the most difficult sites to reforest. It is a 20-gram Biochar teabag with a mix of 15-5-5. All sites except for the 38 km laydown used only one type of fertilizer. The 38 km laydown site is the largest site in the civil works project area at 13ha. The site was divided into three sections with a specific fertilizer used in each area. In 2019, five permanent plots were established in each area. The species and number of conifers in each plot was collected in 2019 and 2020. The data collected over the two years does not differentiate between planted and natural conifers so it is difficult to get completely accurate data on the efficacy of the three fertilizer types. For the 2020 vegetation monitoring assessment, 2019 plots were used as a baseline. The 2020 data was compared to that from 2019. If there were more conifers of a certain species in the 2020 plot it was assumed that these were naturals and were not added to the count to find the survival rate. For example, if there were 4 Douglas-fir in the 2019 plot and 6 Douglas fir in the 2020 plot it was assumed that the plot had 100% survival. This was done for each plot and an average percent survival was determined. Using this method, the areas where the 20-gram Biochar was used, the type recommended for the most difficult sites, had the best survival at 75%. The areas where the 20-gram Chilcotin Worm Blend and the 10-gram Chilcotin PHP fertilizer were applied had nearly the same survival rates at 65% and 66%.

All sites except Boulder Spoil #7 have met or exceeded the target of 1000 sph of conifers. This site was expected to be one of the most difficult to reforest as it has rocky compact soils that are rapidly draining. Some areas are mostly rock with minimal soil and are marginally suitable for growing conifers. The banks of the Boulder Spoil #7 site are contoured to reduce raveling into the adjacent cutblock. The site was planted with 1800 conifers per ha, and all seedlings were planted with Chilcotin fertilizer tea bags to provide extra nutrients in the first year of growth. Although less than 50% of the planted conifers survived, the site is stocked at just below target levels with 800 coniferous stems per ha. Considering the difficult growing conditions and the continuing natural ingress of cottonwoods on the site no further planting treatments are recommended.

The total conifer densities for the sites established in 2020 range from 800 stems per ha on a rocky, well drained site to 7000 stems per ha on a richer site with a viable seed source adjacent to the site. The average number of conifers stems per ha is 2300. The conifers range from 5 cm germinants to 60 cm tall planted conifers. The average height of the conifers is 34 cm. The conifers are free from forest health issues and appear to be growing well. The germinants were counted but until they have grown for a couple of years and have reached a height of 15 cm survival is variable due to their small root systems, minimal foliage and limited capabilities to deal with soil moisture deficits in the summer months.

For the sites established in 2019 and 2020 he total deciduous species densities range from 1600 to 28,800 stems per ha. The deciduous trees are important pioneer species that add biomass to the sites and in the case of alders are nitrogen fixing species that enrich the site and increase nutrient uptake by other species. Due to natural ingress, distribution and densities are variable. The average number of deciduous stems per ha is 10,414. The deciduous stems range from 5 cm to 80 cm in height.

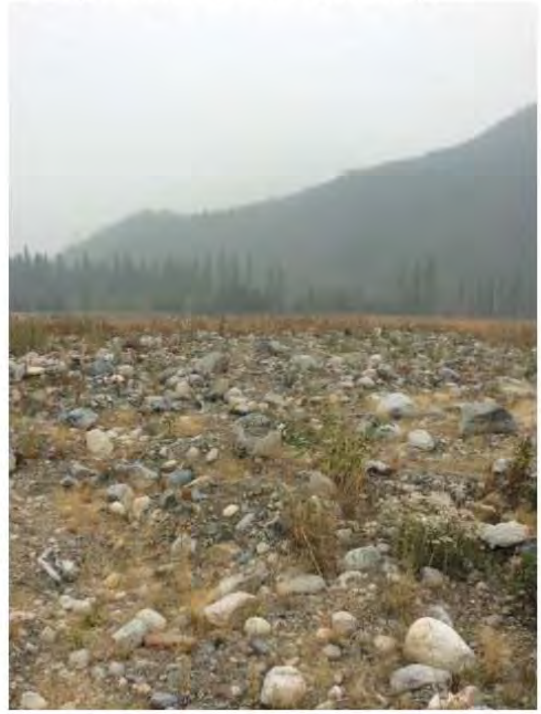
The total shrub species densities range from 0 to 23,800 sph. Where shrub densities are high the shrub species have multiple stems originating from one root crown it was difficult to accurately count the number of plants growing in the plot. An effort was made to accurately count the number of plants in the plot as outlined in Section 5.1. The average number of shrubs per site was 8367 stems per ha. Depending on the species the shrubs ranged from 15 to 70 cm in height. All the shrubs are of good form and vigour and appear to be growing well.

The total percentage ground cover of all layers combined (herb, shrub and tree) in the quadrat surveys ranged between 3% and 13% cover. Due to the sites being dependent on natural ingress of herbaceous and shrub layers, percent cover is lower than on the sites that were grass seeded or planted with shrubs and conifers. These civil work sites were nearly devoid of any vegetation in 2018 and are showing positive signs of recovery with an average percent cover of 6%. The vegetation measured has an average height of 34 cm.

Figure 7. 38 Km Laydown Plot Photos from 2020

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W1/Comments
Overview photo looks South from plot W1.jpg

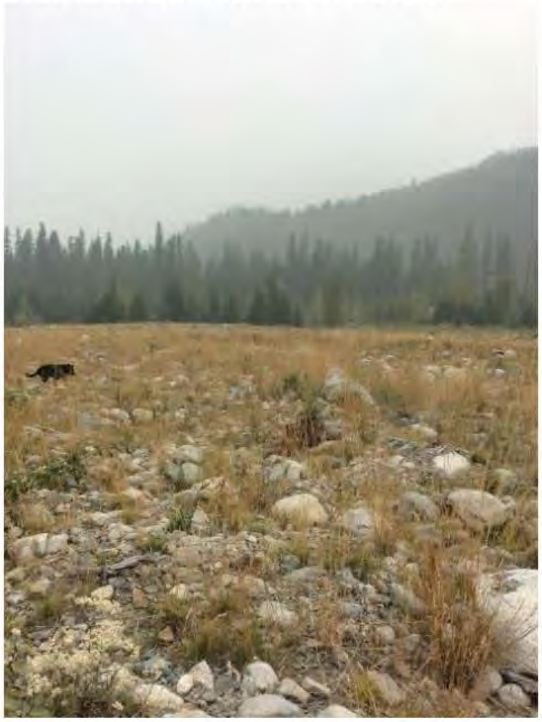
Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W2/Comments
Overview photo looks South from plot W2.jpg



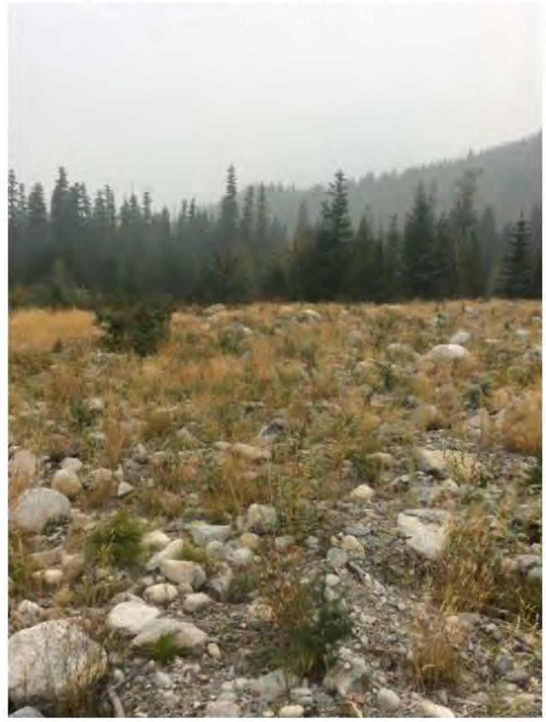
Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W3/Plot Name
Overview photo looks South from plot W3.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W3/Comments
Overview photo looks South from plot W3.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W4/Comments
Overview photo looks South from plot W4.jpg

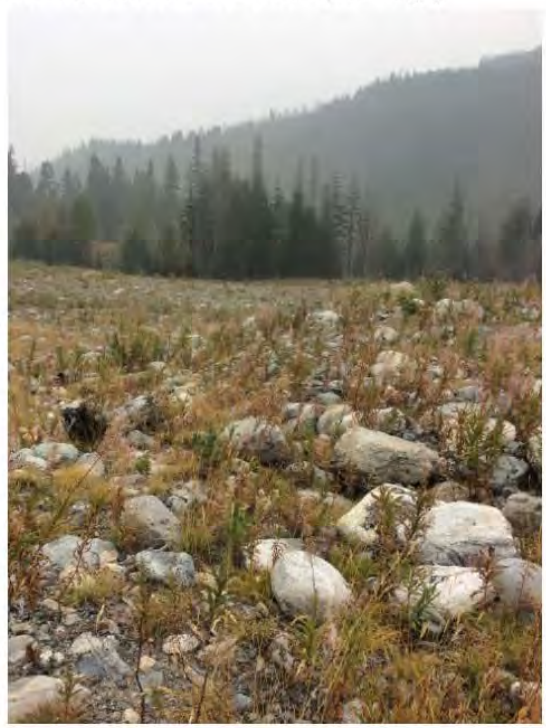


Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W5/Comments
Overview photo looks South from W5.jpg



Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W6/Comments
Overview photo looks South from plot W6.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W7/Comments
Overview photo looks South from plot W7.jpg

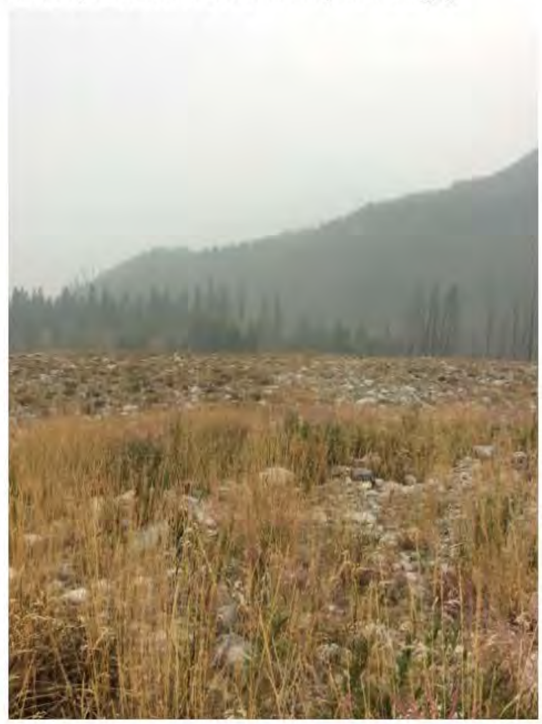


Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W8/Comments
Overview photo looks South from plot W8.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W9/Comments
Overview photo looks South from plot W9.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W10/Comments
Overview photo looks South from plot W10.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W11/Comments
Overview photo looks South from plot W11.jpg

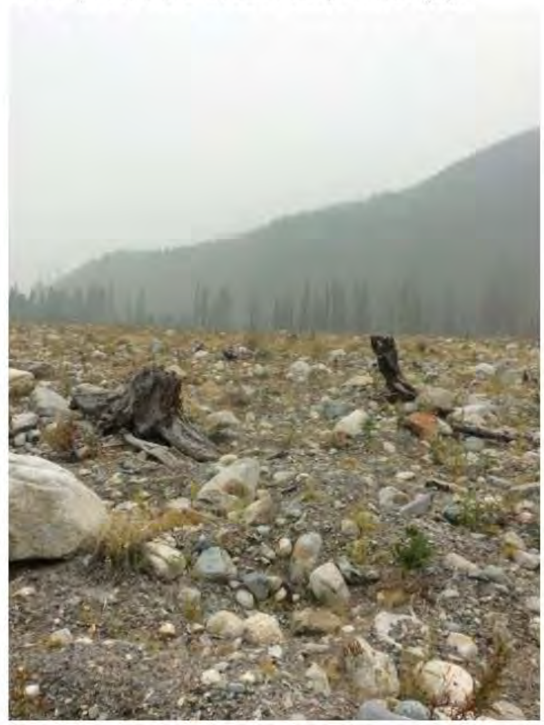


Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W12/Comments
Overview photo looks South from plot W12.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W13/Comments
Overview photo looks South from plot W13.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W14/Comments
Overview photo looks South from W14.jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W15/Comments
Overview photo looks South from plot W15.jpg



Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W1/Species Tally: Amabalis Fir/Tree Species
Ba 20 cm tall .jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W3/Species Tally: Western Red Cedar/Tree Species
Cw 52 cm tall .jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W1/Species Tally: Douglas Fir/Tree Species
Fdc 56 cm tall .jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W1/Species Tally: Lodgepole Pine/Tree Species
Plc 61 cm tall .jpg

Card: Civil Works
Stratum: 2020 38 km Laydown/Plot: W3/Species Tally:
Spruce/Tree Species
Sx 42 cm tall .jpg

Figure 8. 41.7 Km Laydown Plot Photo from 2020

Card: Civil Works
Stratum: 2020 41.7 Km Borrow Pit/Plot: U/Comments
Overview photo looks South from plot U.jpg

Figure 9. Boulder Spoil #4 and #7 Plot Photos from 2020

Card: Civil Works
Stratum: 2020 Boulder Spoil #4/Plot: D1/Comments
Overview photo looks South from plot D1.jpg

Card: Civil Works
Stratum: 2020 Boulder Spoil #7/Plot: E1/Comments
Overview photo looks South from plot E1.jpg

Card: Civil Works
Stratum: 2020 Boulder Spoil #4/Plot: D1/Species Tally:
Douglas Fir/Tree Species
Fdc 64 cm tall .jpg

Card: Civil Works
Stratum: 2020 Boulder Spoil #4/Plot: D1/Species Tally:
Spruce/Tree Species
Sx 59 cm tall .jpg

Figure 10. Camp Photos from 2020

Card: Civil Works
Stratum: 2020 Camp/Plot: B1/Comments
Overview photo looks South from plot B1.jpg

Card: Civil Works
Stratum: 2020 Camp/Plot: V/Comments
Overview photo looks South from plot V.jpg

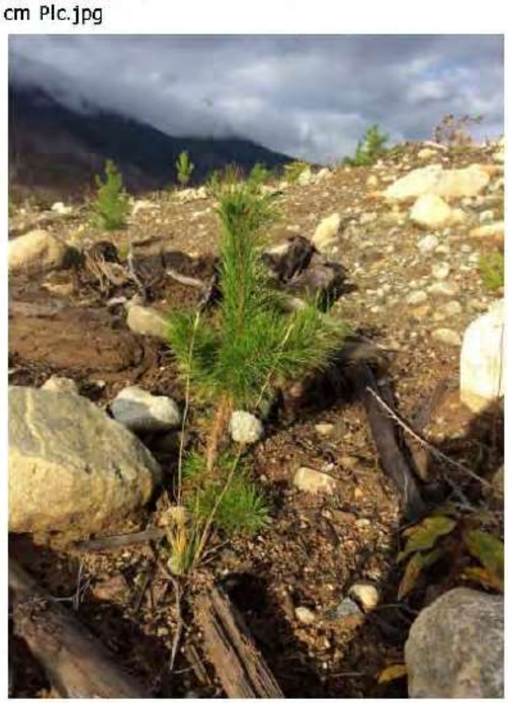
Card: Civil Works
Stratum: 2020 Camp/Plot: W/Comments
Overview photo looks South from plot W.jpg

Card: Civil Works
Stratum: 2020 Camp/Plot: X/Comments
Overview photo looks South from plot X.jpg

Card: Civil Works
Stratum: 2020 Camp/Plot: Y/Plot Name
Overview photo looks South from plot Y.jpg

Card: Civil Works
Stratum: 2020 Camp/Plot: Z/Comments
Overview photo looks South from plot Z.jpg

Card: Civil Works
Stratum: 2020 Camp/Plot: V/Species Tally: Lodgepole Pine/Tree Species
60 cm Plc.jpg



Card: Civil Works
Stratum: 2020 Camp/Plot: W/Species Tally: Douglas Fir/Tree Species
Fdc 58 cm tall .jpg

Figure 11. Upper Spoil #5 Plot Photos from 2020

Card: Civil Works
Stratum: 2020 Upper Spoil #5/Plot: F1/Comments
Overview photo looks South from plot F1.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #5/Plot: F1/Species Tally: Amabalis Fir/Tree Species
Ba 29 cm tall .jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #5/Plot: F1/Species Tally: Douglas Fir/Tree Species
Fdc 15 cm tall.jpg

Card: Civil Works
Stratum: 2020 Upper Spoil #5/Plot: F1/Comments
Hw naturals infilling.jpg

Figure 12. Upper Spoil #7 Plot Photos from 2020

Card: Civil Works
Stratum: 2020 Upper Spoil #7/Plot: T/Comments
Overview photo looks South from plot T.jpg

6.3. Results for Transmission Line Sites

The transmission line plot data collected in Year 3 (2020) has been summarized by site comparing the plant communities present in 2018 (Year 1) and 2020 (Year 3). No new plots were established in 2020 within the transmission line portion of the ULHP revegetation project.

The transmission line road sites continue to successfully regenerate. All sites show an increase in species diversity and density. Some sites did have decreases in the number of sph for one or two species but always had an increase in diversity. The decrease in sph is not a sign of the site being unable to regenerate but is an example of site succession on a small scale. In general, all species of plants were of good form and vigour and free from any forest health pests. The only plants that were looking spindly or weak were being shaded out by more aggressive species. Each surveyed road site is summarized below.

6.3. Transmission Line Road Site 53.1/56.1 Summary

Transmission line road 53.1/56.1 is deactivated and is not drivable. Soils are rapidly draining and coarse with lots of surface rock. This site was grass seeded with a fall rye blend. No conifers were recorded at this site. Black cottonwood numbers have increased since 2018 to 3000 sph. Thimbleberry and red raspberry numbers have also increased significantly over the last two years. The thimbleberry is not growing as vigorously on this site but that may be due to the rapidly draining soils. Species diversity has increased with red osier dogwood and willow now growing onsite. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 13. 53.1/56.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 53.1/56.1/Plot: 31/Comments
Sep 18, 2018 01.29.59 PM.jpg

Card: Transmission Line
Stratum: 2020 53.1/56.1/Plot: 31/Comments
Overview photo looks South from plot 31.jpg

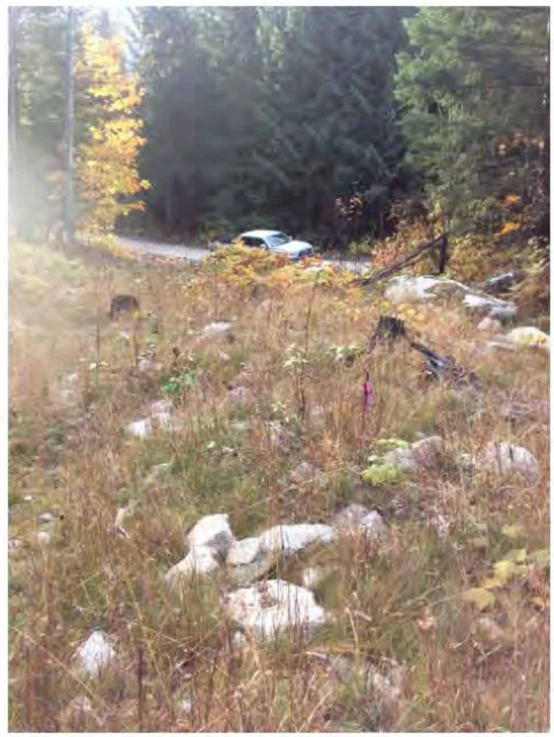


Table 7. 53.1/56.1 - Vegetation Density and Species Diversity from 2018 to 2020

Coniferous Diversity From Plot Data (SPH)

Site	Total SPH Conifers	
	2018	**2020**
53.1/56.1	**0**	**0**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
53.1/56.1	1800	3000	**1800**	**3000**

Shrub Diversity From Plot Data (SPH)

Site	Red Osier Dogwood		Red Raspberry		Thimbleberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
53.1/56.1		200	400	800	800	2200		200	**1200**	**3400**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
53.1/56.1	0	0	1	1	2	4	**3**	**5**

6.3.1 Transmission Line Road 73.1 Summary

Transmission line road 73.1 is deactivated and is not drivable. The soils are coarse but not too rocky. Coarse woody debris was added to the road after it was decompacted. This site is dominated by thimbleberry and red raspberry. The number of sph of thimbleberry have decreased slightly from 17800 in 2018 to 16000 in 2020 but the height and width of the plants has increased significantly. Douglas fir naturals have also filled in at 400 sph. Most of Douglas fir are still quite small ranging from 5 to 18 cm in height. They have seeded in where there is available mineral soil and they are not overtopped by shrubs. Black cottonwood has also seeded in at 5800 sph. Despite the site being dominated by thimbleberry and red raspberry falsebox and willow have seeded in and are growing well on the site. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 14. 73.1 Plot Photos from 2018 and 2020

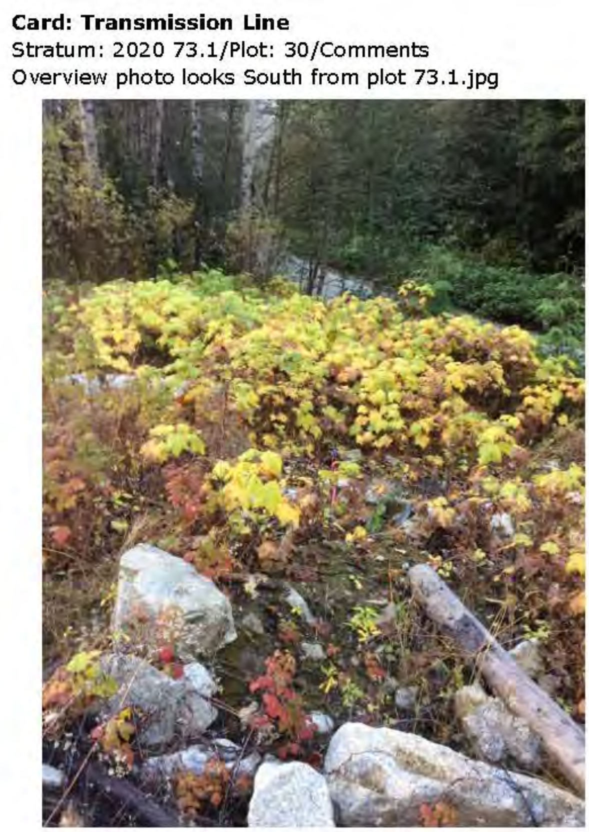


Table 8. 73.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
73.1	0	400	**0**	**400**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
73.1	0	5,800	**0**	**5,800**

Shrub Diversity From Plot Data (SPH)

Site	Falsebox		Red Raspberry		Thimbleberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	***2018***	***2020***
73.1	0	1,200	1,600	10,000	17,800	16,800	0	400	**19,400**	**28,400**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
73.1	0	1	0	1	2	4	**2**	**6**

6.3.2 Transmission Line Road 129.1 Summary

Transmission line road 129.1 is deactivated and is not drivable. Soils are rapidly draining and coarse with lots of surface rock. This site was grass seeded with a fall rye blend. Lodgepole pine continues to seed in naturally and is growing well on this dry site. Lodgepole pine numbers have increased from 1200 sph in 2018 to 1600 sph in 2020. The lodgepole pine range from 30 cm to 55 cm in height. A few black cottonwoods have filled in naturally at 400 sph. This site has decreased in the number of shrubs since 2018. This is likely due to high temperatures in the summer and a lack of soil moisture. Falsebox numbers have decreased by half from 2018 to 2020, there are currently 1000 sph of falsebox onsite. Ceanothus numbers have also decreased from 400 sph in 2018 to 200 sph in 2020. Both of these species are typically drought tolerant, but may be more susceptible to drought conditions when they are smaller and their root system is not developed enough to survive season long drought conditions. The grass seeding treatment could also have created more competition between plants for water. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 15. 29.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 129.1/Plot: 29/Comments
Sep 18, 2018 11.34.17 AM.jpg

Card: Transmission Line
Stratum: 2020 129.1/Plot: 29/Comments
Overview photo looks South from plot 29.jpg

Table 9. 129.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Lodgepole Pine		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
129.1	1,200	1,600	**1,200**	**1,600**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
129.1	0	400	**0**	**400**

Shrub Diversity From Plot Data (SPH)

Site	Ceanothus		Falsebox		Kinnikinnick		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
129.1	400	200	2,000	1,000	0	800	**2,400**	**2,000**

Number of Species by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
129.1	1	1	0	1	2	3	**3**	**5**

6.3.3 Transmission Line Road 130.1 Summary

Transmission line road 130.1 is deactivated and is not drivable. Soils are rapidly draining and coarse with lots of surface rock. This site was grass seeded with a fall rye blend. Lodgepole pine and Douglas fir naturals continue to infill, numbers have increased slightly since 2018 with 3200 sph of lodgepole pine and 600 sph of Douglas fir. The fast growing lodgepole pine range from 15 to 75 cm in height. The Douglas fir range from 5 to 35 cm in height. Black cottonwood numbers have remained constant since 2018 with 400 sph. The number of falsebox sph has decreased since 2018 from 6600 in 2018 down to 1400 in 2020. This may be due to moisture deficits in the hot summer months. Despite the decrease in falsebox numbers shrub diversity has increased with kinnickinnick, willow and blackcap raspberry seeding in naturally since 2018. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 16. 130.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 130.1/Plot: 28/Comments
Sep 18, 2018 11.05.09 AM.jpg

Card: Transmission Line
Stratum: 2020 130.1/Plot: 28/Comments
Overview photo looks South from plot 28.jpg

Table 10. 130.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		Lodgepole Pine		Spruce		**Total SPH Conifers**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
130.1	200	600	3,000	3,200	400	0	**3,600**	**3,800**

Deciduous Diversity From Plot Data (SPH)

Site	Bigleaf Maple		Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	2018	2020	**2018**	**2020**
130.1	0	0	400	400	**400**	**400**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Falsebox		Kinnikinnick		Trailing Blackberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
130.1	0	200	6,600	1,400	0	2,000	200	0	0	400	**6,800**	**4,000**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
130.1	3	2	1	1	2	4	**6**	**7**

6.3.4 Transmission Line Road 133.1 Summary

Transmission line road 133.1 is deactivated and is not drivable. The soils are coarse and there is lots of surface rock present on the site. This site was grass seeded with a fall rye blend. Lodgepole pine and Douglas fir naturals have infilled and are growing well onsite. There are 800 sph of lodgepole pine and 400 sph of Douglas fir the naturals ranging from 10 to 35 cm in height. Black cottonwood and bitter cherry have also seeded in with 200 sph each. Shrub diversity has increased slightly with falsebox and red raspberry now being present onsite. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 17. 133.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 133.1/Plot: Plot 27/Comments
Sep 18, 2018 10.34.16 AM.jpg

Card: Transmission Line
Stratum: 2020 133.1/Plot: 27/Comments
Overview photo looks South from plot 27.jpg

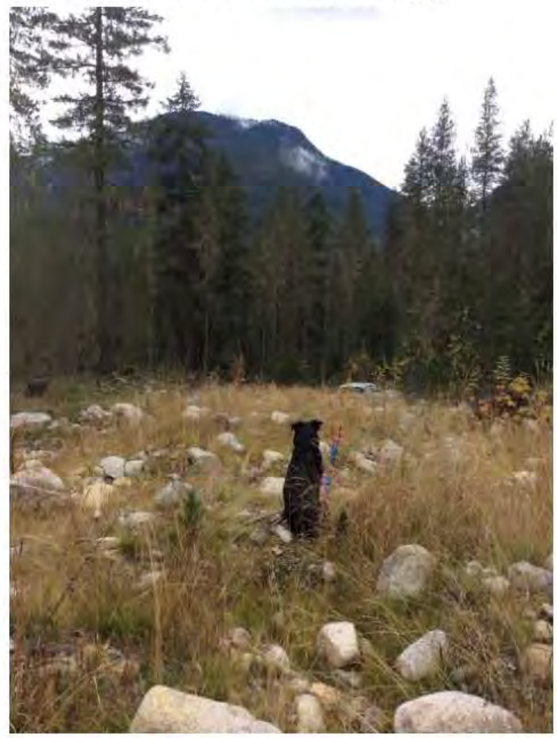


Table 11. 133.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		Lodgepole Pine		**Total SPH Conifers**	
	2018	2020	2018	2020	**2018**	**2020**
133.1	0	400	0	800	**0**	**1,200**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
133.1	0	200	**0**	**200**

Shrub Diversity From Plot Data (SPH)

Site	Bitter Cherry		Falsebox		Red Raspberry		Trailing Blackberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
133.1	0	200	0	200	0	400	200	0	**200**	**800**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
133.1	0	2	0	1	1	3	**1**	**6**

6.3.5 Transmission Line Road 140.1 Summary

Transmission line road 140.1 is deactivated and is not drivable. Scattered coarse woody debris was added to the road after soils were decompacted. This site has been recolonized heavily by red alders suckering up from the stand that previously occupied the site. The number of red alder sph have not increased significantly from 2018 to 2020 but the alder has grown approximately a meter in height since the original plot data was collected. This site has increased in biodiversity since 2018 with Western red cedar, paper birch, red osier dogwood, red raspberry and willow seeding in. The number of thimbleberry plants has decreased from 3000 sph in 2018 to 1600 sph in 2020. The decrease in number of sph is mainly due to an increase in crown closure from the red alder. The shrubs growing under the canopy of red alder are spindly and this site is expected to become less diverse over time. The Western red cedar is growing ok under the canopy as it is tolerant of low light levels. Moss cover is increasing slowly. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

This site falls within the WHA 2-399 and is required to have road and access trails deactivated and non-drivable by ATV. In 2020 when the access points at this site and inspection site 141.1 were reassessed, they remained non-drivable. The second requirement is that at least 50% of the planted stems within the revegetated portion of the Grizzly Bear WHA 2-399 are native fruit bearing shrubs. This requirement is not required for the road access points due to their close proximity to the Lillooet South FSR. The upland areas have a good mix of berry producing shrubs such as thimbleberry, raspberry and red osier dogwood.

Figure 18. 140.1 Plot Photos from 2018 and 2020

Table 12. 140.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Western Red Cedar		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
140.1	0	2,000	**0**	**200**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		Paper Birch		Red Alder		**Total SPH Deciduous**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
140.1	12,000	6,200	0	400	26,400	27,800	**38,400**	**34,400**

Shrub Diversity From Plot Data (SPH)

Site	Red Osier Dogwood		Red Raspberry		Thimbleberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
140.1	0	200	0	200	3,000	1,600	0	200	**3,000**	**2,200**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
140.1	0	1	2	3	1	4	**3**	**8**

6.3.6 Transmission Line Road 163.1 Summary

Transmission line road 163.1 is not deactivated. The plot was established in the middle road in 2018. When the plot was revisited in 2020 the rebar was found on the side of the road and the original plot center could not accurately be relocated. The plot was re-established off the side of the road. Due to different plot locations and the spur road not being deactivated this site should be dropped from revegetation monitoring program. If the road is no longer required to access the transmission line it should be deactivated. This could be completed by decompacting the road and adding coarse woody debris or something less permanent such as putting boulders at the junction of the spur road and the South Lillooet FSR to block access.

Figure 19. 163.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 163.1/Plot: 35/Comments
Sep 25, 2018 02.02.25 PM.jpg

Card: Transmission Line
Stratum: 2020 163.1/Plot: 35A/Comments
Overview photo looks up road from FSR.jpg

6.3.7 Transmission Line Road 237.1 Summary

The plot for transmission line road 237.1 is located within the transmission line ROW but may not require brushing in the future as the ROW was cleared wider here to avoid creating a fringe of standing timber between the transmission line and the Ryan River FSR. The road is deactivated and is not drivable. Coarse woody debris was placed on the road and soils were decompacted. Douglas fir naturals have seeded in from the adjacent mature stands at 8800 sph. This site is dominated by thimbleberry and black cottonwood. The number of sph of thimbleberry has not increased very much but the height and width of the plants has increased significantly covering most of the area. Red alder and Bigleaf maple are also present in the area. The number of bigleaf maple sph have not increased since 2018, this is likely due thimbleberry taking up most of the growing space and creating a shadier growing site. Other new shrub species onsite are willow, high brush cranberry and falsebox. Moss cover is increasing slowly. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 20. 237.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 237.1/Plot: 34/Comments
Sep 25, 2018 11.25.07 AM.jpg

Card: Transmission Line
Stratum: 2020 237.1/Plot: 34/Comments
Overview photo looks South from plot 34.jpg

Table 13. - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
237.1	0	8,800	**0**	**8,800**

Deciduous Diversity From Plot Data (SPH)

Site	Bigleaf Maple		Black Cottonwood		Red Alder		**Total SPH Deciduous**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
237.1	200	200	200	10,800	0	400	**400**	**11,400**

Shrub Diversity From Plot Data (SPH)

Site	Falsebox		Highbrush Cranberry		Rose Species		Thimbleberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
237.1	0	600	0	400	600	0	11,000	14,000	0	1,600	**11,600**	**16,600**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
237.1	0	1	2	3	2	4	**4**	**8**

6.3.8 Transmission Line Road 238.1 Summary

Transmission line road 238.1 is deactivated and is not drivable. Coarse woody debris was placed on the deactivated road and soils were decompacted. This site has moderately rocky soils. Douglas fir naturals have seeded in heavily on this site with 14,000 sph of germinants and seedlings. The Douglas fir range from 3 to 15 cm in height. Some dieback of Douglas fir seedlings is expected due to competition for light and nutrients as the deciduous trees and shrub species get larger and take up more nutrients and soil moisture. Black cottonwood has also sprouted since 2018 at 200 sph. The shrub complex has diversified and increased in density. New shrub species on site are falsebox and Douglas spirea. The number of sph of thimbleberry and ceanothus has also increased by 1600 sph for thimbleberry and 800 sph for ceanothus. Moss cover is increasing slowly and is dependent on microtopography and presence of mineral soil No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 21. 238.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 238.1/Plot: Plot 33/Latitude
Sep 25, 2018 10.53.46 AM.jpg

Card: Transmission Line
Stratum: 2020 238.1/Plot: 33/Plot Name
Overview photo looks South from plot 33.jpg

Table 14. 238.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
238.1	0	14,000	**0**	**14,000**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
238.1	0	200	**0**	**200**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Ceanothus		Douglas Spirea		Falsebox		Thimbleberry		Trailing Blackberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
238.1	0	800	1,200	2,000	0	400	0	5,200	3,200	4,800	800	0	**5,200**	**13,200**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
238.1	0	1	0	1	3	5	**3**	**7**

6.3.9 Transmission Line Road 239.1 Summary

Transmission line road 239.1 takes off from an existing forestry road. The portion of the road built to access pole 239 is deactivated and looks similar to the other roads in the area regarding natural ingress of trees and shrubs. The plot was established on the active portion of the road this location was likely chosen due to its location being outside of the transmission line ROW. Plot data was collected in 2020 but it is recommended that the site be dropped from the monitoring program as the original plot location is not part of the road that Innergex was required to deactivate and actively being used by industry and recreationalists. There was no increase in species diversity and the total sph for the site has decreased from 2000 sph in 2018 to 800 sph in 2020. A new plot could be established in 2022 to assess the success of the revegetation. The plot data could then be compared to adjacent sites.

Figure 22. 239.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 239.1/Plot: 32/Comments
Sep 25, 2018 10.27.43 AM.jpg

Card: Transmission Line
Stratum: 2020 239.1/Plot: 32/Comments
Overview photo looks South from plot 32.jpg

Table 15. 239.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Total SPH Conifers	
	2018	**2020**
239.1	**0**	**0**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		Total SPH Deciduous	
	2018	2020	**2018**	**2020**
239.1	800	400	**800**	**400**

Shrub Diversity From Plot Data (SPH)

Site	Thimbleberry		Total SPH Shrubs	
	2018	2020	**2018**	**2020**
239.1	1,200	400	**1,200**	**400**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		Total Number of Species	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
239.1	0	0	1	1	1	1	**2**	**2**

6.3.11 Transmission Line Road 245.1 Summary

Transmission line road 245.1 is located on a moderately steep slope and is deactivated. Coarse woody debris was placed on the road, soils are rocky and well drained. This site has increased significantly in biodiversity between 2018 and 2020. Douglas fir naturals have seeded in heavily at 8200 sph, with lesser amounts of Western red cedar infilling at 600 sph. The conifers are still in the germinant/seedling phase and range from 3 to 20 cm in height. Black cottonwood and paper birch are also sprouting onsite with 1000 sph of black cottonwood and 400 sph of paper birch. The emerging shrub complex has increased in biodiversity, sph and height since 2018. Moss cover is increasing slowly and is dependent on microtopography and presence of mineral soil. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 23. 245.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 245.1/Plot: 26/Comments
Sep 12, 2018 01.52.39 PM.jpg

Card: Transmission Line
Stratum: 2020 245.1/Plot: 26/Comments
Overview photo looks South from plot 26.jpg

Table 16. 245.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		Western Red Cedar		**Total SPH Conifers**	
	2018	2020	2018	2020	**2018**	**2020**
245.1	0	8,200	0	600	**0**	**8,800**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		Paper Birch		Red Alder		**Total SPH Deciduous**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
245.1	0	1,000	0	400	1,000	0	**1,000**	**1,400**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Ceanothus		Douglas Spirea		Falsebox		Gooseberry		Highbrush Cranberry		Red Raspberry		Thimbleberry		Trailing Blackberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
245.1	0	5,800	0	2,600	0	400	0	1,400	400	0	0	600	0	600	11,000	3,400	400	1,200	**11,800**	**16,000**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
245.1	0	2	1	2	3	8	**4**	**12**

6.3.12 Transmission Line Road 247.1/249.1 Summary

Spur road 247.1/249.1 is deactivated and is not drivable. The plot was established at the junction of the two roads. Soils are rocky and well drained. In 2018 this site was dominated by herbaceous cover and had minimal woody species diversity with only thimbleberry and ceanothus being present in 2018. Conifer and shrub diversity have increased significantly since 2018 with 2000 sph of Douglas fir and 600 sph of bigleaf maple. New shrub species onsite that have infilled naturally include raspberry species, high brush cranberry and Douglas spirea. The Douglas fir and bigleaf maple will eventually require brushing to maintain transmission line security. Moss cover is increasing slowly and is dependent on microtopography and presence of mineral soil. No soil erosion or siltation issues were noted.

Figure 24. 247./249.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 247.1 / 249.1/Plot: 25/Comments
Sep 12, 2018 01.30.59 PM.jpg

Card: Transmission Line
Stratum: 2020 247.1/249.1/Plot: 25/Comments
Oct 02, 2020 11.54.59 AM.jpg

Table 17. 247./249.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
247.1/249.1	0	2,000	**0**	**2,000**

Deciduous Diversity From Plot Data (SPH)

Site	Bigleaf Maple		**Total SPH Deciduous**	
	2018	2020	**2018**	**2020**
247.1/249.1	0	600	**0**	**600**

Shrub Diversity From Plot Data (SPH)

Site	Birchleaf Spirea		Blackcap Raspberry		Ceanothus		Falsebox		Highbrush Cranberry		Red Raspberry		Thimbleberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
247.1/249.1	0	200	0	4,600	1,200	2,000	0	10,800	0	400	0	5,600	7,600	13,000	**8,800**	**36,600**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
247.1/249.1	0	1	0	1	2	7	**2**	**9**

6.3.13 Transmission Line Road 250.1 Summary

Transmission line road 250.1 is deactivated and is not drivable. Large pieces of coarse woody debris were placed across the decompacted road. Soils are rocky and well drained. Douglas fir and Western red cedars have infilled naturally at 16,800 sph and 200 sph respectively. The conifers are still small and some mortality is expected to occur due to competition from the emerging shrub complex. Thimbleberry sph and cover have increased significantly on this site from 1800 sph in 2018 to 5000 sph in 2020. Other new shrub species onsite include falsebox, ceanothus, black cap raspberry and lesser amounts of high brush cranberry and prince's pine. Moss cover is increasing slowly and is dependent on microtopography and presence of mineral soil. No soil erosion or siltation issues were noted and no further revegetation treatments are required.

Figure 25. 250.1 Plot Photos from 2018 to 2020

Card: Transmission Line
Stratum: 2018 250.1/Plot: 24/Comments
Sep 12, 2018 01.00.12 PM.jpg

Card: Transmission Line
Stratum: 2020 250.1/Plot: 24/Comments
Overview photo looks South from plot 24.jpg

Table 18. 250.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		Western Red Cedar		**Total SPH Conifers**	
	2018	2020	2018	2020	**2018**	**2020**
250.1	0	16,800	0	200	**0**	**18,800**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		Red Alder		**Total SPH Deciduous**	
	2018	2020	2018	2020	**2018**	**2020**
250.1	0	3,600	200	0	**200**	**3,600**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Ceanothus		Falsebox		Gooseberry		Highbrush Cranberry		Prince's Pine		Thimbleberry		Trailing Blackberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
250.1	0	1,000	0	1,200	0	2,600	200	0	0	200	0	200	1,800	5,000	200	0	**2,200**	**10,200**

Number of Speices by Site

44.25	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
250.1	0	2	1	1	3	6	**4**	**9**

6.3.14 Transmission Line Road 255.1 Summary

Transmission line road 255.1 is deactivated, and wood chipping was completed onsite. This site has increased significantly in biodiversity and stem counts for conifers, deciduous trees and shrubs. In the 2018 survey there were no conifers. Douglas fir naturals have seeded in heavily since 2018 with 8600 sph in 2020. Western red cedar has also infilled at 1200 sph and lesser amounts of Western hemlock at 200 sph. The conifer naturals are all still in the germinant/seedling phase and range from 3 to 15 cm in height. Black cottonwood and paper birch have also infilled since 2018 with 1200 sph and 200 sph respectively. The shrub complex has also increased in species diversity and sph. Due to this road being located in the ROW the site will eventually require manual brushing to maintain line security. Moss cover is increasing slowly. No soil erosion or siltation issues were noted.

Figure 26. 255.1 Plot Photos from 2018 and 2020

Table 19. 255.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Douglas Fir		Western Hemlock		Western Red Cedar		**Total SPH Conifers**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
255.1	0	8,000	0	200	0	1,200	**0**	**9,400**

Deciduous Diversity From Plot Data (SPH)

Site	Black Cottonwood		Paper Birch		Red Alder		**Total SPH Deciduous**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
255.1	0	800	0	200	200	0	**200**	**1,000**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Ceanothus		Falsebox		Highbrush Cranberry		Red Raspberry		Salmonberry		Thimbleberry		Trailing Blackberry		Willow		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
255.1	0	3,000	0	600	0	5,400	0	200	200	3,400	0	600	1,000	8,600	600	2,600	0	400	**1,800**	**24,800**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
255.1	0	3	1	2	3	9	**4**	**14**

6.3.15 Transmission Line Road 260.1 Summary

Transmission line road 260.1is deactivated, soils were decompacted and large boulders block the access. This site does not have any conifers growing on it at this time. Bigleaf maple has sprouted as single stems and are growing vigorously onsite. The shrub complex continues to increase in density and species diversity. Due to this site being within the right of way (ROW) of the transmission line the hardwoods will eventually need to be brushed to maintain line security. Moss cover is increasing slowly. No soil erosion or siltation issues were noted.

Figure 27. 260.1 Plot Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 260.1/Plot: 21/Comments
Sep 12, 2018 10.03.55 AM.jpg

Card: Transmission Line
Stratum: 2020 260.1/Plot: 21/Comments
Overview photo looks South from plot 21.jpg

Table 20. 260.1 - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	**Total SPH Conifers**	
	2018	**2020**
260.1	**0**	**0**

Deciduous Diversity From Plot Data (SPH)

Site	Bigleaf Maple		Black Cottonwood		**Total SPH Deciduous**	
	2018	2020	2018	2020	**2018**	**2020**
260.1	200	600	200	0	**400**	**600**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Red Raspberry		Saskatoon		Sitka Alder		Thimbleberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
260.1	0	1,800	1,000	0	200	400	0	200	7,800	8,400	**9,000**	**10,800**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
260.1	0	0	2	1	3	4	**5**	**5**

6.3.16 Ryan Crossing Summary

The Ryan Crossing site is located in a narrow corridor with rich organic soils and low light levels. Western red cedar, a low light tolerant species is seeding n naturally from the adjacent stand. The number of seedlings has increased 600 sph in 2018 to 1000 sph in 2020. Shrub densities have also increased and new species are continuing to infill. No erosion or siltation issues were noted. Increases in moss cover are minimal but soil processes are ongoing due to leaf fall from surrounding hardwoods and shrubs.

Figure 28. Ryan Crossing Photos from 2018 and 2020

Card: Transmission Line
Stratum: 2018 Ryan Crossing/Plot: 22/Comments
Sep 12, 2018 10.55.04 AM.jpg

Card: Transmission Line
Stratum: 2020 Ryan Crossing/Plot: 22/Comments
Overview photo looks South from plot 22.jpg

Table 21. Ryan Crossing - Vegetation Density and Species Diversity from 2018 to 2020

Conifer Diversity From Plot Data (SPH)

Site	Western Red Cedar		**Total SPH Conifers**	
	2018	2020	**2018**	**2020**
Ryan Crossing	600	1,000	**600**	**1,000**

Deciduous Diversity From Plot Data (SPH)

Site	**Total SPH Deciduous**	
	2018	**2020**
Ryan Crossing	**0**	**0**

Shrub Diversity From Plot Data (SPH)

Site	Blackcap Raspberry		Red Osier Dogwood		Thimbleberry		Trailing Blackberry		**Total SPH Shrubs**	
	2018	2020	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Ryan Crossing	0	600	0	400	4,200	7,400	600	0	**4,800**	**8,400**

Number of Speices by Site

Site	Total Number of Coniferous Species		Total Number of Deciduous Species		Total Number of Shrub Species		**Total Number of Species**	
	2018	2020	2018	2020	2018	2020	**2018**	**2020**
Ryan Crossing	1	1	0	0	2	3	**3**	**4**

6.4. Quadrat Survey Results

The quadrat data has been summarized separately for the civil works sites and transmission line road sites. The data sets were separated for ease of viewing the tables. Quadrat surveys were completed in 2018 (Year 1) and again in 2020 (Year 3). The data from the two quadrat plots was collected as per Section 5.2 of this document. For comparison the percent cover data was averaged and then compared to the averaged data collected in 2018. The two years of data are displayed in below in Figures 22 to 27.

Some sites had small decreases in percent cover in one of the layers. This is to be expected as some plants succumb to site limiting factors such as drought, interplant competition or biotic damage. Decreases in one layer led to increases in other layers. This is typical in developing plant communities and is an indication of a recovering site.

6.4.1 Civil Works Sites Quadrat Survey Results

For the civil works sites the results of the quadrat survey are positive. The data indicates that the percent ground cover is increasing for all layers. In 2018 the herbaceous layer had an average cover of 5%, in 2020 the percent cover has increased to 11%. The average shrub layer has increased from 2% in 2018 up to 6% in 2020. The tree layer had the largest increase in percent cover between the two survey years increasing from <1% in 2018 to 4% in 2020. The average percent cover for all layers combined in 2018 was 7%, in 2020 the average has tripled to 21%. These incremental increases in vegetation cover demonstrate that the planted and natural species are continuing to grow in size and number and occupy more of these reclaimed sites.

Figure 22. Civil Works Sites - Percent Cover of Herbaceous Layer from Quadrat Plot Data

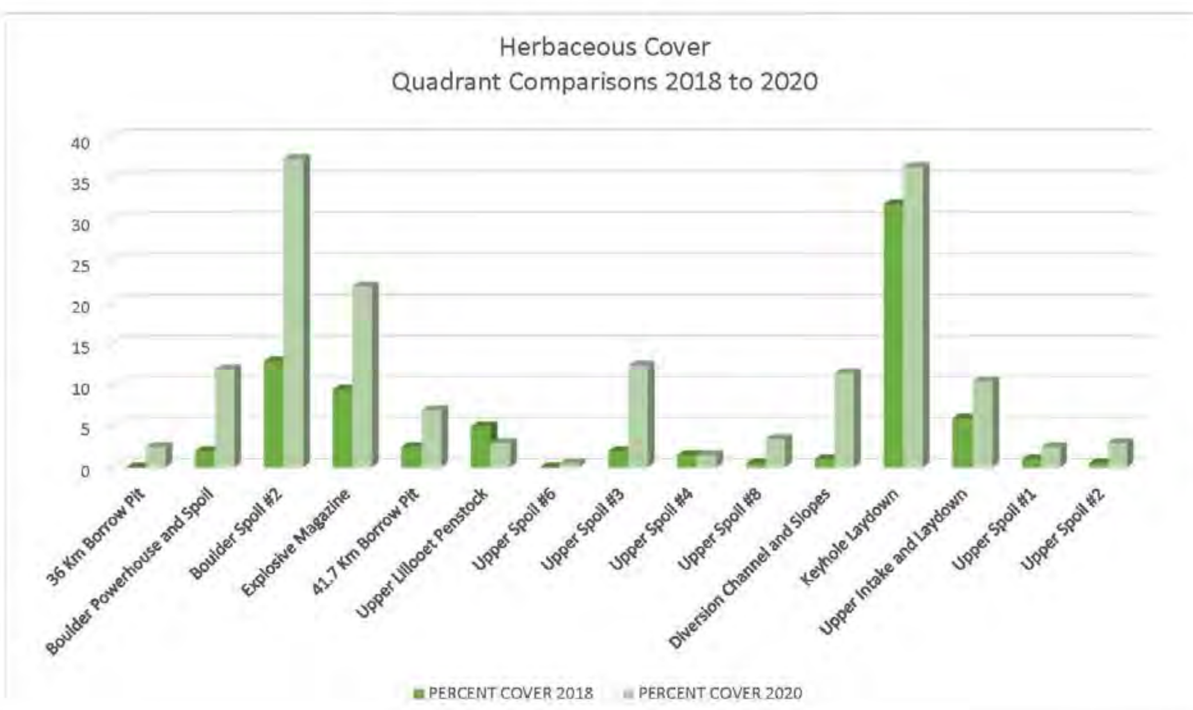


Figure 23. Civil Works Sites - Percent Cover of Shrub Layer from Quadrat Plot Data

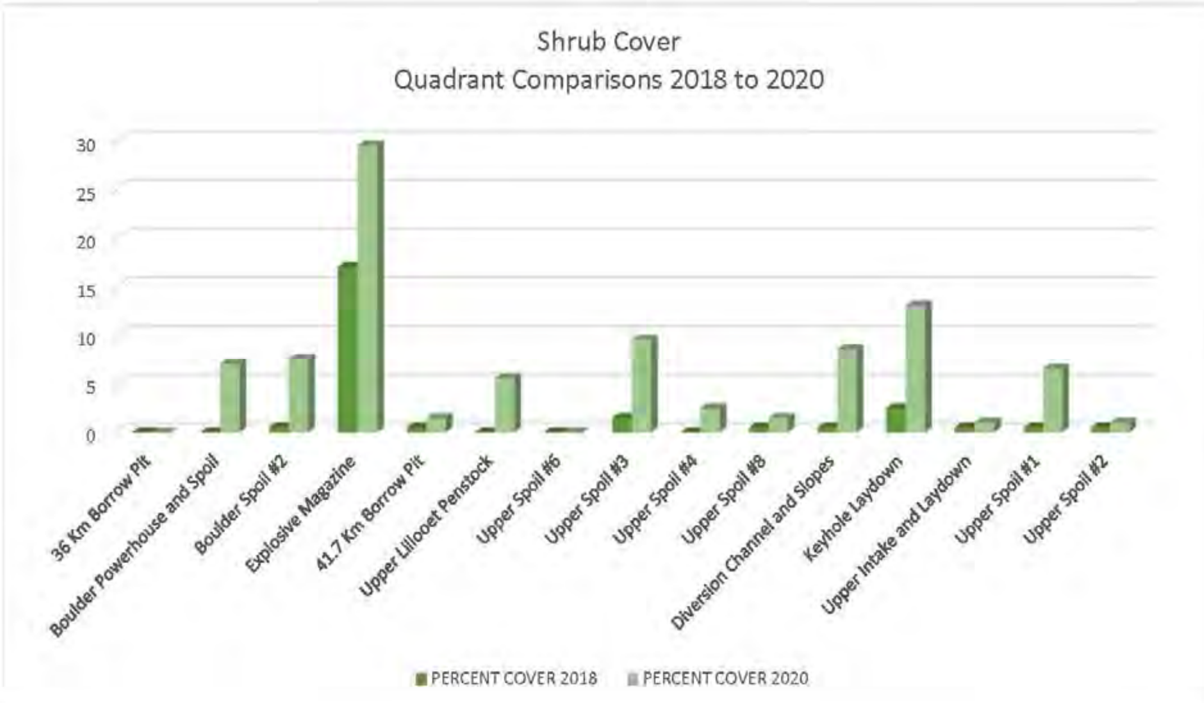
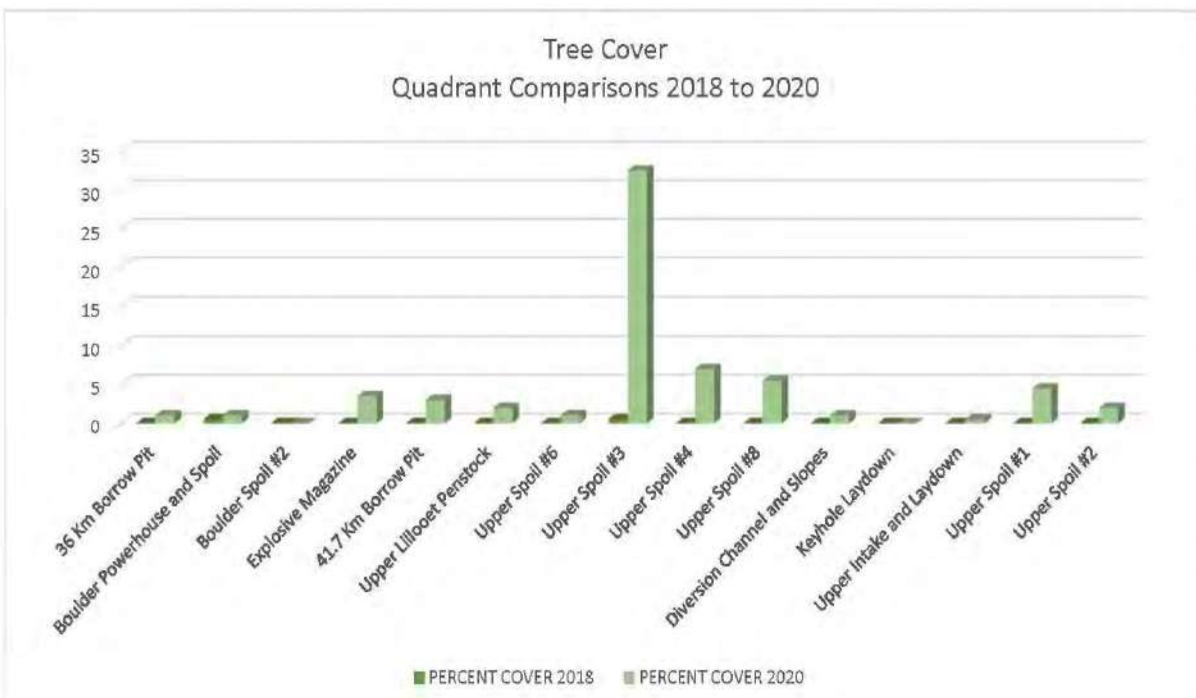


Figure 24. Civil Works Sites - Percent Cover of Tree Layer from Quadrat Plot Data



6.4.2 Transmission Line Quadrat Survey Results

For the transmission line road sites, the results of the quadrat survey are also positive. The herb and shrub layers had the largest gains in percent cover. The tree layer is developing slower but is making small incremental gains. Tree planting activities on the transmission line road sites were completed prior 2018 so any gains in cover for the tree layer have come from natural ingress or trees growing in size since the first set of data was collected. In 2018 the herbaceous layer had an average cover of 10%, the herbaceous layer has more than quadrupled since 2018 to 44% in 2020. The shrub layer also had significant gains in percent cover increasing from 4% in 2018 to 13% in 2020. The tree layer had more modest gains increasing from 1% to 4% in 2020. The slower increase in cover of the tree layer is still positive as tree species grow at a slower rate than the herbaceous and shrub layers that are known for rapid growth during the pioneer stages of site development.

Figure 25. Transmission Line Sites - Percent Cover of Herbaceous Layer from Quadrat Plot Data

Figure 26. Transmission Line Sites - Percent Cover of Shrub Layer from Quadrat Plot Data

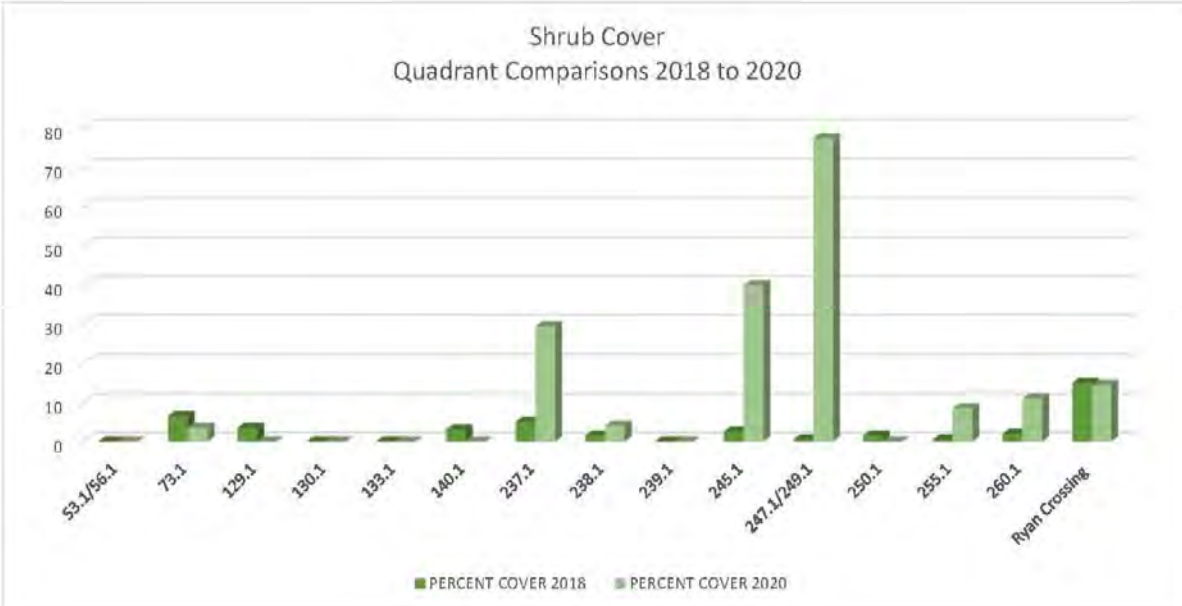
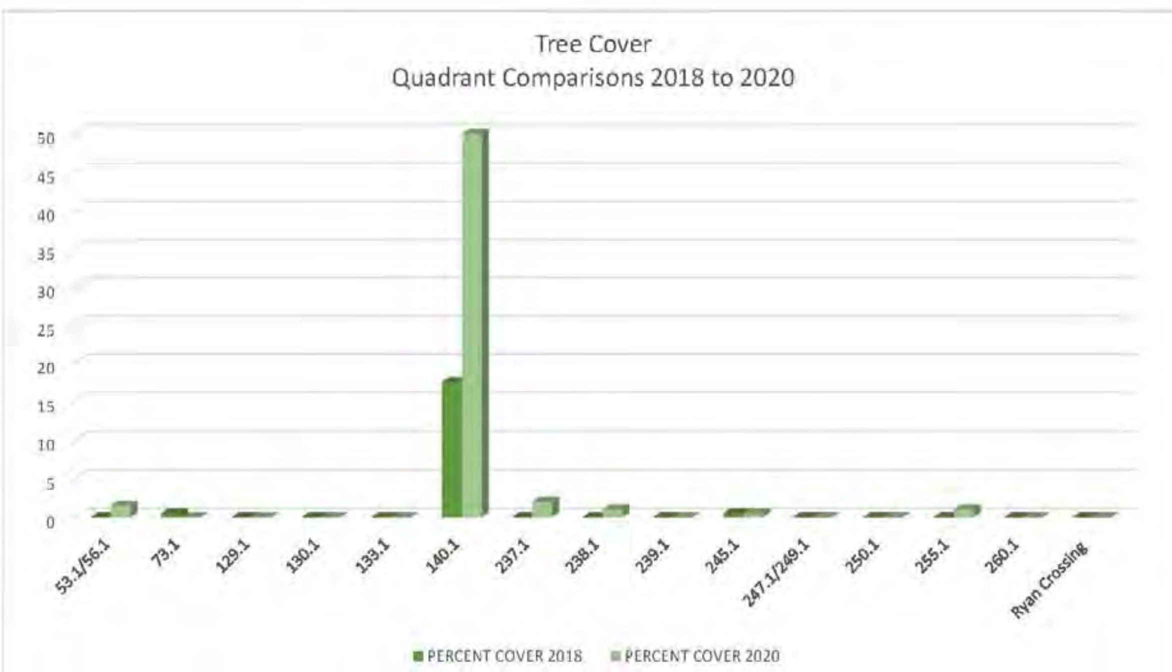


Figure 27. Transmission Line Sites - Percent Cover of Tree Layer from Quadrat Plot Data



6.5. Invasive Plants Monitoring Results

Invasive species are often found on disturbed sites where other native vegetation has not yet colonized the area. Depending on the species and number of plants found on the site these plants may out compete native vegetation for light, water and nutrients and can be unpalatable to wildlife species such as deer and moose. When left untreated invasive species may decrease the productivity of a site

In 2018 small numbers of invasive species were noted while assessing the transmission line and civil work sites. These plants were hand pulled and removed from site by the surveyors. During the 2020 field data collection phase three invasive species were identified on thirteen out of the thirty sites that were visited (see Table 28 for a list of sites and number of plants per site). The invasive plants were not pulled during the 2020 field work due to increased numbers. Population densities are still moderately low but have increased since 2018. Invasive plant species found in 2020 are orange hawkweed (*Hieracium aurantiacum*), bull thistle (*Cirsium vulgare*) and St. Johns-wort (*Hypericum perforatum*). Hawk weed, bull thistle and St. Johns-wort are shade intolerant species and do not typically grow well on sites that have moved past the pioneer phase of reestablishment and into seral stages. With the low number of occurrences, increased plant diversity and native plants continuing to occupy more space, the number of invasive plant occurrences is expected to stabilize and eventually decrease.

These three invasive species are not listed in the I*nvasive Weed Control Act* and *Regulation Schedule A* among the 21 noxious species that require treatment. Industrial users are required to annually report to the Invasive Alien Plant Program (IAPP) any newly discovered invasive plant centers as per Section 3.3.2. of the OEMP. Innergex is not required to treat the invasive plants identified in 2020 as they are not among the 21 noxious species. Reporting the invasive species identified within the project area to IAPP is required.

Table 28. Invasive Species Occurrences by Site

Number of Invasive Plant Occurances by Site			
Site	Orange Hawkweed	St. Johns Wart	Bull Thistle
36 Km Borrow Pit	5		
38 Km Laydown	13	5	
Boulder Powerhouse and Spoil	10		
Camp	15		
Diversion Channel and Slopes	9		
Keyhole Laydown	10		
Upper Lillooet Penstock	1		
163.1			
238.1		5	4
239.1		3	
249.1			3
255.1	5		5
260.1			75

6.6. Species Diversity Results

A complete list of tree and shrub species growing in the ULHP civil work and transmission line sites has been compiled in Table 23. The list includes common and Latin names for clarity. In 2018 there were 23 different tree and shrub species observed across all project sites. This number increased to 39 in 2020. Conifer species diversity increased from 6 species in 2018 to 9 species in 2020. This is in part due to the tree planting activities completed on the civil works sites in the fall of 2018 and natural seeding from adjacent coniferous stands. Deciduous species increased slightly from 3 species in 2018 to 4 species in 2020. Shrubs had the largest increase in species diversity. In 2018 there were 14 different species in 2020 that number has increased to 26 species. All of the new deciduous and shrub species identified in 2020 have seeded in naturally. An increase in species diversity is one of the short-term revegetation goals as noted in Section 4.2 of this report.

Table 29. List of Tree and Shrub Species Observed in the Revegetation Monitoring Plots

Identified Tree and Shrub Species			
Common Name	Latin Name	Present in 2018	Present in 2020
Amabalis Fir	Abies amabalis	✓	✓
Bigleaf Maple	Acer macrophyllum	✓	✓
Birch Leaf Spirea	Spirea betulifolia		✓
Bitter Cherry	Prunus emarginata		✓
Black Cottonwood	Populus balsamifera	✓	✓
Blackcap Raspberry	Rubus occidentalis		✓
Ceanothus	Ceanothus velutinus	✓	✓
Douglas Fir	Pseudotsuga menziesii	✓	✓
Douglas Maple	Acer glabrum		✓
Falsebox	Paxistima myrsinites	✓	✓
Black Gooseberry	Ribes lacustre		✓
Hardhack Spirea	Spirea douglassi		✓
High Brush Cranberry	Viburnum trilobum	✓	✓
Kinnickinnick	Arctostaphylos uva-ursi	✓	✓
Lodgepole Pine	Pinus contorta	✓	✓
Mountain Hemlock	Tsuga mertensiana		✓
Oregon Grape	Mahonia aquifolium	✓	✓
Pacific Dogwood	Cornus nuttallii		✓
Paper Birch	Betula papyrifera		✓
Ponderosa Pine	Pinus ponderosa		✓
Princes Pine	Chimaphila umbellata		✓
Red Alder	Alnus rubra	✓	✓
Red Elderberry	Sambucus racemosa	✓	✓
Red Osier Dogwood	Cornus stolonifera	✓	✓
Red Raspberry	Rubus idaeus	✓	✓
Rose	Rosa species	✓	✓
Salal	Gaultheria shallon	✓	✓
Salmonberry	Rubus spectabilis		✓
Saskatoon	Amelanchier alnifolia		✓
Sitka Alder	Alnus crispa		✓
Sitka Mountain-Ash	Sorbus sitchensis		✓
Spruce	Picea spp	✓	✓
Thimbleberry	Rubus parviflorus	✓	✓
Trailing Blackberry	Rubus ursinus	✓	✓
Trembling Aspen	Populus tremuloides		✓
Vaccinium	Vaccinium spp	✓	✓
Western Hemlock	Tsuga heterophylla	✓	✓
Western Red Cedar	Thuja plicata	✓	✓
Western White Pine	Pinus monticola		✓
Willow	Salix spp	✓	✓

7. Conclusions

All long term revegetation monitoring areas in the ULHP project area that were assessed in 2018 (Year 1) and 2020 (Year 3) are continuing to show development of revegetation processes. On all sites there has been an increase in density of conifers, deciduous trees and shrubs. Biodiversity on almost all sites have continued to increase or stayed the same (see Table 29). Within all sites sampled, pioneering species such as thimbleberry, alder, cottonwood and other early colonizers remain present and numbers are continuing to increase. Percent ground cover has also increased on all sites (see Figures 22 to 27). The plants that were present on the majority of sites are vigorous and healthy and no major disease infestations or damaged areas were observed. No major erosion issues were noted. Slope shaping, soil decompaction and/or other soil treatments allowed for successful root penetration of the newly established vegetation. In conclusion, all of the sites assessed in 2020 are on target to meet project requirements as per Section 5.1 to 5.4 of this document.

Conifer numbers have increased significantly from 2018 (Year 1) to 2020 (Year 3). Many of the conifers are still germinants and their survival is not guaranteed. Until the germinants have grown for a couple of years survival is variable due to small root systems, minimal foliage and limited capabilities to deal with soil moisture deficits in the summer months. If a small to moderate amount of conifer mortality occurs in the future most sites will still be above the target of 1000 sph. Almost all sites that were planted with conifers in 2017 and 2018 are not reliant on germinants to meet target stocking levels. There are two sites within the Civil work sites that were found to be stocked with less than 1000 sph of conifers. Boulder Spoil #2 and Boulder Spoil #7 are located on the Boulder Intake Road. The sites have warm Western aspects and rapidly draining rocky compact soils. Reforestation of these sites was expected to be difficult and take longer to revegetate than other sites within the project.

8. Recommendations

Follow up activities required for the 2020 long term revegetation management program are as follows:

1. Add the Upper Lillooet Penstock area to the annual brushing and danger tree patrols of the ULHP hydro project. This area will not need to be manually brushed for another 3 to 5 years but should be monitored to ensure the integrity of the penstock.
2. Report to the Invasive Alien Plant Program (IAPP) the invasive plant centers identified in the 2020. See table Table 28 for identified invasive species and locations. The identified invasive species do not require treatment at this time.
3. Deactivation of transmission line road site 163.1. This road was not deactivated and remains drivable.

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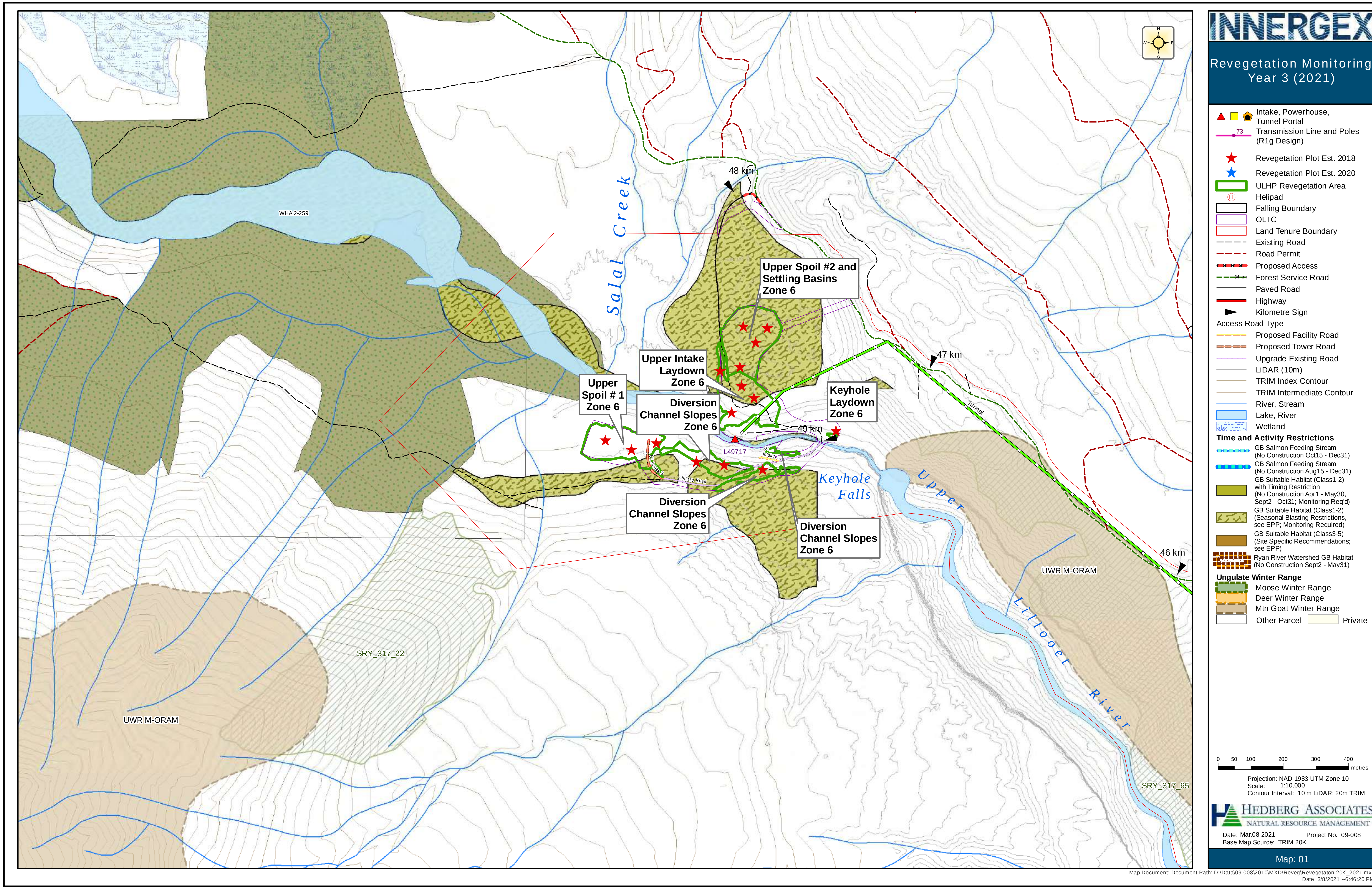
Appendices

Appendix A: Maps of Project Monitoring Program

Appendix B: Civil Works Sites Permanent Monitoring Plot Data Established 2018.

Appendix C: Civil Works Sites Permanent Monitoring Plot Data Established 2020.

Appendix D: Transmission Line Permanent Monitoring Plot Data.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Revegetation Monitoring Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
Time and Activity Restrictions
GB Salmon Feeding Stream (No Construction Oct15 - Dec31)
GB Salmon Feeding Stream (No Construction Aug15 - Dec31)
GB Suitable Habitat (Class1-2) with Timing Restriction (No Construction Apr1 - May30, Sept2 - Oct31; Monitoring Req'd)
GB Suitable Habitat (Class1-2) (Seasonal Blasting Restrictions, see EPP; Monitoring Required)
GB Suitable Habitat (Class3-5) (Site Specific Recommendations; see EPP)
Ryan River Watershed GB Habitat (No Construction Sept2 - May31)
Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 50 100 200 300 400 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:10,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 01
Salal Creek
WHA 2-259
48 km
47 km
49 km
46 km
Upper Spoil #2 and Settling Basins Zone 6
Upper Intake Laydown Zone 6
Upper Spoil # 1 Zone 6
Diversion Channel Slopes Zone 6
Keyhole Laydown Zone 6
Diversion Channel Slopes Zone 6
Diversion Channel Slopes Zone 6
L49717
Intake Road
Tunnel
Keyhole Falls
Upper Lillooet River
UWR M-ORAM
UWR M-ORAM
SRY_317_22
SRY_317_65
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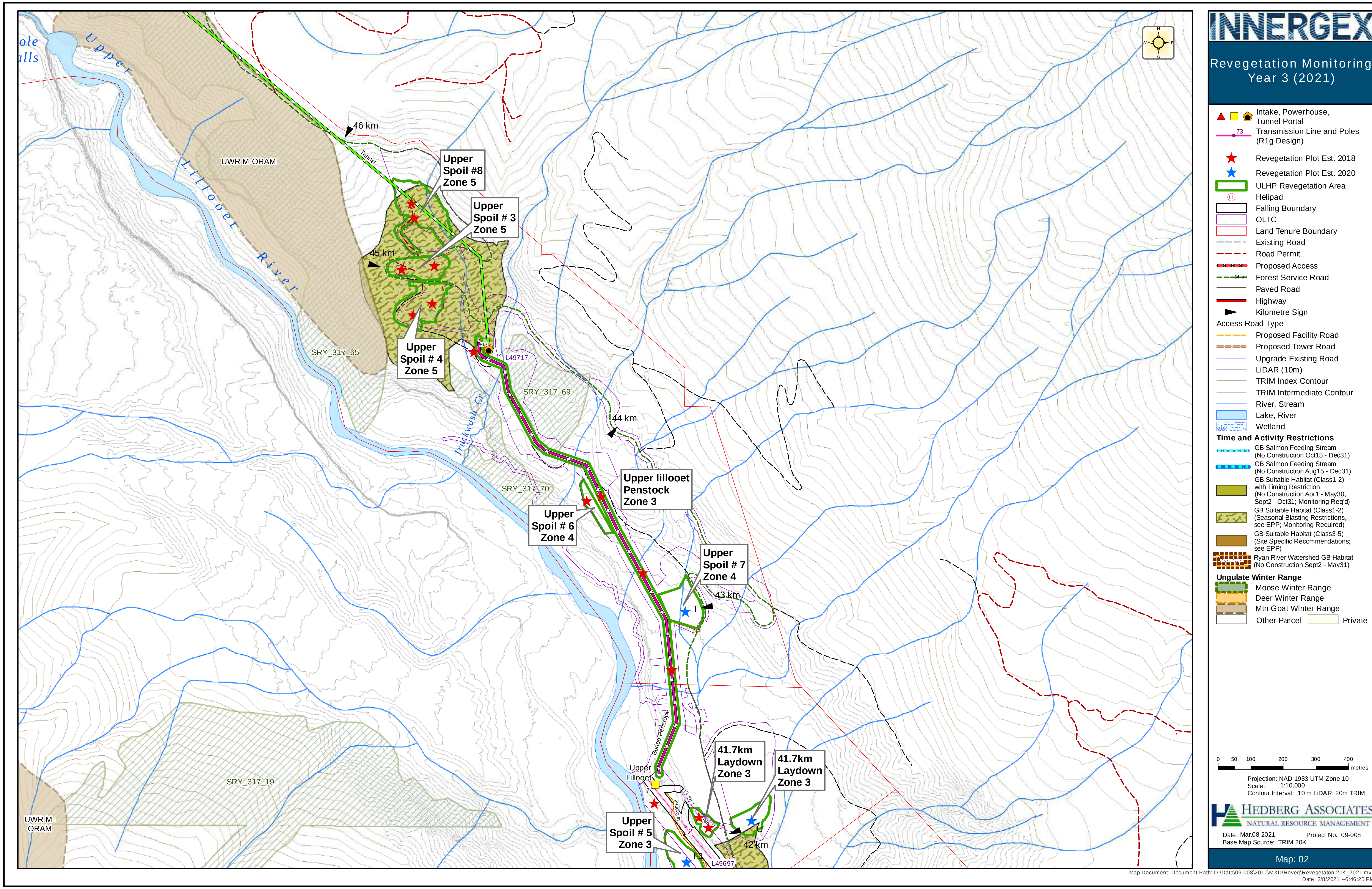

INNERGEX
Revegetation Monitoring
Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
Time and Activity Restrictions
GB Salmon Feeding Stream (No Construction Oct15 - Dec31)
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Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 50 100 200 300 400 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:10,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 02
Upper Lillooet River
UWR M-ORAM
46 km
45 km
44 km
43 km
42 km
Tunnel
Upper Spoil #8 Zone 5
Upper Spoil # 3 Zone 5
Upper Spoil # 4 Zone 5
Upper lillooet Penstock Zone 3
Upper Spoil # 6 Zone 4
Upper Spoil # 7 Zone 4
41.7km Laydown Zone 3
41.7km Laydown Zone 3
Upper Spoil # 5 Zone 3
Upper Lillooet
Buried Penstock
Truckwash Cr
SRY_317_65
SRY_317_69
SRY_317_70
SRY_317_19
L49717
L49697
UWR M-ORAM
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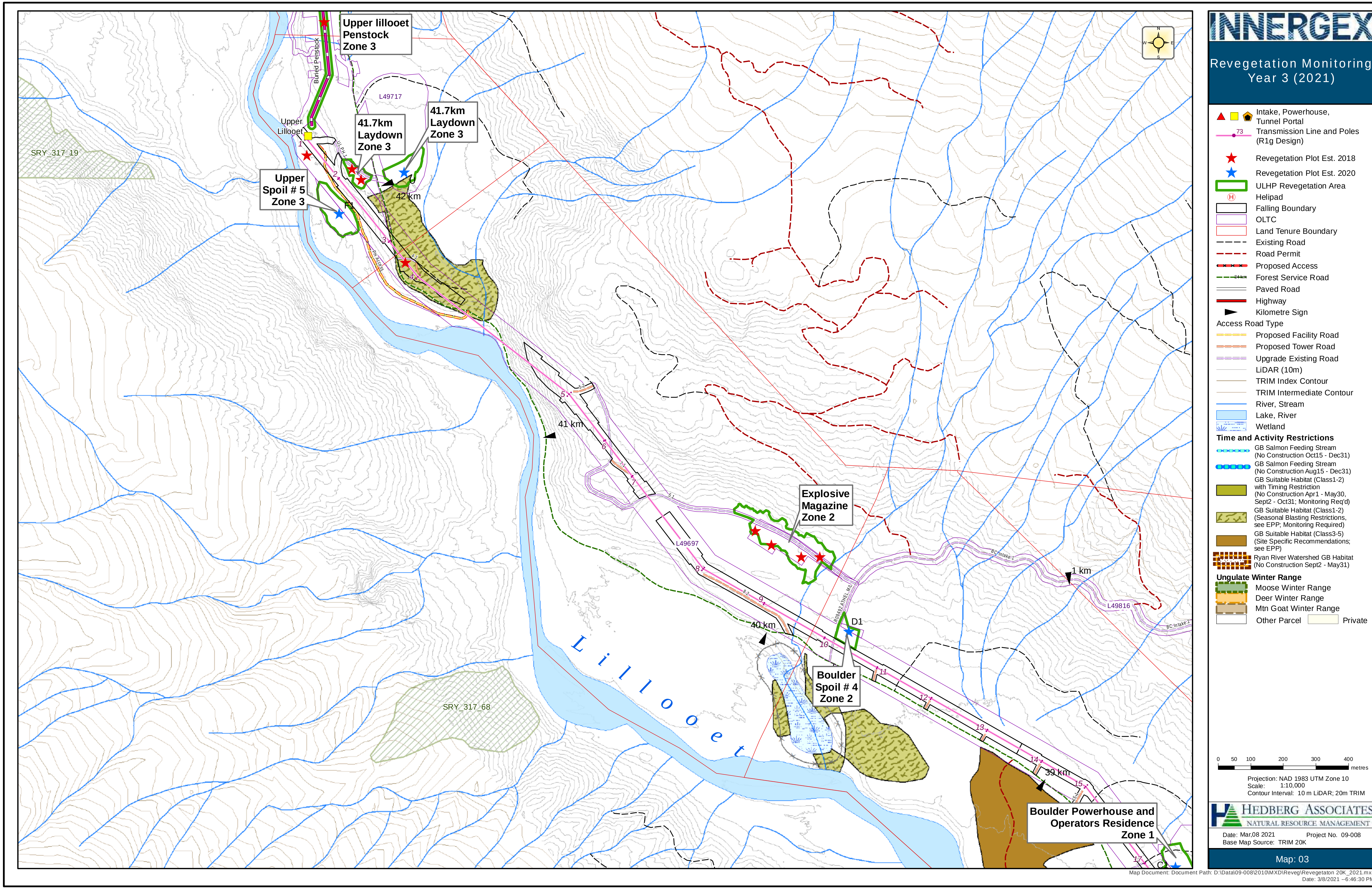

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Revegetation Monitoring Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
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Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
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Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 50 100 200 300 400 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:10,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 03
Upper lillooet Penstock Zone 3
Buried Penstock
L49717
41.7km Laydown Zone 3
41.7km Laydown Zone 3
Upper Lillooet
SRY_317_19
Upper Spoil # 5 Zone 3
F1
42 km
41 km
Explosive Magazine Zone 2
L49697
1 km
L49816
D1
40 km
Boulder Spoil # 4 Zone 2
Lillooet
SRY_317_68
39 km
Boulder Powerhouse and Operators Residence Zone 1
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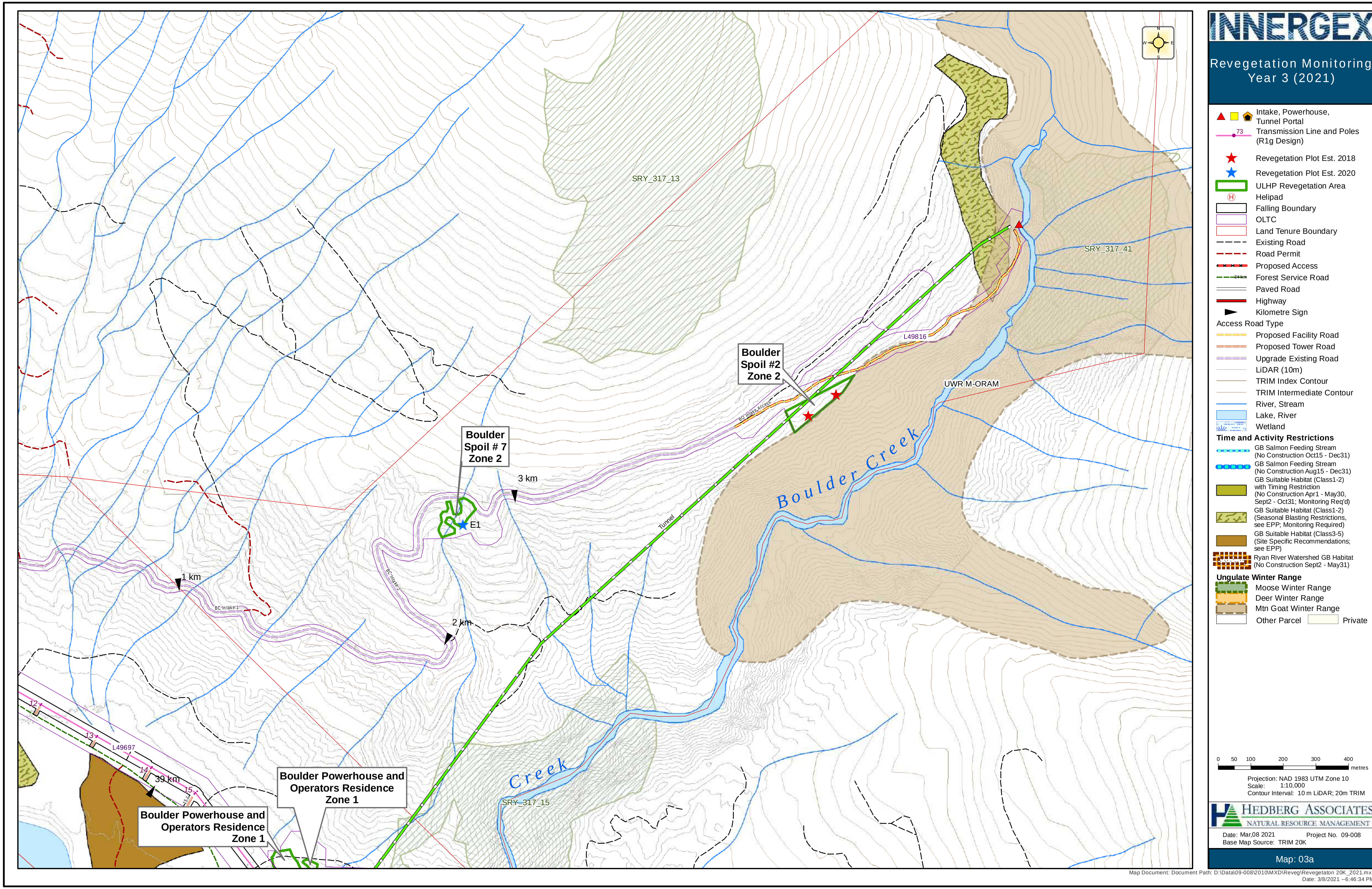

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Revegetation Monitoring Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
Time and Activity Restrictions
GB Salmon Feeding Stream (No Construction Oct15 - Dec31)
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Ryan River Watershed GB Habitat (No Construction Sept2 - May31)
Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 50 100 200 300 400 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:10,000
Contour Interval: 10 m LiDAR; 20m TRIM
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SRY_317_41
SRY_317_15
UWR M-ORAM
L49816
L49697
Boulder Spoil #2 Zone 2
Boulder Spoil # 7 Zone 2
E1
Boulder Creek
Creek
Tunnel
1 km
2 km
3 km
39 km
Boulder Powerhouse and Operators Residence Zone 1
Boulder Powerhouse and Operators Residence Zone 1
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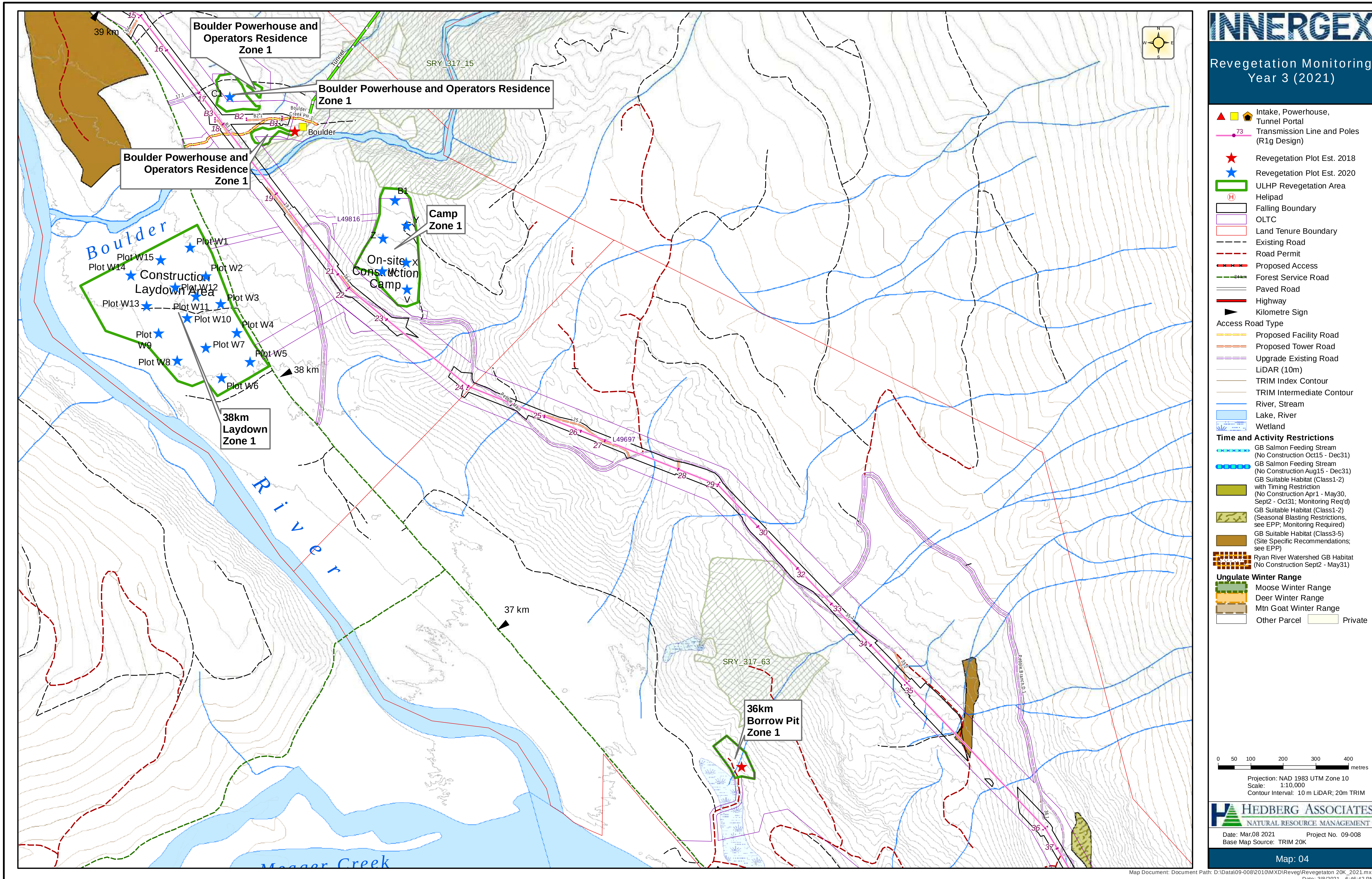
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Revegetation Monitoring Year 3 (2021)
Boulder Powerhouse and Operators Residence Zone 1
Boulder Powerhouse and Operators Residence Zone 1
Boulder Powerhouse and Operators Residence Zone 1
Camp Zone 1
On-site Construction Camp
Boulder Construction Laydown Area
38km Laydown Zone 1
36km Borrow Pit Zone 1
Boulder River
Meager Creek
SRY_317_15
SRY_317_63
L49816
L49697
Boulder
Tunnel
39 km
38 km
37 km
C1
B1
B2
B3
Plot W1
Plot W2
Plot W3
Plot W4
Plot W5
Plot W6
Plot W7
Plot W8
Plot W9
Plot W10
Plot W11
Plot W12
Plot W13
Plot W14
Plot W15
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
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TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
Time and Activity Restrictions
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Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 50 100 200 300 400 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:10,000
Contour Interval: 10 m LiDAR; 20m TRIM
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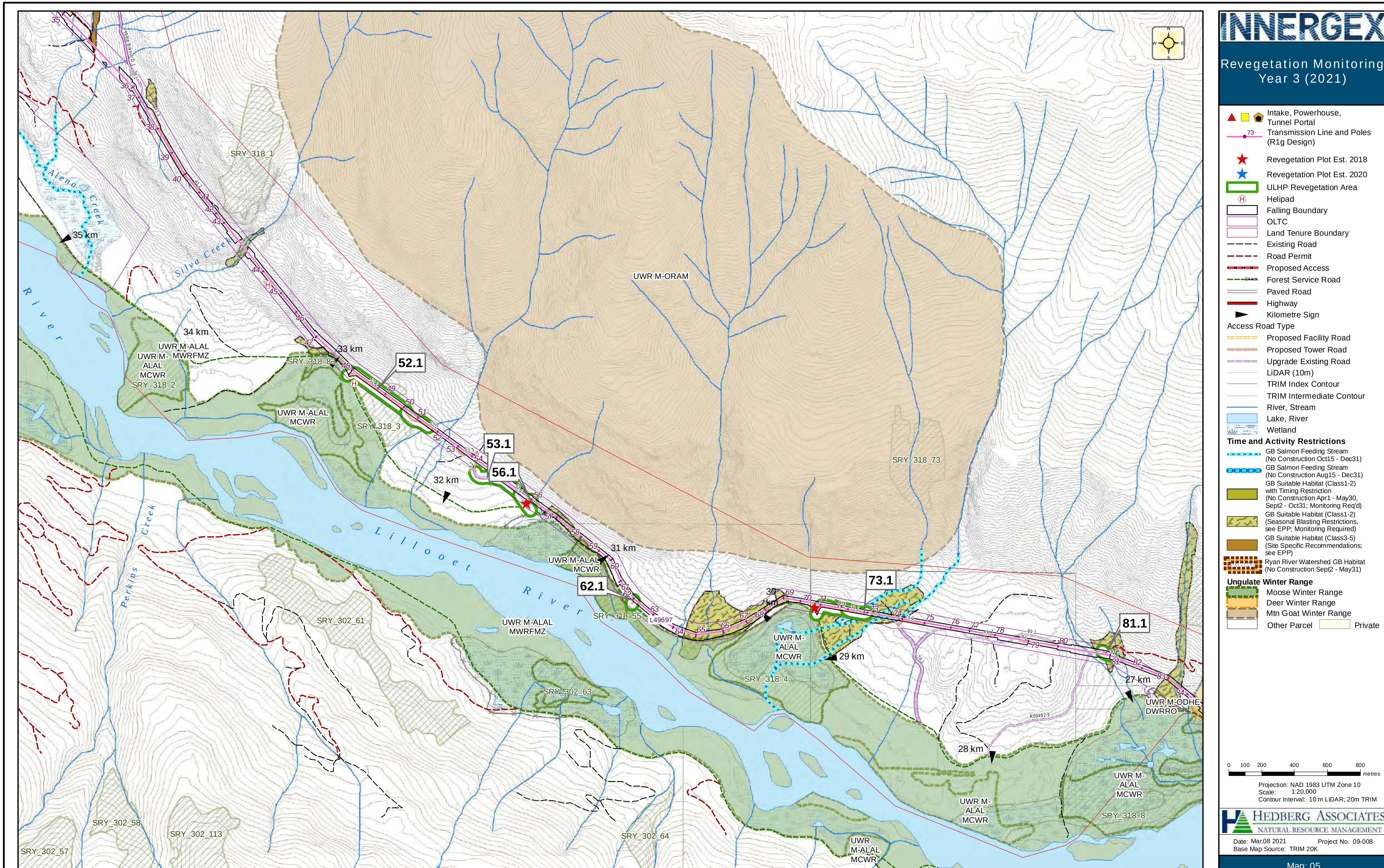

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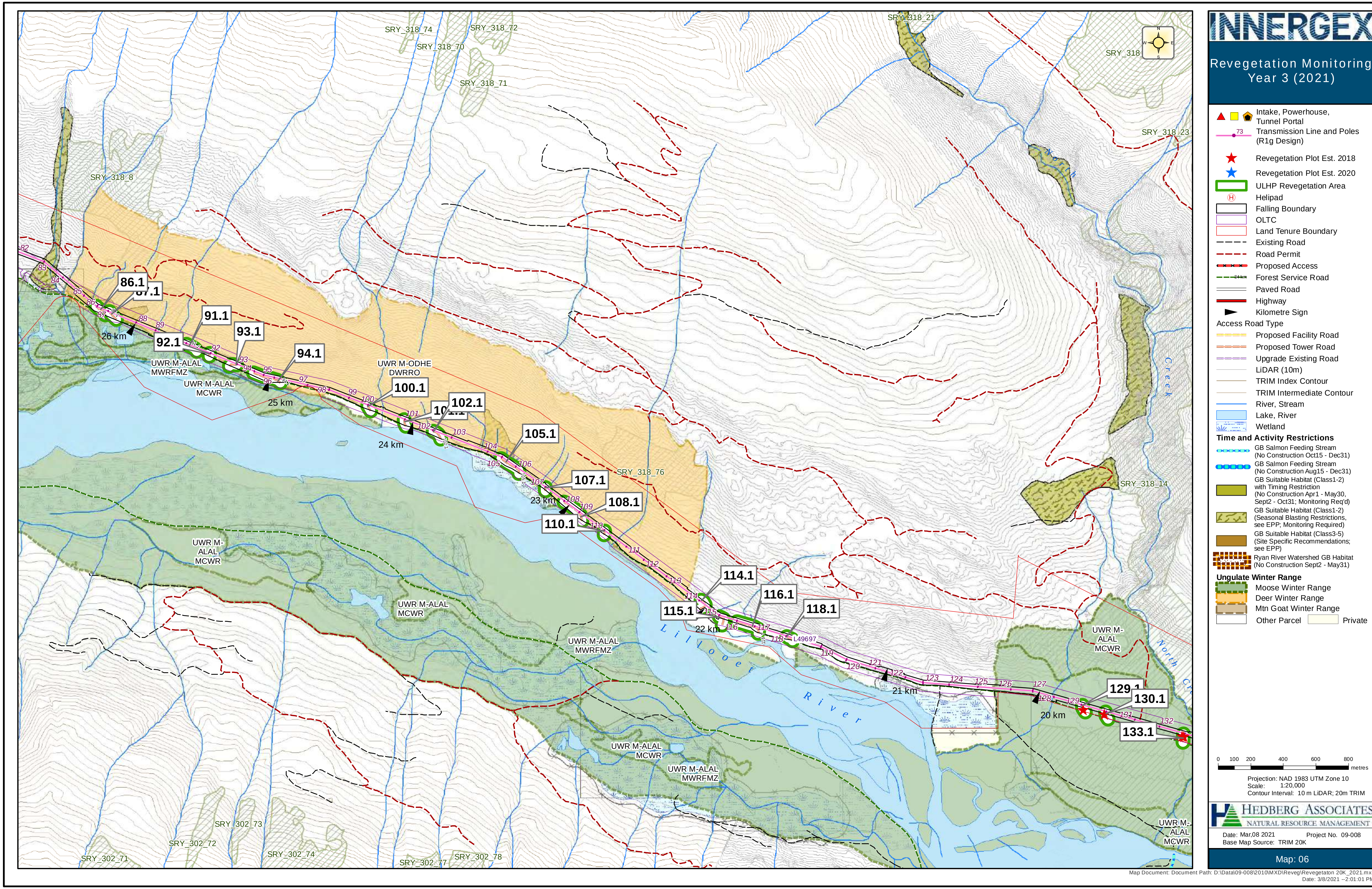
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Revegetation Monitoring
Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
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Kilometre Sign
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TRIM Intermediate Contour
River, Stream
Lake, River
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Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 100 200 400 600 800 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 06
Lillooet River
Creek
North Cr
86.1
87.1
91.1
92.1
93.1
94.1
100.1
102.1
105.1
107.1
108.1
110.1
114.1
115.1
116.1
118.1
129.1
130.1
133.1
26 km
25 km
24 km
23 km
22 km
21 km
20 km
UWR M-ALAL MWRFMZ
UWR M-ALAL MCWR
UWR M-ODHE DWRRO
SRY_318_74
SRY_318_72
SRY_318_70
SRY_318_71
SRY_318_8
SRY_318_21
SRY_318
SRY_318_23
SRY_318_76
SRY_318_14
SRY_302_73
SRY_302_72
SRY_302_71
SRY_302_74
SRY_302_77
SRY_302_78
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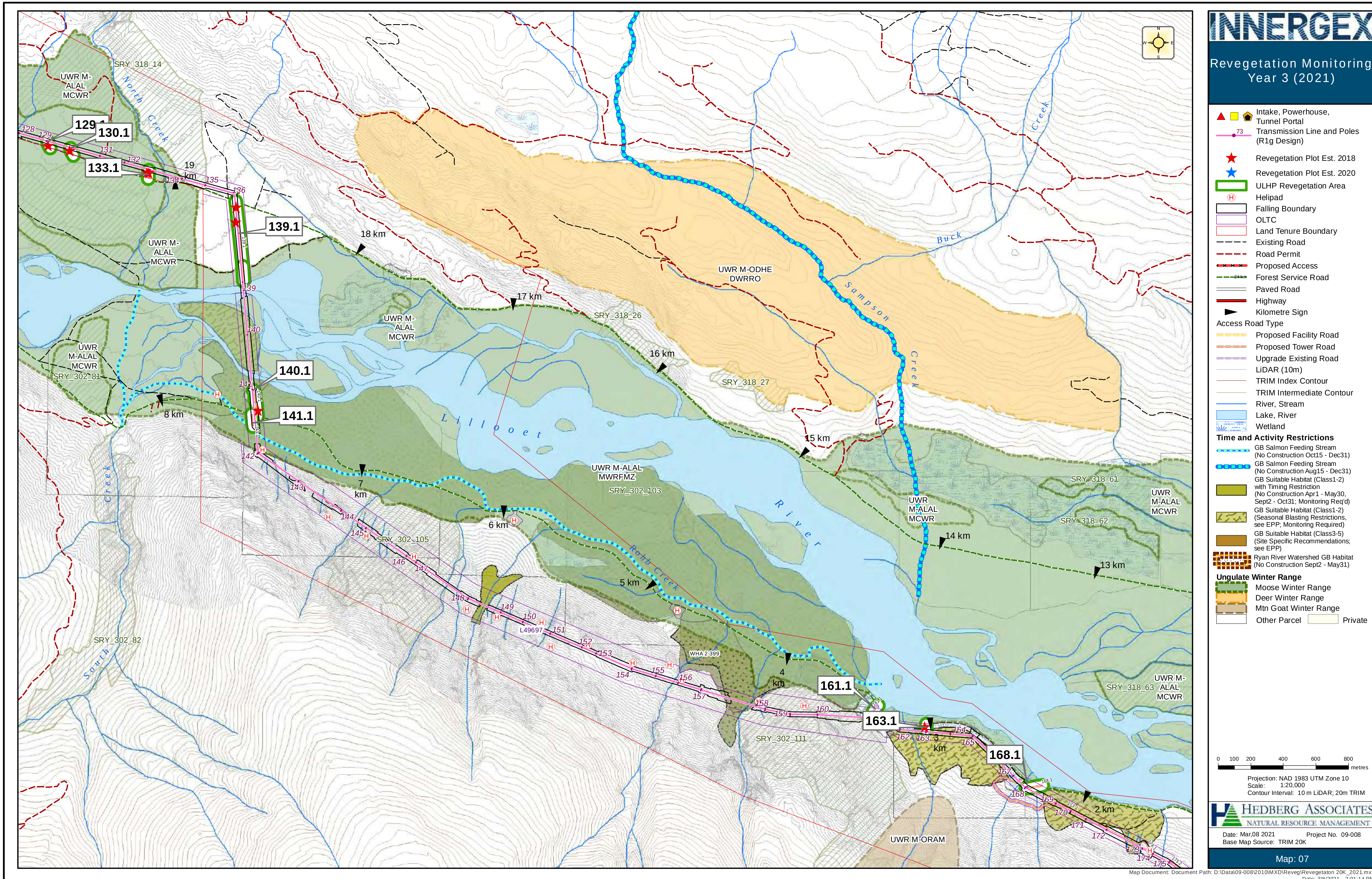
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Revegetation Monitoring Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
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Forest Service Road
Paved Road
Highway
Kilometre Sign
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Proposed Facility Road
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Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
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Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 100 200 400 600 800 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 07
Lillooet River
Sampson Creek
Buck Creek
North Creek
South Creek
Rabb Creek
129.1
130.1
133.1
139.1
140.1
141.1
161.1
163.1
168.1
UWR M-ALAL MCWR
UWR M-ODHE DWRRO
UWR M-ALAL MWRFMZ
UWR M-ORAM
SRY_318_14
SRY_318_26
SRY_318_27
SRY_318_61
SRY_318_62
SRY_318_63
SRY_302_81
SRY_302_82
SRY_302_103
SRY_302_105
SRY_302_111
WHA 2-399
L49697
19 km
18 km
17 km
16 km
15 km
14 km
13 km
8 km
7 km
6 km
5 km
4 km
3 km
2 km
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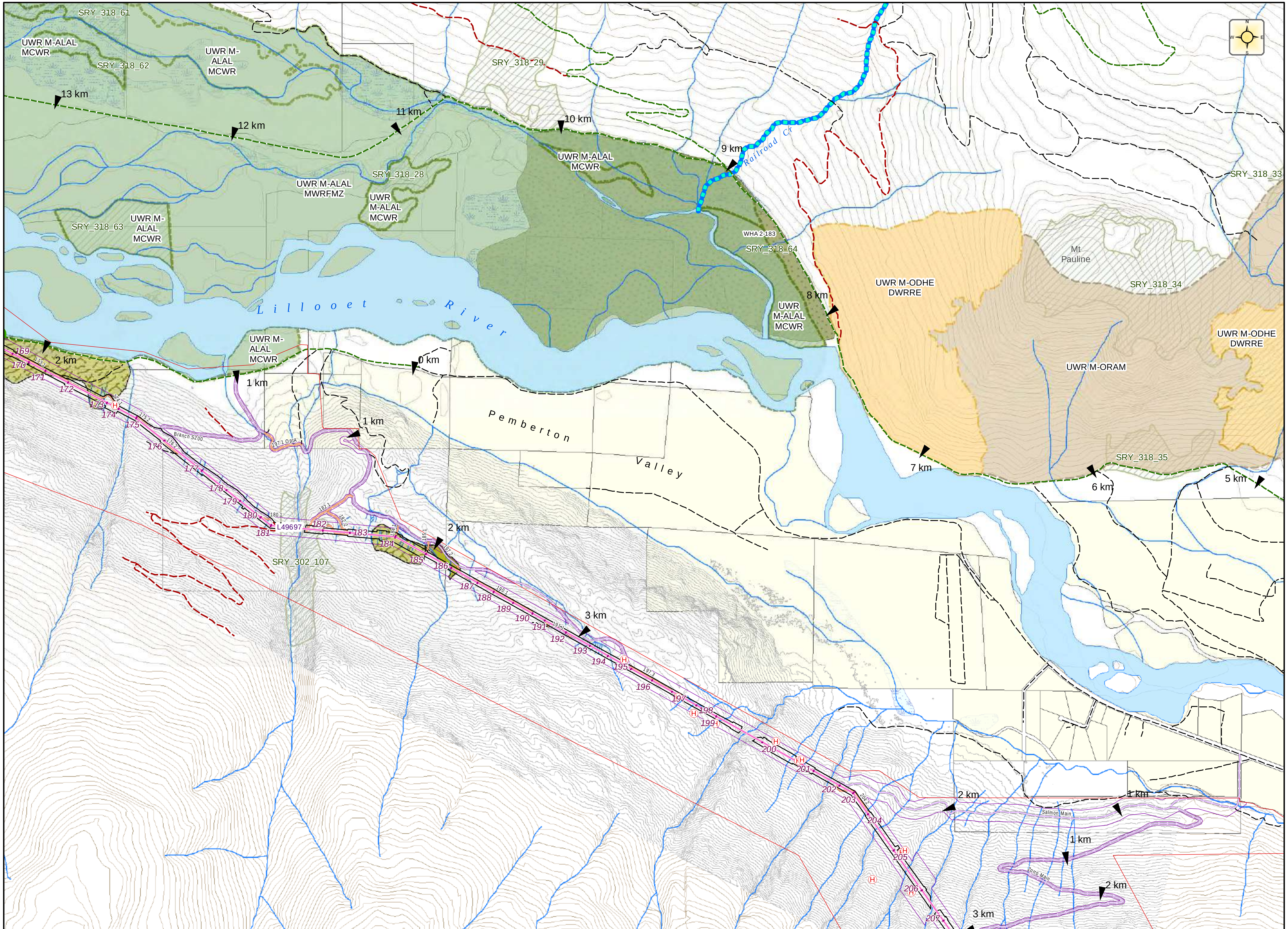

INNERGEX

Revegetation Monitoring Year 3 (2021)

- Intake, Powerhouse, Tunnel Portal
- Transmission Line and Poles (R1g Design)
- Revegetation Plot Est. 2018
- Revegetation Plot Est. 2020
- ULHP Revegetation Area
- Helipad
- Falling Boundary
- OLTC
- Land Tenure Boundary
- Existing Road
- Road Permit
- Proposed Access
- Forest Service Road
- Paved Road
- Highway
- Kilometre Sign

Access Road Type

- Proposed Facility Road
- Proposed Tower Road
- Upgrade Existing Road
- LiDAR (10m)
- TRIM Index Contour
- TRIM Intermediate Contour
- River, Stream
- Lake, River
- Wetland

Time and Activity Restrictions

- GB Salmon Feeding Stream (No Construction Oct15 - Dec31)
- GB Salmon Feeding Stream (No Construction Aug15 - Dec31)
- GB Suitable Habitat (Class1-2) with Timing Restriction (No Construction Apr1 - May30, Sept2 - Oct31; Monitoring Req'd)
- GB Suitable Habitat (Class1-2) (Seasonal Blasting Restrictions, see EPP; Monitoring Required)
- GB Suitable Habitat (Class3-5) (Site Specific Recommendations; see EPP)
- Ryan River Watershed GB Habitat (No Construction Sept2 - May31)

Ungulate Winter Range

- Moose Winter Range
- Deer Winter Range
- Mtn Goat Winter Range
- Other Parcel
- Private

0 100 200 400 600 800 metres

Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Date: Mar,08 2021 Project No. 09-008
Base Map Source: TRIM 20K

Map: 08

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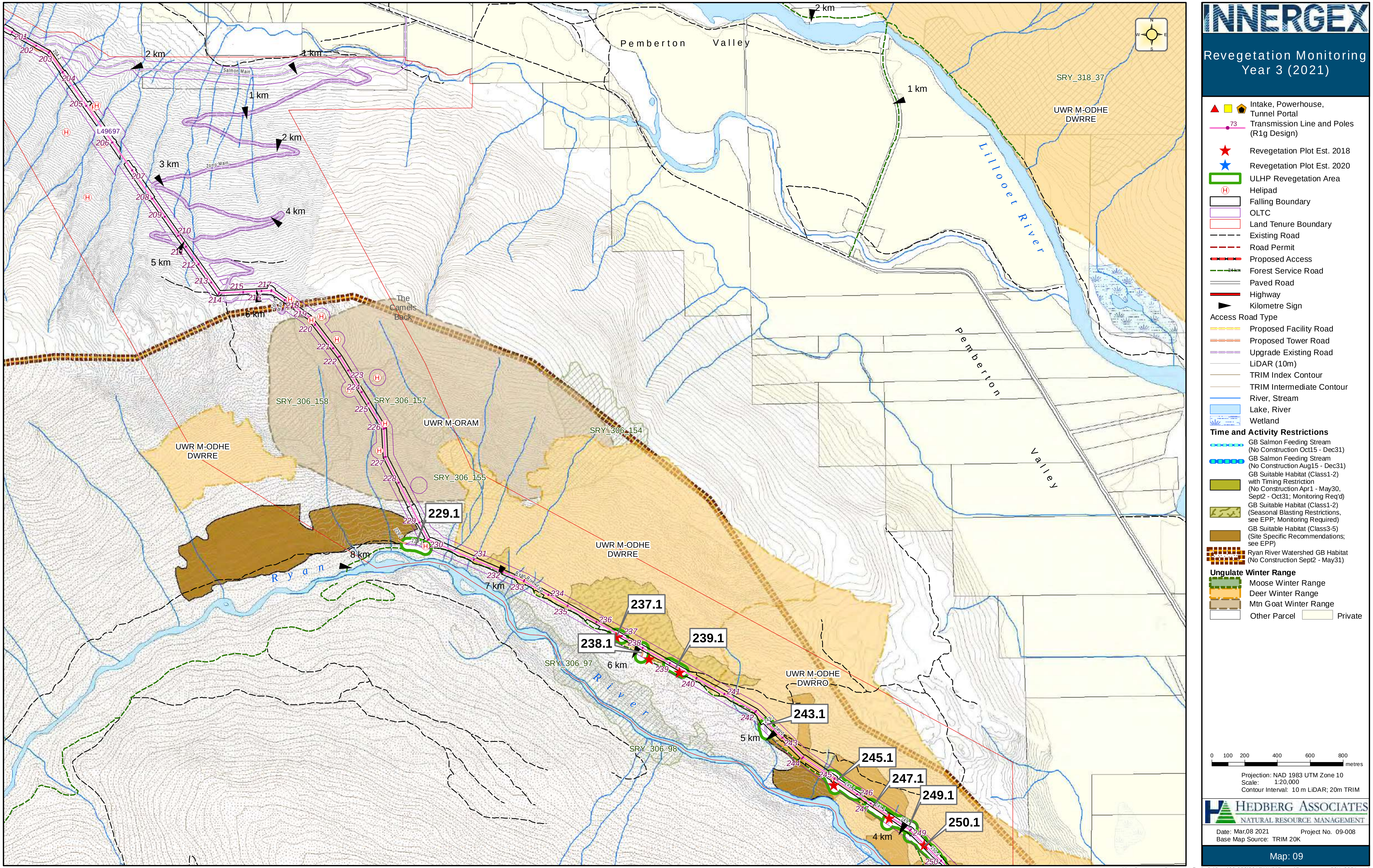

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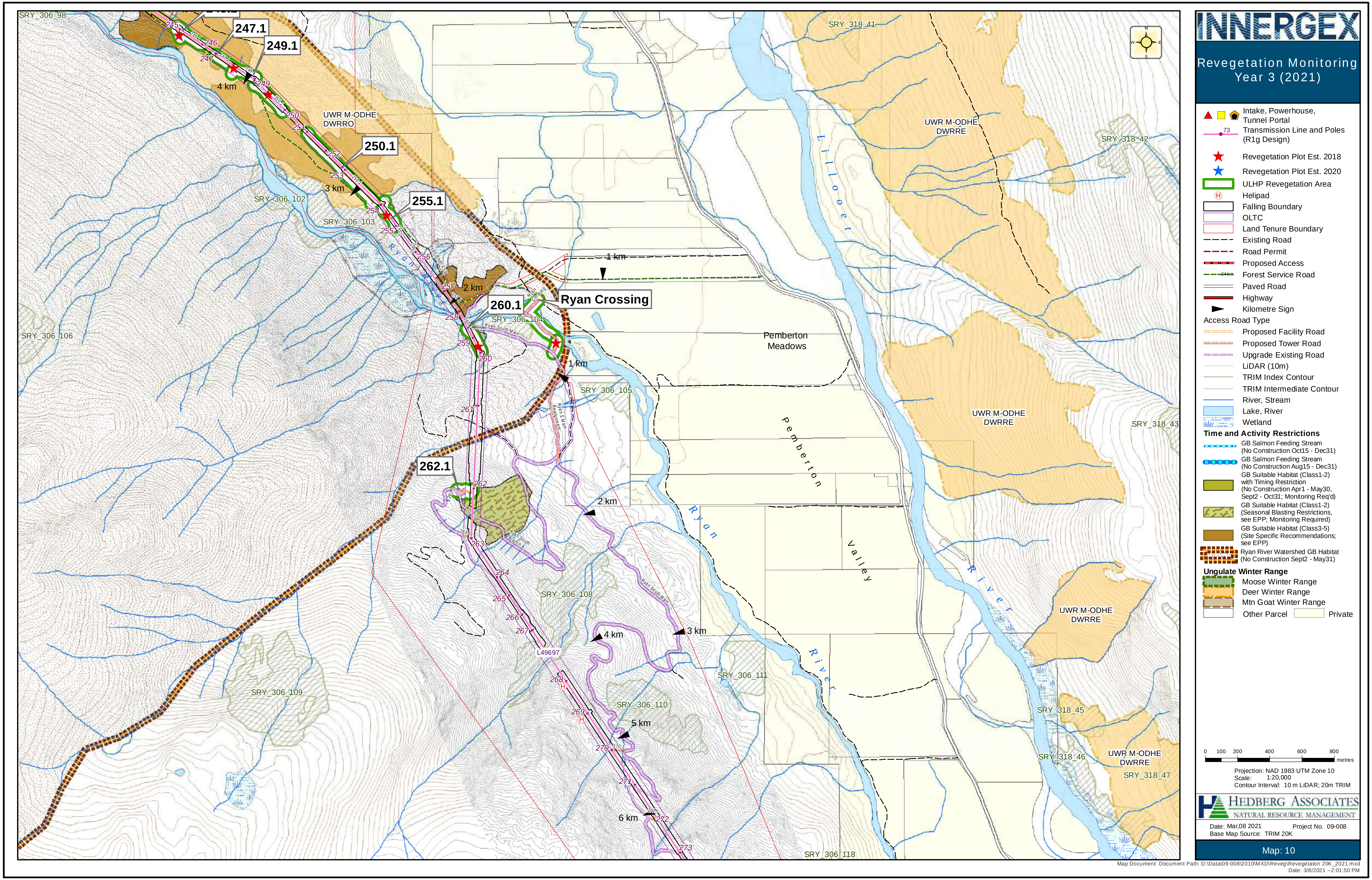
INNERGEX
Revegetation Monitoring Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign
Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland
Time and Activity Restrictions
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Ryan River Watershed GB Habitat (No Construction Sept2 - May31)
Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private
0 100 200 400 600 800 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar.08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 10
247.1
249.1
250.1
255.1
260.1
262.1
Ryan Crossing
Pemberton Meadows
Pemberton Valley
Lillooet River
Ryan River
UWR M-ODHE DWRRO
UWR M-ODHE DWRRE
SRY_306_98
SRY_306_102
SRY_306_103
SRY_306_104
SRY_306_105
SRY_306_106
SRY_306_108
SRY_306_109
SRY_306_110
SRY_306_111
SRY_306_118
SRY_318_41
SRY_318_42
SRY_318_43
SRY_318_45
SRY_318_46
SRY_318_47
L49697
1 km
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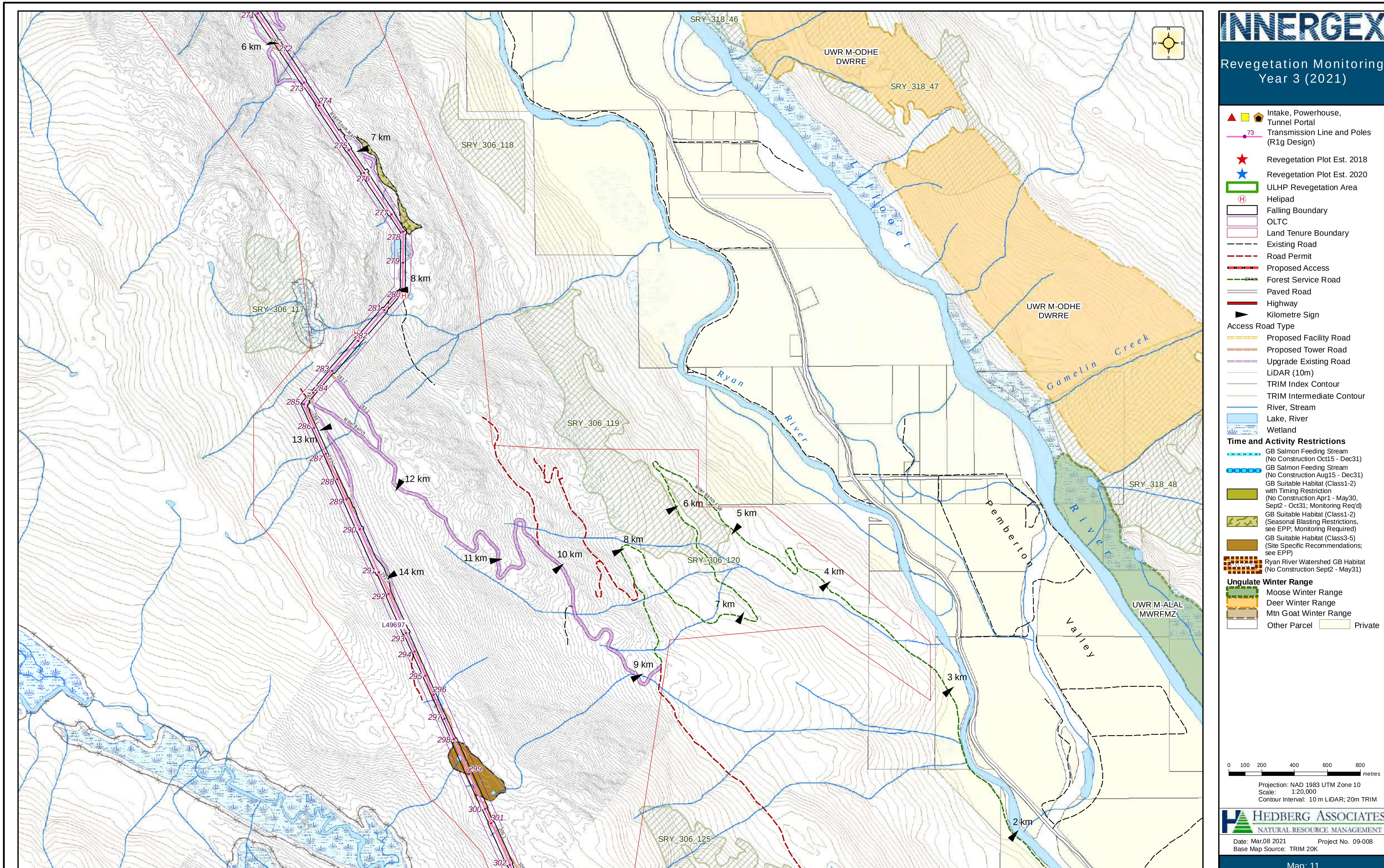

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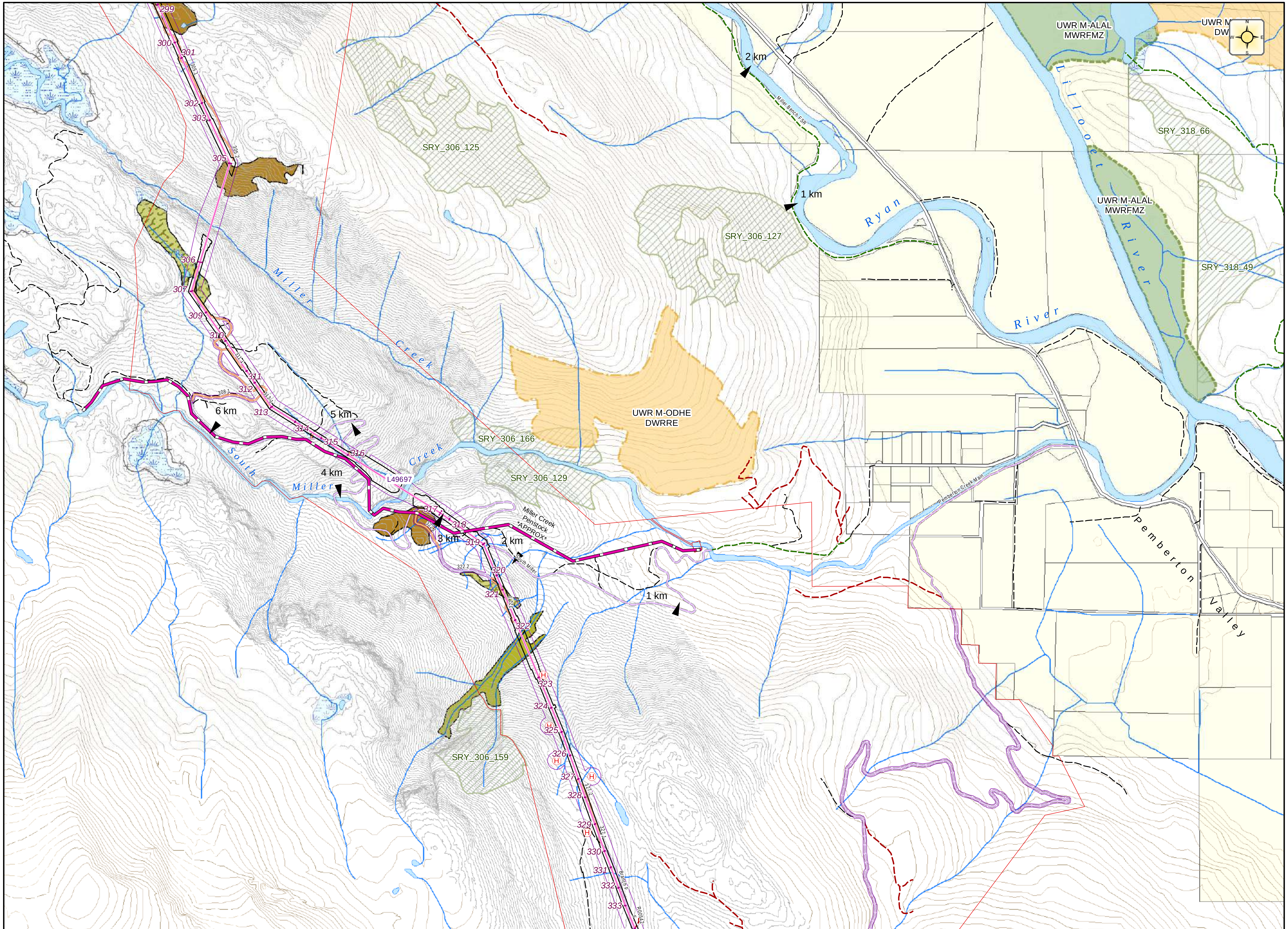

INNERGEX

Revegetation Monitoring Year 3 (2021)

Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
ULHP Revegetation Area
Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
Paved Road
Highway
Kilometre Sign

Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
TRIM Index Contour
TRIM Intermediate Contour
River, Stream
Lake, River
Wetland

Time and Activity Restrictions
GB Salmon Feeding Stream (No Construction Oct15 - Dec31)
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GB Suitable Habitat (Class3-5) (Site Specific Recommendations; see EPP)
Ryan River Watershed GB Habitat (No Construction Sept2 - May31)

Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private

0 100 200 400 600 800 metres

Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K

Map: 12

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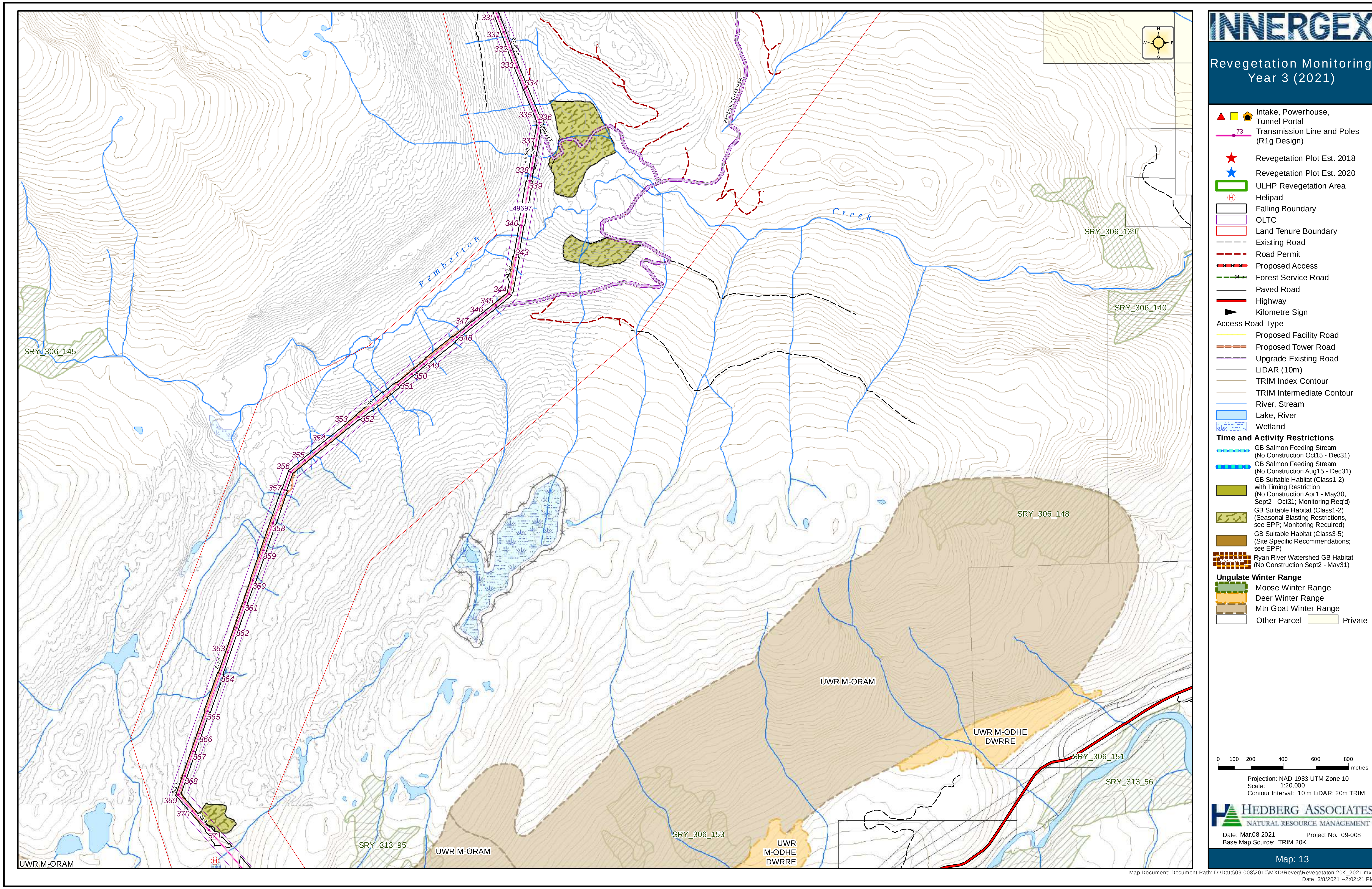
INNERGEX
Revegetation Monitoring
Year 3 (2021)
Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
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Other Parcel
Private
0 100 200 400 600 800 metres
Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM
HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT
Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K
Map: 13
Pemberton
Creek
Pemberton Creek Main
L49697
SRY_306_139
SRY_306_140
SRY_306_145
SRY_306_148
SRY_306_151
SRY_313_56
SRY_306_153
SRY_313_95
UWR M-ORAM
UWR M-ODHE DWRRE
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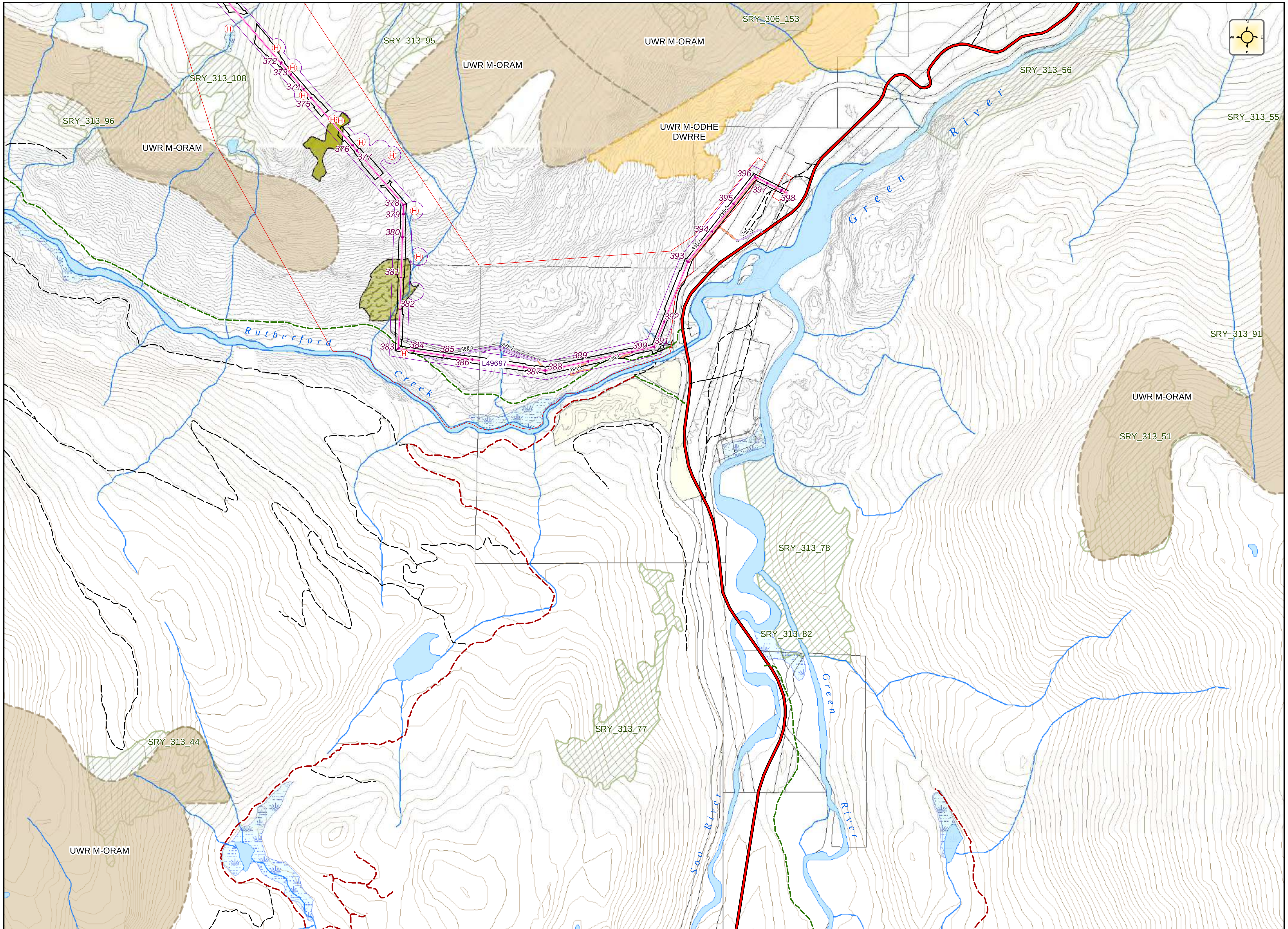

INNERGEX

Revegetation Monitoring Year 3 (2021)

Intake, Powerhouse, Tunnel Portal
Transmission Line and Poles (R1g Design)
Revegetation Plot Est. 2018
Revegetation Plot Est. 2020
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Ungulate Winter Range
Moose Winter Range
Deer Winter Range
Mtn Goat Winter Range
Other Parcel
Private

0 100 200 400 600 800 metres

Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Date: Mar,08 2021
Project No. 09-008
Base Map Source: TRIM 20K

Map: 14

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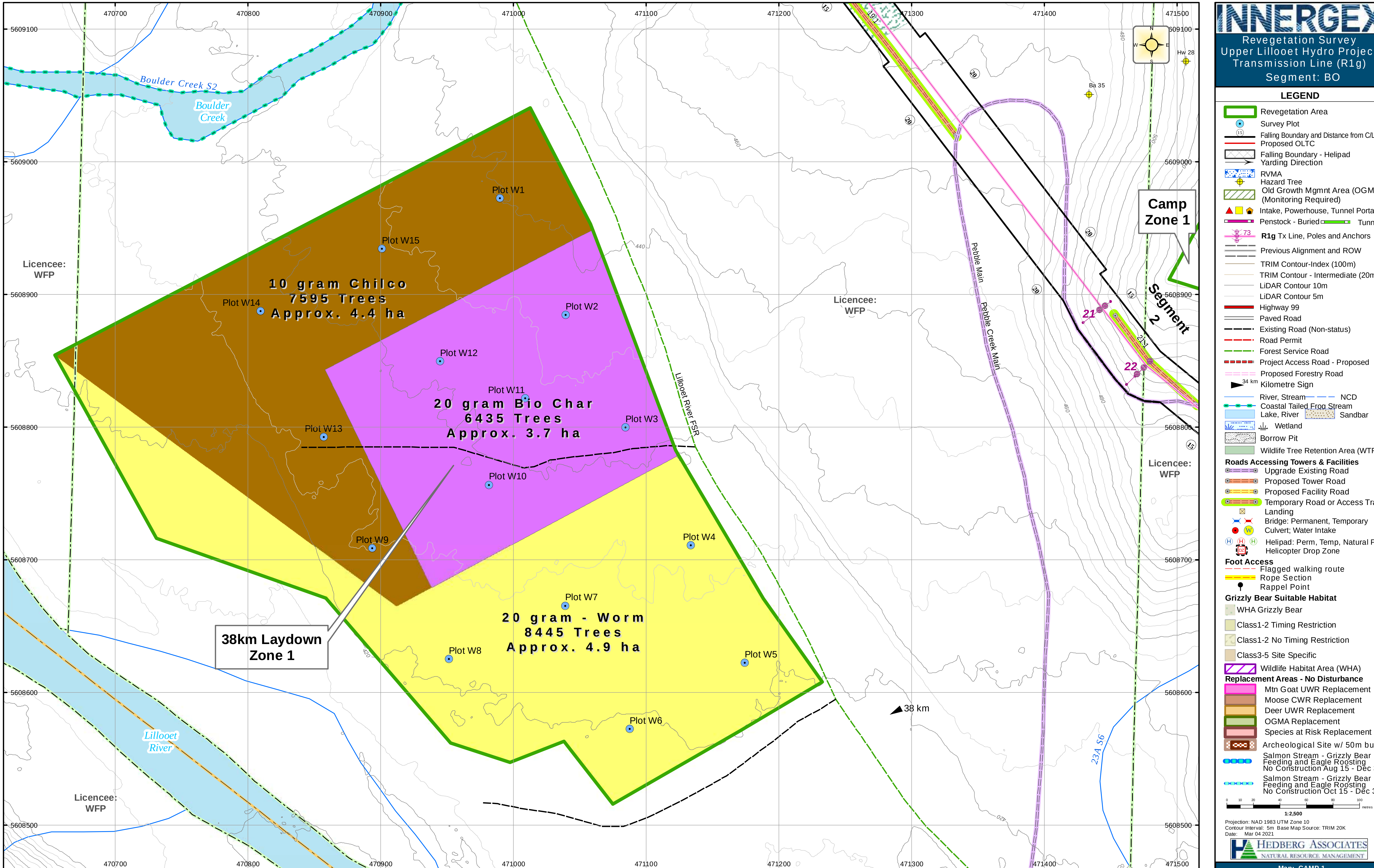

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Civil Works
36 Km Borrow Pit

Project Information

Project: Longterm Longterm Revegetation
Site: 36Km Borrow Pit
Location: Upper Lillooet Hydro Project
Mapsheet: 36 Km Brw
Net Area: 0.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	9,200	81
Douglas Fir	1,200	11
Falsebox	400	4
Red Alder	400	4
Mountain Ash	200	2
Summary:	***11,400***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	5	15	3.5	55.0
Tree 1	2	95		

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

Civil Works

Boulder Powerhouse and Spoil

Project Information

Project: Longterm Longterm Revegetation
Site: Boulder Powerhouse and Spoil
Location: Upper Lillooet Hydro Project
Mapsheet: BO-1
Net Area: 1.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	TS (SPH)	TS %
Black Cottonwood	24,000	57
Red Raspberry	7,200	17
Douglas Fir	5,200	12
Thimbleberry	2,800	7
Falsebox	800	2
Lodgepole Pine	600	2
Western Hemlock	600	1
Western Red Cedar	400	1
Western White Pine	200	-
Kinnikinnick	200	0
Red Osier Dogwood	200	0
Willow	200	0
Summary:	***42,400***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	9	80	8.0	40.0
Herb 2	15	35		
Shrub 1	4	15		
Shrub 2	10	55		
Tree 2	2	15		

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

Affix Professional Seal Here

Civil Works
Boulder Spoil #2

Project Information

Project: Longterm Longterm Revegetation
Site: Boulder Spoil #2
Location: Upper Lillooet Hydro Project
Mapsheet: BO-2
Net Area: 1.3 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 2

Inventory Information

Species	***TS (SPH)***	***TS %***
Thimbleberry	2,000	57
Falsebox	900	26
Vaccinium Spp	300	9
Rosa Spp	200	6
Douglas Fir	100	3
Summary:	***3,500***	***100***

Veg / Brush	***% Cover***	***Avg Ht. (cm)***	***Avg % Cover***	***Avg Ht. (cm)***
Herb 1	42	73	30.0	75.8
Herb 2	33	78		
Shrub 2	15	78		

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

Civil Works
Explosive Magazine

Project Information

Project: Longterm Longterm Revegetation
Site: Explosive Magazine
Location: Upper Lillooet Hydro Project
Mapsheet: Map 3
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 4

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	11,650	46
Salix	9,050	36
Thimbleberry	2,150	8
Douglas Fir	1,300	5
Black Cottonwood	500	2
Western Red Cedar	250	1
Bigleaf Maple	150	1
Ceanothus	100	0
Lodgepole Pine	100	0
Sitka Alder	100	0
Summary:	***25,350***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	35	58	18.3	68.1
Herb 2	9	60		
Shrub 1	36	108		
Shrub 2	23	113		
Tree 1	2	29		
Tree 2	5	40		

Qualified Forest Professional's Statement

Declaration

Forest Professional	Date

Affix Professional Seal Here

Civil Works
41.7 Km Borrow Pit

Project Information

Project: Longterm Longterm Revegetation
Site: 41.7 Km Borrow Pit
Location: Upper Lillooet Hydro Project
Mapsheet: BO-1
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 2

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	3,800	35
Black Cottonwood	3,400	32
Thimbleberry	1,400	13
Douglas Fir	1,300	12
Spruce	600	6
Oregon Grape	200	2
Summary:	***10,700***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	8	13	4.6	27.3
Herb 2	6	13		
Shrub 1	3	35		
Tree 1	5	65		
Tree 2	1	10		

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

Civil Works
Upper Lillooet Penstock

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Lillooet Penstock
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 4.6 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 4

Inventory Information

Species	TS (SPH)	TS %
Red Raspberry	7,850	39
Black Cottonwood	7,800	39
Douglas Fir	2,900	14
Thimbleberry	650	3
Red Alder	450	2
Western Red Cedar	200	1
Willow	150	1
Ceanothus	50	0
Douglas Maple	50	0
Falsebox	50	0
Red Osier Dogwood	50	0
Western White Pine	50	0
Summary:	***20,250***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	5	23	3.5	26.3
Herb 2	1	35		
Shrub 1	7	40		
Shrub 2	4	35		
Tree 1	1	5		
Tree 2	3	20		

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

Civil Works
Upper Spoil #6

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #6
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	7,400	63
Douglas Fir	2,800	24
Western Red Cedar	800	7
Spruce	400	3
Red Alder	200	2
Willow	200	2
Summary:	***11,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	1	8	1.0	7.0
Tree 1	1	6		
Tree 2	1	7		

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

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Spoil #3

INNERGEX

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #3
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 2

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	2,900	45
Douglas Fir	1,300	20
Red Raspberry	1,300	20
Amabalis Fir	300	5
Thimbleberry	300	5
Spruce	200	3
Willow	100	2
Summary:	***6,400***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	13	29	18.2	29.8
Herb 2	12	28		
Shrub 1	10	15		
Shrub 2	9	35		
Tree 1	60	42		
Tree 2	5	30		

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

Affix Professional Seal Here

Civil Works
Upper Spoil #4

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #4
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 1.6 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 2

Inventory Information

Species	TS (SPH)	TS %
Red Raspberry	3,200	49
Douglas Fir	1,100	17
Thimbleberry	800	12
Spruce	700	11
Black Cottonwood	500	8
Amabalis Fir	100	2
Red Osier Dogwood	100	2
Summary:	***6,500***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	1	70	4.4	56.0
Herb 2	2	50		
Shrub 1	5	30		
Tree 1	8	70		
Tree 2	6	60		

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

Civil Works
Upper Spoil #8

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #8
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 2.2 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 2

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	12,700	51
Douglas Fir	4,600	19
Black Cottonwood	4,000	16
Amabalis Fir	1,100	4
Falsebox	500	2
Willow	500	2
Western Hemlock	400	2
Western Red Cedar	300	1
Mountain Hemlock	200	1
Ceanothus	100	0
Red Osier Dogwood	100	0
Sitka Alder	100	0
Spruce	100	0
Western White Pine	100	0
Summary:	***24,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	2	38	4.2	27.5
Herb 2	5	15		
Shrub 1	3	28		
Tree 1	6	36		
Tree 2	5	21		

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

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Diversion Channel and Slopes

INNERGEX

Project Information

Project: Longterm Longterm Revegetation
Site: Diversion Channel and Slopes
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 3

Inventory Information

Species	***TS (SPH)***	***TS %***
Amabalis Fir	2,133	27
Black Cottonwood	1,933	24
Sitka Alder	1,000	13
Salix	933	12
Red Alder	400	5
Spruce	333	4
Vaccinium	267	3
Douglas Fir	133	2
Red Raspberry	133	2
Salal	133	2
Salmonberry	133	2
Sitka Mountain-Ash	133	2
Mountain Hemlock	67	1
Red Elderberry	67	1
Red Osier Dogwood	67	1
Ribes	67	1
Thimbleberry	67	1
Summary:	***8,000***	***100***

Veg / Brush	***% Cover***	***Avg Ht. (cm)***	***Avg % Cover***	***Avg Ht. (cm)***
Herb 1	9	25	7.0	22.8
Herb 2	14	25		
Shrub 1	9	38		
Shrub 2	8	35		
Tree 1	1	8		
Tree 2	1	6		

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

Civil Works
Keyhole Laydown

Project Information

Project: Longterm Longterm Revegetation
Site: Keyhole Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1
Net Area: 0.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	46,400	85
Vaccinium	4,800	9
Amabalis Fir	1,400	3
Red Elderberry	800	1
Ribes	600	1
Willow	400	1
Summary:	***54,400***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	65	46	33.0	42.0
Herb 2	8	25		
Shrub 2	26	55		

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

Civil Works
Upper Intake and Laydown

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Project Information

Project: Longterm Longterm Revegetation
Site: Upper Intake and Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1
Net Area: 2.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 4

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	16,400	78
Amabalis Fir	2,100	10
Willow	1,050	5
Spruce	350	2
Douglas Fir	300	1
Western Red Cedar	250	1
Red Alder	200	1
Rose	100	0
Lodgepole Pine	50	0
Oregon Grape	50	0
Red Elderberry	50	0
Sitka Alder	50	0
Western Hemlock	50	0
Summary:	***21,000***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	13	7	4.8	11.2
Herb 2	8	7		
Shrub 1	1	15		
Shrub 2	1	10		
Tree 1	1	17		

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

Civil Works
Upper Spoil #1

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #1
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1
Net Area: 2.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 3

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	5,467	39
Willow	3,600	26
Sitka Alder	2,667	19
Spruce	1,000	7
Amabalis Fir	533	4
Douglas Fir	200	1
Thimbleberry	133	1
Western Red Cedar	133	1
Red Alder	67	0
Trembling Aspen	67	0
Summary:	***13,867***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	3	15	5.4	31.2
Herb 2	2	15		
Shrub 2	13	42		
Tree 1	5	46		
Tree 2	4	38		

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

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NATURAL RESOURCE MANAGEMENT

Civil Works

INNERGEX

Upper Spoil #2 & Settling Basin

Project Information

Project: Longterm Longterm Revegetation
Site: Upper Spoil #2
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1
Net Area: 2.8 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 4

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	5,050	67
Douglas Fir	600	8
Amabalis Fir	650	7
Red Raspberry	350	5
Spruce	300	4
Red Alder	250	3
Willow	250	3
Salal	50	1
Thimbleberry	50	1
Summary:	***7,550***	***98***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	5	14	2.4	17.4
Herb 2	1	8		
Shrub 1	2	30		
Tree 1	1	9		
Tree 2	3	27		

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

Hedberg Associates — Natural Resource Management

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Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

							Percent Cover of Quadrant Plots		
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
36 Km Borrow Pit	S	Jul 15, 2020 08:19	5607378	472687	Black Cottonwood	46	Herb 1	5	15
					Douglas Fir	6	Tree 1	2	95
					Falsebox	2			
					Mountain Ash	1			
					Red Alder	2			
						57			
						57			
41.7 Km Borrow Pit	M	Sep 8, 2020 14:38	5611549	468613	Black Cottonwood	13	Herb 1	5	10
					Douglas Fir	6	Herb 2	4	15
					Oregon Grape	1	Tree 1	5	65
					Red Raspberry	25	Tree 2	1	10
					Spruce	6			
					Thimbleberry	6			
						57			
	N	Sep 8, 2020 14:55	5611582	468587	Black Cottonwood	21	Herb 1	11	16
					Douglas Fir	7	Herb 2	7	10
					Oregon Grape	1	Shrub 1	3	35
					Red Raspberry	13	Shrub 2	0	50
					Thimbleberry	8			
						50			
						107			
Boulder Powerhouse and Spoil	Q	Sep 8, 2020 11:08	5609341	471322	Black Cottonwood	120	Herb 1	9	80
					Douglas Fir	26	Herb 2	15	35
					Falsebox	4	Shrub 1	4	15
					Kinnikinnick	1	Shrub 2	10	55
					Lodgepole Pine	3	Tree 2	2	15
					Red Osier Dogwood	1			
					Red Raspberry	36			
					Willow	1			
					Thimbleberry	14			
					Western Hemlock	3			
					Western Red Cedar	2			
					Western White Pine	1			
						212			
						212			
Boulder Spoil #2	K	Sep 18, 2020 12:09	5610838	472716	Falsebox	2	Herb 1	7	80
					Rosa Spp	2	Herb 2	60	75
					Thimbleberry	3	Shrub 2	20	110
						7			
	L	Sep 18, 2020 12:30	5610905	472805	Douglas Fir	1	Herb 1	76	65
					Falsebox	7	Herb 2	5	80
					Thimbleberry	17	Shrub 2	10	45
					Vaccinium Spp	3			
						28			
						35			
Diversion Channel and Slopes	008	Aug 14, 2020 11:10	5614012	466028	Amabalis Fir	7	Herb 1	6	38
					Black Cottonwood	12	Herb 2	16	40
					Mountain Hemlock	1	Tree 1	1	8
					Red Alder	6	Tree 2	1	6
					Red Raspberry	2			
					Willow	12			
					Spruce	3			
					Thimbleberry	1			
						44			
	009	Aug 14, 2020 11:31	5613986	466110	Amabalis Fir	5	Shrub 2	8	35
					Black Cottonwood	15			
					Douglas Fir	2			
					Red Osier Dogwood	1			
					Salal	1			
					Willow	2			
					Sitka Alder	6			
					Spruce	2			
					Vaccinium	1			
						35			

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
	013	Aug 14, 2020 11:43	5613983	466234	Amabalis Fir	20	Herb 1	11	12
					Black Cottonwood	2	Herb 2	11	10
					Red Elderberry	1	Shrub 1	9	38
					Ribes	1			
					Salal	1			
					Salmonberry	2			
					Sitka Alder	9			
					Sitka Mountain-Ash	2			
					Vaccinium	3			
						41			
						120			
Explosive Magazine	001	Sep 8, 2020 12:36	5610397	469958	Douglas Fir	6	Herb 2	3	65
					Red Raspberry	57	Shrub 1	90	220
					Willow	133	Shrub 2	32	220
						196			
	002	Sep 8, 2020 13:31	5610442	469890	Black Cottonwood	6	Herb 1	14	33
					Douglas Fir	10	Herb 2	12	30
					Lodgepole Pine	1	Shrub 1	9	50
					Red Raspberry	33	Shrub 2	20	60
					Willow	13	Tree 1	2	48
					Sitka Alder	2			
					Thimbleberry	10			
					Western Red Cedar	4			
						79			
	003	Sep 8, 2020 12:41	5610394	469947	Black Cottonwood	4	Herb 1	17	70
					Douglas Fir	7	Herb 2	12	45
					Lodgepole Pine	1	Shrub 2	17	60
					Red Raspberry	143	Tree 1	1	10
					Willow	18	Tree 2	5	40
					Thimbleberry	3			
						176			
	004	Sep 17, 2020 11:39	5610390	470022	Bigleaf Maple	3	Herb 1	75	70
					Ceanothus	2	Herb 2	8	100
					Douglas Fir	3	Shrub 1	10	55
					Willow	17			
					Thimbleberry	30			
					Western Red Cedar	1			
						56			
						507			
Keyhole Laydown	007	Aug 14, 2020 12:25	5614079	466444	Amabalis Fir	7	Herb 1	65	46
					Red Elderberry	4	Herb 2	8	25
					Red Raspberry	232	Shrub 2	26	55
					Ribes	3			
					Willow	2			
					Vaccinium	24			
						272			
						272			
Upper Intake and Laydown	014	Jul 15, 2020 12:54	5614287	466095	Amabalis Fir	33	Shrub 2	1	10
					Black Cottonwood	273	Tree 1	1	17
					Lodgepole Pine	1			
					Red Alder	4			
					Willow	17			
					Spruce	1			
					Western Red Cedar	3			
						332			
	A	Jul 15, 2020 13:09	5614242	466166	Amabalis Fir	6	Shrub 1	1	15
					Black Cottonwood	46	Tree 1	1	17
					Douglas Fir	1			
					Rose	2			
					Willow	4			
					Spruce	1			
					Western Red Cedar	2			
						62			
	B	Aug 14, 2020 13:06	5614199	466204	Douglas Fir	2	Herb 1	13	7
					Sitka Alder	1	Herb 2	8	7
					Spruce	4			
						7			
	C	Aug 14, 2020 12:50	5614154	466136	Amabalis Fir	3			

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
					Black Cottonwood	9			
					Douglas Fir	3			
					Oregon Grape	1			
					Red Elderberry	1			
					Spruce	1			
					Western Hemlock	1			
						19			
						420			
Upper Lillooet Penstock	H	Oct 20, 2020 13:27	5613021	467886	Black Cottonwood	8		0	0
					Douglas Fir	26			
					Red Alder	9			
					Red Raspberry	32			
					Willow	3			
					Thimbleberry	9			
					Western Red Cedar	1			
						88			
	I	Sep 15, 2020 13:06	5612549	468275	Black Cottonwood	25	Herb 1	8	20
					Douglas Fir	11	Shrub 1	7	40
					Red Osier Dogwood	1	Shrub 2	4	35
					Red Raspberry	121	Tree 2	4	20
					Thimbleberry	4			
					Western Red Cedar	1			
						163			
	O	Sep 15, 2020 13:45	5612325	468415	Black Cottonwood	9	Herb 1	1	25
					Ceanothus	1	Herb 2	1	35
					Douglas Fir	8			
					Falsebox	1			
					Red Raspberry	4			
					Western Red Cedar	2			
						25			
	P	Sep 15, 2020 13:59	5612025	468502	Black Cottonwood	114	Tree 1	1	5
					Douglas Fir	13	Tree 2	1	20
					Douglas Maple	1			
					Western White Pine	1			
						129			
						405			
Upper Spoil #1	010	Aug 14, 2020 10:15	5614048	465825	Amabalis Fir	1	Herb 1	3	15
					Black Cottonwood	11	Herb 2	2	15
					Douglas Fir	1	Shrub 2	13	42
					Red Alder	1			
					Willow	9			
					Spruce	6			
					Thimbleberry	1			
					Western Red Cedar	1			
						31			
	011	Aug 14, 2020 10:20	5614073	465752	Amabalis Fir	3			
					Douglas Fir	2			
					Sitka Alder	1			
					Spruce	3			
					Western Red Cedar	1			
						10			
	012	Aug 14, 2020 10:37	5614057	465895	Amabalis Fir	4	Tree 1	5	46
					Black Cottonwood	71	Tree 2	4	38
					Willow	45			
					Sitka Alder	39			
					Spruce	6			
					Thimbleberry	1			
					Trembling Aspen	1			
						167			
						208			

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NATURAL RESOURCE MANAGEMENT

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Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

							Percent Cover of Quadrant Plots		
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
Upper Spoil #2 and Settling Basin	015	Jul 15, 2020 13:20	5614307	466155	Amabalis Fir	2	Herb 1	13	20
					Black Cottonwood	67	Herb 2	1	5
					Douglas Fir	1			
					Red Alder	2			
					Red Raspberry	7			
					Willow	3			
					Spruce	1			
						83			
	016	Aug 14, 2020 13:27	5614378	466205	Amabalis Fir	3	Tree 1	1	9
					Black Cottonwood	7	Tree 2	4	44
					Douglas Fir	2			
					Willow	2			
					Spruce	3			
						17			
	017	Aug 14, 2020 12:47	5614298	466162	Amabalis Fir	7	Herb 1	1	10
					Black Cottonwood	23			
					Douglas Fir	5			
					Red Alder	3			
					Thimbleberry	1			
						39			
	018	Aug 14, 2020 12:48	5614170	466152	Amabalis Fir	1	Herb 1	1	11
					Black Cottonwood	4	Herb 2	1	10
					Douglas Fir	4	Shrub 1	2	30
					Salal	1	Tree 2	1	10
					Spruce	2			
						12			
						151			
Upper Spoil #3	D	Jul 15, 2020 12:08	5613251	467673	Amabalis Fir	1	Herb 1	17	38
					Black Cottonwood	4	Herb 2	5	25
					Douglas Fir	9	Shrub 2	9	35
					Red Raspberry	13	Tree 1	60	42
					Willow	1			
					Spruce	1			
						29			
	E	Jul 15, 2020 12:24	5613276	467777	Amabalis Fir	2	Herb 1	8	20
					Black Cottonwood	25	Herb 2	19	30
					Douglas Fir	4	Shrub 1	10	15
					Spruce	1	Tree 2	5	30
					Thimbleberry	3			
						35			
						64			
Upper Spoil #4	F	Jul 15, 2020 11:26	5613158	467768	Black Cottonwood	3	Herb 1	1	70
					Douglas Fir	8	Herb 2	2	30
					Red Osier Dogwood	1	Herb 2	1	70
					Red Raspberry	21	Tree 1	8	70
					Spruce	3			
					Thimbleberry	8			
						44			
	G	Jul 15, 2020 11:43	5613118	467712	Amabalis Fir	1	Shrub 1	5	30
					Black Cottonwood	2	Tree 2	6	60
					Douglas Fir	3			
					Red Raspberry	11			
					Spruce	4			
						21			
						65			
Upper Spoil #6	J	Sep 15, 2020 12:54	5612564	468266	Black Cottonwood	37	Herb 1	1	8
					Douglas Fir	14	Tree 1	1	6
					Red Alder	1	Tree 2	1	7
					Willow	1			
					Spruce	2			
					Western Red Cedar	4			
						59			
						59			

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT

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Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
2020 Upper Spoil #8	005	Sep 15, 2020 11:49	5613456	467696	Amabalis Fir	4	Herb 1	2	38
					Black Cottonwood	17	Herb 2	5	15
					Ceanothus	1	Shrub 1	3	28
					Douglas Fir	6	Tree 2	6	16
					Falsebox	5			
					Mountain Hemlock	1			
					Red Osier Dogwood	1			
					Red Raspberry	127			
					Spruce	1			
					Western Red Cedar	3			
					Western White Pine	1			
						167			
	006	Sep 15, 2020 12:04	5613508	467675	Amabalis Fir	7	Tree 1	6	36
					Black Cottonwood	23	Tree 2	3	25
					Douglas Fir	40			
					Mountain Hemlock	1			
					Willow	5			
					Sitka Alder	1			
					Western Hemlock	4			
						81			
						248			
						5051			

Civil Works
38 Km Laydown

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NATURAL RESOURCE MANAGEMENT

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Project Information

Project: Longterm Revegetation Monitoring
Site: 38 Km Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: Map 4
Net Area: 15.2 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 15

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	1,573	31
Red Raspberry	1,160	23
Falsebox	667	13
Douglas Fir	653	13
Lodgepole Pine	347	7
Spruce	200	4
Thimbleberry	80	2
Western Red Cedar	80	2
Kinnikinnick	67	1
Blackcap Raspberry	53	1
Red Alder	40	1
Salix	40	1
Amabalis Fir	27	1
Ceanothus	27	1
Red Osier Dogwood	27	1
Saskatoon	13	0
Summary:	***5,053***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	16	46	6.6	33.5
Herb 2	13	37		
Shrub 1	2	28		
Shrub 2	2	13		
Tree 1	2	37		
Tree 2	5	40		

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

Civil Works
41.7 Km Borrow Pit

Project Information

Project: Longterm Revegetation Monitoring
Site: 41.7 Km Borrow Pit
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	
Black Cottonwood	9,800	39	
Red Raspberry	9,800	39	
Salix	1,800	7	
Thimbleberry	1,800	7	
Douglas Fir	800	3	
Spruce	600	2	
Mountain Hemlock	400	2	
Sitka Alder	200	1	
Summary:	***25,200***	***100***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	6	30	5.0	29.7
Herb 2	10	15		
Shrub 1	5	40		
Shrub 2	7	75		
Tree 1	1	8		
Tree 2	1	10		

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

Civil Works
Boulder Powerhouse and Spoil

Project Information

Project: Longterm Revegetation Monitoring
Site: Boulder Powerhouse and Spoil
Location: Upper Lillooet Hydro Project
Mapsheet: BO-1
Net Area: 1.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	TS (SPH)	TS %				
Black Cottonwood	24,000	57				
Red Raspberry	7,200	17				
Douglas Fir	5,200	12				
Thimbleberry	2,800	7				
Falsebox	800	2				
Lodgepole Pine	600	1				
Western Hemlock	600	1				
Western Red Cedar	400	1				
Kinnikinnick	200	0				
Red Osier Dogwood	200	0				
Salix	200	0				
Western White Pine	200	0				
Summary:	***42,400***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	9	80	8.0	40.0
Herb 2	15	35		
Shrub 1	4	15		
Shrub 2	10	55		
Tree 2	2	15		

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

Affix Professional Seal Here

Civil Works
Boulder Spoil #4

Project Information

Project: Longterm Revegetation Monitoring
Site: Boulder Spoil #4
Location: Upper Lillooet Hydro Project
Mapsheet: Map 3
Net Area: 0.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	5,800	59
Black Cottonwood	1,200	12
Douglas Fir	1,200	12
Spruce	800	8
Thimbleberry	600	6
Falsebox	200	2
Summary:	***9,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	14	45	12.7	35.0
Herb 2	11	30		
Shrub 2	13	30		

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

Civil Works
Boulder Spoil #7

Project Information

Project: Longterm Revegetation Monitoring
Site: Boulder Spoil #7
Location: Upper Lillooet Hydro Project
Mapsheet: BO-3a
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	15,200	95
Douglas Fir	800	5
Summary:	***16,000***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 2	1	30	4.3	38.3
Tree 1	6	40		
Tree 2	6	45		

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

Civil Works
Camp

Project Information

Project: Longterm Revegetation Monitoring
Site: Camp
Location: Upper Lillooet Hydro Project
Mapsheet: Map 4
Net Area: 6.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 6

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	1,900	34
Douglas Fir	1,567	28
Falsebox	867	15
Lodgepole Pine	767	14
Red Raspberry	233	4
Western Red Cedar	100	2
Ponderosa Pine	67	1
Birch Leaf Spirea	33	1
Saskatoon	33	1
Thimbleberry	33	1
Summary:	***5,600***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	2	20	3.0	34.5
Herb 2	6	58		
Shrub 2	2	30		
Tree 1	2	30		

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

Civil Works
Upper Spoil #5

Project Information

Project: Longterm Revegetation Monitoring
Site: Upper Spoil #5
Location: Upper Lillooet Hydro Project
Mapsheet: Map 3
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	23,600	92
Black Cottonwood	800	3
Spruce	600	2
Amabalis Fir	200	1
Douglas Fir	200	1
Sitka Alder	200	1
Summary:	***25,600***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	5	7	3.7	20.0
Herb 2	5	40		
Tree 1	1	13		

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

Civil Works
Upper Spoil #7

Project Information

Project: Longterm Revegetation Monitoring
Site: Upper Spoil #7
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2
Net Area: 0.6 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of Plots: 1

Inventory Information

Species	TS (SPH)	TS %
Black Cottonwood	28,800	73
Red Raspberry	6,400	16
Willow	1,400	4
Douglas Fir	1,200	3
Amabalis Fir	800	2
Red Osier Dogwood	200	1
Sitka Alder	200	1
Thimbleberry	200	1
Summary:	***39,200***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 2	1	45	3.0	38.3
Shrub 2	4	30		
Tree 2	4	40		

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

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2020)

							Percent Cover of Quadrant Plots		
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
38 km Laydown	W1	Sep 14, 2020 14:21	5608973	470993	Amabalis Fir	1	Herb 1	5	32
					Black Cottonwood	7	Herb 2	7	12
					Douglas Fir	4	Shrub 1	3	30
					Lodgepole Pine	3	Tree 2	1	20
					Red Alder	1			
					Red Raspberry	5			
					Salix	2			
					Thimbleberry	1			
						24			
	W2	Sep 14, 2020 14:35	5608885	471041	Black Cottonwood	1	Herb 1	34	40
					Blackcap Raspberry	2	Herb 2	11	15
					Douglas Fir	4			
					Red Raspberry	23			
						30			
	W3	Sep 14, 2020 15:19	5608803	471090	Douglas Fir	5	Herb 1	8	50
					Falsebox	1	Herb 2	1	65
					Lodgepole Pine	9	Shrub 1	1	40
					Red Raspberry	18	Shrub 2	1	20
					Saskatoon	1			
					Spruce	3			
					Western Red Cedar	1			
						38			
	W4	Sep 14, 2020 15:32	5608715	471140	Black Cottonwood	3	Herb 1	12	40
					Blackcap Raspberry	1	Herb 2	15	30
					Douglas Fir	4	Shrub 1	4	10
					Falsebox	20	Shrub 2	2	5
					Kinnikinnick	4	Tree 1	1	13
					Lodgepole Pine	1			
						33			
	W5	Sep 14, 2020 15:44	5608620	471177	Black Cottonwood	3	Herb 2	30	50
					Douglas Fir	2	Tree 1	2	52
					Falsebox	1			
					Spruce	2			
					Western Red Cedar	1			
						9			
	W6	Sep 14, 2020 12:34	5608574	471087	Black Cottonwood	38	Herb 1	10	24
					Douglas Fir	4	Herb 2	3	17
					Falsebox	2			
					Lodgepole Pine	2			
						46			
	W7	Sep 14, 2020 12:48	5608658	471041	Black Cottonwood	3	Herb 1	15	75
					Douglas Fir	2	Herb 2	36	65
					Falsebox	2			
					Lodgepole Pine	4			
					Red Alder	1			
					Red Raspberry	14			
					Spruce	2			
					Western Red Cedar	2			
						30			
	W8	Sep 14, 2020 13:06	5608622	470953	Black Cottonwood	3	Herb 1	4	12
					Blackcap Raspberry	1	Herb 2	14	52
					Ceanothus	1			
					Douglas Fir	4			
					Falsebox	2			
					Spruce	3			
					Thimbleberry	1			
						15			
	W9	Sep 14, 2020 13:26	5608705	470885	Black Cottonwood	6	Herb 1	5	65
					Douglas Fir	5	Herb 2	1	10
					Falsebox	1			
						12			

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2020)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
	W10	Sep 14, 2020 15:07	5608761	470987	Douglas Fir	7	Herb 1	8	80
					Falsebox	8	Herb 2	24	85
					Lodgepole Pine	1	Shrub 1	1	30
					Red Raspberry	7			
					Spruce	2			
					Thimbleberry	3			
						28			
	W11	Sep 14, 2020 14:56	5608821	471016	Douglas Fir	2	Herb 1	100	45
					Falsebox	1	Herb 2	24	40
					Kinnikinnick	1			
					Red Raspberry	2			
					Spruce	1			
					Western Red Cedar	1			
						8			
	W12	Sep 14, 2020 14:46	5608852	470946	Black Cottonwood	21	Herb 1	3	30
					Douglas Fir	2	Herb 2	8	40
					Red Raspberry	2	Tree 2	10	53
					Salix	1			
						26			
	W13	Sep 14, 2020 13:38	5608795	470855	Black Cottonwood	5	Herb 1	9	55
					Ceanothus	1	Herb 2	13	38
					Douglas Fir	1			
					Falsebox	5			
					Red Alder	1			
					Red Raspberry	3			
					Spruce	2			
						18			
	W14	Sep 14, 2020 13:53	5608881	470815	Black Cottonwood	17	Herb 1	4	45
					Douglas Fir	1	Herb 2	10	30
					Falsebox	6	Tree 1	2	45
					Lodgepole Pine	3	Tree 2	5	47
					Red Raspberry	3			
					Thimbleberry	1			
						31			
	W15	Sep 14, 2020 14:07	5608935	470899	Amabalis Fir	1	Herb 1	7	45
					Black Cottonwood	11	Herb 2	5	10
					Douglas Fir	2			
					Falsebox	1			
					Lodgepole Pine	3			
					Red Osier Dogwood	2			
					Red Raspberry	10			
					Western Red Cedar	1			
						31			
						379			
41.7 Km Borrow Pit	U	Sep 15, 2020 14:49	5611566	468747	Black Cottonwood	49	Herb 1	6	30
					Douglas Fir	4	Herb 2	10	15
					Mountain Hemlock	2	Shrub 1	5	40
					Red Raspberry	49	Shrub 2	7	75
					Salix	9	Tree 1	1	8
					Sitka Alder	1	Tree 2	1	10
					Spruce	3			
					Thimbleberry	9			
						126			
						126			
Boulder Powerhouse and Spoil	C1	Sep 17, 2020 11:05	5609435	471112	Black Cottonwood	40	Herb 1	1	3
					Douglas Fir	4	Tree 1	4	20
					Falsebox	4			
					Lodgepole Pine	2			
					Thimbleberry	2			
					Western White Pine	1			
						265			

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2020)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
Boulder Spoil #7	E1	Sep 17, 2020 12:15	5610505	471657	Black Cottonwood	76	Herb 2	1	30
					Douglas Fir	4	Tree 1	6	40
							Tree 2	6	45
						80			
						80			
Boulder Spoil # 4	D1	Sep 17, 2020 11:27	5610158	470110	Black Cottonwood	6	Herb 1	14	45
					Douglas Fir	6	Herb 2	11	30
					Falsebox	1	Shrub 2	13	30
					Red Raspberry	29			
					Spruce	4			
					Thimbleberry	3			
						49			
						49			
Camp	B1	Sep 17, 2020 10:36	5609117	471619	Black Cottonwood	6	Herb 1	4	30
					Douglas Fir	10	Herb 2	4	60
					Falsebox	6			
					Red Raspberry	1			
					Western Red Cedar	3			
						26			
	V	Sep 17, 2020 09:27	5608844	471656	Black Cottonwood	27		0	0
					Douglas Fir	3			
					Falsebox	3			
					Lodgepole Pine	11			
					Red Raspberry	1			
						45			
	W	Sep 17, 2020 09:38	5608900	471580	Black Cottonwood	1	Herb 1	1	3
					Douglas Fir	11	Herb 2	7	65
					Falsebox	8			
						20			
	X	Sep 17, 2020 09:49	5608927	471653	Black Cottonwood	10	Shrub 2	2	30
					Douglas Fir	6			
					Falsebox	7			
					Lodgepole Pine	5			
						28			
	Y	Sep 17, 2020 10:08	5609039	471655	Birch Leaf Spirea	1	Herb 1	3	15
					Black Cottonwood	4	Herb 2	6	50
					Douglas Fir	9	Tree 1	1	25
					Falsebox	2			
					Lodgepole Pine	7			
					Ponderosa Pine	1			
					Red Raspberry	5			
					Thimbleberry	1			
						30			
	Z	Sep 17, 2020 10:25	5609000	471582	Black Cottonwood	9	Herb 1	1	30
					Douglas Fir	8	Tree 1	3	35
					Ponderosa Pine	1			
					Saskatoon	1			
						19			
						168			
Upper Spoil #5	F1	Sep 17, 2020 12:44	5611439	468547	Amabalis Fir	1	Herb 1	5	7
					Black Cottonwood	4	Herb 2	5	40
					Douglas Fir	1	Tree 1	1	13
					Red Raspberry	118			
					Sitka Alder	1			
					Spruce	3			
						128			
						128			

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2020)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
Upper Spoil #7	T	Sep 15, 2020 14:32	5612207	468544	Amabalis Fir	4	Herb 2	1	45
					Black Cottonwood	144	Shrub 2	4	30
					Douglas Fir	6	Tree 2	4	40
					Red Osier Dogwood	1			
					Red Raspberry	32			
					Salix	7			
					Sitka Alder	1			
					Thimbleberry	1			
						196			
						196			
						1391			

Transmission Line Surveys

53.1/56.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 53.1/56.1
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	3,000	47
Thimbleberry	2,200	34
Red Raspberry	800	13
Red Osier Dogwood	200	3
Willow	200	3
Summary:	***6,400***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	90	70	53.7	43.3
Herb 2	68	20		
Tree 2	3	40		

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

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

73.1 Road

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: 73.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 1

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	TS (SPH)	TS %
Thimbleberry	16,000	47
Red Raspberry	10,000	30
Black Cottonwood	5,800	17
Falsebox	1,200	4
Douglas Fir	400	1
Willow	400	1
Summary:	***33,800***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	3	10	7	40
Herb 2	16	80		
Shrub 1	8	50		
Shrub 2	7	45		
Tree 1	1	17		

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

Transmission Line Surveys

129.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 129.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Lodgepole Pine	1,600	40
Falsebox	1,000	25
Kinnickinnick	800	20
Black Cottonwood	400	10
Ceanothus	200	5
Summary:	***4,000***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	60	15	33.0	25.0
Herb 2	6	35		

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

Transmission Line Surveys

130.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 130.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 2

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	TS (SPH)	TS %
Lodgepole Pine	3,200	39
Kinnickinnick	2,000	24
Falsebox	1,400	17
Douglas Fir	600	7
Black Cottonwood	400	5
Willow	400	5
Blackcap Raspberry	200	2
Summary:	***8,200***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	22	15	51.0	17.5
Herb 2	80	20		

Pest / Disease	Host Species	Dead Trees (SPH)	Live Trees (SPH)	% Total Affected	% Conifers Affected	% Host Trees Affected
DSG Western Gall Rust	PLC	200	200	5	200	-

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

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Transmission Line Surveys

133.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 133.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet:
Net Area:

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Lodgepole Pine	800	36
Douglas Fir	400	18
Red Raspberry	400	18
Bitter Cherry	200	9
Black Cottonwood	200	9
Falsebox	200	9
Summary:	***2,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	100	25	82.5	22.5
Herb 2	65	20		

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

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Transmission Line Surveys

140.1 Road

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	140.1 Road	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 18, 2020
Mapsheet:		**Field Finish:**	Oct 19, 2020
Net Area:		**# of plots:**	1

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Alder	27,800	72
Black Cottonwood	6,200	16
Western Red Cedar	2,000	5
Thimbleberry	1,600	4
Paper Birch	400	1
Red Osier Dogwood	200	1
Red Raspberry	200	1
Willow	200	1
Summary:	***38,600***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Tree 1	100	270	100.0	260.0
Tree 2	100	250		

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

Transmission Line Surveys

237.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 237.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Thimbleberry	14,000	38
Black Cottonwood	10,800	29
Douglas Fir	8,800	24
Willow	1,600	4
Falsebox	600	2
High Brush Cranberry	400	1
Red Alder	400	1
Bigleaf Maple	200	1
Summary:	***36,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	5	15	22	51
Herb 2	65	60		
Shrub 1	55	45		
Shrub 2	4	50		
Tree 1	1	35		
Tree 2	3	100		

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

Hedberg Associates
Natural Resource Management

Transmission Line Surveys

238.1 Road

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: 238.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	TS (SPH)	TS %
Douglas Fir	14,000	51
Falsebox	5,200	19
Thimbleberry	4,800	18
Ceanothus	2,000	7
Blackcap Raspberry	800	3
Douglas Spirea	400	1
Black Cottonwood	200	1
Summary:	***27,400***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	35	25	21	22
Herb 2	80	35		
Shrub 1	5	25		
Shrub 2	3	25		
Tree 1	1	9		
Tree 2	1	10		

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

Affix Professional Seal Here

Transmission Line Surveys
239.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 239.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	TS (SPH)	TS %
Black Cottonwood	400	50
Thimbleberry	400	50
Summary:	***800***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	85	40	85.0	40.0
Herb 2	85	40		

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

Transmission Line Surveys

245.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 245.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Douglas Fir	8,200	31
Blackcap Raspberry	5,800	22
Thimbleberry	3,400	13
Ceanothus	2,600	10
Falsebox	1,400	5
Trailing Blackberry	1,200	5
Black Cottonwood	1,000	4
High Brush Cranberry	600	2
Red Raspberry	600	2
Western Red Cedar	600	2
Douglas Spirea	400	2
Paper Birch	400	2
Summary:	***26,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	40	20	33	34
Herb 2	45	20		
Shrub 1	40	50		
Shrub 2	40	70		
Tree 1	1	10		

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

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys
245.1 Road

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: 245.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Douglas Fir	8,200	31
Blackcap Raspberry	5,800	22
Thimbleberry	3,400	13
Ceanothus	2,600	10
Falsebox	1,400	5
Trailing Blackberry	1,200	5
Black Cottonwood	1,000	4
High Brush Cranberry	600	2
Red Raspberry	600	2
Western Red Cedar	600	2
Douglas Spirea	400	2
Paper Birch	400	2
Summary:	***26,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	40	20	33	34
Herb 2	45	20		
Shrub 1	40	50		
Shrub 2	40	70		
Tree 1	1	10		

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

Transmission Line Surveys
247.1/249.1 Road

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT — INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: 247.1/249.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Thimbleberry	13,000	33
Falsebox	10,800	28
Red Raspberry	5,600	14
Blackcap Raspberry	4,600	12
Ceanothus	2,000	5
Douglas Fir	2,000	5
Bigleaf Maple	600	2
High Brush Cranberry	400	1
Birch leaf Spirea	200	1
Summary:	***39,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	50	45	64	50
Herb 2	50	30		
Shrub 1	90	60		
Shrub 2	65	65		

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

Transmission Line Surveys

250.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 250.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 5

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Douglas Fir	16,800	55
Thimbleberry	5,000	16
Black Cottonwood	3,600	12
Falsebox	2,600	8
Ceanothus	1,200	4
Blackcap Raspberry	1,000	3
High Brush Cranberry	200	1
Prince's Pine	200	1
Western Red Cedar	200	1
Summary:	***30,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	8	30	8.5	40.0
Herb 2	9	50		

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

Transmission Line Surveys
255.1 Road

Project Information

Project: Longterm Revegetation Monitoring
Site: 255.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: Map 6

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 18, 2020
Field Finish: Oct 19, 2020
# of plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Thimbleberry	8,600	24
Douglas Fir	8,000	23
Falsebox	5,400	15
Red Raspberry	3,400	10
Blackcap Raspberry	3,000	9
Trailing Blackberry	2,600	7
Western Red Cedar	1,200	3
Black Cottonwood	800	2
Ceanothus	600	2
Salmonberry	600	2
Willow	400	1
Paper Birch	200	1
Highbrush Cranberry	200	1
Western Hemlock	200	1
Summary:	***35,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	20	20	10	25
Herb 2	21	35		
Shrub 1	9	40		
Shrub 2	8	30		
Tree 1	1	10		
Tree 2	1	15		

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

Transmission Line Surveys
260.1 Road

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	260.1 Road	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 18, 2020
Mapsheet:	Map 6	**Field Finish:**	Oct 19, 2020
		# of plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*
Thimbleberry	8,400	74
Blackcap Raspberry	1,800	16
Bigleaf Maple	600	5
Saskatoon	400	4
Sitka Alder	200	2
Summary:	***11,400***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Avg % Cover*	*Avg Ht. (cm)*
Herb 1	55	40	37	51
Herb 2	70	50		
Shrub 1	5	50		
Shrub 2	17	65		

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

Transmission Line Surveys
Ryan Crossing

Project Information

Project: Longterm Revegetation Monitoring
Site: Ryan Crossing
Location: Upper Lillooet Hydro Project
Mapsheet: Map 6

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Jul 15, 2020
Field Finish: Oct 20, 2020
# of plots: 1

Inventory Information

Species	TS (SPH)	TS %
Thimbleberry	7,400	79
Western Red Cedar	1,000	11
Blackcap Raspberry	600	6
Red Osier Dogwood	400	4
Summary:	***9,400***	***100***

Veg / Brush	% Cover	Avg Ht. (cm)	Avg % Cover	Avg Ht. (cm)
Herb 1	12	25	13	31
Herb 2	11	20		
Shrub 1	13	40		
Shrub 2	16	40		

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

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

							Percent Cover of Quadrant Plots		
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
53.1/56.1	31	Sep 18, 2020 13:23	5604651	476007	Black Cottonwood	15	Herb 1	90	70
					Red Osier Dogwood	1	Herb 2	68	20
					Red Raspberry	4	Tree 2	3	40
					Thimbleberry	11			
					Willow	1			
						32			
						32			
73.1	30	Sep 18, 2020 13:47	5604016	477759	Black Cottonwood	29	Herb 1	3	10
					Douglas Fir	2	Herb 2	16	80
					Falsebox	6	Shrub 1	8	50
					Red Raspberry	50	Shrub 2	7	45
					Thimbleberry	80	Tree 1	1	17
					Willow	2			
						169			
						169			
129.1	29	Oct 19, 2020 14:07	5600841	486288	Black Cottonwood	2	Herb 1	60	15
					Ceanothus	1	Herb 2	6	35
					Falsebox	5			
					Kinnickinick	4			
					Lodgepole Pine	8			
						20			
						20			
130.1	28	Oct 19, 2020 13:50	5600806	486419	Black Cottonwood	2	Herb 1	22	15
					Blackcap Raspberry	1	Herb 2	80	20
					Douglas Fir	3			
					Falsebox	7			
					Kinnickinick	10			
					Lodgepole Pine	16			
					Willow	2			
						41			
						41			
133.1	27	Oct 19, 2020 13:29	5600673	486898	Bitter Cherry	1	Herb 1	100	25
					Black Cottonwood	1	Herb 2	65	20
					Douglas Fir	2			
					Falsebox	1			
					Lodgepole Pine	4			
					Red Raspberry	2			
						11			
						11			

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
140.1	35	Oct 19, 2020 11:06	5599221	487568	Black Cottonwood	31	Tree 1	100	270
					Paper Birch	2	Tree 2	100	250
					Red Alder	139			
					Red Osier Dogwood	1			
					Red Raspberry	1			
					Thimbleberry	8			
					Western Red Cedar	10			
					Willow	1			
						193			
						193			
163.1	35A	Oct 19, 2020 11:54	5597276	491657	Douglas Fir	5	Herb 1	19	14
					Falsebox	3	Herb 2	25	10
					Gooseberry	1	Shrub 1	12	40
					Pacific Dogwood	2	Shrub 2	21	35
					Paper Birch	15			
					Red Osier Dogwood	1			
					Red Raspberry	92			
					Saskatoon	1			
					Thimbleberry	27			
						147			
						147			
237.1	34	Sep 18, 2020 06:30	5590785	500653	Bigleaf Maple	1	Herb 1	5	15
					Black Cottonwood	54	Herb 2	65	60
					Douglas Fir	44	Shrub 1	55	45
					Falsebox	3	Shrub 2	4	50
					High Brush Cranberry	2	Tree 1	1	35
					Red Alder	2	Tree 2	3	100
					Thimbleberry	70			
					Willow	8			
						184			
						184			
238.1	33	Sep 18, 2020 07:46	5590639	500853	Black Cottonwood	1	Herb 1	35	25
					Blackcap Raspberry	4	Herb 2	80	35
					Ceanothus	10	Shrub 1	5	25
					Douglas Fir	70	Shrub 2	3	25
					Douglas Spirea	2	Tree 1	1	9
					Falsebox	26	Tree 2	1	10
					Thimbleberry	24			
						137			
						137			

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
239.1	32	Sep 18, 2020 06:27	5590571	501029	Black Cottonwood	2	Herb 1	85	40
					Thimbleberry	2	Herb 2	85	40
						4			
						4			
245.1	26	Sep 18, 2020 06:32	5589865	501981	Black Cottonwood	5	Herb 1	40	20
					Blackcap Raspberry	29	Herb 2	45	20
					Ceanothus	13	Shrub 1	40	50
					Douglas Fir	41	Shrub 2	40	70
					Douglas Spirea	2	Tree 1	1	10
					Falsebox	7			
					High Brush Cranberry	3			
					Paper Birch	2			
					Red Raspberry	3			
					Thimbleberry	17			
					Trailing Blackberry	6			
					Western Red Cedar	3			
						131			
						131			
247.1/249.1	25	Sep 18, 2020 06:38	5589674	502321	Bigleaf Maple	3	Herb 1	50	45
					Blackcap Raspberry	23	Herb 2	50	30
					Ceanothus	10	Shrub 1	90	60
					Douglas Fir	10	Shrub 2	65	65
					Douglas Spirea	1			
					Falsebox	54			
					High Brush Cranberry	2			
					Red Raspberry	28			
					Thimbleberry	65			
						196			
						196			
250.1	24	Oct 9, 2020 12:16	5589558	502458	Black Cottonwood	18	Herb 1	8	30
					Blackcap Raspberry	5	Herb 2	9	50
					Ceanothus	6			
					Douglas Fir	84			
					Falsebox	13			
					High Brush Cranberry	1			
					Prince's Pine	1			
					Thimbleberry	25			
					Western Red Cedar	1			
						154			
						154			

HEDBERG ASSOCIATES NATURAL RESOURCE MANAGEMENT

INNERGEX

Project: Longterm Revegetation Monitoring 2020 (Year 3)

Civl Work Sites (Plots established in 2018)

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Percent Cover of Quadrant Plots: Species	% Cover	Height (cm)
255.1	23	Sep 18, 2020 07:25	5588767	503270	Black Cottonwood	4	Herb 1	20	20
					Blackcap Raspberry	15	Herb 2	21	35
					Ceanothus	3	Shrub 1	9	40
					Douglas Fir	40	Shrub 2	8	30
					Falsebox	27	Tree 1	1	10
					Paper Birch	1	Tree 2	1	15
					Red Raspberry	17			
					Highbrush Cranberry	1			
					Salmonberry	3			
					Thimbleberry	43			
					Trailing Blackberry	13			
					Western Hemlock	1			
					Western Red Cedar	6			
					Willow	2			
						176			
						176			
260.1	21	Sep 18, 2020 07:31	5587958	503833	Bigleaf Maple	3	Herb 1	55	40
					Blackcap Raspberry	9	Herb 2	70	50
					Saskatoon	2	Shrub 1	5	50
					Sitka Alder	1	Shrub 2	17	65
					Thimbleberry	42			
						57			
						57			
Ryan Crossing	22	Sep 18, 2020 07:28	5587958	504319	Blackcap Raspberry	3	Herb 1	12	25
					Red Osier Dogwood	2	Herb 2	11	20
					Thimbleberry	37	Shrub 1	13	40
					Western Red Cedar	5	Shrub 2	16	40
						47			
						47			
						1699			

Appendix C. Representative Water Temperature and Air Temperature Site Photographs, 2021

LIST OF FIGURES

Figure 1. Looking upstream at ULL-USWQ03 on May 11, 2021 1

Figure 2. Looking downstream at ULL-USWQ03 on May 11, 2021. 1

Figure 3. Looking at ULL-USAT02 on May 11, 2021 2

Figure 4. Looking at ULL-USAT02 on May 11, 2021 2

Figure 5. Looking upstream at ULL-DVWQ01 on September 15, 2021. 3

Figure 6. Looking at the Tidbit location at ULL-DVWQ01 on May 11, 2021 3

Figure 7. Looking upstream at ULL-TAILWQ on May 11, 2021. 4

Figure 8. Looking RR to RL at ULL-TAILWQ on May 11, 2021. 4

Figure 9. Looking downstream at ULL-TAILWQ on October 21, 2021 5

Figure 10. Looking upstream at ULL-TAILWQ on October 21, 2021. 5

Figure 11. Looking upstream at ULL-DSWQ on May 11, 2021 6

Figure 12. Looking downstream at ULL-DSWQ on May 11, 2021. 6

Figure 13. Looking upstream at ULL-DSWQ on December 9, 2021. 7

Figure 14. Looking downstream at ULL-DSWQ on December 9, 2021. 7

Figure 15. Looking at ULL-DSAT on May 11, 2021 8

Figure 16. Looking at ULL-DSAT on September 15, 2021. 8

Figure 17. Looking upstream at BDR-USWQ2 on October 30, 2021 9

Figure 18. Looking downstream at BDR-USWQ2 on October 30, 2021. 9

Figure 19. Looking upstream at NTH-USWQ1 on October 30, 2021. 10

Figure 20. Looking downstream at NTH-USWQ1 on October 30, 2021 10

Figure 21. Looking upstream at BDR-DVWQ on October 22, 2021 11

Figure 22. Looking downstream at BDR-DVWQ on October 22, 2021. 11

Figure 23. Looking at Tidbit location at BDR-DVWQ on December 9, 2021. 12

Figure 24. Looking upstream at BDR-TAILWQ on May 11, 2021 12

Figure 25. Looking downstream at BDR-TAILWQ on May 11, 2021. 13

Figure 26. Looking upstream at BDR-TAILWQ on October 21, 2021. 13

Figure 27. Looking downstream at BDR-TAILWQ on October 21, 2021 14

Figure 28. Looking upstream at Tidbit 1 at BDR-DSWQ on May 11, 2021. 14

Figure 29. Looking downstream at BDR-DSWQ on May 11, 2021. 15
Figure 30. Looking upstream at Tidbit 1 at BDR-DSWQ on October 21, 2021. 15
Figure 31. Looking upstream at Tidbit 2 at BDR-DSWQ on October 21, 2021. 16

1. UPPER LILLOOET RIVER

Figure 1. Looking upstream at ULL-USWQ03 on May 11, 2021.

Figure 2. Looking downstream at ULL-USWQ03 on May 11, 2021.

Figure 3. Looking at ULL-USAT02 on May 11, 2021

Figure 4. Looking at ULL-USAT02 on May 11, 2021.

Figure 5. Looking upstream at ULL-DVWQ01 on September 15, 2021.

Figure 6. Looking at the Tidbit location at ULL-DVWQ01 on May 11, 2021.

Figure 7. Looking upstream at ULL-TAILWQ on May 11, 2021.

Figure 8. Looking RR to RL at ULL-TAILWQ on May 11, 2021.

Figure 9. Looking downstream at ULL-TAILWQ on October 21, 2021.

Figure 10. Looking upstream at ULL-TAILWQ on October 21, 2021.

Figure 11. Looking upstream at ULL-DSWQ on May 11, 2021.

Figure 12. Looking downstream at ULL-DSWQ on May 11, 2021.

Figure 13. Looking upstream at ULL-DSWQ on December 9, 2021.

Figure 14. Looking downstream at ULL-DSWQ on December 9, 2021.

Figure 15. Looking at ULL-DSAT on May 11, 2021.

Figure 16. Looking at ULL-DSAT on September 15, 2021.

2. BOULDER CREEK

Figure 17. Looking upstream at BDR-USWQ2 on October 30, 2021.

Figure 18. Looking downstream at BDR-USWQ2 on October 30, 2021.

Figure 19. Looking upstream at NTH-USWQ1 on October 30, 2021.

Figure 20. Looking downstream at NTH-USWQ1 on October 30, 2021.

Figure 21. Looking upstream at BDR-DVWQ on October 22, 2021.

Figure 22. Looking downstream at BDR-DVWQ on October 22, 2021.

Figure 23. Looking at Tidbit location at BDR-DVWQ on December 9, 2021.

Figure 24. Looking upstream at BDR-TAILWQ on May 11, 2021.

Figure 25. Looking downstream at BDR-TAILWQ on May 11, 2021.

Figure 26. Looking upstream at BDR-TAILWQ on October 21, 2021.

Figure 27. Looking downstream at BDR-TAILWQ on October 21, 2021.

Figure 28. Looking upstream at Tidbit 1 at BDR-DSWQ on May 11, 2021.

Figure 29. Looking downstream at BDR-DSWQ on May 11, 2021.

Figure 30. Looking upstream at Tidbit 1 at BDR-DSWQ on October 21, 2021.

Figure 31. Looking upstream at Tidbit 2 at BDR-DSWQ on October 21, 2021.

Appendix D. Water Temperature Guidelines and Data Summary

LIST OF FIGURES

Figure 1. Baseline water temperature at ULL-USWQ1 from 2008 to 2013. Black dots show water temperature at intervals of 15 minutes. 2

Figure 2. Operational water temperature at ULL-USWQ02 from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes. 5

Figure 3. Operational water temperature at ULL-USWQ03 from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 6

Figure 4. Baseline water temperature at ULL-DVWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes. 8

Figure 5. Operational water temperature at ULL-DVWQ01 from 2018 to 2020. Black dots show water temperature at intervals of 15 minutes. 10

Figure 6. Operational water temperature at ULL-TAILWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 11

Figure 7. Operational water temperature at ULL-DSWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 13

Figure 8. Baseline water temperature at NTH-USWQ1 from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes. 15

Figure 9. Operational water temperature at NTH-USWQ1 from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 17

Figure 10. Baseline water temperature at BDR-USWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes. 19

Figure 11. Operational water temperature at BDR-USWQ2 from 2019 to 2021. Black dots show water temperature at intervals of 15 minutes. 21

Figure 12. Baseline water temperature at BDR-DVWQ from 2008 to 2013. Black dots show water temperature at intervals of 15 minutes. 23

Figure 13. Operational water temperature at BDR-DVWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 26

Figure 14. Operational water temperature at BDR-TAILWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 28

Figure 15. Operational water temperature at BDR-DSWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes. 30

Figure 16. Baseline air temperature at ULL-USAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes. 32

Figure 17. Operational air temperature at ULL-USAT01 from 2018 to 2019. Black dots show air temperature at intervals of 15 minutes. 34

Figure 18. Operational air temperature at ULL-USAT02 from 2019 to 2021. Black dots show air temperature at intervals of 15 minutes. 35

Figure 19. Baseline air temperature at ULL-DVAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes. 36

Figure 20. Operational air temperature at ULL-DSAT from 2018 to 2021. Black dots show air temperature at intervals of 15 minutes. 38

Figure 21. Baseline air temperature at BDR-DVAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes. 40

Figure 22. Operational air temperature at BDR-DVAT from 2018 to 2021. Black dots show air temperature at intervals of 15 minutes. 42

Figure 23. Daily mean water temperature collected during baseline monitoring in the Upper Lillooet River (2008 to 2013)....51

Figure 24. Daily mean water temperature collected during baseline monitoring in Boulder Creek and North Creek (2008 to 2013)....51

Figure 25. 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. Positive values denote that impact sites were warmer than upstream sites and vice versa. 52

Figure 26. Cumulative frequency distribution of differences in baseline instantaneous water temperature between the upstream control site on Boulder Creek (BDR-USWQ) and the North Creek upstream site (NTH-USWQ1) and the Boulder Creek diversion site (BDR-DVWQ). Positive values denote that impact sites were warmer than upstream sites and vice versa....53

Figure 27. 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. 54

Figure 28. Baseline hourly rate of change in water temperature at the upstream site in nearby North Creek (NTH-USWQ1), and upstream (BDR-USWQ) and diversion (BDR-DVWQ) water temperature monitoring sites in Boulder Creek from 2008 to 2013. 55

LIST OF TABLES

Table 1. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001, MECCS 2021). 1

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. 45

Table 3. Baseline monthly summary statistics at the upstream (NTH-USWQ1) site in North Creek and upstream (BDR-USWQ) and diversion (BDR-DVWQ) sites in Boulder Creek from 2008 to 2013. 47

Table 4. Upper Lillooet River baseline (2010 to 2013) air temperature monthly data summary statistics. 49

Table 5. Boulder Creek baseline (2010 to 2013) air temperature monthly data summary statistics. 50

1. WATER TEMPERATURE GUIDELINES

Table 1. Water temperature guidelines for the protection of freshwater aquatic life (Oliver and Fidler 2001, MECCS 2021).

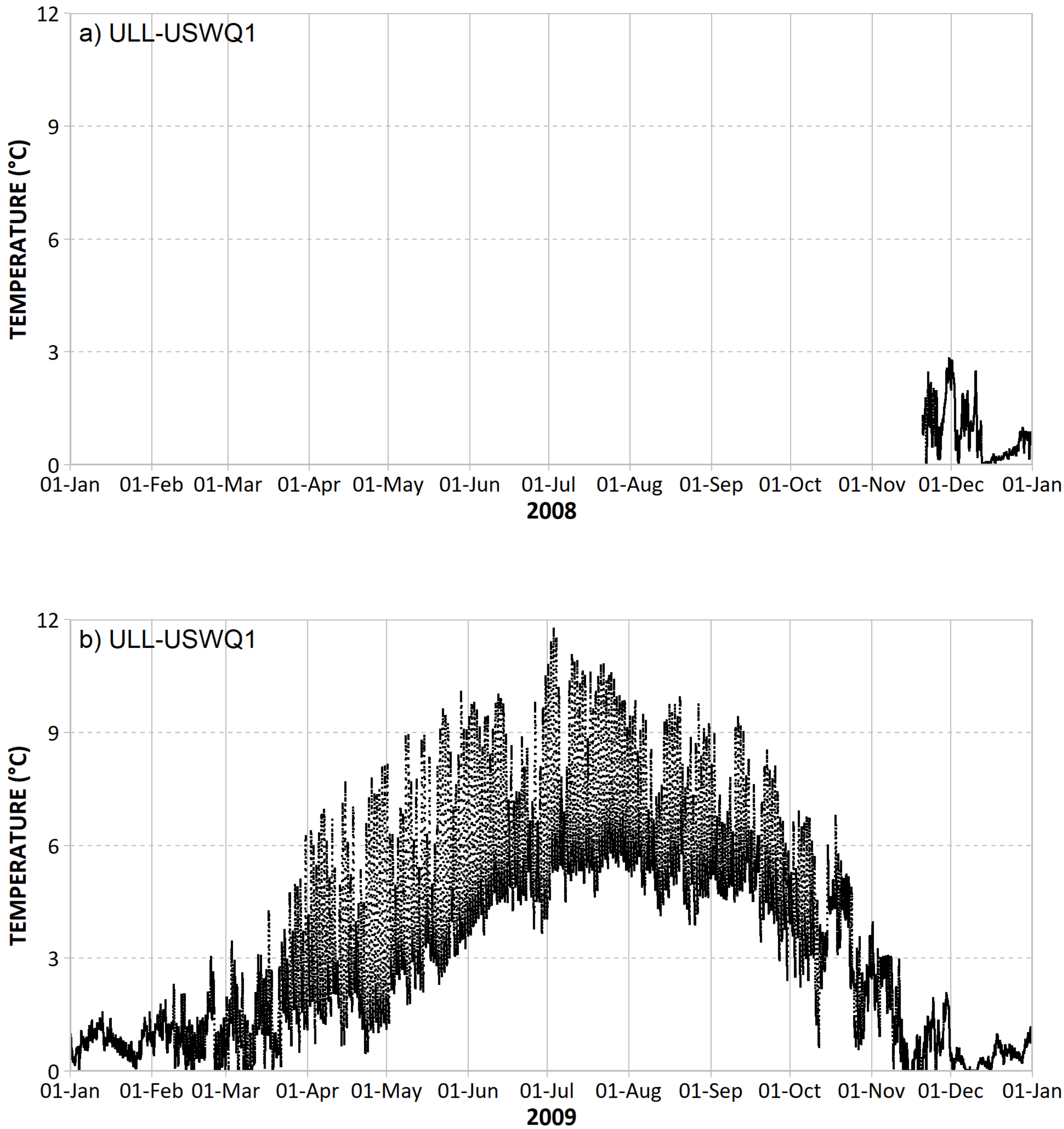
Category	Guideline[1]
All Streams	the rate of temperature change in natural water bodies not to exceed 1°C/hr
	temperature metrics to be described by the mean weekly maximum temperature (MWMxT)
Streams with Known Fish Presence	mean weekly maximum water temperatures should not exceed ±1°C beyond the optimum 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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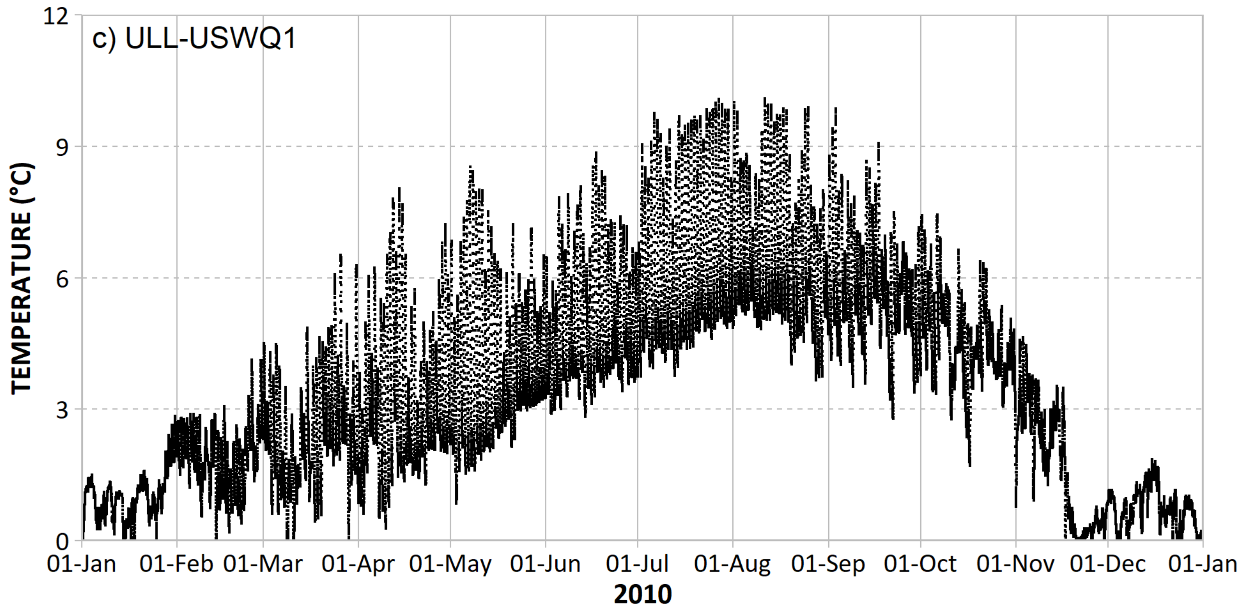


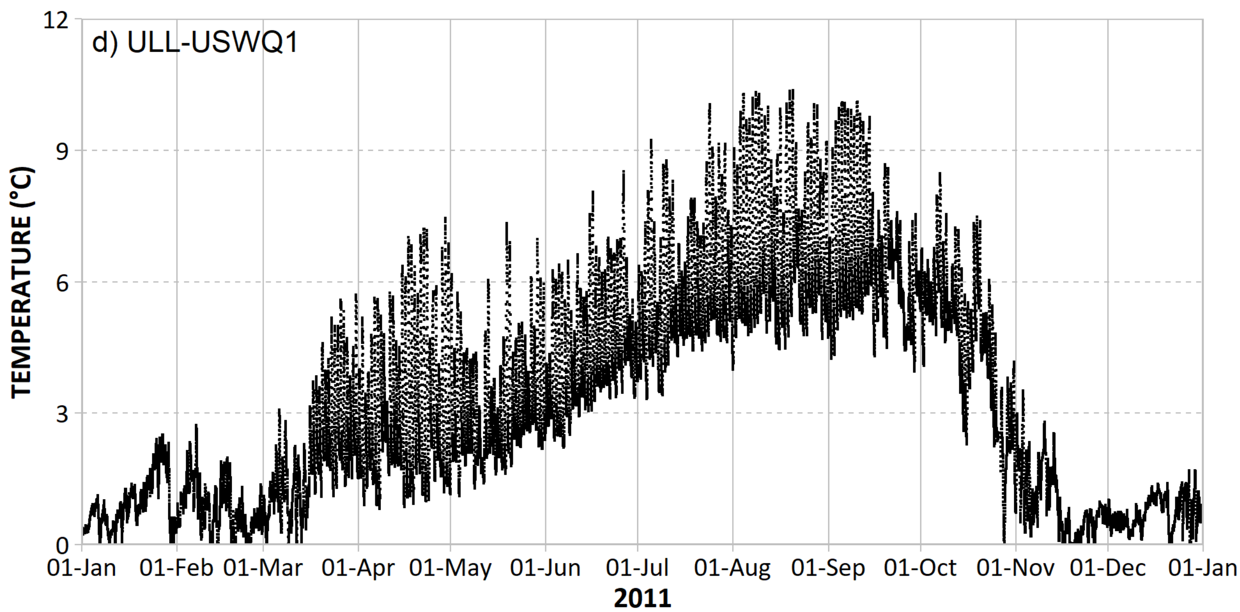
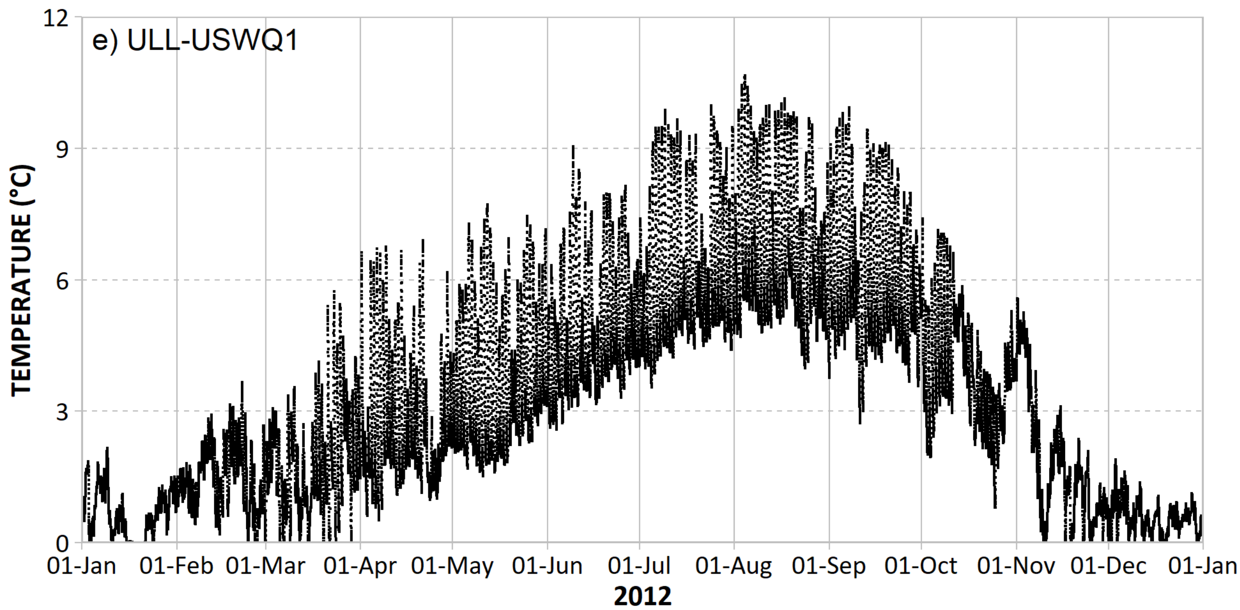


Figure 1. Continued.



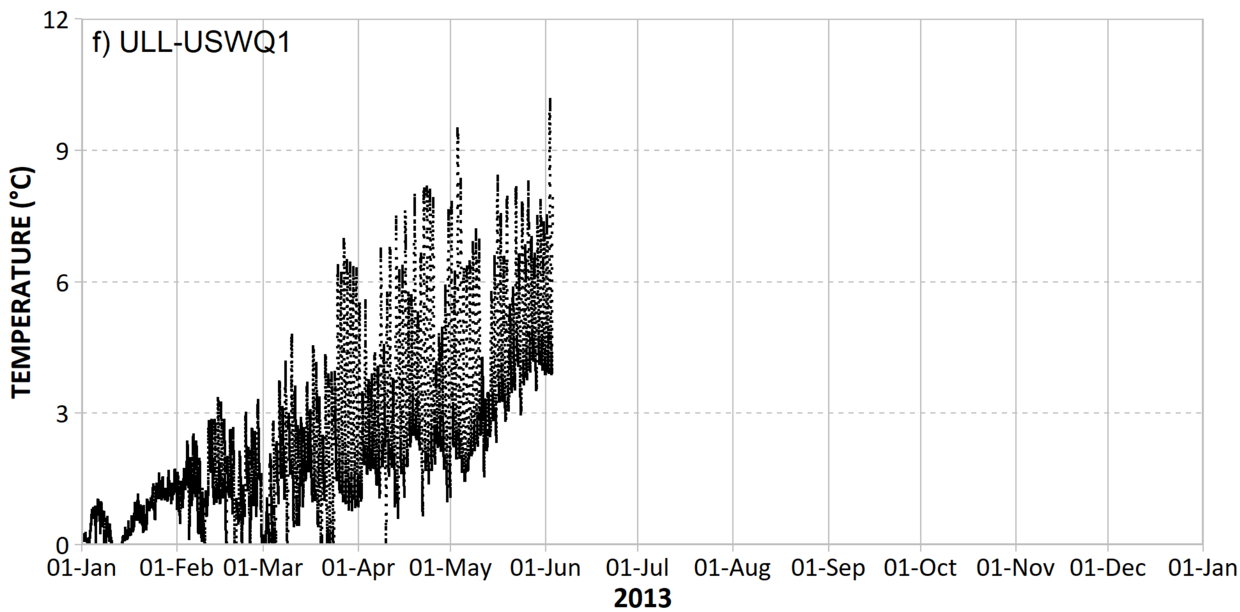


Figure 2. Operational water temperature at ULL-USWQ02 from 2018 to 2019. Black dots show water temperature at intervals of 15 minutes.

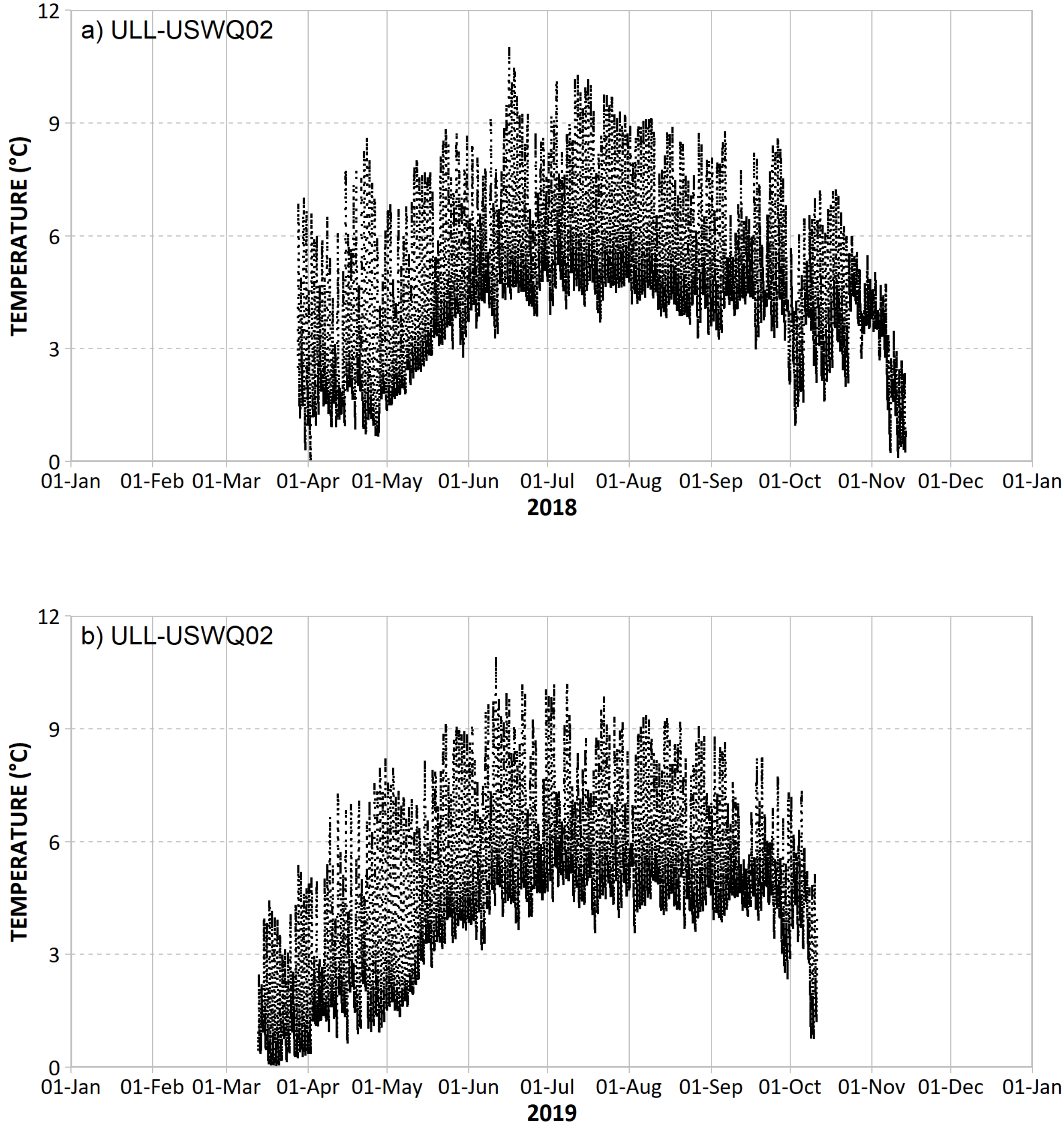
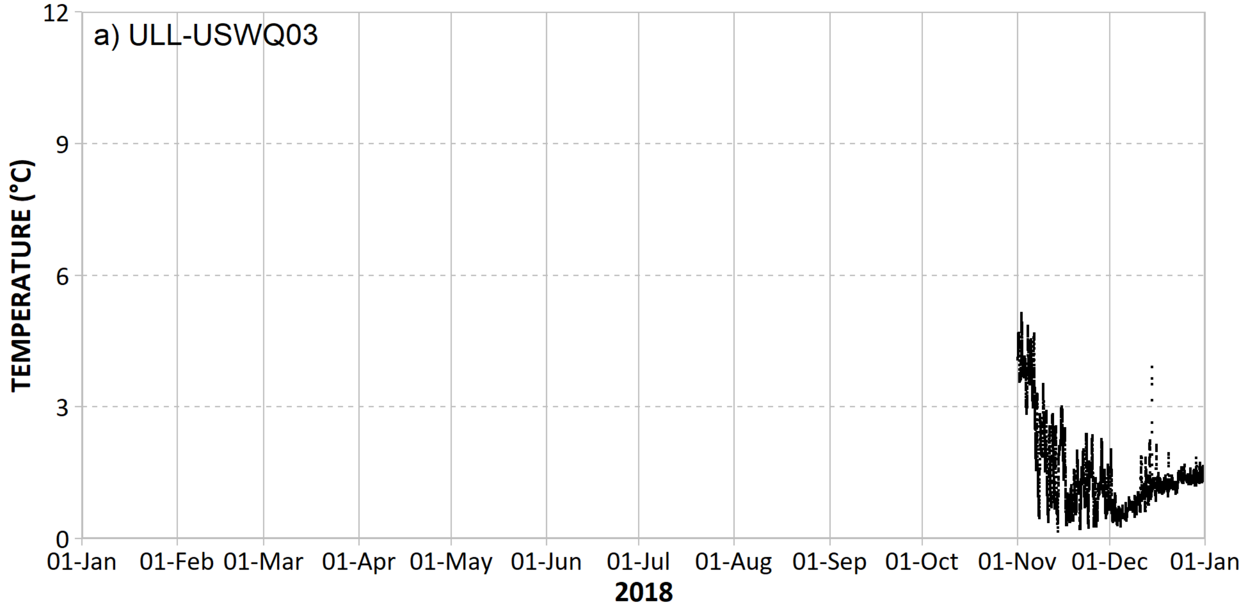
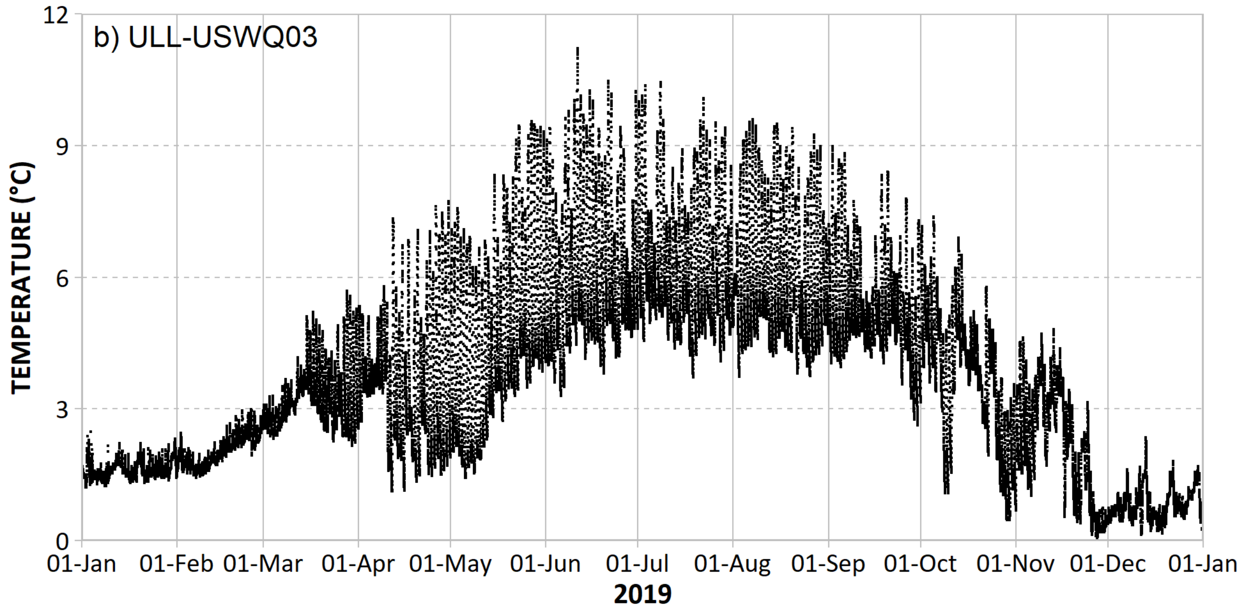


Figure 3. Operational water temperature at ULL-USWQ03 from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.





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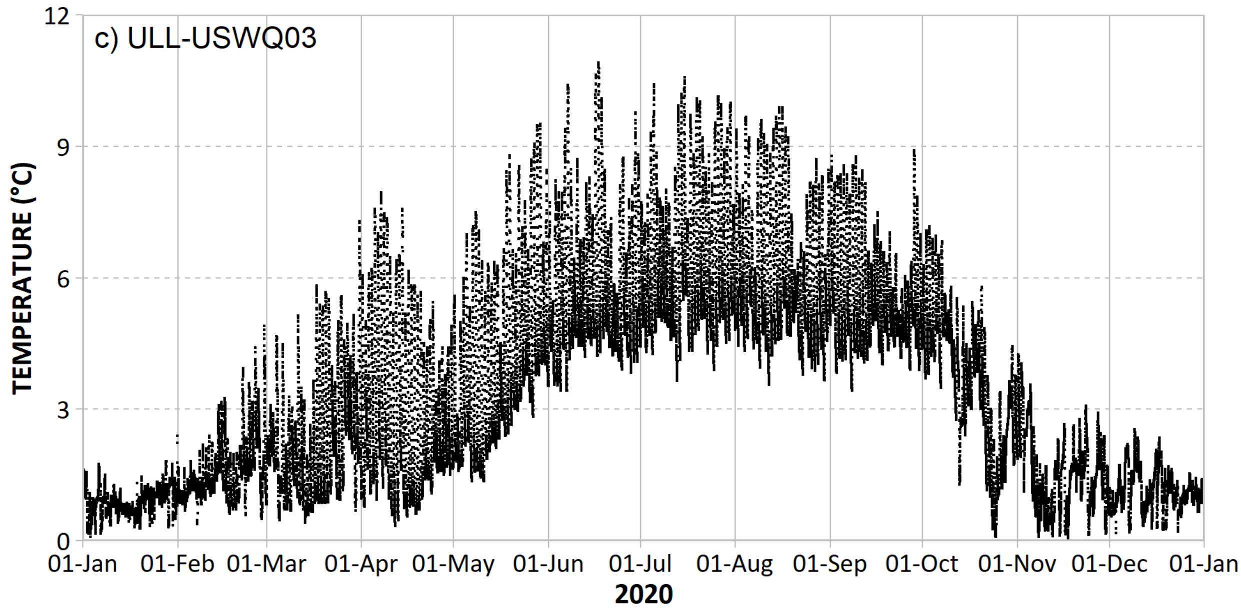


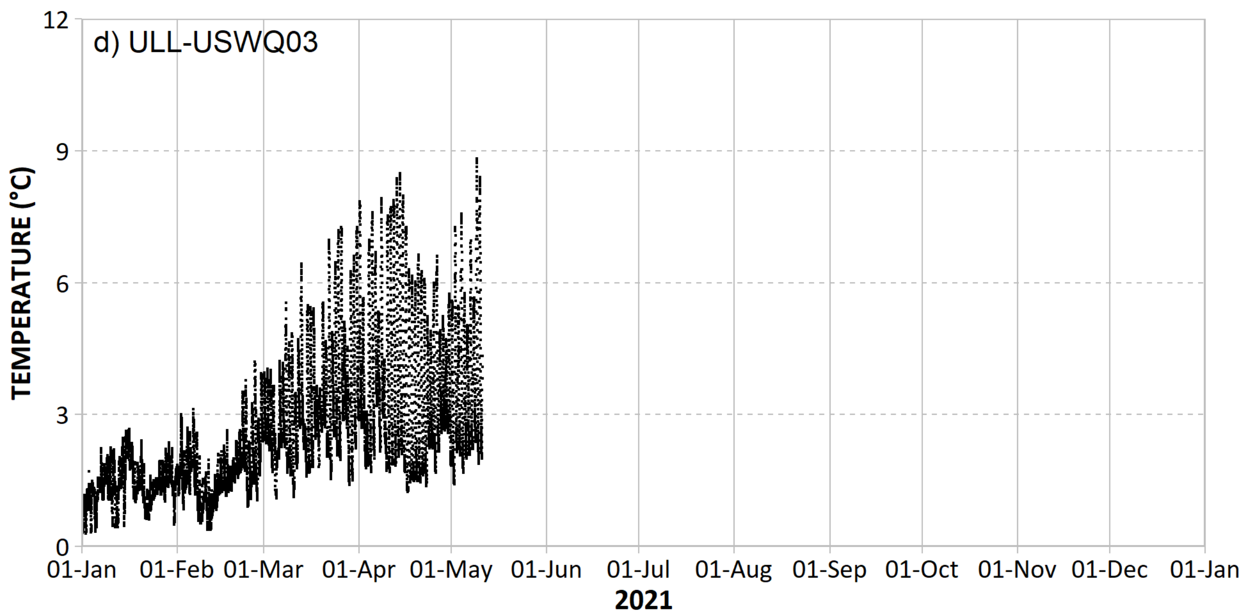
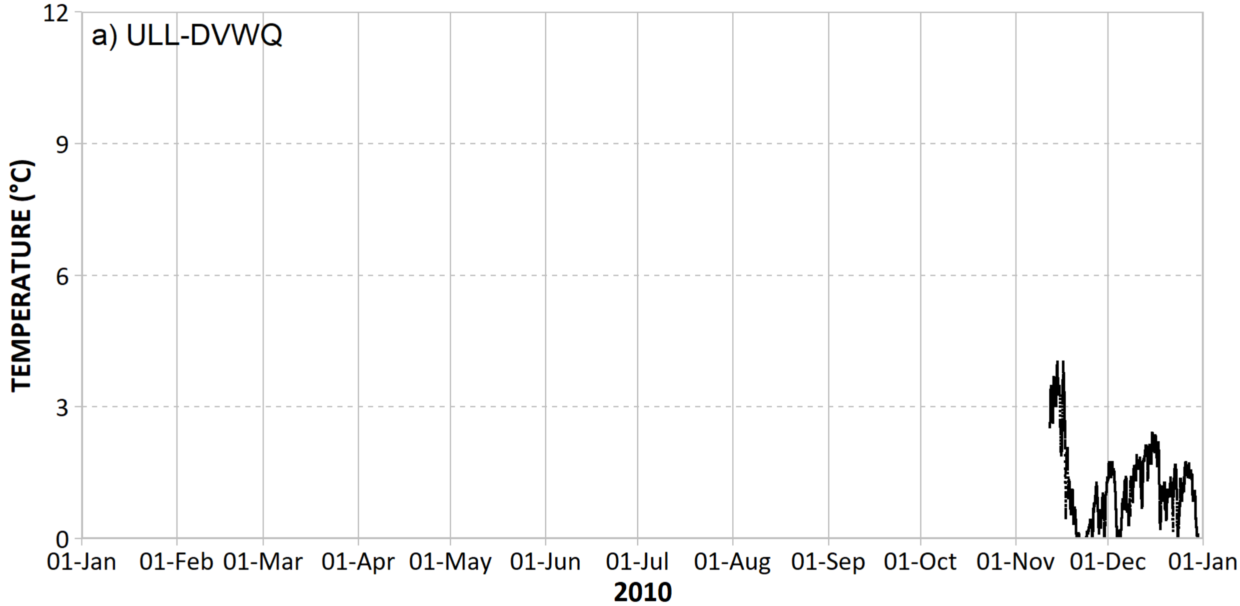
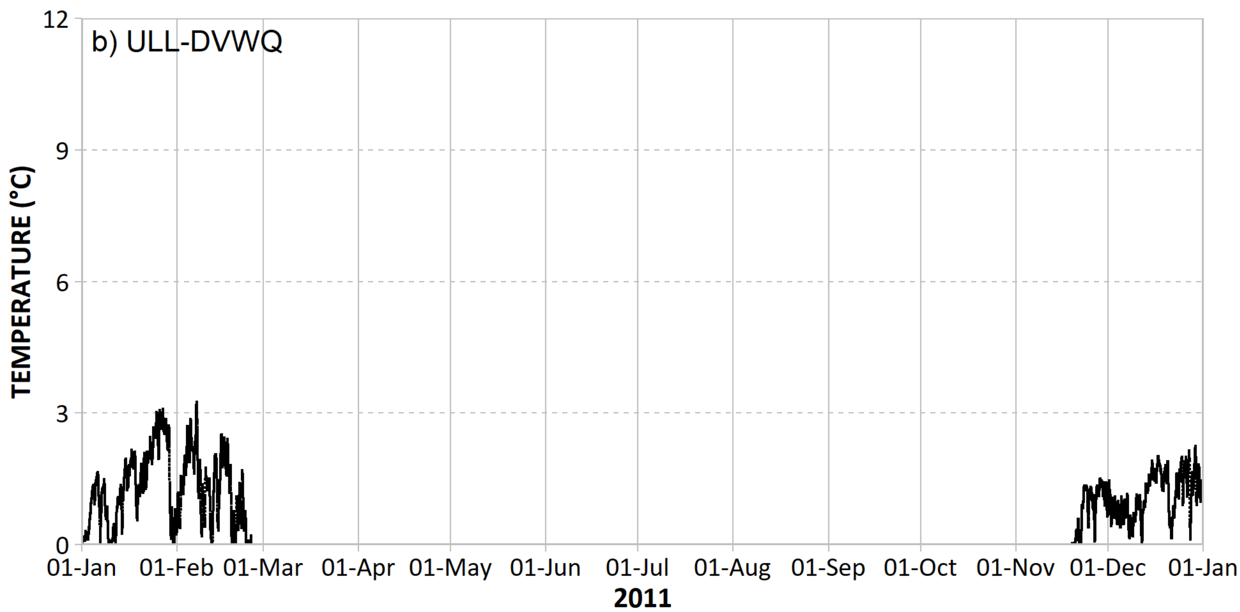


Figure 4. Baseline water temperature at ULL-DVWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.





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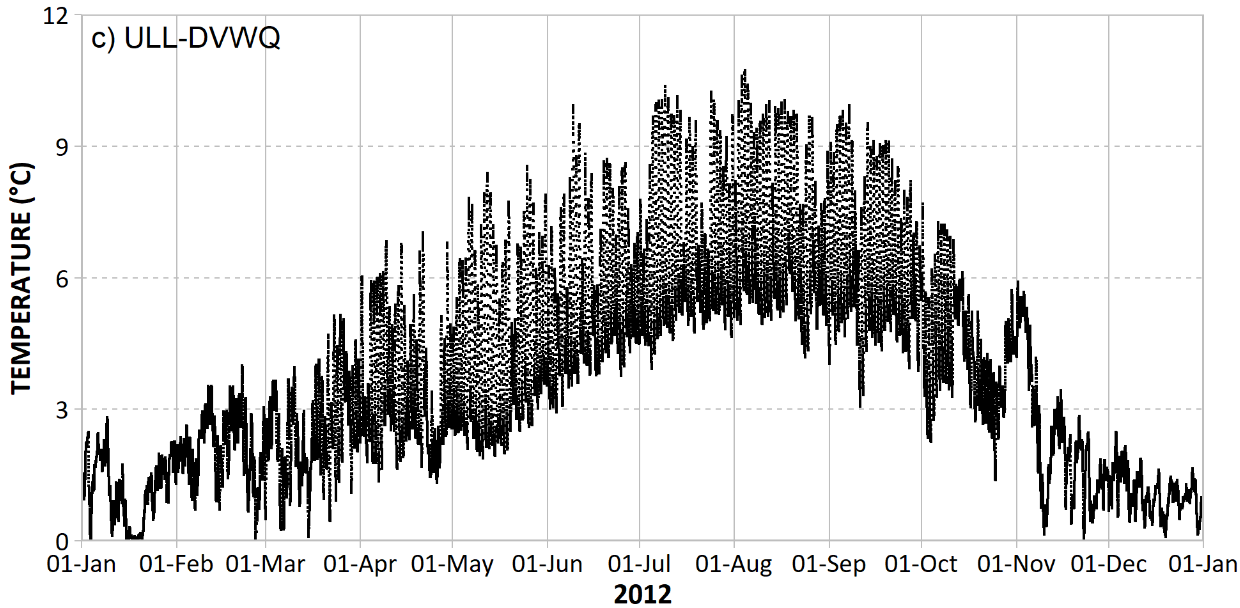


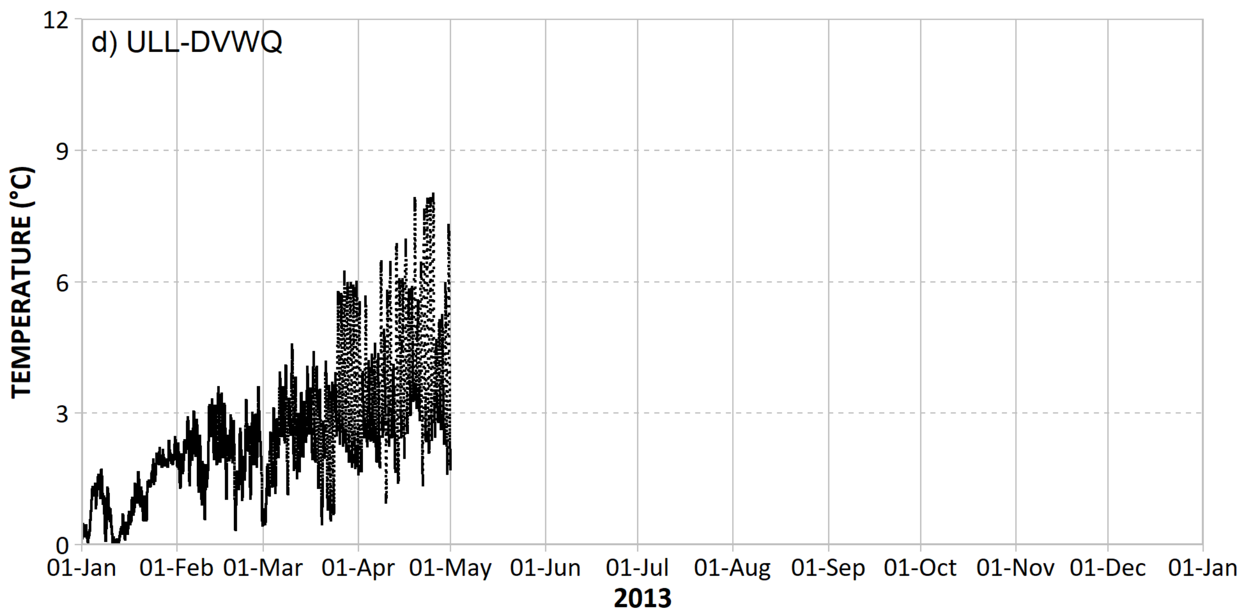


Figure 5. **Operational water temperature at ULL-DVWQ01 from 2018 to 2020. Black dots show water temperature at intervals of 15 minutes.**

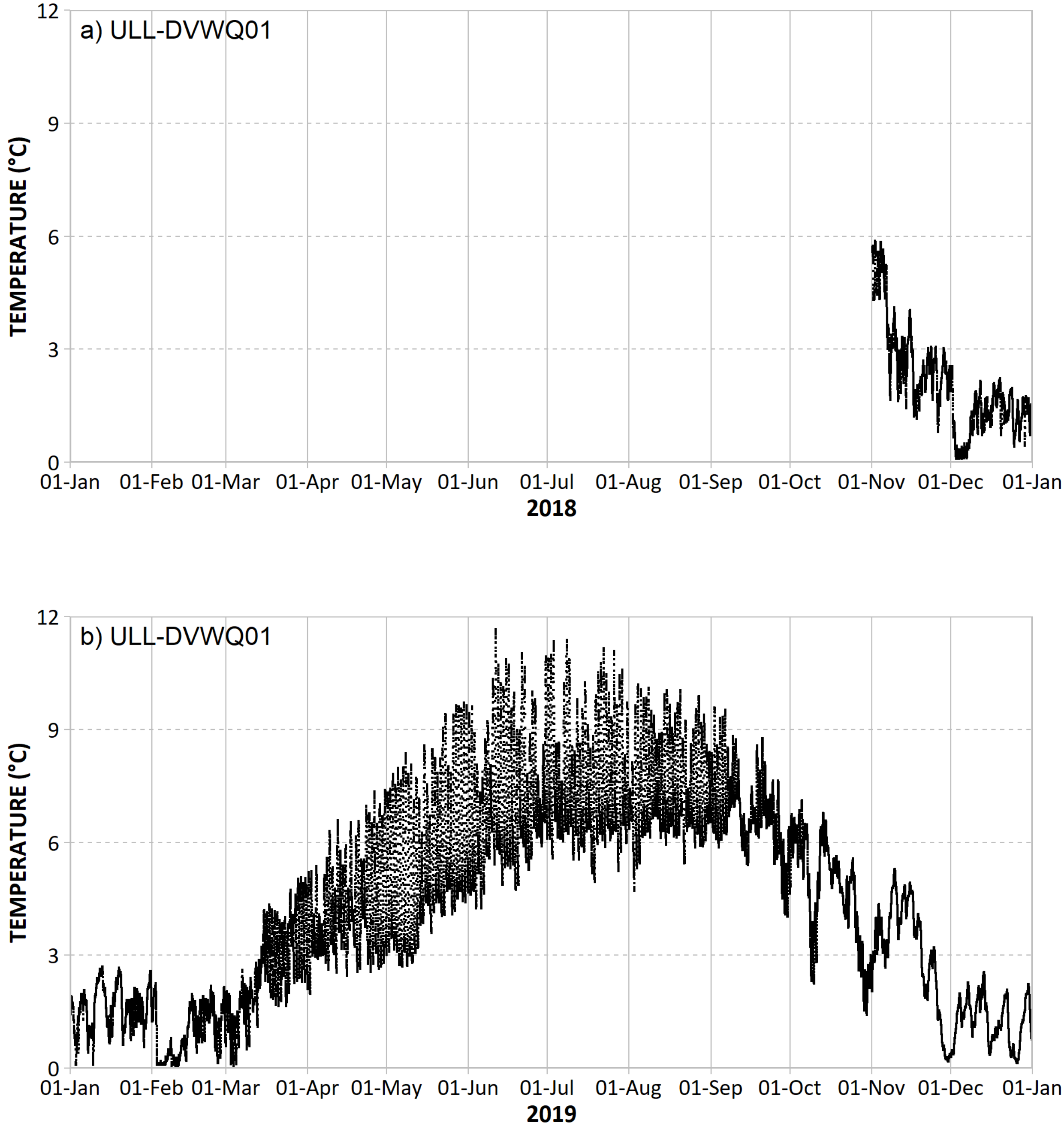


Figure 5. Continued.

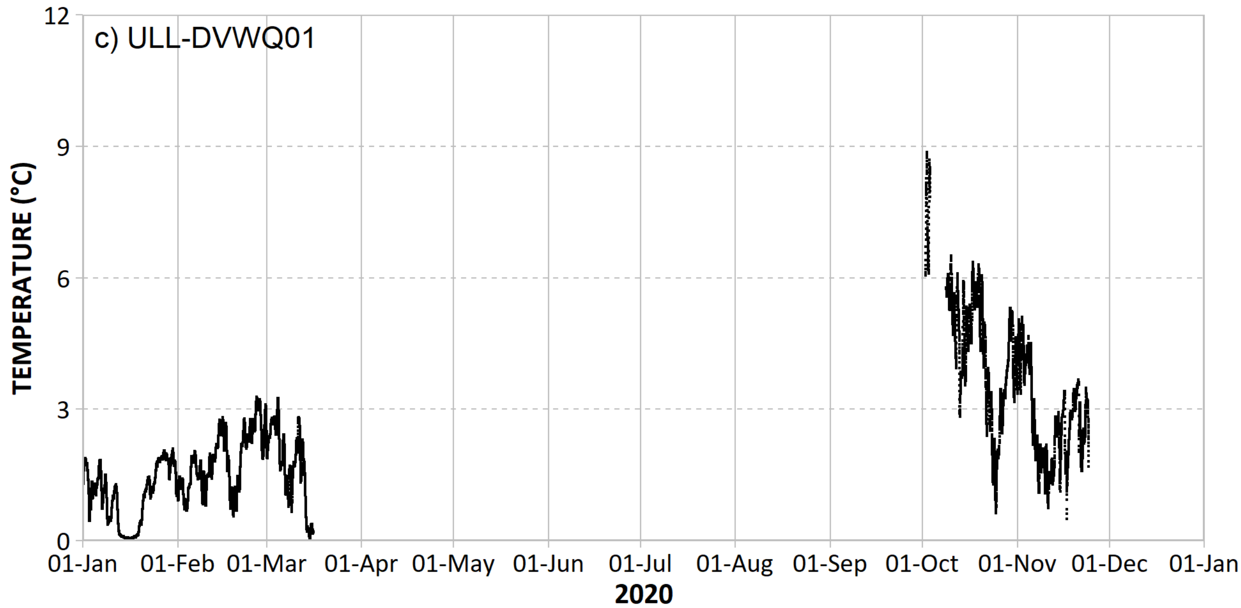
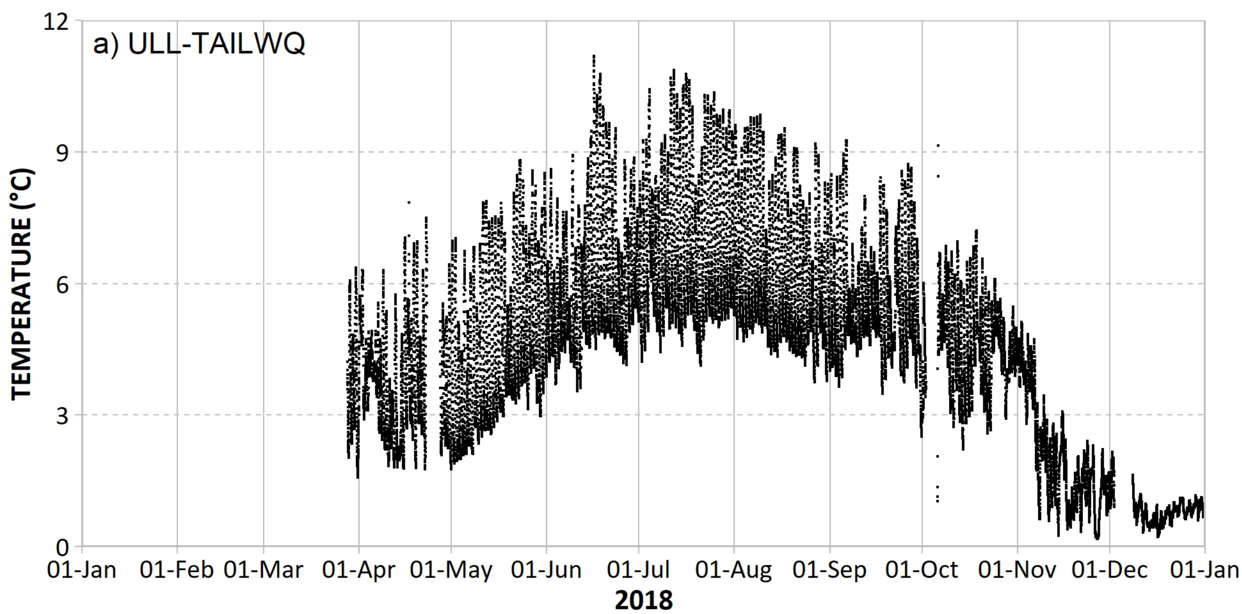


Figure 6. Operational water temperature at ULL-TAILWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.



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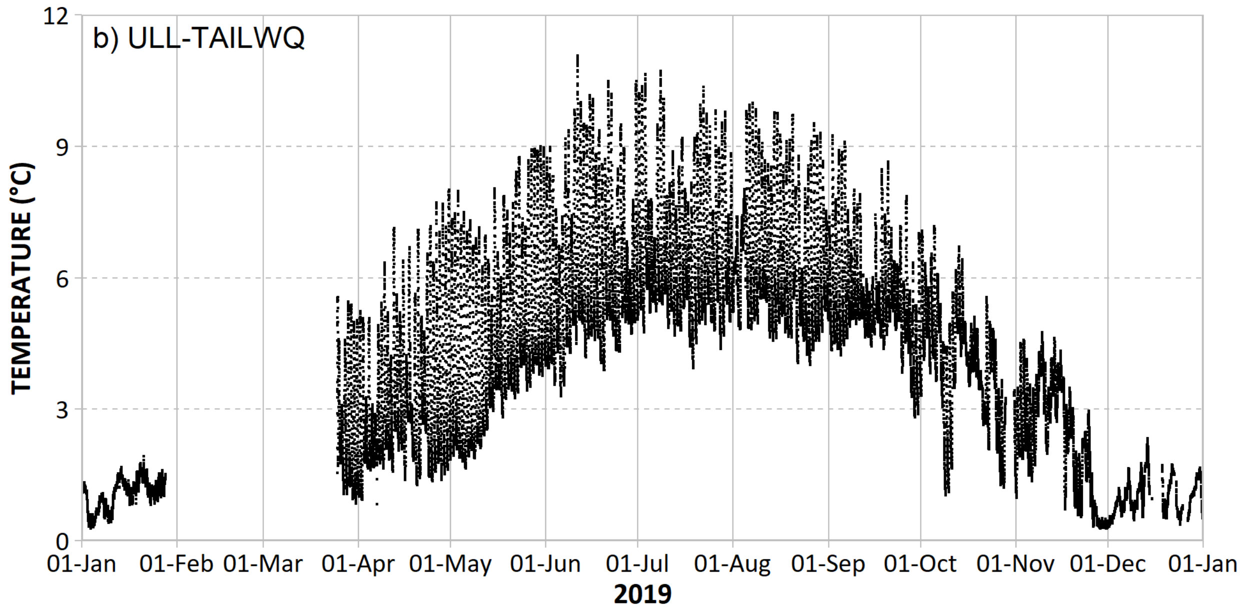

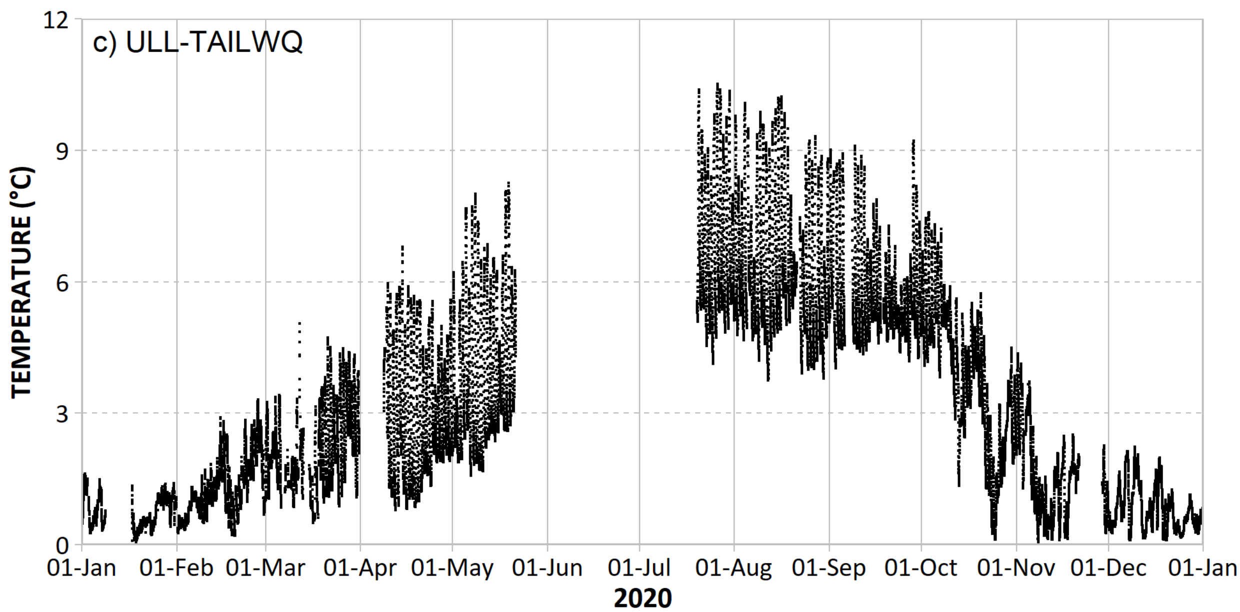

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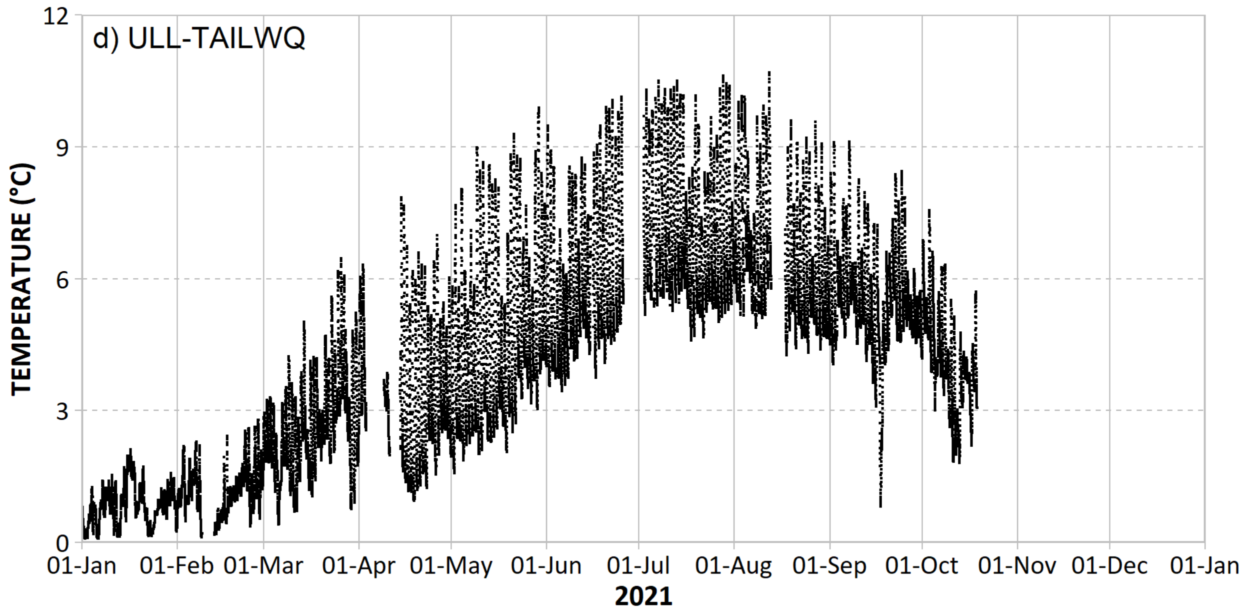
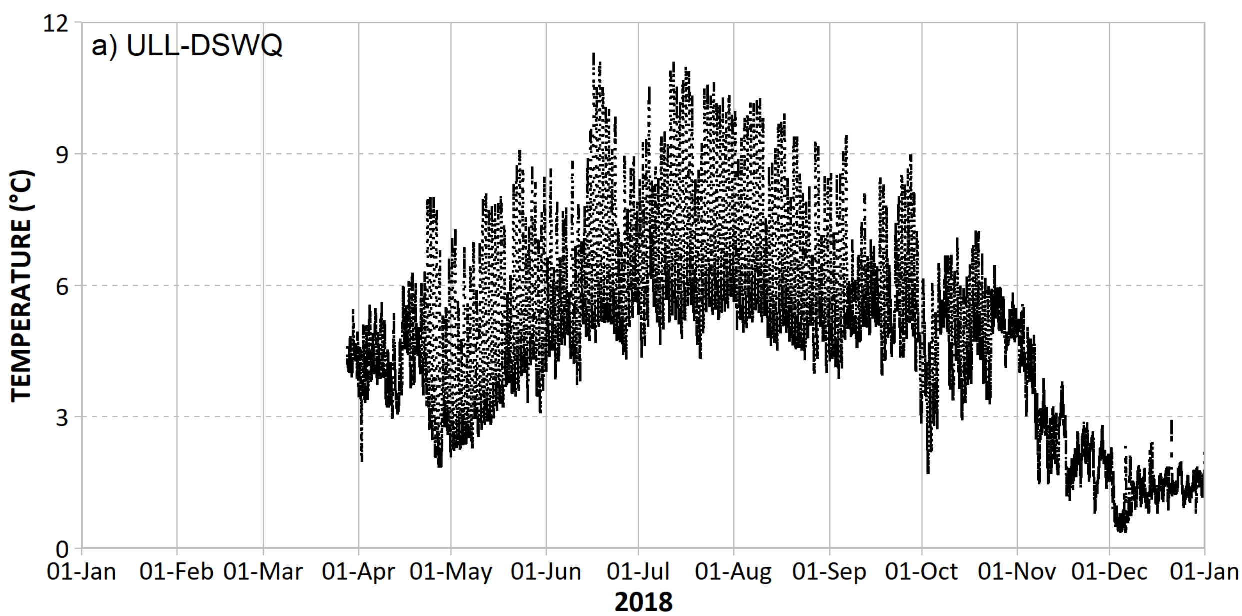


Figure 7. **Operational water temperature at ULL-DSWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.**



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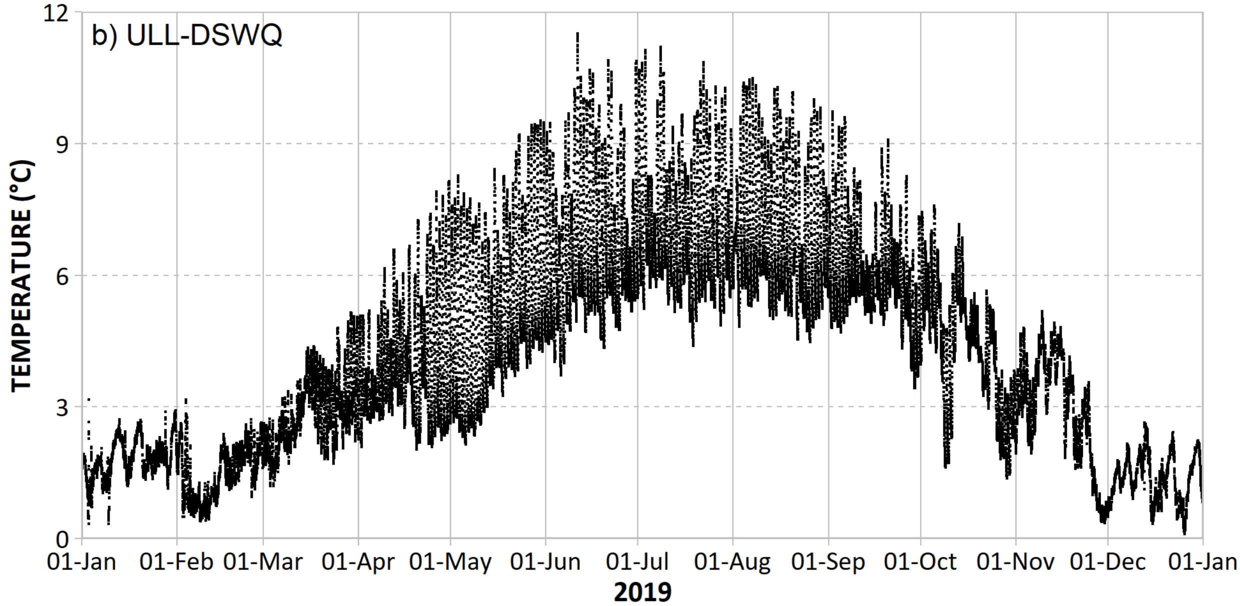

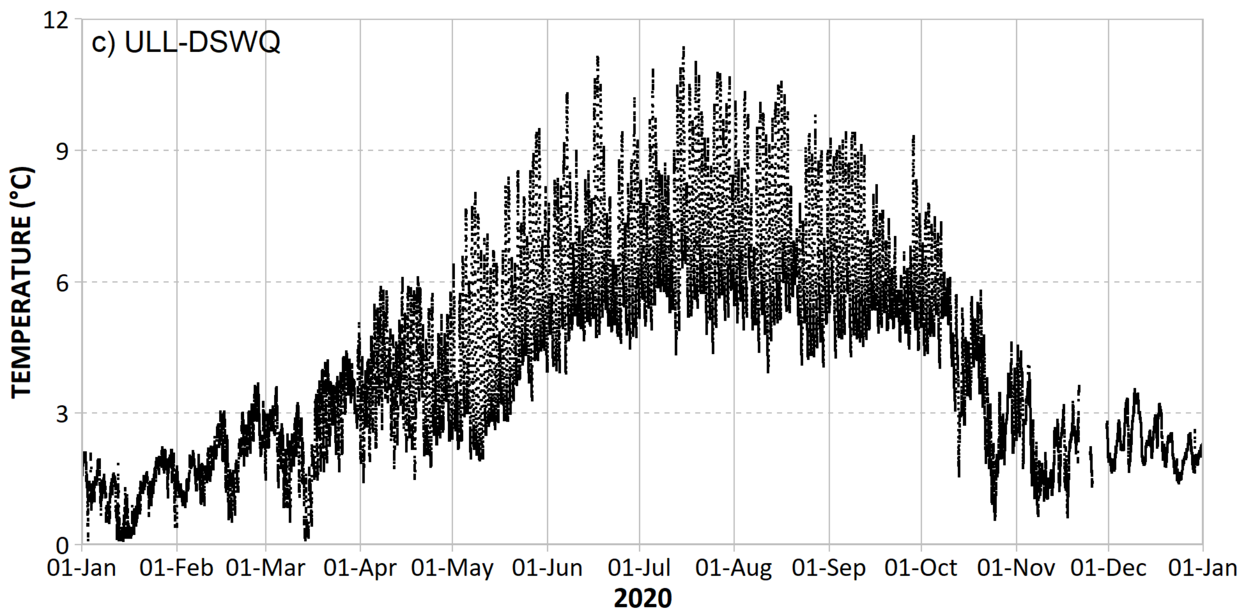

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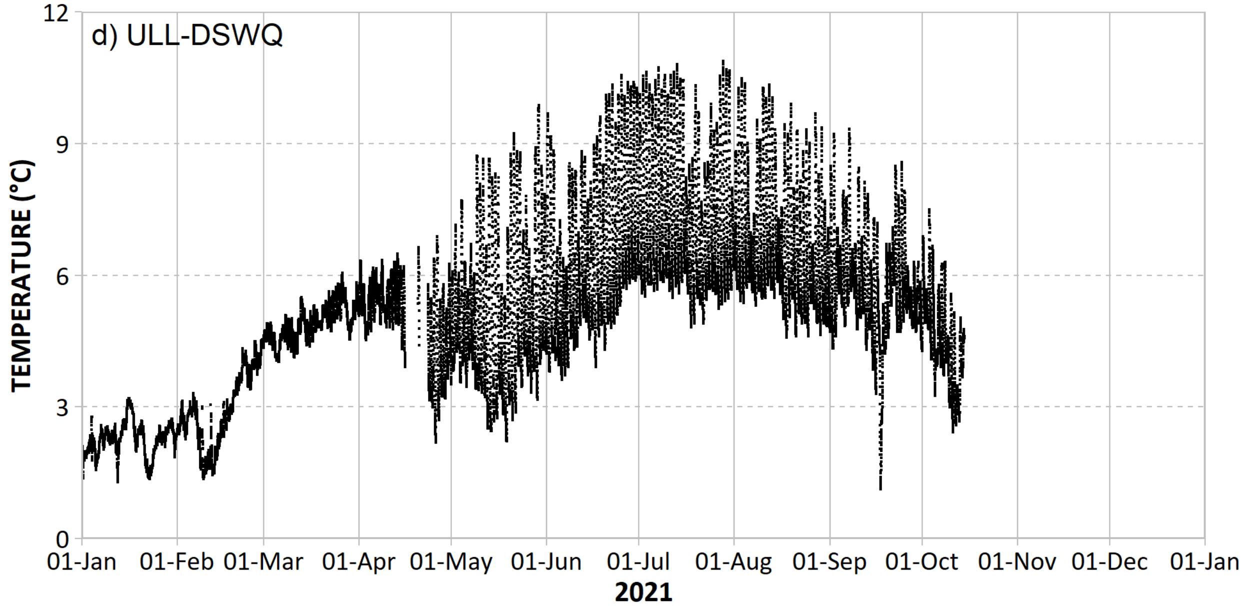
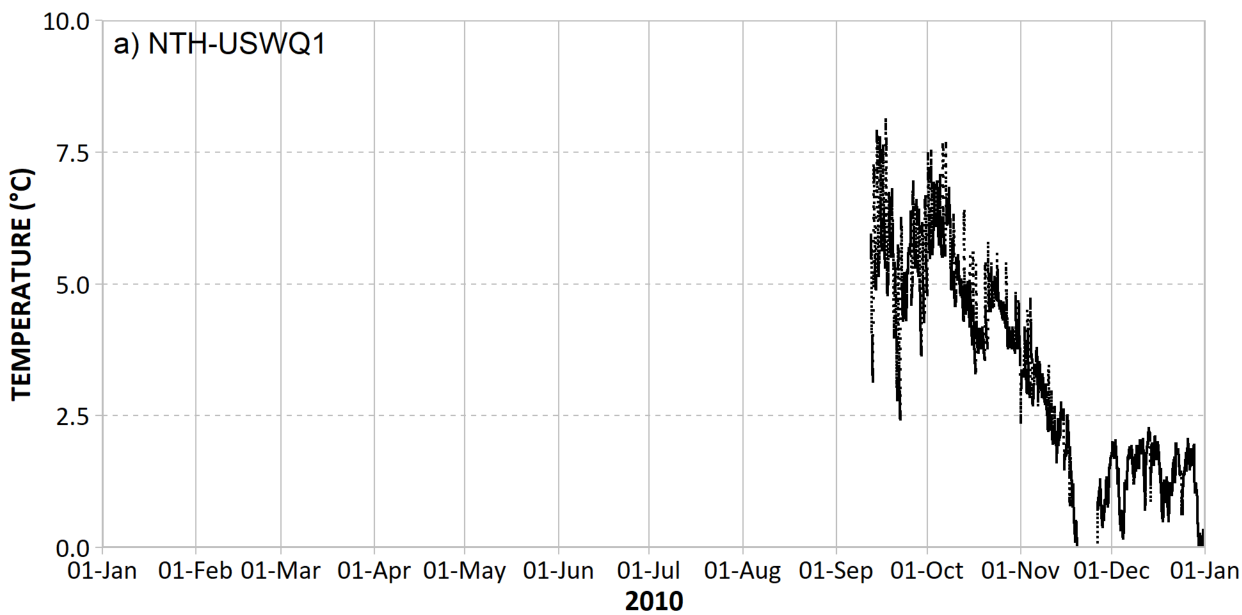


2.2. Boulder Creek

Figure 8. Baseline water temperature at NTH-USWQ1 from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.



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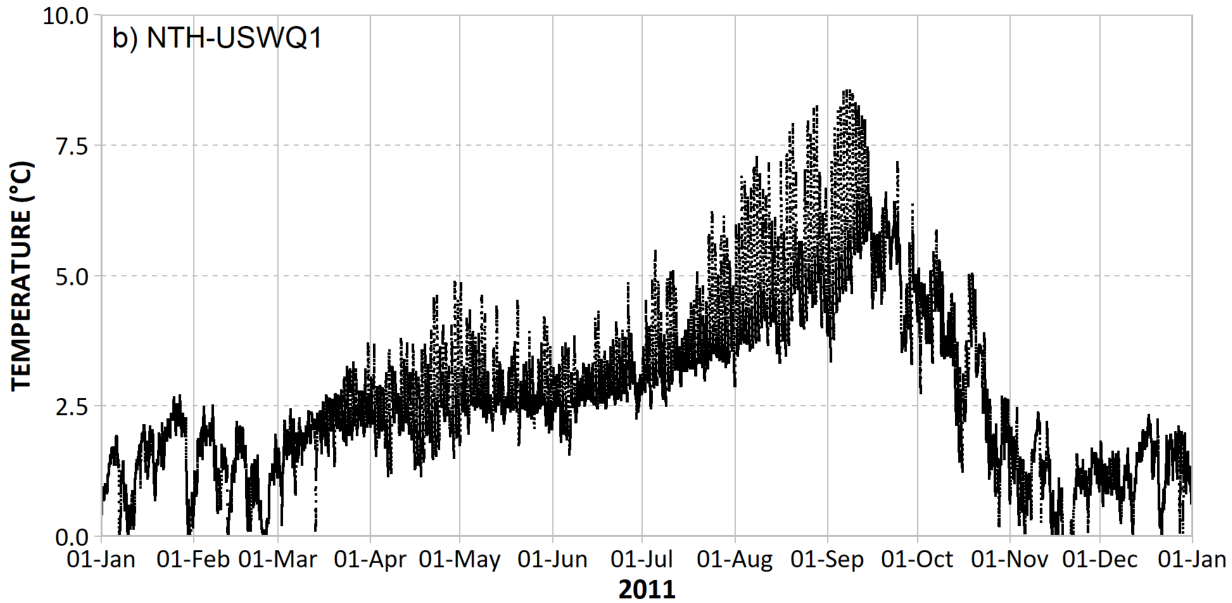

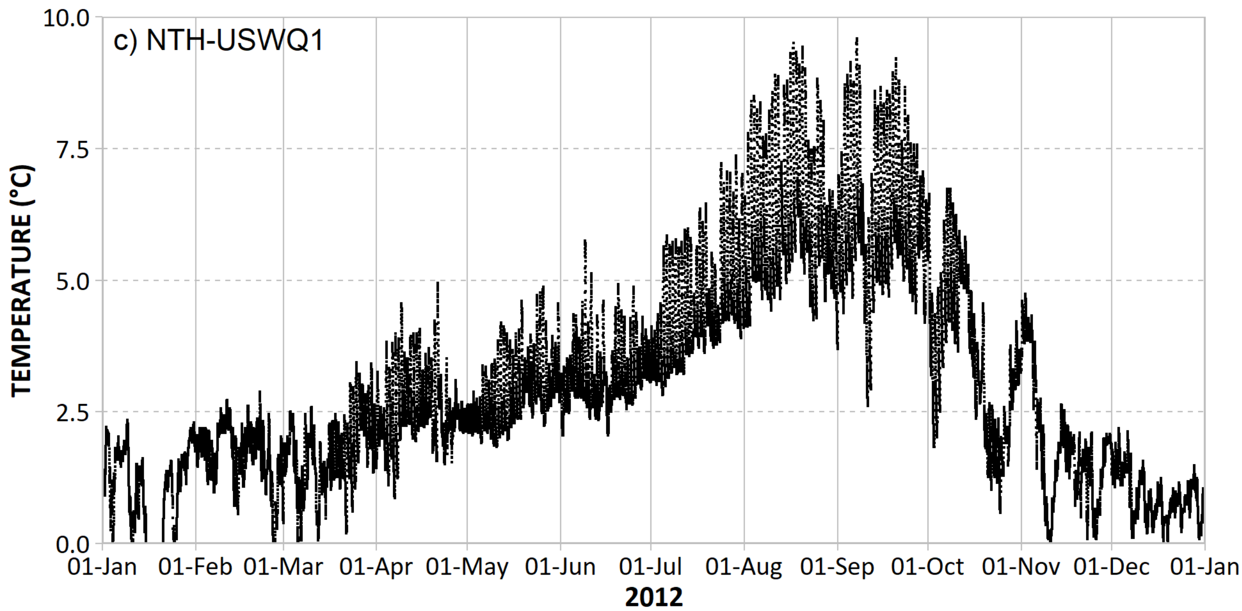

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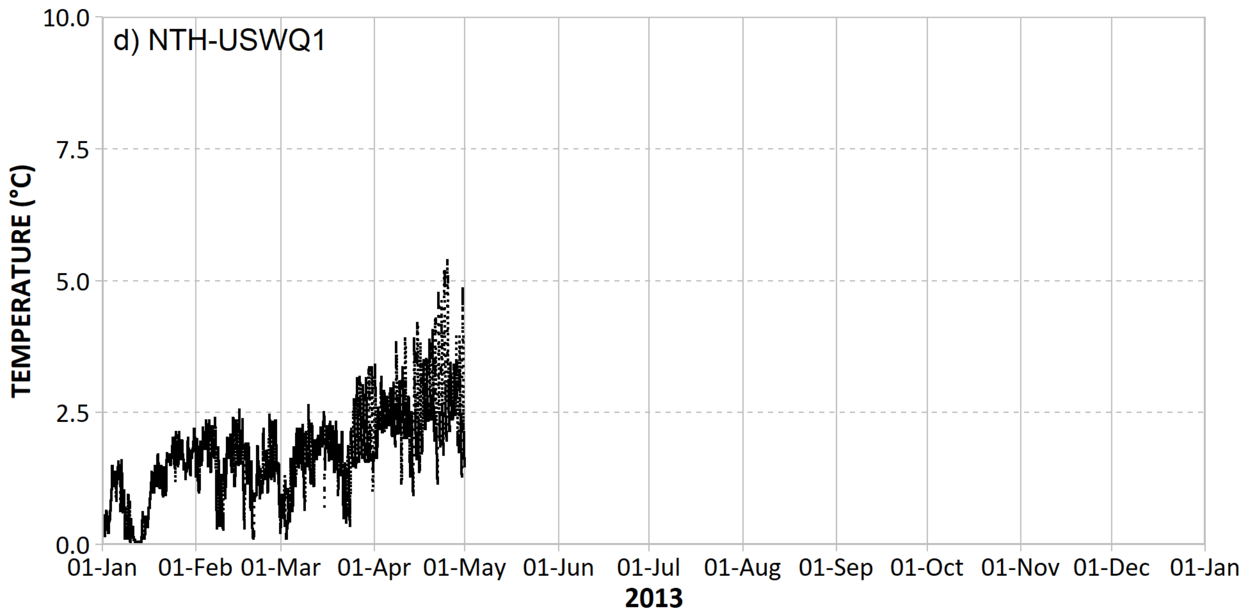
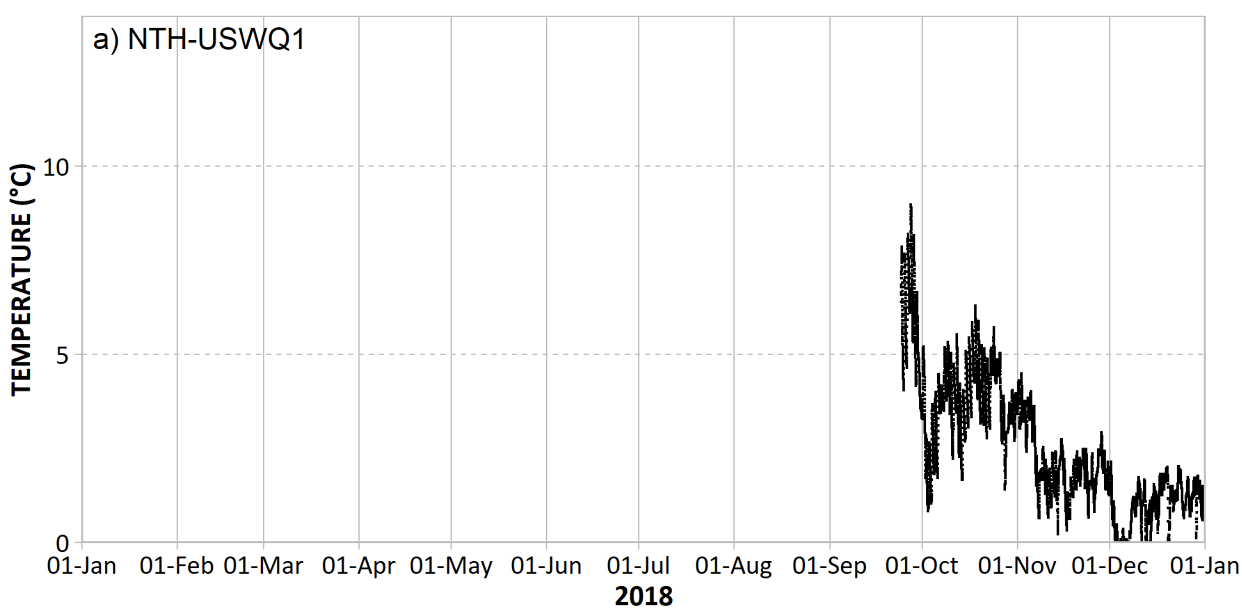


Figure 9. Operational water temperature at NTH-USWQ1 from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.



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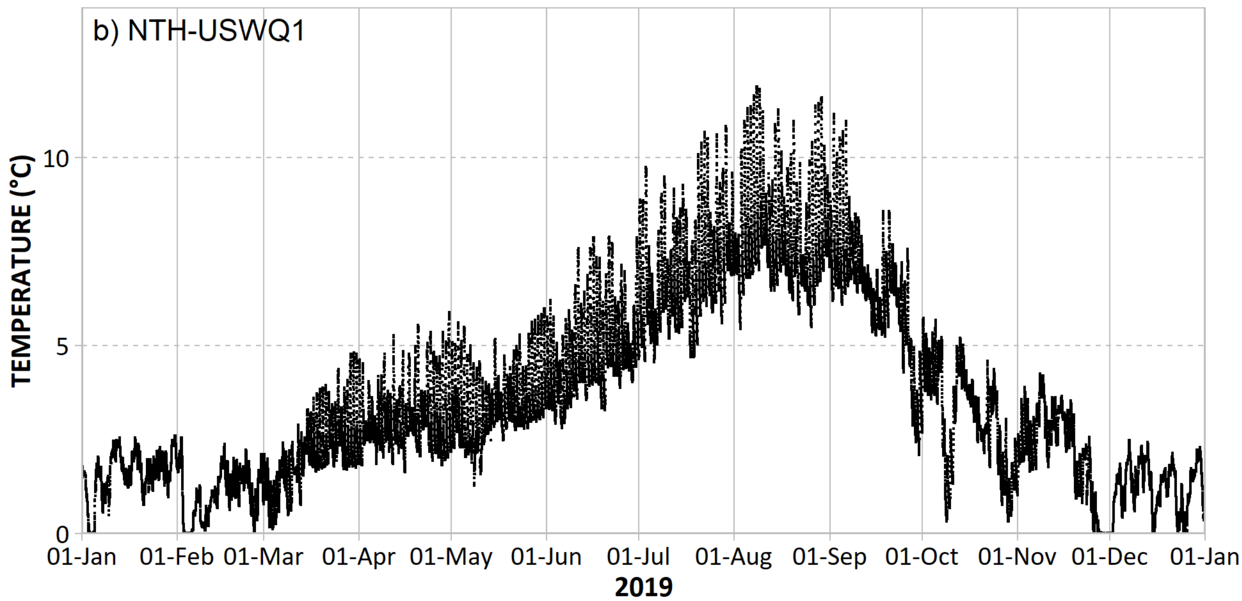


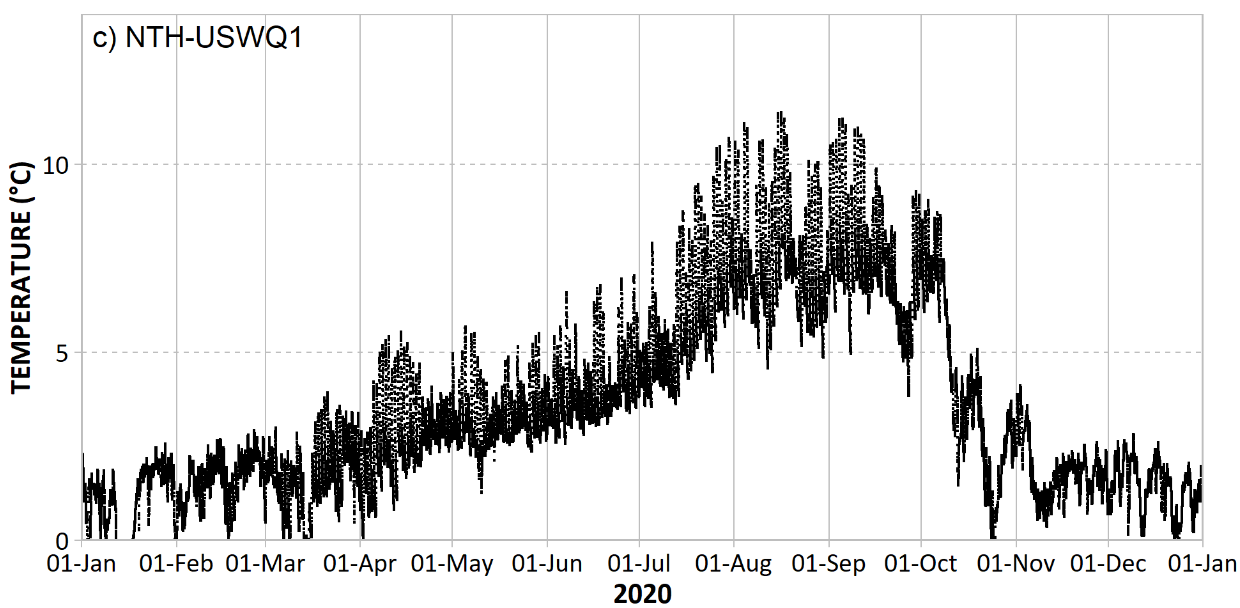


Figure 9. Continued.

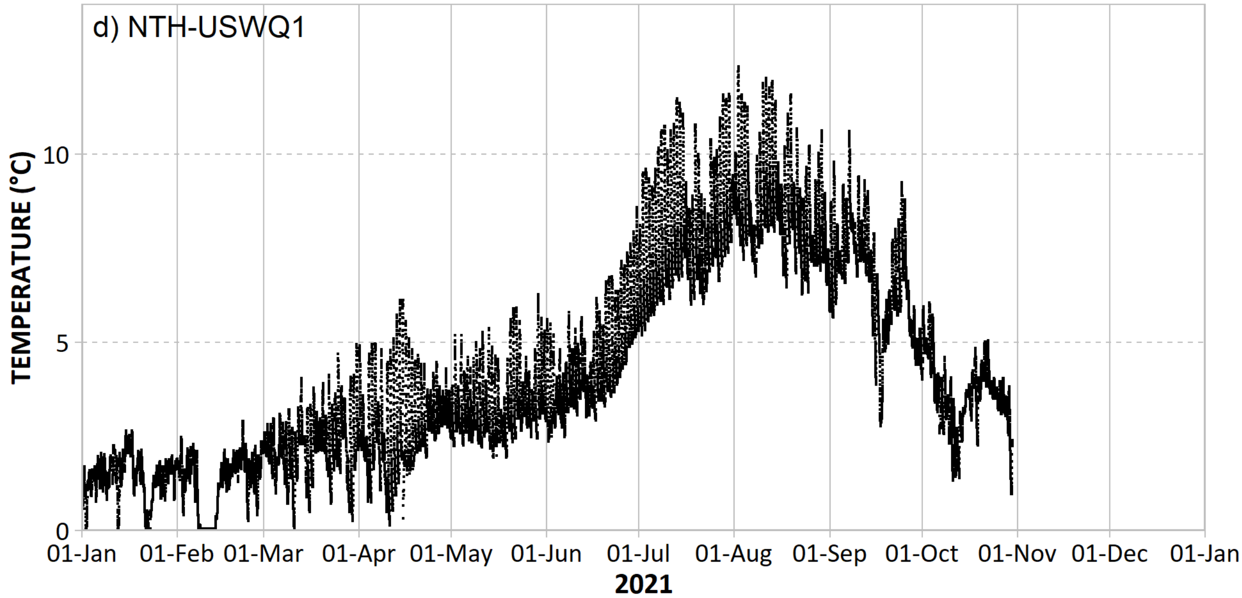
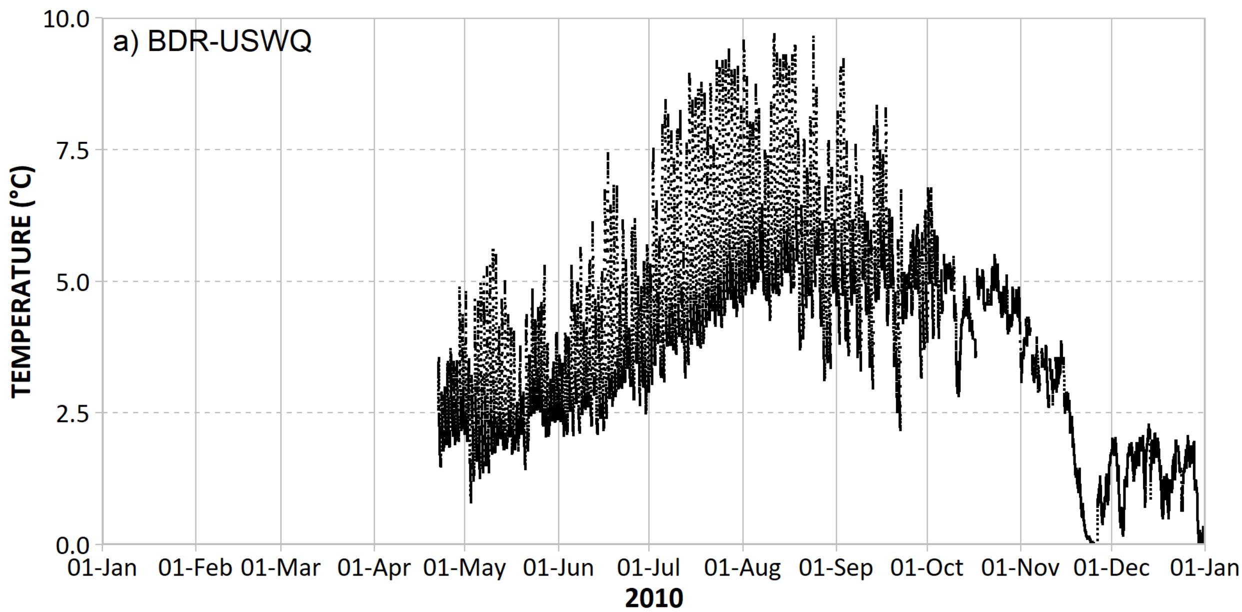


Figure 10. Baseline water temperature at BDR-USWQ from 2010 to 2013. Black dots show water temperature at intervals of 15 minutes.



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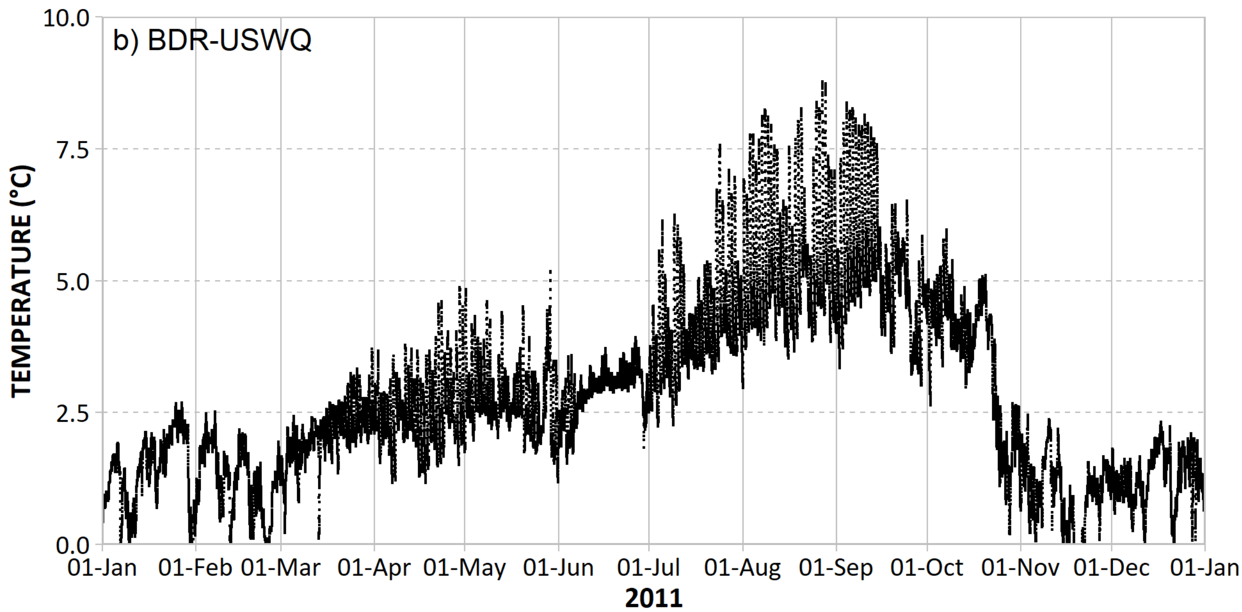


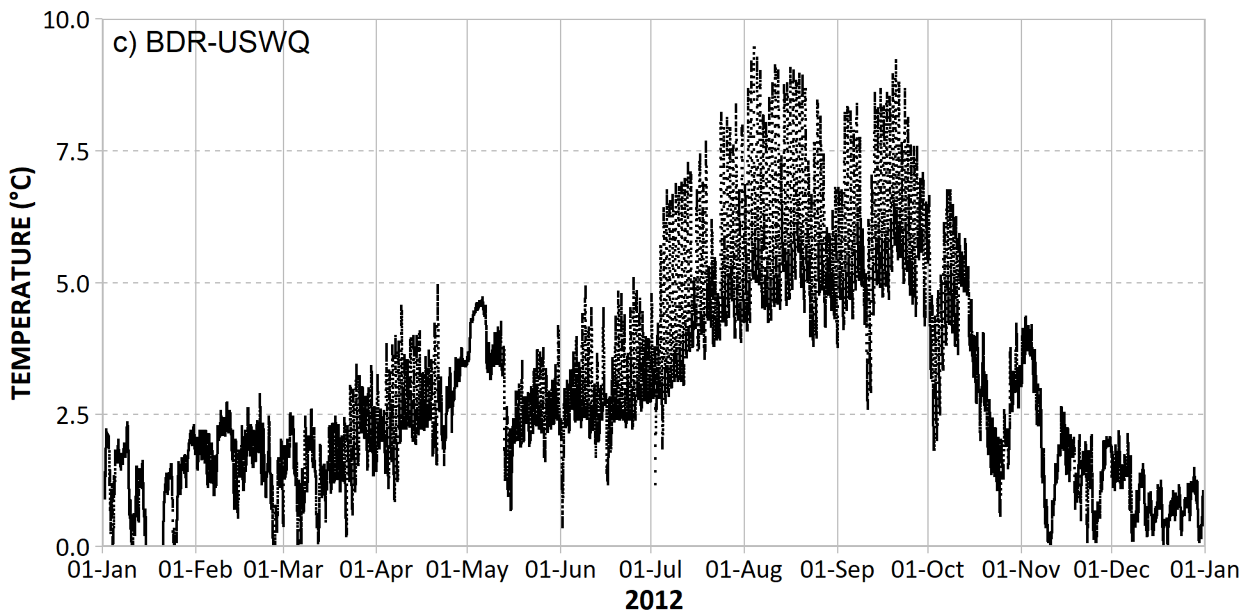


Figure 10. Continued.

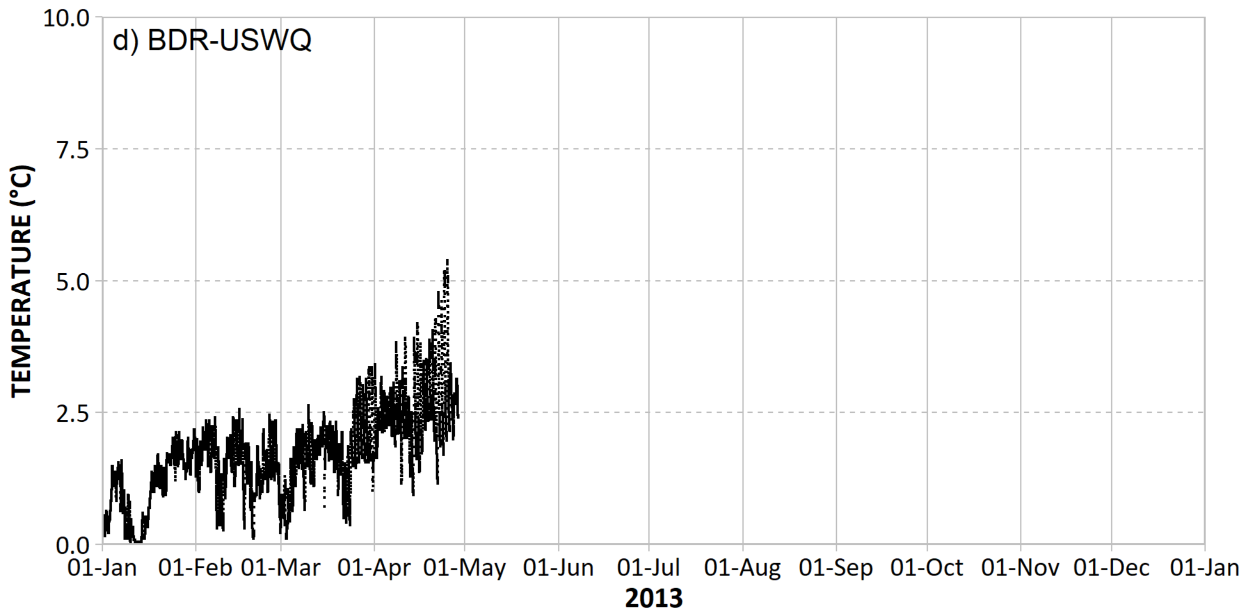
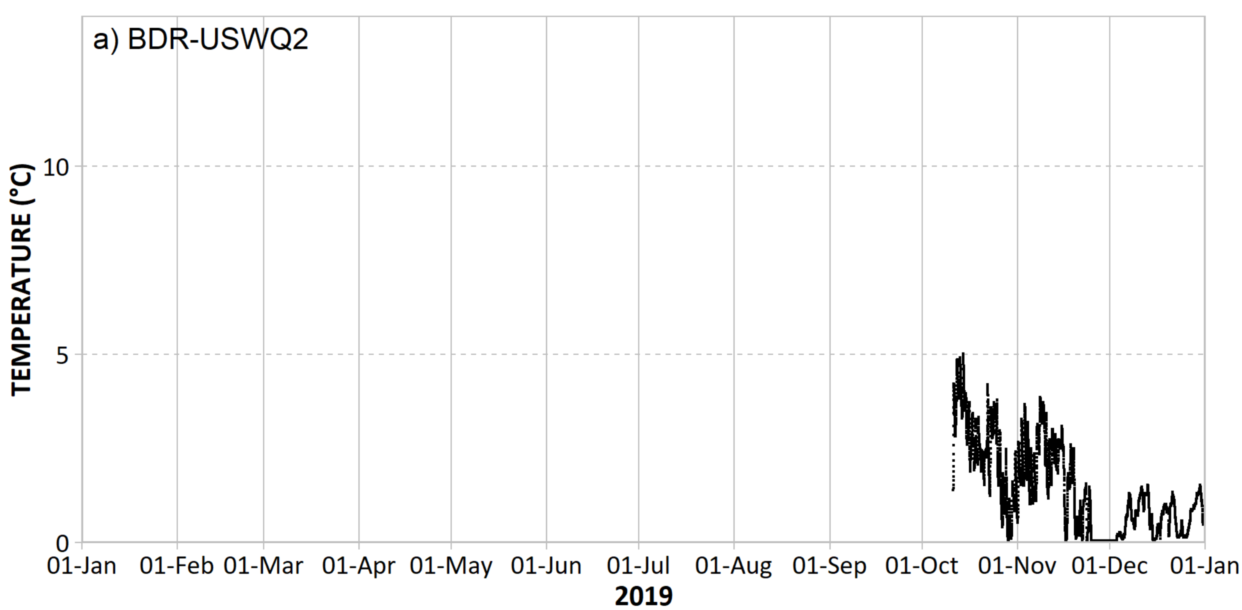


Figure 11. Operational water temperature at BDR-USWQ2 from 2019 to 2021. Black dots show water temperature at intervals of 15 minutes.



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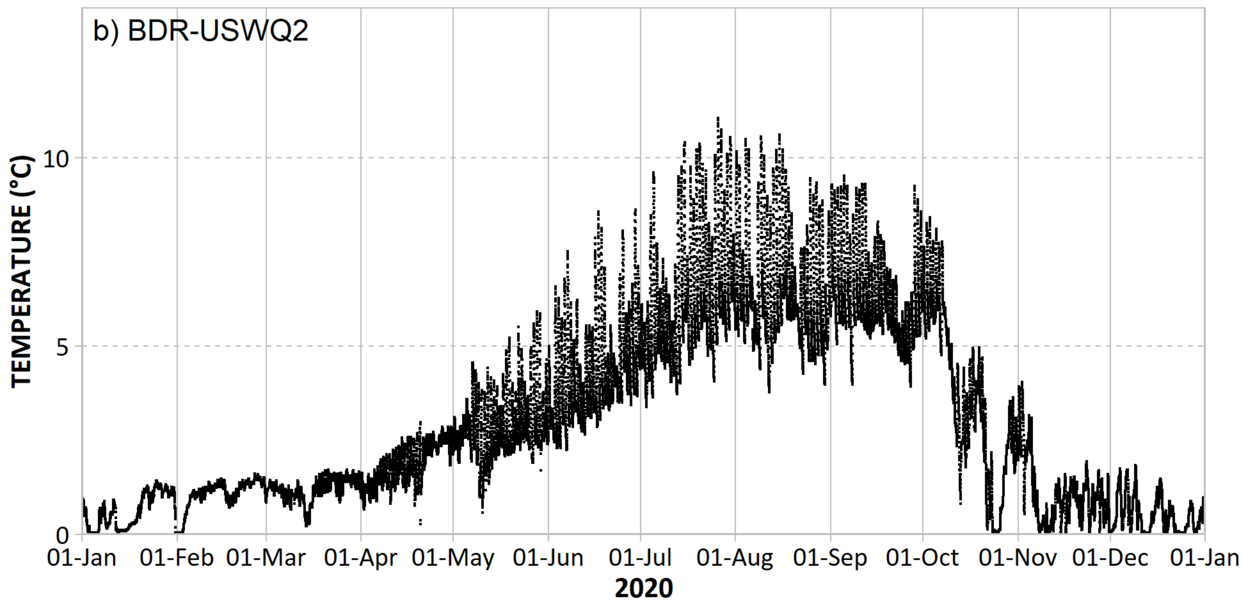


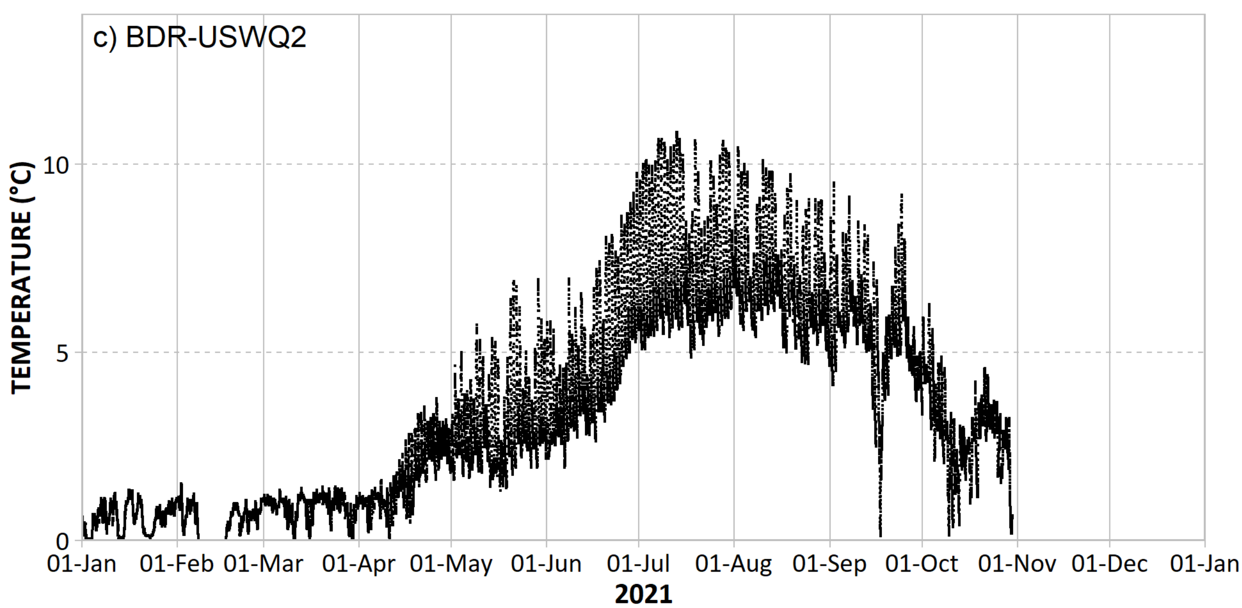


Figure 12. Baseline water temperature at BDR-DVWQ from 2008 to 2013. Black dots show water temperature at intervals of 15 minutes.

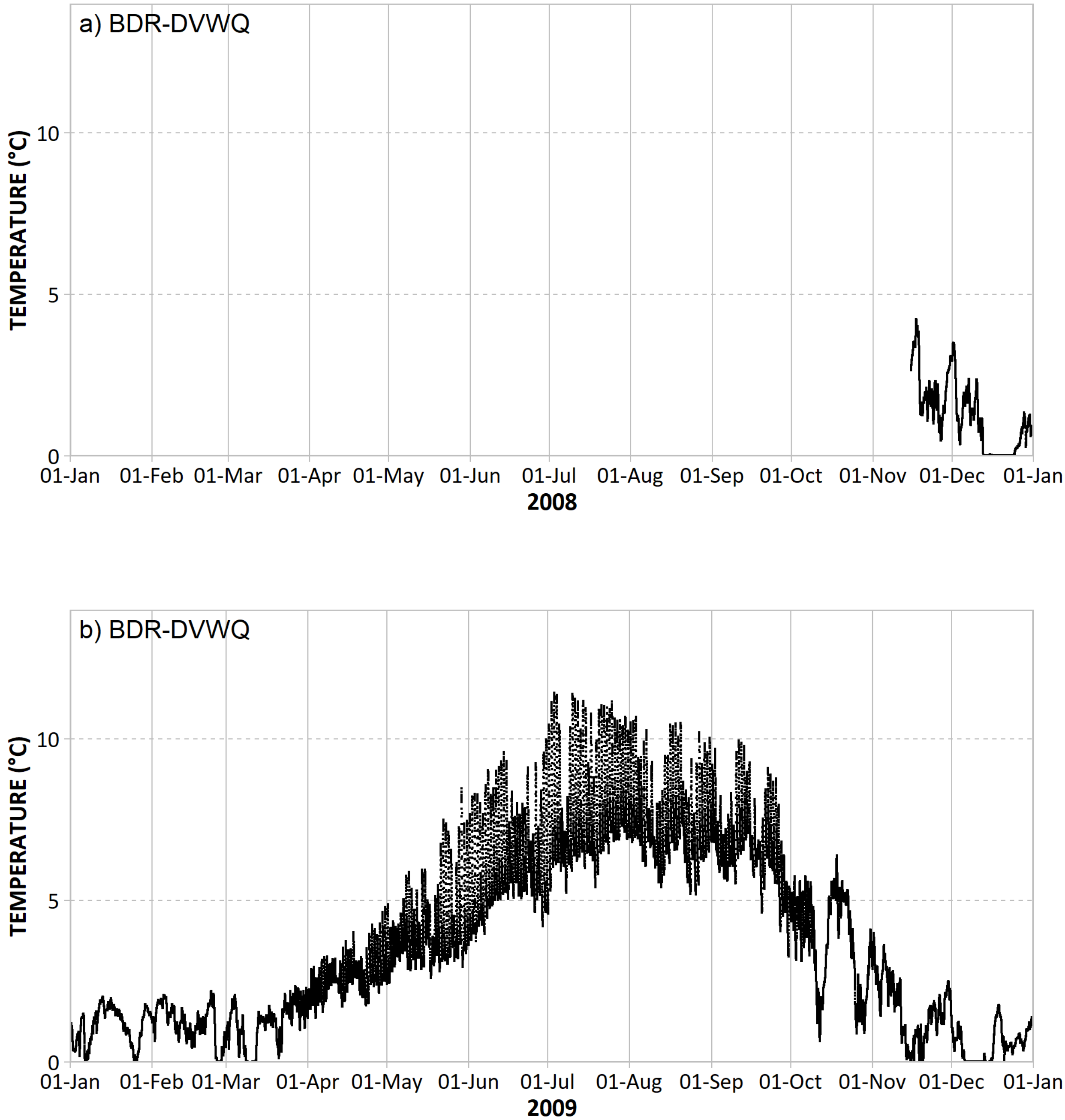
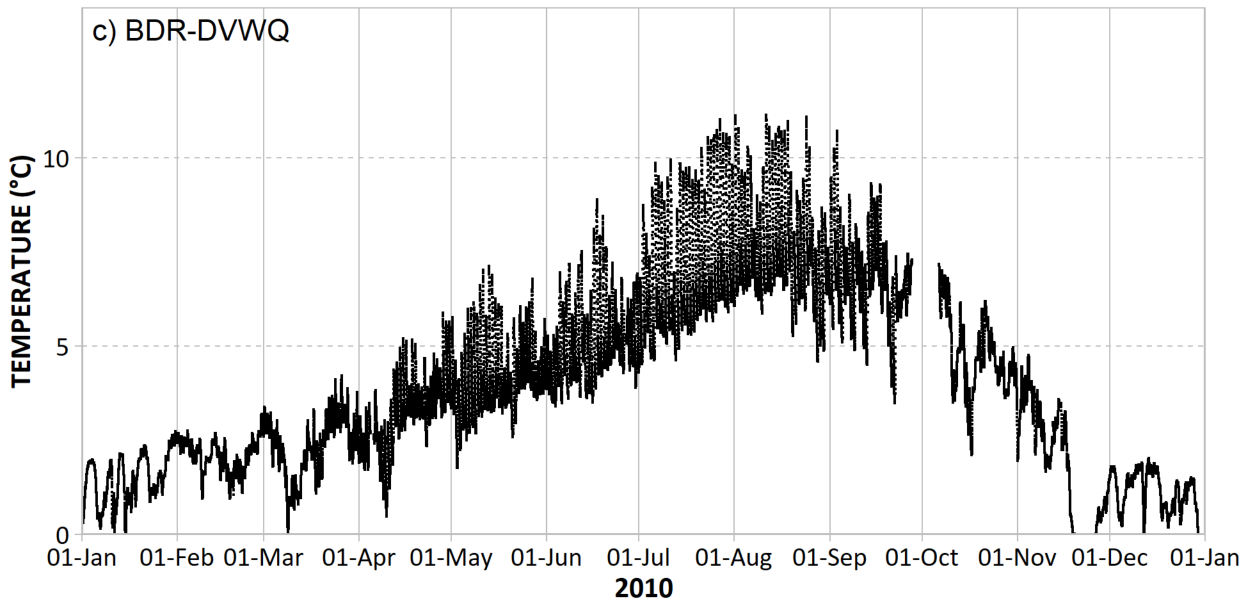


Figure 12. Continued.



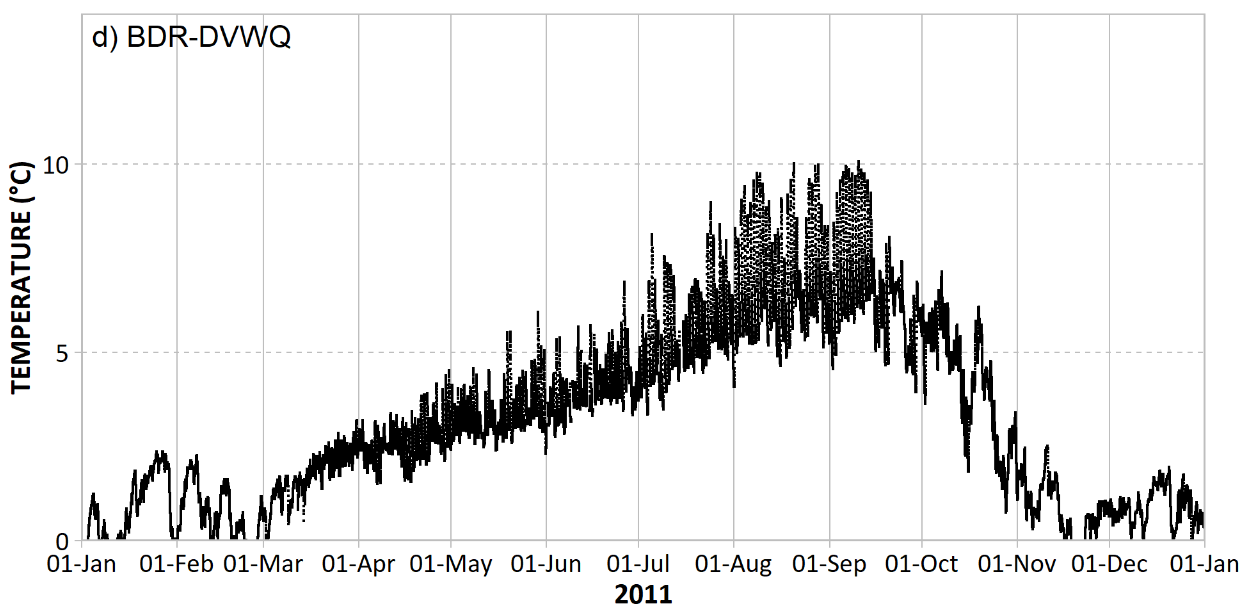
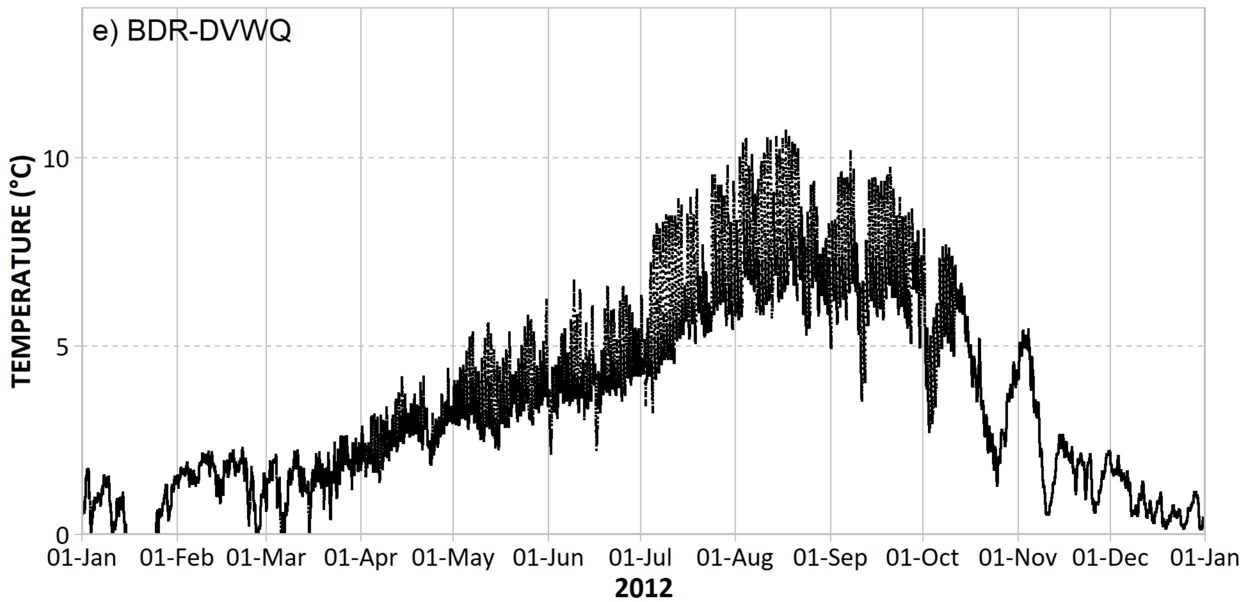


Figure 12. Continued.



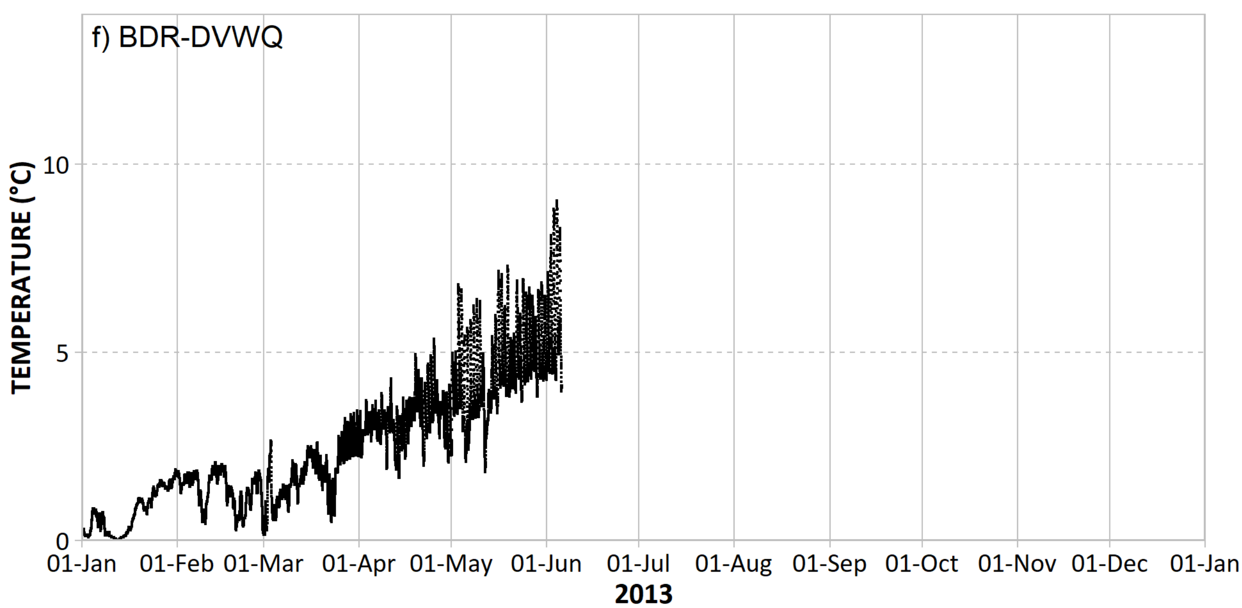
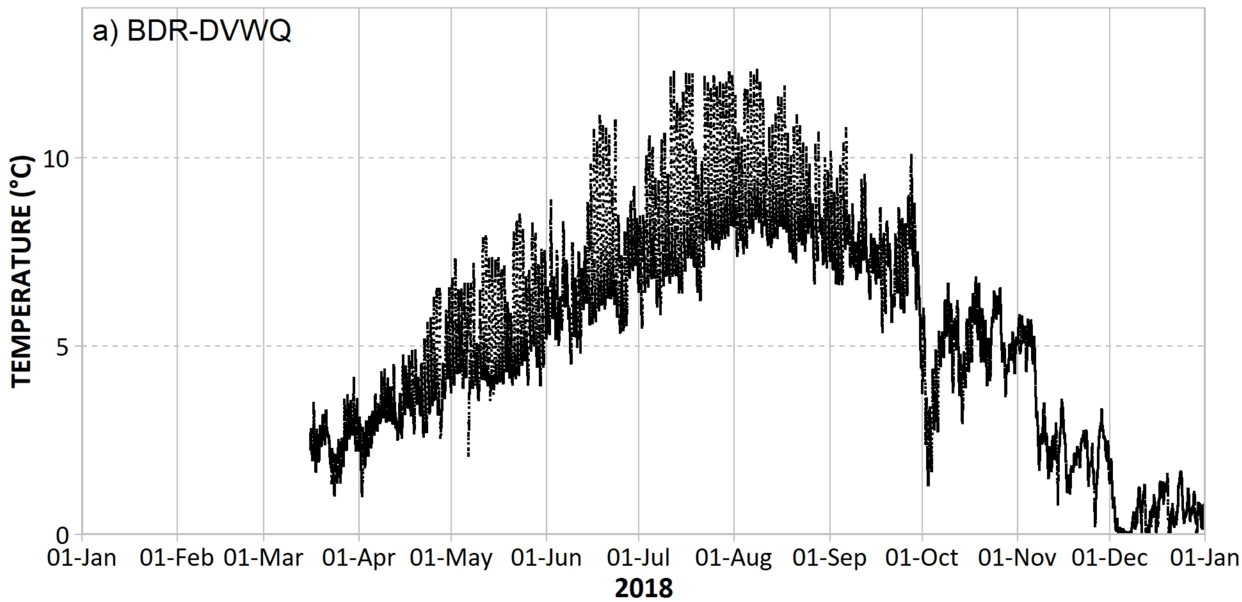
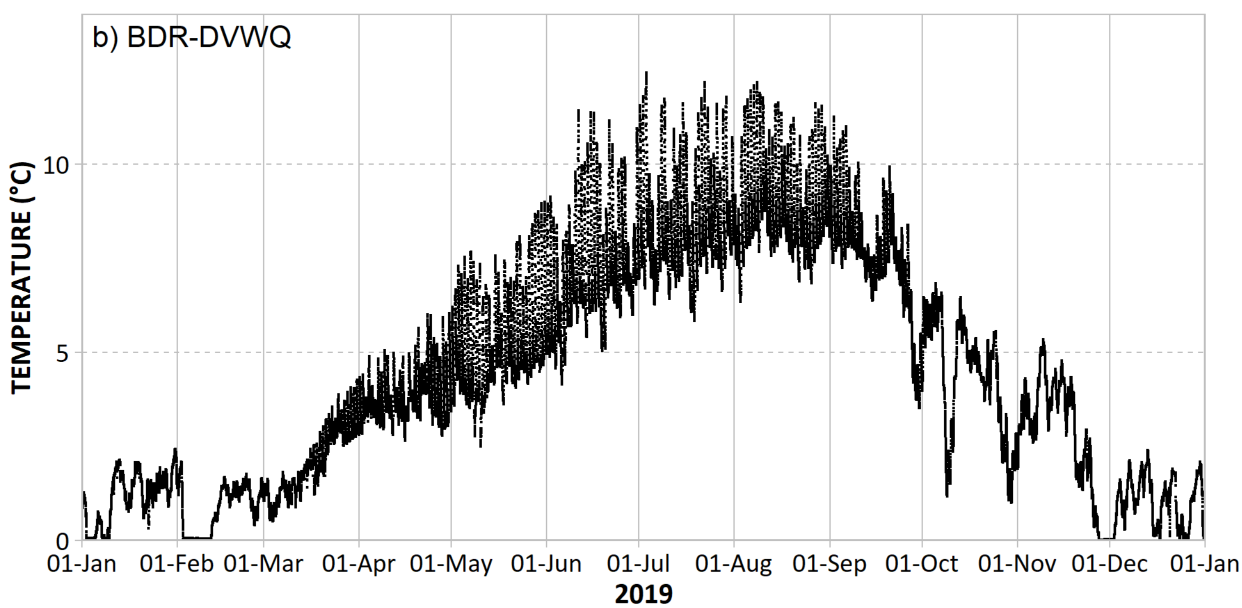


Figure 13. Operational water temperature at BDR-DVWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.





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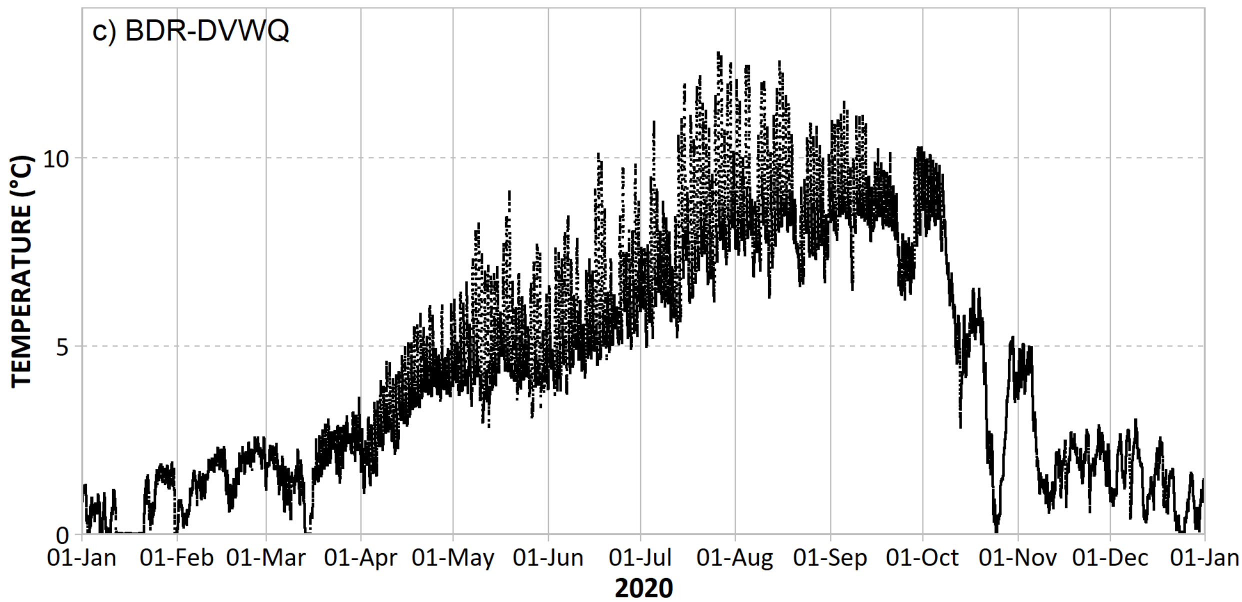


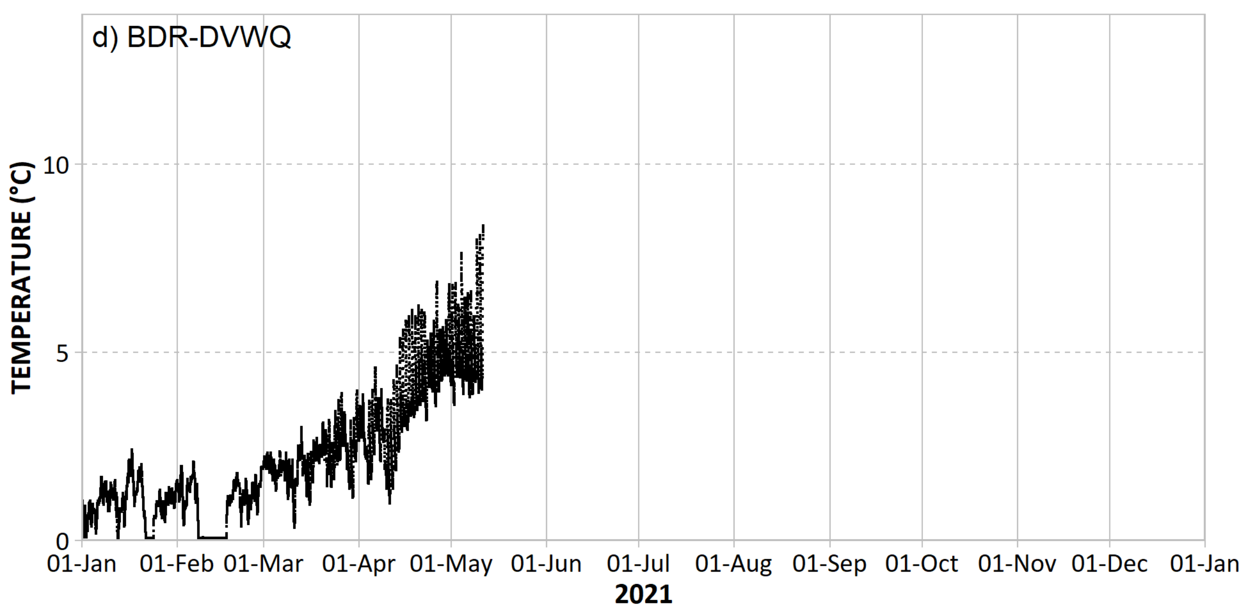
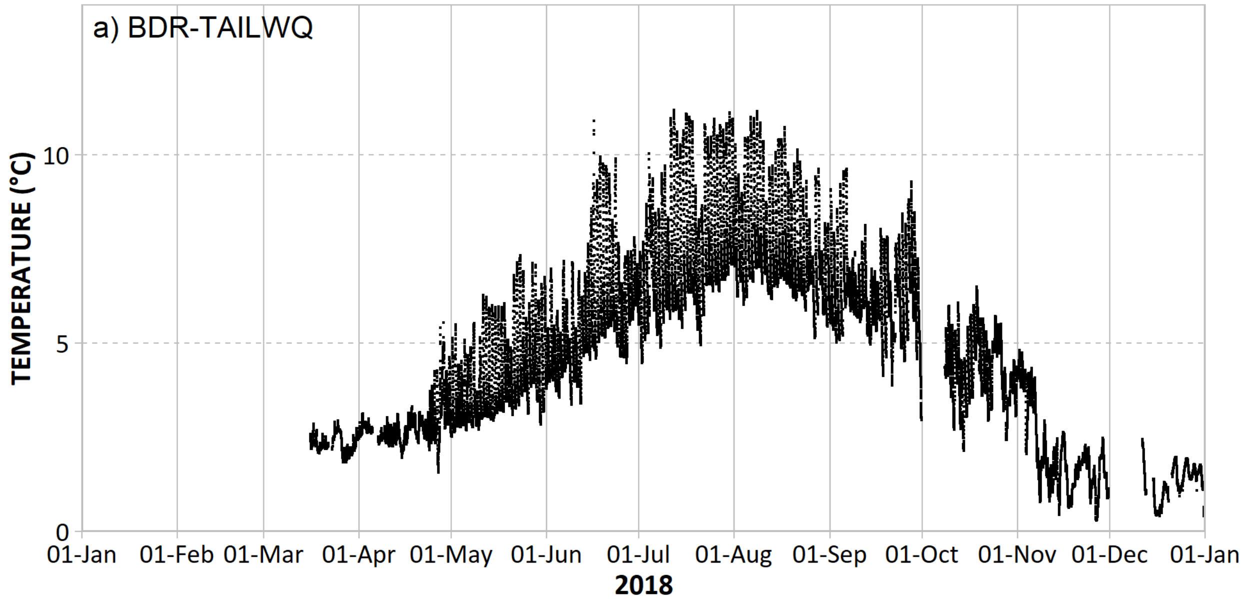
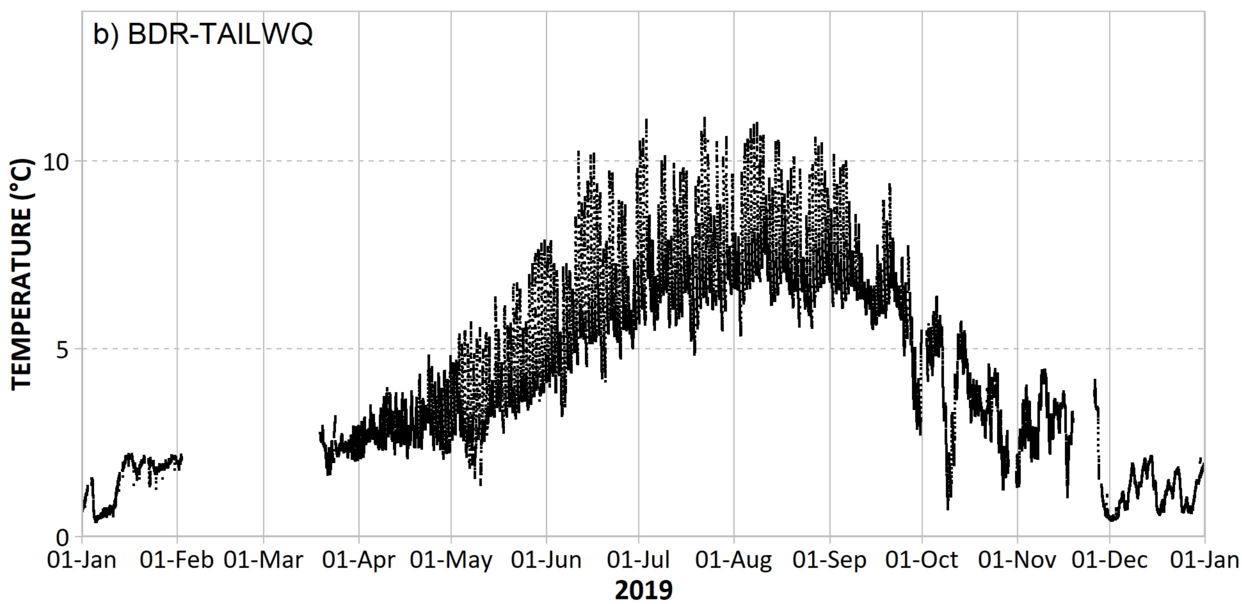


Figure 14. Operational water temperature at BDR-TAILWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.





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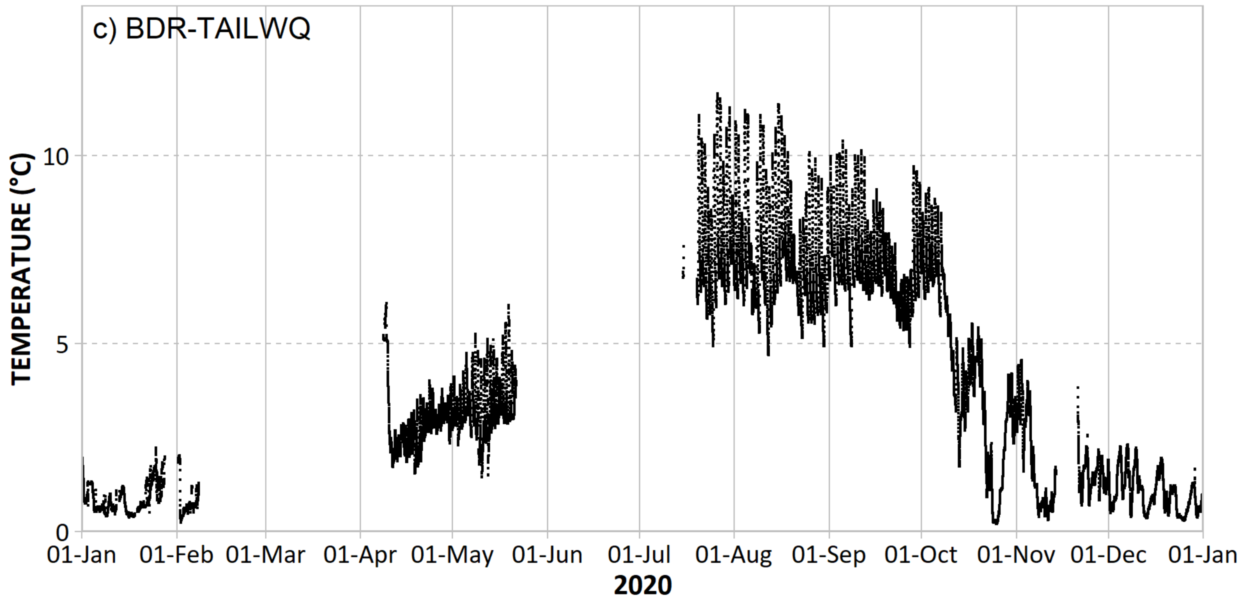


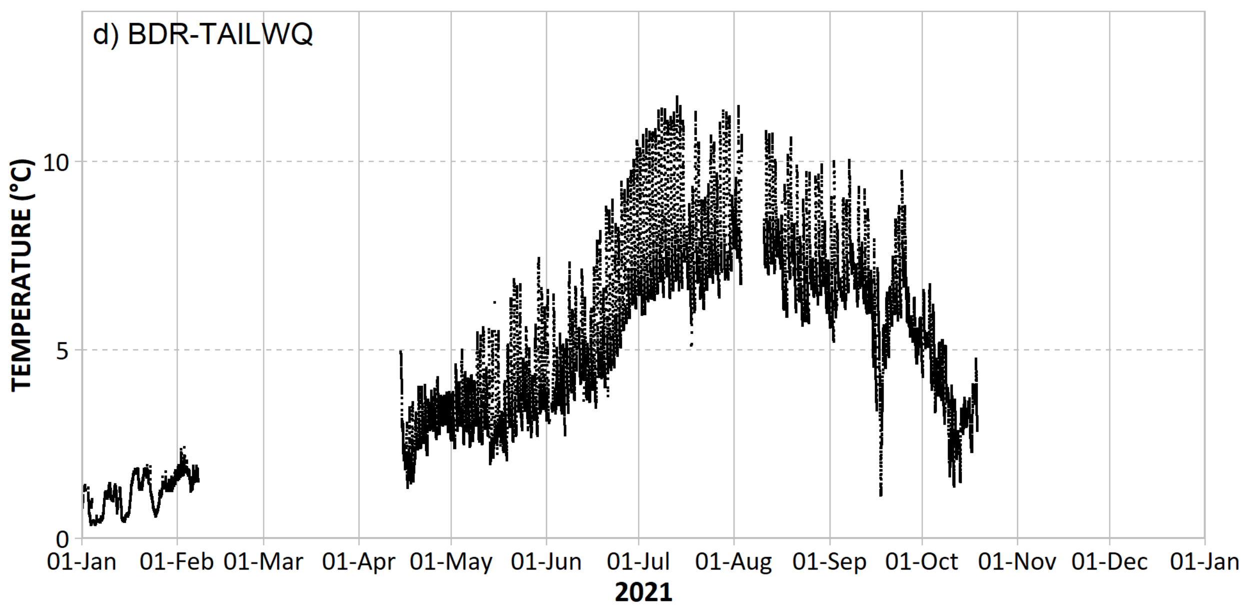
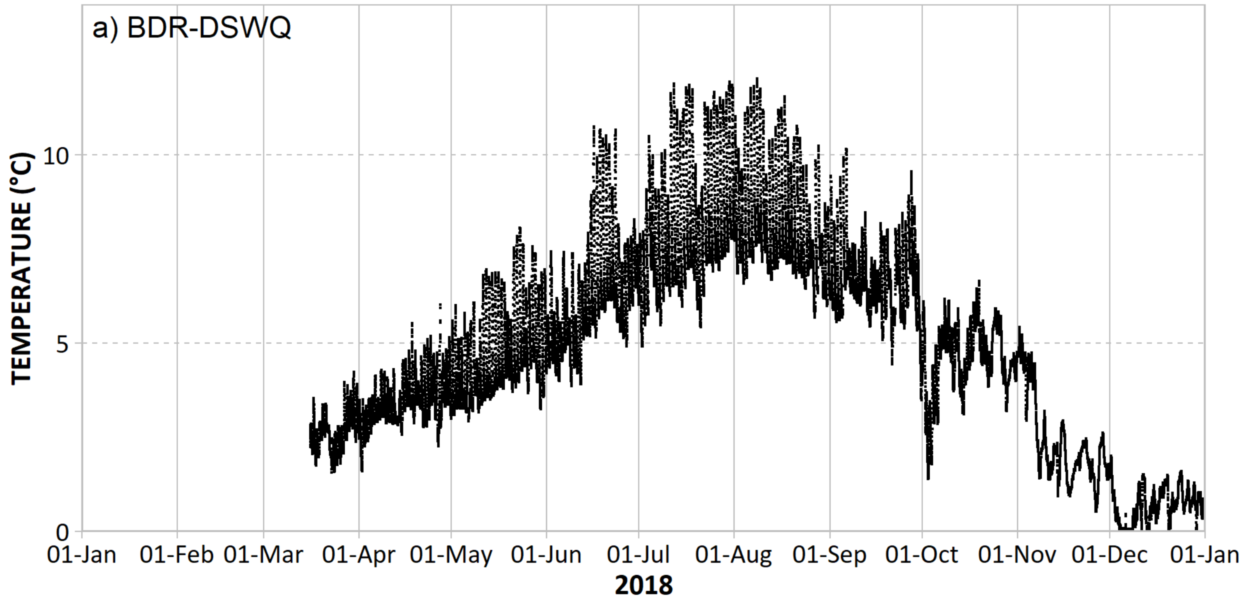


Figure 15. Operational water temperature at BDR-DSWQ from 2018 to 2021. Black dots show water temperature at intervals of 15 minutes.



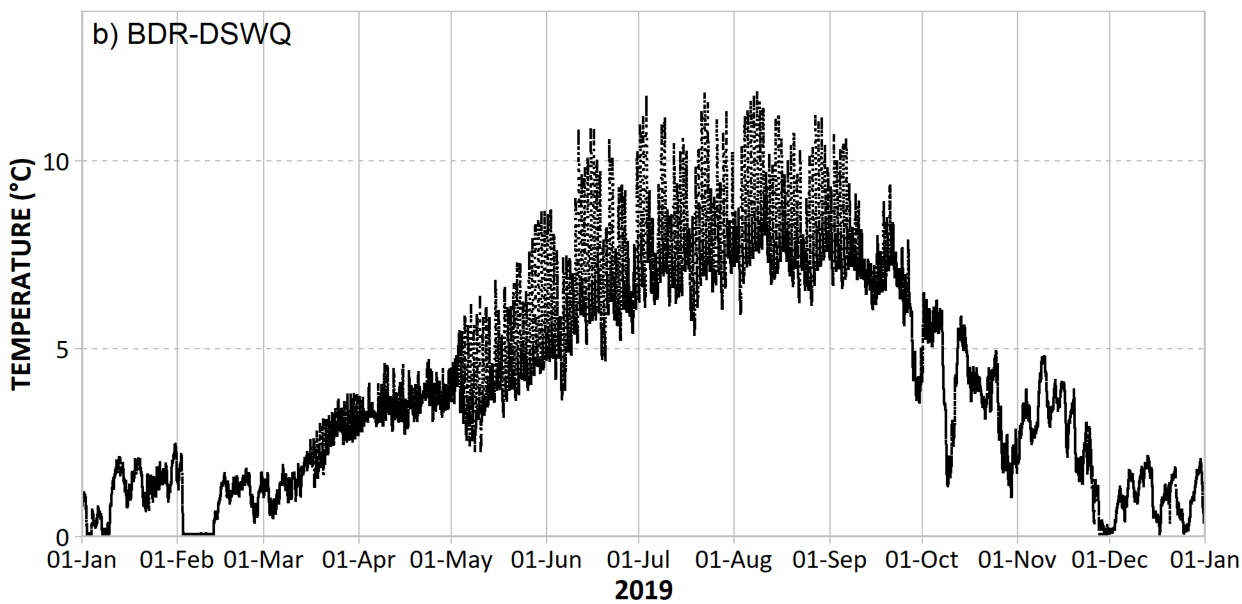
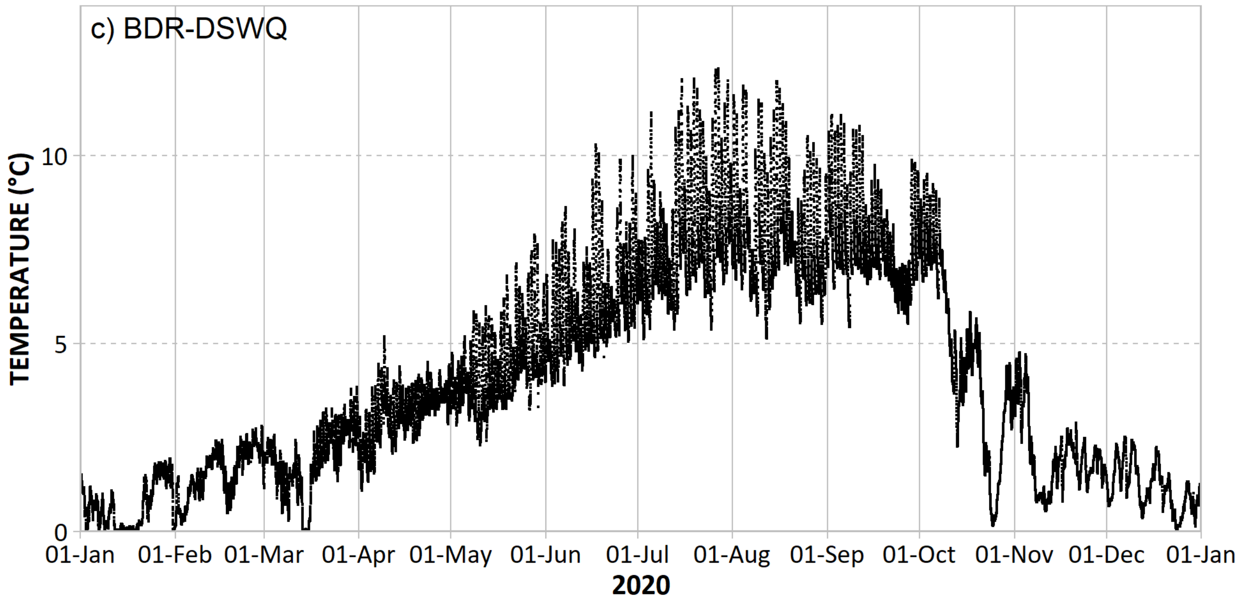
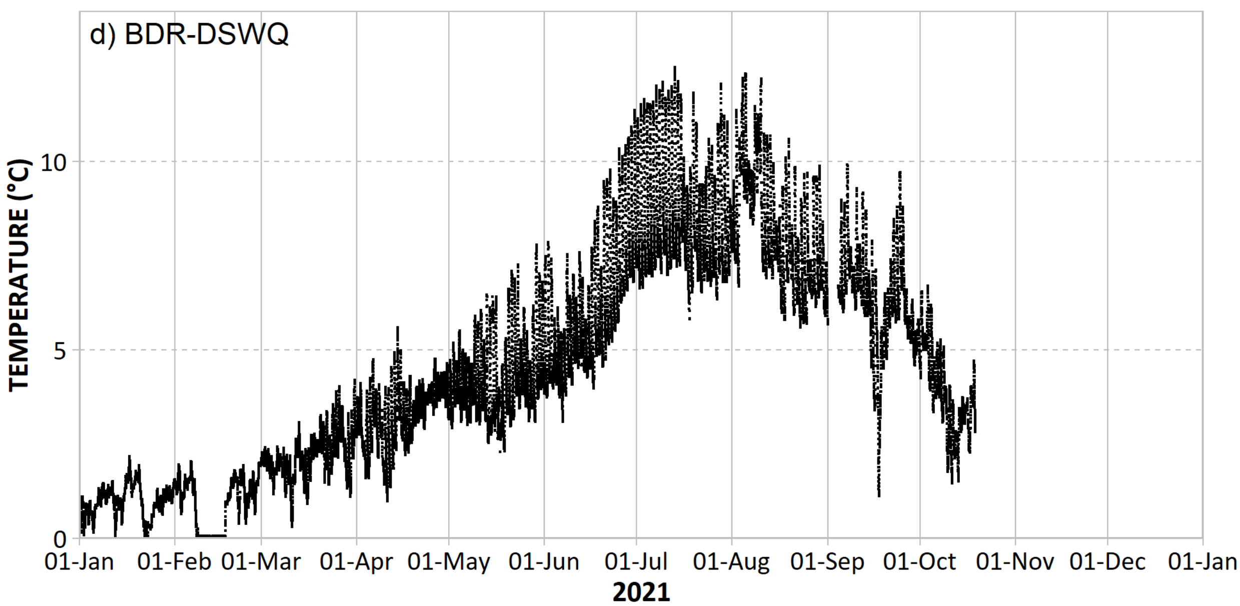


Figure 15. Continued.

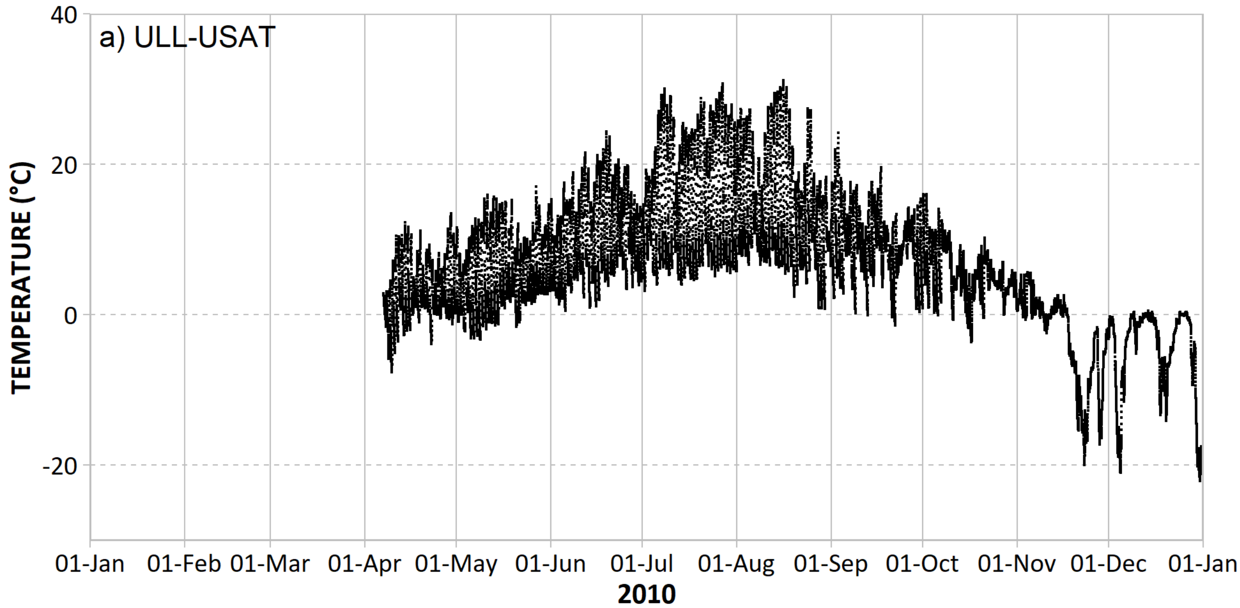


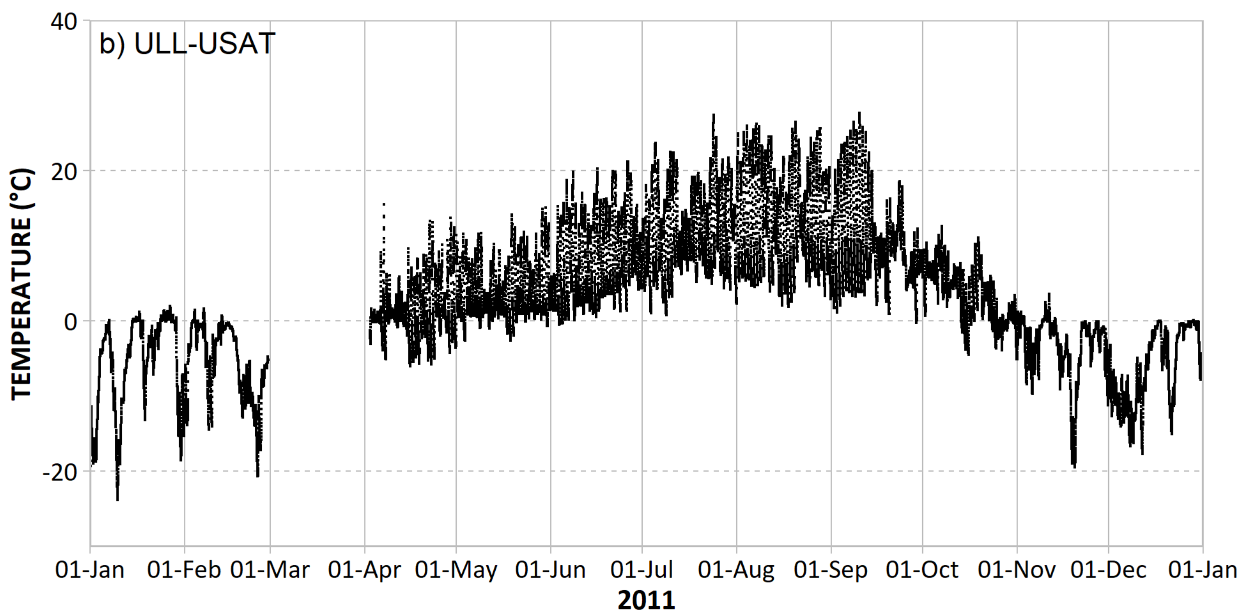


3. AIR TEMPERATURE DATA

3.1. Upper Lillooet River

Figure 16. Baseline air temperature at ULL-USAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes.





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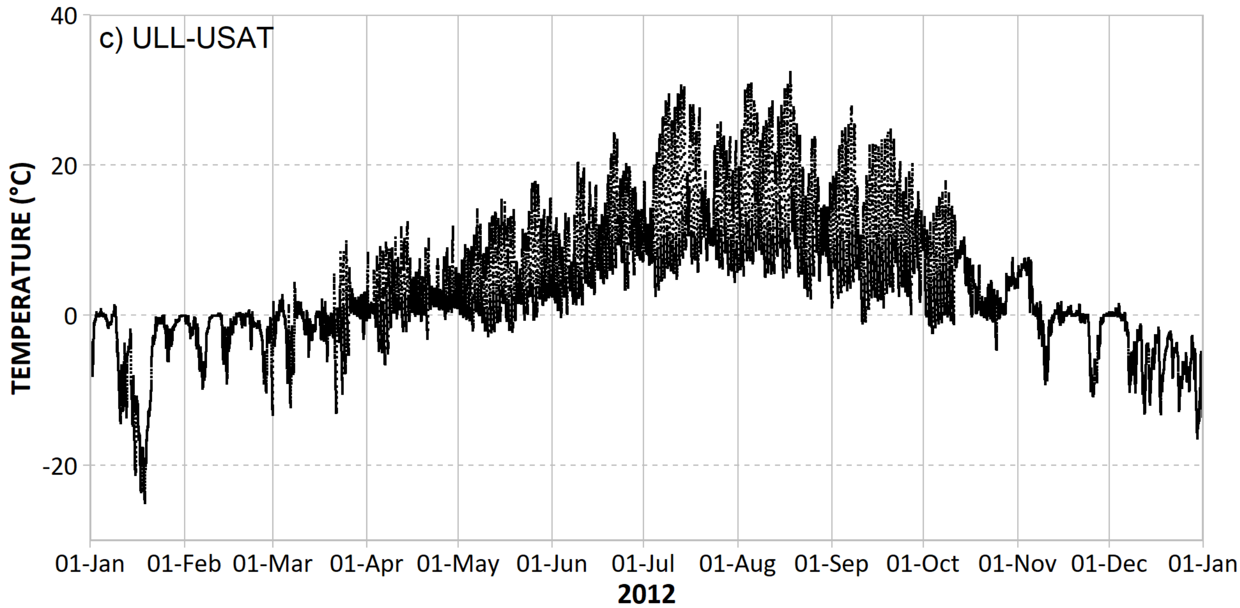


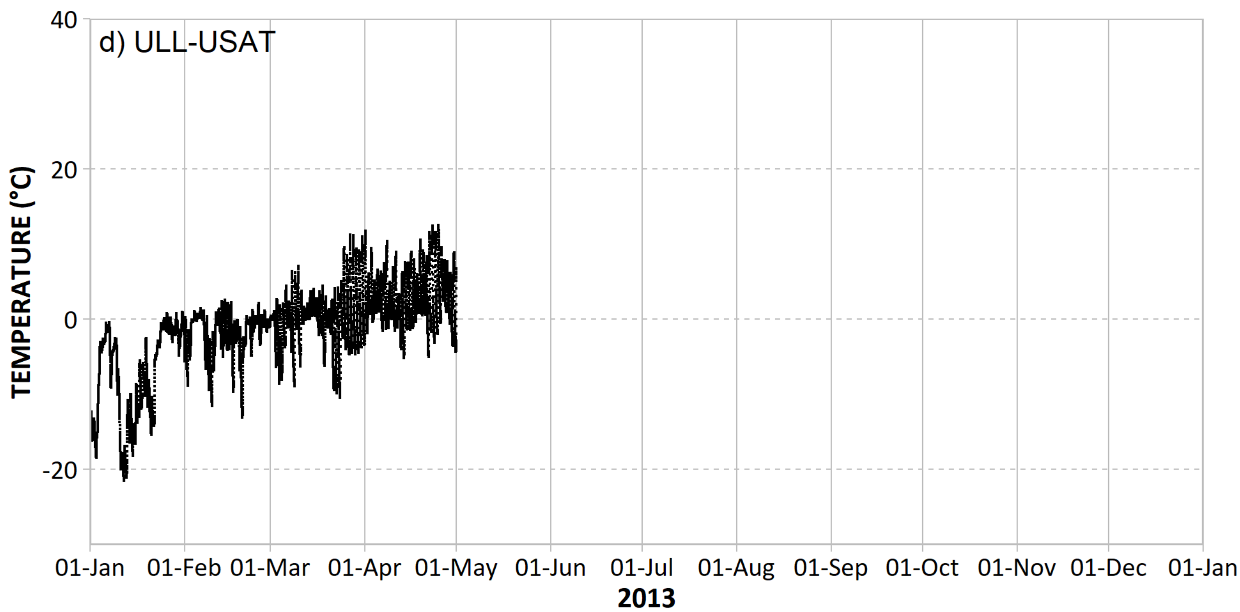


Figure 17. Operational air temperature at ULL-USAT01 from 2018 to 2019. Black dots show air temperature at intervals of 15 minutes.

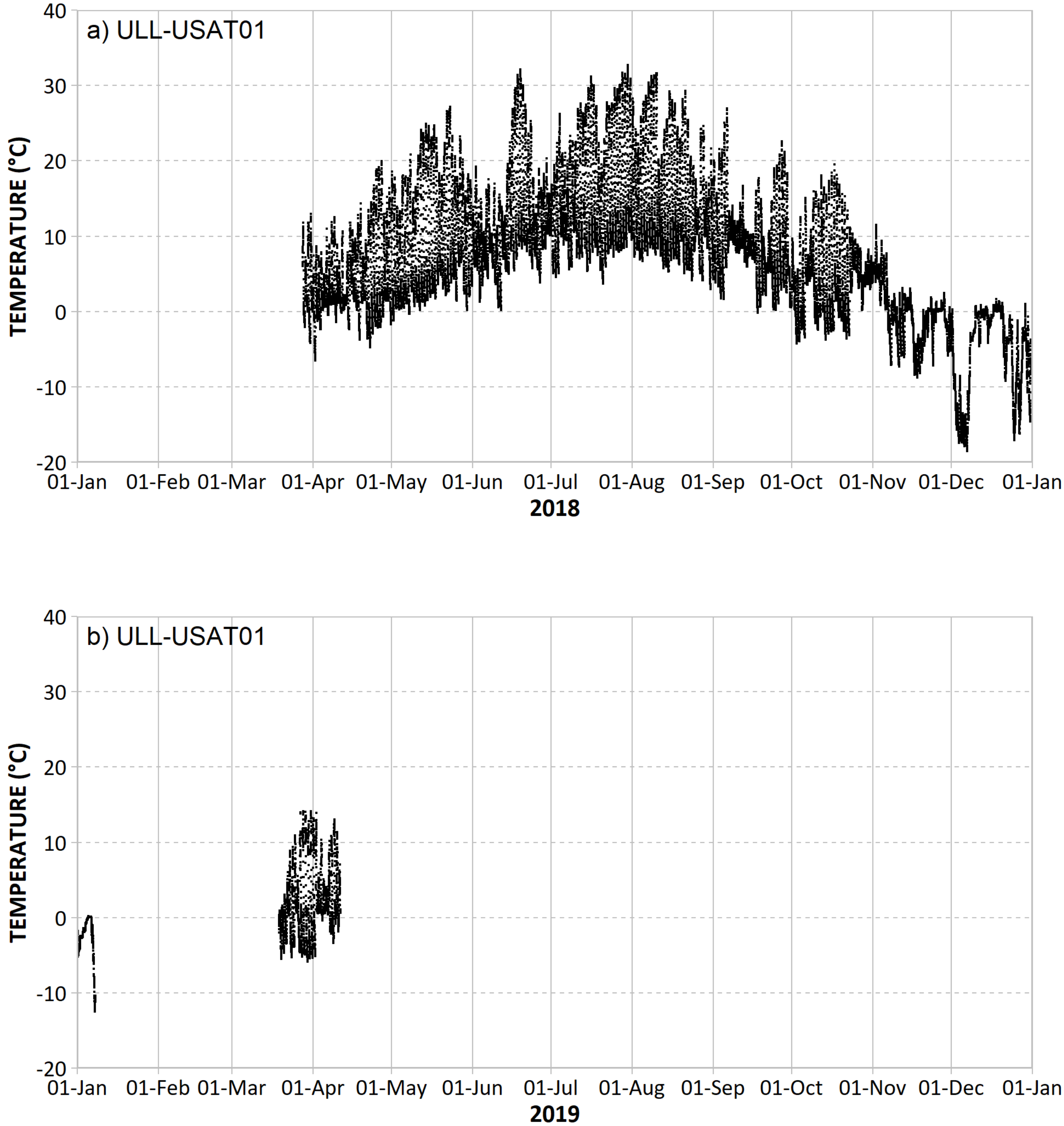
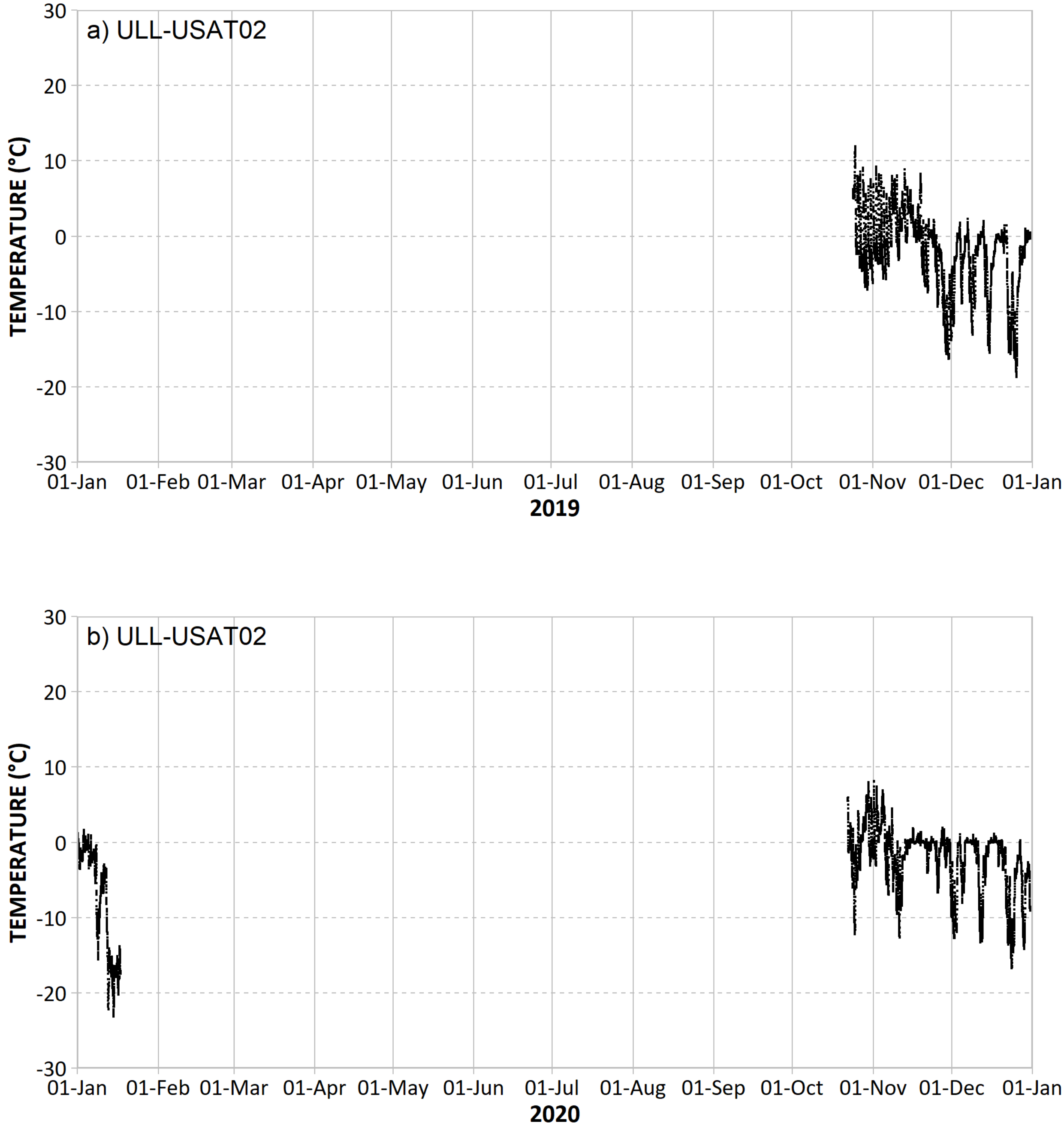


Figure 18. Operational air temperature at ULL-USAT02 from 2019 to 2021. Black dots show air temperature at intervals of 15 minutes.



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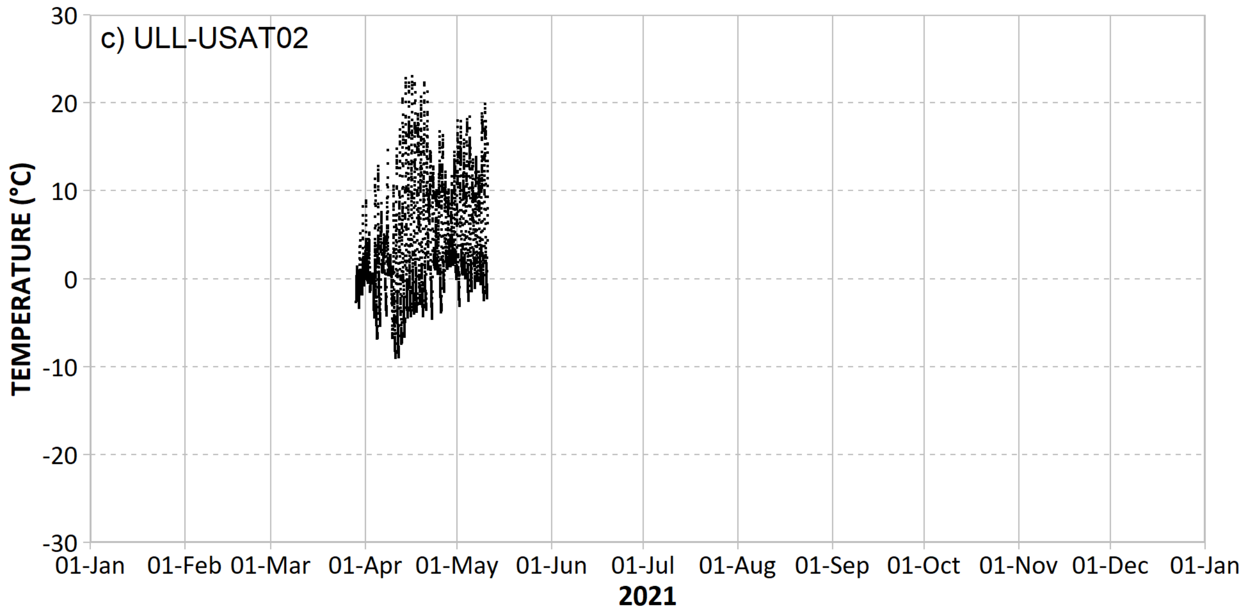
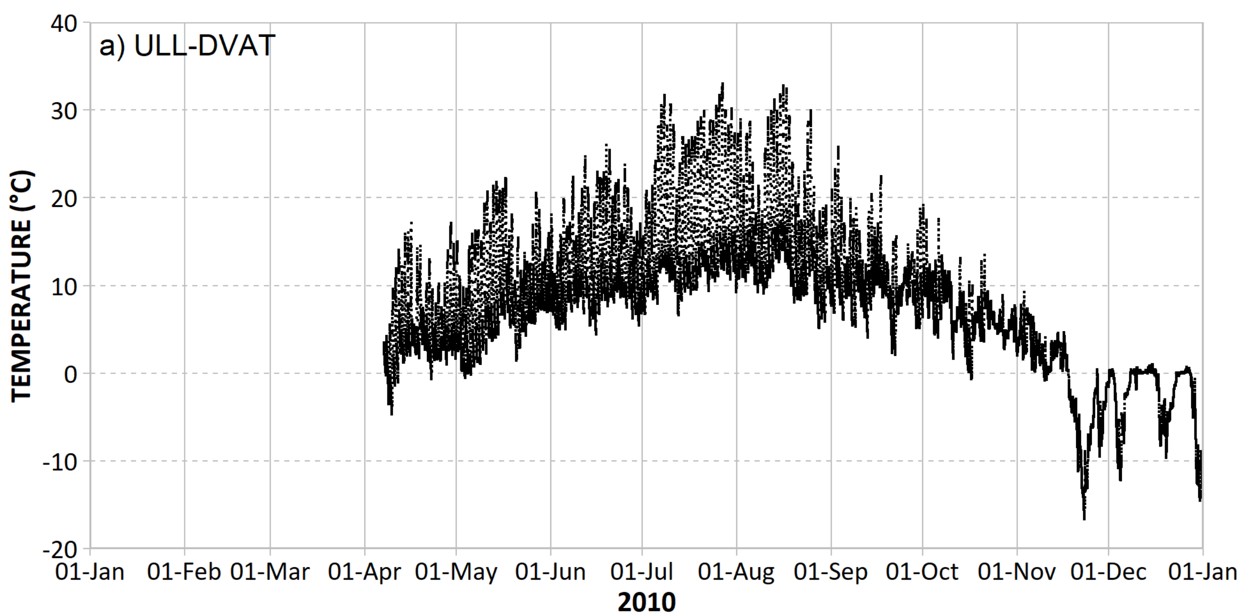


Figure 19. Baseline air temperature at ULL-DVAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes.



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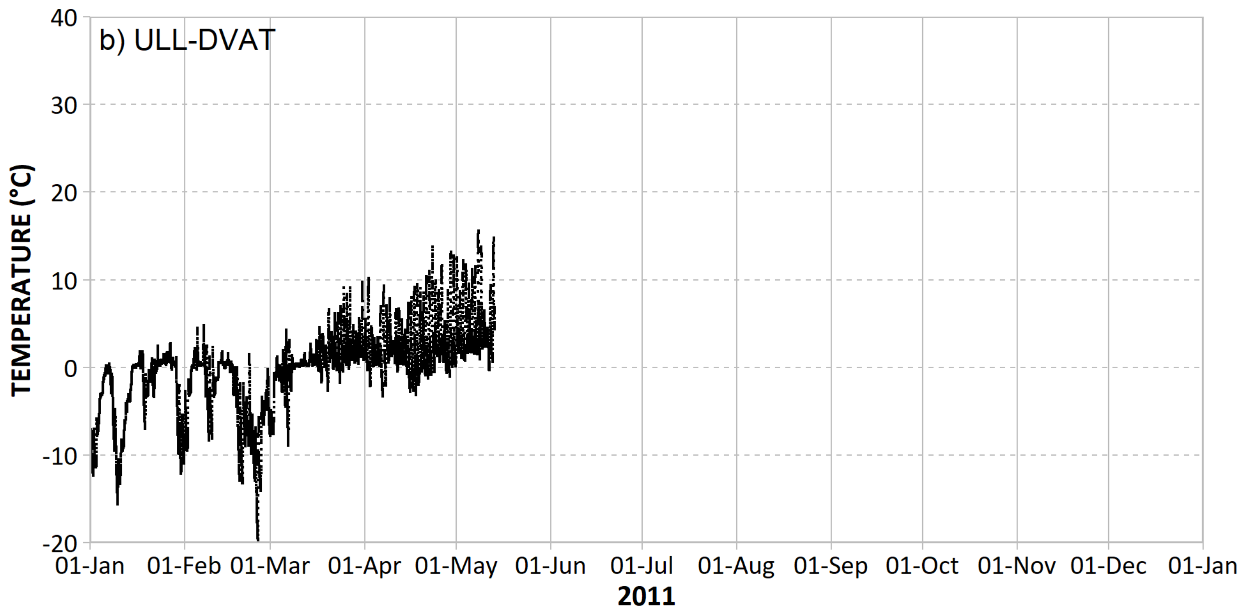

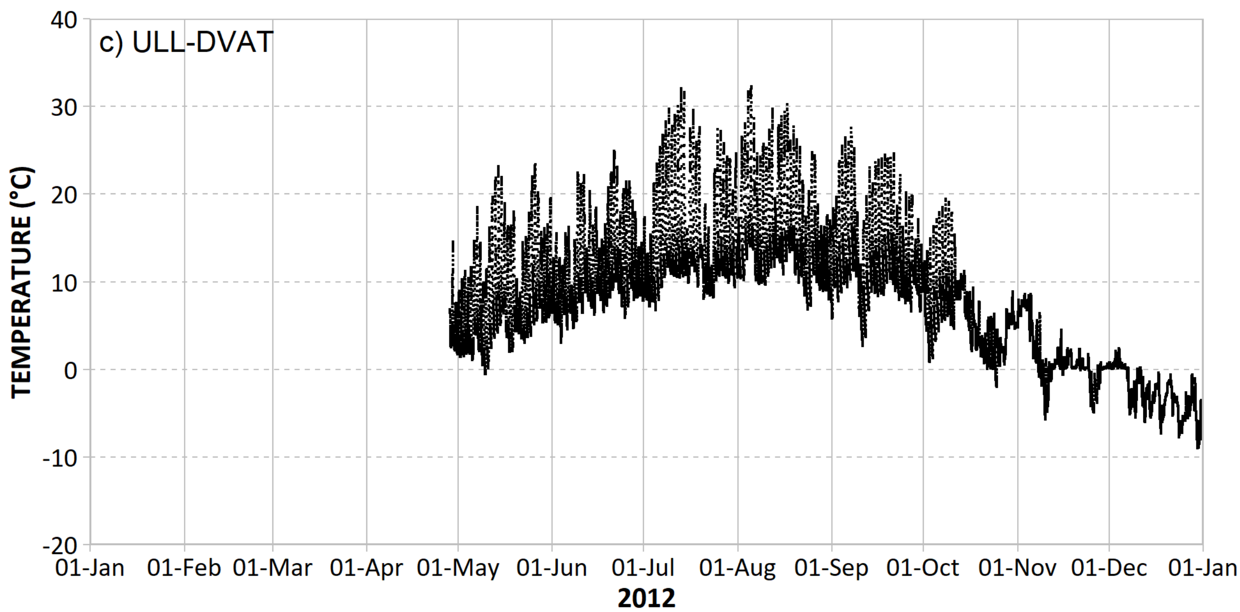

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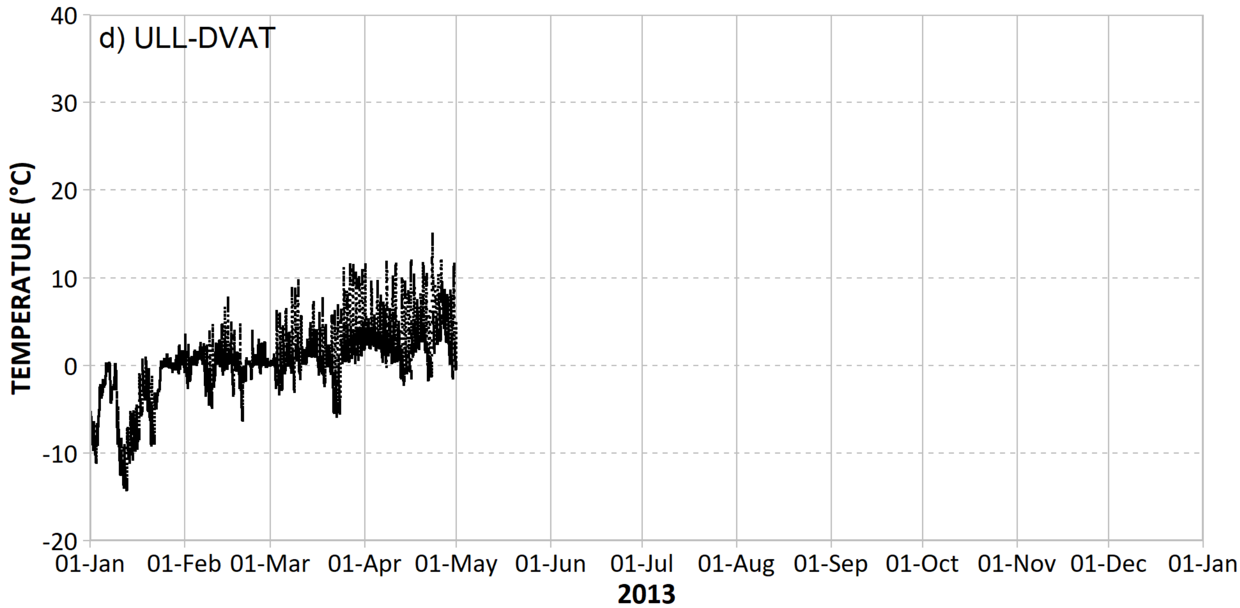


Figure 20. Operational air temperature at ULL-DSAT from 2018 to 2021. Black dots show air temperature at intervals of 15 minutes.

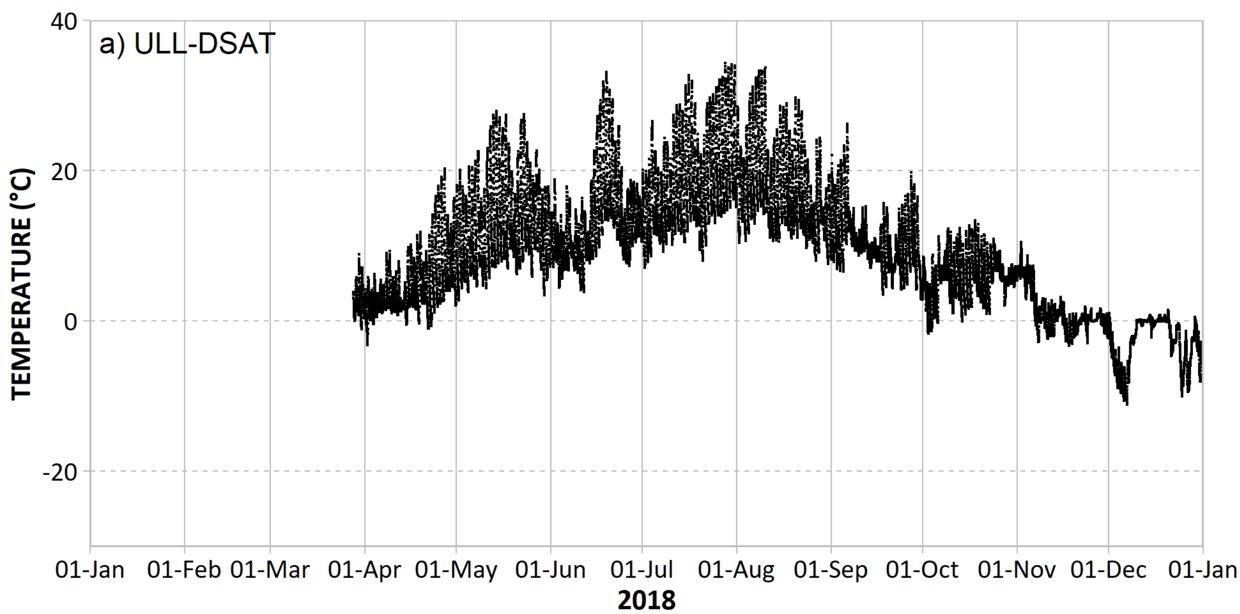
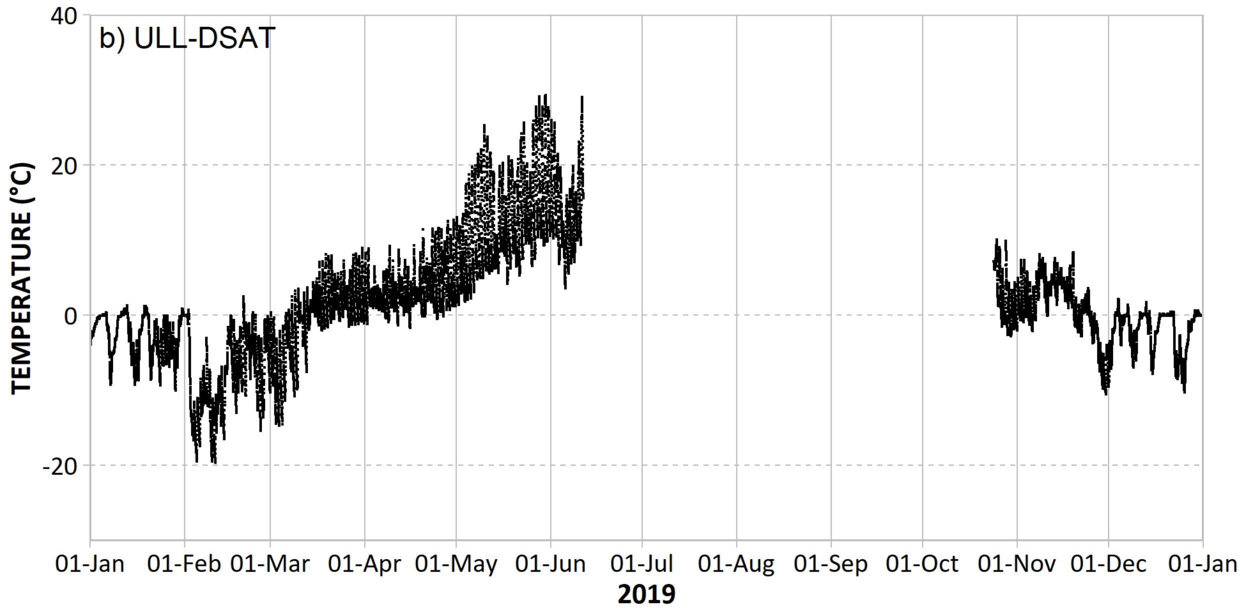
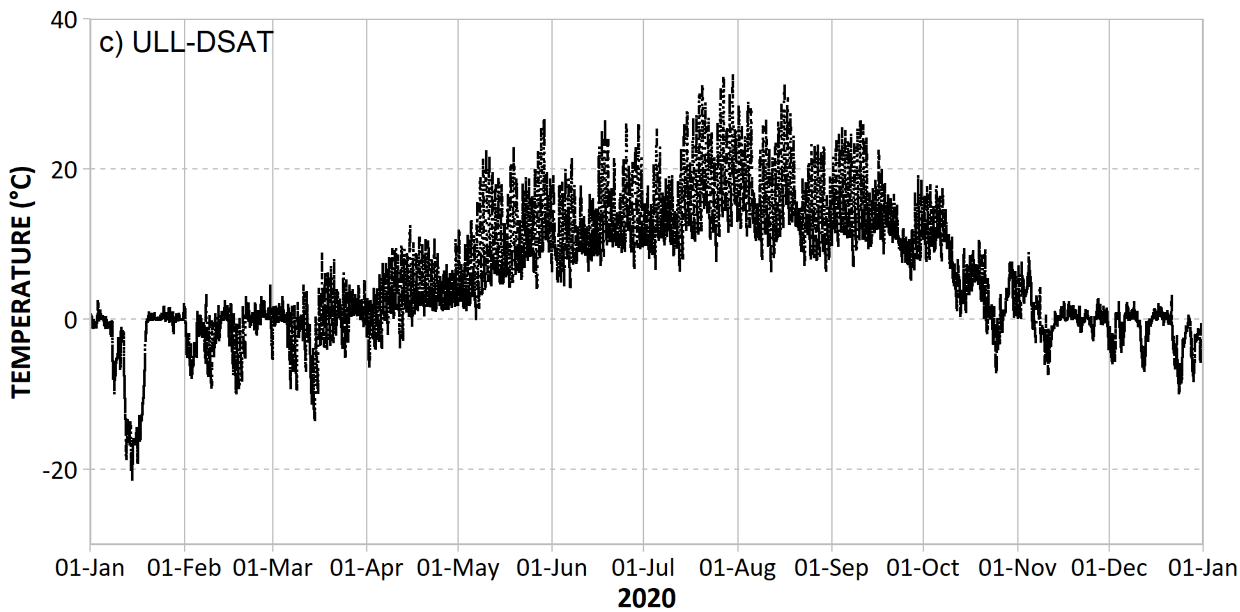


Figure 20. Continued.





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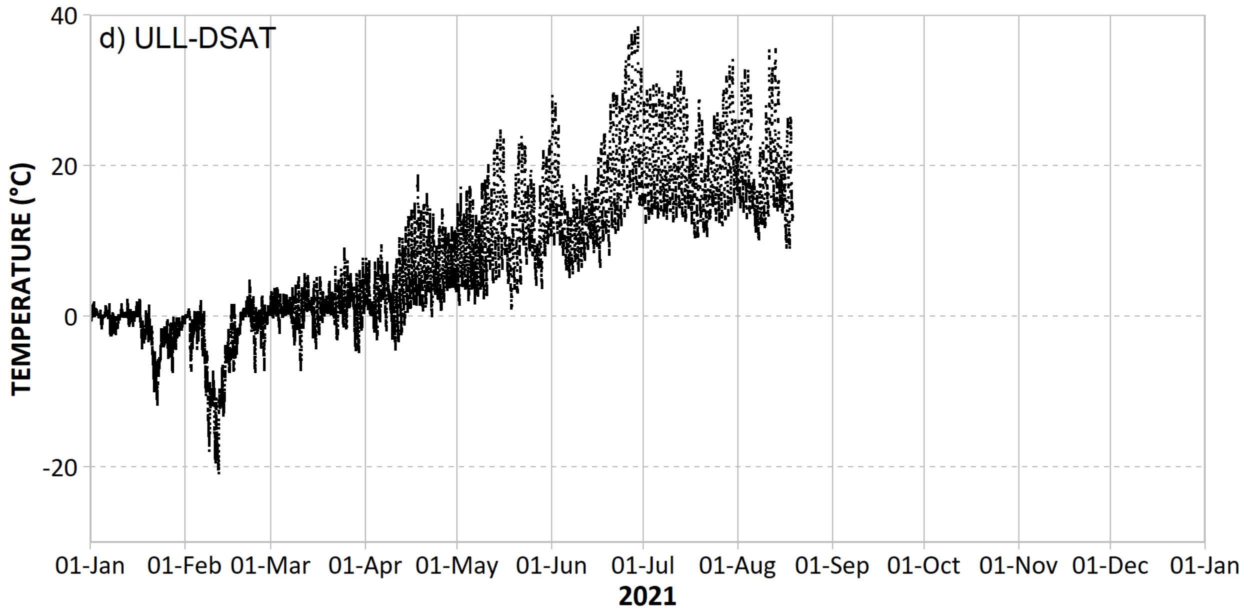
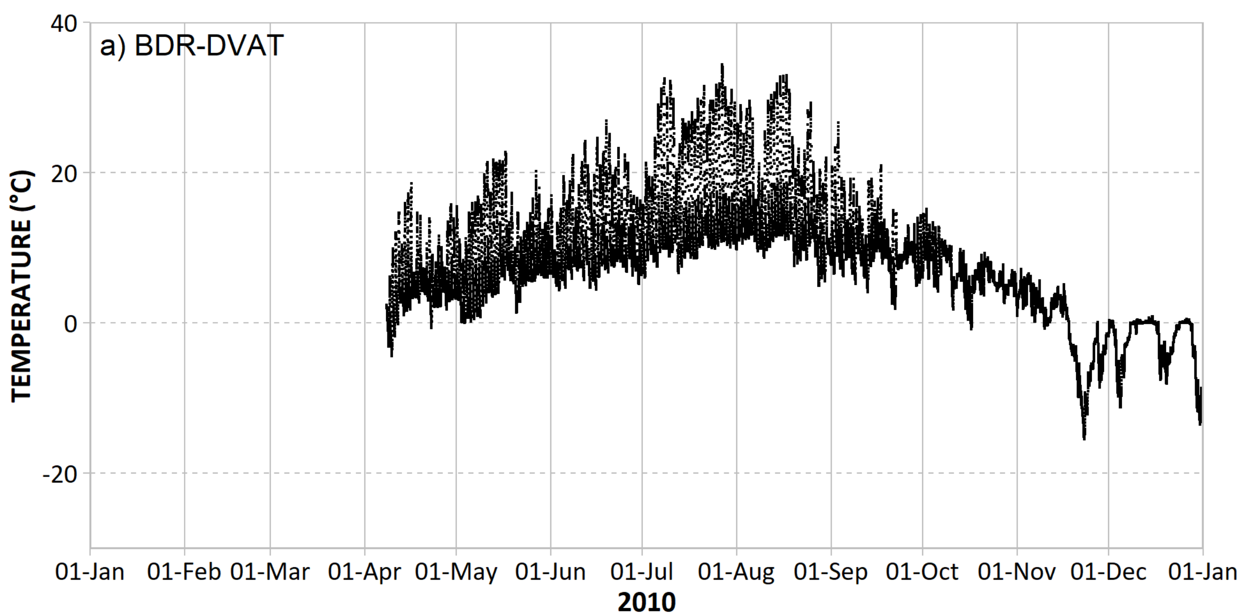


3.2. Boulder Creek

Figure 21. Baseline air temperature at BDR-DVAT from 2010 to 2013. Black dots show air temperature at intervals of 15 minutes.



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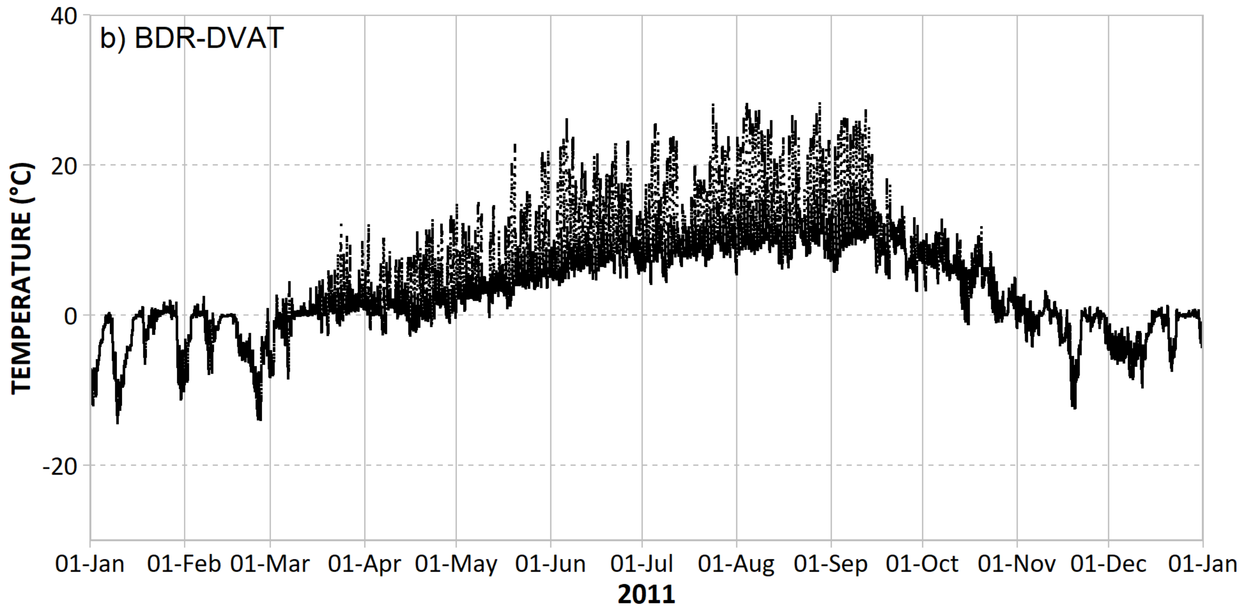


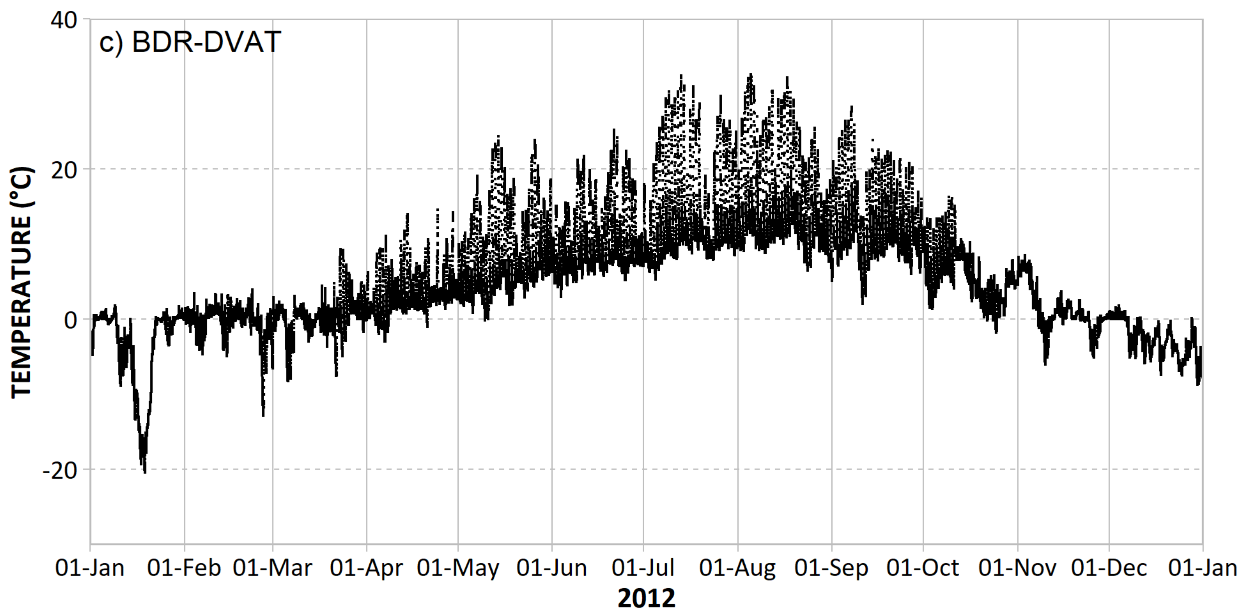


Figure 21. Continued.

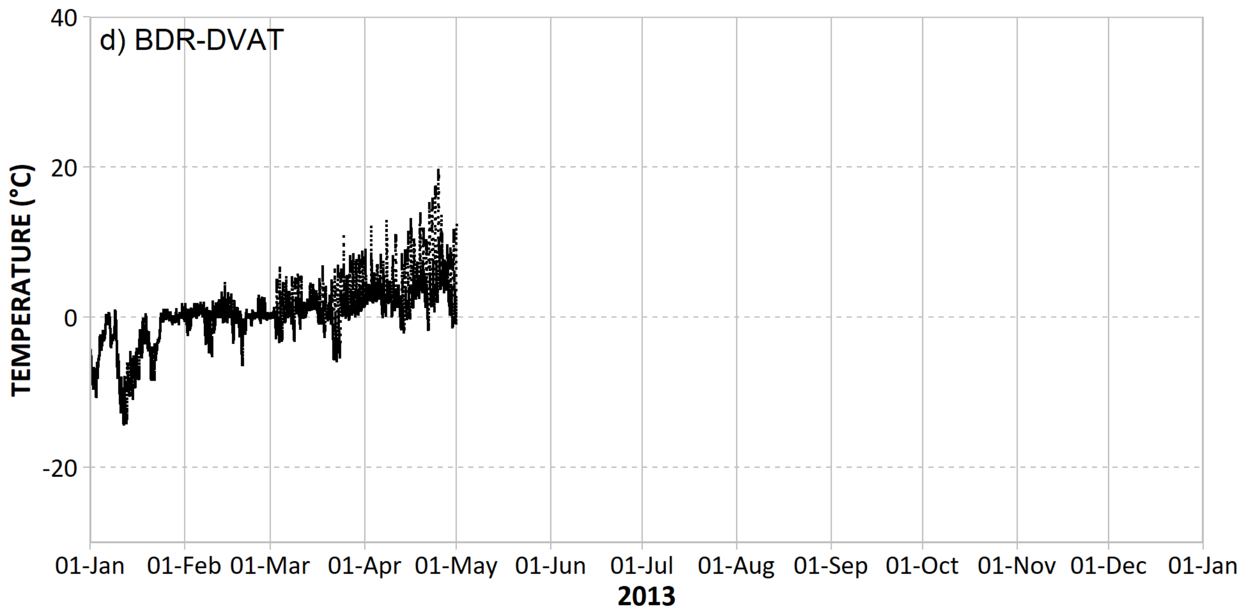


Figure 22. Operational air temperature at BDR-DVAT from 2018 to 2021. Black dots show air temperature at intervals of 15 minutes.

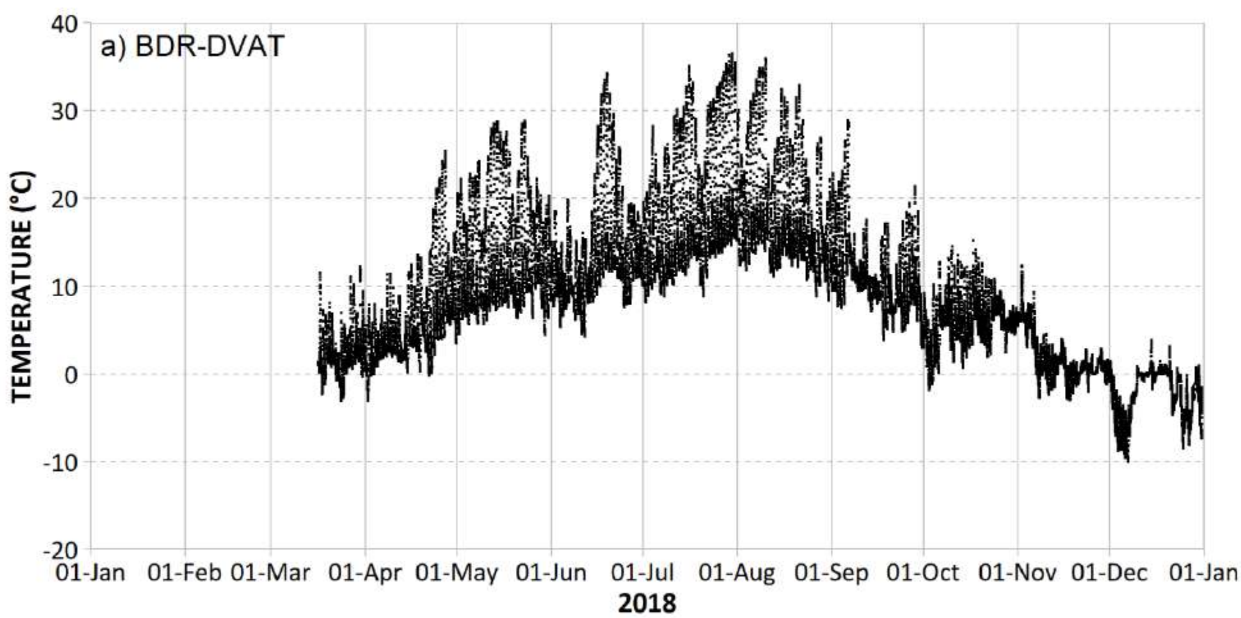
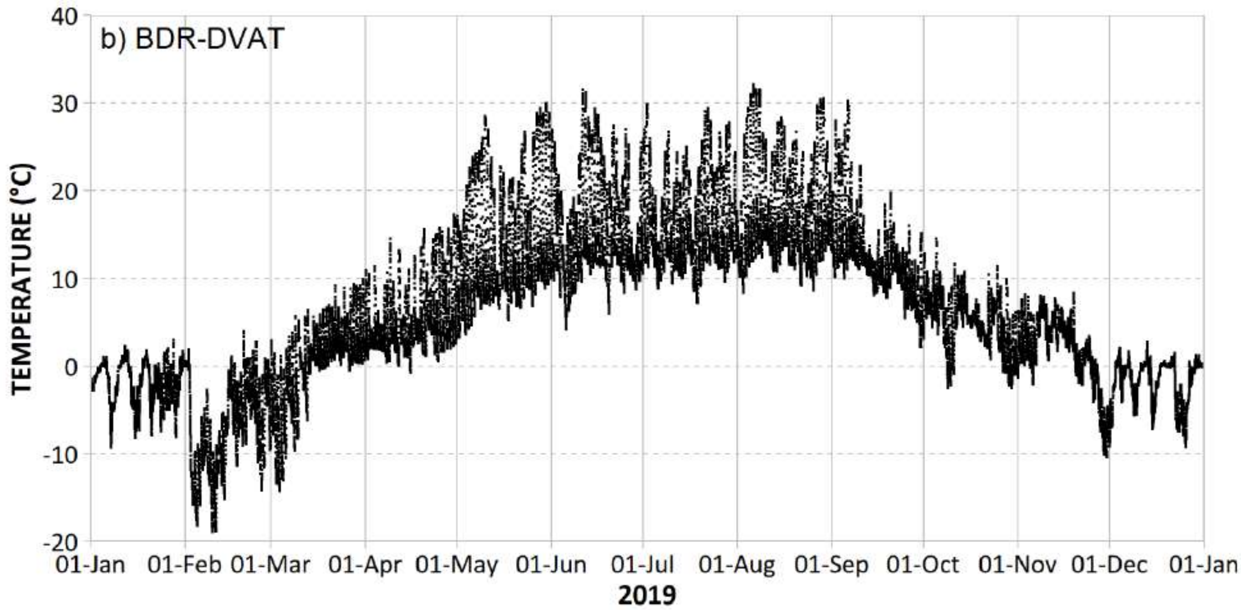


Figure 22. Continued.



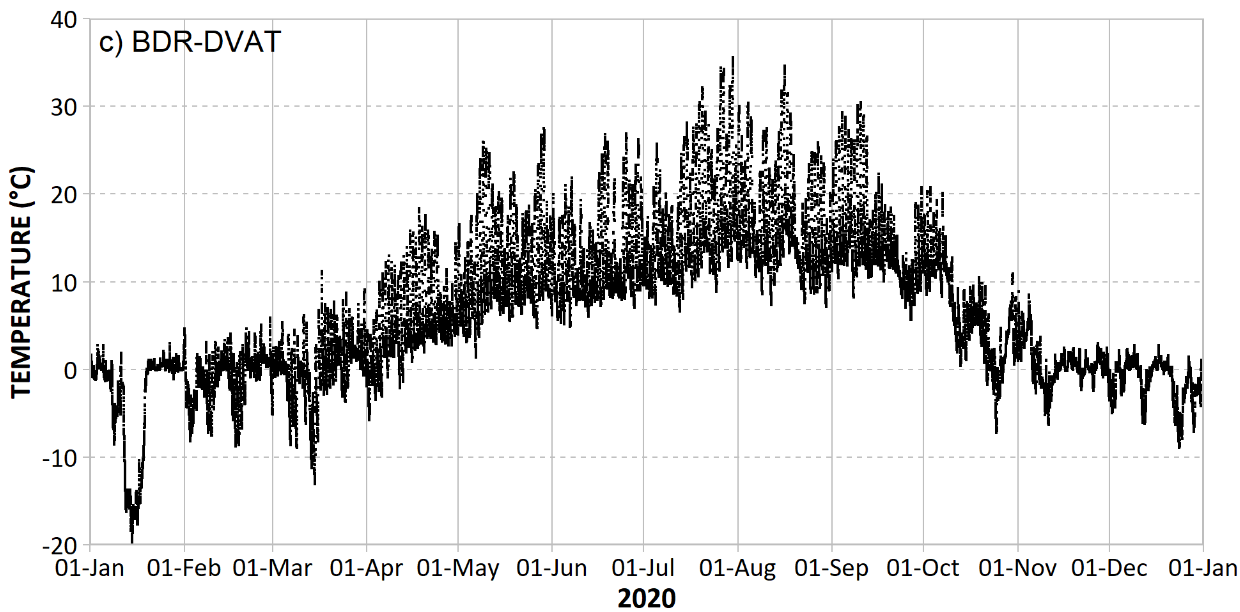
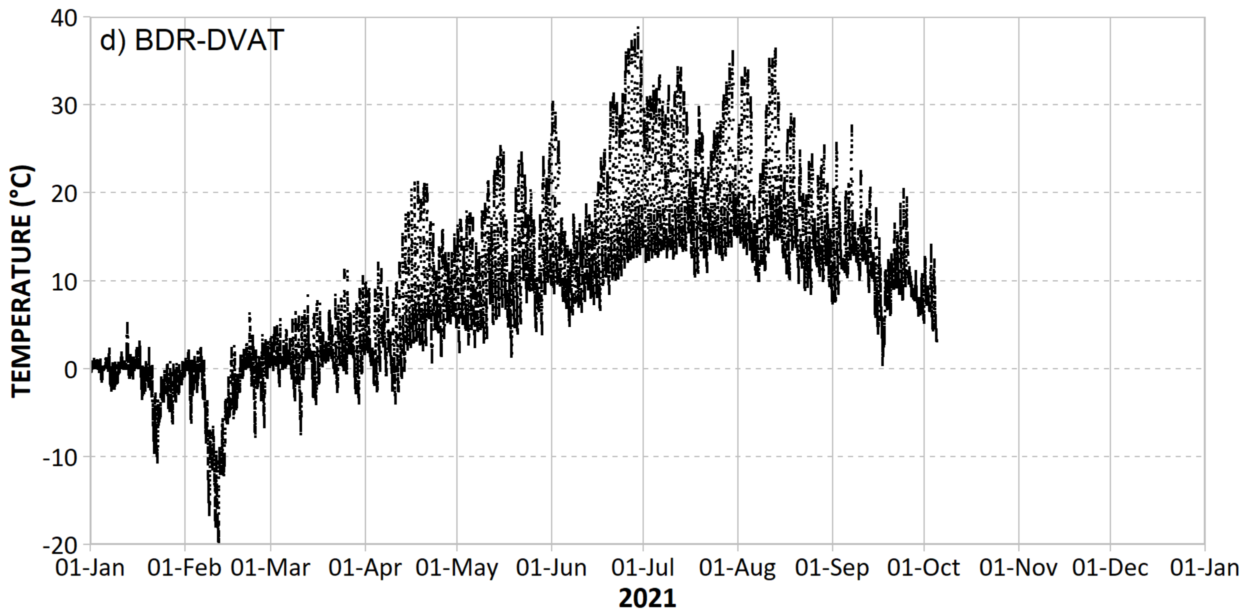


Figure 22. Continued.



4. WATER TEMPERATARUE 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 60 minute intervals. Statistics were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 2. Continued (2 of 2).

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 60 minute intervals. Statistics were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

4.2. Boulder Creek

Table 3. Baseline monthly summary statistics at the upstream (NTH-USWQ1) site in North Creek and upstream (BDR-USWQ) and diversion (BDR-DVWQ) sites in Boulder Creek from 2008 to 2013.

Year	Month	Water Temperature[1] (°C)											
		NTH-USWQ1				BDR-USWQ				BDR-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2008	Nov	-	-	-	-	-	-	-	-	-	-	-	-
	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	4.9	3.3	7.7	0.9	4.7	2.8	6.8	0.6	4.7	2.1	7.2	1.0
	Nov	1.7	0.0	4.7	1.3	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	1.4	0.0	2.3	0.5	1.1	0.0	2.0	0.6

[1] Statistics based on continuous data logged at 60 minute intervals. Statistics were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 3. Continued (2 of 2).

Year	Month	Water Temperature[1] (°C)											
		NTH-USWQ1				BDR-USWQ				BDR-DVWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD
2011	Jan	1.4	0.0	2.7	0.7	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	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	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	2.5	1.2	4.9	0.7	2.6	1.5	4.5	0.5
	May	2.8	1.8	4.8	0.5	2.7	1.3	5.2	0.7	3.3	2.4	6.1	0.6
	Jun	2.8	1.6	4.8	0.5	2.9	1.2	3.9	0.5	4.1	2.3	6.9	0.7
	Jul	3.7	2.5	6.2	0.7	4.1	2.2	7.6	1.0	5.5	3.3	9.0	1.1
	Aug	5.0	2.9	8.2	1.1	5.4	3.0	8.8	1.2	6.8	4.1	10.0	1.3
	Sep	5.6	3.3	8.5	1.1	5.2	3.0	8.4	1.1	6.6	3.9	10.1	1.3
	Oct	3.3	0.2	5.9	1.2	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	0.9	0.0	2.5	0.6	0.8	0.0	2.5	0.7
	Dec	1.2	0.0	2.3	0.5	1.2	0.0	2.3	0.5	0.9	0.0	2.0	0.5
2012	Jan	1.0	0.0	2.4	0.7	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	1.7	0.0	2.9	0.6	1.5	0.0	2.3	0.5
	Mar	1.7	0.0	3.4	0.7	1.7	0.0	3.4	0.7	1.5	0.0	2.6	0.5
	Apr	2.5	0.9	5.0	0.7	2.7	0.9	5.0	0.7	2.6	1.4	4.4	0.5
	May	2.8	1.8	4.9	0.6	3.0	0.7	4.7	0.9	3.7	2.3	6.2	0.7
	Jun	3.2	2.1	5.7	0.6	2.9	0.4	5.1	0.7	4.3	2.2	6.7	0.8
	Jul	4.4	2.8	7.4	1.0	4.7	1.2	8.4	1.3	6.3	3.2	9.8	1.4
	Aug	6.2	4.1	9.5	1.3	6.0	3.8	9.5	1.4	7.6	5.3	10.7	1.3
	Sep	6.1	2.6	9.6	1.3	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	3.5	0.6	6.7	1.4	4.4	1.3	8.1	1.6
	Nov	1.8	0.1	4.7	1.1	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	0.9	0.1	2.2	0.4	0.8	0.1	2.2	0.5
2013	Jan	1.0	0.0	2.2	0.6	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	1.5	0.1	2.6	0.5	1.4	0.3	2.1	0.4
	Mar	1.6	0.1	3.4	0.6	1.6	0.1	3.4	0.6	1.7	0.2	3.5	0.7
	Apr	2.6	0.9	5.4	0.7	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 60 minute intervals. Statistics were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

5. AIR TEMPERATURE MONTHLY STATISTICS – BASELINE

Table 4. 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 data logged at 30-minute intervals and were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

Table 5. Boulder Creek baseline (2010 to 2013) air temperature monthly data summary statistics.

Year	Month	Air Temperature[1] (°C)			
		BDR-DVAT			
		Avg	Min	Max	SD
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
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
	May	-	-	-	-

[1] Statistics based on data logged at 30-minute intervals and were not generated for months with less than three weeks of data. Minimum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in blue. Maximum monthly average and instantaneous temperatures recorded at each site during the baseline monitoring period are shaded in red.

6. DAILY WATER TEMPERATURE SUMMARY FIGURES - BASELINE

Figure 23. Daily mean water temperature collected during baseline monitoring in the Upper Lillooet River (2008 to 2013).

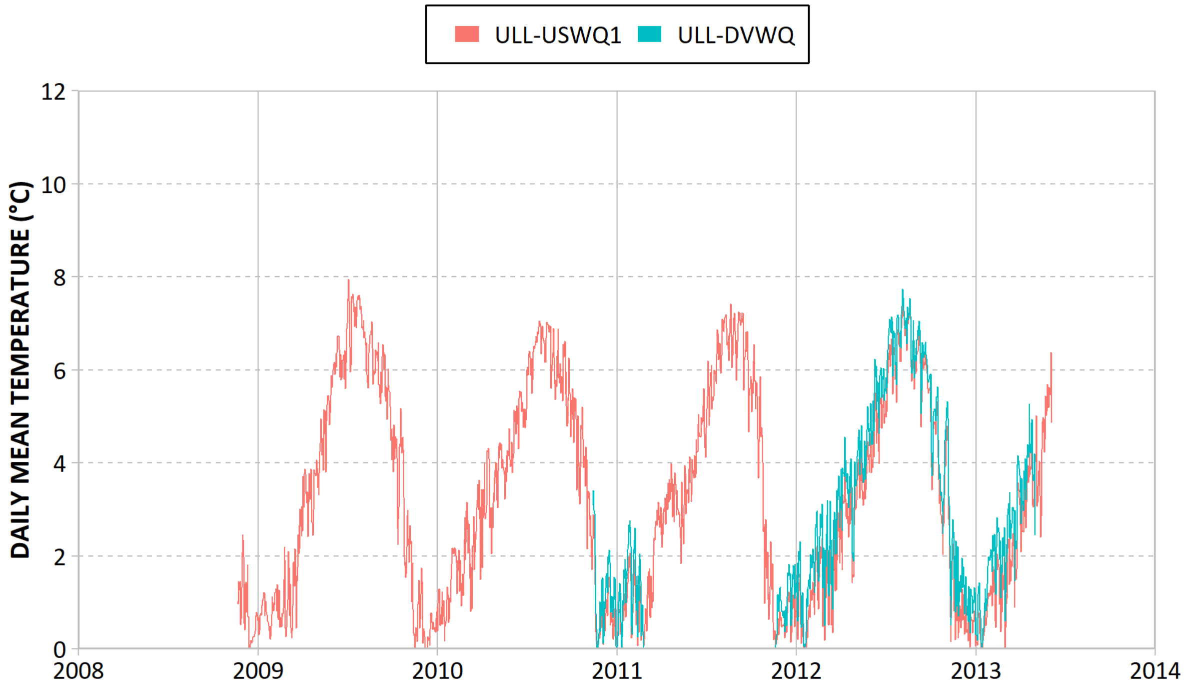
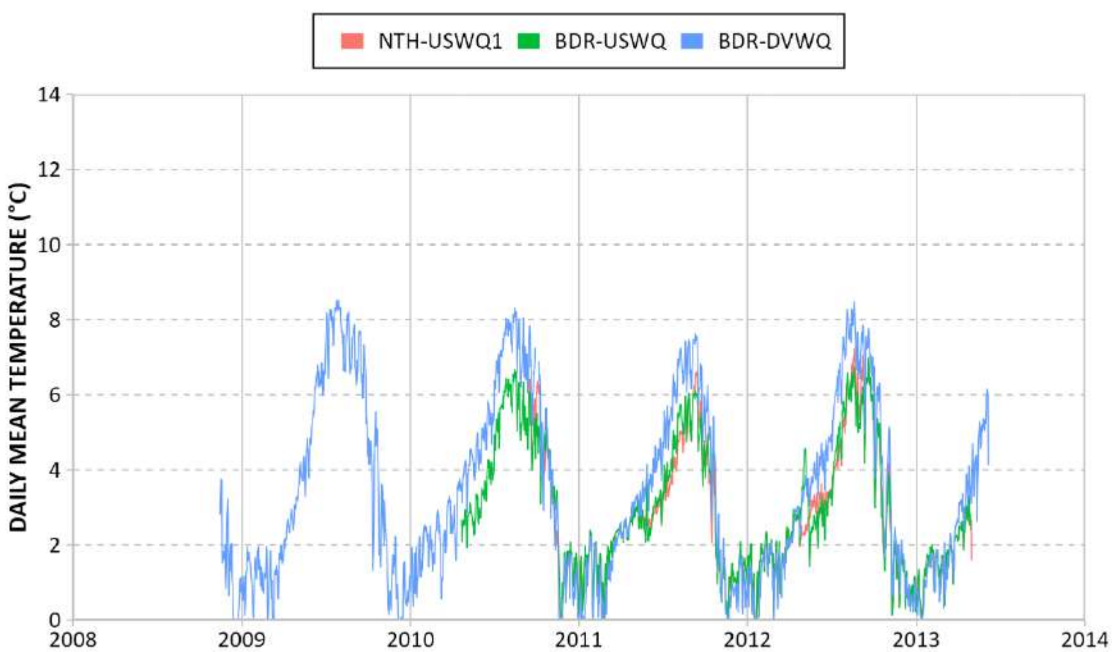


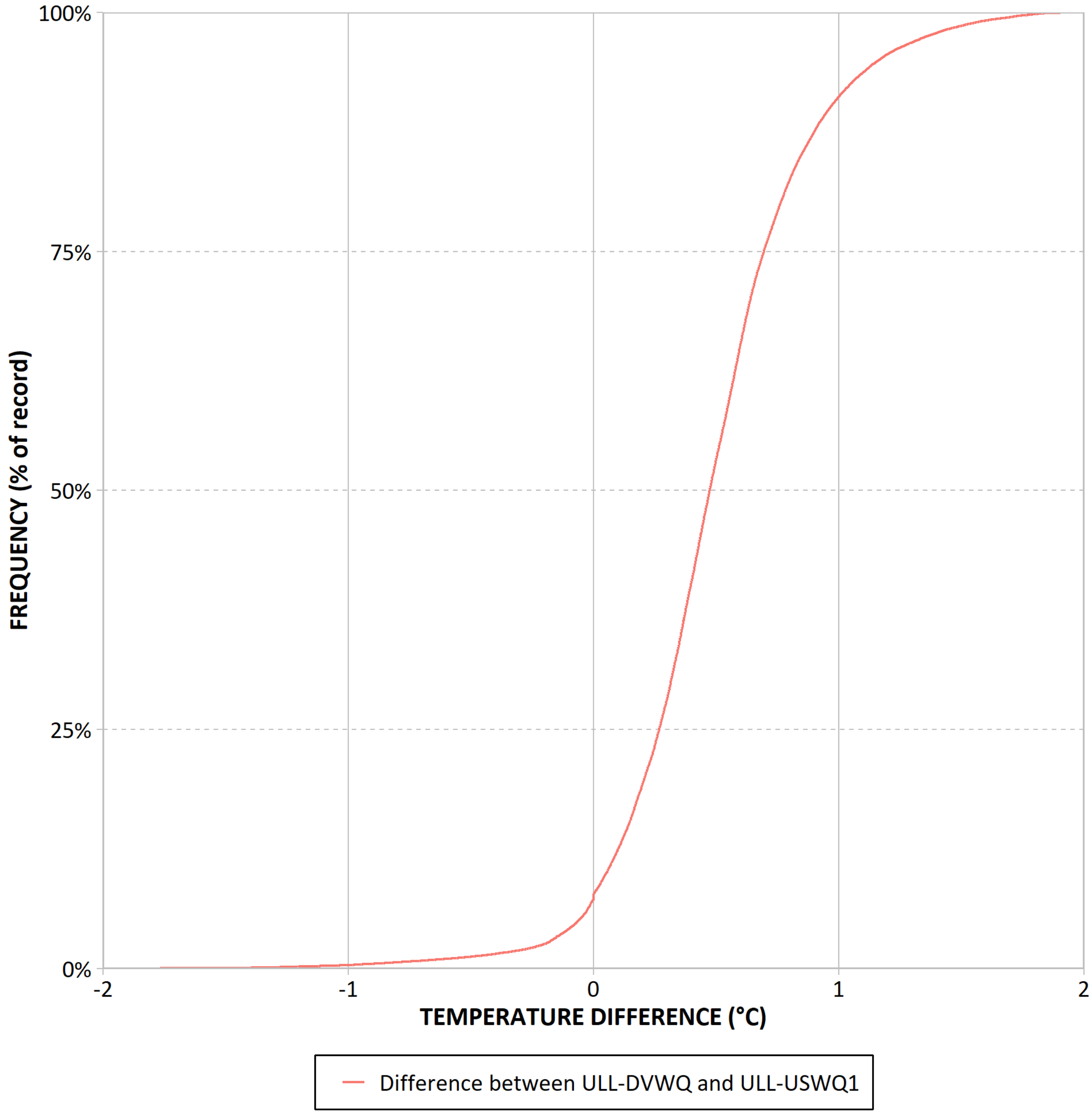
Figure 24. Daily mean water temperature collected during baseline monitoring in Boulder Creek and North Creek (2008 to 2013).



7. INTER-SITE COMPARISON – BASELINE CONDITIONS

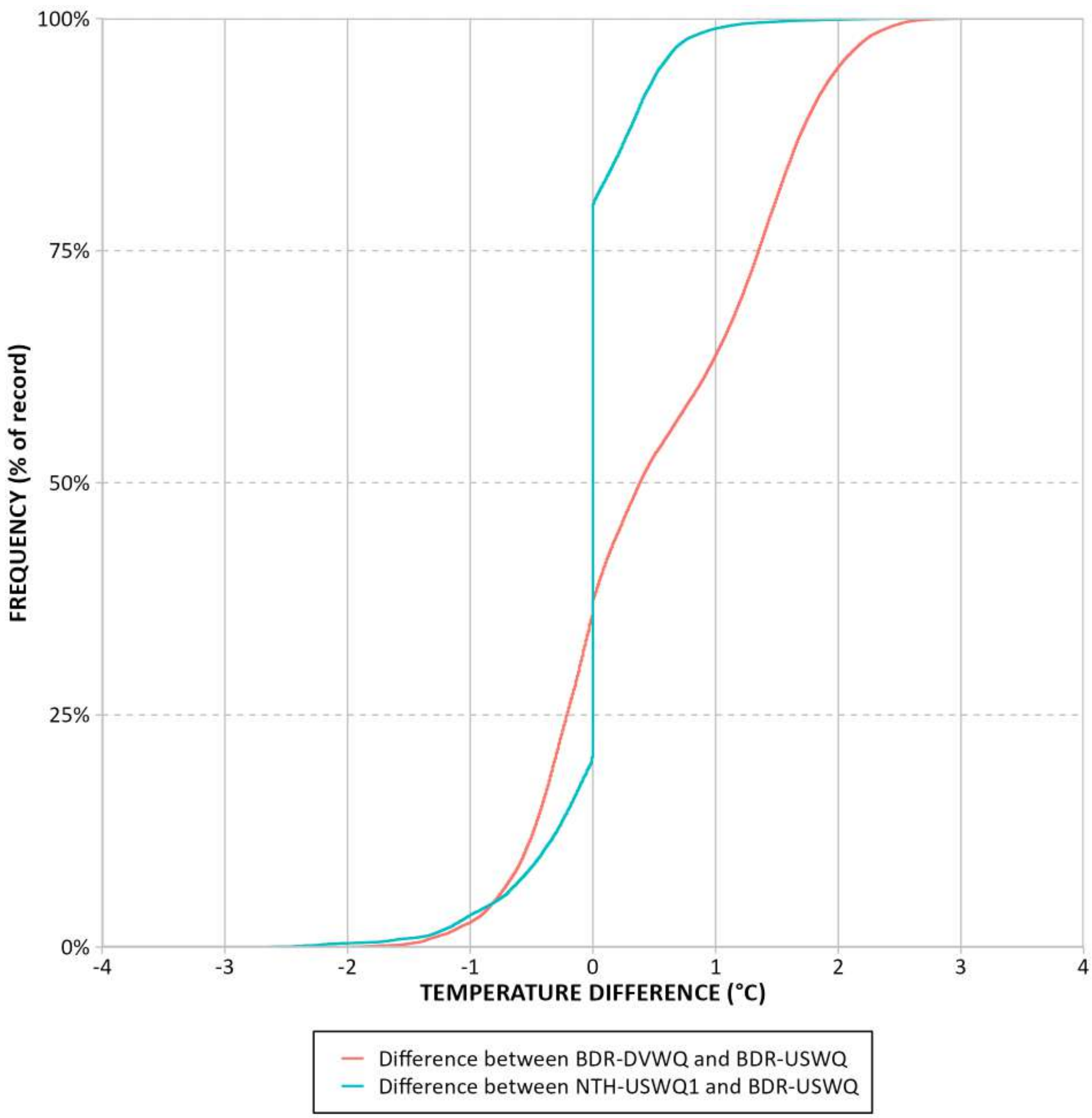
7.1. Upper Lillooet River

Figure 25. 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. Positive values denote that impact sites were warmer than upstream sites and vice versa.



7.2. Boulder Creek

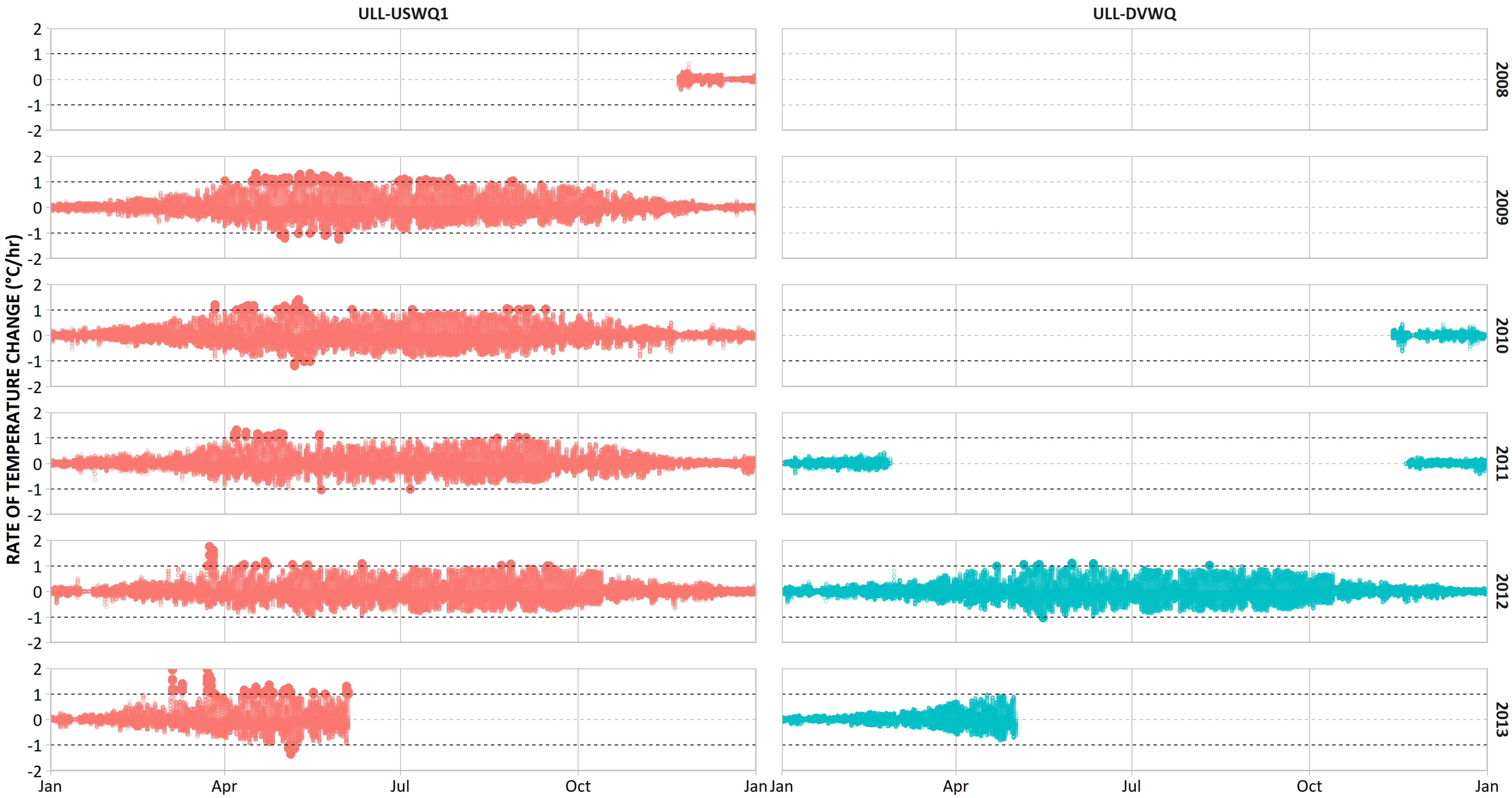
Figure 26. Cumulative frequency distribution of differences in baseline instantaneous water temperature between the upstream control site on Boulder Creek (BDR-USWQ) and the North Creek upstream site (NTH-USWQ1) and the Boulder Creek diversion site (BDR-DVWQ). Positive values denote that impact sites were warmer than upstream sites and vice versa.



8. HOURLY RATE OF WATER TEMPERATURE CHANGE - BASELINE

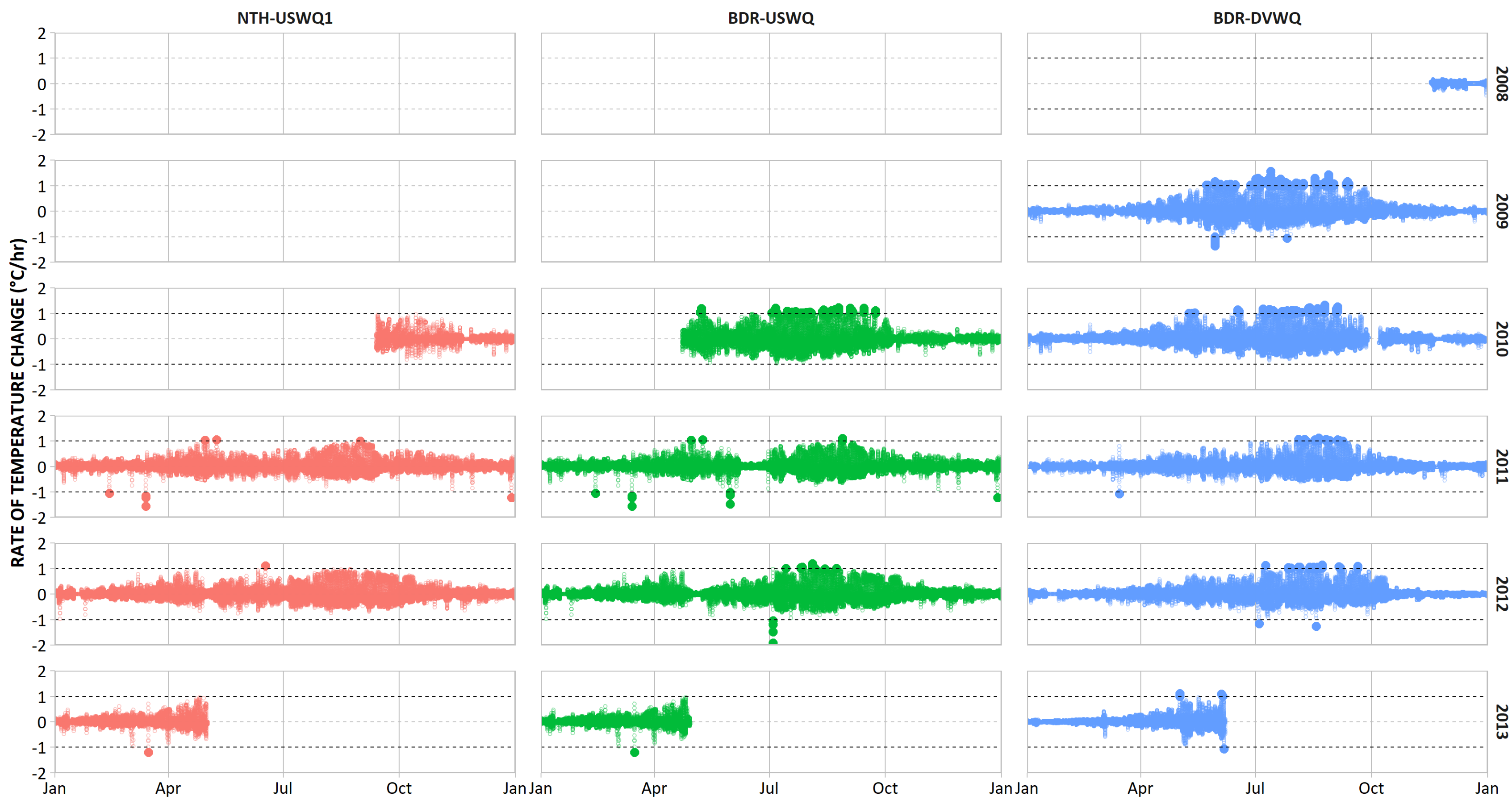
8.1. Upper Lillooet River

Figure 27. 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.



8.2. Boulder Creek

Figure 28. Baseline hourly rate of change in water temperature at the upstream site in nearby North Creek (NTH-USWQ1), and upstream (BDR-USWQ) and diversion (BDR-DVWQ) water temperature monitoring sites in Boulder Creek from 2008 to 2013.



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Appendix E. Upper Lillooet Hydro Project Standard Operating Procedure: Harlequin Duck Spot Check Protocol

UPPER LILLOOET HYDRO PROJECT

STANDARD OPERATING PROCEDURE

Harlequin Duck Spot Check Protocol

TABLE OF CONTENTS

LIST OF FIGURES .... **II**

LIST OF TABLES .... **II**

1. INTRODUCTION **1**

2. SPOT CHECK METHODS **1**

2.1. LOCATIONS 1
2.2. TIMING 4
2.2.1. Pre-incubation (May) *4*
2.2.2. Brood-rearing (August 1 – August 30) *4*
2.3. WHAT TO RECORD 4
2.4. EQUIPMENT REQUIRED 5

3. HARLEQUIN DUCK FACT SHEET **7**

3.1. PHYSICAL DESCRIPTION 7
3.2. LIFE HISTORY 7
3.3. HABITAT 8

4. OTHER WATERFOWL COMMON IN HEADPONDS **8**

4.1. BARROW'S GOLDENEYE AND COMMON GOLDENEYE 8
4.2. BUFFLEHEAD 8
4.3. COMMON MERGANSER 9

LIST OF FIGURES

Figure 1. View of ULL-HADU01a on April 30, 2018..2
Figure 2. View of ULL-HADU01b on May 31, 2018..3
Figure 3. View of ULL-HADU02 on May 3, 2018...3

LIST OF TABLES

Table 1. Harlequin Duck monitoring points at the intake..2
Table 2. Harlequin Duck spot check datasheet...6

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


Female with brood

- 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.

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

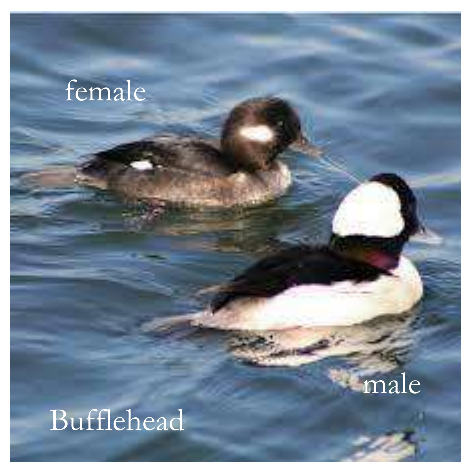
- Can be distinguished from Harlequin Ducks by their orange bills and dark grey bodies which contrast with their brown heads. (Harlequin Duck females and juveniles have uniformly brown bodies and heads.)

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 F. Water Temperature QA/QC Figures, 2021

LIST OF FIGURES

Figure 1. Spot temperature QA/QC plots for ULL-DVWQ and ULL-DVWQ01............................1

Figure 2. Spot temperature QA/QC plots for ULL-USWQ02 and ULL-USWQ03..........................4

Figure 3. Spot temperature QA/QC plots for ULL-TAILWQ...5

Figure 4. Spot temperature QA/QC plots for ULL-DSWQ. 6

Figure 5. Spot temperature QA/QC plots for BDR-DVWQ...8

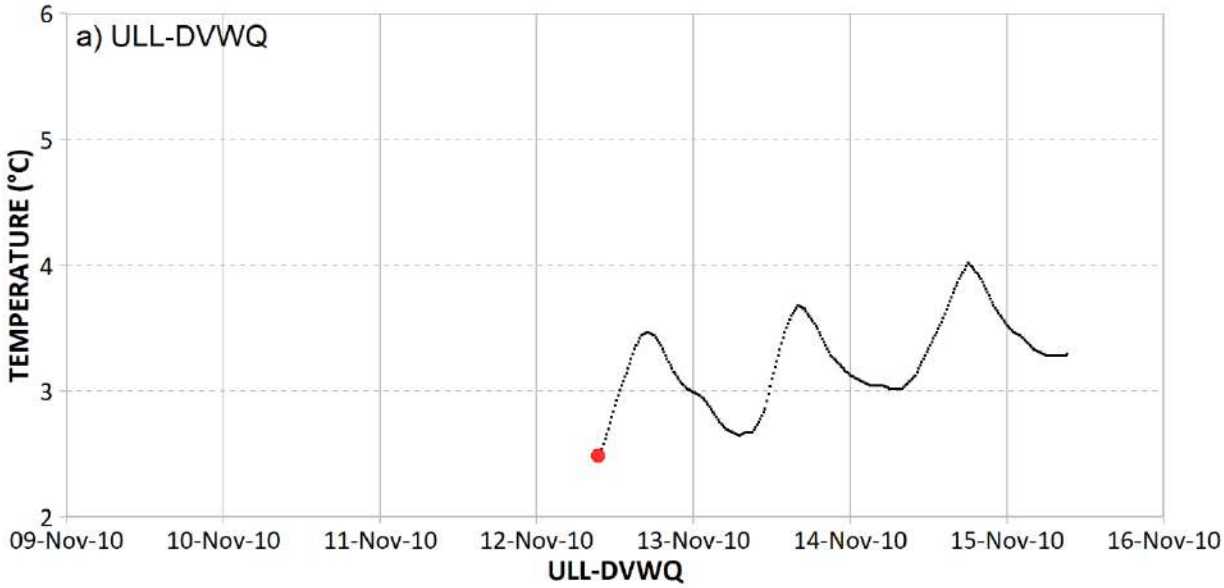
Figure 6. Spot temperature QA/QC plots for BDR-TAILWQ. 9

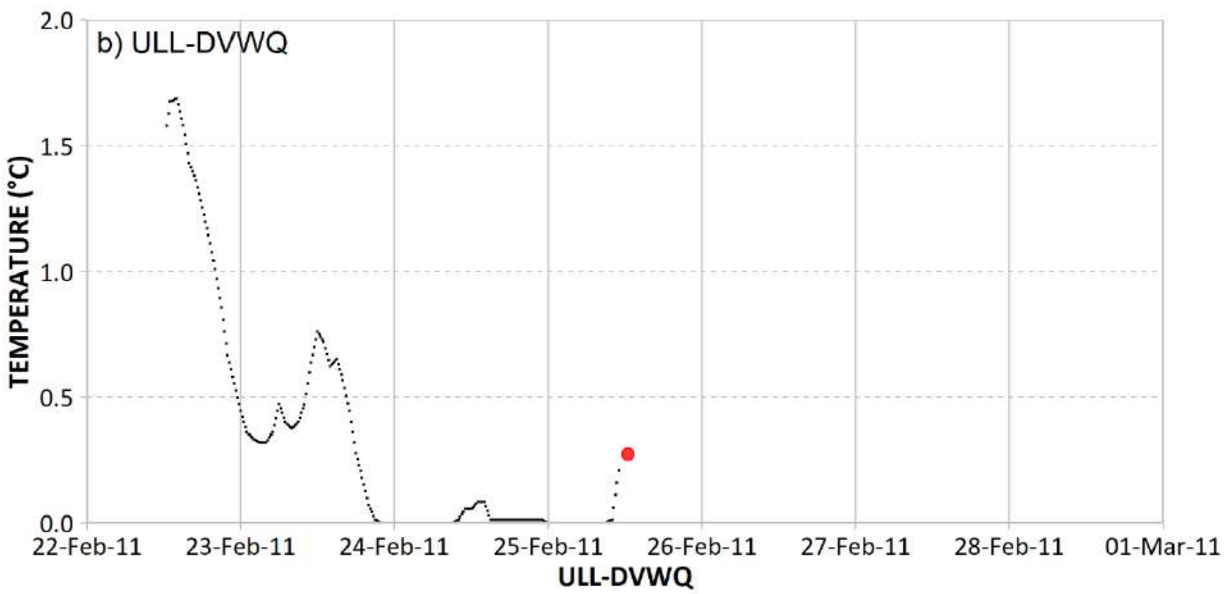
Figure 7. Spot temperature QA/QC plots for BDR-DSWQ..10

1. QA/QC SPOT TEMPERATURE MEASUREMENTS

1.1. Upper Lillooet River

Figure 1. Spot temperature QA/QC plots for ULL-DVWQ and ULL-DVWQ01.





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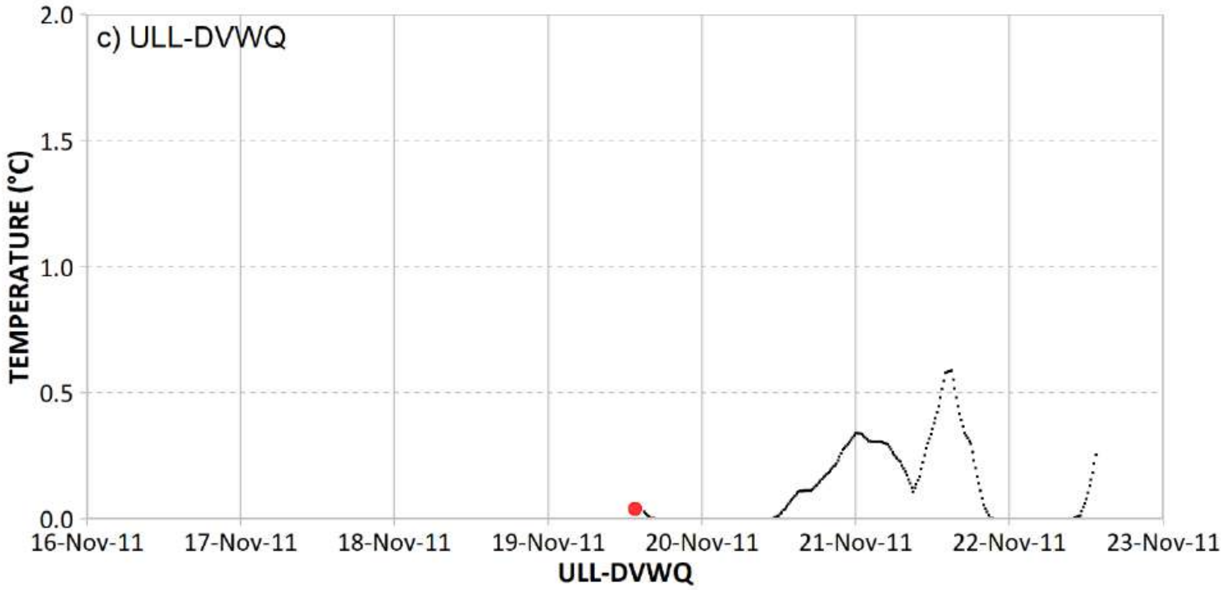


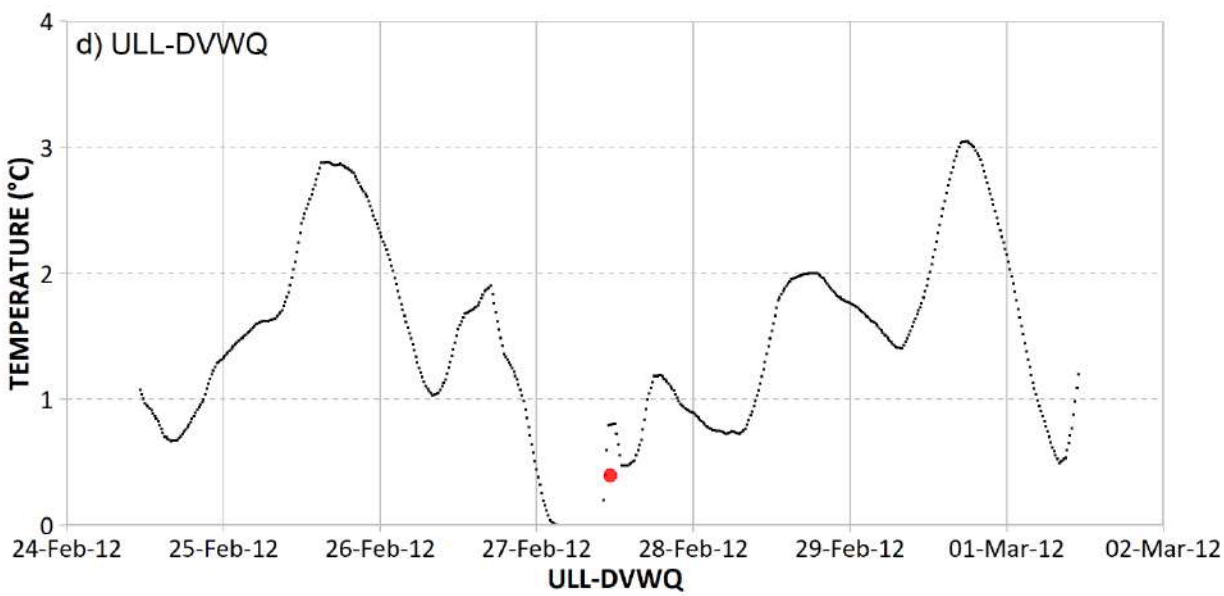
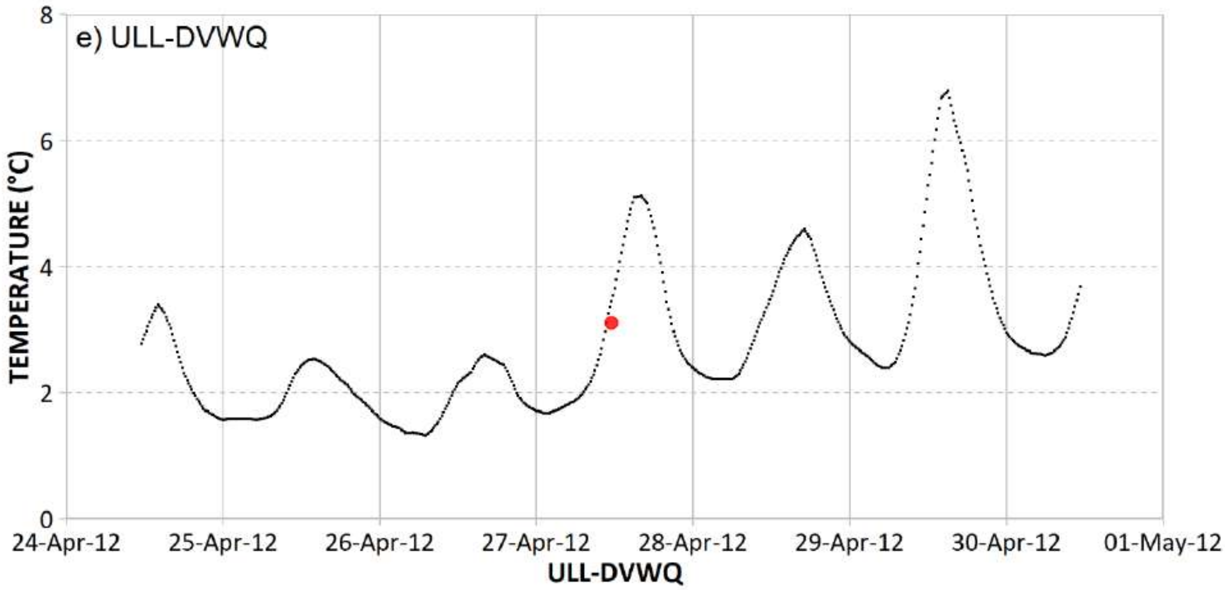


Figure 1. Continued.



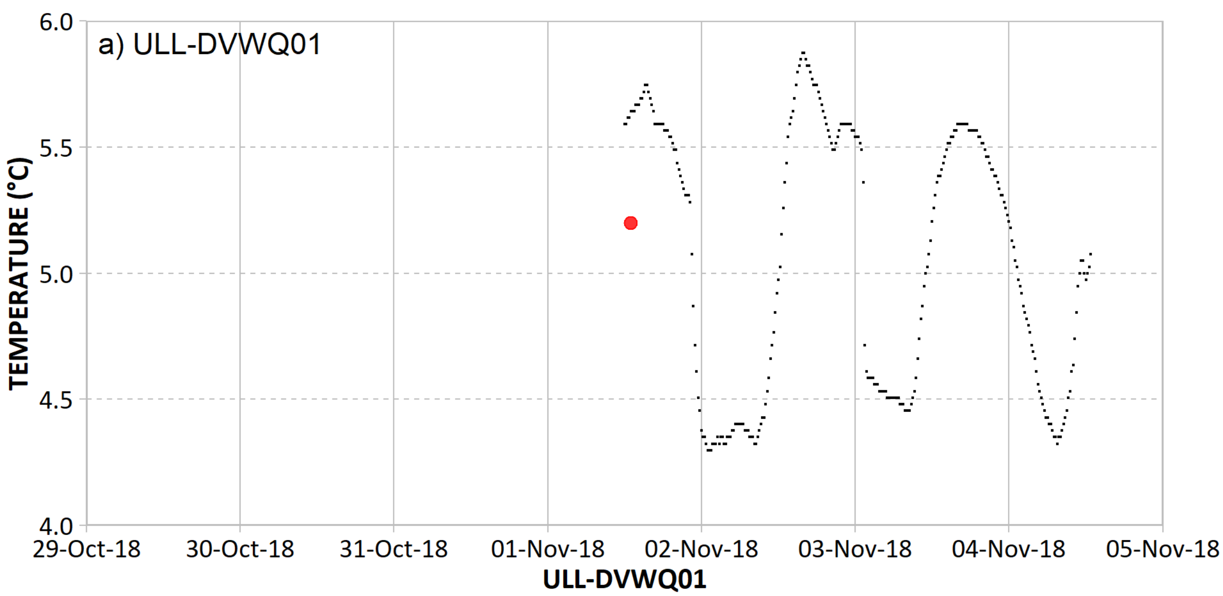
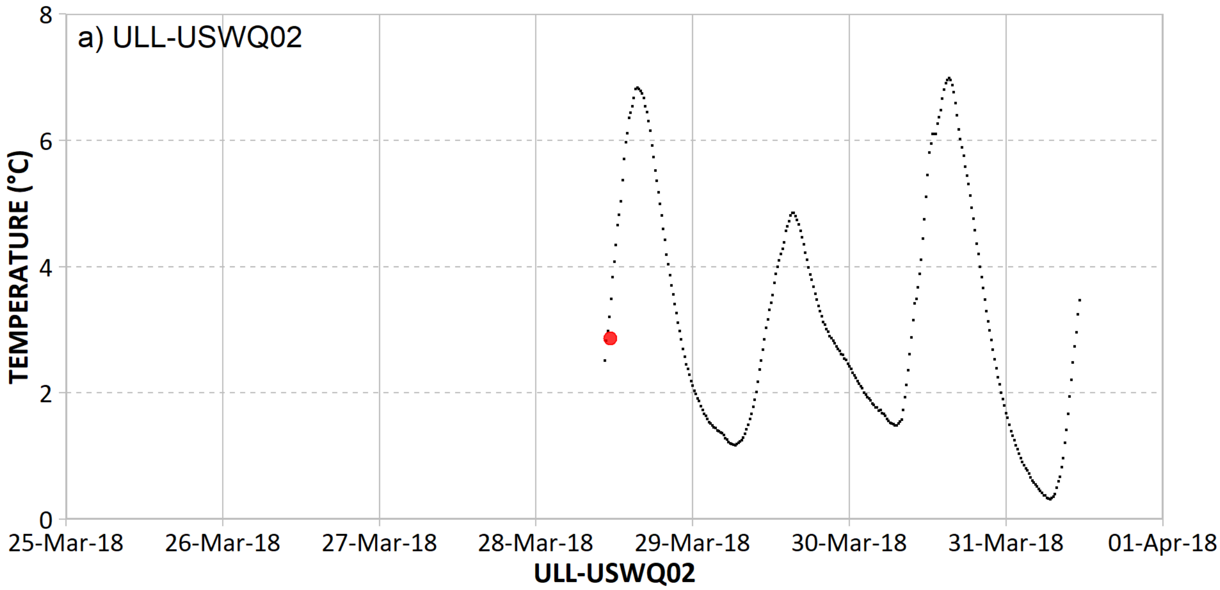


Figure 2. Spot temperature QA/QC plots for ULL-USWQ02 and ULL-USWQ03.



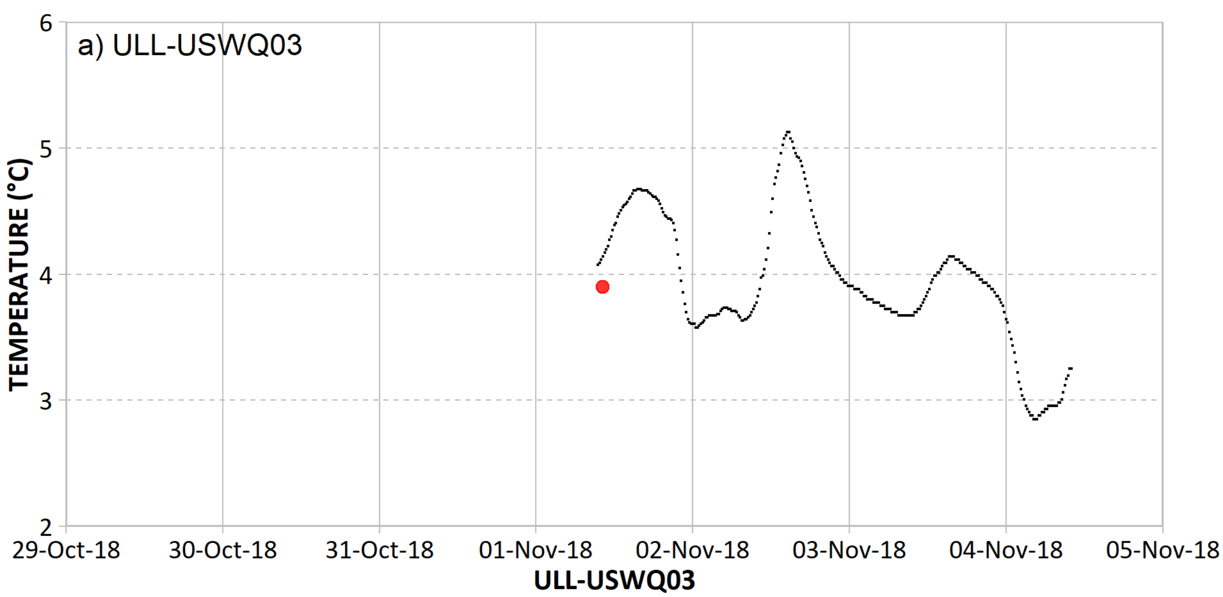
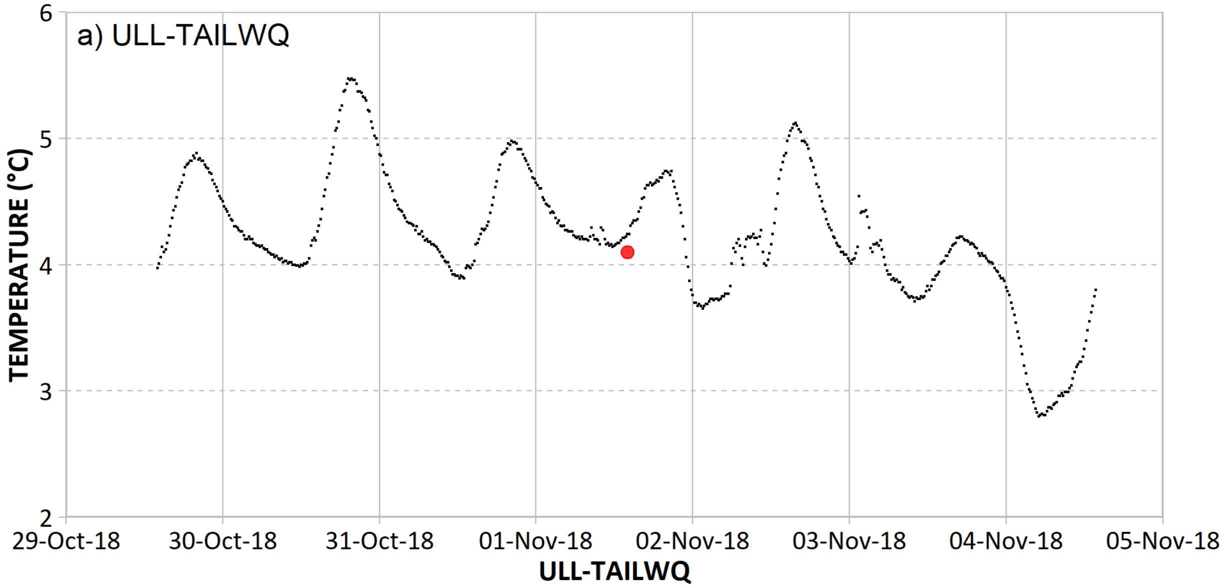


Figure 3. Spot temperature QA/QC plots for ULL-TAILWQ.



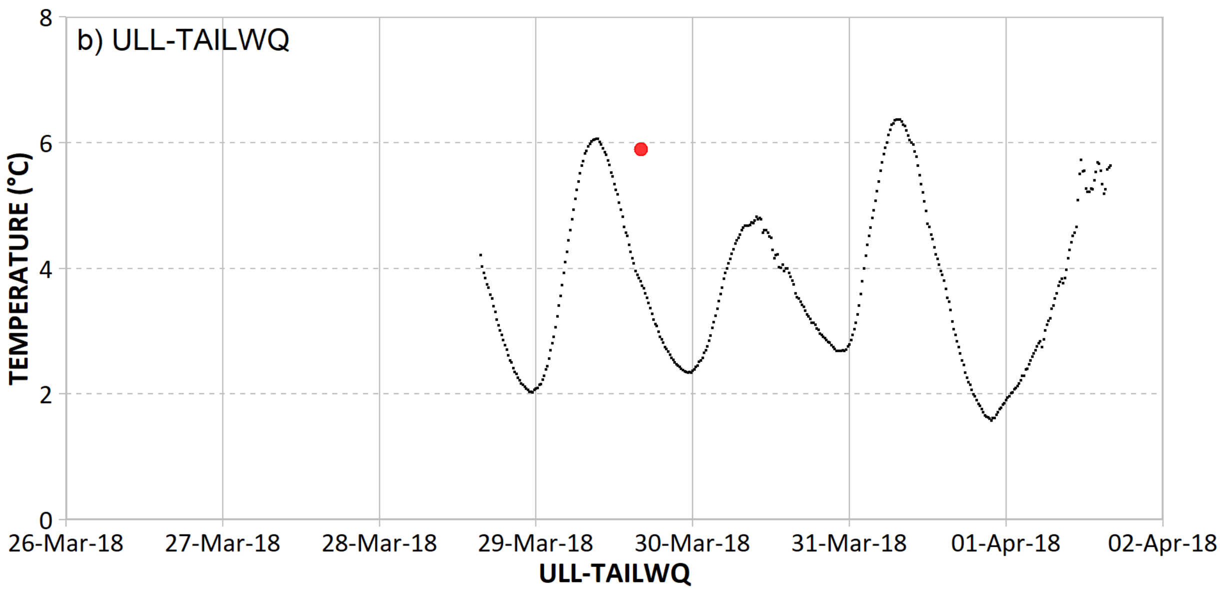
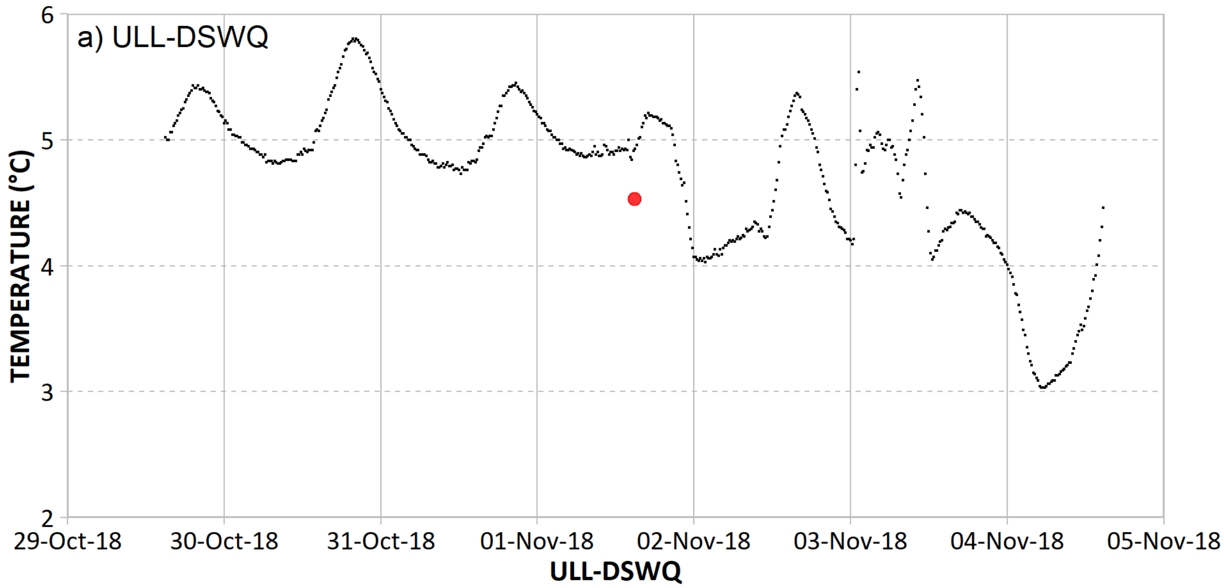
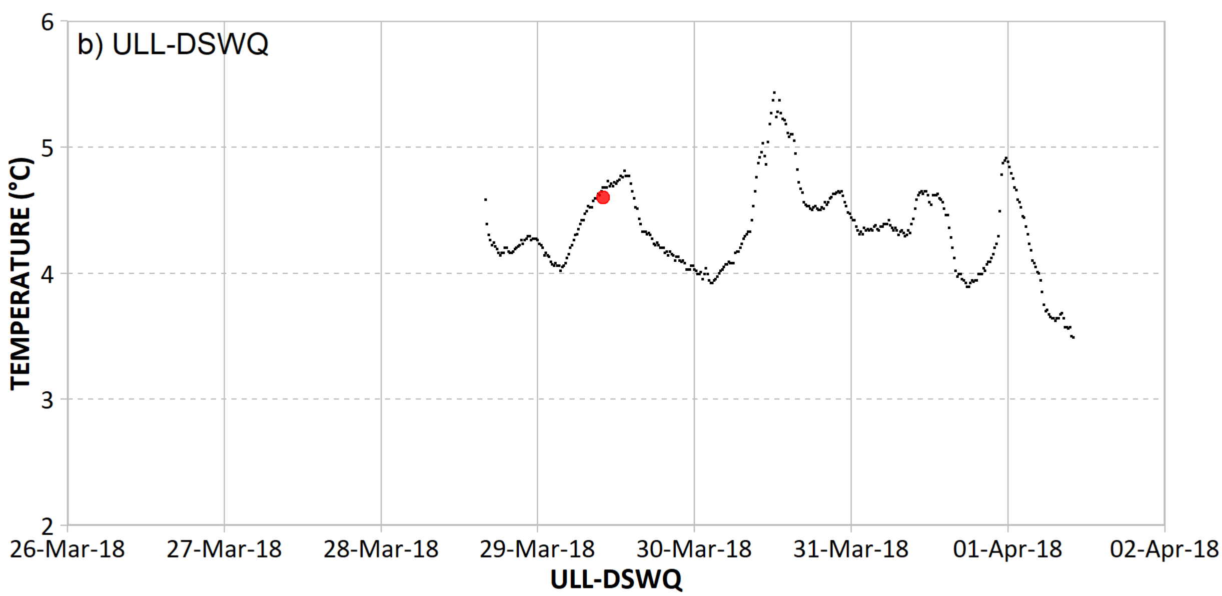
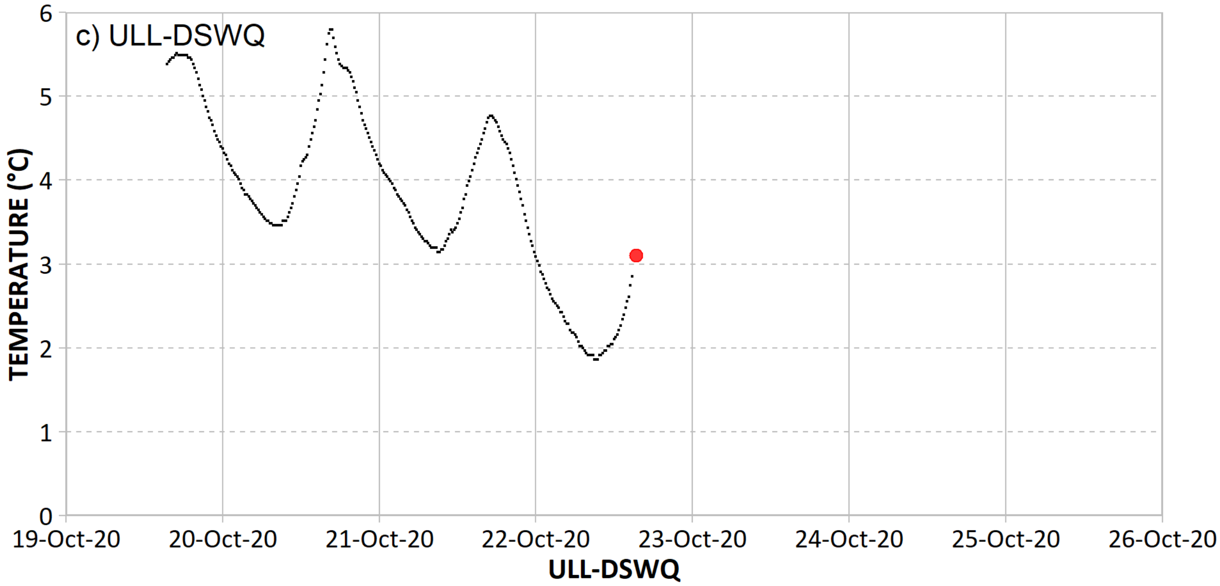


Figure 4. Spot temperature QA/QC plots for ULL-DSWQ.

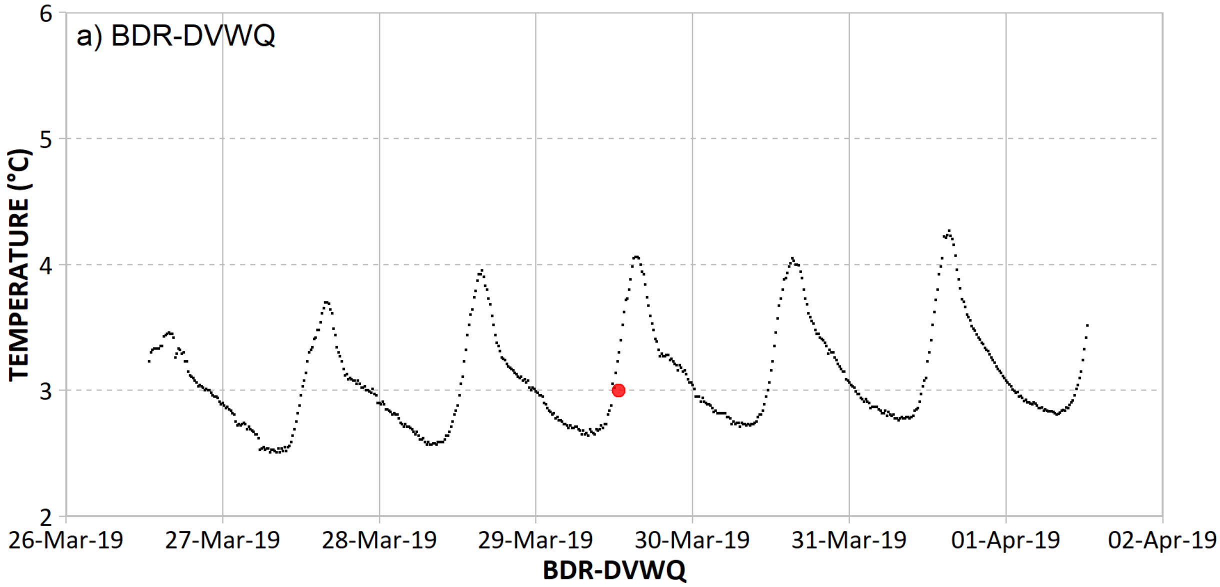





c) ULL-DSWQ
TEMPERATURE (°C)
0
1
2
3
4
5
6
19-Oct-20
20-Oct-20
21-Oct-20
22-Oct-20
23-Oct-20
24-Oct-20
25-Oct-20
26-Oct-20
ULL-DSWQ

1.2. Boulder Creek

Figure 5. Spot temperature QA/QC plots for BDR-DVWQ.



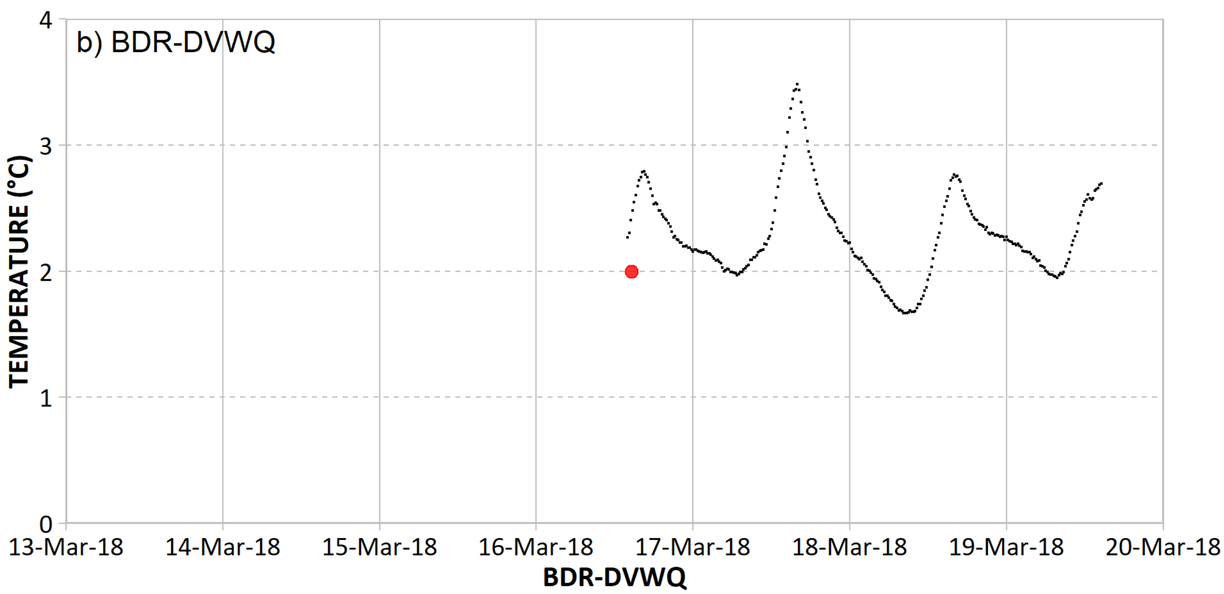
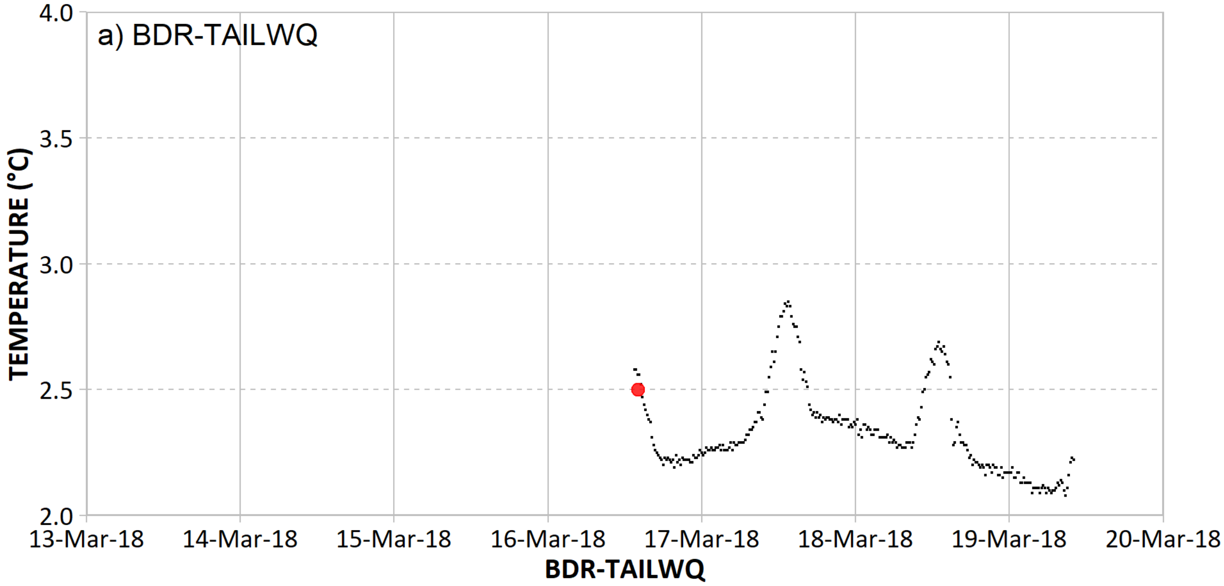


Figure 6. Spot temperature QA/QC plots for BDR-TAILWQ.



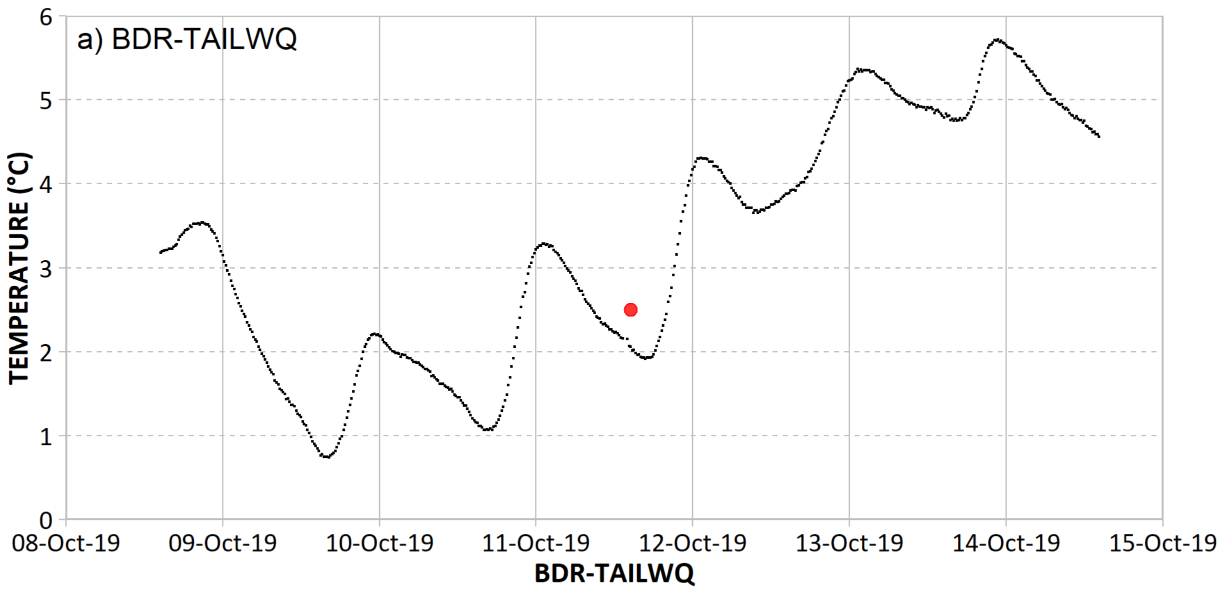
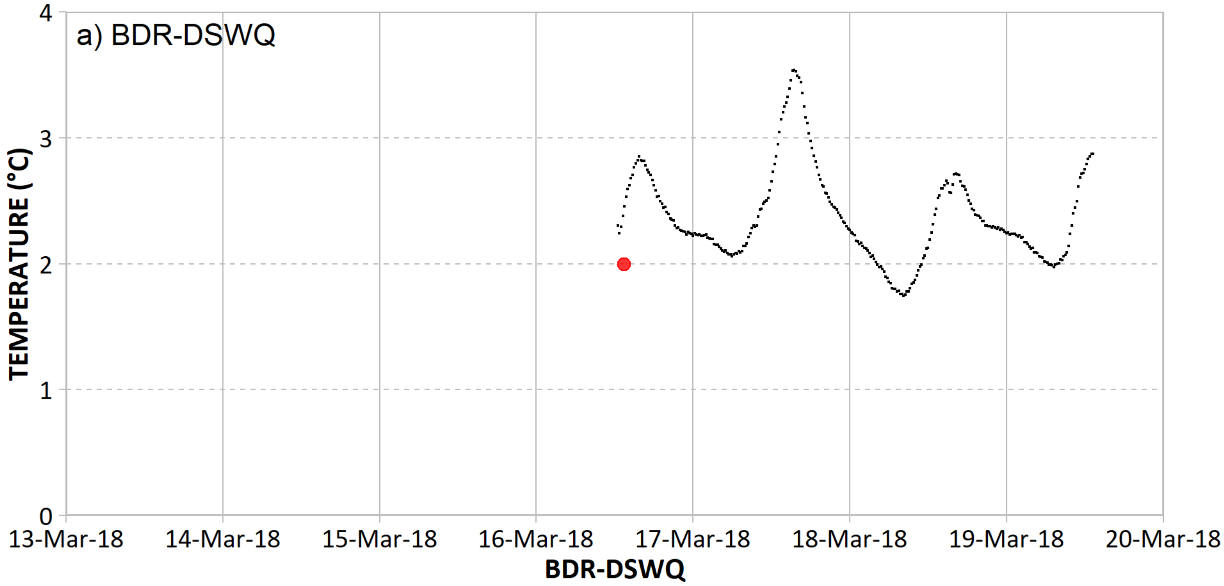


Figure 7. Spot temperature QA/QC plots for BDR-DSWQ.



Appendix G. Angling Site Representative Photographs, Site Conditions Summary, and Individual Fish Data

LIST OF FIGURES

Figure 1. Looking upstream at BDR-DVAG01 on October 5, 2021 ... 1
Figure 2. Looking downstream at BDR-DVAG04 on October 5, 2021. ... 1
Figure 3. Looking upstream at BDR-DVAG05 on September 13, 2021. ... 2
Figure 4. Looking downstream from river right at BDR-TRAG01 on September 13, 2021. ... 2
Figure 5. Looking upstream at BDR-DSAG01 on September 13, 2021. ... 3
Figure 6. Looking downstream at BDR-DSAG02 on October 5, 2021. ... 3
Figure 7. Looking upstream at BDR-DSAG06 on September 13, 2021. ... 4
Figure 8. Looking upstream at ULL-DVAG15 on September 15, 2021. ... 4
Figure 9. Looking upstream at ULL-DVAG16 on September 15, 2021. ... 5
Figure 10. Looking from river right to river left at ULL-TRAG01 on September 15, 2021. ... 5
Figure 11. Looking upstream at ULL-DSAG08 on October 21, 2021. ... 6
Figure 12. Looking downstream at ULL-DSAG10 on September 15, 2021 ... 6
Figure 13. Looking downstream at NTH-DSAG01 on October 06, 2021. ... 7
Figure 14. Looking river right to river left at NTH-DSAG05 on October 20, 2021 ... 7
Figure 15. Looking downstream at NTH-DSAG06 on October 20, 2021. ... 8
Figure 16. Looking upstream at NTH-DVAG04 on October 20, 2021. ... 8
Figure 17. Looking upstream at NTH-DVAG05 on October 20, 2021. ... 9
Figure 18. Looking upstream at NTH-DVAG06 on October 20, 2021. ... 9

LIST OF TABLES

Table 1. Summary of angling sites in Boulder Creek in fall 2021. 10

Table 2. Summary of angling sites in Lillooet River in fall 2021. 11

Table 3. Summary of angling sites in North Creek in fall 2021. 12

Table 4. Summary of all fish captured during angling in Boulder Creek in fall 2021. 13

Table 5. Summary of all fish captured during angling in Lillooet River in fall 2021. 15

Table 6. Summary of all fish captured during angling in North Creek in fall 2021. 16

Figure 1. Looking upstream at BDR-DVAG01 on October 5, 2021.

Figure 2. Looking downstream at BDR-DVAG04 on October 5, 2021.

Figure 3. Looking upstream at BDR-DVAG05 on September 13, 2021.

Figure 4. Looking downstream from river right at BDR-TRAG01 on September 13, 2021.

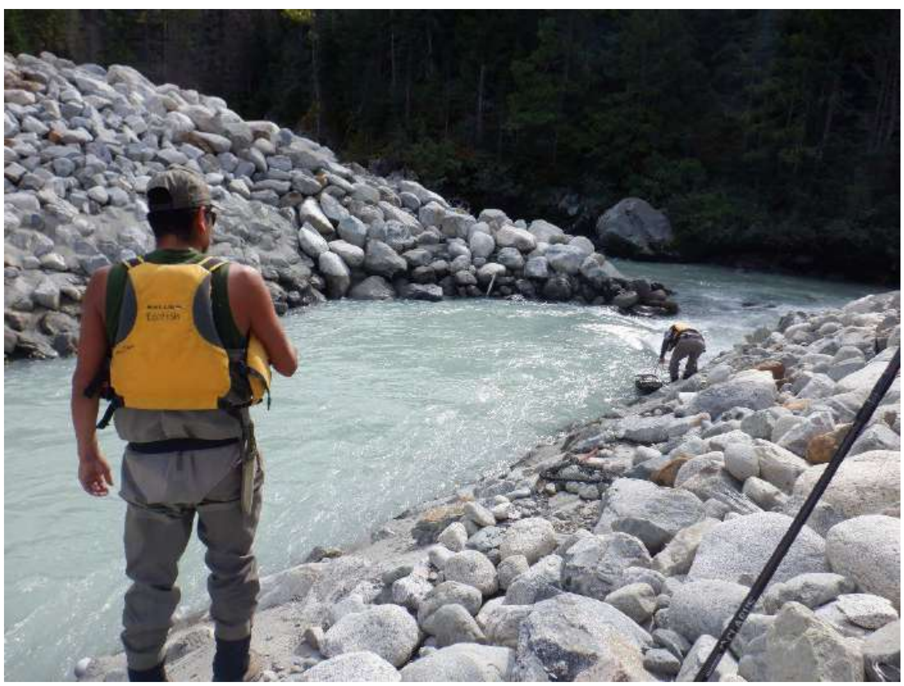


Figure 5. Looking upstream at BDR-DSAG01 on September 13, 2021.

Figure 6. Looking downstream at BDR-DSAG02 on October 5, 2021.

Figure 7. Looking upstream at BDR-DSAG06 on September 13, 2021.

Figure 8. Looking upstream at ULL-DVAG15 on September 15, 2021.

Figure 9. Looking upstream at ULL-DVAG16 on September 15, 2021.

Figure 10. Looking from river right to river left at ULL-TRAG01 on September 15, 2021.

Figure 11. Looking upstream at ULL-DSAG08 on October 21, 2021.

Figure 12. Looking downstream at ULL-DSAG10 on September 15, 2021.

Figure 13. Looking downstream at NTH-DSAG01 on October 06, 2021.

Figure 14. Looking river right to river left at NTH-DSAG05 on October 20, 2021.

Figure 15. Looking downstream at NTH-DSAG06 on October 20, 2021.

Figure 16. Looking upstream at NTH-DVAG04 on October 20, 2021.

Figure 17. Looking upstream at NTH-DVAG05 on October 20, 2021.

Figure 18. Looking upstream at NTH-DVAG06 on October 20, 2021.

Table 1. Summary of angling sites in Boulder Creek in fall 2021.

Site	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	13-Sep	9.5	34.0	11.5	3.0	391	102	25
		05-Oct	4.1	34.0	18.0	5.0	612	170	20
		20-Oct	4.6	34.0	11.5	4.0	391	544	30
BDR-DSAG02	Cascade	13-Sep	9.5	12.0	11.5	3.0	138	36	25
		05-Oct	4.1	15.0	19.0	6.0	285	90	20
		20-Oct	4.6	12.0	12.0	4.0	144	48	30
BDR-DSAG06	Cascade	13-Sep	6.7	22.5	11.0	11.0	248	248	60
		05-Oct	4.4	29.0	10.0	3.0	290	87	30
		19-Oct	3.3	25.5	9.5	6.0	242	153	60
BDR-DVAG01	Cascade/Pool	05-Oct	5.1	33.0	10.0	5.0	330	660	50
BDR-DVAG03	Run	13-Sep	10.0	31.0	7.5	6.0	233	186	75
		05-Oct	5.2	22.0	8.0	3.0	176	264	30
		19-Oct	3.5	24.0	11.5	9.0	276	216	80
BDR-DVAG04	Cascade/Pool	13-Sep	10.1	46.0	11.0	5.0	506	1380	40
		19-Oct	3.5	15.0	9.0	6.0	135	90	60
BDR-DVAG05	Cascade	13-Sep	9.8	45.0	8.0	4.0	360	360	50
		05-Oct	4.7	34.0	6.0	5.0	204	510	70
		19-Oct	3.3	19.0	12.0	7.0	228	133	50
BDR-TRAG01	Run	13-Sep	6.7	44.0	9.0	9.0	396	1980	80
		05-Oct	4.9	34.0	9.5	4.5	323	459	50
		19-Oct	3.4	35.0	8.0	8.0	280	280	80

Table 2. Summary of angling sites in Lillooet River in fall 2021.

Site	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-DSAG05	Run	15-Sep	5.2	28.5	25.0	5.0	713	285	25
		07-Oct	6.0	31.0	21.0	10.0	651	310	50
		21-Oct	5.2	34.0	24.0	18.0	816	612	60
ULL-DSAG08	Riffle/Pool	15-Sep	5.6	44.0	31.0	6.0	1364	792	25
		07-Oct	6.0	49.0	21.0	9.0	1029	882	40
		21-Oct	5.0	50.0	25.0	12.0	1250	600	50
ULL-DSAG10	Riffle/Pool	15-Sep	6.1	14.0	25.0	4.0	350	168	20
		07-Oct	6.1	14.0	22.0	3.0	308	42	10
		21-Oct	4.4	15.0	23.0	3.0	345	90	10
ULL-DVAG15	Cascade	15-Sep	7.7	52.0	16.0	3.0	832	156	20
		07-Oct	6.2	28.0	8.0	3.0	224	84	30
		21-Oct	5.3	30.0	21.0	4.0	630	120	35
ULL-DVAG16	Step/Pool	15-Sep	7.8	45.0	16.5	5.0	743	225	40
		07-Oct	6.2	46.0	13.0	5.0	598	230	40
		21-Oct	5.4	30.0	20.0	2.0	600	60	10
ULL-TRAG01	Step/Pool	15-Sep	6.1	16.0	43.0	3.0	688	48	10
		07-Oct	6.1	20.0	45.0	8.0	900	160	20
		19-Oct	4.0	15.0	5.0	5.0	75	75	100

Table 3. Summary of angling sites in North Creek in fall 2021.

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	14-Sep	8.9	25.0	9.0	4.0	225	100	40
		06-Oct	5.3	25.0	8.0	3.5	200	88	30
		20-Oct	6.0	20.0	10.0	3.5	200	140	35
NTH-DSAG05	Cascade/Pool	14-Sep	8.9	18.0	8.1	5.0	146	270	50
		06-Oct	5.1	10.0	9.5	3.0	95	90	20
		20-Oct	5.4	10.0	10.0	3.5	100	70	25
NTH-DSAG06	Run	14-Sep	8.9	16.0	7.0	4.0	112	64	50
		06-Oct	5.1	21.0	5.0	3.0	105	63	30
		20-Oct	5.7	21.5	5.0	3.0	108	65	30
NTH-DVAG04	Cascade/Pool	14-Sep	9.0	27.0	12.5	5.0	338	270	60
		06-Oct	4.9	31.0	10.0	5.0	310	465	40
		20-Oct	5.7	31.0	11.0	6.0	341	186	55
NTH-DVAG05	Cascade/Pool	14-Sep	8.8	16.0	7.0	6.0	112	480	80
		06-Oct	4.8	24.0	9.0	8.0	216	192	70
		20-Oct	5.5	23.0	9.0	8.0	207	552	70
NTH-DVAG06	Cascade/Pool	14-Sep	8.4	25.0	10.0	4.0	250	600	50
		06-Oct	4.8	34.0	11.0	4.0	374	136	40
		20-Oct	5.4	33.0	10.0	4.0	330	264	40

[1] Site labels for North Creek are historic. No downstream or diversion exist.

Table 4. Summary of all fish captured during angling in Boulder Creek in fall 2021.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Diversion	13-Sep	BDR-DVAG03	BT	303	301	1.08	n/c	n/c	11	989001039049591
			BT	275	228	1.10	n/c	n/c		989001031378634
			BT	225	121	1.06	n/c	n/c	8	989001039049966
			BT	228	113	0.95	n/c	n/c	7	989001039049947
			BT	470	1000	0.96	n/c	n/c	9	989001039049950
			BT	163	50	1.15	n/c	n/c	10	989001039049989
		BDR-DVAG04	BT	250 [2]	n/c	n/c	n/c	n/c		n/c
		BDR-DVAG05	BT	248	161	1.06	n/c	n/c	6	989001039049944
			BT	238	125	0.93	n/c	n/c	5	989001039049935
Tailrace	13-Sep	BDR-TRAG01	BT	390	613	1.03	n/c	n/c	1	989001039049977
			BT	419	723	0.98	n/c	n/c	2	989001039049970
			BT	388	592	1.01	n/c	n/c	3	989001039049930
			BT	346	468	1.13	n/c	n/c	n/c	989001006696285
			BT	237	123	0.92	n/c	n/c	4	989001039049937
Downstream	13-Sep	BDR-DSAG01	BT	215	100	1.01	n/c	n/c	13	989001039049961
		BDR-DSAG02	BT	387	238	0.41	n/c	n/c	12	989001039049994
		BDR-DSAG06	NFC							
Diversion	05-Oct	BDR-DVAG01	BT	219	95	0.90	SC	6		989001039049927
			BT	250	159	1.02	SC	5	n/c	989001039049957
			BT	250	162	1.04	SC	7	n/c	989001032067114
			BT	225	114	1.00	SC	8	n/c	989001038120897
		BDR-DVAG03	BT	235	132	1.02				989001039050036
			BT	422	827	1.10	SC	9	n/c	989001032067160
			BT	249	153	0.99	SC	10	n/c	989001032067138
			BT	319	328	1.01	SC	11	n/c	989001032067164

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.

[2] Fish escaped from bucket. Estimated length.

n/c = Not collected.

Table 4. Continued (2 of 2).

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Diversion	05-Oct	BDR-DVAG05	BT	241	154	1.10	n/c	n/c	n/c	989001038120898
			BT	240	140	1.01	SC	4		989001038120892
			BT	280	236	1.08	FR		n/c	989001032067111
Tailrace	05-Oct	BDR-TRAG01	BT	219	104	0.99	FR	2	n/c	989001032067132
			BT	225	175	1.54	FR	1	n/c	989001032067181
			BT	195	81	1.09	FR	3	n/c	989001032067147
Downstream	05-Oct	BDR-DSAG01	BT	390	597	1.01	SC	15	n/c	989001039049988
			BT	420	798	1.08	FR	14	n/c	989001038120927
			BT	450	952	1.04	SC	16	n/c	989001038120871
		BDR-DSAG02	BT	245	171	1.16	FR	n/c	n/c	989001038120913
		BDR-DSAG06	BT	410	660	0.96	FR	13	n/c	989001038120938
Diversion	19-Oct	BDR-DVAG03	BT	268	191	0.99	FR			9891032067153
		BDR-DVAG04	NFC							
		BDR-DVAG05	BT	246	152	1.02	FR	n/c	n/c	9891038120898
Tailrace	19-Oct	BDR-TRAG01	BT	274	216	1.05	FR	n/c	n/c	9891038120951
Downstream	19-Oct	BDR-DSAG06	NFC							
Downstream	20-Oct	BDR-DSAG01	BT	405	674	1.01	FR	n/c	n/c	9891032067152
			BT	395	660	1.07	FR	n/c	n/c	n/c
			BT	224	105	0.93	FR	n/c	n/c	9891032067126
			BT	207	93	1.05	n/c	n/c	n/c	n/c
		BDR-DSAG02	NFC							

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.
n/c = Not collected.

Table 5. Summary of all fish captured during angling in Lillooet River in fall 2021.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Diversion	15-Sep	ULL-DVAG15	BT	229	122	1.02	n/c	n/c	9	989001039049981
		ULL-DVAG16	BT	210	60	0.65	n/c	n/c	10	989001039049931
Tailrace	15-Sep	ULL-TRAG01	NFC							
Downstream	15-Sep	ULL-DSAG05	BT	180	58	0.99	n/c	n/c	5	989001039049979
			BT	280	220	1.00	n/c	n/c	4	989001039049953
		ULL-DSAG08	BT	225	116	1.02	n/c	n/c	1	989001039049999
			BT	215	82	0.83	n/c	n/c	2	989001039049955
			BT	173	56	1.08	n/c	n/c	3	989001039049954
		ULL-DSAG10	BT	420	714	0.96	n/c	n/c	7	989001039049925
			BT	566	1650	0.91	n/c	n/c	6	989001039050018
			BT	359	431	0.93	n/c	n/c	8	989001039049985
Diversion	07-Oct	ULL-DVAG15	CT	220	100	0.94	n/c	n/c	n/c	989001032067200
		ULL-DVAG16	NFC							
Tailrace	07-Oct	ULL-TRAG01	CT	261	141	0.79	n/c	n/c	3	989001032067196
Downstream	07-Oct	ULL-DSAG05	BT	282	212	0.95	n/c	n/c	n/c	989001039049953
		ULL-DSAG08	BT	410	716	1.04	n/c	n/c	2	989001039050028
			BT	401	689	1.07	n/c	n/c	1	989001032067166
		ULL-DSAG10	NFC							
Tailrace	19-Oct	ULL-TRAG01	NFC							
Diversion	21-Oct	ULL-DVAG15	NFC							
		ULL-DVAG16	BT	212	93	0.98	n/c	n/c	n/c	9891032067113
Downstream	21-Oct	ULL-DSAG05	NFC							
		ULL-DSAG08	NFC							
		ULL-DSAG10	BT	385	536	0.94	n/c	n/c	n/c	9891032067182
			BT	257	175	1.03	n/c	n/c	n/c	9891032067163

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.
n/c = Not collected.

Table 6. Summary of all fish captured during angling in North Creek in fall 2021.

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
N/A	14-Sep	NTH-DVAG04	BT	183	n/c	n/c	n/c	n/c	12	989001039050000
			RB	301	286	1.05	n/c	n/c	11	989001039049945
		NTH-DVAG05	BT	410	726	1.05	n/c	n/c	9	989001039049929
			BT	340	404	1.03	n/c	n/c	6	989001039049958
			BT	282	230	1.03	n/c	n/c	7	989001039049995
			BT	355	537	1.20	n/c	n/c	8	989001039049938
			BT	200	79	0.99	n/c	n/c	10	989001039049965
		NTH-DVAG06	BT	450	1037	1.14	n/c	n/c	4	989001039050003
			BT	422	690	0.92	n/c	n/c	2	989001039080013
			BT	445	951	1.08	n/c	n/c	1	989001039049968
			BT	343	366	0.91	n/c	n/c	n/c	989001038120826
			BT	409	676	0.99	n/c	n/c	3	989001039049920
			BT	490	1216	1.03	n/c	n/c	5	989001039049980
		NTH-DSAG01	BT	350	307	0.72	n/c	n/c	17	989001039049922
		NTH-DSAG05	BT	390	557	0.94	n/c	n/c	14	989001039049926
			BT	488	1152	0.99	n/c	n/c	16	989001039049946
			BT	385	515	0.90	n/c	n/c	15	989001039049969
		NTH-DSAG06	BT	468	1095	1.07	n/c	n/c	13	989001039049941
	06-Oct	NTH-DVAG04	BT	440	817	0.96	n/c	n/c	1	989001039049923
			BT	349	381	0.90	n/c	n/c	2	989001039050090
			BT	288	256	1.07	n/c	n/c	3	989001039050017
		NTH-DVAG05	NFC							
		NTH-DVAG06	NFC							
		NTH-DSAG01	BT	425	778	1.01	n/c	n/c	n/c	989001038120957

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.

n/c = Not collected.

Table 6. Continued (2 of 2).

Reach	Date	Site	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
N/A	06-Oct	NTH-DSAG05	BT	289	253	1.05	n/c	n/c	6	989001032067120
		NTH-DSAG05	BT	489	1090	0.93	n/c	n/c	4	989001032067142
		NTH-DSAG05	BT	511	1226	0.92	n/c	n/c	5	989001039049962
		NTH-DSAG06	NFC							
	20-Oct	NTH-DVAG04	BT	423	695	0.92	n/c	n/c	n/c	989103206144
		NTH-DSAG01	BT	184	61	1	n/c	n/c	n/c	9891039049949
		NTH-DSAG01	BT	427	754	0.97	n/c	n/c	n/c	9891032067108
		NTH-DSAG05	BT	272	199	0.99	n/c	n/c	n/c	9891039050061
		NTH-DSAG05	BT	302	303	1.10	n/c	n/c	n/c	9891039049921
		NTH-DSAG06	NFC							
		NTH-DVAG05	BT	324	345	1.01	n/c	n/c	n/c	9891032067168
		NTH-DVAG05	BT	235	127	0.98	n/c	n/c	n/c	9891039050062
		NTH-DVAG05	BT	280	220	1.00	n/c	n/c	n/c	9891039049995
		NTH-DVAG06	BT	244	147	1.01	n/c	n/c	n/c	9891032067143
		NTH-DVAG06	BT	335	360	0.96	n/c	n/c	n/c	9891038120914

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.

n/c = Not collected.

Appendix H. Incidental Wildlife Observations

LIST OF TABLES

Table 1. Incidental wildlife sightings: Mammals. 1

Table 2. Incidental wildlife sightings: Avian. 2

Table 3. Incidental wildlife sightings: Amphibian..2

Table 4. Truckwash Creek Wildlife Camera Observations: Mammal. 3

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 Black Bear	*Ursus americanus*	3-May-2021	7:00:00	471164	5608742	38.5km ULL FSR	Sighting	walking then fleeing	1	TF	U	Adult
		19-May-2021	10:00:00	468443	5611626	ULL Powerhouse	Sighting	walking towards the river	1	FL	U	Juvenile
		17-Nov-2021	12:45:00	472896	5606909	Alena Creek	Sign	Black bear tracks, appears to be feeding on salmon.	1	LI	U	Unknown
Grey Wolf	*Canis lupus*	22-May-2021	08:00:00	472686	5606940	36km ULL FSR	Sighting	walking towards the river	1	TF	F	Adult
		22-May-2021	08:00:00	472686	5606940	36km ULL FSR	Sighting	walking towards the river 2 pups	2	TF	U	Immature
		10-Jun-2021	13:00:00	468554	5612078	43km ULL FSR	Sighting	running, black wolf	1	FL	U	Unknown
		5-Jul-2021	09:00:00	468554	5612078	43km ULL FSR	Sighting	crossing the road	1	TF	U	Unknown
		1-Sep-2021	07:00:00	483944	5601457	22km ULL FSR	Sighting	running up the hill	4	FL	U	Unknown
		8-Sep-2021	15:00:00	466082	5614160	ULL headpond	Sighting	feeding and swimming	1	FD	U	Unknown
		10-Sep-2021	07:30:00	476292	5604453	31km ULL FSR	Sighting	crossing the road	1	FL	U	Adult
		17-Nov-2021	10:08:00	473321	5606049	Alena Creek	Sign	near the confluence, appears to be feeding on salmon.	1	LI	U	Unknown
			12:40:00	472958	5606870	Alena Creek	Sign	appear to be feeding on salmon.	1	LI	U	Unknown
Grizzly Bear	*Ursus arctos*	26-Apr-2021	07:00:00	497276	5596491	7km ULL FSR	Sighting		1	LI	U	Adult
Moose	*Alces americanus*	21-Apr-2021	08:00:00	492313	5598286	13km ULL FSR	Sighting	cow and calf travelling on the road	1	FL	F	Adult
		21-Apr-2021	08:00:00	492313	5598286	13km ULL FSR	Sighting	cow and calf travelling on the road	1	FL	U	Juvenile
		18-May-2021	14:00:00	470236	5609982	40km ULL FSR	Sighting	travelling on the road	1	TF	U	Unknown
		1-Sep-2021	14:00:00	470585	5609783	39.7km ULL FSR	Sighting	cow and calf crossing the road	1	FL	F	Adult
		1-Sep-2021	14:00:00	470585	5609783	39.7km ULL FSR	Sighting	cow and calf crossing the road	1	FL	U	Juvenile
Mountain Goat	*Oreamnos americanus*	26-Jan-2022	12:10:00	472773	5611039	above Boulder Intake road	Sign	tracks observed during camera maintenance along the upper road; between BDR-CAM08 and BDR-CAM04	1	LI	(blank)	Unknown
		26-Jan-2022	15:00:00	473223	5611177	Boulder intake road	Sign	tracks observed during camera maintenance along the lower road	3	LI	(blank)	Unknown
Mule Deer	*Odocoileus hemionus*	11-Jun-2021	10:00:00	466638	5614369	46km ULL FSR	Sighting	running	4	FL	U	Unknown
Snowshoe Hare	*Lepus americanus*	4-Jan-2021	20:30:00	472876	5610976	BDR-CAM02	Sighting	captured on the wildlife camera	1	LI	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							
Bald Eagle	*Haliaeetus leucocephalus*	5-Nov-2021	12:35:00	473072	5606624	Alena Creek	Sighting	-	1	LI	U	Unknown
			13:55:00	472995	5606849	Alena Creek	Sighting	-	3	LI	U	Unknown
			14:20:00	472685	5606933	Alena Creek	Sighting	in a tree	2	LI	U	Unknown
		17-Nov-2021	12:00:00	473115	5606586	Alena Creek	Sighting	in a tree	1	LI	U	Unknown
			12:10:00	473018	5606692	Alena Creek	Sighting	in a tree	4	LI	U	Unknown
			12:28:00	473020	5606714	Alena Creek	Sighting	in a tree	3	LI	U	Unknown
		6-Dec-2021	11:05:00	473024	5606725	Alena Creek	Sighting	in trees, could be mix of adults/juveniles during spawner survey	6	LI	U	Unknown
			12:00:00	473033	5606809	Alena Creek	Sighting	in trees, could be mix of adults/juveniles during spawner survey	3	LI	U	Unknown
			12:20:00	473028	5606763	Alena Creek	Sighting	in trees, during spawner survey	1	LI	U	Unknown
			12:40:00	473021	5606817	Alena Creek	Sighting	in trees, could be mix of adults/juveniles	3	LI	U	Unknown
			13:10:00	473250	5606146	Alena Creek	Sighting	in trees, could be mix of adults/juveniles during spawner survey	4	LI	U	Unknown
Barrow's Goldeneye	*Bucephala islandica*	8-Sep-2021	15:00:00	466093	5614101	ULL headpond	Sighting	feeding and swimming	1	FD	U	Unknown
Great Blue Heron	*Ardea herodias*	17-Nov-2021	12:20:00	473030	5606769	Alena Creek	Sighting	in a tree	1	LI	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 3. Incidental wildlife sightings: Amphibian

Species		Date	Time	UTM Coordinates (10U)		Location	Sighting or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Northern Red-legged Frog	*Rana aurora*	3-Sep-2021	-	473079	5606614	Alena Creek	Sighting	observed during a fish salvage, relocated upstream	1	LI	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 4. Truckwash Creek Wildlife Camera Observations: Mammal.

Species		Date	Time	UTM Coordinates (10U)		Location	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing						
American Black Bear	*Ursus americanus*	2020-10-26	14:36:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
		2021-04-29	12:12:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
American Marten	*Martes americana*	2021-01-07	19:54:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
		2021-01-16	06:02:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
		2021-03-16	04:08:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
Canada Lynx	*Lynx canadensis*	2020-12-22	06:04:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
		2021-01-18	12:33:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
		2021-01-20	17:17:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
Cougar	*Puma concolor*	2020-11-07	14:23:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
Grizzly Bear	*Ursus arctos*	2020-10-28	12:13:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Adult
Mountain Goat	*Oreamnos americanus*	2021-01-29	16:18:00	467982	5612841	ULL-CAM15	gradual horn curvature, thick horn bases with smaller distance between, pronounced shoulder hump	1	TF	Male	Adult
Mule Deer	*Odocoileus hemionus*	2021-04-28	12:08:00	467982	5612841	ULL-CAM15		1	TF		
		2021-04-29	01:20:00	467982	5612841	ULL-CAM15		4	TF		
		2021-04-30	04:00:00	467982	5612841	ULL-CAM15		1	TF		
		2021-05-01	10:25:00	467982	5612841	ULL-CAM15		2	TF		
		2021-05-02	16:41:00	467982	5612841	ULL-CAM15		2	TF		
		2021-05-03	02:20:00	467982	5612841	ULL-CAM15		16	TF		
		2021-05-04	10:20:00	467982	5612841	ULL-CAM15		4	TF		
		2021-05-05	07:43:00	467982	5612841	ULL-CAM15		7	TF		
		2021-05-06	01:34:00	467982	5612841	ULL-CAM15		17	TF		
		2021-05-07	04:48:00	467982	5612841	ULL-CAM15		8	TF		
		2021-05-08	05:37:00	467982	5612841	ULL-CAM15		9	TF		
		2021-05-09	00:39:00	467982	5612841	ULL-CAM15		11	TF		
		2021-05-10	00:06:00	467982	5612841	ULL-CAM15		16	TF		
		2021-05-11	04:34:00	467982	5612841	ULL-CAM15		6	TF		
		2021-05-12	05:57:00	467982	5612841	ULL-CAM15		8	TF		
		2021-05-13	05:29:00	467982	5612841	ULL-CAM15		6	TF		
		2021-05-14	03:18:00	467982	5612841	ULL-CAM15		15	TF		
		2021-05-15	04:37:00	467982	5612841	ULL-CAM15		8	TF		
		2021-05-16	04:34:00	467982	5612841	ULL-CAM15		13	TF		
Snowshoe Hare	*Lepus americanus*	2021-01-14	00:29:00	467982	5612841	ULL-CAM15		1	TF	Unknown	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 4. Continued (2 of 2).

Species		Date	Time	UTM Coordinates (10U)		Location	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing						
Squirrel		2021-02-04	10:12:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-02-10	11:13:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-02-15	07:14:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Unknown
		2021-02-17	06:56:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Unknown
		2021-02-18	07:19:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-02-23	07:19:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-02-27	06:43:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Unknown
		2021-02-28	08:03:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Unknown
		2021-03-04	07:04:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-03-08	06:53:00	467982□	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-03-09	06:47:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Adult
		2021-03-12	06:27:00	467982	5612841	ULL-CAM15		1	LI	Unknown	Unknown
Ungulate		2021-02-28	02:35:00	467946	5613055	ULL-CAM02	leg captured in the camera	1	LI	Unknown	Unknown
Wolverine	*Gulo gulo*	2020-12-24	16:19:00	467982	5612841	ULL-CAM15		1	TF	Unknown	Unknown
		2021-01-16	21:23:00	467982	5612841	ULL-CAM15		1	TF	Unknown	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