Upper Lillooet Hydro Project

Operational Environmental Monitoring: Year 1

Prepared for:

Upper Lillooet River Power Limited Partnership,
Boulder Creek Power Limited Partnership,
900 – 1185 West Georgia Street
Vancouver, BC, V6E 4E6

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Prepared by:

Ecofish Research Ltd.

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For inquiries contact: Technical Lead documentcontrol@ecofishresearch.com 250-334-3042

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Senior Reviewers:

Heidi Regehr, Ph.D., R.P. Bio. No. 2386

Wildlife Biologist

Sean Faulkner, M.Sc., R.P. Bio. No. 2242

Fisheries Biologist/Project Manager

Kevin Ganshorn, M.Sc., R.P. Bio. No. 2448

Biologist/Project Manager

Technical Leads:

Deborah Lacroix, M.Sc., R.P.Bio. No. 2089
Wildlife Biologist/Project Director

Sean Faulkner, M.Sc., R.P. Bio. No. 2242
Fisheries Biologist/Project Manager

Kevin Ganshorn, M.Sc., R.P. Bio. No. 2448
Biologist, Project Manager

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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 one of the operational environmental monitoring program (OEMP, aka LTMP) for the Upper Lillooet Hydro Project (ULHP) (the Project). The Project is comprised of two hydroelectric facilities (HEF), the largest of which is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119). The other facility is located on Boulder Creek (WC: 119-848100).

The ULHP infrastructure is located in the Upper Lillooet watershed (Map 1). The Lillooet River is a 164.5 km long, sixth order river with a magnitude of 860 that flows in a south easterly direction into Harrison Lake (MOE 2013). The project infrastructure in the Upper Lillooet River is located in a confined section starting 6.7 km upstream of Meager Creek. The powerhouse is located 82.9 km upstream of Lillooet Lake and the intake is located 86.7 km upstream of Lillooet Lake, and approximately 0.6 km upstream of Keyhole Falls. Water is diverted around approximately 3.8 km of river length through the intake structure and water conveyance structure (i.e., tunnel and penstock) to the powerhouse.

Boulder Creek flows into the Upper Lillooet River 78.8 km upstream of Lillooet Lake. Boulder Creek is an 18.6 km long, third order stream with a magnitude of 19 that flows in a southwest direction (MOE 2013). The intake is located approximately 4.7 km upstream of the Boulder Creek confluence with the Upper Lillooet River. Water is diverted around approximately 3.7 km of stream through the intake and water conveyance structures (i.e., tunnel) to the powerhouse located approximately 1.0 km upstream of the confluence.

A 72 km long 230 kV transmission line transports electricity produced by the Project to the point of interconnection, south of Pemberton, near Rutherford Creek (Map 1). The transmission line crosses the Upper Lillooet River downstream of the confluence with North Creek.

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

Aquatic and Riparian Habitat

Riparian Revegetation Assessment

The objective of riparian revegetation effectiveness monitoring is to evaluate whether efforts to revegetate temporarily cleared riparian areas meet the performance measures prescribed in the OEMP

(Harwood *et al.* 2017). The performance measures (80% survival of planted stock, tree density at or above 1,200 stems/ha, and shrub density at or above 2,000 stems/ha) were based on the DFO and MELP (1998) revegetation guidelines, as recommended by the Long-term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects (Lewis *et al.* 2013). Riparian vegetation restoration monitoring also contributed to Coastal Tailed Frog (*Ascaphus truei*) habitat compliance monitoring at disturbed riparian areas along the Coastal Tailed Frog tributary crossed by the Upper Lillooet River (ULR) Hydroelectric Facility (HEF) penstock.

Twelve permanent revegetation monitoring plots ("plots") were assessed on September 6 and 7, 2018 to evaluate the effectiveness of revegetation efforts. Plot locations were selected to provide a representative sample of site conditions of riparian revegetation areas associated with three infrastructure components for the ULR HEF (intake, penstock, and powerhouse) and one (the powerhouse) for the Boulder Creek HEF. In Year 1 of the five-year monitoring program, average tree and shrub stem densities (7,317 tree stems/ha (± 7,073) and 2,817 shrub stems/ha (± 883)) from all permanent revegetation monitoring plots combined surpassed the density targets of 1,200 tree stems/ha and 2,000 shrub stems/ha. Although there was substantial variability in tree and shrub stem density among plots, targets for trees and shrubs were met at most plots (tree and shrub targets were not met at one and four plots, respectively) and in no plot was one of the targets not met. Five tree and twelve shrub species were documented within plots, which demonstrated a good distribution and diversity. Thus, monitoring results indicate that woody vegetation is establishing and beginning to contribute to riparian habitat function. Not all of the revegetation areas were planted; however, plant growth through natural regeneration is abundant in several locations. Percent vegetation cover, measured within vegetation cover quadrats, was estimated at 7% (ranging from 1% to 14%). Although the overall vegetation cover is low, overall tree and shrub stem densities are above the targets, which indicates that revegetation is generally progressing well.

Additional years of natural regeneration are likely to contribute to the rehabilitation of the riparian revegetation areas. However, we recommend the following revegetation and monitoring actions to enhance and accelerate the condition of specific revegetation areas to meet the OEMP targets by the last year of planned monitoring in Year 5:

- Add rocky material to cover areas of exposed geotextile at ULL-PRM09, by the Coastal Tailed Frog stream (ULL-ASTR04) crossed by the penstock (this recommendation also applies to amphibian habitat restoration monitoring). The area of exposed geotextile is small enough that this work can be accomplished by hand, using local materials already on site.

Footprint Impact Verification

The footprint impact verification components of the OEMP were completed and issued as a separate report in May 2018. The document is provided within as Appendix A.

Water Temperature

The objective of monitoring water temperature is to determine Project effects on stream temperature and assess whether project-related effects are biologically significant and affect growth, survival, or reproductive success of Upper Lillooet River and Boulder Creek fish populations. To achieve this, water temperature will be monitored continuously for the first five years of operation and compared to the baseline data using a BACI design. Temperature metrics include daily and monthly temperature, length of the growing season, number of extreme temperature days, rate of temperature change, and mean weekly maximum temperature (MWMxT). These metrics are compared to water temperature BC WQG (Oliver and Fidler 2001, MOE 2018) to assess potential impacts on aquatic life and on fish species present in the Project area.

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

The operational water temperature response monitoring component of the OEMP was successfully implemented in the Upper Lillooet River and Boulder Creek in 2018 (Year 1) of operations. In March 2018 water temperature data loggers were installed at a control site, lower diversion impact site, in the tailrace and a downstream impact site in both creeks, with the exception of the upstream site in Boulder Creek which was installed in September 2018. Temperature loggers were also installed in North Creek in September 2018 to concurrently collect water temperature data for at least a year of operational monitoring to establish the relationship between water temperatures at the two sites. The purpose of concurrent monitoring is to establish if the Boulder Creek upstream site is influenced by groundwater and if so, to make minor adjustment to the baseline data set. Following a year of data collection, a QP will review the results to determine whether further concurrent data collection in North Creek is required.

Air temperature loggers were installed in the control and lower diversion reaches in the Upper Lillooet River to aid in characterization of the thermal regime.

A limited operational dataset was available at the time of writing (as water and air temperature tidbit were installed in March 2018), this limitation was anticipated and thus the water temperature analysis will be completed in Year 2 once a complete year of water temperature data are available for the monitoring sites. We recommend that the monitoring program continue in 2019 (Year 2), based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017).

Frazil Ice Monitoring

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

Crews have performed two frazil ice assessments since the protocol was established. On December 23-24, 2017, surface ice covered between 10% and 25% of the available fish habitat in the Upper Lillooet River diversion reach monitoring sites but no frazil or anchor ice was observed. In contrast, frazil ice displaced approximately 30% to 50% of the wetted habitat and anchor ice encased approximately 20% to 50% of the substrate within the in the Boulder Creek diversion reach monitoring sites visited on these dates. On January 2, 2018, however, no frazil or anchor ice was observed at any of the monitoring sites surveyed in the diversion reach of either HEF. Because frazil ice did not occupy >50% of fish holding habitat, neither HEF was required to shut down, however, following assessments, local conditions were monitored until the risk of frazil and anchor ice formation abated. We recommend continued monitoring for frazil ice using the current protocol prescribed in the OEMP in Year 2. Recommendations for refinement of the protocol and thresholds will be provided once additional data are collected.

Fish Community

The objective of the fish community monitoring program is to assess fish community response during operations and identify any changes in abundance, density, condition, distribution, or timing of migration relative to baseline primarily through a Before-After-Control-Impact (BACI) study design. This report presents data from Year 1 of operational monitoring (2018) on measures of fish abundance, condition, and distribution of juvenile and adult Cutthroat and Bull Trout populations within the diversion (impact) and upstream (control) reaches of the Upper Lillooet River as well as the diversion (impact) and downstream (control) reaches of Boulder Creek in support of the fish density and biomass component prescribed by the OEMP. It also presents data on the migration and distribution of spawning adult Bull Trout in the both HEF diversion and downstream reaches, Cutthroat Trout access to tributaries in the diversion reach of the Upper Lillooet River HEF, and on Cutthroat Trout abundance in an Upper Lillooet River HEF headpond tributary in support of an assessment of potential fish entrainment. Sampling sites and methods in 2018 were consistent with those used during baseline monitoring in 2010 through 2014. Juvenile fish monitoring was conducted through closed-site electrofishing within the Upper Lillooet River and mark re-sight snorkeling surveys in Boulder Creek. Adult migration and distribution monitoring was conducted through a mixture of angling, spawning, and open-site electrofishing surveys, as well as assessments of connectivity and barriers to fish passage.

Juvenile Density and Biomass

In the Upper Lillooet River, in general, densities of Cutthroat Trout were slightly higher in the diversion reach than in the upstream reach, whereas, due to the high proportion of larger individuals, Cutthroat Trout biomass was higher in the upstream reach. Fry had the highest densities among age classes in the diversion reach, but were not captured in the upstream reach, whereas juveniles and adults were captured in both reaches in 2018. For most age classes densities and biomass of Cutthroat Trout were highly variable across years and no clear trends among baseline and Year 1 operational monitoring were evident within either reach. The one exception was an apparent increasing trend in fry density within the diversion reach from 2010 to 2018. Juvenile densities and biomass were the highest among survey years in 2018 within the upstream reach, but were generally lower than those of baseline years within the diversion reach. In contrast, adult densities and biomass were generally lower in the upstream reach in 2018 than baseline values, but were similar to those in the diversion reach.

Bull Trout are only present in the diversion reach of Upper Lillooet River with fry, juveniles, and resident adults captured in 2018. Densities of Bull Trout juveniles in 2018 were highest among all age classes, while those of adults were lowest. In contrast, adults had the highest observed biomass among all age classes in 2018. No clear trends in Bull Trout density or biomass among baseline and Year 1 operations were evident for any age classes. Overall, the density of all Bull Trout age classes combined was lower in 2018 than in 2010 and 2014 but slightly higher than in 2012, and biomass in 2018 was similar to 2012 and 2014 but lower than in 2010. Fry and juvenile densities and biomass in 2018 were similar to those in baseline years, while those of adults were roughly 50% lower than in 2012 (the only other year when this age class was captured).

In Boulder Creek, juvenile Bull Trout densities were most prevalent in the downstream reach, and over two times higher than those in the diversion reach. In contrast, adult resident Bull Trout densities were most prevalent in the diversion reach, and much higher than those in the downstream reach. Only one Bull Trout fry was observed in the downstream reach in 2018. 2018 was also the first year that Cutthroat Trout have been observed during mark re-sight surveys in Boulder Creek, though at relatively low densities, with several adults observed in the diversion reach and several juveniles observed in the downstream reach.

Overall, throughout baseline and in 2018, Bull Trout densities were consistently higher in the downstream reach of Boulder Creek than in the diversion reach. Bull Trout densities were lower in the downstream reach in 2018 compared to baseline years. In contrast, Bull Trout densities were more consistent among years in the diversion reach, though the age classes that dominated estimates differed among years. In particular, Bull Trout fry densities have been particularly low in both reaches, and only a single fry was observed within the diversion reach in 2013. Notably, there was considerably less of a difference between overall Bull Trout densities in the downstream and diversion in 2018 relative to baseline years, and densities of adults were at least two times higher within the diversion reach in 2018 compared to baseline years.

Abundance action thresholds (AAT) were defined by Harwood *et al.* (2012) and in the OEMP for individual age classes and all age classes combined of juvenile Bull Trout within the diversion reach of Boulder Creek. Densities of Bull Trout juveniles observed in Year 1 monitoring (for individual age classes, and all combined) were compared to these AATs, and although highly variable among years, there were no declines that exceeded AATs in the diversion reach of Boulder Creek that were not mirrored by similar or more severe declines in the downstream control reach. Boulder Creek was also subject to a forest fire in the summer of 2015 and large flood events during the falls of 2016 and 2017, between baseline and operational monitoring periods. In particular, the flood event in November 2016 lead to considerable geomorphologic changes in the diversion and downstream reach, which may have influenced fish habitat and the fish community, which was further affected by the large flood event in November 2017. These non-operational factors may also influence the monitoring results. With all age classes combined there was no evidence of a decline in Bull Trout in the diversion reach in 2018 relative to baseline. As prescribed in the OEMP, densities of Bull Trout juveniles within the diversion reach will continue to be compared to AATs in conjunction with densities in the downstream control reach in the remaining years of operational monitoring and additional monitoring will be initiated in the event that any exceedances occur that are deemed to be due to Boulder Creek HEF operations.

Adult Migration and Distribution

Adult fish distribution and migration during the spawning period within the diversion and downstream reaches of both the Upper Lillooet River and Boulder Creek were assessed through angling surveys in 2018. These surveys were conducted to determine if access to the diversion reach was impacted by water diversion. Adult Bull Trout were captured in the diversion and downstream reaches of Boulder Creek and the Upper Lillooet River. All assessed portions of the diversion reaches were also deemed to be accessible to fish, with no barriers to migration identified. Adult spawning surveys were also conducted in a reference tributary at km 29.2 of the Upper Lillooet River (29.2 km Tributary) and Alena Creek. The numbers of spawning adult Bull Trout in these reference streams were lower in 2018 than during baseline surveys in 2011 with only three Bull Trout in Alena Creek compared to the nine observed during baseline, and two observed in 29.2 km Tributary compared to eight during baseline. The reference stream data suggests that overall Bull Trout numbers may have been lower in 2018 than during baseline. Regardless, the lack of a build-up of Bull Trout below the powerhouses and detection of them in the diversion reaches suggests that movement into the diversion reach was not inhibited by operations at either HEF in 2018; however, there were shutdowns of both HEFs during the sampling program which may have influenced flows and allowed passage. Given the shutdowns that occurred during the Bull Trout spawning period in 2018, we recommend that the surveys be conducted again in 2019, but only if the HEFs are operating during the mid-September to mid-October spawning period.

Connectivity and adult fish access assessments were also conducted in the three possible Cutthroat Trout spawning tributaries of the Upper Lillooet River diversion reach (ULL-83.2 km, ULL-83.6 km, and ULL-83.7 km) as prescribed by the OEMP. These surveys were conducted to confirm that Cutthroat Trout may access these tributaries to spawn during operations. Similar to baseline, obstacles to upstream fish migration were observed within two meters of the confluence with the Upper Lillooet River in two of the three tributaries (ULL-83.2 km and ULL-83.6 km); while the third tributary (ULL-83.7 km) had 155 m of accessible habitat under the assessment conditions (flows of 41.5 m³/s at ULL-DSI). Open-site electrofishing surveys conducted within the tributaries in October 2018 confirmed that Cutthroat Trout fry were present in the same two tributaries (ULL-83.2 km and ULL-83.7 km) in which fry were observed during baseline but fry were absent from ULL-83.6 km. These results indicate that Cutthroat Trout spawning in 2018 likely occurred in the same tributaries as baseline and no further assessment is recommended as per the OEMP.

Assessment of Entrainment at the Upper Lillooet River Intake

The assessment of fish entrainment includes examining densities and biomass of Cutthroat Trout in a tributary to the headpond (at river km 87.0), and in two clusters of five mainstem upstream sites. The five lower upstream sites sampled in 2011 and 2012 are located in relatively close proximity (~1.5 km) to the intake. In 2014 a further five sites were added approximately 1.8 km upstream of the existing upstream sites to provide a control for potential entrainment effects, which are most likely to be evident in the five original upstream sites located in relatively close proximity to the intake. Densities and biomass of Cutthroat Trout in the headpond tributary at km 87.0 were lower in 2018 than baseline values in 2013 (16% and 34% with all age classes combined, respectively). This was due to lower densities and biomass of adults and fry; however, increases in parr were detected between years. Cutthroat Trout densities in the two clusters of sites in the upstream reach were similar in 2018. Although some age classes of fish were absent in both baseline years and 2018, when considering all age classes of Cutthroat Trout, densities in 2018 were similar to those observed during baseline in the lower cluster and higher in 2018 in the upper cluster of sites. Monitoring of the upstream sites, along with those in the tributary at km 87.0 will continue in Year 2 of operational monitoring as prescribed in the OEMP.

Water Quality

Quarterly sampling of water quality parameters in the Upper Lillooet River and Boulder Creek is recommended in the currently approved version of the OEMP (Harwood *et al.* 2017). Subsequent revisions to the OEMP were made and submitted to MFLNRORD in February of 2018 (Harwood *et al.* 2018), prior to the 2018 field season. Year 1 (2018) operational data collection was planned in accordance with recommendations presented in the revised version of the OEMP. Water quality parameters (pH, specific conductivity, total dissolved solids, total suspended solids, turbidity, dissolved oxygen and total gas pressure) were measured upstream of the Project (control site), in the lower diversion reach, in the tailrace and downstream of the tailrace in Upper Lillooet River, bi-annually during year 1 (2018) of operations. Water quality sampling was not specified for Boulder Creek in the revised version of the OEMP (Harwood *et al.* 2018).

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 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 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, it is recommended that that the water quality monitoring component be removed from the OEMP in Years 2, 3, 4, and 5.

Wildlife Species Monitoring

Harlequin Ducks

The objective of Harlequin Duck (*Histrionicus histrionicus*) response monitoring, which is a requirement of the Project's EAC (Condition #3 of the TOC), is to confirm that Harlequin Ducks continue to use the ULR HEF area post-construction. Monitoring is being conducted through vantage point surveys (spot checks), using standardized protocols, along with the recording and compilation of incidental observations, to allow comparison of relative abundance among time periods (before and after construction). Spot checks were conducted by Ecofish or Innergex personnel at vantage points established at the intake and at the powerhouse during the pre-incubation period ("pair" survey conducted in May) and during the brood-rearing period ("brood" survey conducted in late July to late August), with one exception: on August 9 the survey at the intake was conducted with the use of zoomable surveillance cameras from a room inside the powerhouse because the intake vantage point could not be accessed due to high landslide risk. Three spot checks were conducted during each period in 2018.

In Year 1, Harlequin Ducks were observed only during one of the pair surveys (on May 3, 2018) when two adult females were seen in the ULR HEF headpond. No Harlequin Ducks were seen during the brood surveys or near the powerhouse. Incidental observations included a pair of Harlequin Ducks in the headpond on April 20, 2018 and two female Harlequin Ducks (which could also have been juveniles) in the headpond on September 16, 2018. Monitoring results from Year 1 indicated that Harlequin Ducks are still using the Project area but evidence of breeding is inconclusive (i.e., due to the timing of incidental observations, which were early and late in the breeding season, individuals may have been passing through the Project area). Continued annual monitoring for the next four years (with reporting in Years 3 and 5), in accordance with the Project's EAC (Condition #3 of the TOC) and as specified in the OEMP, is recommended to allow further evaluation of Harlequin Duck use of the immediate Project area. Overall counts and numbers of pairs at the intake and powerhouse during the pair (May) and brood (August) surveys are reduced relative to what was observed prior to Project construction; however, given data limitations (one year of post-construction data from three pair and three brood surveys), results from additional monitoring years will be needed to evaluate Harlequin Duck use of the immediate Project area for breeding post-construction.

Species at Risk & Regional Concern

Wildlife species at risk and of regional concern are being monitored through the recording of incidental observations during the first five years of Project operations to contribute to the provincial database and to inform Project operations on situations that may require consideration of wildlife species likely to be present. A total of ten mammal, three amphibian, and eight avian species, including nine species at risk and of regional concern, were incidentally observed in the Project area in 2018 by Ecofish personnel and Project operators. Incidental observations of species at risk and of regional concern in 2018 included those of Grizzly Bears (*Ursus arctos*), Moose (*Alces americanus*), Mountain Goats (*Oreamnos americanus*), Mule Deer (*Odocoileus hemionus)*, Wolverines (*Gulo gulo luscus*), Bald Eagles (*Haliaeetus leucocephalus*), Harlequin Ducks, Coastal Tailed Frogs, and Western Toads (*Anaxyrus boreas*).

To reduce the potential for human-wildlife conflict, observations of Grizzly Bears and Moose in particular, specifically Moose along the Lillooet River FSR, should be given special consideration by Project operations. Grizzly Bears were recorded incidentally near Truckwash Creek on two occasions, including one occasion when Innergex personnel observed a Grizzly Bear feeding on honey being produced in commercial beehives that had been placed at this location. Innergex has requested that the honey bee hive owners not place the hives near Project infrastructure to reduce the potential for human-wildlife interactions where Project operators and environmental field technicians commonly work. A total of nine Moose were observed along the Lillooet River FSR on three occasions in April, October, and November. Moose sign was also documented at the Lillooet River transmission line crossing, along the Boulder Creek HEF intake access road, and along Alena Creek.

Wolverines continue to use the Project area during operations, as evidenced by tracks detected approximately 500 m upstream of the Boulder Creek HEF intake on March 7, 2018 and near the Keyhole Falls bridge on March 14, 2018.

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

Wildlife Habitat Monitoring – Habitat Restoration

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 conducted post-construction to evaluate: 1) vegetation clearing works and potential site restoration within the transmission line RoW; 2) effectiveness of sediment and erosion control; and 3) instream and riparian restoration success of ULL-ASTR04 in accordance with site-specific prescriptions. Habitat restoration monitoring of transmission line stream crossings involved ensuring that vegetation clearing was restricted to topping trees, cut wood was left in place, and identifying any erosion issues. Monitoring of compliance of instream habitat restoration at ULL-ASTR04 was assessed through a comparison of key habitat characteristics pre and post-construction at three reaches: a control reach upstream of the penstock crossing (ULL-ASTR04US), the impact reach at the penstock crossing (ULL-ASTR04IM), and the downstream impact reach below the penstock crossing (ULL-ASTR04DS). Riparian habitat at ULL-ASTR04 was evaluated under the riparian revegetation assessment component of the OEMP by establishing two permanent monitoring plots in riparian habitat at the penstock crossing location and recording vegetation and site characteristics within these plots.

At all sites, where restoration monitoring of riparian habitat at transmission line crossings over suitable Coastal Tailed Frog streams was conducted, monitoring confirmed that vegetation clearing had been restricted to topping trees, effective sediment and erosion control was in place, and any cut wood was left in place. Monitoring at the penstock crossing of ULL-ASTR04 indicated that, in general, instream habitat characteristics were similar between pre and post-construction periods and/or minor differences were also observed in the upstream control reach. Coastal Tailed Frog tadpoles were also incidentally observed in the stream channel at the penstock crossing and upstream during habitat surveys in 2018 – a notable observation given that neither Coastal Tailed Frogs nor tadpoles had been observed in this location since the Boulder Creek Wildfire that burned through the area in June 2015. Channel width and wetted width were slightly smaller at the penstock crossing and especially downstream of the crossing between periods, although considering results from the two pre-construction years, differences were relatively small. Embeddedness decreased slightly in all reaches, minor changes to mesohabitat were observed but were also observed in the upstream reach, and there was little change in substrate at either the penstock crossing reach or the downstream reach, although substrate size was slightly larger at the penstock crossing and downstream of the crossing post-construction. An exception to documented compliance with instream restoration prescriptions was that geotextile was exposed within the riparian area and stream channel, which has the potential to prevent Coastal Tailed Frogs from accessing potential subsurface flows or refugia. Good survival of planted stock was observed throughout the riparian area and documented within the two riparian revegetation monitoring plots at ULL-ASTR04, and good natural regeneration of vegetation was observed within 1 – 2 m of the stream edge, although geotextile was also exposed in a portion of the riparian habitat. CWD distribution and density was confirmed to be in compliance with restoration prescriptions.

Monitoring of transmission line crossing over suitable Coastal Tailed Frog streams is considered to be complete. Riparian habitat at ULL-ASTR04 will be monitored again in Year 3 under the riparian revegetation assessment component, as prescribed in the OEMP.

Recommendations for further restoration at ULL-ASTR04 include:

- Covering the areas of exposed geotextile within the riparian areas with additional rocky substrate (this recommendation also applies to riparian revegetation effectiveness monitoring); and
- Covering the area of exposed geotextile within the stream channel impact reach (ULL-ASTR04IM) with additional rocky substrate.

The area of exposed geotextile is small enough that this work can be accomplished by hand, using local materials already on site. Given exposed geotextile within the stream channel the following monitoring action is also recommended:

- A spot check of instream Coastal Tailed Frog habitat at the penstock crossing (ULL-ASTR04) should be conducted in coordination with riparian revegetation monitoring at this location in Year 3 to evaluate potential exposure of geotextile.

Avian Habitat

Objectives of avian habitat restoration monitoring were to confirm compliance with restoration measures prescribed for Peregrine Falcons (*Falco peregrinus*) and Harlequin Ducks because habitat for these two species had the potential to be impacted during Project construction. Monitoring involved: 1) confirming that clearing of high quality Harlequin Duck breeding habitat within the transmission line RoW had been restricted to topping trees and reducing shrub height, that shrubs were maintained along the RoW edge, and that coarse woody debris had been retained; and 2) that transmission line poles were placed away from three suitable Peregrine Falcon nesting ledges as per requirements of the Project's EAC (Condition #24 of the TOC).

At all Harlequin Duck monitoring sites, it was confirmed that clearing of riparian habitat had occurred in accordance with prescribed habitat restoration prescriptions (clearing had been restricted to topping trees, tree and shrub heights were acceptable, and coarse woody debris was documented naturally present where possible given site conditions). Compliance with habitat restoration measures prescribed for Peregrine Falcons was also confirmed: when vertical and horizontal distances were considered along with orientation of the nesting ledges and power poles, the locations of the nearest poles were considered to not compromise the suitability of the nesting ledges for Peregrine Falcons. Given compliance with avian habitat restoration prescriptions, no recommendations were made for additional work or monitoring and this monitoring component is now complete.

Mammal Habitat

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

Roads (FSR), where the transmission line RoW is within 10 m of an active FSR and the transmission line RoW passes through legislated protected habitat (Ungulate Winter Range (UWR) or Wildlife Habitat Area (WHA)) or high value Grizzly Bear habitat; and 2) that the composition of planted stems met species-specific requirements (Appendix C), as required by conditions of the Project's EAC and GWM exemptions. For Grizzly Bears, compliance monitoring also confirmed deactivation of access tracks/roads within WHA 2-399 (Appendix C) and adherence to food attractant management requirements (as per the Human-Bear Conflict Management Plan required by Condition #12 of the TOC). Monitoring was conducted at 29 monitoring sites from June 6 to June 21, 2018. Assessment of the requirements for revegetation involved establishing one 3.99 m radius plot per site in which stems were counted, plants were identified to species, and height and density of plants was recorded.

Monitoring results indicated that, although at most sites a vegetated screen was confirmed to be present, many vegetation screens had not attained the required height (5 m) and some screens also did not have the required width, which is not unexpected for the first year of monitoring. In most cases, natural regeneration and vegetation growth is anticipated to create an adequate screen over time; however, future reassessment in Year 3 will be required to confirm that requirements have been met. In addition to species-specific planting requirements evaluated in Appendix E, percent of Grizzly Bear forage species was higher than the required 50% in two plots within Grizzly Bear WHA 2-399. Inspections of the ULR HEF and Boulder Creek HEF powerhouses and intakes found no issues with bear attractant management at either of the intakes; however, potential bear attractants (i.e., a few empty food wrappers, empty beverage containers and an empty oil container) were observed in two open garbage bins outside of both powerhouses during one site visit. Although the Project's Environment Supervisor was notified of this issue, it is recommended that compliance with proper disposal of food waste at facilities with waste management requirements is confirmed in Year 2.

Wildlife Habitat Monitoring – Mitigation Effectiveness

Avian Collisions

The objective of avian collisions effectiveness monitoring is to evaluate the effectiveness of bird diversion markers installed on the transmission line to increase visibility where it crosses the Upper Lillooet River and the Ryan River in mitigating mortality risk for migrating birds. Monitoring involved conducting surveys for avian carcasses during peak spring and fall avian migration periods at the Lillooet River and Ryan River transmission line crossings. Transects were approximately 10 m wide, running roughly parallel to the river, and covered a total 1,630 m^2 at the Lillooet River transmission line crossing and 2,420 m^2 at the Ryan River transmission line crossing. One spring and one fall survey was conducted at each of three high risk locations (north side of Lillooet River transmission line crossing, south side of Lillooet River transmission line crossing, Ryan River transmission line crossing). No avian carcasses were observed during any of the six surveys. Ground visibility was limited by dense vegetation on the south side of the Lillooet River transmission line crossing and detection conditions were suboptimal due to high flows during the fall survey at the Ryan River transmission line crossing; however, avian carcasses were also not observed during surveys where vegetation was less dense or when flows were lower. Although results do not confirm that no birds are colliding with power lines (scavengers are likely to remove carcasses soon after they appear), results suggest that additional surveys are unlikely to be useful. Thus, we are not recommending that additional surveys be conducted in future years.

Mountain Goats – Upper Lillooet River HEF

The objective of Year 1 operational Mountain Goat effectiveness monitoring at the Upper Lillooet River (ULR) HEF was to evaluate the effectiveness of the downstream penstock portal design at Truckwash Creek in maintaining post-construction Mountain Goat use of the migration corridor (located between the Mountain Goat winter range situated in the Keyhole Falls canyon (UWR u-2-002 UL 11) and the higher elevation Mountain Goat winter range (UWR u-2-002 UL 19)), and in maintaining use of the Keyhole Falls canyon UWR, especially by nannies. Monitoring involved data collected by remote infrared cameras (from January 2017 through Year 1) strategically placed along the Mountain Goat migration corridor, systematic ground-based surveys for Mountain Goat sign, opportunistic monitoring of the Keyhole Falls Mountain Goat UWR, and the recording and compilation of incidental sightings. Results from all survey methods indicated that the Truckwash Creek migration corridor is still being used by Mountain Goats post-construction: infrared cameras documented Mountain Goats Sensitive location and timing information has been removed to protect this species. [redacted], systematic winter ground-based surveys documented the presence of Mountain Goat sign (tracks and sign) in the vicinity of the portal, and opportunistic monitoring of the Keyhole Falls Mountain Goat UWR (u-2-002 UL 11) indicated that Mountain Goats, including nannies, are continuing to use this winter range. Given the success of results from the first monitoring year in demonstrating continued use of the migration corridor and UWR u-2-002 UL 11 by Mountain Goats, we recommend that Mountain Goat mitigation effectiveness monitoring at the ULR HEF be discontinued.

Mountain Goats – Boulder Creek HEF

The objectives of Mountain Goat effectiveness monitoring at the Boulder Creek HEF are to: 1) to evaluate the effectiveness of the gate in preventing public access to the intake during winter; and 2) to evaluate predator presence and behavior within the UWR post-construction which will be used to assess potential access-related increase in predation risk to goats. These monitoring objectives were met in Year 1 of post-construction monitoring through the use of remote infrared cameras placed along the access road and through systematic ground-based surveys conducted to evaluate predator use of the Boulder Creek HEF intake area. Mountain Goat tracks were documented [redacted] on two occasions in 2018.

Access monitoring results obtained from the three remote infrared cameras installed along the Boulder Creek HEF access road indicated that the access road was likely inaccessible to the public by motorized vehicle except on one documented occasion when the gate was required to be closed (preventing motorized public access). On November 19, 2018, a hunter on an ATV was photographed by two of the remote infrared cameras (BDR-CAM01 and BDR-CAM02) along the access road past the location of the gate. However, because the camera that was installed to provide a view of the gate (BDR-CAM03) was not functioning at this time, it was not possible to determine how access was gained. Monitoring also indicated that the gate becomes non-functional during the winter months due to burial from snow and therefore will not impede snowmobile access. However, no incidents of the public passing the gate when it was buried in snow were documented, thus potential gate inadequacies during these conditions are not currently identified as an issue. Based on access monitoring results, it is recommended that:

- an automated electronic reminder and sign-off system is setup to confirm the gate is kept closed during the required period (November 1 to June 15), the effectiveness of which will be ensured through monitoring in future years;
- signage is posted at the base of the access road to inform 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; and
- a barricade will be installed on the upslope side of the gate to block the potential passage of smaller vehicles, in such as manner as not to impede drainage of the ditch on the upslope side of the road.

Predator monitoring results did not identify differences in predator use or activity pre and post-construction. Comparison of camera monitoring and ground-based and/or aerial survey results to date suggest that the amount and type of predator sign detected during the winter season for Mountain Goats (December through May) was similar between the two periods. However, owing to the typically low frequency of predator detections, which makes it difficult to obtain adequate sample sizes for meaningful comparison, and in accordance with requirements of the OEMP, continued predator monitoring in the following years is needed to document whether or not a notable increase in predator use of the area is observed, as the road receives less Project-related use during winter and predators potentially discover the road and adjust their habitat use.

Vegetation Monitoring

The objectives of vegetation monitoring are to qualify and quantify the re-growth of vegetation in terrestrial areas disturbed through the construction of the Project, to mitigate short-term habitat loss and to prevent the introduction of invasive species that may occur through site disturbance. Vegetation monitoring consisted of assessing the species composition and density of trees and shrubs (professional judgement to be used to assess deciduous tree and shrub growth; targeting 1,000 stems/hectare for conifers) and the percent cover of all vegetation layers (targeting steadily increasing cover of later successional species). In addition, if disturbed areas overlapped a UWR, WHA or high-value Grizzly Bear habitat, vegetation was assessed relative to specific targets for Moose, Mule Deer and Grizzly Bear forage species. The Year 1 monitoring of non-riparian vegetation growth was completed by Hedberg and Associates Consulting Ltd. (Hedberg) and is presented in Appendix C. A brief summary of results and recommendations is provided below, objectives are summarized in Section 2.10 and recommendations are detailed in Section 5.7

Revegetation evaluations were carried out at 66 sites across the Project area in September 2018, covering both rehabilitated transmission line access roads and civil works areas. An extensive tree planting program occurred at most of the civil works sites in October 2018 and therefore those sites were not expected to show high tree densities at the time of the vegetation survey. All Mule Deer and Moose specific vegetation planting requirements were met in 2018 and require no further monitoring efforts. Access roads in WHA 2-399 were confirmed to be deactivated through the placement of large logs. The effective deactivation of access roads within WHA- 2-399 will continue to be monitored in future years. No major erosion issues were noted. Very few invasive species were noted and all species that were observed within plots were removed during the survey. Pioneering species were noted along all sites sampled. The mean density of all plots assessed in 2018 was 7,970 stems/hectare; 9,906 stems/hectare at transmission line access sites, and 5,909 stems/hectare at civil works sites. The mean percent cover of all vegetation layers combined (herbs, shrubs and trees) across all plots surveyed was 11.4%; 16% across all transmission line site plots, and 7% across the civil works site plots.

Vegetation monitoring is scheduled annually for Years 1-5 in the approved version of the OEMP (Harwood *et al.* 2017). Subsequent revisions to the OEMP were proposed to MFLNRORD in February 2018 (Harwood *et al.* 2018) that include reducing the frequency of the vegetation monitoring program to Years 1, 3 and 5 which would match the riparian vegetation monitoring schedule. Hedberg recommends following this revised monitoring schedule. However, a survival survey is recommended in Year 2 (2019) to assess the general survival rates of trees planted in civil works sites in October 2018. No further revegetation treatments are recommended at this time.

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1. INTRODUCTION

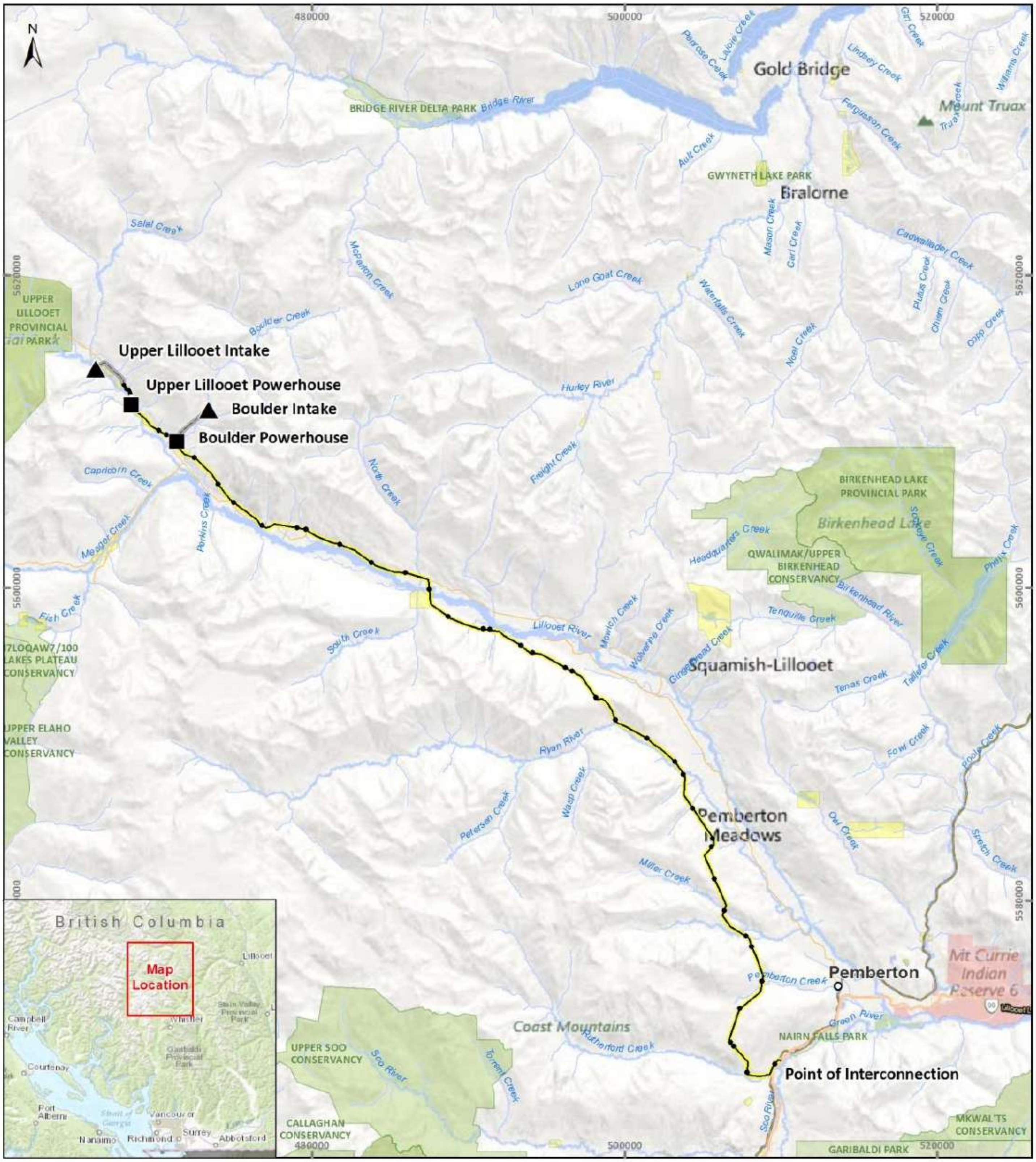
The Upper Lillooet Hydro Project (ULHP) (the Project) is a run-of-river hydro project comprised of two hydroelectric facilities (HEFs) located in the Upper Lillooet watershed, northwest of Pemberton, BC (Map 1). The largest of the two HEFs is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119), and the smaller is located on Boulder Creek (WC: 119-848100). Each HEF consists of a powerhouse and intake, and water is diverted, via penstock and/or tunnel, around approximately 3.8 km of river length 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, aka Long Term Monitoring Plan (LTMP)) was developed for the Project by Ecofish Research Ltd. (Ecofish) to assess potential Project effects on the environment, fish, wildlife, and wildlife habitat present in the Project area (Harwood *et al.* 2017). The OEMP addresses the operational monitoring conditions identified during the environmental assessments (EAs) (Lewis *et al.* 2012, Leigh-Spencer *et al.* 2012, Hedberg and Associates 2011, Lacroix *et al.* 2011a, b, c, d, NHC 2011) and the conditions listed in Schedule B (Table of Conditions (TOC)) of the Project's Environmental Assessment Certificate (EAC) (E13-01; EAO 2013). The aquatic components of the OEMP are also based on the *Fisheries and Oceans Canada (DFO) Long-term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects* (Lewis *et al.* 2013a). Monitoring requirements address two types of effects: footprint and operational. Footprint effects are associated with Project structure and can be short or long-term, depending on the permanence of the infrastructure and associated disturbance, whereas 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 Conditional Water Licences (CWL's C130613 for the Upper Lillooet River HEF and C129969 and C131153 for the Boulder Creek HEF) are adhered to. Effectiveness monitoring is conducted to verify that mitigation and compensation measures implemented for a project are effective, and response monitoring is the long-term monitoring of environmental parameters to establish empirical links between project development and operation and any effects on the environment. Compliance and effectiveness monitoring are conducted at specific locations based on the parameter being monitored. Response monitoring often requires data collection at multiple sites, with the locations dependent on the parameter(s) in question, so that Project effects can be assessed through a comparative study design. Effectiveness and response monitoring can lead to, and facilitate, the adaptive management of impacts.

This report presents monitoring results from Year 1 (2018) of operational monitoring in accordance with requirements of the OEMP (Harwood *et al.* 2017). Monitoring requirements include aquatic and terrestrial components, each of which have monitoring parameters with specific monitoring requirements including frequency, duration, and reporting, as summarized in Table 1 and Table 2 for aquatic and terrestrial components, respectively. Aquatic monitoring requirements follow recommendations from Hatfield *et al.* (2007) and Lewis *et al.* (2013a) (with a few exceptions noted in Harwood *et al.* (2018)), and include primary parameters (water flow, mitigation and compensation measures, footprint impact verification, water temperature, stream channel morphology, fish community) and secondary parameters (water quality, species at risk and of concern) (Harwood *et al.* 2017) (Table 1). Although invertebrate drift was considered as a secondary parameter, invertebrate drift monitoring was not included in the OEMP (as approved by Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), now referred to as Ministry of Forests, Lands, Natural Resource Operations & Rural Development (FLNRORD); Rosenboom, pers. comm. 2013, Barrett, pers. comm. 2013) given the low statistical power associated with the baseline data (Harwood *et al.* 2013a, b) and the low magnitude of potential effect (Lewis *et al.* 2013b). Aquatic monitoring parameters and components included in the OEMP are instream flow (reported separately), habitat compensation, aquatic and riparian habitat, frazil ice, fish community, and water quality (Table 1). This report addresses aquatic and riparian habitat, frazil ice, fish community, and water quality; the Year 1 & 2 Alena Creek habitat compensation components have been summarized in standalone reports (Appendix A, Appendix B). Terrestrial monitoring parameters and components included in the OEMP are wildlife species, wildlife habitat, and vegetation (Harwood *et al.* 2017) (Table 2). This report addresses wildlife species and wildlife habitat components for terrestrial monitoring; vegetation monitoring is being conducted by Hedberg and Associates and Year 1 monitoring results are presented in Appendix C.

Project Overview



Legend

- ○ Cities

ULHP Infrastructure

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

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 2 4 6 8 10 12 14 km

Scale: 1:350,000

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

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

ECOFISH RESEARCH

Map 1

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

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

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

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

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

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

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

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

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

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

ULL = Upper Lillooet River, BDR = Boulder Creek

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

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

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

[4] Monitoring may be extended if required.

2. OBJECTIVES AND BACKGROUND

2.1. Instream Flow Monitoring

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

2.2. Mitigation and Compensation Measures

Habitat Compensation for the ULHP HEFs was completed on Alena Creek. Monitoring results are included in the Compensation Habitat reports (Appendix A, Appendix B).

2.3. Aquatic and Riparian Habitat

2.3.1. Riparian Revegetation Assessment

The objective of the riparian revegetation effectiveness monitoring component of the OEMP (Harwood *et at.* 2017) is to evaluate the early successional growth and survival of natural and planted vegetation within riparian areas disturbed by Project construction and thereby to ensure compliance criteria are met. During permitting, the Project committed to restoration of riparian areas that had been temporarily impacted during Project construction in accordance with the DFO and MELP (1998) riparian areas and revegetation protocols and site restoration protocols outlined in Standards and Best Practices for Instream Works (MWLAP 2004). Following the completion of the Project, the construction contractor (CRT-ebc) was required to revegetate disturbed areas, and a detailed site-specific reclamation and revegetation plan was developed (McKeachie 2016) that was consistent with requirements in the Construction Environmental Management Plan (CEMP). In combination with amphibian habitat restoration monitoring (Section 2.9.1.1), riparian revegetation monitoring also contributes to the assessment of disturbed riparian areas along Coastal Tailed Frog streams.

The Independent Environmental Monitor confirmed that reclamation works were complete for the Project (Hicks 2017). In addition, Hedberg and Associates Consulting Ltd. (Barker and Staven 2017) confirmed that revegetation was completed at the Boulder Creek Hydroelectric Facility (HEF) powerhouse and the Upper Lillooet River (ULR) HEF intake, penstock (including at two Coastal Tailed Frog streams), downstream portal, and powerhouse. Riparian site reclamation (i.e., replacement of stockpiled topsoil and coarse wood) and revegetation began in the fall of 2014 and was completed by the spring of 2017 (Woodruff *et al* 2017). Riparian reclamation and revegetation efforts included, but were not limited to, preparing the substrate, adding topsoil, distributing coarse woody debris, and planting vegetation to density, species composition, spacing, and distribution specifications (McKeachie *et al.* 2016). Dave Polster provided additional direction on the application of local alder seed on the steep slopes above the portal and laydown area of the ULR HEF intake sites (CRT-ebc 2016).

Successful riparian revegetation is evaluated during effectiveness monitoring in accordance with DFO and MELP (1998) revegetation guidelines. Operational monitoring of revegetation is currently recommended in years 1, 3, and 5 of operations (Table 1). This monitoring schedule differs from that proposed in the DFO long-term monitoring protocols (years 1 through 5) because results from similar projects suggest that annual monitoring is not required. However, if concerns are identified, additional monitoring and/or management actions may be required (Harwood *et al.* 2017). This report presents riparian revegetation monitoring results from Year 1.

2.3.2. Footprint Impact Verification

The footprint impact verification components of the OEMP (Harwood *et al.* 2017), Condition #9 of the EAC (EAO 2013), and the *Fisheries Act* Authorization (DFO 2013, 2014) were completed and issued as a separate report in May 2018 (Appendix D, Parsamanesh *et al.* 2018).

2.4. Water Temperature and Air Temperature

Water extraction has the potential to increase water temperature in the summer and decrease water temperature in the winter (Meier *et al.* 2003). Fish may be vulnerable to both small increases and decreases in water temperature, with tolerance levels varying between species and life-history stages. Water temperature will be monitored continuously in the Upper Lillooet River and Boulder Creek for the life of each of the two projects (Harwood *et al.* 2017). The objective of monitoring water temperature is to identify any biologically significant differences (as defined in Harwood *et al.* 2012) between baseline and operational temperature regimes in the streams. To achieve this, water temperature dataloggers will be maintained upstream of the intake and headpond (control site), in the diversion reach (impact), in the tailrace, and in the downstream reach in the Upper Lillooet River and Boulder Creek. It was identified that the baseline water temperature regime at the upstream site in Boulder Creek was influenced by groundwater from late fall to early spring, therefore a new upstream location was established for operational sampling. The upstream baseline temperature data for this period will be replaced with data collected in North Creek following a year of concurrent water temperature monitoring. Therefore, during Year 1 water and air temperature loggers were installed in the Upper Lillooet River (Map 2), Boulder Creek and in North Creek (one upstream site) (Map 3).

This report provides the methodology and installation details; however, the operational water and air temperature data will be presented in the Year 2 annual monitoring report when at least one full calendar year of operational data are available (i.e., March 2018 to March 2019).

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 being monitored for conditions that may result in ice formation. When the climate and weather conditions indicate that there is potential for frazil or anchor ice formation, a protocol is initiated that, depending on local air temperatures, the status of Project operations, and visible evidence of ice formation within the HEF diversion reaches, may result in a field survey to evaluate the extent of frazil ice formation and to determine the appropriate response. As stated in the OEMP, HEF shutdowns will be recommended if visual site assessments indicate that frazil ice displaces ≥50% of the fish holding habitat within the hydraulic units (monitoring sites) surveyed, otherwise HEF shutdowns will not be recommended, but monitoring of air temperatures and monitoring sites will continue until the risk of frazil ice abates.

2.5. Stream Channel Morphology

Operational monitoring of stream morphology will be conducted 5 years after facility commissioning or after a 1 in 10-year daily discharge event, whichever comes first.

2.6. Fish Community Monitoring

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

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

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

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

3. Assessment of entrainment at the Upper Lillooet River intake, the objective of which is to evaluate whether fish entrainment in the Upper Lillooet HEF intake is having a population-level effect on the Cutthroat Trout population upstream of the intake.

For the juvenile fish density and biomass component, monitoring is conducted in the diversion reach (impact) and the upstream reach (control) of the Upper Lillooet River and in the diversion reach (impact) and the downstream reach (control) of Boulder Creek. For the adult migration and distribution component, monitoring is conducted in the diversion and downstream reaches of both the Upper Lillooet River and Boulder Creek (impact reaches) as well as in two reference streams (tributary at river km 29.2 of the Upper Lillooet River and Alena Creek). Alena Creek is also the location of the offset enhancement habitat for the Project. For the fish entrainment component at the Upper Lillooet River Intake the upstream reach (control) sites are sampled but split into two clusters closest to the headpond (potential impact) and furthest from the headpond (control) along with the km 87.0 Tributary (impact).

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 study design. Water use during operations can affect water quality indirectly by altering the volume of water remaining in a channel, or directly by returning water of altered quality to the river (Hatfield *et al.* 2007). However, on-going monitoring of similar hydroelectric projects, reviewed by DFO (2016), suggest that biologically significant effects of Project operations on water quality are not likely, therefore water chemistry is considered a secondary monitoring component.

General water quality parameters (pH, specific conductivity, total dissolved solids, total suspended solids and turbidity) and dissolved gases (dissolved oxygen and total gas pressure (TGP)) were monitored within the Upper Lillooet River for the first year of operations at four sites: upstream of the intake and headpond (control), in the diversion reach immediately upstream of the tailrace, in the tailrace, and downstream of the powerhouse. The tailrace site was specified to monitor potential increase in TGP during power generation. If atmospheric gases are entrained during passage through the turbines, the increase in pressure may result in elevated levels of TGP at the tailrace. Dissolved gas supersaturation measured as ΔP (pressure mm Hg) is a common feature of many BC watercourses, therefore additional gas entrainment may result in TGP levels that exceed the BC WQG for the protection of aquatic life (MOE 2018).

Based on the use of Francis turbines in the Upper Lillooet River HEF powerhouse, quarterly monitoring of water quality parameters sensitive to run-of-river project operations was recommended (Harwood *et al.* 2017). Subsequent revisions to the OEMP were made and submitted to MFLNRORD prior to the start of the 2018 field season (Harwood *et al.* 2018). Water quality sampling was reduced in frequency within the Upper Lillooet River (bi-annual sampling at the start and end of growing season) and the requirement to sample water quality in Boulder Creek was removed. Rational to remove water quality sampling in Boulder Creek was primarily due to the use of Pelton wheels at the

Boulder Creek HEF, which fully aerate powerhouse flows and are therefore not expected to increase TGP in the tailrace or downstream of the Project. In October of 2018, MFLNRORD approved these recommendations (Katamay-Smith, pers. comm. 2018a). Ecofish completed sampling bi-annual water quality sampling in the Upper Lillooet River and did not sample water quality in Boulder Creek in 2018, based on the rational provided in the revised version of the OEMP (Harwood *et al.* 2018).

Alkalinity will continue to be monitored once per year in conjunction with fish sampling for use in calculations of stream productivity. Alkalinity will be monitored in years 1, 2 and 5 post construction, consistent with the fish community monitoring schedule as recommended by Harwood *et al.* 2017, provided that an increase or no change in fish density is observed in Years 1 & 2 (see Section 2.6).

Some water quality parameters (e.g., dissolved oxygen, TGP, conductivity) will be measured in situ using appropriate equipment and methodology (Clark 2013). For other parameters (e.g., alkalinity), water quality samples will be collected and handled following approved protocols outlined in the Ambient Freshwater and Effluent Sampling Manual (Part E of Clark 2013), and sent to an accredited environmental laboratory for analysis. Laboratory sample collection methods during operational monitoring will be consistent with the British Columbia Field Sampling Manual (Clark 2013) which specifies that QA/QC in the range of 20 to 30% is considered appropriate. Rather than collecting triplicate samples at all sites on all dates, the QA/QC consists of the collection of triplicate samples at one site on each stream per sampling trip, and one travel blank and one field blank to cover both Project streams for each sampling trip.

Following the first year of operational monitoring, the need for further water quality sampling will be reviewed by the QP by comparing operational results with the natural range of values observed under baseline conditions within the Upper Lillooet River (Harwood *et al.* 2018).

This report provides a summary of the operational water quality results for Year 1 (2018) and an evaluation of the need to continue the water quality monitoring program in subsequent years (Year 2 – Year 5).

2.8. Wildlife Species Monitoring

Project footprint and operational effects are being evaluated for select wildlife species through response monitoring. Response monitoring is prescribed in the OEMP for Harlequin Ducks (*Histrionicus histrionicus*) and for species at risk and of regional concern. Although response monitoring was also originally prescribed for Coastal Tailed Frogs (*Ascaphus truei*), the Boulder Creek wildfire in 2015 severely impacted Coastal Tailed Frog habitat at the intended monitoring location and the monitoring component was therefore shifted to compliance monitoring of stream restoration (Harwood *et al.* 2017). 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.

The objective of wildlife species monitoring is to evaluate potential operational Project effects on select species and to thereby provide an opportunity for adaptively managing any such identified effects. An overview of the monitoring approaches for Harlequin Ducks and Species at Risk and of regional concern is provided in the following sections.

2.8.1. Harlequin Ducks

Although Harlequin Ducks are not federally listed and are provincially secure (Yellow-listed) (CDC 2019), Environment Canada and the BC Ministry of Environment (MOE) have identified Harlequin Ducks as a species of concern due to their potential interaction with hydroelectric development and operation (DFO 2007). Habitat modifications of breeding streams, which may include changes in prey availability, riparian habitat, and stream flow, may occur during development of hydroelectric projects and may pose a potential threat to Harlequin Duck populations (Esler *et al.* 2007, Rodway 1998). The Upper Lillooet River contains a substantial amount of high quality Harlequin Duck habitat and the species has been documented in the Project area (Lacroix *et al.* 2011a), with most observations recorded in the vicinity of the Upper Lillooet River HEF (adjacent to the Upper Lillooet River HEF powerhouse site, within the diversion reach, within the headpond area, and upstream of the headpond area). Given that Harlequin Duck habitat and use of the Project area may be affected by Project development, Harlequin Duck response monitoring was included as a component of the OEMP, in accordance with the Project's EAC (Condition #3 of the TOC).

The objective of Harlequin Duck 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) (RIC 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).

2.8.2. Species at Risk & Regional Concern

Monitoring of wildlife species at risk and of regional concern (as identified within the Sea to Sky Land and Resource Management Plan (MAL 2008)) has two main objectives. First, the collection of data on the presence and distribution of wildlife species at risk and of regional concern will be used to determine occupancy and locations of occurrences relative to Project infrastructure. This will allow identification of occurrences that may be affected by Project operations and will inform Project operations on situations that may require consideration (e.g., modification of timing of activities). Second, collection and submission of data on occurrences of species at risk and of regional concern to the province will contribute to the provincial database. Species at risk and of regional concern are being monitored through the recording of incidental observations during the first five years of Project operations (Table 2).

2.9. Wildlife Habitat Monitoring

Wildlife habitat monitoring involves both compliance monitoring and effectiveness monitoring (Table 2). Compliance monitoring was conducted immediately post-construction to confirm that mitigation commitments associated with species-specific habitat restoration prescriptions that are outlined in the

EAs (Leigh-Spencer *et al.* 2012, Lacroix *et al.* 2011a,b,c,d) and specified as conditions of the TOC (EAO 2013) and the General Wildlife Measures (GWM) Exemptions (Berardinucci 2013a,b, Barrett 2015, Blackburn 2016) have been met. Effectiveness monitoring is used to verify that Project design mitigation prescriptions are effective in avoiding or minimizing impacts to targeted wildlife species (Lacroix *et al.* 2011a, b) and the duration of this monitoring varies in accordance with the potential effects addressed. An overview of the components of wildlife habitat compliance and effectiveness monitoring is provided in the following sections.

2.9.1. Habitat Restoration

Species-specific habitat restoration prescriptions were assessed within the first year of construction for compliance with the EAs (Leigh-Spencer *et al.* 2012, Lacroix *et al.* 2011a,b,c,d) and the conditions of the EAC (EAO 2013) and the GWM Exemptions (Berardinucci 2013a,b, Barrett 2015, Blackburn 2016). These documents specify habitat restoration measures that need to be implemented post-construction for targeted amphibian, avian, and mammal species (as described in the sections below). It should be noted that mitigation measures or commitments associated with long-term vegetation maintenance are considered part of the vegetation monitoring requirements, the Year 1 results of which are presented separately (Appendix C).

2.9.1.1. Amphibian Habitat

Coastal Tailed Frogs are federally listed as Special Concern under Schedule 1 of the *Species at Risk Act*, as the species is particularly sensitive to human activities and natural events. Provincially, the species was listed as vulnerable to extirpation or extinction (Blue-listed) when the Project was initiated and the EA was conducted, although provincial conservation status has recently been downgraded to Yellow (CDC 2019). The EA (Lacroix *et al.* 2011b) determined that Coastal Tailed Frog terrestrial (riparian) habitat could be impacted within the transmission line Right-of-Way (RoW) where the transmission line crosses over suitable Coastal Tailed Frog streams, and that both riparian and instream habitat would be impacted at the location of the Upper Lillooet River HEF penstock tributary crossing (ULL-ASTR04). As such, habitat restoration measures were prescribed for Coastal Tailed Frogs. The objective of amphibian habitat restoration monitoring is therefore to confirm that key habitat restoration prescriptions were implemented post-construction (Table 3). Compliance monitoring, which was conducted immediately post-construction, was used to evaluate: 1) vegetation clearing works and site restoration within transmission line RoW; 2) effectiveness of sediment and erosion control; and 3) instream and riparian restoration success of ULL-ASTR04 in accordance with site-specific prescriptions (Woodruff and Lacroix 2014) and as specified in the Application for EAC Amendment #7 (Lacroix *et al.* 2015).

Table 3. Compliance monitoring required for Coastal Tailed Frogs (from Harwood *et al.* 2017).

Species	Project Component	Facility	Location	Prescription
Coastal Tailed Frog	Upper Lillooet River HEF	Transmission Line	Suitable Coastal Tailed Frog streams	Transmission line RoW clearing within 30 m of suitable Coastal Tailed Frog streams restricted to topping trees and that cut wood was left in place.
		Penstock	Penstock Crossing ULL-ASTR04	<ins>Instream habitat</ins>: habitat characteristics and value similar to pre-construction conditions, as measured during two years of pre-construction habitat surveys and evaluated once following restoration. Key habitat characteristics include substrate size, stream embeddedness, channel morphology, and mesohabitat characteristics. <ins>Riparian habitat</ins>: Terrestrial revegetation and reclamation follows the prescriptions outlined in Woodruff and Lacroix 2014.
		Transmission Line & Penstock	Suitable Coastal Tailed Frog streams	Effective sediment and erosion control measures implemented.

2.9.1.2. Avian Habitat

Avian habitat restoration measures were prescribed for Peregrine Falcons (*Falco peregrinus*) and Harlequin Ducks because habitat for these two species at risk or of regional concern had the potential to be impacted during Project construction. Objectives of avian habitat restoration monitoring were to confirm compliance with prescribed measures (Table 4). For Harlequin Ducks, this involved confirming that clearing of riparian habitat within high quality breeding areas during transmission line construction within the transmission line RoW had occurred in accordance with prescribed EA mitigation (Lacroix *et al.* 2011a), and for Peregrine Falcons, this involved ensuring that transmission line poles were placed away from suitable nesting ledges as per requirements of the Project's EAC (Condition #24 of the TOC).

Table 4. Compliance monitoring required for avian species (from Harwood et al. 2017).

Species	Project Component	Facility	Location	Prescription
Harlequin Duck	Upper Lillooet River HEF	Transmission Line	Ryan River and Lillooet River Crossing	Clearing within 30 m from high water mark restricted to topping trees and maintaining shrub layer during RoW clearing and vegetation maintenance. If necessary, the height of the shrub layer may have been reduced.
Peregrine Falcon	Upper Lillooet River HEF	Transmission Line	Lillooet River FSR and South Lillooet River FSR (ULH-PEFA01, ULH-PEFA04, ULH-PEFA16)	Transmission line poles were placed away from suitable Peregrine Falcon nesting ledges.[1]

[1] Condition 24 of the Project's EA Certificate (EAO 2013).

2.9.1.3. 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 5). For Grizzly Bears, compliance monitoring also confirmed 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).

Table 5. Compliance monitoring required for mammal species (from Harwood *et al.* 2017).

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).

2.9.2. Mitigation Effectiveness

Mitigation effectiveness monitoring is being used to confirm that key mitigation measures that had been developed to avoid and minimize potential adverse Project effects on wildlife were functioning as intended. Specifically, mitigation measures that are being evaluated during mitigation effectiveness monitoring are those developed to: 1) minimize avian mortality due to transmission line collisions for species migrating over the Upper Lillooet River and Ryan River; 2) protect Mountain Goats (*Oreamnos americanus*) migrating along Truckwash Creek between two UWRs from sensory disturbance and movement disruption; and 3) protect 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. Mitigation effectiveness monitoring is being implemented during the first three years of operation (Table 2).

2.9.2.1. Avian Collisions

The potential for avian collisions with the transmission line, where it crosses over large drainages such as the Upper Lillooet River and the Ryan River, was identified in the EA as a potential mortality risk for migrating birds (Lacroix *et al.* 2011a). As such, mitigation was developed to minimize bird collisions with transmission lines, and Condition #18 of the Project's TOC requires that bird diversion markers be placed on the transmission lines where they cross the Upper Lillooet and Ryan Rivers. The objective of avian collisions effectiveness monitoring is to evaluate the effectiveness of this mitigation measure, and this is being conducted through surveys for avian carcasses during peak avian migration periods at the Upper Lillooet River and Ryan River transmission line crossings during at least the first year of Project operations (at which time a QP is to evaluate the potential need for additional data collection).

2.9.2.2. Mountain Goats

Upper Lillooet River HEF

During supporting studies for the EA, Truckwash Creek was confirmed to be an important migration corridor for Mountain Goats moving between the Mountain Goat winter range situated in the Keyhole Falls canyon (UWR u-2-002 UL 11) and the higher elevation Mountain Goat winter range (UWR u-2-002 UL 19) (Map 4). Thus, movement disruption was identified as a potential adverse effect owing to Project-related activity in the vicinity of this migration corridor during construction (Leigh-Spencer *et al.* 2012). As such, Condition #15 of the TOC requires that a visual and partial auditory barrier be designed and constructed between the ULR HEF downstream tunnel portal and Truckwash Creek, which is intended to allow for the continued use of this migration corridor by Mountain Goats.

The objective of Mountain Goat effectiveness monitoring at the ULR HEF is to evaluate the effectiveness of the barrier design. Monitoring of Mountain Goat use of the Truckwash Creek migration corridor occurred prior to construction and during the Project's construction phase, and the OEMP specifies that it is to continue for at least one year post-construction to evaluate continued effectiveness of the barrier (at which time a QP would evaluate the potential need for additional data collection). Monitoring has been conducted through photographic data collection by remote infrared cameras, ground-based surveys for Mountain Goat sign, opportunistic monitoring of the Keyhole Falls Mountain Goat winter range (UWR u-2-002 UL 11), and the recording and compilation of incidental sightings.

Boulder Creek HEF

The intake and ancillary components for the Boulder Creek HEF were placed within a Mountain Goat winter range (UWR u-2-002 UL 12) (Map 5). Thus, upgrades to a pre-existing road and construction of a new segment of road required for the intake presented potential risks to Mountain Goats through increased access into the winter range by people and Mountain Goat predators. The Project's TOC (Condition #15) and conditions of the GWM Exemption that was issued to allow construction and operation of the Boulder Creek HEF within the winter range (Berardinucci 2013a, Barrett 2015, Blackburn 2016) therefore required that a gate must be installed and kept closed to prevent motorized public access during winter and spring (November 1 to June 15; Barrett 2015) and that it must be effective in preventing such access. The GWM Exemption also required that the presence and behaviour of predators, which may have changed due to new access into the winter range, must be monitored to allow assessment of associated risk to Mountain Goats.

Given the requirements of the EAC and GWM Exemption, there are two objectives of Mountain Goat effectiveness monitoring at the Boulder Creek HEF: 1) to evaluate the effectiveness of the gate in preventing public access during winter; and 2) to evaluate predator presence and behavior within the winter range post-construction which will be used to assess potential access-related increase in risk to Mountain Goats. Monitoring is being conducted for the first three years of operations (after which a QP will evaluate the potential need for additional data collection) through the strategic placement of remote infrared cameras and systematic ground-based surveys conducted to detect predator sign.

2.10. Vegetation Monitoring

The objectives of vegetation monitoring are to qualify and quantify the re-growth of vegetation in terrestrial areas disturbed through the construction of the Project, to mitigate short-term habitat loss and to prevent the introduction of invasive species that may occur through site disturbance. Vegetation monitoring consisted of assessing the species composition and density of trees and shrubs (professional judgement to be used to assess deciduous tree and shrub growth; targeting 1,000 stems/hectare for conifers) and the percent cover of all vegetation layers (targeting steadily increasing cover of later successional species). In addition, if disturbed areas overlapped a UWR, WHA or high-value Grizzly Bear habitat, vegetation was assessed relative to specific targets for Moose, Mule Deer and Grizzly Bear forage species. The Year 1 monitoring of non-riparian vegetation growth was completed by Hedberg and Associates Consulting Ltd. (Hedberg) and is presented in Appendix C.

3. METHODS

3.1. Aquatic and Riparian Habitat

3.1.1. Riparian Revegetation Assessment

Riparian revegetation effectiveness monitoring is designed to allow tracking of revegetation progress and thereby to confirm that a diversity of well-established native tree and shrub species with low observed mortality rate is achieved. The monitoring design has three main elements (Harwood *et al.* 2017):

1) use of permanent revegetation monitoring plots to estimate density, species composition, and survival of woody vegetation;
2) use of quadrats to estimate percent vegetation cover; and
3) use of photopoint monitoring to provide a visual qualitative evaluation of revegetation success.

Twelve permanent revegetation monitoring plots (also referred to as "plots") were established in 2018 (Year 1) within revegetated riparian areas associated with Project infrastructure and ancillary components as a means of tracking revegetation progress. Eleven of these plots were placed in association with ULR HEF infrastructure: three at the intake, six along the penstock, and two near the powerhouse. Two of the ULR HEF penstock plots (ULL-PRM08 and ULL-PRM09) were placed adjacent to a Coastal Tailed Frog stream (Map 6) to contribute to the assessment of disturbed riparian areas along ULL-ASTR04 (Section 3.6.1.1. One plot was placed near the Boulder Creek HEF powerhouse (Table 6, Map 6).

Plot locations were selected to be representative of the site conditions (e.g., soil, slope, moisture) present in the revegetated areas they represented. Their locations were also selected to be at or near vantage points with views of the revegetated areas, which was needed for effective photographic monitoring. Plot locations selected in Year 1 of the monitoring program will be used for the Year 3 and Year 5 monitoring. Revegetation monitoring in Year 1 was conducted on September 6 and 7, 2018.

Each of the three main monitoring elements is described in the sections below.

Table 6. Locations of permanent riparian revegetation monitoring plots surveyed on September 6 and 7, 2018.

Location	Permanent Monitoring Plot	UTM Coordinates			Description
		Zone	Easting	Northing	
Boulder Creek HEF Powerhouse	BDR-PRM01	10U	471338	5609325	River right of the Boulder powerhouse tailrace. Representative of the revegetation on the slope below the road adjacent to Boulder Creek.
Upper Lillooet River HEF Intake	ULL-PRM01	10U	466045	5614094	River right of Upper Lillooet River and upstream of the intake. Site provides a view of naturally revegetating slope.
	ULL-PRM02	10U	466236	5614031	River right of Upper Lillooet River and downstream of the intake. Site provides view of naturally revegetating slope. Slope is rough and loose.
	ULL-PRM03	10U	466112	5614110	River left of Upper Lillooet River and upstream of the intake. Site provides view for monitoring the revegetation on the slope below the road and above the intake.
Upper Lillooet River HEF Penstock	ULL-PRM04	10U	467946	5612993	River right of Truckwash Creek.
	ULL-PRM05	10U	468001	5612957	River left of Truckwash Creek.
	ULL-PRM06	10U	468188	5612695	River right of a tributary to the Lillooet River and upslope of the road.
	ULL-PRM07	10U	468215	5612654	River left of a tributary to the Lillooet River and downslope of the road.
	ULL-PRM08	10U	468392	5612384	River right of ULL-ASTR04, representative of the revegetated upper bench.
	ULL-PRM09	10U	468398	5612361	River left of ULL-ASTR04.
Upper Lillooet River HEF Powerhouse	ULL-PRM10	10U	468428	5611630	River left of the Upper Lillooet River HEF tailrace. Representative of the revegetated slope above the tailrace.
	ULL-PRM11	10U	468407	5611689	River right of the Upper Lillooet River HEF tailrace, representative of the revegetated slope above the tailrace.

3.1.1.1. Density, Species Composition, and Survival of Woody Vegetation

Woody vegetation is the primary focus of riparian revegetation monitoring due to its long-term contribution to the maintenance and enhancement of riparian habitat and function. Permanent revegetation monitoring plots (also referred to as plots) were established to measure the density and survival of perennial woody vegetation. The fixed-area circular plots were 50 m^2 in size, in accordance with the BC Silviculture Stocking Survey Procedures (MFLNRO 2015) and vegetation tally procedures employed by Stand Development Monitoring Protocol (MFLNRO 2014).

Revegetation performance was evaluated in permanent revegetation monitoring plots through comparison with the DFO and MELP (1998) riparian revegetation guideline target stem density values. Effective revegetation is evaluated based on 80% survival of initial plant stock with a maximum target spacing of 2.0 m (or less if appropriate considering the size of mature stock). Spacing and target densities were calculated with the following formula: spacing (m) = √(11,547/# stems per hectare) (Forest Renewal BC 2001). Thus, the density of single-stemmed plugs planted 2.0 m apart is 2,887 stems per hectare (stems/ha). To meet the target of 80% survival, spacing must average 2.2 m and vegetation must have a density of 2,309 stems/ha. This density was considered when setting the average target densities of 1,200 tree stems/ha and 2,000 shrub stems/ha by the end of the monitoring period (Harwood *et al.* 2017). To evaluate whether this target has been achieved across all revegetation areas, 90% confidence limits (lower confidence limits of 600 tree stems/ha and 1,000 shrub stems/ha), calculated from a two-tailed t-distribution, were generated to reflect sample size and among-plot variability.

Within each of the twelve permanent revegetation monitoring plots established in 2018 (Table 6, Map 6), the number of "stems" of all native perennial woody plants (which includes trees and shrubs, and excludes forbs, grasses, and mosses) were counted and health and mortality checks were conducted. Stems are defined as those stems of a plant that are distinctly individual at ground level regardless of spacing or plant species. Tree or shrub seedlings that had secondary leaves that were at least the size of a quarter were large enough to be considered established and were counted, and stems were counted regardless of plant height, spacing, or species. No distinction was made between vegetation that had been planted and that which had regenerated naturally because the objective of the monitoring was to evaluate successful revegetation by any means. Stems showing signs of abiotic stress, insect damage, fungal blights or other afflictions were all counted as living although incidences of the disease and the host plant species were noted. As invasive plant species can impede the establishment of native woody vegetation, invasive plant species were recorded and hand-pulled if feasible when encountered.

3.1.1.2. Percent Vegetation Cover

Grasses and herbs, in addition to woody species, provide sediment and erosion interception and ground stabilization early in the revegetation process. Quadrats were used to estimate the percent cover of vegetation within the revegetation areas represented by the permanent monitoring plots. Percent cover of vegetation was estimated within a 0.25 m^2 quadrat divided into 25 - 10 x 10 cm squares. Quadrats were placed on the ground and the 25 squares were used to guide estimates. For example, if 20 squares were filled with vegetation, the total estimated percent cover of the quadrat would be 80% because each of the squares equals 4% of the total area. Squares that were partially filled with vegetation were combined and a single cover estimate made. For example, if one square was half filled with vegetation, one was a quarter filled, and three squares had only two small blades of grass each, the combination of these would be equal to one full square of cover, or 4%. Percent vegetation cover was estimated as an average value of ten replicates randomly placed within each of the revegetation areas represented by the twelve permanent revegetation monitoring plots. Percent vegetation cover was considered when assessing the overall trajectory and success of riparian revegetation and the potential for erosion and sedimentation.

3.1.1.3. Photopoint Comparison

Photopoint monitoring was conducted to allow visual qualitative evaluation of changes in revegetation among years (i.e., year 1, 3, and 5 of operations) and thereby aid in interpretation of results from the two quantitative revegetation effectiveness evaluation methods. Photos were taken from the centre of plots and, given plot locations at vantage points, this provided a good vantage point for the revegetation area represented by the plot. Standard photographs were taken from 1.3 m above each of the plot's centre facing north (0º), east (90º), south (180º), and west (270º), and of the plot centre. Additional photographs were taken of specific areas where revegetation challenges were identified or successes were observed to support professional opinions on site-specific revegetation effectiveness or future revegetation requirements. Photographs were archived to provide documentation of changes in vegetation over time.

3.2. Water Temperature

3.2.1. Study Design

In the Upper Lillooet River, baseline water temperature was monitored continuously at the upstream control site (ULL-USWQ1) and the lower diversion site (ULL-DVWQ). Air temperature was also monitored continuously at two sites established in close proximity to the water temperature site locations, one upstream (ULL-USAT) and one in the lower diversion (ULL-DVAT). Baseline water and air temperature site names, site elevations, period of record, number of days with valid data, and the percent of the period of record where there are data gaps is summarized in Table 7. Detailed water and air temperature baseline methodology and data analysis corresponding to the period of data collection from 2008 to 2013 are provided in the aquatic baseline report (Harwood *et al.* 2016a,b).

Operational water temperature monitoring in the Upper Lillooet River commenced in March 2018 at five monitoring sites: (upstream (ULL-USWQ02, ULL-USWQ03), lower diversion (ULL-DVWQ01), tailrace (ULL-TAILWQ) and downstream (ULL-DSWQ) (Table 7). The locations of water and air temperature monitoring sites in relation to Project infrastructure are shown in Map 2 and summarized in Table 7. Two upstream sites are currently established: due to difficult access to ULL-USWQ02 a new site USWQ03 was established in November 2018 (Table 7).

Operational air temperature monitoring in the Upper Lillooet River commenced in March 2018 to facilitate modeling and analysis of the effects of change in water flow on water temperature (Table 7). Air temperature data are collected at two sites: upsteam control (ULL-USAT01) and impact site in the downstream reach (ULL-DSAT).

Operational water temperature monitoring in the Boulder Creek commenced in March 2018 at three monitoring sites: lower diversion (BDR-DVWQ), tailrace (BDR-TAILWQ) and downstream (BDR-DSWQ) and in September 2018 at the upstream site (BDR-USWQ2) (Table 8). The locations of water temperature monitoring sites in relation to Project infrastructure are shown in Map 3. An additional upstream site was established in North Creek at NTH-USWQ in September, 2018 to provide overlapping data with BDR-USWQ2 (Table 8). The need to replace baseline water temperature data from the upstream site on Boulder Creek with data from North Creek for the period from late fall to early spring due to the influence of groundwater was identified in the OEMP. This concurrent monitoring will occur for at least a year of operational monitoring to establish the relationship between temperatures at the two sites. Following a year of data collection, a QP will review the results to determine whether further concurrent data collection is required. The relationship between temperatures at the two sites will be used to make minor adjustments to the 2010 to 2013 record of late fall to early spring temperatures to more reliably represent baseline temperatures in the upstream reach of Boulder Creek for comparison with operational data. Representative site photos for each water temperature monitoring site are provided in Appendix E.

Table 7. Summary of water and air temperature site names, location and period of data record in Upper Lillooet River baseline (2008 to 2013) and operational monitoring (2018).

Water/ Air	Type	Reach	Project Phase	Site[1]	Elevation (masl)	Period of Record		Length of Record (day)	Valid Data (day)	Gaps in Record (%)
						Start Date	End Date			
Water	Control	Upstream	Baseline	ULL-USWQ1	670	19-Nov-08	3-Jun-13	1,657	1,656	0.0
			Operational	ULL-USWQ02	684	28-Mar-18	-	-	-	-
				ULL-USWQ03	673	1-Nov-18	-	-	-	-
	Impact	Diversion	Baseline	ULL-DVWQ	490	12-Nov-10	1-May-13	901	634	29.6
			Operational	ULL-DVWQ01	484	1-Nov-18	-	-	-	-
		Tailrace	Operational	ULL-TAILWQ	474	28-Mar-18	1-Nov-18	-	-	-
		Downstream	Operational	ULL-DSWQ	464	29-Mar-18	1-Nov-18	-	-	-
Air	-	Upstream	Baseline	ULL-USAT	670	7-Apr-10	1-May-13	1,120	1,087	3.0
			Operational	ULL-USAT01	687	28-Mar-18	-	-	-	-
		Downstream	Baseline	ULL-DVAT	485	7-Apr-10	1-May-13	1,120	768	31.4
			Operational	ULL-DSAT	485	28-Mar-18	1-Nov-18	-	-	-

A dash indicates temperature data download was not completed due to site access, temperature logger (tidbit) retrieval issues or loss of temperature loggers.

[1] ULL-USWQ03 was installed in 2018 to provide better access.
ULL-DVWQ01 - both tidbits installed in March 2018 were lost, therefore new tidbits were installed on November 1, 2018.
ULL-DVAT was re-named ULL-DSAT in 2018.

Table 8. Summary of water temperature site names, location and period of data record in Boulder Creek baseline (2008 to 2013) and operational monitoring (2018).

Type	Reach	Project Phase	Site[1]	Elevation (masl)	Period of Record		Length of Record (day)	Valid Data (day)	Gaps in Record (%)
					Start Date	End Date			
Control	Upstream	Baseline	BDR-USWQ	1,005	22-Apr-10	22-Sep-11	1,105	637	57.7
		Operational	NTH-USWQ1	911	25-Sep-18	-	-	-	-
			BDR-USWQ2	1,030	24-Sep-18	-	-	-	-
Impact	Diversion	Baseline	BDR-DVWQ	488	21-Nov-08	1-May-13	1,628	14	0.9
		Operational			16-Mar-18	-	-	-	-
	Tailrace	Operational	BDR-TAILWQ	488	16-Mar-18	-	-	-	-
	Downstream	Operational	BDR-DSWQ	488	16-Mar-18	-	-	-	-
Air		Baseline	BDR-DVAT	490	8-Apr-10	1-May-13	1,119	0	0.0
		Operational			16-Mar-18	-	-	-	-

[1] NTH-USWQ1 is a supplementary site located in North Creek, required to verify the baseline upstream temperature data set.

Operational logging interval is 15 min. for water temperature loggers and 30 min. for air temperature loggers.

3.2.1.1. Fish Species Distribution

The fish distribution of the Upper Lillooet River has been described in previous baseline monitoring documents and in the OEMP (Harwood *et al.* 2017). The fish species targeted for monitoring in the Upper Lillooet River and Boulder Creek are Bull Trout and Cutthroat Trout. Cutthroat Trout may be present at all temperature monitoring site locations in the Upper Lillooet River while Bull Trout is limited to the diversion and downstream locations of both the Upper Lillooet River and Boulder Creek. Bull Trout is the most thermally sensitive species present in the Project area.

Table 9. Fish species distribution in the Upper Lillooet River and Boulder Creek and BC WQG optimum temperature ranges (MOE 2018).

Project	**Fish Species**	**Fish Species Presence**	**Optimum Water Temperature (°C) Range (MOE 2018)**[1]			
			Incubation	**Rearing**	**Spawning**	**Migration**
Upper Lillooet River	Cutthroat Trout	Upstream, diversion and downstream sites	9.0-12.0	7.0-16.0	9.0-12.0	-
	Bull Trout	Diversion and downstream sites	2.0-6.0	6.0-14.0	5.0-9.0	-
	Coho Salmon	Diversion and downstream sites	4.0-13.0	9.0-16.0	4.4-12.8	7.2-15.6
Boulder Creek	Cutthroat Trout	Lower diversion and downstream sites	9.0-12.0	7.0-16.0	9.0-12.0	-
	Bull Trout	Lower diversion and downstream sites	2.0-6.0	6.0-14.0	5.0-9.0	-

[1] Optimal temperature ranges for water quality guideline application are provided in the BC WQG for the protection of aquatic life (MOE 2018). The water quality guideline range is ± 1 °C change beyond optimum temperature range for each life history phase of the most sensitive salmonid species present.

3.2.2. Data Collection and Analysis

Data processing of water temperature is deferred until Year 2 (2019) after collection of a more complete water and air temperature data set. Typically, data are processed as follows. First, outliers are identified and removed. This is done for each logger by comparing temperature data from the duplicate station loggers and the loggers at the other stations. For example, occasional drops in water level which exposed the temperature loggers to the air are considered as outliers and removed from the dataset. Second, the records from duplicate loggers are averaged and records from different download dates are combined into a single time-series for each monitoring station. The time series for all stations are then interpolated to a regular interval of 15 minutes (where data are not already logged on a 15-minute interval), starting at the full hour.

Water temperature data from the duplicate station loggers (where available) and the loggers at the other stations are compared to identify and remove outliers from the data sets. Following this, the records from duplicate loggers are averaged and records from different download dates are combined into a single time-series for each monitoring station. The time series for all stations are then interpolated to a regular interval of 15 minutes (where data are not already logged on a 15 minute interval), starting at the full hour.

For data presentation, plots are generated from water and air temperature data collected at 15 minute intervals where possible, or interpolated to 15 minute intervals when data are collected at 60 minute intervals. Plots are also generated for the hourly rates of change in water temperature as per the water temperature BC WQG for the protection of aquatic life (Oliver and Fidler 2001, MOE 2018).

Analysis of the water temperature data involves computing the following summary statistics: mean, minimum, and maximum water temperatures for each month of the record (monthly statistics were not generated for months with less than three weeks of data), differences in water temperature between stations, hourly rate of change of temperature, number of days with mean daily temperature >20°C, >18°C, and <1°C, number of days outside the recommended maximum and minimum threshold for Bull Trout/Dolly Varden, the length of the growing season, and the accumulated thermal units in the growing season and the mean weekly maximum water temperature (MWMxT). Table 10 defines these statistics and describes how they are calculated and guideline application is described in Section 3.2.2.2.

3.2.2.1. Quality Assurance/Quality Control

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

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

Operational water temperature was recorded at intervals of 15 minutes, using self-contained TidbiT® data loggers. The loggers are accurate to ±0.2°C and have a resolution of 0.02°C. Two TidbiT® loggers were installed on separate anchors at each location. This redundancy ensures availability of data in case one of the loggers malfunctioned or was lost. In 2018, two loggers were lost at ULL-DVWQ01. 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).

3.2.2.2. Applicable Guidelines

Hourly Rates of Water Temperature Change

Large, rapid changes in water temperature (greater than ±1.0°C/hr) can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature are compared to the provincial guidelines, which specify that the hourly rate of water temperature change should not exceed ±1.0°C/hr (Oliver and Fidler 2001).

Daily Extremes

Extreme cold temperatures are monitored as part of the water temperature component since the Project is situated in a location with cold air temperatures and historically cold winter water temperatures. The number of days when the daily mean temperature was <1°C, >18°C and >20°C are calculated.

Mean Weekly Maximum Temperature (MWMxT)

The mean weekly maximum water temperature (MWMxT) is an important indicator of prolonged periods of cold and warm water temperatures that fish are exposed to. The guideline 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).

Accordingly, MWMxT values (see Table 10 for method of calculation) are compared to the optimum temperature ranges for fish species in the Project area (Table 9).

Table 10. 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.

3.2.3. Frazil Ice

A protocol was established in December 2017 to monitor frazil ice conditions in the Upper Lillooet River and Boulder Creek diversion reaches and the potential effects of frazil ice formation on fish habitat availability. An automated alarm system was set up that triggers an email alert to Ecofish QPs when mean daily air temperatures of -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 three monitoring sites have been established in the diversion reach of each HEF (Map 7), located either in stranding sensitive monitoring sites (SSMSs) or closed-site electrofishing sites where fish are known to overwinter.

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

3.3. Fish Community

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

3.3.1. Juvenile Fish Density and Biomass

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

Consistent with baseline monitoring, juvenile fish sampling was conducted in March within both the Upper Lillooet River and Boulder Creek, when conditions are most suitable for closed-site electrofishing and mark-re-sight snorkel surveys (e.g., low flow and low turbidity). Consistent with baseline monitoring, sampling of juvenile fish within both systems was conducted at night because juvenile salmonids and char are known to be nocturnal and hide in interstitial spaces during the day in the winter (Campbell and Neuner 1985, Thurow *et al.* 2006). An overview of Ecofish fish sampling locations in the Project area is provided in Map 8. Upper Lillooet River electrofishing sites are shown in Map 9 and Boulder Creek mark re-sight snorkel sites are shown in Map 10.

3.3.1.1. Upper Lillooet River

Closed-Site Electrofishing

Juvenile fish within the Upper Lillooet River were monitored through closed-site multi-pass electrofishing performed by experienced crews in a manner consistent with baseline sampling. As during baseline sampling, electrofishing was conducted within an impact stream section located within the diversion reach and a control section within the upstream reach at sites composed of high-quality fish habitats that were selected through a stratified non-random process during baseline monitoring.

In total, five sites have been established within the diversion and ten sites have been established in the upstream reach (Map 9). As per the revised OEMP, the five uppermost upstream sites were established in 2014 upstream of the five original upstream sites to act as additional control sites to assess potential facility-related entrainment effects within the original five sites which were located relatively close to the Upper Lillooet River HEF intake. Previously established sample sites were relocated in 2018 with a handheld GPS unit and flagging, bench marks, and site photographs.

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

All captured fish were anaesthetized prior to processing. During processing, fish were identified to species, weighed (±0.1 g, or 1 g for fish over 200 g), measured for fork length (±1 mm), and photographed. Scale samples were collected from subsamples of Cutthroat Trout representing all life stages and were mounted directly on microscope slides in the field for future laboratory aging. To ensure adequate representation of each life stage in the scale samples, scale samples were collected from each reach from at least two suspected young-of-year (<60 mm), and from a representative sample of juvenile sized individuals (60 mm to 150 mm) and adults (>150 mm). Fin ray samples were collected from all Bull Trout ≥100 mm in length. Small fin clip samples were also collected from captured fish and preserved in 95% ethanol for future DNA analysis to verify species identification. 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 for recovery. Upon recovery, and after all electrofishing passes were completed, fish were released back into the sample site. Any fish mortalities associated with electrofishing activities were recorded.

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

Age Analysis

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

The fish density and biomass analysis, and comparison between control and impact sites, requires that the fish species of interest be separated into age classes. To define discrete age classes of Cutthroat Trout, the length-frequency histograms for fish captured during electrofishing were reviewed along with all of the length at age data from the scale analysis. Based on a review of these data, discrete fork length ranges, that allow all fish to be assigned an age class based on fork length, were defined for each of the following age/life history classes: fry (0+), juvenile (1-2+) and adult (≥3+) for Cutthroat Trout and fry (0+), juvenile (1-3+) and adult (≥4+) for Bull Trout. For the juvenile fish sampling in the late spring, winter annuli from the previous winter are not detected on aging structures. Thus, the age classes presented for this sampling are consistent with the fall of the previous year consistent with baseline sampling (e.g. fry (0+) detected in the spring of 2018 actually emerged in 2017). Fin ray samples collected from Bull Trout were not processed and aged in 2018 because of the small sample size of this species and the uncertainty in the aging of Bull Trout fin ray samples in the Project area during baseline. For these reasons, age classes for this species were derived primarily from length-frequency results and consistent with baseline. Fin ray samples have been collected and archived and may be examined in the future if required.

Fish Metrics and Condition

The analysis of data from individual fish consisted of defining age class structure and describing other characteristics of the fish populations, including length-frequency distributions, length-weight relationships, Fulton's condition factor (K), and length at age. Fulton's condition factor (*K*) was calculated for all captured fish using the following equation:

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

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

Density and Biomass Estimates

Fish density and biomass were calculated from abundance estimates by age class (fry (0+), juvenile, adult, and all ages combined) for each species in each electrofishing site. Individual fish were assigned to specific age classes based on the age-length relationship analysis described in the *Age Analysis* section above. Fish abundance estimates were computed using the Carle-Strub K-Pass removal depletion function (Carle and Strub 1978) within the FSA package (Ogle 2016) in R (R Core Team 2018). Site and age class-specific fish abundance estimates were then divided by site areas to standardize to fish numbers per unit area (i.e., density). Density estimates of each age class and age class grouping were then multiplied by the corresponding average biomass values to get an estimate of biomass per unit area. Fish density and biomass estimates are expressed as FPUobs (#/100 m²) and BPUobs (g/100 m²), respectively.

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

3.3.1.2. Boulder Creek

Night Snorkelling Mark Re-sight

Juvenile fish within Boulder Creek were monitored through night snorkeling mark re-sight surveys performed by experienced crews in a manner consistent with baseline sampling. As during baseline sampling, snorkel surveys were conducted within an impact stream reach located within the diversion reach and a control section within the downstream reach at sites composed of high-quality fish habitats that were selected through a stratified non-random process during baseline monitoring. In total, ten sites were revisited in 2018 (five sites in each reach; Map 10). Sites were first visited during daylight when sampling areas were measured, photographed, and marked with flagging tape.

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

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

Following the re-sight swim, snorkelers captured as many fish as possible using dip nets to collect data on weights, length at age, and to verify fork lengths estimated by snorkelers. Captured fish were processed using the same methods described in section 3.3.1.1, including collection of fin ray and fin clips, scanning all fish for PIT tags, and PIT tagging fish greater than approximately 90 mm in length if none were detected in order to monitor recaptures and movement in future years. After sufficient recovery time, fish were released back into the sites where they were originally captured. Habitat data were collected and site conditions were recorded at each snorkel site as described in section 3.3.1.1 above, with the exception of depth-velocity transects which were not collected in Boulder similar to baseline sampling.

Age Analysis

The fish density estimates and comparison between control and impact sites, requires that fish be separated into age classes. Aging of scale samples was conducted following the same methods described above in the *Age Analysis* subsection of section 3.3.1.1. Density analyses were conducted based on general age classes derived from combined length-frequency results from both reaches and all years of monitoring rather than reach- and year-specific length at age data consistent with baseline.

Fish Metrics and Condition

Data from individual captured fish were analyzed following the same methods described in the *Fish Metrics and Condition* subsection of section 3.3.1.1 above. Length-frequency distributions were created using all fish lengths collected: including fish captured and marked on the first night of sampling and those captured following the re-sight swim on the second night. The length-weight relationship included fewer data points as only the fish captured following the re-sight swim were weighed.

Density Estimates

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

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

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

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

$$Abundance = \frac{O}{oe}$$

where *O* is the number of fish observed during the re-sight survey.

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

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

Due to the low numbers of fish marked at each site, the mark re-sight data were pooled in order to calculate mean observer efficiency. The mean observer efficiency of Bull Trout was also used to calculate abundance estimates of Cutthroat Trout due to the exceptionally low number of Cutthroat Trout captured. The density per area (#/100 m²) of each age class within each site was then calculated by dividing the abundance estimate by the sampled area of the site. Densities are presented for individual sites and as overall averages per age class and age class grouping. Biomass estimates were not calculated for fish in Boulder Creek due to the small sample size of captured fish.

Abundance Action Threshold (AAT)

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

3.3.2. Adult Migration and Distribution

3.3.2.1. Bull Trout Surveys

Bull Trout migration and spawning were monitored in downstream and diversion reaches of both Upper Lillooet River and Boulder Creek using angling surveys and in two reference streams (29.2 km and Alena Creek) using bank walk surveys. The sampling of two reference streams is consistent with Table 9 of the OEMP (Harwood *et al.* 2017); however, we note that text in section 2.6.2 also references North Creek as a reference stream. To avoid confusion future years of sampling will also include North Creek as a reference stream.

Angling surveys were conducted in the downstream and diversion reaches of the Upper Lillooet River and Boulder Creek during the spawning migration window (September 14 to October 10 in 2018). The survey area within the Boulder Creek lower diversion was limited to ~1.7 km upstream of the confluence with the Upper Lillooet River due to the presence of an entrenched canyon section, which limits access. Angling surveys were conducted at key sites, in high-grade Bull Trout habitat, as assessed by experienced fisheries technicians. Each survey was conducted by two to three experienced anglers, with effort scaled to account for the fishable area of each site, but for no less than 0.75 rod hours.

Angling was primarily conducted using roe on a float as bait because this proved to be most effective during baseline monitoring. All captured fish were processed as per methods described in section 3.3.1.1 before being live released back into the location where they were captured. Relevant site characteristics and conditions were also collected during angling surveys in September 2018.

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

Bull Trout spawner surveys were conducted at two tributaries of the Upper Lillooet River as specified in the OEMP; the tributary at km 29.2 of the Lillooet River (29.2 km Tributary) and Alena Creek. Alena Creek and the 29.2 km Tributary are being monitored as a reference stream to help assess potential confounding effects of the Capricorn/Meager slide in August 2010 on results of the monitoring program in the Upper Lillooet River and Boulder Creek. The additional monitoring allows an assessment of changes to the fish populations in the Project and reference streams by using trend by time metrics to identify the recovery rate of both the Project and reference streams from the slide.

Spawner surveys were conducted by walking along the shore during the Bull Trout spawning period (between mid-September and early December) and recording the number of spawning fish, carcasses, and redds. Tissue and scale samples were taken from carcasses for potential DNA analysis and confirmation of the individual's sex; carcasses were also assessed for stage and/or extent of spawning and were measured for length (post-orbital hypural length (POHL)).

3.3.2.2. Cutthroat Trout Tributary Access

Visual assessments (as described above) of the potential for fish passage and upstream access by adult Cutthroat Trout were also conducted in June 2018 on three tributaries of the lower diversion of the Upper Lillooet River (at river km's 83.2, 83.6, and 83.7, hereafter referred to ULL-83.2 km, ULL-83.6 km, and ULL-83.7 km, respectively) that were identified during baseline monitoring as being at risk of connectivity loss.

Open-site electrofishing surveys were also conducted late in the growing season (October 18, 2018) in the three tributaries of the Upper Lillooet River assessed in June 2018 for adult access to determine the presence of Cutthroat Trout fry and juveniles as evidence to whether adults were successfully spawning within them. An experienced crew worked through high quality fish habitat in each tributary in an upstream direction, attempting to capture all observed fish. All captured fish were identified to species and processed following methods described in section 3.3.1.1. Habitat data, and survey area conditions and characteristics were also recorded following the same methods described in section 3.3.1.1.

3.3.3. Assessment of Entrainment at the Upper Lillooet River Intake

Baseline sampling indicated that the Cutthroat Trout population in the upstream reach of the Upper Lillooet River is highly dependent on tributary habitat and movement by fish into and out of these tributaries creates a potential risk of entrainment in the Upper Lillooet River HEF intake. This risk is greatest for resident Cutthroat Trout in the mainstem, and those moving back and forth between tributary and mainstem habitat, in the vicinity of the intake. Assessment of entrainment at the Upper Lillooet River HEF intake was conducted by sampling and tagging fish at three sites established in 2013 in the unnamed tributary that flows into the facility's headpond at the 87.0 km marker upstream from Lillooet Lake (hereafter referred to as "87.0 km Tributary") as well as in the original lower five upstream juvenile fish monitoring sites and the five additional uppermost upstream sites established in 2014. Recaptures of tagged fish are intended to provide a coarse assessment of movement within the mainstem, between the mainstem and tributary habitat, and how movements vary with season (spring and fall), in order to evaluate entrainment risk. As described above in section 3.3.1.1, the five uppermost upstream sites also act as additional control sites to assess these potential facility-related entrainment effects within the original five sites and 87.0 km Tributary.

3.3.3.1. Closed-Site Electrofishing

Fish sampling was conducted through closed-site multi-pass removal electrofishing following the same methods described in Section 3.3.1.1 and at the same sites established during baseline studies in 2013. The ten Upper Lillooet River upstream sites were sampled during annual fish monitoring in March but 87.0 km Tributary sites were sampled in October because it is covered in ice and snow in March when mainstem fish sampling is conducted. All captured fish were processed as per methods described in Section 3.3.1.1, including the collection of age and DNA tissue samples, and scanning for, and application of PIT tags. Aging and fish metrics and condition analyses were conducted following the corresponding methods described in section 3.3.1.1.

Physical habitat data were collected at each of the sites in accordance with guidelines outlined in RISC (2001) and Appendix A of Lewis *et al.* (2004), following methods described in section 3.3.1.1.

3.3.3.2. Density and Biomass Estimates

Fish abundance, density, and biomass per unit area were calculated by age class and age class grouping at each electrofishing site using the methods described in section 3.3.1.1, and are similarly expressed as FPUobs (#/100 m^2) and BPUobs (g/100 m^2), respectively.

3.4. Water Quality - Secondary Component

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

Five operational water quality monitoring sites in the Upper Lillooet River were established and sampled in 2018 (Table 11). Sites were located upstream of the intake (ULL-USWQ02, ULL-USWQ03), in the diversion (ULL-DVWQ01) at the tailrace (ULL-TAILWQ; *in-situ* only) and downstream of the tailrace (ULL-DSWQ) (Map 2). ULL-USWQ02 is a helicopter only access site, for this reason a new site ULL-USWQ03 was established in 2018 to provide easier access for water quality and water temperature monitoring moving forward. Operational sampling of water quality was not required for Boulder Creek.

Table 11. Summary of operational Year 1 (2018) water quality sampling locations and sampling schedule.

Site	UTM Coordinates (Zone 10 U)		Elevation (masl)[1]	Sampling Dates
	Easting	Northing		
ULL-USWQ02	464122	5614982	684	28-Mar-18
ULL-USWQ03	465530	5614484	673	01-Nov-18
ULL-DVWQ01	468346	5612055	484	29-Mar-18, 01-Nov-18
ULL-TAILWQ	468423	5611670	474	28-Mar-18, 01-Nov-18
ULL-DSWQ	468601	5611202	464	29-Mar-18, 01-Nov-18

[1] Estimated using Google Earth.

Water quality sampling was completed using two distinct methods at each site: *in situ* measurement and collection of water samples for laboratory analysis. The parameters measured *in-situ* (Table 12) and in the laboratory (Table 13) were consistent with those prescribed in the Project OEMP (Harwood *et al.* 2017). Representative site photos are presented in Appendix E.

Table 12. Water quality parameters measured *in situ* in 2018.

Parameter	Units	Meter
General Water Quality		
pH	pH units	YSI Pro Plus/YSI 556
Specific Conductivity	µS/cm	YSI Pro Plus/YSI 556
Water Temperature	°C	YSI Pro Plus/ YSI 556
Dissolved Gases		
Dissolved Oxygen	mg/L and % saturation	YSI Pro Plus/YSI 556
Total Gas Pressure	mm Hg and % saturation	P4Tracker
Barometric Pressure	mm Hg	P4Tracker
Δ Pressure	mm Hg	P4Tracker

Table 13. Water quality parameters measured in ALS Environmental Laboratory in 2018.

Parameter	Units	Minimum Detection Limit (MDL)
pH	pH units	0.10
Specific Conductivity	µS/cm	2.0
Total Dissolved Solids	mg/L	10.0
Total Suspended Solids	mg/L	1.0
Turbidity	NTU	0.10

3.4.1. Quality Assurance and Quality Control

In situ water quality meters were maintained and operated following manufacturer recommendations. Maintenance included calibration, cleaning, periodic replacement of components, and proper storage. Triplicate *in situ* readings were recorded during in situ sampling and triplicate samples were collected at one site during each sampling trip. Triplicate sampling improves our ability to detect outliers and erroneous data resulting from travel, field or laboratory sample contamination.

Laboratory sample collection methods during operational monitoring were consistent with the British Columbia Field Sampling Manual (Clark 2002) which specifies that QA/QC in the range of 20 to 30% is considered appropriate. The QA/QC consists of the collection of triplicate samples at one site on each stream per sampling trip, the collection of one field blank and inclusion of one travel blank per sampling trip.

Sampling procedures for in situ and water sample collection for lab analysis as well as assignment of detection limits followed the guidelines of the Ambient Fresh Water and Effluent Sampling Manual within the British Columbia Field Sampling Manual (Clark 2013). Water quality samples for laboratory analysis were collected in bottles provided by ALS laboratory. Samples were packaged in clean coolers that were filled with ice packs and couriered to the laboratory. Standard Chain of Custody procedure was strictly adhered to. ALS maintains a Quality Management System that adheres to the requirements of the ISO:IEC 17025:2005 standards. Laboratory QC procedures included replicate analysis of a subset of samples, analysis of standard reference materials, and method blanks. Laboratory results and Quality Control (QC) reports are provided in Appendix F.

The RISC manual "Guidelines for Interpreting Water Quality Data" (RISC 1998) was referred to for data analysis as it provides detailed direction for screening, editing, compiling, presenting, analysing, and interpreting water quality data.

It is a common occurrence in clear fast flowing mountain streams to have concentrations of a number of parameters that are less than, or near, the minimum detection limit (MDL). In this report, any values that were "less than" the MDL were assigned the actual MDL values and averaged with the results of the other replicates if replicate samples were collected. In this case the average is also considered to be less than the value reported.

Exceedance of pH hold times (0.25 hours) is unavoidable; and is observed for all samples. *In-situ* pH is also measured at all sites. In general hold times are conservative in nature in order to provide guidance for a number of different water quality sample types ranging in complexity (e.g., wastewater may require a more stringent hold time in comparison to clear flowing surface water samples) (Langlais, pers. comm. 2012). If hold times are exceeded, the results are reviewed and any outliers are identified.

In-situ and laboratory results were reviewed for outliers in the event that qualifiers were identified during the QA/QC procedure. The relative standard deviation (RSD) as described in RISC 1998 was calculated for all triplicates to determine if variability is greater than 18%. Triplicate results are evaluated and data are flagged if high variability between replicates was identified. Results of the QA/QC analysis are provided in Appendix G.

3.4.2. Guidelines for the Protection of Aquatic Life

Water quality guidelines for the protection of aquatic life and typical ranges of water quality parameters in British Columbia waters that were considered for this report are provided in Appendix G. Water quality parameter results were compared to provincial water quality guidelines where they exist. For parameters without provincial or federal guidelines (e.g., alkalinity, and specific conductivity) results were compared to typical ranges found in British Columbia streams (Appendix G). Any results for water quality parameters that approached or exceeded guidelines for the protection of aquatic life or ranges typical for British Columbia are evaluated in greater detail.

3.5. Wildlife Species Monitoring

3.5.1. Harlequin Ducks

Harlequin Duck monitoring was conducted through vantage point surveys (spot checks) (RIC 1998) along with the recording and compilation of incidental observations. Spot checks were conducted by Ecofish or Innergex personnel at specifically selected vantage points near the intake and powerhouse of the Upper Lillooet River HEF (Map 11) using standardized protocols (protocols, including survey locations, timing, frequency, and methods, are provided in Appendix H). One vantage point was used for all spot checks at the powerhouse and one vantage point was used for most surveys at the intake with an alternative used once in early May when snow prevented access to the main vantage point. As an exception, the survey on the August 9 at the intake was conducted with the use of zoomable surveillance cameras from a room inside the powerhouse because the intake vantage point could not be accessed due to high landslide risk. 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 1, spot checks were conducted at both the intake and the powerhouse on May 3, 17, and 31, and on August 9, 16, and 23. Spot checks were coordinated with the Upper Lillooet River HEF intake Quick Flush[1] in Year 1 for two of the surveys: spot checks were conducted at the intake and powerhouse before the Quick Flush on May 17 and before and after the Quick Flush on August 16.

During spot checks, the water, exposed instream rocks, and riparian areas close to the water's edge were scanned with binoculars, and enough time was spent searching to allow detection of diving birds or those that may be difficult to spot given cryptic colouration (females and broods). As an exception, the August 9 brood survey at the intake was conducted with the use of zoomable surveillance cameras from a room inside the powerhouse, when the intake vantage point could not be accessed due to high landslide risk. Data collected during spot checks included survey date, location, time, number of individuals observed, age and sex of individuals, and behaviour (e.g., feeding, flying, group or pair behaviour). Any other 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 also recorded opportunistically by plant operations staff, consulting biologists, and technicians throughout the year.

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[1] The Quick Flush is a sediment management procedure associated with periodic sluicing of the Upper Lillooet River HEF headpond.

3.5.2. 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 1 were recorded and were compiled according to provincial format to facilitate data sharing.

3.6. Wildlife Habitat Monitoring

3.6.1. Habitat Restoration

Methods for habitat restoration monitoring for amphibians (Coastal Tailed Frogs), birds (Harlequin Ducks and Peregrine Falcon), and mammals (Grizzly Bear, Moose, and Mule Deer) are provided in the sections below. It should be noted that in addition to the species-specific monitoring methods described below, habitat restoration compliance monitoring also included assessment of habitat restoration measures addressed within the vegetation restoration monitoring component, which involved ensuring that temporarily disturbed areas were revegetated, that coarse woody debris was installed in revegetated areas, and for UWR and WHA that species specific forage species were planted in areas sufficiently away from human presence. The results of vegetation monitoring are presented separately (Appendix C).

3.6.1.1. Amphibian Habitat

Compliance monitoring for Coastal Tailed Frogs was implemented where habitat was impacted at two types of disturbance locations: 1) where the transmission line crosses over suitable Coastal Tailed Frog streams and riparian habitat was impacted; and 2) at the location of the Upper Lillooet River HEF penstock tributary crossing (ULL-ASTR04) where both riparian and instream habitat were impacted (Map 12). Thus, only riparian areas were monitored for transmission line crossings, whereas both riparian and instream habitat were monitored at ULL-ASTR04.

Habitat restoration monitoring of transmission line crossings over suitable Coastal Tailed Frog streams involved documenting vegetation characteristics and presence of coarse woody debris. Although the Project's OEMP states that riparian vegetation characteristics will be recorded and measured within 3.99 m radius monitoring plots (Harwood *et al.* 2017), monitoring plots were not required given that planting had not taken place. Rather, trees had been topped and shrubs had been maintained. Thus, monitoring included ensuring that clearing was restricted to topping trees, cut wood was left in place and there were no erosion or sedimentation issues. Photographs were taken at all locations.

Monitoring of compliance of the habitat restoration at ULL-ASTR04 was assessed through a comparison of key habitat characteristics known to be important for Coastal Tailed Frogs pre and post-construction. Three reaches were defined for instream monitoring, one control reach placed upstream of all disturbance caused by penstock installation (ULL-ASTR04US); and two impact reaches, one at the penstock crossing location (ULL-ASTR04IM) and one downstream of the penstock crossing location (ULL-ASTR04DS). The upstream reach was 100 m in length; however, impact and downstream reaches were restricted to 50 m in length because the length of the disturbance footprint at the penstock crossing was less than 100 m and because the downstream impact reach was restricted by topographical limitations (i.e., a steep drop in the channel). Locations of monitoring reaches and dates of the assessments are shown in Table 14. Details on methods and dates of the assessment of riparian habitat at ULL-ASTR04 are given in Section 3.1.1.

Methods for measuring instream habitat characteristics at ULL-ASTR04 included quantification of substrate size, stream embeddedness, channel morphology, and mesohabitat characteristics. A modified Reconnaissance (1:20,000) Fish and Fish Habitat Inventory (RIC 2001) was completed to collect channel morphology data, including bank full width, bank full depth, wetted width, and wetted depths. Measurements began at 0 m and were collected at a minimum of six locations. The mesohabitat characteristics of the reach were categorized for the lower (0-50 m for ULL-ASTR04US; 0-25 m for ULL-ASTR04IM and ULL-ASTR04DS) and upper (50-100 m for ULL-ASTR04US; 25-50 m for ULL-ASTR04IM and ULL-ASTR04DS) reach sections, and values were averaged. Embeddedness was evaluated as moderate, high, or low at 0 m for all reaches, in the middle of the reach (at 50 m for ULL-ASTR04US, at 25 m for ULL-ASTR04IM and ULL-ASTR04DS), and at the top of the reach (at 100 m for ULL-ASTR04US, at 50 m for ULL-ASTR04IM and ULL-ASTR04DS). A particle size substrate survey was conducted following a modified Wolman Pebble Count (Malt 2012). Survey methods followed the procedures outlined in Malt (2012) and those outlined in the Wildlife Baseline Monitoring Report (Regehr *et al.* 2016).

Riparian habitat at ULL-ASTR04 was evaluated under the riparian revegetation assessment component of the OEMP (Section 3.1.1) by establishing 3.99 m radius representative plots on each side of the stream at the penstock crossing location and recording tree and shrub composition and density, and the number of woody debris pieces by decay class within these plots. Photographs were also taken and any erosion issues were noted. Results of riparian habitat restoration monitoring at ULL-ASTR04 are compared with site specific restoration prescriptions (Woodruff and Lacroix 2014b).

Table 14. Locations of Coastal Tailed Frog instream compliance monitoring reaches and dates of pre (2012 and 2013) and post (2018) construction assessments.

Site	Reach (relative to penstock crossing)	Reach Length (m)	Date Surveyed			UTM Coordinates (Zone 10U)	
			2012	2013	2018	Easting	Northing
ULL-ASTR04US	Upstream	100	October 13	June 25	August 31	468476	5612486
ULL-ASTR04IM	Impact (at crossing)	50	October 11	June 25	August 31	468417	5612406
ULL-ASTR04DS	Downstream Impact	50	October 11	June 25	August 31	468366	5612258

3.6.1.2. Avian Habitat

Harlequin Ducks

Avian habitat restoration compliance monitoring for Harlequin Ducks involved confirming that riparian habitat clearing along the transmission line RoW on either side of the Lillooet River (Map 13) and Ryan River (Map 14) was restricted to topping trees and reducing shrub height within 30 m of the high water mark, and that shrubs were maintained along the RoW edge. In addition to providing confirmation that these clearing prescriptions were adhered to, riparian vegetation characteristics were documented at four compliance monitoring sites (two each along the Lillooet River and the Ryan River) by providing a visual estimate of average tree and shrub height (averaged from three measurements, to the nearest m), confirming whether coarse woody debris had been retained, and taking photographs. Locations of Harlequin Duck monitoring sites and dates of the assessments are shown in Table 15.

Table 15. **Locations of Harlequin Duck compliance monitoring sites and dates of assessments.**

Location	Site	Date	UTM Coordinates (Zone 10U)	
			Easting	Northing
Lillooet River Transmission Line Crossing - north side (river left)	ULH-HADUCM01	21-Sep-2018	487470	5600014
Lillooet River Transmission Line Crossing - south side (river right)	ULH-HADUCM02	21-Sep-2018	487485	5599923
Ryan River Transmission Line Crossing - north side (river left)	ULH-HADUCM03	19-Jun-2018	503737	5588124
Ryan River Transmission Line Crossing - south side (river right)	ULH-HADUCM04	19-Jun-2018	503759	5588081

Peregrine Falcons

Compliance monitoring for Peregrine Falcons involved ensuring that transmission line poles have been placed away from suitable nesting ledges identified in the EA (habitat polygons ULH-PEFA01 and ULH-PEFA04 along the Upper Lillooet FSR, and ULH-PEFA16 located along the Lillooet South FSR; Lacroix *et al.* 2011c) (Map 15). Placing power poles away from nesting ledges was a requirement of the EAC to minimize the potential for habitat alteration (as identified in the EA; Lacroix *et al.* 2011c). The assessment involved estimating the vertical and horizontal distances between the nesting ledge and the nearest power pole in ArcMap, and then field verifying the estimates and photographing the areas from a helicopter on September 24, 2018, outside of the Peregrine Falcon nesting season (which is between March 30 and July 20; Harwood *et al.* 2017), to prevent disturbing Peregrine Falcons at a nest site.

3.6.1.3. Mammal Habitat

Mammal habitat restoration compliance monitoring for Grizzly Bears involved confirming compliance with prescribed habitat restoration measures, which included confirmation of the presence and adequacy of vegetated screens where required (between active FSR and the transmission line RoW where the RoW passes through WHA 2-399 or other high value (Class 1 and Class 2) habitat) (Table 16), and proper disposal of food waste at facilities with waste management requirements (Table 5). For Moose and Mule Deer, compliance monitoring involved confirming the presence and adequacy of vegetated screens where required (between active FSR and the transmission line RoW where the RoW passes through Moose or Mule Deer UWR). Monitoring was conducted from June 6 to June 21 at 29 monitoring sites (Table 16, Map 16). Some monitoring sites were established to monitor requirements for a single species and others applied to more than one species. Revegetation away from road verges within Grizzly Bear WHA 2-399 and other high value Grizzly Bear habitat, Moose UWR, and Mule Deer UWR, is evaluated in accordance with species-specific revegetation requirements in Appendix C. Deactivation of temporary roads or access tracks within Grizzly Bear WHA 2-399 is also evaluated in Appendix C.

Assessment of the requirements for vegetated screens between active FSR and the transmission line RoW where the RoW passes through high value habitat (i.e., UWR, WHA, and high value Grizzly Bear habitat) for all three mammal species involved confirmation of screen presence as well as assessment of screen characteristics. The latter was conducted by taking three sets of measurements of screen height and width and estimating percent coverage of visibility through the screen. Density of woody vegetation (stems > 20 cm tall) within a representative 3.99 m plot was also recorded and photos were taken to photo-document screen appearance and condition.

In addition to results presented in Appendix C, assessment of whether at least 50% of planted stems within the Grizzly Bear WHA are native fruit bearing forage shrubs was conducted using species and density of woody vegetation (stems > 20 cm tall) within one representative 3.99 m radius plot per site.

For Grizzly Bears, animal proof waste containers were inspected and photographed at the intakes and powerhouses of the Upper Lillooet HEF and Boulder Creek HEF.

Table 16. Locations of mammal vegetation screen monitoring sites and dates of assessments.

Site	Species and Habitat[1]	Date	UTM Coordiantes (Zone 10U)	
			Easting	Northing
ULH-MAMCM01	Grizzly Bear - High Value	14-Jun-2018	468741	5611299
ULH-MAMCM02	Grizzly Bear - High Value	14-Jun-2018	468915	5611147
ULH-MAMCM03	Moose - UWR	14-Jun-2018	474863	5605535
ULH-MAMCM04A	Grizzly Bear - High Value	14-Jun-2018	476900	5603889
ULH-MAMCM04B	Grizzly Bear - High Value	14-Jun-2018	476857	5603920
ULH-MAMCM05	Grizzly Bear - High Value Mule Deer - UWR	14-Jun-2018	480101	5603391
ULH-MAMCM06	Grizzly Bear - High Value Mule Deer - UWR	14-Jun-2018	480898	5603041
ULH-MAMCM07	Grizzly Bear - High Value Mule Deer - UWR	14-Jun-2018	481528	5602826
ULH-MAMCM08	Mule Deer - UWR	14-Jun-2018	481796	5602741
ULH-MAMCM09	Grizzly Bear - High Value Mule Deer - UWR	14-Jun-2018	482647	5602427
ULH-MAMCM10	Mule Deer - UWR	14-Jun-2018	482954	5602219
ULH-MAMCM11	Mule Deer - UWR	14-Jun-2018	483369	5601923
ULH-MAMCM12	Moose - UWR	14-Jun-2018	485810	5600967
ULH-MAMCM13	Moose - UWR	14-Jun-2018	486489	5600797
ULH-MAMCM14	Grizzly Bear - WHA 2-399 Moose - UWR	6-Jun-2018	487543	5599229
ULH-MAMCM15	Moose - UWR	6-Jun-2018	487551	5599178
ULH-MAMCM16	Grizzly Bear - WHA 2-399 Moose - UWR	6-Jun-2018	487541	5599211
ULH-MAMCM17	Grizzly Bear - South Lillooet River FSR	6-Jun-2018	491512	5597274
ULH-MAMCM18	Grizzly Bear - South Lillooet River FSR	6-Jun-2018	491964	5597244
ULH-MAMCM19	Grizzly Bear - South Lillooet River FSR	6-Jun-2018	492224	5596959
ULH-MAMCM20	Mule Deer - UWR	19-Jun-2018	499728	5591270
ULH-MAMCM21	Grizzly Bear - High Value Mule Deer - UWR	19-Jun-2018	499872	5591204
ULH-MAMCM22	Grizzly Bear - High Value	19-Jun-2018	500113	5591109
ULH-MAMCM23	Grizzly Bear - High Value	19-Jun-2018	501095	5590537
ULH-MAMCM24	Grizzly Bear - High Value Mule Deer - UWR	19-Jun-2018	501418	5590366
ULH-MAMCM25	Grizzly Bear - High Value Mule Deer - UWR	19-Jun-2018	502437	5589574
ULH-MAMCM26	Grizzly Bear - High Value Mule Deer - UWR	19-Jun-2018	503208	5588834
ULH-MAMCM27	Grizzly Bear - High Value	21-Jun-2018	507825	5577642
ULH-MAMCM28	Grizzly Bear - High Value	21-Jun-2018	507856	5577626

[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).

3.6.2. Mitigation Effectiveness

3.6.2.1. Avian Collisions

Surveys for avian carcasses were conducted during peak spring and fall avian migration periods at the Lillooet River (Map 13) and Ryan River (Map 14) transmission line crossings where birds fling up or down the river valleys have the potential to collide with the transmission line wires. One survey transect was established under the transmission line on each side of the Lillooet River and a single transect was established under the transmission line at the Ryan River, following the bridge from one side of the Ryan River to the other. Transects covered all accessible land under the transmission lines at these two crossings. Transects were walked while searching for avian carcasses, with the intent of counting and identifying to species any individuals found. Transects were approximately 10 m wide, running roughly parallel to the river, and covered a total 1,630 m^2 at the Lillooet River transmission line crossing and 2,420 m^2 at the Ryan River transmission line crossing (Table 17). Spring surveys were conducted between April 30 and May 23, and fall surveys were conducted between September 21 and November 2, 2018. Although one survey was conducted well past the peak songbird migration period (November 2), many ducks were still migrating through the area at that time.

Table 17. Avian collision survey locations and dates for surveys conducted at the Lillooet River and Ryan River transmission line crossings.

Location	Transect UTM Coordinates (Zone 10U)				Transect Size			Survey Period	Survey Date
	Start		End		Length (m)	Width (m)	Area (m^2)		
	Easting	Northing	Easting	Northing					
Lillooet River Transmission Line Crossing - north side (river left)	487465	5600110	487473	5600005	105	10	1,050	Spring Fall	30-Apr-2018 21-Sep-18
Lillooet River Transmission Line Crossing - south side (river right)	487487	5599862	487485	5599920	58	10	580	Spring Fall	23-May-2018 21-Sep-18
Ryan River Transmission Line Crossing - river right, river left and bridge	503684	5588206	503794	5587991	242	10	2,420	Spring Fall	4-May-2018 2-Nov-2018

3.6.2.2. Mountain Goats

Upper Lillooet River HEF

A number of methods were used to determine Mountain Goat presence and movement patterns post-construction and allow comparison to records collected prior to, and during, construction. It should be noted that although aerial surveys were conducted during baseline surveys, aerial surveys were not permitted for post-construction monitoring (Berardinucci 2013). Due to this change in methods, ground-based and aerial survey results were combined for baseline data (see Section 4.3.1.1 of Regehr *et al.* (2016) for rationale for combining data from the two survey types).

The first method used to document Mountain Goat presence and movement was the strategic placement of five remote infrared cameras along the Truckwash Creek Mountain Goat migration corridor (Map 4, Map 17, Table 18). These cameras were maintained for one year post-construction. Photographic data were retrieved and all except two of the cameras (ULL-CAM02 and ULL-CAM16) were removed on January 30, 2019. Photographs from the cameras were viewed and data on Mountain Goat detections were compiled. Results from photographic data recorded during the pre-construction period (November 2010 to April 2014) are presented in the wildlife baseline monitoring report (Regehr *et al.* 2016) and results compiled for the construction period (up to January 26, 2017) were reported on in earlier memos (Newbury *et al.* 2015, 2016, Regehr *et al.* 2017); thus, results reported in here are from the time period between January 26, 2017 to January 30, 2019, covering Year 1 of the post-construction monitoring period in addition to the data collected since the end of the last construction period memo (Regehr *et al.* 2017).

Systematic winter ground-based surveys (snow-tracking surveys) were also used to evaluate the continued use of the Truckwash Creek migration corridor by Mountain Goats. Transects were established along Truckwash Creek near the ULR HEF downstream tunnel portal which were surveyed during winter for signs of Mountain Goat presence (Map 17). Transect locations were modified post-construction for safety reasons when a certified avalanche technician identified safety risk as a result of updated avalanche information and changes to the forested habitat following the Boulder Creek wildfire. After the first post-construction survey on January 14, 2018, transects were adjusted once more to minimize safety hazards and optimize track detections. Nevertheless, the data collected during surveys following the change in transect locations was considered comparable to the data collected previously, and the change was judged to not affect monitoring effectiveness (Faulkner *et al.* 2018). Post-construction ground-based surveys were conducted for Year 1 of operations (January 2018 through January 2019) between December and May. Although the Project's OEMP specified that bimonthly surveys would be conducted during November and December and again in April and May, surveys were not conducted in November 2018 due to lack of snow, and only one survey was completed in May 2018 and December 2018 due to lack of snow in May and avalanche risk in December. During surveys, all wildlife sign detected was recorded. Number of days since the last snowfall (> 5 cm), and measurements of snow coverage, depth and hardness (scored categorically from very soft to very hard) were also recorded during each survey.

The Keyhole Falls Mountain Goat winter range (UWR u-2-002 UL 11) was monitored opportunistically (with survey frequency and timing varying based on winter conditions and safety) (Table 19) from November to May to determine if Mountain Goats, specifically nannies, continue to utilize the winter range post-construction. The winter range was observed from the monitoring station selected during construction (Lacroix *et al.* 2013) (Map 4). In addition to targeted surveys, all incidental observations of Mountain Goats were recorded and compiled.

Table 18. Wildlife camera locations within the Truckwash Creek Mountain Goat migration corridor during the post-construction monitoring period.

Camera	Location	UTM Coordinates (Zone 10U)	Comments Relevant to Monitoring Period (26-Jan-2017 to 30-Jan-2019)
ULL-CAM02	[redacted]	[redacted]	Snow on camera lens started to obscure view on January 17, 2019 but camera still captured wildlife movement until January 30, 2019 when it was repositioned higher on the tree.
ULL-CAM08	[redacted]	[redacted]	Camera was not functional when it was checked on December 21, 2017. The last time the camera was triggered to take photographs prior to this was on October 28, 2017, so this camera was potentially not functional from October 28 to December 21, 2017.
ULL-CAM14	[redacted]	[redacted]	Camera was buried in snow when accessed on January 30, 2019; however, no photos were taken since it was last maintained on September 7, 2018 so the period when it was non-functional is uncertain. Observations ULL-CAM02 indicate the camera likley became buried in snow around mid-January.
ULL-CAM15	[redacted]	[redacted]	Functional for the entire period.
ULL-CAM16	[redacted]	[redacted]	Camera was buried in snow when accessed on January 30, 2019; however no photos were taken since October 2, 2018 so the period when it was non-functional is uncertain. Observations from ULL-CAM02 indicate the camera likley became buried in snow around mid-January.

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

Table 19. Keyhole Falls Mountain Goat UWR viewpoint location and survey dates.

Viewpoint	UTM Coordinates (Zone 10U)		Date	Start Time	End Time
	Easting	Northing			
ULL-MGOBS02			2018-01-14	10:15	10:30
			2018-02-15	10:50	11:30
			2018-03-07	11:00	11:20
Sensitive location and timing information has been removed to protect this species.			2018-04-12	10:57	11:20
			2018-04-20	10:40	10:50
			2018-05-03	10:50	11:05
			2018-11-30	15:24	15:36
			2019-01-30	10:40	10:58

Boulder Creek HEF

Operational monitoring at the Boulder Creek HEF intake was conducted to evaluate gate effectiveness and Mountain Goat predator presence and behaviour. Monitoring involved the use of remote infrared cameras and systematic winter ground-based surveys. The post-construction monitoring period for which data are presented in this report began on December 21, 2017, when the cameras for Year 1 post-construction monitoring were installed, and ended on January 17, 2019, when the last data from Year 1 camera monitoring were downloaded. Baseline data from the pre-construction period (November 2010 to April 2014) are presented in the wildlife baseline monitoring report (Regehr *et al.* 2016).

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 winter range (UWR u-2-002 UL 12) during winter (November 1 to June 15 as per Project's EAC) is being monitored through the strategic placement of three remote infrared cameras along the Boulder Creek HEF intake access road (Map 5). The first camera was placed at the gate (BDR-CAM03). The other two cameras (BDR-CAM01 and BDR-CAM02) were installed along the access road, past the gate (Map 5). Table 20 provides a summary of the locations and functionality of these three cameras (only BDR-CAM01, BDR-CAM02, and BDR-CAM03 are located along the access road and were used to conduct access monitoring). It should be noted that although BDR-CAM03 was not functional for a portion of the monitoring period, any vehicles that drove through the gate past BDR-CAM03 would likely also pass, and be photographed by, BDR-CAM02 and BDR-CAM01 because all three cameras have a view of the same access road.

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 post-construction through the use of remote infrared cameras and systematic winter ground-based surveys (snow-tracking surveys). Although the Project's OEMP specified that systematic ground-based surveys would continue for three years post-construction, these ground-based surveys were discontinued in November 2018 due to safety concerns in the vicinity of the Boulder Creek HEF intake and access road during winter (Newbury *et al.* 2018). To compensate, four additional remote infrared cameras were installed along the systematic winter ground-based survey transects on November 30, 2018. The three cameras that had been installed for the entire monitoring period (BDR-CAM01, BDR-CAM02, BDR-CAM03; Table 20) were the same ones used to evaluate gate effectiveness in preventing public access (note that this differs slightly from what is specified in the OEMP because one of the previous camera locations became unsuitable) (Map 5). Another camera (BDR-CAM04) had also been installed near the top of transect BDR-SNTR03 since May 8, 2018. The four additional cameras installed in 2018 that replaced the systematic winter ground-based surveys at the end of Year 1 are located along survey transects BDR-SNTR02 (BDR-CAM05 and BDR-CAM06) and BDR-SNTR03 (BDR-CAM07 and BDR-CAM08) (Table 20, Map 5). All photographs taken by the remote infrared cameras during the Year 1 monitoring period were viewed and data were compiled.

Systematic winter ground-based surveys were conducted along three transects (BDR-SNTR01, BDR-SNTR02, BDR-SNTR03) in Year 1 post-construction monitoring (Map 5). Transects were traversed with snow shoes, and surveyors recorded and photographed all wildlife sign, including location and type of sign, species, numbers of individuals (e.g., group size), and observations of kills or other Mountain Goat predator behaviour that is detectable from sign. Number of days since the last snowfall (> 5 cm) and measurements of snow coverage, depth and hardness were recorded for each transect during each survey. As per the Project's OEMP, the systematic winter ground-based surveys were intended to occur monthly from November to January and bimonthly from February to May, reflecting critical winter periods for Mountain Goats. However, survey frequency and timing were adjusted in accordance with winter conditions and safety (i.e., avalanche risk). In addition, BDR-SNTR01 could not be surveyed in May or November 2018 due to insufficient snow: in May, snow was lacking due to spring melt, and in November, the road had been ploughed (to facilitate inspections at the intake in early December) and the patches of hard-packed snow remaining was not suitable for snow-tracking surveys.

Table 20. Remote infrared camera locations at the Boulder Creek HEF intake and intake access road and camera functionality during the Year 1 monitoring period (December 21, 2017 to January 17, 2019).

Camera	Location	UTM Coordinates (Zone 10U)		Functionality during Monitoring Period (December 21, 2017 to January 17, 2019)
BDR-CAM01				Functional for the entire period.
BDR-CAM02				Functional for the entire period.
BDR-CAM03				Camera was not functional from August 4, 2018 to November 30, 2018. Camera was buried in snow when accessed on January 17, 2019. This camera didn't take any photos since it was last serviced on November 30, 2018.
BDR-CAM04				Functional from May 8, 2018.
BDR-CAM05				Functional from November 30, 2018.
BDR-CAM06				Functional from November 30, 2018.
BDR-CAM07				Functional from November 30, 2018.
BDR-CAM08				Functional from November 30, 2018.

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

4. RESULTS

4.1. Aquatic and Riparian Habitat

4.2. Water Temperature

4.2.1. Riparian Revegetation Assessment

In Year 1, density targets of 1,200 tree stems/ha and 2,000 shrub stems/ha were surpassed, on average, in permanent riparian revegetation monitoring plots. Average vegetated ground cover was approximately 7%. Results from photopoint monitoring (Appendix I and Appendix J) concur with these results. No invasive plant species were documented in the vicinity of the permanent vegetation monitoring plots during Year 1 monitoring. Overall, Year 1 monitoring results indicate that site conditions are generally good (e.g., adequate soil retention, adequate amounts of topsoil), and woody vegetation is becoming established, although ground cover vegetation is sparse. Results from the two penstock plots adjacent to the Coastal Tailed Frog stream crossed by the ULR HEF penstock (ULL-ASTR04) are also relevant to amphibian habitat restoration monitoring (Section 4.6.1.1).

4.2.1.1. Density, Species Composition, and Survival of Woody Vegetation

In Year 1 of the five-year monitoring program, average tree and shrub stem densities (7,317 tree stems/ha (± 7,073) and 2,817 shrub stems/ha (± 883)) from all permanent revegetation monitoring plots combined surpassed the density targets of 1,200 tree stems/ha and 2,000 shrub stems/ha (Table 21). Although there was substantial variability in tree and shrub stem density among plots (living tree stem density ranged from 4 to 251 and living shrub stems ranged from 2 to 29; Table 21), targets for trees and shrubs were met at most plots (shrub targets were not met at four ULR HEF plots (three intake plots and one penstock plot) and tree targets were not met at one ULR HEF plot (penstock plot); Table 22, Table 23, Table 24, Table 25). In no plot was one of the targets not met. In general, stem densities were highest within the Upper Lillooet River HEF powerhouse plots, especially in ULL-PRM10, which had a much higher tree density than the other plots due to abundant natural regeneration of black cottonwood (*Populus balsamifera ssp. trichocarpa)*. Only seven dead stems were observed in all plots combined; thus, although this is the first year of monitoring, the proportion of living to dead stems suggests that the target of 80% survival (DFO and MELP 1998, Harwood *et al.* 2017) has been met.

At the Boulder Creek HEF powerhouse plot (BDR-PRM01) the stem density was estimated at 4,800 stems/ha, with an equal distribution between tree and shrub stems (Table 22). The planted stock was observed to be in good health; however, there was limited natural regenerating vegetation within the plot (Figure 1).

At the ULR HEF intake, the average density of living woody stems was estimated at 3,267 stems/ha (2,667 tree stems/ha, 600 shrub stems/ha), based on the three permanent monitoring plots combined (ULL-PRM01, ULL-PRM02 and ULL-PRM03) (Table 23), which is largely due to the presence of naturally regenerating black cottonwood. Tree stem densities in all three plots were above the 1,200 stem/ha target; however, shrub stem densities were below the 2,000 stem/ha target. No planted woody vegetation was observed at ULL-PRM01 (Figure 2) or ULL-PRM02 (Figure 3); although shrubs were planted in the less steep areas of these sites (CRT-ebc 2016), plantings may not have been distinguishable from natural regeneration. Additional trees were planted in the less steep areas of these sites in October of 2018 (Appendix C), after the riparian revegetation assessment field surveys were complete, so survival of planted trees will be assessed in future monitoring years. Survival of planted stock was good at ULL-PRM03. Exposed soil was noted in all three plots at the ULR HEF intake, especially in ULL-PRM02, but there were no signs of erosion.

Along the ULR HEF penstock, the average density of living woody stems was estimated at 7,300 stems/ha (3,467 tree stems/ha, 3,833 shrub stems/ha) based on six permanent monitoring plots combined (Table 24). Tree stem densities in all but one (ULL-PRM08) of these plots exceeded the target, ranging from 800 tree stems/ha (ULL-PRM08) to 7,000 stems/ha (ULL-PRM05). It was generally noted that planted stock was in good health and there was abundant natural revegetation, particularly black cottonwood (Figure 4 and Figure 5). However, at ULL-PRM07 the planted western redcedars (*Thuja plicata*) appeared stressed, likely due to sun exposure (Figure 6). Substantial deer movement was documented at ULL-PRM04, although there was no obvious evidence of browsing.

At the Upper Lillooet powerhouse, average tree stem density was higher than at other locations, averaging 28,300 stems/ha for the two plots combined (ULL-PRM10 and ULL-PRM11) (Table 25, Figure 7, Figure 8). This was due to abundant natural regeneration of black cottonwood in both plots. Average shrub stem density (3,300 stems/ha) was similar to other locations.

A total of 608 living trees/shrubs, represented by 5 tree and 12 shrub species, were documented during Year 1 monitoring within the plots (Table 26), demonstrating a good distribution and diversity of species across the riparian revegetation areas. Black cottonwood, coastal Douglas-fir (*Pseudotsuga menziesii var. menziesii*), red alder (*Alnus rubra*), western hemlock (*Tsuga heterophylla*), western redcedar, black raspberry (*Rubus leucodermis*), Kinnikinnick (*Arctostaphylos uva-ursi*), Nootka rose (*Rosa nutkana*), red-osier dogwood (*Cornus stolonifera*), salmonberry (*Rubus spectabilis*), thimbleberry (*Rubus parviflorus*), huckleberry (*Vaccinium sp.*), and willow (*Salix sp.*) were each present in at least two plots. Black huckleberry (*Vaccinium membranaceum*), false azalea (*Menziesia ferruginea*), Oregon grape (*Mahonia sp.*), and western mountain-ash (*Sorbus scopulina*) were each only found in a single plot.

All of the plots contained at least one tree species. Black cottonwood was the most abundant tree species (a total of 5,000 stems/ha (± 4,798)) and was well distributed among the revegetation areas, with stems found in every plot except for the Boulder powerhouse plot (BDR-PRM01). Western hemlock was the second most abundant tree species (a total of 1,417 stems/ha (± 2,351)). Salmonberry was the most abundant shrub species (a total of 814 stems/ha (±524) and was found in seven of ten plots.

Table 21. Numbers of living and dead woody stems within permanent revegetation monitoring plots (50 m^2).

Location	Permanent Monitoring Plot	Count of Woody Vegetation Stems within Plot			
		Live Trees	Live Shrubs	Total Live	Dead
Boulder Creek HEF Powerhouse	BDR-PRM01	12	12	24	5
Upper Lillooet River HEF Intake	ULL-PRM01	15	2	17	0
	ULL-PRM02	16	5	21	0
	ULL-PRM03	9	2	11	1
Upper Lillooet River HEF Penstock	ULL-PRM04	9	19	28	0
	ULL-PRM05	35	18	53	0
	ULL-PRM06	19	29	48	1
	ULL-PRM07	10	9	19	0
	ULL-PRM08	4	18	22	0
	ULL-PRM09	27	22	49	0
Upper Lillooet River HEF Powerhouse	ULL-PRM10	251	21	272	0
	ULL-PRM11	32	12	44	0
Mean		36.58	14.08	50.67	0.58
Standard Deviation		68.21	8.51	71.15	1.44
Standard error of the mean		19.69	2.46	20.54	0.42
t-value_90%		1.7959	1.7959	1.7959	1.7959
Confidence Interval		35.36	4.41	36.89	0.75
Expected Density (stems/ha)		**7,317**	**2,817**	**10,133**	**117**
Confidence Interval (± stems/ ha)		**7,073**	**883**	**7,377**	**150**

Table 22. **Estimated vegetation density within permanent revegetation monitoring plots and percent vegetation cover within the associated riparian revegetation areas at the Boulder Creek HEF powerhouse.**

Location	Permanent Monitoring Plot	Estimated Tree Vegetation Density (stems/ha)	Estimated Shrub Vegetation Density (stems/ha)	Total Estimated Woody Vegetation Density (stems/ha)	Estimated Vegetation Cover (%)	Comments
Boulder Creek HEF Powerhouse	BDR-PRM01	2,400	2,400	4,800	5	There is good survival of planted stock, limited natural regeneration and low percent ground cover. Four mortalities recorded within the natural regeneration. Exposed soil was documented but no signs of erosion on the gentle slope.
Mean		*2,400*	*2,400*	*4,800*	*5*	

Table 23. **Estimated vegetation density within permanent revegetation monitoring plots and percent vegetation cover within the associated riparian revegetation areas along the Upper Lillooet River HEF intake.**

Location	Permanent Monitoring Plot	Estimated Tree Vegetation Density (stems/ha)	Estimated Shrub Vegetation Density (stems/ha)	Total Estimated Woody Vegetation Density (stems/ha)	Estimated Vegetation Cover (%)	Comments
Upper Lillooet River HEF Intake	ULL-PRM01	3,000	400	3,400	11	Abundant naturally regenerating grass and fireweed and limited woody stem regeneration. Shrubs were planted in the less steep areas of this site (CRT-ebc 2016); however, planted shrubs were not observed during the survey in 2018 and plantings may not have been distinguishable from natural regeneration. Trees were planted in the less steep areas of this site in October 2018 (Appendix C), following this revegetation survey. Patches of exposed soil but no signs of erosion observed.
	ULL-PRM02	3,200	1,000	4,200	6	This site was seeded with alder (CRT-ebc 2016) and shrubs were planted in less steep areas; however, planted shrubs were not observed during the survey in 2018 and plantings may not have been distinguishable from natural regeneration. Trees were planted in the less steep areas of this site in October 2018 (Appendix C), following this revegetation survey. The ground is rough, rocky and loose with moderate herbaceous regeneration but limited woody stem regeneration. Exposed soil was documented but no signs of erosion observed.
	ULL-PRM03	1,800	400	2,200	6	Good survival of planted stock and abundant coarse woody debris, in accordance with the Intake Revegetation Plan (Woodruff and Lacroix 2014a). Natural regeneration is limited. The area was not recommended to be hydroseeded (Woodruff and Lacroix 2014a), thus, exposed soil was documented; however, there are no signs of erosion.
Mean		*2,667*	*600*	*3,267*	*8*	

Table 24. **Estimated vegetation density within permanent revegetation monitoring plots and percent vegetation cover within the associated riparian revegetation areas along the Upper Lillooet River HEF penstock.**

Location	Permanent Monitoring Plot	Estimated Tree Vegetation Density (stems/ha)	Estimated Shrub Vegetation Density (stems/ha)	Total Estimated Woody Vegetation Density (stems/ha)	Estimated Vegetation Cover (%)	Comments
Upper Lillooet River HEF Penstock	ULL-PRM04	1,800	3,800	5,600	3	Good survival of planted stock. Conifers regenerating naturally. There were no obvious signs of browsing, though deer movement appears to be frequent in the area. Exposed soil was documented but no signs of erosion.
	ULL-PRM05	7,000	3,600	10,600	4	Abundant natural regeneration of red alder on the slope and good survival of planted stock. Exposed soil was documented but no signs of erosion.
	ULL-PRM06	3,800	5,800	9,600	8	The planted stock appears well established, with abundant natural regeneration, particularly of black cottonwood. Abundant coarse woody debris distributed throughout the area. No signs of erosion.
	ULL-PRM07	2,000	1,800	3,800	1	The planted western redcedars appear stressed, possibly due to exposure, although the other planted stock appears in good condition. Natural regeneration is limited. Exposed soil was documented but no signs of erosion.
	ULL-PRM08	800	3,600	4,400	14	The planted stock appears in good health, and abundant natural revegetation occurring approximately 1-2 m from the wetted edge. There are four pieces of class 2 coarse woody debris within the plot. Exposed soil was documented but no signs of erosion on the gentle slopes.
	ULL-PRM09	5,400	4,400	9,800	11	There is abundant natural regeneration within 1-2 m of the wetted edge, particularly of black cottonwood. The planted stock appears to be in good health. Two pieces of class 2 coarse woody debris within the plot. Recommend adding rocky material to areas of exposed cloth. Exposed soils were documented but no signs of erosion on the gentle slopes.
Mean		*3,467*	*3,833*	*7,300*	*7*	

Table 25. Estimated vegetation density within permanent revegetation monitoring plots and percent vegetation cover within the associated riparian revegetation areas along the Upper Lillooet River HEF powerhouse.

Location	Permanent Monitoring Plot	Estimated Tree Vegetation Density (stems/ha)	Estimated Shrub Vegetation Density (stems/ha)	Total Estimated Woody Vegetation Density (stems/ha)	Estimated Vegetation Cover (%)	Comments
Upper Lillooet River HEF Powerhouse	ULL-PRM10	50,200	4,200	54,400	9	There is abundant natural regeneration, particularly of black cottonwood. The planted stock appears to be in good health. Exposed soils were documented but no signs of erosion on the gentle slopes.
	ULL-PRM11	6,400	2,400	8,800	5	The planted stock appears in good health but generally sparse. Abundant natural regeneration, particularly of black cottonwood. Exposed soils were documented with signs of erosion on the steeper slopes.
Mean		*28,300*	*3,300*	*31,600*	*7*	

Table 26. Number of trees and shrubs by species in the thirteen permanent revegetation monitoring plots in 2018.

Location	Permanent Monitoring Plot	Trees					Shrubs												*Total*
		black cottonwood (*Populus balsamifera ssp. trichocarpa*)	coastal Douglas-fir (*Pseudotsuga menziesii var. menziesii*)	red alder (*Alnus rubra*)	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	black huckleberry (*Vaccinium membranaceum*)	black raspberry (*Rubus leucodermis*)	false azalea (*Menziesia ferruginea*)	Kinnikinnick (*Arctostaphylos uva-ursi*)	Oregon grape (*Mahonia sp.*)	Nootka rose (*Rosa nutkana*)	red-osier dogwood (*Cornus stolonifera*)	salmonberry (*Rubus spectabilis*)	thimbleberry (*Rubus parviflorus*)	Huckleberry (*Vaccinium sp.*)	western mountain-ash (*Sorbus scopulina*)	willow (*Salix sp.*)	
Boulder Powerhouse	BDR-PRM01	0	1	5	4	2	0	0	0	1	0	0	1	3	6	0	0	1	24
Upper Lillooet Intake	ULL-PRM01	15	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	17
	ULL-PRM02	13	1	2	0	0	0	0	0	0	0	0	0	3	0	0	1	1	21
	ULL-PRM03	1	3	2	1	2	0	0	0	1	0	1	0	0	0	0	0	0	11
Upper Lillooet Penstock	ULL-PRM04	3	4	0	0	2	0	0	0	0	0	0	4	13	0	0	0	2	28
	ULL-PRM05	26	9	0	0	0	0	0	0	0	0	0	0	11	0	0	0	7	53
	ULL-PRM06	17	0	0	1	1	0	0	0	3	2	0	1	12	11	0	0	0	48
	ULL-PRM07	2	2	0	0	6	0	0	0	1	0	0	1	0	5	0	0	2	19
	ULL-PRM08	1	2	1	0	0	0	0	1	4	0	2	2	2	6	1	0	0	22
	ULL-PRM09	26	1	0	0	0	2	0	0	1	0	1	1	5	5	0	0	7	49
Upper Lillooet Powerhouse	ULL-PRM10	168	2	2	79	0	0	10	0	0	0	0	4	0	1	0	0	6	272
	ULL-PRM11	28	2	0	0	2	0	4	0	0	0	0	7	0	0	0	0	1	44
Mean		25	2	1	7	1	0	1	0	1	0	0	2	4	3	0	0	2	51
Standard Deviation		46.28	2.42	1.54	22.68	1.76	0.58	3.01	0.29	1.31	0.58	0.65	2.18	5.05	3.66	0.39	0.29	2.71	71.15
Standard error of the mean		13.36	0.70	0.44	6.55	0.51	0.17	0.87	0.08	0.38	0.17	0.19	0.63	1.46	1.06	0.11	0.08	0.78	20.54
t-value_90%		1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959	1.7959
Confidence Interval		23.99	1.25	0.80	11.76	0.91	0.30	1.56	0.15	0.68	0.30	0.34	1.13	2.62	1.90	0.20	0.15	1.40	36.89
Expected Density (stems/ha)		5,000	450	200	1,417	250	33	233	17	183	33	67	350	817	567	33	17	467	10,133
Confidence Interval (± stems/ ha)		4,798	251	159	2,351	183	60	312	30	136	60	68	226	524	380	40	30	281	7,377

Figure 1. Looking upslope of Boulder Creek at BDR-PRM01 on September 6, 2018.

Figure 2. Abundant grasses and fireweed present at ULL-PRM01 on September 7, 2018.

Figure 3. Rough and loose substrate with limited woody stem regeneration at ULL-PRM02 on September 7, 2018.

Figure 4. Good planted stock survival at ULL-PRM04 on September 7, 2018.

Figure 5. Naturally regenerating black cottonwood at ULL-PRM05 on September 7, 2018.

Figure 6. Stressed western redcedars at ULL-PRM07 on September 6, 2018.

Figure 7. Woody stems at ULL-PRM10 on September 6, 2018.

Figure 8. Sparse but healthy planted stock at ULL-PRM11 on September 6, 2018.

4.2.1.2. Percent Vegetation Cover

The percent vegetation cover estimated from all vegetation cover quadrats combined averaged 7% in Year 1, (Table 22, Table 23, Table 24, Table 25). Estimated percent vegetation cover varied by revegetation area, ranging from 1% at ULL-PRM07 to 14% at ULL-PRM08 (Table 24). Substantial exposed soil and a general low percentage of ground cover were documented throughout all of the revegetation areas, as expected in the first year of operational monitoring. Hydroseeding was specifically not recommended at most sites as it can prevent the establishment of more desirable woody vegetation species, thus, high percent vegetation cover is not expected within the first five years of operational monitoring. Additionally, it was documented that there were areas of exposed geotextile at ULL-PRM09.

Herbaceous cover is monitored because it stabilizes the soil and provides sediment interception and erosion control functions early in the revegetation process. However, woody vegetation also contributes to this function. Thus, although vegetation cover was relatively sparse, shrub and tree stem density targets are already exceeded in the majority of the plots, and revegetation in general is considered to be progressing well. Vegetation cover may increase as existing vegetation fills the growing space and new plants are recruited. Suboptimal herbaceous cover was not associated with sedimentation or erosion issues at the time of the assessment, although there is potential for erosion given the amount of exposed soil present.

4.2.1.3. Photopoint Comparison

Standard photographs, taken through plot centres facing north (0°), are presented in Appendix I. These photographs will be compared to photographs taken from the same vantage point during monitoring in future years to visually track vegetation changes. Additional repeatable representative photographs that show specific parts of the riparian revegetation areas are presented in Appendix J. Comparison of these photographs will also be used to aid in evaluation of revegetation performance and the need for additional revegetation or monitoring work. All standard photographs taken from above the plot centre to the east (90º), south (180º), and west (270º), are available upon request.

4.2.2. Water Temperature

Water temperature analysis will be presented in the Year 2 (2019) annual report following collection of a full year of temperature data (March 2018 – February 2019) at all monitoring sites.

4.2.3. Air Temperature

Air temperature analysis will be presented in the Year 2 (2019) annual report following collection of a full year of temperature data (March 2018 – February 2019) at all monitoring sites.

4.2.4. Frazil Ice

The protocol for frazil ice monitoring was initiated on two occasions during Year 1 monitoring; each of which are described below.

4.2.5. December 2017 Frazil Ice Assessment

On December 21, 2017, an alarm was triggered indicating that the mean daily air temperature at Pemberton and/or Callaghan Valley stations was forecasted to be -5°C or below for five consecutive days. After these conditions persisted for three consecutive days, and as the HEFs were still operating, an Ecofish QP contacted operators to request photographs of the diversion reaches. However, because it was not possible to get photographs to conduct a pre-field visual assessment, a crew was mobilized to site to conduct frazil ice monitoring under direction of the QP. Results from the field survey are provided for each HEF separately in the sections below.

Upper Lillooet River

The crew arrived at the Upper Lillooet River HEF powerhouse at 12:00 on December 23, 2017, and assessed all monitoring sites in the diversion. No frazil or anchor ice was observed at any of the monitoring sites and limited surface ice was present (estimated to cover between 10% and 25% of water surface at the sites; Table 27). Monitoring sites were revisited on December 24, 2017 and conditions were the same (Figure 9). Accordingly, a shut-down of the HEF was not recommended, however air temperature conditions were monitored until they decreased in severity.

Figure 9. Looking river left to river right at ULL-DVIC01 on December 24, 2017 showing the lack of frazil or anchor ice and limited shelf ice.

Table 27. Summary of icing conditions present at the Upper Lillooet River HEF during frazil ice assessments.

Date	Site	Anchor Ice (%)	Frazil Ice (%)
23-Dec-17	ULL-DVIC01	0	0
	ULL-DVIC02	0	0
	ULL-DVIC03	0	0
	ULL-DVIC04	0	0
	ULL-DVIC05	0	0
24-Dec-17	ULL-DVIC01	0	0
	ULL-DVIC02	0	0
	ULL-DVIC03	0	0
	ULL-DVIC04	0	0
	ULL-DVIC05	0	0
02-Jan-18	ULL-DVIC01	0	0
	ULL-DVIC02	0	0
	ULL-DVIC03	0	0
	ULL-DVIC04	0	0
	ULL-DVIC05	0	0

Boulder Creek

The crew arrived at the Boulder Creek HEF at 14:15 on December 23, 2017 and observed frazil and anchor ice conditions at the tailrace. Assessments were then conducted at the five monitoring sites (BDR-DVIC01 to BDR-DVIC05). Overall, frazil ice displaced approximately 30% to 40% of the fish holding habitat largely in the shallow areas and margins of the hydraulic units assessed and anchor ice encased approximately 20% to 50% of the substrate (to a maximum 70% at one site, Figure 10; Table 28). The fish habitat most affected by ice formation was the boulder and cobble cover that provides daytime refuge for fish. However, flows in the diversion reach were estimated to be close to 1 m^3/s, which was ample to maintain open water holding habitat, and considerable surface ice was observed. In addition, anchor and frazil ice formation at hydraulic control locations lead to backwatering of hydraulic units and an increase in deep water holding habitat. Thus, it is likely that the loss of stream margin holding areas and cover due to ice formation was offset by the presence of deep water holding habitat and surface ice cover in areas free of frazil and anchor ice. The ice presence was also highest in the lowermost section of the diversion reach, which was the focus of the assessment area. Assessment of the furthest upstream sites revealed much less ice formation in typical overwintering habitat targeted for fish community monitoring (Figure 11). However, given the presence of frazil ice in <50% of holding habitat an additional assessment was recommended for December 24, 2017 to determine if there was any change to frazil ice conditions. Three monitoring sites (BDR-DVIC01 to BDR-DVIC03) were revisited on December 24, 2017 and conditions remained stable with frazil ice in <50% of holding habitat. Accordingly, a shut-down of the HEF was not recommended; however, air temperature conditions were monitored until they decreased in severity.

Figure 10. The river right side channel at BDR-DVIC03 on December 23, 2017 showing one of the deepest sections of frazil ice.

Figure 11. **Ice conditions at BDR-DVIC05 on December 23, 2017 showing ice coverage at typical overwintering habitat (BDR-DVSN04).**

Table 28. **Summary of icing conditions present at the Boulder Creek HEF during frazil ice assessments.**

Date	Site	Anchor Ice (%)	Frazil Ice (%)
23-Dec-17	BDR-DVIC01	30	35
	BDR-DVIC02	70	40
	BDR-DVIC03	35	40
	BDR-DVIC04	30	40
	BDR-DVIC05	30	20
24-Dec-17	BDR-DVIC01	30	35
	BDR-DVIC02	70	40
	BDR-DVIC03	35	40
02-Jan-18	BDR-DVIC01	0	0
	BDR-DVIC02	0	0
	BDR-DVIC03	0	0

4.2.6. January 2018 Frazil Ice Assessment

On December 29, 2018, an alarm was triggered indicating that the mean daily air temperature at Pemberton and/or Callaghan Valley stations was forecasted to be -5°C or below for five consecutive days. After these conditions persisted for three consecutive days, and as the HEFs were still operating, an Ecofish QP contacted operators to request photographs of the diversions. However, because conditions were worse than the previous monitoring surveys in December 2017, and because operators were not onsite to provide photographs to allow for a pre-field visual assessment, a crew was mobilized to site to conduct frazil ice monitoring under direction of the QP.

Upper Lillooet River

The crew arrived at the Upper Lillooet River HEF tailrace at 11:50 on January 2, 2018 to assess frazil and anchor ice conditions. The crew noted that the flows appeared to be unimpeded and the margin ice was minimal (approximately 10 cm to 20 cm in width; Figure 12). No frazil or anchor ice was observed at any of the monitoring sites visited.

Figure 12. Looking from river left to river right at ULL-DVIC01 on January 2, 2018 showing the minimal margin ice and lack of frazil or anchor ice.

Boulder Creek

The crew arrived at the Boulder Creek HEF tailrace at 12:40 on January 2, 2018 and assessed frazil and anchor ice at the three monitoring sites (BDR-DVIC01, BDR-DVIC02, and BDR-DVIC03). No frazil or anchor ice was observed at these three sites, which were the sites with the most ice detected during the December assessment. Flows were unimpeded at these three sites and all of the shelf ice present was above the water surface (Figure 13).

Figure 13. Looking from river right to river left at BDR-DVIC01 on January 2, 2018 showing the margin ice above the water level and the lack of frazil and anchor ice.

4.3. Fish Community

4.3.1. Juvenile Fish Density and Biomass

4.3.1.1. Upper Lillooet River

Closed-Site Electrofishing

Closed-site electrofishing was conducted from March 24 to 27, 2018. Habitat summaries, usability, and representative photographs of closed-site electrofishing sites are provided in Appendix K. Sites were similar in the diversion and upstream reaches; they were primarily composed of riffles, with some runs and glides, with average gradients ranging from 1.0% to 3.0%. Substrates varied considerably among sites, but were typically dominated by cobble, with either boulders or gravel and fines also making up a large proportion of substrates in some sites. Cover primarily consisted of boulder and cobble.

Sites ranged from 19 m to 22 m in length and 83 m^2 to 176 m^2 in area in the diversion reach and from 17 m to 21 m in length and 54 m^2 to 126 m^2 in area in the upstream reach (Table 29). Sampling conditions were also similar among sites in the diversion reach and upstream reach at the time of sampling (Table 29). Average daily flow was 4.46 m^3/s in the diversion reach and between 5.96 m^3/s and 6.17 m^3/s in the upstream reach. Conductivity ranged from 160 µS/cm to 170 µS/cm in the diversion and from 160 µS/cm to 190 µS/cm at upstream sites, and water temperature ranged from

3.2°C to 3.6°C and 3.4°C and 4.5°C in the diversion and upstream sites, respectively. Water turbidity was medium within the diversion and ranged from low to medium in the upstream sites, and water alkalinity measured in the diversion was 40 mg/L at all sites and between 34 mg/L and 37 mg/L in the upstream sites (Table 29).

Two to three electrofishing passes were conducted at all sites with total effort ranging from 1,804 seconds to 1,920 seconds in the diversion reach, and from 1,801 seconds to 2,441 seconds in the upstream reach (Table 29). In total, nine Cutthroat Trout and six Bull Trout were captured during electrofishing in the diversion reach and 11 Cutthroat Trout were captured in the upstream reach (Table 29).

Table 29. Summary of closed-site electrofishing site characteristics, conditions, effort, and fish captures in the Upper Lillooet River in 2018.

Reach	Site	Sampling Date	Daily Average Flow (m^3/s)[1]	Conductivity (µS/cm)	Water Temp. (°C)	Turbidity	Alkalinity (mg/L)	Sampled Site		Total Electrofishing Effort (sec)				Electrofishing Catch (# of fish)							
								Length (m)	Area (m^2)					Cutthroat Trout				Bull Trout			
										Pass 1	Pass 2	Pass 3	Total	Pass 1	Pass 2	Pass 3	Total	Pass 1	Pass 2	Pass 3	Total
Diversion	ULL-DVEF02b	24-Mar-18	4.46	170	3.6	Medium	40	19	123	1,012	804	-	1,816	3	0	-	3	0	2	0	2
	ULL-DVEF04	24-Mar-18	4.46	160	3.3	Medium	40	20	100	1,113	807	-	1,920	2	0	-	2	0	2	0	2
	ULL-DVEF05	24-Mar-18	4.46	160	3.5	Medium	40	21	83	1,028	852	-	1,880	1	0	-	1	0	2	0	2
	ULL-DVEF06	24-Mar-18	4.46	170	3.6	Medium	40	22	176	1,034	800	-	1,834	3	0	-	3	0	0	0	0
	ULL-DVEF07b	24-Mar-18	4.46	170	3.2	Medium	40	20	93	1,000	804	-	1,804	0	0	-	0	0	0	0	0
							Diversion Total	**102**	**576**				**9,254**				**9**				6
							Diversion Average	**20**	**115**				**1,851**				**2**				1
Upstream	ULL-USEF01	26-Mar-18	5.99	190	3.4	Low	35	19	99	1,029	870	-	1,899	0	0	-	0	0	0	0	0
	ULL-USEF02b	26-Mar-18	5.99	190	3.4	Low	35	18	126	1,010	809	-	1,819	0	0	-	0	0	0	0	0
	ULL-USEF03	26-Mar-18	5.99	190	3.4	Low	35	17	75	1,007	800	-	1,807	0	0	-	0	0	0	0	0
	ULL-USEF06	25-Mar-18	5.96	180	4.5	Medium	35	18	123	1,021	854	-	1,875	1	0	-	1	0	0	0	0
	ULL-USEF07	25-Mar-18	5.96	180	4.5	Medium	34	19	89	1,007	800	634	2,441	4	1	0	5	0	0	0	0
	ULL-USEF10	26-Mar-18	5.99	160	3.8	Medium	37	21	97	1,000	801	-	1,801	1	0	-	1	0	0	0	0
	ULL-USEF11	27-Mar-18	6.17	160	4.3	Medium	37	18	54	1,060	932	-	1,992	1	0	-	1	0	0	0	0
	ULL-USEF12	27-Mar-18	6.17	170	4.3	Medium	37	18	90	1,002	800	-	1,802	2	0	-	2	0	0	0	0
	ULL-USEF13	27-Mar-18	6.17	170	4.3	Medium	37	20	103	1,006	807	-	1,813	0	0	-	0	0	0	0	0
	ULL-USEF14	27-Mar-18	6.17	170	4.3	Medium	35	21	66	1,036	834	-	1,870	1	0	-	1	0	0	0	0
							Upstream Total	**189**	**923**				**19,119**				**11**				0
							Upstream Average	**19**	**92**				**1,912**				**1**				0
							Combined Total	**291**	**1,499**				**28,373**				**20**				6
							Combined Average	**19**	**100**				**1,892**				**1**				0

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[1] Upstream flows were calculated as diversion flows as measured at ULL-DSI + powerhouse flows.

Age Analysis

Length-frequency distributions, length-weight relationships, and length at age relationships of Bull Trout and Cutthroat Trout captured during 2018 in closed-site electrofishing surveys in the Upper Lillooet River diversion and upstream reaches, as well as data on individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix L. No Bull Trout fin ray samples were aged in 2018, but a total of eight and 11 scale samples were aged from Cutthroat trout captured in the diversion and upstream reaches, respectively. Based on a review of aging data and length-frequency distributions, discrete fork length ranges were defined for fry, juvenile, and adult age classes of both Bull Trout (Table 30) and Cutthroat Trout (Table 31). Juvenile Bull Trout included 1+ to 3+ fish, with ≥4+ fish considered adults, whereas for Cutthroat Trout which mature at an earlier age in the Upper Lillooet River, 1+ and 2+ fish were considered juveniles, and ≥3+ fish considered adults.

Table 30. Fork length range used to define age classes of Bull Trout captured in the Upper Lillooet River in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	30 - 90
Juvenile (1-3+)	149 - 162
Adult (≥4+)	≥ 231

Table 31. Fork length ranges used to define age classes of Cutthroat Trout in the Upper Lillooet River in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	41 - 69
Juvenile (1-2+)	95 - 198
Adult (≥3+)	≥ 217

Fish Metrics and Condition

Fork length, weight, and condition factor for all captured Bull Trout and Cutthroat Trout are summarized by age class and reach in Table 32 and Table 33, respectively. Weights were assigned to all fish not weighed in the field from the established length-weight relationships (Appendix L). Average condition factor for all age classes of Bull Trout in the diversion reach were the same. Comparison of average condition factor for Cutthroat Trout suggests that fish in the diversion reach were in slightly better condition (averaging 1.07 to 1.11) than in the upstream reach (averaging 0.92 to 0.97).

Table 32. Summary of fork length, weight, and condition for Bull Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.

Reach	Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	2	60	30	90	1	8.8	8.8	8.8	1	1.21	1.21	1.21
	Juvenile (1-3+)	3	154	149	162	3	44.1	40.9	48.0	3	1.21	1.02	1.37
	Adult (≥4+)	1	231	231	231	1	149.0	149.0	149.0	1	1.21	1.21	1.21
	All	**6**	**136**	**30**	**231**	**5**	**58.0**	**8.8**	**149.0**	**5**	**1.21**	**1.02**	**1.37**

Table 33. Summary of fork length, weight, and condition for Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.

Reach	Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	6	61	41	69	6	2.6	0.6	3.5	6	1.04	0.87	1.16
	Juvenile (1-2+)	1	144	144	144	1	33.1	33.1	33.1	1	1.11	1.11	1.11
	Adult (≥3+)	2	232	217	247	2	136.7	103.1	170.2	2	1.07	1.01	1.13
	All	**9**	**108**	**41**	**247**	**9**	**35.7**	**0.6**	**170.2**	**9**	**1.05**	**0.87**	**1.16**
Upstream	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-2+)	10	152	95	198	10	38.7	9.5	81.6	10	0.97	0.80	1.14
	Adult (≥3+)	1	219	219	219	1	96.4	96.4	96.4	1	0.92	0.92	0.92
	All	**11**	**158**	**95**	**219**	**11**	**43.9**	**9.5**	**96.4**	**11**	**0.96**	**0.80**	**1.14**

Density and Biomass Estimates

Bull Trout

During closed-site electrofishing in the Upper Lillooet River in 2018, Bull Trout fry, juveniles, and adults were captured within the diversion reach (Table 34, Table 35, and Figure 14). Bull Trout are not present in the upstream reach on the Upper Lillooet River. Observed fish densities (FPUobs; #/100 m^2) and biomass (BPUobs; g/100 m^2) are the focus of the results below, with habitat adjusted values (FPUadj and BPUadj) provided in tables for reference (Table 35). Densities of Bull Trout juveniles were highest among all age classes, while those of adults were lowest. In contrast, Adults had the highest observed biomass among all age classes within the diversion.

Table 34. Observed and habitat suitability adjusted density and biomass by age class of Bull Trout determined from closed-site electrofishing in the Upper Lillooet River in 2018.

A) Fry (0+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU$_{obs}$ (#/100 m^2)	BPU$_{obs}$ (g/100 m^2)	FPU$_{adj}$ (#/100 m^2)	BPU$_{adj}$ (g/100 m^2)
Diversion	ULL-DVEF02b	50.5%	0.8	7.1	1.6	14.1
	ULL-DVEF04	24.7%	0.0	0.0	0.0	0.0
	ULL-DVEF05	44.0%	1.2	0.3	2.7	0.7
	ULL-DVEF06	48.9%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	21.6%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	8.6%	0.0	0.0	0.0	0.0
	ULL-USEF02b	2.5%	0.0	0.0	0.0	0.0
	ULL-USEF03	8.8%	0.0	0.0	0.0	0.0
	ULL-USEF06	23.4%	0.0	0.0	0.0	0.0
	ULL-USEF07	18.8%	0.0	0.0	0.0	0.0
	ULL-USEF10	37.7%	0.0	0.0	0.0	0.0
	ULL-USEF11	38.4%	0.0	0.0	0.0	0.0
	ULL-USEF12	10.9%	0.0	0.0	0.0	0.0
	ULL-USEF13	1.4%	0.0	0.0	0.0	0.0
	ULL-USEF14	5.6%	0.0	0.0	0.0	0.0

B) Juvenile (1-3+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU$_{obs}$ (#/100 m^2)	BPU$_{obs}$ (g/100 m^2)	FPU$_{adj}$ (#/100 m^2)	BPU$_{adj}$ (g/100 m^2)
Diversion	ULL-DVEF02b	50.5%	0.8	33.1	1.6	65.7
	ULL-DVEF04	24.7%	1.0	48.0	4.0	194.1
	ULL-DVEF05	44.0%	1.2	51.9	2.7	118.0
	ULL-DVEF06	48.9%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	21.6%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	8.6%	0.0	0.0	0.0	0.0
	ULL-USEF02b	2.5%	0.0	0.0	0.0	0.0
	ULL-USEF03	8.8%	0.0	0.0	0.0	0.0
	ULL-USEF06	23.4%	0.0	0.0	0.0	0.0
	ULL-USEF07	18.8%	0.0	0.0	0.0	0.0
	ULL-USEF10	37.7%	0.0	0.0	0.0	0.0
	ULL-USEF11	38.4%	0.0	0.0	0.0	0.0
	ULL-USEF12	10.9%	0.0	0.0	0.0	0.0
	ULL-USEF13	1.4%	0.0	0.0	0.0	0.0
	ULL-USEF14	5.6%	0.0	0.0	0.0	0.0

C) Adult (≥4+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU$_{obs}$ (#/100 m^2)	BPU$_{obs}$ (g/100 m^2)	FPU$_{adj}$ (#/100 m^2)	BPU$_{adj}$ (g/100 m^2)
Diversion	ULL-DVEF02b	33.2%	0.0	0.0	0.0	0.0
	ULL-DVEF04	35.6%	1.0	148.9	2.8	417.7
	ULL-DVEF05	60.9%	0.0	0.0	0.0	0.0
	ULL-DVEF06	39.8%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	26.4%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	36.9%	0.0	0.0	0.0	0.0
	ULL-USEF02b	20.0%	0.0	0.0	0.0	0.0
	ULL-USEF03	22.5%	0.0	0.0	0.0	0.0
	ULL-USEF06	47.3%	0.0	0.0	0.0	0.0
	ULL-USEF07	64.8%	0.0	0.0	0.0	0.0
	ULL-USEF10	39.7%	0.0	0.0	0.0	0.0
	ULL-USEF11	50.7%	0.0	0.0	0.0	0.0
	ULL-USEF12	41.7%	0.0	0.0	0.0	0.0
	ULL-USEF13	14.1%	0.0	0.0	0.0	0.0
	ULL-USEF14	33.3%	0.0	0.0	0.0	0.0

D) All

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU$_{obs}$ (#/100 m^2)	BPU$_{obs}$ (g/100 m^2)	FPU$_{adj}$ (#/100 m^2)	BPU$_{adj}$ (g/100 m^2)
Diversion	ULL-DVEF02b	33.2%	1.6	40.3	1.6	14.1
	ULL-DVEF04	35.6%	2.0	196.8	2.8	417.7
	ULL-DVEF05	60.9%	2.4	52.3	2.7	0.7
	ULL-DVEF06	39.8%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	26.4%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	36.9%	0.0	0.0	0.0	0.0
	ULL-USEF02b	20.0%	0.0	0.0	0.0	0.0
	ULL-USEF03	22.5%	0.0	0.0	0.0	0.0
	ULL-USEF06	47.3%	0.0	0.0	0.0	0.0
	ULL-USEF07	64.8%	0.0	0.0	0.0	0.0
	ULL-USEF10	39.7%	0.0	0.0	0.0	0.0
	ULL-USEF11	50.7%	0.0	0.0	0.0	0.0
	ULL-USEF12	41.7%	0.0	0.0	0.0	0.0
	ULL-USEF13	14.1%	0.0	0.0	0.0	0.0
	ULL-USEF14	33.3%	0.0	0.0	0.0	0.0

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

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

3. FPU$_{adj}$ = FPU$_{obs}$/Usability (%)

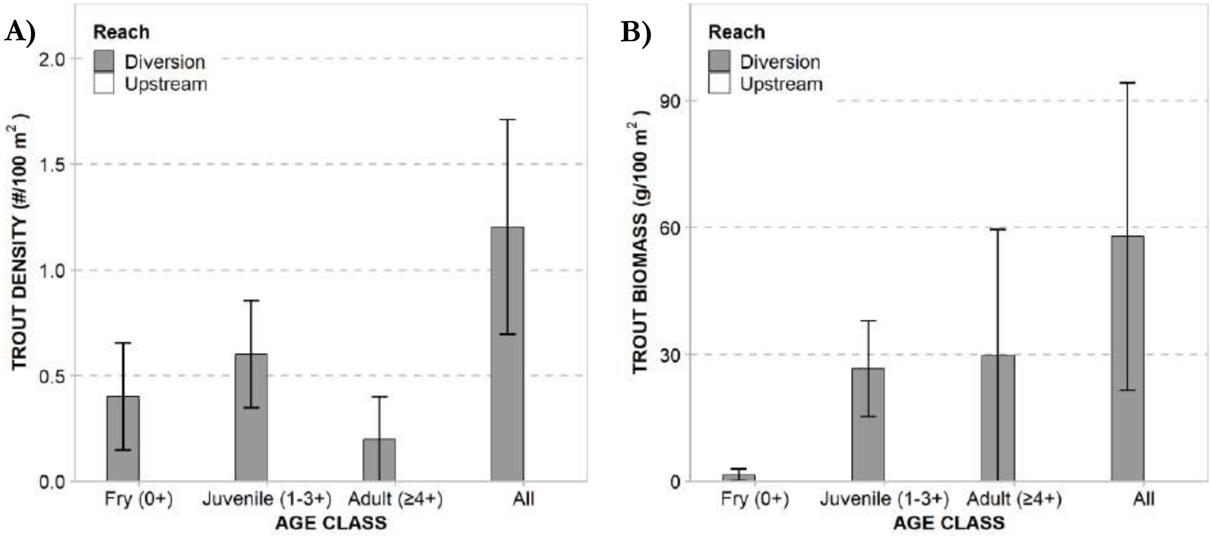
4. BPU$_{adj}$ = BPU$_{obs}$/Usability (%)

Table 35. **Observed and habitat suitability adjusted average Bull Trout densities and biomass by age class determined from closed-site electrofishing in the Upper Lillooet River in 2018.**

Reach	Age Class	FPUobs (#/100 m²)[1]		BPUobs (g/100 m²)[1]		FPUadj (#/100 m²)[1]		BPUadj (g/100 m²)[1]	
		Average	SE	Average	SE	Average	SE	Average	SE
Diversion	Fry (0+)	0.4	0.3	1.5	1.4	0.9	0.6	3.0	2.8
	Juvenile (1-3+)	0.6	0.3	26.6	11.3	1.7	0.8	75.6	37.0
	Adult (≥4+)	0.2	0.2	29.8	29.8	0.6	0.6	83.5	83.5
	All	1.2	0.5	57.9	36.3	1.4	0.6	86.5	82.8
Upstream	Fry (0+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Juvenile (1-3+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Adult (≥4+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	All	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[1] SE = Standard Error

Figure 14. **Average observed densities (± standard error) by age class of Bull Trout determined from closed-site electrofishing in the Upper Lillooet River in 2018 presented as: A) fish density per 100 m² (FPUobs), and B) fish biomass per 100 m² (BPUobs).**



Cutthroat Trout

Cutthroat Trout fry were only captured in the diversion reach while juveniles and adults were captured both in the diversion and upstream reaches. Among the three age classes within the diversion reach, adults and juveniles had lowest observed densities, and fry had the highest (Table 36, Table 37, and Figure 15). As observed for Bull Trout, the observed biomass of adult Cutthroat Trout in the diversion reach was higher than that of the other age classes. No Cutthroat Trout fry were captured in the upstream reach and juveniles had the highest observed densities and biomass. In general, observed densities of all Cutthroat Trout age classes combined were slightly higher in the diversion reach than in the upstream reach, whereas, due to the high proportion of juveniles, the observed biomass was higher in the upstream reach.

Table 36. Observed and habitat suitability adjusted density and biomass by age class of Cutthroat Trout determined from closed-site electrofishing in the Upper Lillooet River in 2018

A) Fry (0+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	23.3%	2.4	7.5	10.4	32.3
	ULL-DVEF04	58.2%	2.0	2.8	3.4	4.8
	ULL-DVEF05	53.9%	0.0	0.0	0.0	0.0
	ULL-DVEF06	33.3%	0.6	1.8	1.7	5.5
	ULL-DVEF07b	13.0%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	17.3%	0.0	0.0	0.0	0.0
	ULL-USEF02b	1.3%	0.0	0.0	0.0	0.0
	ULL-USEF03	16.2%	0.0	0.0	0.0	0.0
	ULL-USEF06	10.7%	0.0	0.0	0.0	0.0
	ULL-USEF07	34.0%	0.0	0.0	0.0	0.0
	ULL-USEF10	46.3%	0.0	0.0	0.0	0.0
	ULL-USEF11	42.3%	0.0	0.0	0.0	0.0
	ULL-USEF12	16.2%	0.0	0.0	0.0	0.0
	ULL-USEF13	1.9%	0.0	0.0	0.0	0.0
	ULL-USEF14	11.2%	0.0	0.0	0.0	0.0

B) Juvenile (1-2+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	23.3%	0.0	0.0	0.0	0.0
	ULL-DVEF04	58.2%	0.0	0.0	0.0	0.0
	ULL-DVEF05	53.9%	1.2	39.7	2.2	73.7
	ULL-DVEF06	33.3%	0.0	0.0	0.0	0.0
	ULL-DVEF07b	13.0%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	17.3%	0.0	0.0	0.0	0.0
	ULL-USEF02b	1.3%	0.0	0.0	0.0	0.0
	ULL-USEF03	16.2%	0.0	0.0	0.0	0.0
	ULL-USEF06	10.7%	0.8	28.1	7.6	262.4
	ULL-USEF07	34.0%	5.6	246.1	16.6	723.3
	ULL-USEF10	46.3%	1.0	43.1	2.2	93.1
	ULL-USEF11	42.3%	0.0	0.0	0.0	0.0
	ULL-USEF12	16.2%	2.2	69.9	13.7	430.7
	ULL-USEF13	1.9%	0.0	0.0	0.0	0.0
	ULL-USEF14	11.2%	1.5	43.6	13.5	388.9

C) Adult (≥3+)

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	38.9%	0.0	0.0	0.0	0.0
	ULL-DVEF04	26.1%	0.0	0.0	0.0	0.0
	ULL-DVEF05	42.8%	0.0	0.0	0.0	0.0
	ULL-DVEF06	49.8%	1.1	155.3	2.3	311.8
	ULL-DVEF07b	53.4%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	52.1%	0.0	0.0	0.0	0.0
	ULL-USEF02b	46.9%	0.0	0.0	0.0	0.0
	ULL-USEF03	60.7%	0.0	0.0	0.0	0.0
	ULL-USEF06	73.7%	0.0	0.0	0.0	0.0
	ULL-USEF07	73.9%	0.0	0.0	0.0	0.0
	ULL-USEF10	34.7%	0.0	0.0	0.0	0.0
	ULL-USEF11	37.0%	1.9	179.5	5.0	484.5
	ULL-USEF12	54.4%	0.0	0.0	0.0	0.0
	ULL-USEF13	42.8%	0.0	0.0	0.0	0.0
	ULL-USEF14	62.0%	0.0	0.0	0.0	0.0

D) All

Reach	Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
			FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
Diversion	ULL-DVEF02b	38.9%	2.4	7.5	10.4	32.3
	ULL-DVEF04	26.1%	2.0	2.8	3.4	4.8
	ULL-DVEF05	42.8%	1.2	39.7	0.0	0.0
	ULL-DVEF06	49.8%	1.7	157.1	4.0	317.3
	ULL-DVEF07b	53.4%	0.0	0.0	0.0	0.0
Upstream	ULL-USEF01	52.1%	0.0	0.0	0.0	0.0
	ULL-USEF02b	46.9%	0.0	0.0	0.0	0.0
	ULL-USEF03	60.7%	0.0	0.0	0.0	0.0
	ULL-USEF06	73.7%	0.8	28.1	0.0	0.0
	ULL-USEF07	73.9%	5.6	246.1	0.0	0.0
	ULL-USEF10	34.7%	1.0	43.1	0.0	0.0
	ULL-USEF11	37.0%	1.9	179.5	5.0	484.5
	ULL-USEF12	54.4%	2.2	69.9	0.0	0.0
	ULL-USEF13	42.8%	0.0	0.0	0.0	0.0
	ULL-USEF14	62.0%	1.5	43.6	0.0	0.0

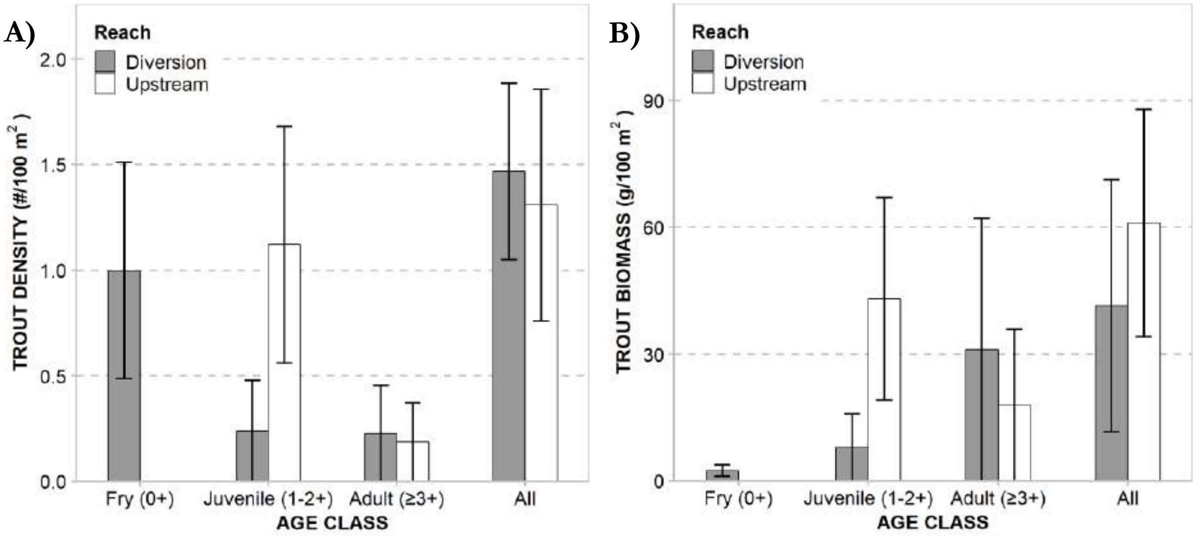
1. FPU_{obs} = Observed fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R.
2. BPU_{obs} = Biomass of fish per unit (100 m^2) based on population estimates computed using the removal (K-pass) function in the FSA package in R.
3. $FPU_{adj} = FPU_{obs}/\text{Usability (\%)}$
4. $BPU_{adj} = BPU_{obs}/\text{Usability (\%)}$

Table 37. **Observed and habitat suitability adjusted average Cutthroat Trout densities and biomass by age class determined from closed-site electrofishing in the Upper Lillooet River in 2018.**

Reach	Age Class	FPUobs (#/100 m²)[1]		BPUobs (g/100 m²)[1]		FPUadj (#/100 m²)[1]		BPUadj (g/100 m²)[1]	
		Average	SE	Average	SE	Average	SE	Average	SE
Diversion	Fry (0+)	1.0	0.5	2.4	1.4	3.1	1.9	8.5	6.1
	Juvenile (1-2+)	0.2	0.2	7.9	7.9	0.4	0.4	14.7	14.7
	Adult (≥3+)	0.2	0.2	31.1	31.1	0.5	0.5	62.4	62.4
	All	1.5	0.4	41.4	29.8	3.6	1.9	70.9	61.9
Upstream	Fry (0+)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Juvenile (1-2+)	1.1	0.6	43.1	23.9	5.4	2.2	189.8	80.1
	Adult (≥3+)	0.2	0.2	18.0	18.0	0.5	0.5	48.5	48.5
	All	1.3	0.5	61.0	26.9	0.5	0.5	48.5	48.5

[1] SE = Standard Error

Figure 15. **Average observed densities (± standard error) by age class of Cutthroat Trout determined from closed-site electrofishing in the Upper Lillooet River in 2018 presented as: A) fish density per 100 m^2 (FPUobs), and B) fish biomass per 100 m^2 (BPUobs).**



Comparison Among Years

Bull Trout

No apparent trends in Bull Trout density and biomass among baseline and Year 1 operational monitoring were evident within the diversion reach for any age class (Figure 16, Figure 17). Bull Trout are not present in the upstream reach on the Upper Lillooet River. Bull Trout fry densities and biomass in 2018, were similar to those in 2010, and juvenile densities and biomass in 2018 were similar to those in 2012 and 2014. The densities and biomass of Adult Bull Trout (which were only captured in 2012 and 2018) were roughly twice as high on average in 2012 than in 2018. Overall, the density of all Bull Trout age classes combined were lower in 2018 than in 2010 and 2014 but slightly higher than in 2012, and biomass in 2018 was similar to 2012 and 2014 but lower than in 2010.

Figure 16. **Average observed Bull Trout densities (FPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River in 2010, 2012, 2014, and 2018 presented by age class: A) fry (0+); B) juveniles (1-3+); C) adult (≥4+); and D) all age classes combined.**

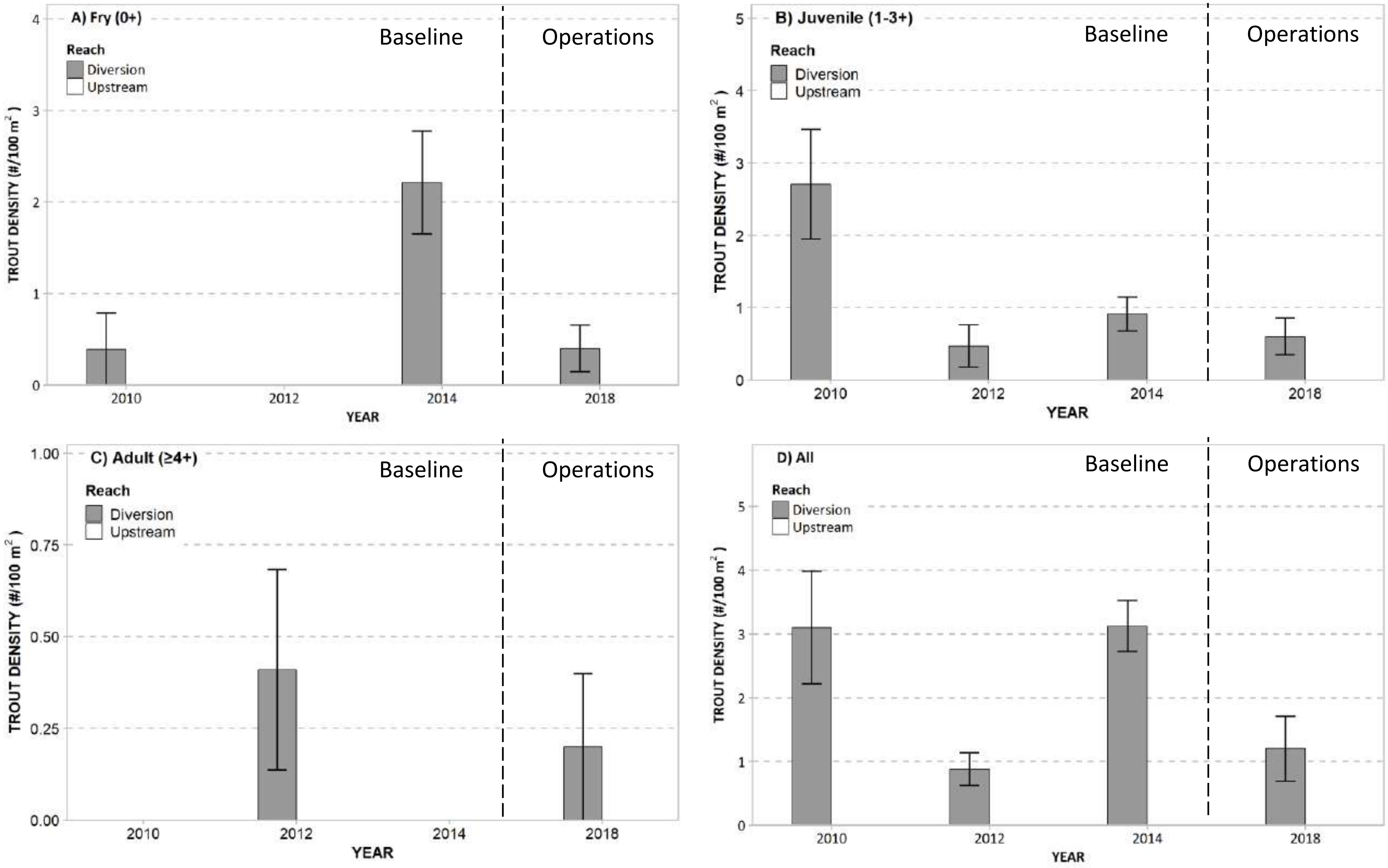
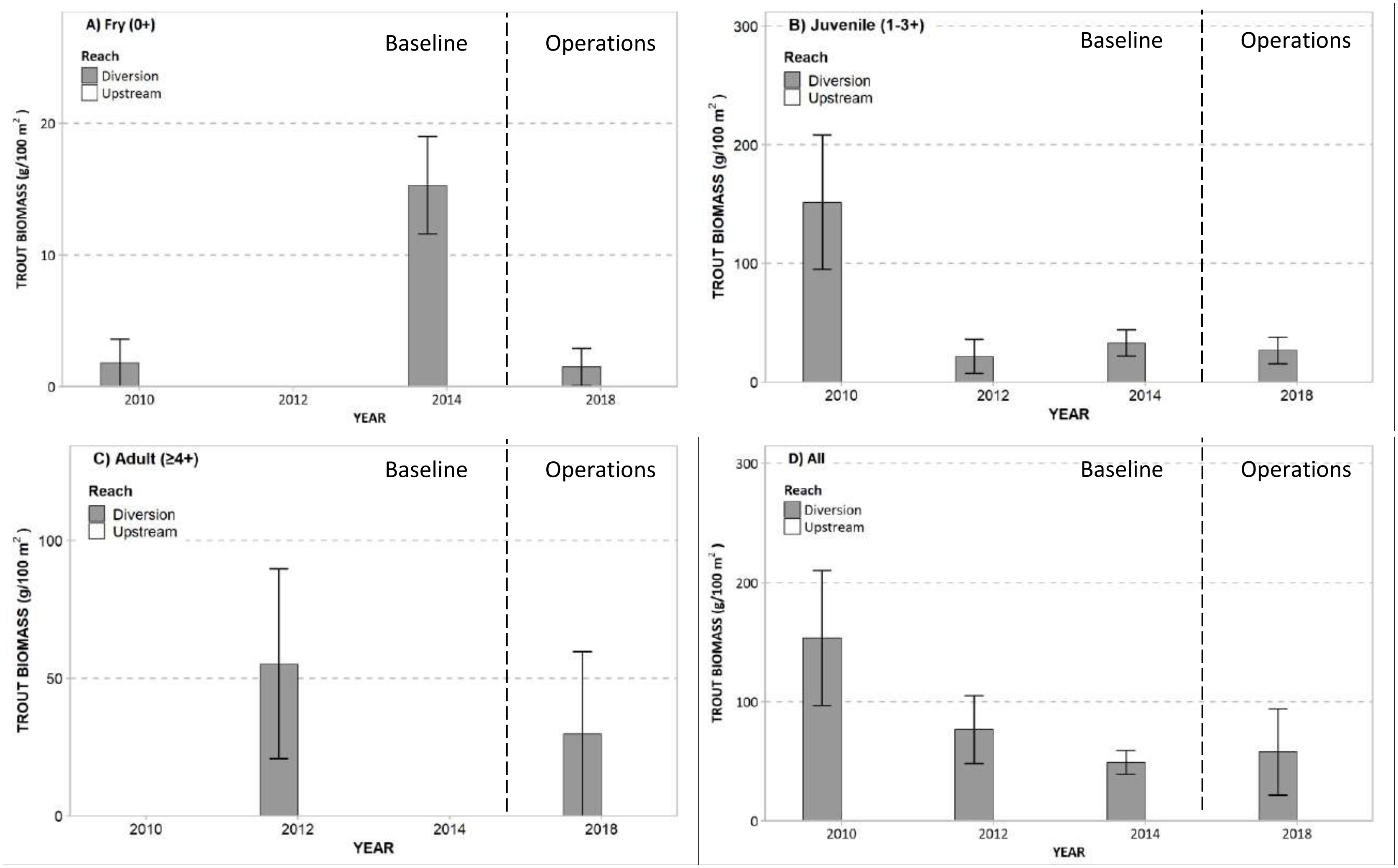


Figure 17. Average observed Bull Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River in 2010, 2012, 2014, and 2018 presented by age class: A) fry (0+); B) juveniles (1-3+); C) adult (≥4+); and D) all age classes combined.



Cutthroat Trout

No clear trends in Cutthroat Trout density and biomass among baseline and Year 1 operational monitoring were evident for any age class or within either reach with one exception (Figure 18, Figure 19). The exception is an apparent increasing trend in fry density within the diversion reach from 2010 to 2018 (although there was little difference in average density in the last two years). No Cutthroat Trout fry were captured in the upstream reach in 2018, which was also the case in 2010. Juvenile densities and biomass were the highest among survey years in 2018 within the upstream reach, but were lower than those in 2012 and 2014, and similar to those in 2010 within the diversion reach. Cutthroat Trout adult densities and biomass were lower in the upstream reach in 2018 than in 2010 or 2012 (no adults were captured upstream in 2014). In contrast, while no adult Cutthroat Trout were observed within the diversion reach in 2010, observed adult densities and biomass were similar in 2012, 2014, and 2018.

For all age classes combined, density of Cutthroat Trout in the diversion reach in 2018 was higher than in 2010 or 2012, but lower than in 2014 (Figure 18), whereas biomass was highest in 2012 and similar in 2014 and 2018 (Figure 19). In the upstream reach, density and biomass of all age classes combined was slightly lower in 2018 than in 2010 or 2012, but considerably higher than in 2014.

Figure 18. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River in 2010, 2012, 2014, and 2018 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adult (≥3+); and D) all age classes combined.

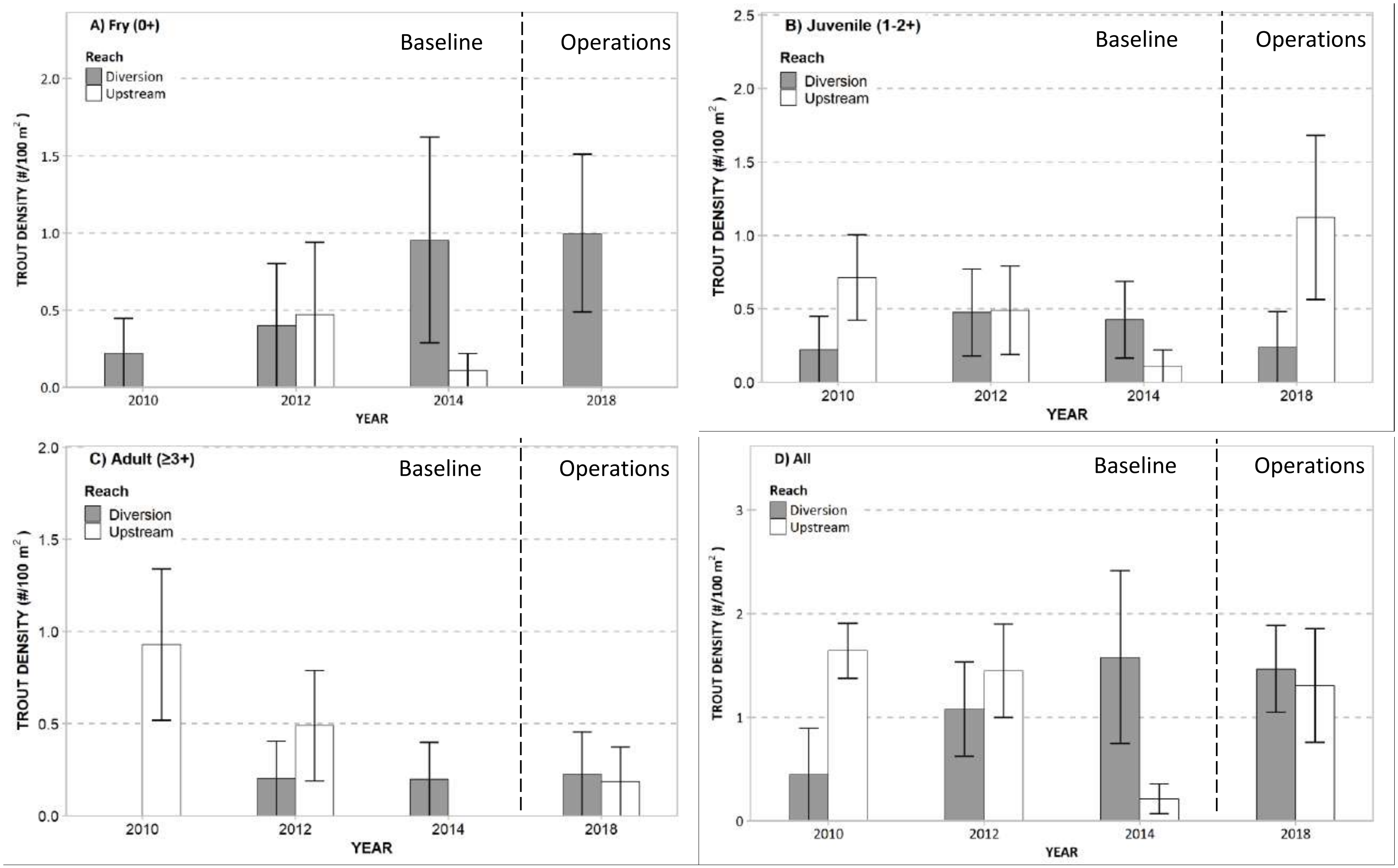
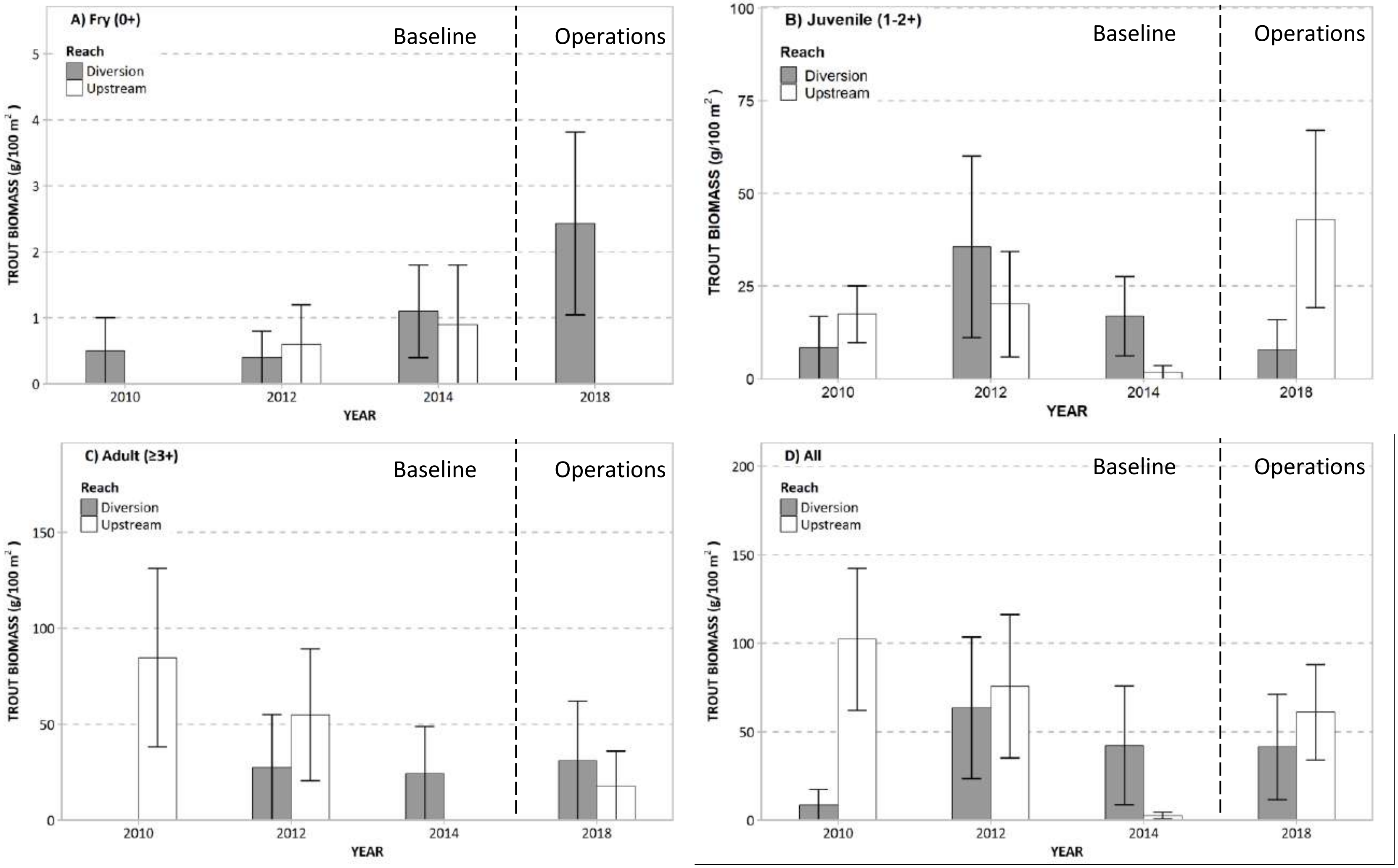


Figure 19. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the Upper Lillooet River in 2010, 2012, 2014, and 2018 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adult (≥3+); and D) all age classes combined.



4.3.1.2. Boulder Creek

Night Snorkelling Mark Re-sight

Night snorkelling mark re-sight surveys were conducted in Boulder Creek from March 13 to 16, 2018. Habitat summaries and representative photographs of mark re-sight sites are provided in Appendix M. Sites were composed of cascade or riffle mesohabitat types and had average gradients that ranged from 3.0% to 8.0%. Stream substrate was primarily composed of boulder, cobble, and gravel, and cover was provided primarily by boulder and cobble.

Sites ranged from 91 m to 108 m in length and 606 m^2 to 1,001 m^2 in area in the diversion reach and from 99 m to 111 m in length and 957 m^2 to 1,188 m^2 in area in the upstream reach. Maximum depths of sites were similar in both reaches, ranging from 0.8 m to 1.8 m. Due to the large size and depth of snorkel sites, and considerable flow rates at the channel thalweg, only 57% to 90% of their total areas were surveyed (resulting in sampled areas ranging from 424 m^2 to 989 m^2; Table 38). At the time of sampling, the water temperature was between 2.0°C and 2.5°C and the water was relatively clear with visibility was estimated to be between 4.0 m and 6 m. Average flow over the survey period was between 0.70 m^3/s and 0.73 m^3/s in the diversion reach, and 0.92 m^3/s and 0.93 m^3/s in the downstream reach.

During the first night of snorkelling, 14 Bull Trout were observed in the diversion reach, of which 11 were measured and marked, with zero to seven fish observed at individual sites (Table 39). In the downstream reach, 33 Bull Trout were observed, of which 24 were measured and marked, with five to nine fish observed at individual sites (Table 39). Three Cutthroat Trout were observed in the diversion reach of which two were captured and measured and marked, while neither of the two Cutthroat Trout observed in the downstream reach were captured to allow them to be measured or marked (Table 40).

During the second (re-sight) night of snorkelling on March 14, 2018, 11 Bull Trout were observed in the diversion reach, of which five were marked (Table 39). In the downstream reach, 25 Bull Trout were observed, of which 11 were marked (Table 39). During the re-sight swim, four Cutthroat Trout were observed in the diversion reach, of which two were marked, and two unmarked Cutthroat Trout were observed in the downstream reach (Table 40). Observer efficiency for Bull Trout ranged from 0.25 to 0.63 and was 0.46 when considering all marked and re-sighted fish from both reaches (Table 39). For Cutthroat Trout, observer efficiency could only be calculated for a single site where two fish were observed and re-sighted resulting in an observer efficiency of 1.0 (Table 40).

Table 38. Summary of mark re-sight snorkeling site characteristics, conditions, effort, and fish observations in Boulder Creek in 2018.

Project Reach	Sampling Type[1]	Sampling Type[1]	Site	Date	Water Temp. (°C)	Estimated Visibility (m)	Daily Average Flow (m^3/s)[2]	Sampled Area (m^2)	Shorkelling Effort (min)	Number of Fish[3]		
										BT	CT	Total
Diversion	Mark	Mark	BDR-DVSN01	15-Mar-18	2.0	6.0	0.70	446	130	7	0	7
			BDR-DVSN02	15-Mar-18	2.0	4.5	0.70	424	94	3	2	5
			BDR-DVSN03	15-Mar-18	2.0	4.5	0.70	605	102	4	0	4
			BDR-DVSN04	15-Mar-18	2.0	6.0	0.70	582	94	0	1	1
			BDR-DVSN05	15-Mar-18	2.0	4.5	0.70	599	80	0	0	0
	Recap	Re-sight	BDR-DVSN01	16-Mar-18	2.0	6.0	0.73	446	82	6	0	6
			BDR-DVSN02	16-Mar-18	2.5	4.5	0.73	424	88	2	2	4
			BDR-DVSN03	16-Mar-18	2.3	6.0	0.73	605	108	3	1	4
			BDR-DVSN04	16-Mar-18	2.0	6.0	0.73	582	90	0	1	1
			BDR-DVSN05	16-Mar-18	2.0	6.0	0.73	599	84	0	0	0
							Mark Total	**2,657**	**499**	**14**	**3**	**17**
							Re-sight Total	**2,657**	**451**	**11**	**4**	**15**
Downstream	Mark	Mark	BDR-DSSN01B	13-Mar-18	2.0	4.5	0.92	964	114	5	0	5
			BDR-DSSN02B	13-Mar-18	2.0	6.0	0.92	989	120	6	1	7
			BDR-DSSN03	13-Mar-18	2.0	4.0	0.92	852	112	9	0	9
			BDR-DSSN04	13-Mar-18	2.0	6.0	0.92	832	120	7	1	8
			BDR-DSSN05	13-Mar-18	2.0	4.5	0.92	760	94	6	0	6
	Recap	Re-sight	BDR-DSSN01B	14-Mar-18	2.3	5.0	0.93	964	106	7	1	8
			BDR-DSSN02B	14-Mar-18	2.0	0.0	0.93	989	120	5	1	6
			BDR-DSSN03	14-Mar-18	2.0	5.0	0.93	852	106	7	0	7
			BDR-DSSN04	14-Mar-18	2.0	6.0	0.93	832	122	2	0	2
			BDR-DSSN05	14-Mar-18	2.0	5.0	0.93	760	108	4	0	4
							Mark Total	**4,398**	**559**	**33**	**2**	**35**
							Re-sight Total	**4,398**	**562**	**25**	**2**	**27**
							Grand Mark Total	**7,054**	**1,058**	**47**	**5**	**52**
							Grand Re-sight Total	**7,054**	**1,013**	**36**	**6**	**42**

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

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

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

Table 39. **Summary of the number of observed, marked, and re-sighted Bull Trout, and species-specific observer efficiency, during mark re-sight snorkelling surveys in Boulder Creek in 2018.**

Project Reach	Site	Number of Fish[1]				Observer Efficiency
		T	M	C	R	
Diversion	BDR-DVSN01	7	6	6	3	0.50
	BDR-DVSN02	3	2	2	1	0.50
	BDR-DVSN03	4	3	3	1	0.33
	BDR-DVSN04	0	0	0	0	-
	BDR-DVSN05	0	0	0	0	-
	Total	**14**	**11**	**11**	**5**	**0.45**
Downstream	BDR-DSSN01B	5	4	7	2	0.50
	BDR-DSSN02B	6	5	5	2	0.40
	BDR-DSSN03	9	8	7	5	0.63
	BDR-DSSN04	7	4	2	1	0.25
	BDR-DSSN05	6	3	4	1	0.33
	Total	**33**	**24**	**25**	**11**	**0.46**
	Overall Total	**47**	**35**	**36**	**16**	**0.46**

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

Table 40. **Summary of the number of observed, marked, and re-sighted Cutthroat Trout, and species-specific observer efficiency, during mark re-sight snorkelling surveys in Boulder Creek in 2018.**

Project Reach	Site	Number of Fish[1]				Observer Efficiency
		T	M	C	R	
Diversion	BDR-DVSN01	0	0	0	0	-
	BDR-DVSN02	2	2	2	2	1.00
	BDR-DVSN03	0	0	1	0	-
	BDR-DVSN04	1	0	1	0	-
	BDR-DVSN05	0	0	0	0	-
	Total	**3**	**2**	**4**	**2**	**1.00**
Downstream	BDR-DSSN01B	0	0	1	0	-
	BDR-DSSN02B	1	0	1	0	-
	BDR-DSSN03	0	0	0	0	-
	BDR-DSSN04	1	0	0	0	-
	BDR-DSSN05	0	0	0	0	-
	Total	**2**	**0**	**2**	**0**	**-**
	Overall Total	**5**	**2**	**6**	**2**	**1.00**

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

Age Analysis

Length-frequency distributions, length-weight relationships, and length at age relationships of Bull Trout and Cutthroat Trout captured in 2018 during snorkel mark re-sight surveys in the Boulder Creek diversion and downstream reaches, as well as data on individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix N. As with Upper Lillooet River sampling, no Bull Trout fin ray samples were aged in 2018, but scale samples were aged from four Cutthroat trout; two adults from the diversion reach and one adult and one juvenile from the downstream reach. Based on a review of aging data and length-frequency distributions from baseline years and 2018, discrete fork length ranges were defined for fry, juvenile, and adult age classes of Bull Trout (Table 41), whereas only two juvenile (130-139 mm) and nine adult Cutthroat Trout (≥ 171 mm) were observed or captured in 2018. In line with age class assignment of fish captured in the Upper Lillooet River, 1+ to 3+ and ≥4+ Bull Trout were considered juveniles and adults, respectively, whereas for Cutthroat Trout, 1+ to 2+ and ≥3+ fish were considered juveniles and adults, respectively.

Table 41. Fork length range used to define age classes of Bull Trout captured in Boulder Creek in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	25 - 80
Juvenile (1-3+)	81 - 203
Adult (≥4+)	≥ 204

Fish Metrics and Condition

Fork lengths, weights, condition factor, and percent fat are summarized by age class and reach for all captured Bull Trout in Table 42 and for Cutthroat Trout in Table 43. Comparison of condition factors generally suggested that there was little support for differences in body condition for Bull Trout between locations and among age classes with the exception that adults appear to be in slightly better condition in the diversion than in the downstream reach and in slightly better condition than juveniles in the downstream reach, although the difference and sample size was small. Percent fat content was fairly similar in the downstream reach and diversion reach.

For Cutthroat Trout, there was also little difference in condition of weighed fish: the average condition factor for adult Cutthroat Trout was slightly higher in the downstream reach (K = 0.96) than in the diversion reach (K = 0.93). Only three adult Cutthroat Trout were measured for percent fat content, all in the diversion reach, therefore no comparison of this measure of condition could be made among age classes or reach.

It should be noted that 2018 is the first year that Cutthroat Trout have been observed during mark re-sight snorkelling surveys in Boulder Creek and the first time they have been observed in any year in the diversion reach. Previously, Cutthroat Trout were observed and captured in the downstream reach:

one juvenile Cutthroat Trout was observed during reconnaissance electrofishing on April 4, 2010 at site BDR-037 km and one adult Cutthroat Trout was captured during angling on October 1, 2011 at site BDR-0.08 km.

Table 42. **Summary of fork length, weight, condition, and percent fat of Bull Trout captured during mark re-sight snorkeling within Boulder Creek in 2018.**

Reach	Age Class	Fork Length (mm)[1]				Weight (g)[1]				Condition Factor (K)[1]				Percent Fat (%)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-3+)	6	157	145	178	3	42	31	57	3	1.00	0.98	1.01	0	n/a	n/a	n/a
	Adult (≥4+)	14	283	234	353	6	264	131	423	6	1.09	0.92	1.55	5	3.0	2.8	3.5
	All	**20**	**246**	**145**	**353**	**9**	**190**	**31**	**423**	**9**	**1.06**	**0.92**	**1.55**	**5**	**3.0**	**2.8**	**3.5**
Downstream	Fry (0+)	1	75	75	75	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-3+)	27	150	119	191	13	39	19	69	13	1.00	0.90	1.07	2	3.5	3.4	3.6
	Adult (≥4+)	17	257	204	340	8	177	84	325	8	0.96	0.83	1.01	7	3.2	2.6	3.7
	All	**45**	**189**	**75**	**340**	**21**	**91**	**19**	**325**	**21**	**0.99**	**0.83**	**1.07**	**9**	**3.3**	**2.6**	**3.7**

[1] Summary only includes measured values.

Table 43. **Summary of fork length, weight, condition, and percent fat of Cutthroat Trout captured during mark re-sight snorkeling within Boulder Creek in 2018.**

Reach	Age Class	Fork Length (mm)[1]				Weight (g)[1]				Condition Factor (K)[1]				Percent Fat (%)			
		n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Diversion	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-2+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Adult (≥3+)	6	238	215	265	4	133	92	180	4	0.93	0.84	1.00	3	1.2	1.0	1.4
	All	**6**	**238**	**215**	**265**	**4**	**133**	**92**	**180**	**4**	**0.93**	**0.84**	**1.00**	**3**	**1.2**	**1.0**	**1.4**
Downstream	Fry (0+)	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
	Juvenile (1-2+)	1	139	139	139	1	25	25	25	1	0.94	0.94	0.94	0	n/a	n/a	n/a
	Adult (≥3+)	1	172	172	172	1	50	50	50	1	0.98	0.98	0.98	0	n/a	n/a	n/a
	All	**2**	**156**	**139**	**172**	**2**	**38**	**25**	**50**	**2**	**0.96**	**0.94**	**0.98**	**0**	**n/a**	**n/a**	**n/a**

[1] Summary only includes measured values.

Density Estimates

Bull Trout

Bull Trout densities (observed and adjusted for observer efficiency) are presented by site in Table 44. The average adjusted density for all age classes was calculated to be 1.15 fish/100 m^2 (± 0.58 Standard Error (SE)) in the diversion reach and 1.45 fish/100 m^2 (± 0.16 SE) in the downstream reach. Juveniles had the highest adjusted density among age classes in the downstream reach (0.98 fish/100 m^2 ± 0.21 SE), and were more than twice as abundant in the downstream reach than in the diversion reach. In contrast, adult Bull Trout had the highest adjusted density among age classes in the diversion reach (0.75 fish /100 m^2 ± 0.32 SE) but were found in much lower densities in the downstream reach (0.45

fish /100 m^2 ± 0.12 SE) than in the diversion reach. Only one Bull Trout fry was observed in the downstream reach while none were observed in the diversion reach.

Table 44. Observed and observer efficiency adjusted densities of Bull Trout by age determined from mark re-sight snorkelling in Boulder Creek in 2018.

A) Fry (0+)

Project Reach	Site	Area (m^2)	Number of Fish Observed[1]		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	424	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	605	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Downstream	BDR-DSSN01B	964	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	989	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	852	1	0	0.12	0.00	0.06	0.26	0.00	0.13
	BDR-DSSN04	832	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	760	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.02**	**0.00**	**0.01**	**0.05**	**0.00**	**0.03**
				SE	**0.02**	**0.00**	**0.01**	**0.05**	**0.00**	**0.03**

B) Juveniles (1-3+)

Project Reach	Site	Area (m^2)	Number of Fish Observed[1]		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	3	4	0.67	0.90	0.78	1.47	1.96	1.72
	BDR-DVSN02	424	1	0	0.24	0.00	0.12	0.52	0.00	0.26
	BDR-DVSN03	605	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.18**	**0.18**	**0.18**	**0.40**	**0.39**	**0.39**
				SE	**0.13**	**0.18**	**0.15**	**0.29**	**0.39**	**0.33**
Downstream	BDR-DSSN01B	964	4	6	0.41	0.62	0.52	0.91	1.36	1.13
	BDR-DSSN02B	989	2	2	0.20	0.20	0.20	0.44	0.44	0.44
	BDR-DSSN03	852	7	6	0.82	0.70	0.76	1.80	1.54	1.67
	BDR-DSSN04	832	6	1	0.72	0.12	0.42	1.58	0.26	0.92
	BDR-DSSN05	760	3	2	0.39	0.26	0.33	0.86	0.58	0.72
				Mean	**0.51**	**0.38**	**0.45**	**1.12**	**0.84**	**0.98**
				SE	**0.11**	**0.12**	**0.09**	**0.25**	**0.26**	**0.21**

C) Adults (≥4+)

Project Reach	Site	Area (m^2)	Number of Fish Observed[1]		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	4	2	0.90	0.45	0.67	1.96	0.98	1.47
	BDR-DVSN02	424	2	2	0.47	0.47	0.47	1.03	1.03	1.03
	BDR-DVSN03	605	4	3	0.66	0.50	0.58	1.45	1.09	1.27
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.41**	**0.28**	**0.34**	**0.89**	**0.62**	**0.75**
				SE	**0.18**	**0.12**	**0.14**	**0.39**	**0.25**	**0.32**
Downstream	BDR-DSSN01B	964	1	1	0.10	0.10	0.10	0.23	0.23	0.23
	BDR-DSSN02B	989	4	3	0.40	0.30	0.35	0.88	0.66	0.77
	BDR-DSSN03	852	1	1	0.12	0.12	0.12	0.26	0.26	0.26
	BDR-DSSN04	832	1	1	0.12	0.12	0.12	0.26	0.26	0.26
	BDR-DSSN05	760	3	2	0.39	0.26	0.33	0.86	0.58	0.72
				Mean	**0.23**	**0.18**	**0.20**	**0.50**	**0.40**	**0.45**
				SE	**0.07**	**0.04**	**0.06**	**0.15**	**0.09**	**0.12**

D) All

Project Reach	Site	Area (m^2)	Number of Fish Observed[1]		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	7	6	1.57	1.35	1.46	3.43	2.94	3.19
	BDR-DVSN02	424	3	2	0.71	0.47	0.59	1.55	1.03	1.29
	BDR-DVSN03	605	4	3	0.66	0.50	0.58	1.45	1.09	1.27
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.59**	**0.46**	**0.53**	**1.29**	**1.01**	**1.15**
				SE	**0.29**	**0.25**	**0.27**	**0.63**	**0.54**	**0.58**
Downstream	BDR-DSSN01B	964	5	7	0.52	0.73	0.62	1.13	1.59	1.36
	BDR-DSSN02B	989	6	5	0.61	0.51	0.56	1.33	1.11	1.22
	BDR-DSSN03	852	9	7	1.06	0.82	0.94	2.31	1.80	2.05
	BDR-DSSN04	832	7	2	0.84	0.24	0.54	1.84	0.53	1.18
	BDR-DSSN05	760	6	4	0.79	0.53	0.66	1.73	1.15	1.44
				Mean	**0.76**	**0.56**	**0.66**	**1.67**	**1.23**	**1.45**
				SE	**0.09**	**0.10**	**0.07**	**0.21**	**0.22**	**0.16**

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

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

Cutthroat Trout

2018 is the first year that Cutthroat Trout have been observed during mark re-sight snorkel surveys in Boulder Creek. Cutthroat Trout densities (observed and adjusted for observer efficiency) are presented by site in Table 45. Although no juveniles were observed in the diversion reach, they were the only age class observed in the downstream reach with average adjusted densities of 0.09 fish/100 m^2 (± 0.04 SE). In contrast, adults were only observed in the diversion reach, at a considerably higher average adjusted density of 0.32 fish/100 m^2 (± 0.19 SE). No Cutthroat Trout fry were observed in either the downstream or diversion reach in 2018.

Table 45. Observed and observer efficiency adjusted densities of Cutthroat Trout by age class determined from mark re-sight snorkelling in Boulder Creek in 2018.

A) Fry (0+)

Project Reach	Site	Area (m^2)	Number of Fish		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	424	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	605	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Downstream	BDR-DSSN01B	964	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	989	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	852	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN04	832	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	760	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

B) Juveniles (1-2+)

Project Reach	Site	Area (m^2)	Number of Fish		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	424	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN03	605	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN04	582	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Downstream	BDR-DSSN01B	964	0	1	0.00	0.10	0.05	0.00	0.23	0.11
	BDR-DSSN02B	989	1	1	0.10	0.10	0.10	0.22	0.22	0.22
	BDR-DSSN03	852	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN04	832	1	0	0.12	0.00	0.06	0.26	0.00	0.13
	BDR-DSSN05	760	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.04**	**0.04**	**0.04**	**0.10**	**0.09**	**0.09**
				SE	**0.03**	**0.03**	**0.02**	**0.06**	**0.05**	**0.04**

C) Adults (≥3+)

Project Reach	Site	Area (m^2)	Number of Fish		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	424	2	2	0.47	0.47	0.47	1.03	1.03	1.03
	BDR-DVSN03	605	0	1	0.00	0.17	0.08	0.00	0.36	0.18
	BDR-DVSN04	582	1	1	0.17	0.17	0.17	0.38	0.38	0.38
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.13**	**0.16**	**0.15**	**0.28**	**0.35**	**0.32**
				SE	**0.09**	**0.09**	**0.09**	**0.20**	**0.19**	**0.19**
Downstream	BDR-DSSN01B	964	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN02B	989	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN03	852	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN04	832	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN05	760	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
				SE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

D) All

Project Reach	Site	Area (m^2)	Number of Fish		Observed Density (fish/100 m^2)			Adjusted Density[2] (fish/100 m^2)		
			Mark	Re-sight	Mark	Re-sight	Average	Mark	Re-sight	Average
Diversion	BDR-DVSN01	446	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DVSN02	424	2	2	0.47	0.47	0.47	1.03	1.03	1.03
	BDR-DVSN03	605	0	1	0.00	0.17	0.08	0.00	0.36	0.18
	BDR-DVSN04	582	1	1	0.17	0.17	0.17	0.38	0.38	0.38
	BDR-DVSN05	599	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.13**	**0.16**	**0.15**	**0.28**	**0.35**	**0.32**
				SE	**0.09**	**0.09**	**0.09**	**0.20**	**0.19**	**0.19**
Downstream	BDR-DSSN01B	964	0	1	0.00	0.10	0.05	0.00	0.23	0.11
	BDR-DSSN02B	989	1	1	0.10	0.10	0.10	0.22	0.22	0.22
	BDR-DSSN03	852	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	BDR-DSSN04	832	1	0	0.12	0.00	0.06	0.26	0.00	0.13
	BDR-DSSN05	760	0	0	0.00	0.00	0.00	0.00	0.00	0.00
				Mean	**0.04**	**0.04**	**0.04**	**0.10**	**0.09**	**0.09**
				SE	**0.03**	**0.03**	**0.02**	**0.06**	**0.05**	**0.04**

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

[2] Density corrected by mean observer efficiency for all age classes of Bull Trout combined of 0.46 as too few Cutthroat Trout observed to measure observer efficiency for this species.

Comparison Among Years

Bull Trout

Adjusted Bull Trout densities varied considerably between reaches and among years and are compared in Figure 20. Overall Bull Trout densities were consistently higher in the downstream reach and considerably more variable among years than those in the diversion reach, and were the highest in 2013 and lowest in 2018 (with the exceptions that adult densities were higher in the diversion reach in 2018). Though densities were relatively consistent in the diversion, the age class that dominated the catch differed among years. Overall, higher density of Bull Trout in the downstream reach is likely due to a combination of factors such as better habitat quality and greater accessibility from the Upper Lillooet River than for sites in the diversion reach. However, results for the downstream reach need to be interpreted within the context that this reach received very high channel forming flows in the late fall of 2016 and again in 2017, which likely had large influences on fish habitat within it.

Age class specific densities are highly variable from year to year, due to the relatively low densities of fish within the two reaches. Juveniles had the highest densities in 2012, but lowest densities in 2013, whereas adult densities were relatively consistent during all baseline years and then increased in 2018. Fry densities have been particularly variable. This age class has been observed in low densities in the downstream reach in all years with only one individual captured in 2018, whereas in the diversion reach, fry have been absent in all years, with the exception of one individual observed in 2013.

Abundance Action Threshold (AAT)

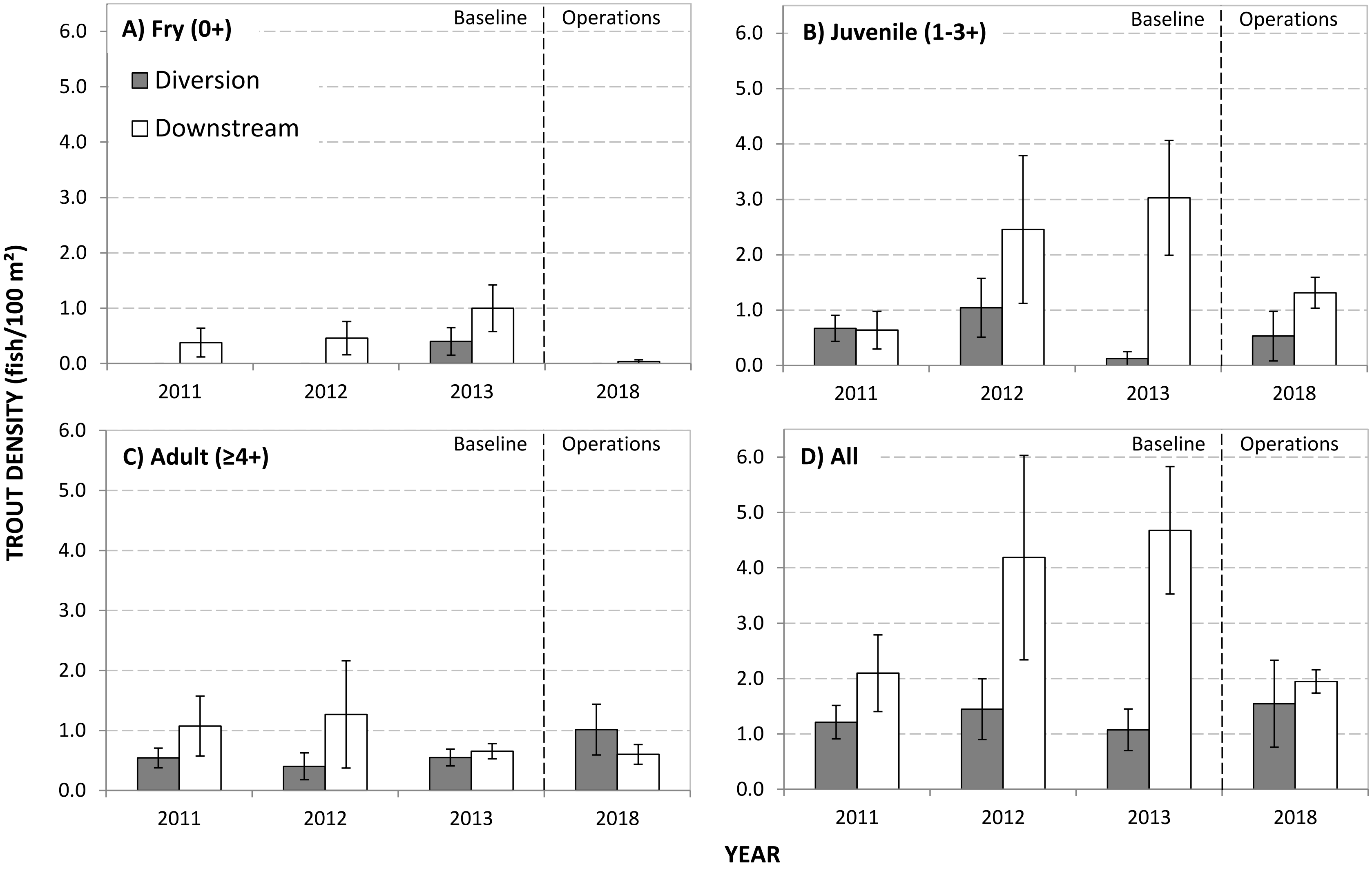
Abundance action thresholds (AAT) were defined by Harwood *et al.* (2012) and in the OEMP for individual age classes and all age classes combined of juvenile Bull Trout within the diversion reach of Boulder Creek. Densities of Bull Trout juveniles observed in Year 1 monitoring (for individual age classes, and all combined) were compared to these AATs, and although variable among years, there were no declines that exceeded AATs in the diversion reach of Boulder Creek that were not mirrored by similar or more severe declines in the downstream control reach. Although fry density has declined by 100% (over the 80% AAT for individual age classes) in the diversion reach in Year 1 of operations, fry density has also declined by 96% in the downstream reach, which does not trigger the AAT threshold. However, the average baseline density for fry in the diversion reach is based on a single fry observed in only one of the three years of baseline (2013), thus the absence of them in 2018 was not unexpected. Fry density in the downstream reach has also been low with one to three fry being observed in any given year during baseline and 2018. Juvenile and fry densities combined (0 to 3+) in the diversion reach were 47% lower than the baseline average, with a corresponding 62% decline in the downstream reach. Juvenile densities (1+ to 3+) in the diversion reach were 36% lower than the baseline average, with a corresponding 62% decline in the downstream reach. Overall densities of Bull Trout (all age classes combined) are only 8% lower than the baseline average in the diversion, compared to a 60% decline in the downstream reach. Densities of adult Bull Trout have also increased by 52% from average baseline in the diversion, while dropping by 55% in the downstream.

Non-operational factors between baseline and year 1 of operation may also have influenced the monitoring results and need to be considered in the assessment. Boulder Creek was subject to a forest fire in the summer of 2015 and large flood events during the fall of 2016 and 2017 between the baseline and operational monitoring period. The flood event in November 2016 particularly lead to large geomorphological changes in the diversion and downstream reach, which may have influenced fish habitat and the fish community, which was further affected by the large flood event in November 2017. The influence of these factors is unknown. However, with all age classes combined there was no evidence of a decline in Bull Trout in the diversion reach in 2018 relative to baseline. As prescribed in the OEMP, densities of Bull Trout juveniles within the diversion and control reach will continue to be compared to AATs in the remaining years of operational monitoring and additional monitoring will be initiated in the event that any exceedances occur that are deemed to be due to Boulder Creek HEF operation.

Cutthroat Trout

Cutthroat Trout were only detected in both the diversion and downstream reach in 2018 and were absent during baseline. Comparison among years will be provided in future years of monitoring.

Figure 20. Average observer efficiency adjusted densities (± standard error) of Bull Trout determined from mark re-sight snorkelling in Boulder Creek in 2011, 2012, 2013, and 2018 for: A) fry (0+), B) juveniles (1-3+), C) adults (≥4+), and D) all age classes combined.



4.3.2. Adult Migration and Distribution

4.3.2.1. Bull Trout Surveys

Habitat summaries and representative photographs of angling site in the Upper Lillooet River and Boulder Creek are presented in Appendix O. Capture results from angling surveys in Upper Lillooet River and Boulder Creek are presented in Table 46 and site-specific results and individual fish data are provided in Appendix P. Totals of 20 and 26 Bull Trout were captured in the Upper Lillooet River and Boulder Creek, respectively. Approximately 20% of the Bull Trout captured in each stream were sexually mature. Bull Trout captured in the Upper Lillooet River ranged from 178 mm to 400 mm in fork length with the largest fish captured in the diversion, while those captured in Boulder Creek ranged from 195 mm to 450 mm in fork length with the largest fish captured in the downstream reach (Table 47). For reference, Bull Trout with fork lengths greater than 370 mm have been found to have a high probability (>0.8) of undergoing seasonal migrations (Monnot *et al.* 2008) and are considered to be migratory adults. As observed during baseline studies, the presence of such large Bull Trout in both HEF streams suggests that a proportion of these fish are migratory. In addition, no barriers to migration were observed during the assessment of fish passage and upstream access conducted during angling surveys within the lower 1.7 km of Boulder Creek nor were any barriers observed in the lower diversion reach of the Upper Lillooet River. The lack of a build-up of Bull Trout below the powerhouses and detection of them in the diversion reaches of both streams further suggests that movement into the diversion reach was not inhibited by operations in 2018. However, there were shutdowns of both facilities during this time (the Boulder Creek HEF from October 1 to October 8 and the Upper Lillooet River HEF from October 1 to October 6), which influenced flows and may have allowed fish passage.

A summary of effort and fish observations during spawning surveys in Alena Creek and 29.2 km Tributary in the fall and early winter of 2018 are presented in Table 48. Surveyed distances upstream ranged from 584 m to 1,911 m in Alena Creek, and 724 m in 29.2 km Tributary. A total of three adult Bull Trout (150 mm to 270 mm estimated fork length) and one Cutthroat Trout (300 mm estimated fork length) were observed during surveys in Alena Creek in October and early November, while two Bull Trout adults (150 to 300 mm estimated fork length) and no Cutthroat Trout were observed in 29.2 km Tributary. Adult Coho Salmon spawners were much more abundant, with a total of 185 live individuals and 26 carcasses observed in Alena Creek in November, and 10 live adults, and four carcasses observed in 29.2 km Tributary in early December; as many as 42 Coho Salmon redds were also observed in Alena Creek, and one was observed in 29.2 km Tributary. The abundance of spawning Bull Trout within both tributaries were considerably lower than those observed during baseline monitoring in 2011 when nine and eight spawning Bull Trout were observed in Alena Creek and 29.2 km Tributary, respectively.

Table 46. Summary of Bull Trout capture data during angling surveys conducted in the Upper Lillooet River and Boulder Creek during the fall of 2018.

Stream	Date	Project Area	# of Sites	Effort (rod hrs)	Fish Captures[1]		CPUE (fish/hr)[1]		% Sexually Mature BT[1]
					BT	CT	BT	CT	
Upper Lillooet River	13-Sep-18	Diversion	1	1.1	1	0	0.9	0.0	0%
		Tailrace	1	1.1	1	0	0.9	0.0	0%
		Downstream	2	3.5	2	0	0.6	0.0	50%
	28-Sep-18	Diversion	2	2.7	3	1	1.1	0.4	33%
		Tailrace	1	1.1	2	0	1.8	0.0	0%
		Downstream	3	3.4	4	0	1.2	0.0	75%
	09-Oct-18	Diversion	1	1.0	2	0	2.0	0.0	0%
		Tailrace	1	1.2	1	0	0.9	0.0	0%
		Downstream	3	3.6	4	0	1.1	0.0	25%
	10-Oct-18	Diversion	1	1.2	0	0	0.0	0.0	n/a
2018 Total:		**Diversion**	**5**	**6.0**	**6**	**1**	**1.0**	**0.2**	**17%**
		Tailrace	**3**	**3.4**	**4**	**0**	**1.2**	**0.0**	**0%**
		Downstream	**8**	**10.4**	**10**	**0**	**1.0**	**0.0**	**50%**
Boulder Creek	14-Sep-18	Diversion	3	3.7	3	0	0.8	0.0	0%
		Tailrace	1	1.7	4	0	2.4	0.0	50%
		Downstream	4	4.5	7	0	1.6	0.0	29%
	27-Sep-18	Diversion	4	4.3	1	0	0.2	0.0	0%
		Tailrace	1	1.0	1	0	1.0	0.0	0%
		Downstream	4	4.8	7	0	1.5	0.0	86%
	10-Oct-18	Diversion	4	5.3	0	0	0.0	0.0	n/a
		Tailrace	1	1.3	1	0	0.8	0.0	0%
		Downstream	4	5.1	2	0	0.4	0.0	0%
2018 Total:		**Diversion**	**11**	**13.3**	**4**	**0**	**0.3**	**0.0**	**0%**
		Tailrace	**3**	**4.0**	**6**	**0**	**1.5**	**0.0**	**33%**
		Downstream	**12**	**14.4**	**16**	**0**	**1.1**	**0.0**	**50%**

[1] BT = Bull Trout, CT = Cutthroat Trout. Only one immature male adult Cutthroat Trout was captured.

Table 47. Summary of fork length, weight, and condition factor for Bull trout captured during angling surveys in the Upper Lillooet River and Boulder Creek in the fall of 2018.

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	6	266	194	400	6	231	76	630	6	1.06	0.98	1.13
	Tailrace	4	237	184	283	4	152	86.1	228	4	1.13	1.01	1.38
	Downstream	10	235	178	285	10	140	58	220	10	1.02	0.94	1.08
	Total:	**26**	**276**	**195**	**450**	**25**	**264**	**83**	**1,055**	**25**	**1.05**	**0.94**	**1.20**
Boulder Creek	Diversion	4	233	195	290	4	147	87	260	4	1.10	1.07	1.17
	Tailrace	6	260	206	312	5	222	96	308	5	1.08	1.00	1.20
	Downstream	16	294	196	450	16	306	83	1055	16	1.03	0.94	1.16
	Total:	**20**	**245**	**178**	**400**	**20**	**170**	**58**	**630**	**20**	**1.05**	**0.94**	**1.38**

Table 48. Summary of results from spawning surveys conducted in Alena Creek and 29.2 km Tributary in the fall of 2018.

Stream	Date	Survey Time (hrs)	Survey Distance (m)	Number Observed[1]								
				Live Adults			Adult Carcasses			Redds		
				BT	CT	CO	BT	CT	CO	BT	CT	CO
Alena Creek	14-Sep-18	1.5	1,631	0	0	0	0	0	0	0	0	0
	11-Oct-18	4.1	1,719	2	0	0	0	0	0	0	0	0
	05-Nov-18	2.7	1,703	1	1	126	0	0	4	0	0	41
	15-Nov-18	2.4	1,911	0	0	49	0	0	18	0	0	42
	05-Dec-18	1.9	584	0	0	10	0	0	4	0	0	12
	Total:	**12.5**	**7,547**	**3**	**1**	**185**	**0**	**0**	**26**	**0**	**0**	**95**
29.2 km Tributary	13-Sep-18	1.3	724	0	0	0	0	0	0	0	0	0
	28-Sep-18	0.8	724	0	0	0	0	0	0	0	0	0
	09-Oct-18	0.8	724	2	0	0	0	0	0	0	0	1
	Total:	**2.8**	**2,172**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

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

4.3.2.2. Cutthroat Trout Tributary Access

The operational daily average flow in the Upper Lillooet River diversion reach on the day of June tributary assessments was 41.5 m³/s. Of the three assessed tributaries of the Upper Lillooet River diversion reach (ULL-83.2 km, ULL-83.6 km, and ULL-83.7 km), only ULL-83.2 km was deemed to be accessible to Cutthroat Trout for an appreciable distance at these flows similar to baseline conditions, with approximately 155 m of accessible habitat in which two Cutthroat Trout juveniles were observed during the assessment. In contrast, only 2 m of ULL-83.7 km were easily accessible, though one Cutthroat Trout juvenile was observed in this length of stream during the assessment. Similarly, there is a cascade obstacle within a meter of the confluence of ULL-83.6 km and the Upper Lillooet River that restricts fish passage at the operational flows recorded on the day of the assessment (Figure 21).

Open-site electrofishing was conducted on October 18, 2018 to assess if Cutthroat Trout spawned in these three tributaries. Fish captures, sampling conditions, and effort for open-site electrofishing surveys are presented in Table 49. Sampled areas ranged from 60 m² to 110 m², with a total sampled area in all three tributaries of 275 m² for a combined effort of 1,843 electrofishing seconds. A total of 27 juvenile Cutthroat Trout and eight Bull Trout were captured.

The majority of juvenile Cutthroat Trout were captured in the most downstream tributary (ULL-83.2 km), while no fish were captured or observed in ULL-83.6 km, and all eight Bull Trout were captured in ULL-83.7 km. Most of the juvenile Cutthroat Trout were aged 1+ (10 fish between 84 mm and 103 mm fork length) or 2+ (12 fish between 111 mm and 163 mm fork length) juveniles. Five Cutthroat

Trout fry were also observed (≤ 74 mm fork length), four of which were captured in ULL-83.2 km and one of which was captured in ULL-83.7 km. The average fork length of all Cutthroat Trout was 101 mm (Table 50). All captured Bull Trout were fry with fork lengths ranging from 64 mm to 73 mm.

Results from 2018 were similar to those from baseline surveys during which similar limitations to fish access were observed and Cutthroat Trout were only being observed in ULL-83.2 km and ULL-83.7 km. These results indicate that Cutthroat Trout spawning in 2018 occurred in the same tributaries as during baseline years (Harwood *et al.* 2016).

Figure 21. Obstacle to fish passage in the tributary at km 83.6 at daily average Upper Lillooet River flows of 41.5 m³/s on June 18, 2018.

Table 49. Summary of electrofishing effort and fish captures in three tributaries of the lower diversion of the Upper Lillooet River on October 18, 2018.

Tributary Site	Date	Water Temp. (°C)	Est. Visibility (m)	Conductivity (µS/cm)	Sampled Area (m²)	Electrofishing Effort (sec)	Captures (# of fish)[1]			Density (fish/m^2)[1]			CPUE (fish/min)[1]		
							BT	**CT**	**Total**	**BT**	**CT**	**Total**	**BT**	**CT**	**Total**
ULL-DVTB83.2km	18-Oct-18	7.6	2	90	105	357	0	22	22	0.00	0.21	0.21	0.00	3.70	3.70
ULL-DVTB83.6km	18-Oct-18	7.5	2	90	60	602	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
ULL-DVTB83.7km	18-Oct-18	6.4	2	60	110	884	8	5	13	0.07	0.05	0.12	0.54	0.34	0.88
Grand Total:					**275**	**1,843**	**8**	**27**	**35**	**0.03**	**0.10**	**0.13**	**0.26**	**0.88**	**1.14**

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

Table 50. Summary of fish metrics for Cutthroat Trout captured in three tributaries of the lower diversion of the Upper Lillooet River on October 18, 2018.

Tributary Site	Fork Length (mm)				Weight (g)				Condition Factor (k)			
	n	**Average**	**Min**	**Max**	**n**	**Average**	**Min**	**Max**	**n**	**Average**	**Min**	**Max**
ULL-DVTB83.2km	22	102	39	163	22	13.4	0.4	43.3	22	1.0	0.7	1.2
ULL-DVTB83.6km	0	n/a	n/a	n/a	0	n/a	n/a	n/a	0	n/a	n/a	n/a
ULL-DVTB83.7km	5	98	49	143	5	12.5	1.2	27.9	5	1.1	0.8	1.3
Grand Total	**27**	**101**	**39**	**163**	**27**	**13.2**	**0.4**	**43.3**	**27**	**1.0**	**0.7**	**1.3**

4.3.3. Assessment of Entrainment at the Upper Lillooet River Intake

4.3.3.1. Closed-Site Electrofishing in Tributary

Closed-site electrofishing was completed within the unnamed tributary at 87.0 km on the Upper Lillooet River (87.0 km Tributary) on October 24 and 25, 2018. A total area of 448 m^2 was surveyed and the total electrofishing effort for all sites combined was 7,504 seconds (Table 51 and Table 52). Numbers of captured fish ranged from 21 to 39 Cutthroat Trout per site, and a total of 98 individuals were captured at all sites combined (Table 52). No other species were captured during sampling, which is consistent with the known fish distribution upstream of Keyhole Falls, where only Cutthroat Trout have been detected.

Table 51. Summary of closed-site electrofishing site characteristics and conditions during sampling in 87.0 km Tributary in 2018.

Site	Sampling Date	Conductivity (µS/cm)	Water Temp. (^oC)	Turbidity	Sampling Length (m)	Sampling Area (m^2)
ULL-HPTB87EF01	16-Oct-18	60	3.4	Clear	40	116
ULL-HPTB87EF02	17-Oct-18	60	3.7	Clear	43	136
ULL-HPTB87EF03	17-Oct-18	50	5.5	Clear	54	195
Tributary Total:					**137**	**448**

Table 52. Summary of closed-site electrofishing effort and fish captures in 87.0 km Tributary in 2018.

	Sampling Date	Total Electrofishing Effort (sec)				Electrofishing Catch (# of fish)			
		Pass 1	Pass 2	Pass 3	Total	Pass 1	Pass 2	Pass 3	Total
ULL-HPTB87EF01	16-Oct-18	1,032	809	603	2,444	29	5	4	38
ULL-HPTB87EF02	17-Oct-18	1,103	808	614	2,525	16	3	2	21
ULL-HPTB87EF03	17-Oct-18	1,095	810	630	2,535	30	8	1	39
Tributary Total:		**3,230**	**2,427**	**1,847**	**7,504**	**75**	**16**	**7**	**98**

4.3.3.2. Age Analysis

The length-frequency distribution, length-weight relationship, and length at age relationship of Cutthroat Trout captured during closed-site electrofishing surveys in 87.0 km Tributary in 2018, as well as data on individual captured fish (including length, weight, and marks/tags applied) are provided in Appendix L. Based on a review of aging data and length-frequency distributions, discrete fork length ranges were defined for age classes fry (0+), juveniles (1-2+), and adults (≥3+) of Cutthroat Trout (Table 53).

Table 53. Fork length range used to define age classes of Cutthroat Trout captured in 87.0 km Tributary in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	31 - 38
Juvenile (1-2+)	56 - 135
Adult (≥3+)	≥138

4.3.3.3. Fish Metrics and Condition

Fork length, weight, and condition factor for all captured Cutthroat Trout are summarized by age class in Table 54. Weights were assigned to all fish not weighed in the field from the established length-weight relationships (Appendix L).

Table 54. Summary of fork length, weight and condition of Cutthroat Trout captured in 87.0 km Tributary in 2018.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	7	34	31	38	7	0.4	0.4	0.6	7	1.14	0.93	1.34
Juvenile (1-2+)	62	92	57	135	62	10.5	2.2	28.1	62	1.12	0.89	1.30
Adult (≥3+)	28	159	138	206	28	46.1	25.5	106.0	28	1.09	0.90	1.21
All	**97**	**95**	**31**	**206**	**97**	**19.0**	**0.4**	**106.0**	**97**	**1.12**	**0.91**	**1.34**

4.3.3.4. Density and Biomass Estimates

Observed and habitat-adjusted density and biomass estimates of Cutthroat Trout determined from closed-site electrofishing in 87.0 km Tributary are summarized by age class in Table 56. Observed fish densities (FPUobs; #/100 m²) and biomass (BPUobs; g/100 m²) are the focus of the results below, with habitat adjusted values (FPUadj and BPUadj) provided in tables for reference. Observed densities and biomass of Cutthroat Trout are compared by age class in Figure 22. Fry and juveniles had the lowest and highest observed densities among age classes, respectively (Table 56). Although densities of adults were lower than those of juveniles, adults had the highest biomass among age classes given their greater size.

Table 55. Density and biomass of Cutthroat Trout determined from closed-site electrofishing in 87.0 km Tributary in 2018.

A) Fry (0+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	65.6%	1.7	0.7	2.6	1.0
ULL-HPTB87.0EF02	80.4%	3.7	1.6	4.6	2.0
ULL-HPTB87.0EF03	75.4%	0.0	0.0	0.0	0.0

B) Parr (1-2+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	21.6%	24.1	254.2	111.6	1,179.1
ULL-HPTB87.0EF02	24.9%	8.8	138.7	35.4	557.5
ULL-HPTB87.0EF03	33.5%	11.8	86.3	35.1	257.5

C) Adult (≥3+)

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	21.6%	6.9	209.6	31.9	972.27
ULL-HPTB87.0EF02	24.9%	2.9	107.5	11.8	432.15
ULL-HPTB87.0EF03	33.5%	8.2	460.6	24.4	1,373.57

D) All

Site	Usability (%)	Observed Densities[1,2]		Adjusted Densities[3,4]	
		FPU_{obs} (#/100 m^2)	BPU_{obs} (g/100 m^2)	FPU_{adj} (#/100 m^2)	BPU_{adj} (g/100 m^2)
ULL-HPTB87.0EF01	21.6%	32.6	464.5	146.1	2,152.4
ULL-HPTB87.0EF02	24.9%	15.4	247.7	51.8	991.7
ULL-HPTB87.0EF03	33.5%	20.0	546.9	59.5	1,631.0

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

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

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

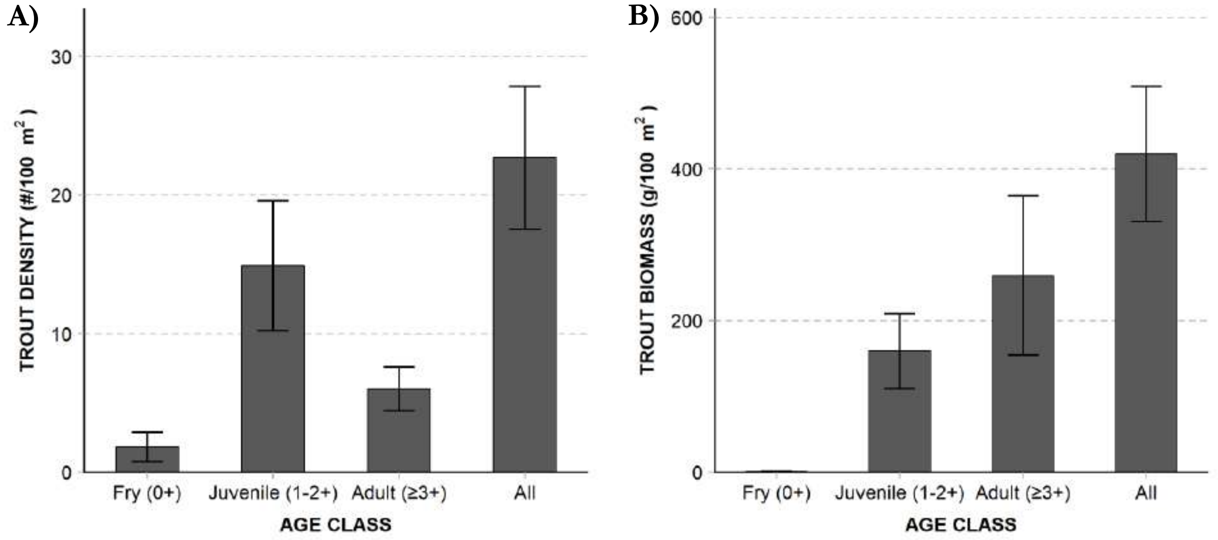
[4] $BPU_{adj} = BPU_{obs}/Usability$ (%)

Table 56. Observed and habitat suitability adjusted average Cutthroat Trout densities and biomass by age class determined from closed-site electrofishing in 87.0 km Tributary in 2018.

Age Class	FPUobs (#/100 m^2)[1]		BPUobs (g/100 m^2)[1]		FPUadj (#/100 m^2)[1]		BPUadj (g/100 m^2)[1]	
	Average	SE	Average	SE	Average	SE	Average	SE
Fry (0+)	1.8	1.1	0.8	0.5	2.4	1.3	1.0	0.6
Juvenile (1-2+)	14.9	4.7	159.7	49.6	60.7	25.4	664.7	271.4
Adult (3+)	6.0	1.6	259.2	104.9	22.7	5.9	926.0	272.7
All	22.7	5.2	419.7	89.2	85.8	30.2	1,591.7	335.6

[1] SE = Standard Error.

Figure 22. Observed densities by age class of Cutthroat Trout 87.0 km Tributary determined from closed-site electrofishing presented as: A) fish density per 100 m^2 (FPUobs), and B) fish biomass per 100 m^2 (BPUobs).



4.3.3.5. Comparison Among Years

Observed densities and biomass of Cutthroat Trout by age class and between years are compared in Figure 23 and Figure 24, respectfully. Densities and biomass of Cutthroat Trout in the tributary were lower in 2018 than in 2013 (16% and 34%, respectively) for all age classes combined (Figure 23; Figure 24,). This trend between years was consistent for all age classes except parr which had densities and biomass in 2018 that were higher than those observed in 2013 (77% and 102% higher, respectively). This trend will be examined further in future years.

Densities and biomass of Cutthroat Trout within the upper and lower clusters of Upper Lillooet River upstream sites varied considerably by age class among years. Results from these Upper Lillooet River upstream sites are presented combined in Section 4.3.1.1. Fry were observed within the lower cluster in 2012 and in the upper cluster in 2014, juveniles were absent from the lower cluster in 2014 only and were observed in the upper in 2014 and 2018, and adults were absent from both clusters in 2014, from the lower cluster in 2018, and from the upper cluster in 2010 and 2012 (Figure 25 and Figure 26). Overall, considering all age classes together, in 2018, Cutthroat Trout densities and biomass in the lower cluster of five upstream sites were slightly lower than those observed in 2010 and 2012, but were higher than those observed in 2014 when no Cutthroat were detected in these five sites. In 2018, overall Cutthroat Trout densities and biomass in the upper cluster of five upstream sites were higher than in 2014. The lack of Cutthroat Trout detections in the lower cluster in 2014 makes it difficult to distinguish trends between the two areas of the upstream reach, and between baseline years and year one of operation, but overall, there is no evidence of a decline in the lower cluster of sites in the upstream reach or in the tributary. However, future years of operational monitoring are required to evaluate the consistency of these patterns.

Figure 23. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in 87.0 km Tributary in 2013 and 2018 presented by age class for: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined.

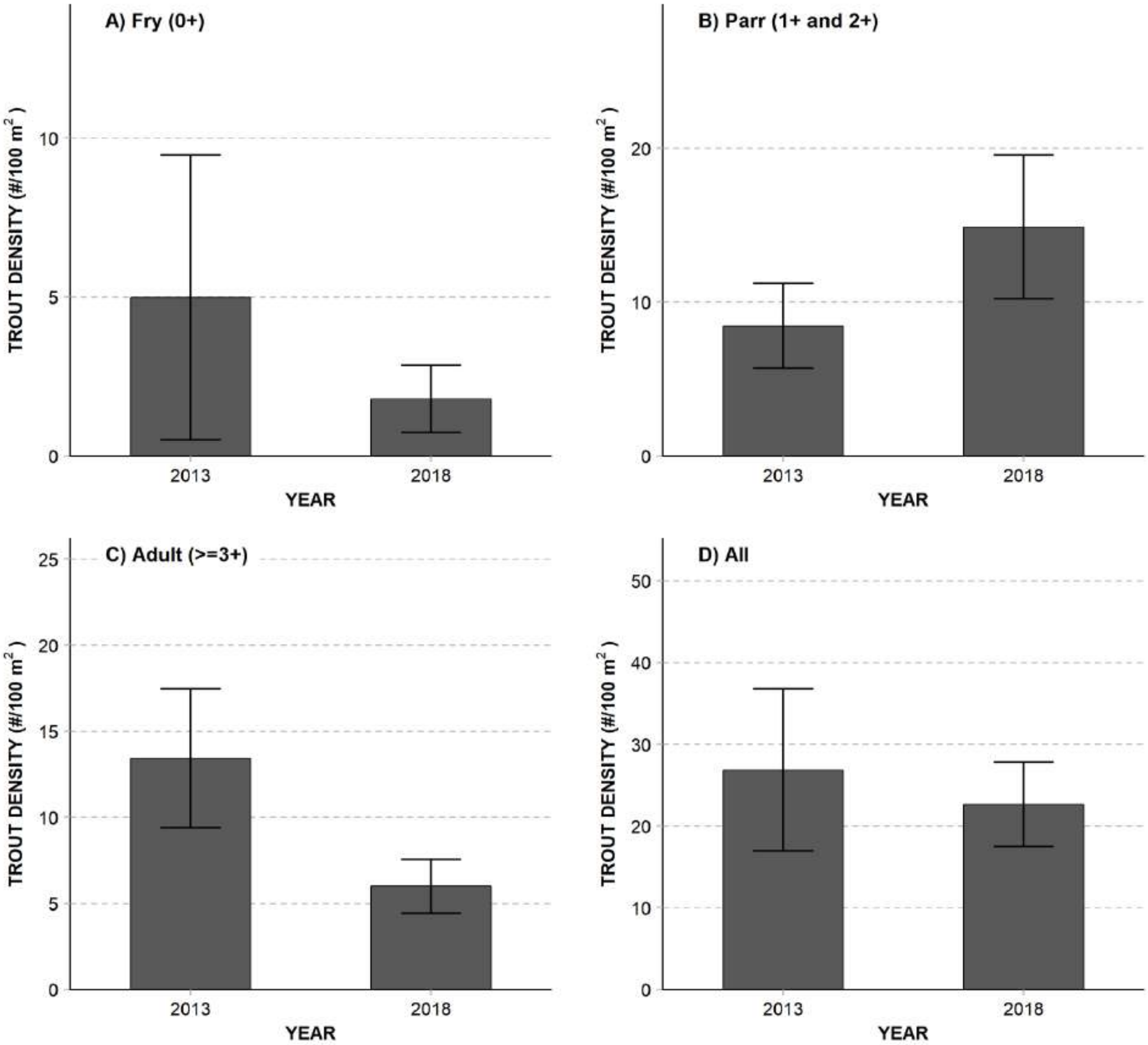


Figure 24. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in 87.0 km Tributary in 2013 and 2018 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined.

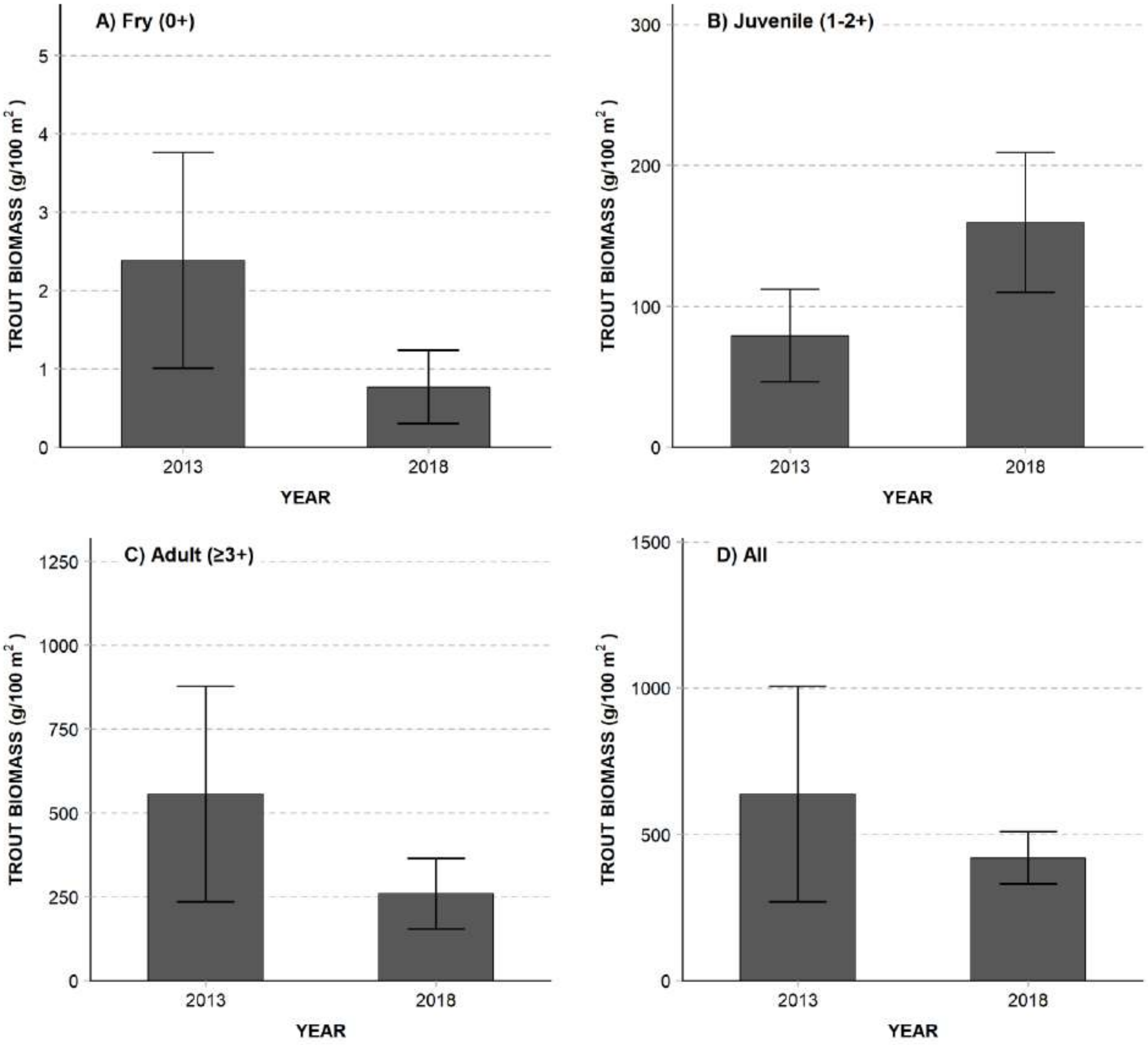


Figure 25. Average observed Cutthroat Trout density (FPUobs; ± standard error) determined from closed-site electrofishing in the upper and lower clusters of upstream sites in 2010, 2012, 2014, and 2018 presented by age class for: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined. Note that the upper cluster of sites was not added until 2014.

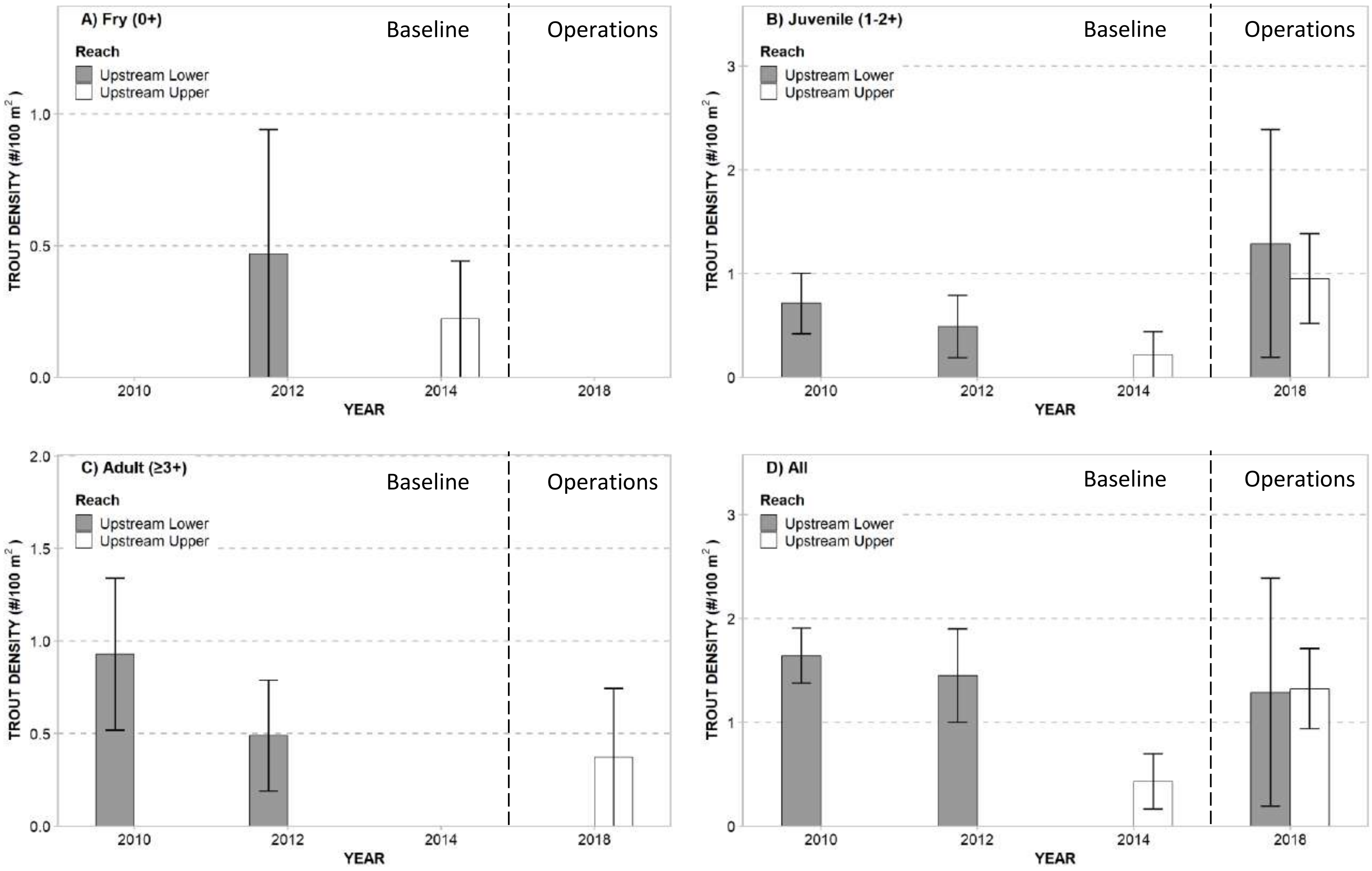
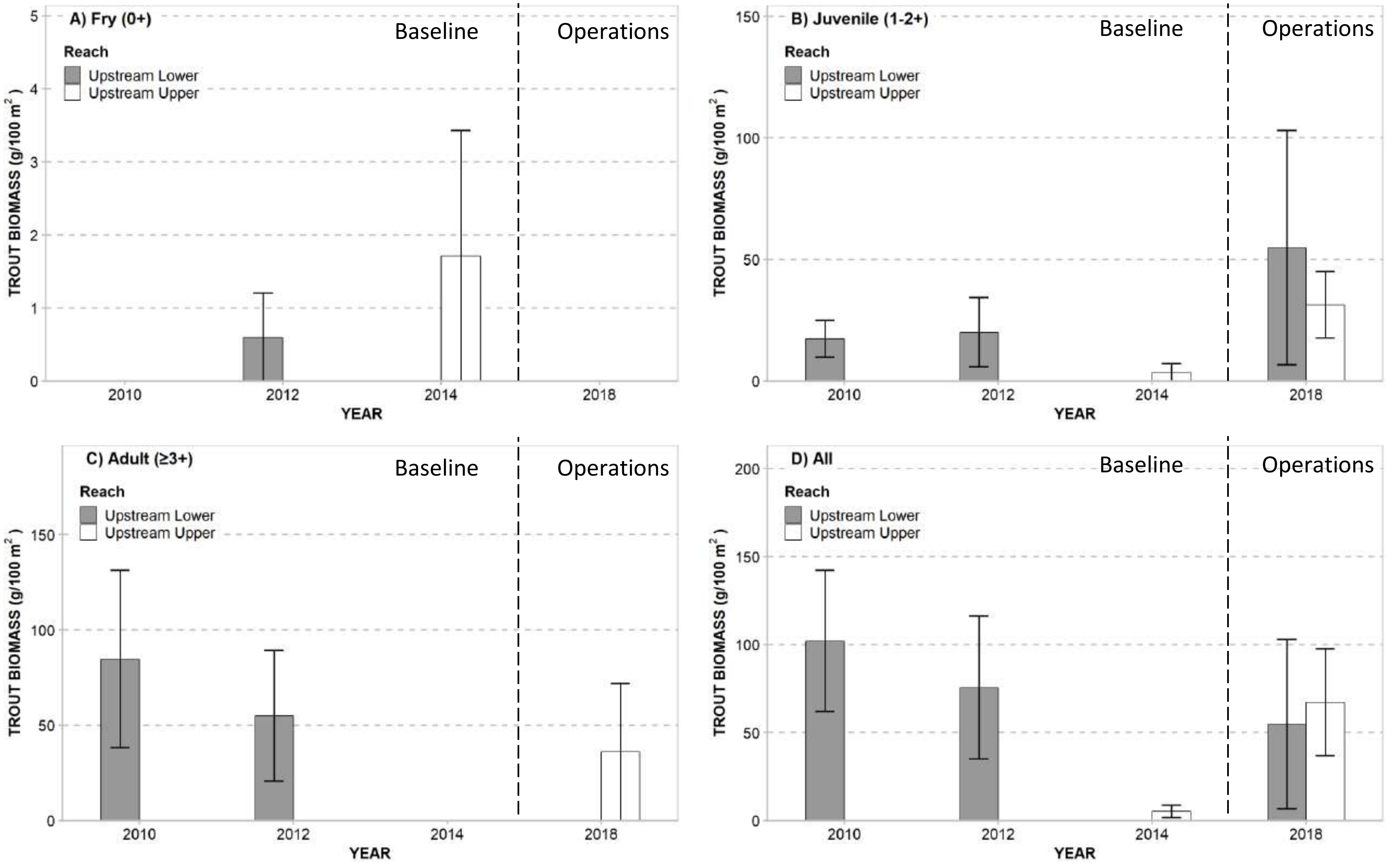


Figure 26. Average observed Cutthroat Trout biomass (BPUobs; ± standard error) determined from closed-site electrofishing in the upper and lower clusters of upstream sites in 2010, 2012, 2014, and 2018 presented by age class: A) fry (0+); B) juveniles (1-2+); C) adults (≥3+); and D) all age classes combined. Note that the upper cluster of sites was not added until 2014.



4.4. Water Quality Monitoring

In-situ and laboratory water quality sampling for the Upper Lillooet River HEF was completed at four sites: upstream of the intake (ULL-USWQ02, ULL-USWQ03), in the diversion (ULL-DVWQ01) at the tailrace (ULL-TAILWQ; *in-situ* only) and downstream of the tailrace (ULL-DSWQ). In the first year of operations, sampling was conducted near the beginning (March 28, 2018, March 29, 2018) and end of the growing season (November 1, 2018). The baseline (2010 to 2012) and operational (2018) water quality sampling results are summarized in Appendix G. Applicable BC WQG (MOE 2018) for the protection of aquatic life and typical freshwater ranges for pH, TSS, turbidity, dissolved oxygen and TGP are also provided in Appendix G for reference. Data ranges measured during baseline and operational Year 1 sampling were compiled and screened against applicable BC WQG (Table 57).

The QA/QC objectives were met in most cases in 2018 (Appendix G). One field blank, one travel blank and one set of triplicate samples were collected during each sampling period resulting in 57% (4/7) QA/QC samples which exceeds the QA/QC objective of 20 to 30% (Section 3.4.1).

In-situ water quality meter malfunction occurred on March 28 and March 29, 2018, therefore *in-situ* data were not recorded for pH, specific conductivity, and dissolved oxygen (Appendix G). pH and specific conductivity were successfully measured in the lab for these dates, providing the necessary parameter values for comparison to the baseline data range. TGP (% saturation, mm Hg) and ΔP (mm Hg) were also successfully measured *in-situ* in March 2018. TGP ranged from 102 % to 103 % indicating slight supersaturation of the water with dissolved gases (i.e., >100%). These results suggest that dissolved oxygen would also exhibit well saturated conditions. All parameters were successfully measured *in-situ* and via lab analysis in November 2018.

There were no hold time exceedances for the March 2018 sampling and one hold time exceedance on November 1, 2018 for turbidity (Appendix G). The actual hold time was 4 days, exceeding the recommended hold time of 3 days. These results were reviewed and no substantial effect on data quality is expected. Field blank and travel blank results indicate samples were not contaminated; all results were non-detectable for all the parameters measured, with the exception of pH as expected.

Precision between triplicates met the QA/QC objective (RSD <18%) with the exception of ΔP where the RSD was 39% (triplicate values were 5 mm Hg, 3 mm Hg and 7 mm Hg). Data were reviewed and it was concluded that this level of variability is likely naturally occurring and is not expected to affect data quality. Data were screened against the applicable BC WQG and any exceedances highlighted in the data summary tables (Appendix G).

The range in parameter values during baseline sampling (2010 to 2012) and during operational sampling in 2018 are provided in Table 57, along with applicable BC WQG. The baseline and operational data are within typical ranges observed in BC and do not exceed BC WQG; the range in values observed under operational conditions is also similar to that observed under baseline conditions. Each key parameter is discussed briefly below and the data summaries are provided in Appendix G.

pH values in the project area are ~7 to 8, and the pH measured in 2018 was within the range observed under baseline conditions (Table 57), and within the typical range for BC freshwater streams and watercourses. Natural fresh waters have a pH range from 4 to 10, lakes tend to have a pH ≥ 7.0 and coastal streams commonly have pH values of 5.5 to 6.5 (RISC 1998).

Coastal British Columbia streams are reported to generally have a specific conductivity of ~100 µS/cm (RISC 1998), similar to what is observed in the Project area under both baseline (43 µS/cm to 166 µS/cm) and operational (102 µS/cm to 166 µS/cm) monitoring (Table 57).

The buffering function of alkalinity is important in streams as abrupt changes in pH can negatively impact aquatic life. Alkalinity measurements taken in the Upper Lillooet River indicate a low to moderate sensitivity to acidic inputs (RISC 1998) under both baseline (14 mg/L to 45 mg/L as $CaCO_3$) and operational (26.7 mg/L to 44.5 mg/L as $CaCO_3$) monitoring (Table 57).

For both turbidity and TSS, natural values in BC vary extensively from one waterbody to another and can have large variation within a day and among seasons. The range in these parameters measured during Project operation is effectively within the range measured during the baseline sampling, with only turbidity being measured at a marginally lower value in operations (1.52 NTU) compared to baseline (1.59 NTU) (Table 57).

In BC, surface waters generally have dissolved oxygen concentrations greater than 10 mg/L (RISC 1998), which is consistent with the baseline (11.58 mg/L to 14.62 mg/L) and operational (11.40 mg/L to 11.62 mg/L) data. Dissolved gas supersaturation is a natural feature of many BC watercourses with ΔP commonly being between 50 to 80 mm Hg (Fidler and Miller 1994). ΔP during operations fell within the baseline range (Table 57), and no evidence of excessive gas entrainment during power generation through the Francis turbines was detected at the tailrace site (Table 58). Values at (ULL-TAILWQ) were slightly less than those measured in the lower diversion site (ULL-DVWQ) on both sample dates (Table 58).

Table 57. Range in baseline (2010 to 2012) and operational (2018) water quality parameters and comparison to BC WQG.

Parameter	Units	Baseline (2010-2012)		Operational (2018)		BC WQG[1] Short Term Maximum
		Min.	Max.	Min.	Max.	
pH (lab)	pH units	7.23	8.06	7.57	7.92	<6.5 (no decrease in pH from background)
pH (*in-situ*)	pH units	5.38	8.28	6.56	8.00	
Specific conductivity	µS/cm	43.0	166.0	102.0	166.0	-
Alkalinity (as $CaCO_3$)	mg/L	14.0	45.0	26.7	44.5	-
Total dissolved solids (TDS)	mg/L	-	-	78	112	-
Total suspended solids (TSS)	mg/L	3.1	66.0	3.5	8.3	EQ
Turbidity	NTU	1.59	69.60	1.52	9.39	EQ
Dissolved oxygen	mg/L	11.58	14.62	11.40	11.62	Minimum: 6 mg/L; Minimum 9 mg/L for buried life
Δ Pressure (TGP)	mm Hg	-7	23	3	20	shallow water: ΔP<24 deep water: ΔP<76

[1] BC Water Quality Guidelines for the Protection of Aquatic Life (MOE 2018). EQ indicates that an equation is used to calculate the BC WQG. In the case of TSS and turbidity the BC WQG is based on background conditions at the time of sampling.

Grey shading indicates BC WQG have been exceeded.

Table 58. TGP (%) and ΔP (mm Hg) measured during Project operation in 2018.

Year	Date	Site	TGP (%)				Δ P (mm Hg)			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2018	28-Mar	ULL-USWQ02	103	102	103	2	17	16	18	1
	29-Mar	ULL-DVWQ01	103	103	103	0	18	18	18	0
		ULL-TAILWQ	102	102	102	0	15	14	16	1
		ULL-DSWQ	102	102	102	0	16	15	16	1
	01-Nov	ULL-USWQ03	101	101	102	1	9	7	10	2
		ULL-DVWQ01	103	102	103	1	19	17	20	2
		ULL-TAILWQ	102	102	102	0	15	13	17	2
		ULL-DSWQ	101	100	101	1	5	3	7	2

[1] Average of three replicate measurements (n=3), unless otherwise indicated.

4.5. Wildlife Species Monitoring

4.5.1. Harlequin Ducks

In 2018, Harlequin Ducks were observed in the ULR HEF headpond during targeted spot check surveys and incidentally. No Harlequin Ducks were observed in the vicinity of the ULR HEF powerhouse.

Harlequin Ducks were observed during spot checks in Year 1 monitoring only during the pair survey conducted on May 3. Two adult females were observed feeding in the headpond from the intake vantage point on this date (Table 59, Figure 27, Map 11). No Harlequin Ducks were seen during the brood surveys in August or from the powerhouse vantage point during any survey. Three other species of waterfowl were also recorded in the headpond on the May 3 survey (American Wigeon (*Mareca Americana*), Barrow's Goldeneye (*Bucephala islandica*) and Mallard (*Anas platyrhynchos*)) and a Spotted Sandpiper (*Actitis macularius*) was seen on the shore of the headpond on May 31 (Table 59).

Harlequin Ducks were incidentally observed outside of scheduled pair and brood surveys on two occasions (Table 60). A pair of Harlequin Ducks was observed feeding in the ULR HEF headpond on April 20, 2018 and Project operators observed two female[2] Harlequin Ducks in the ULR HEF headpond on September 16, 2018 (Figure 28). No Harlequin Ducks were seen at the powerhouse or intake on June 14, while Ecofish crews were on site for the ULL Quick Flush; however, this was during the incubation period for Harlequin Ducks when detections are unlikely.

Observations in the headpond of a Harlequin Duck pair in April, two female Harlequin Ducks in May, and two female[2] Harlequin Ducks in September indicate that Harlequin Ducks are still visiting the Project area. The adult male Harlequin Duck incidentally observed with the female in April was the only adult male Harlequin Duck observed during monitoring; thus, it is possible that this pair was passing through the area to breed at a different location. No males were seen with the two females observed during the pair survey in May, and although it is possible that males were present but were not observed, this is unlikely because males are brightly coloured and more visible than females. Lack of detections during the brood surveys supports evidence of lack of breeding in the Project area vicinity. However, it is also possible that, given the small number of surveys and the possibility that pairs were missed, breeding occurred but females and broods were missed (females and juveniles are cryptic and can be difficult to spot) or that breeding failed and females left the area prior to the brood surveys. The two "female" Harlequin Ducks incidentally observed on September 16 could have been two adult females, two juveniles, or an adult female with a juvenile, as it is difficult to distinguish adult females from juveniles at the end of the breeding season. Given the late date of the observation, if juveniles were in the group they would have been flight-capable, and it is therefore possible that the two individuals were passing through the Project area on their way to the coast. Thus, evidence of potential breeding in the vicinity of the ULR HEF headpond is inconclusive.

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[2] At the end of the breeding season it is difficult to distinguish adult females from juveniles of either sex.

Most observations of Harlequin Ducks in the Project area during baseline studies were in the vicinity of the Upper Lillooet River HEF and habitat quality was classified as high from the Upper Lillooet River HEF intake to approximately 8 km upstream into the Upper Lillooet Provincial Park (Lacroix *et al.* 2011a). Baseline Harlequin Duck observations comparable to observations from monitoring spot checks included two pairs (four birds) documented within the (then proposed) headpond location on May 19 in 2011 and one female adjacent to the powerhouse location in June 2009. Thus, overall counts, as well as numbers of pairs, from the pair (May) and brood (August) surveys during the first monitoring year are reduced at these two locations relative to what was observed prior to Project construction. However, given small sample size (one year of post-construction data from three pair and three brood surveys), results from additional monitoring years will be needed to evaluate Harlequin Duck use of the intake and powerhouse areas for breeding. No attempts are being made to assess use of the river upstream of the headpond (where habitat quality for Harlequin Ducks was also documented to be high and numerous individuals were seen during baseline studies) or within the diversion reach (where habitat quality was reduced relative to upstream areas and Harlequin Ducks have not been seen; Lacroix *et al.* 2011a), and monitoring results thus pertain only to the areas within the vicinity of the ULR HEF intake and powerhouse.

Figure 27. Two adult female Harlequin Ducks observed with other waterfowl in the ULR HEF headpond on May 3, 2018.

Figure 28. Two Harlequin Ducks observed in the ULR HEF headpond on September 16, 2018.

Table 59. Results of Harlequin Duck spot check surveys at the ULR HEF intake and powerhouse in 2018.

Survey Type	Date	Infrastructure	Spot Check Vantage Point UTM Coordinates (Zone 10U)		Harlequin Ducks Observed	Observation Location	Other Waterbirds Observed
			Easting	Northing			
pair	3-May-2018	intake	466156	5614170	2 adult females	headpond	American Wigeon - 3 adult females, 1 adult male Barrow's Goldeneye - 3 adult females, 2 adult males Mallard - 1 adult female, 3 adult males
		powerhouse	468416	5611634	0	-	-
	17-May-2018	intake	466105	5614110	0	-	-
		powerhouse	468416	5611634	0	-	-
	31-May-2018	intake	466105	5614110	0	-	Spotted Sandpiper - 2 adults
		powerhouse	468416	5611634	0	-	-
brood	9-Aug-2018	intake[1]	-	-	0	-	-
		powerhouse	468416	5611634	0	-	-
	16-Aug-2018	intake	466105	5614110	0	-	-
		powerhouse	468416	5611634	0	-	-
	23-Aug-2018	intake	466105	5614110	0	-	-
		powerhouse	468416	5611634	0	-	-

[1] Surveys conducted with zoomable surveillance cameras from inside the powerhouse due to high landslide risk at the intake site.

Table 60. Incidental observations of Harlequin Ducks in the Project area in 2018.

Location	Date	UTM Coordinates (Zone 10U)		Harlequin Ducks observed
		Easting	Northing	
ULR HEF headpond	20-Apr-2018	466023	5614192	1 male and 1 female (pair)
ULR HEF headpond	16-Sep-2018	466035	5614167	2 females[1]

[1] At the end of the breeding season it is difficult to distinguish adult females from juveniles of either sex.

4.5.2. Species at Risk & Regional Concern

A total of ten mammal, three amphibian, and eight avian species were incidentally observed and recorded by Ecofish personnel and Project operators in the Project area in 2018 (Appendix R, Table 61, Map 4). Incidental observations of species at risk and of regional concern in 2018 included those of Grizzly Bears, Moose, Mountain Goats, Mule Deer, Wolverines (*Gulo gulo luscus*), Bald Eagles (*Haliaeetus leucocephalus*), Harlequin Ducks, Coastal Tailed Frogs, and Western Toads (*Anaxyrus boreas*). In order to reduce the potential for human-wildlife conflict, observations in 2018 of Grizzly Bears and Moose in particular, specifically Moose along the Lillooet River FSR, should be given special consideration by Project operations. Observations of species not at risk or of regional concern are also summarized in Table 61.

Grizzly Bears and American Black Bears

Grizzly Bears (provincially blue-listed and federally listed as Special Concern (CDC 2019)), were recorded incidentally near Truckwash Creek on two occasions. Grizzly Bear tracks were observed near the Truckwash Creek bridge on April 9, 2018 (Figure 29), and on September 15, 2018, a Grizzly Bear was observed by Innergex personnel feeding on honey being produced in commercial beehives that had been placed at this location. Commercial honey bee hives (10 hives total) were situated in four locations near Project infrastructure in 2018; four hives on the Boulder Creek HEF access road and six hives along the Lillooet River FSR (two at the hairpin turn near Truckwash Creek, one at 44.2 km and three near Boulder Creek). Innergex has requested that the honey bee hive owners not place the hives near Project infrastructure to reduce the potential for human-wildlife interactions where Project operators and environmental field technicians commonly work (Mancinelli, pers. comm. 2018).

American Black Bears (*Ursus americanus*) were observed three times and tracks were documented seven times within the Project area in 2018. All three sightings were on June 27, 2018 along the Lillooet River FSR; one crossing the road at the bridge over Boulder Creek, one crossing the road at the 20.5

km mark, and one (likely the same bear) under the transmission line near the 20.5 km mark a few hours later. American Black Bear tracks were documented in six locations along Alena Creek (four on November 15, 2018 and two on December 5, 2018). Tracks were also observed on the south side of the Lillooet River transmission line crossing on May 23, 2018. Bear scat (unknown species) was observed on April 30, 2018 at the access road to the Boulder Creek HEF intake.

Moose

There were ten incidental observations of Moose recorded by Ecofish and Innergex personnel within the Project area in 2018. Moose were observed along the Lillooet River FSR on three occasions: three adults and three juveniles between km 12 and 13 on April 9; a lone Moose at km 14 on October 12, 2018; and a female and calf at km 37 on November 22. Moose sign (i.e., scat or tracks) were observed: at the Lillooet River transmission line crossing on May 23, 2018 (Figure 30); along the Boulder Creek HEF intake access road on April 30; and along Alena Creek on November 15 and December 5, 2018.

Mountain Goat

Mountain Goats (provincially Blue-listed (CDC 2019)) were incidentally observed in the Project area on three occasions. A herd of at least eight Mountain Goats of varying age and sex were observed feeding [redacted] Sensitive location and timing information has been removed to protect this species. On [redacted] tracks were documented near the [redacted] (Figure 31). The incidental observations of Mountain Goats [redacted] are discussed further with the snow tracking survey and wildlife camera results under Section 4.6.2.2.

Mule Deer

No incidental sightings of Mule Deer were documented in the Project area during 2018; however, approximately six Mule Deer carcasses were found along an old road near the Lillooet River transmission line crossing on April 30, 2018 (Figure 32). The carcasses were likely left there by hunters. Three Cougar (*Puma concolor*) carcasses and the feathers of an unidentified bird were also found in this location.

Wolverine

Wolverine (provincially blue-listed and federally listed as Special Concern (CDC 2019)) tracks were incidentally observed twice within the Project area in 2018. The tracks of a Wolverine were observed in the snow on March 7, 2018 near Keyhole Falls Bridge and on March 14, 2018 approximately 500 m upstream of the Boulder Creek HEF diversion. The observation of Wolverine tracks near the Boulder Creek HEF diversion are considered further in relation to Mountain Goat predator monitoring at the Boulder Creek HEF intake under Section 4.6.2.2.

Harlequin Duck and Other Waterbirds

Harlequin Ducks were incidentally observed twice within the Upper Lillooet River HEF headpond. A pair of Harlequin Ducks was observed feeding in the ULR HEF headpond on April 20, 2018 and two female (potentially including a juvenile male or female) Harlequin Ducks were observed in the headpond on September 16, 2018. These observations are listed in Table 60 and implications of these sightings are discussed in Section 4.5.1. A large number of water birds also observed feeding in the headpond with the Harlequin Ducks on April 20, 2018, including approximately 40 Mallards (*Anas platyrhynchos*), 20 American Wigeon (*Mareca americana*), 20 Ring-necked Ducks (*Aythya collaris*), 12 Barrow's Goldeneye (*Bucephala islandica*), six ducks of undetermined species (possibly Green-winged Teal (*Anas crecca*)), three Bufflehead (*Bucephala albeola*), and one Common Merganser (*Mergus merganser*). The ducks observed in the headpond were likely on their way to summer breeding grounds.

Bald Eagle

Bald Eagles were incidentally observed along Alena Creek, the Lillooet River FSR, and near the ULR HEF headpond. On November 5, 2018 a single Bald Eagle was observed in flight over the Upper Lillooet River HEF headpond. Along Alena Creek, seven Bald Eagles were observed perched in trees on November 15, 2018 and four were observed on December 5, 2018. Along the Lillooet River FSR, one Bald Eagle was observed sitting in a tree at km 41 on November 22, 2018 and two individuals were observed at km 36 on December 15, 2018.

Coastal Tailed Frog

Five Coastal Tailed Frogs (federally listed as Special Concern (CDC 2019)) were incidentally observed during the habitat survey (Section 4.6.1.1) of the Coastal Tailed Frog stream crossed by the ULR HEF penstock on August 31, 2018 (ULL-ASTR04). One metamorph was observed in ULL-ASTR04US and three age class 2 or 3 tadpoles were observed near the upstream culvert on ULL-ASTR04US. One age class 3 tadpole was observed in ULL-ASTR04IM.

Western Toad and other Pond-breeding Amphibians

Western Toads (federally listed as Special Concern (CDC 2019)), were incidentally observed four times and Northern Pacific Treefrogs (*Pseudacris regilla*) were observed once near Meager Creek. Approximately 500 Western Toad tadpoles and 200 Northern Pacific Treefrog tadpoles were observed rearing on May 17, 2018 in a puddle located in the Meager Creek landslide area. On both June 28 and July 5, 2018, an adult Western Toad was observed basking on a gravel bar along the Lillooet River near the confluence with Meager Creek.

Table 61. Wildlife incidentally observed in the Project area during 2018.

Category	Species		Number of Sightings	Number of Sign (e.g., tracks, scat) Observations	Total
	Common Name	Scientific Name			
Species at Risk and of Regional Concern					
	Grizzly Bear	*Ursus arctos*	1	1	2
	Moose	*Alces americanus*	5	5	10
	Mountain Goat	*Oreamnos americanus*	1	2	3
	Mule Deer	*Odocoileus hemionus*	-	1	1
	Wolverine	*Gulo gulo*	-	2	2
	Harlequin Duck	*Histrionicus histrionicus*	3	-	3
	Bald Eagle	*Haliaeetus leucocephalus*	5	-	5
	Coastal Tailed Frog	*Ascaphus truei*	3	-	3
	Western Toad	*Anaxyrus boreas*	4	-	4
Other Species					
Amphibian	Northern Pacific Treefrog	*Pseudacris regilla*	1	-	1
Avian	American Wigeon	*Anas americana*	2	-	2
	Barrow's Goldeneye	*Bucephala islandica*	2	-	2
	bird	*unidentified species*	-	1	1
	Bufflehead	*Bucephala albeola*	2	-	2
	Common Merganser	*Mergus merganser*	1	-	1
	Duck	*unidentified species*	1	-	1
	Mallard	*Anas platyrhynchos*	2	-	2
	Ring-necked Duck	*Aythya collaris*	2	-	2
Mammals	American Black Bear	*Ursus americanus*	3	7	10
	Bear	*unidentified species*	-	1	1
	Bobcat	*Lynx rufus*	-	1	1
	Cougar	*Puma concolor*	-	2	2
	Ermine	*Mustela erminea*	1	-	1
	Grey Wolf	*Canis lupus*	-	1	1
	mammal	*unidentified species*	-	1	1

Figure 29. Grizzly Bear tracks near Truckwash Creek Bridge on April 9, 2018.

Figure 30. Moose scat at the Lillooet River transmission line crossing on May 23, 2018.

Figure 31. **Mountain Goat tracks near the** Sensitive location and timing information has been removed to protect this species.

Figure 32. **Mule Deer carcass found at an old road near the Lillooet River transmission line crossing on April 30, 2018.**

4.6. Wildlife Habitat Monitoring

4.6.1. Habitat Restoration

4.6.1.1. Amphibian Habitat

The requirement for habitat restoration monitoring of transmission line crossings over suitable Coastal Tailed Frog streams was assessed at nine sites (ULH-ASTRCM01 to ULH-ASTRCM09; Table 62, Map 12). At three of the nine sites, assessment was deemed not necessary due to: 1) the transmission line crossing a non-classified drainage at a location where Coastal Tailed Frogs had been documented to be not present (ULH-ASTRCM07); or 2) the transmission line being high enough that topping was not necessary (ULH-ASTRCM01 and ULH-ASTRCM08). At the remaining six sites, monitoring confirmed that vegetation clearing had been restricted to topping trees, effective sediment and erosion control was in place, and the cut wood was left in place (Table 62). Photos of each site are presented along with a summary of data collected in Appendix S. It should be noted that Coastal Tailed Frog tadpoles were incidentally observed in the stream channel at the penstock crossing and upstream during habitat surveys in 2018 (Section 4.5.2).

Key instream habitat characteristics known to be important for Coastal Tailed Frogs are compared between pre-construction (2012 and 2013) and post-construction (2018) in three reaches (at the ULR HEF penstock crossing, upstream and downstream) of tributary ULL-ASTR04 (Table 62, Table 63). Overall, all instream habitat characteristics recorded were similar between pre and post-construction periods, and minor changes similar to those documented at the penstock crossing and downstream of the crossing were also observed in the upstream reach, which served as a control site (penstock installation did not alter this reach). Water temperatures varied slightly by year, as would be expected given that monitoring was conducted during different months, and this difference in timing accounts for the higher temperatures at all three reaches in 2013 and 2018 (which were assessed in summer) compared to 2012 (assessed in fall). Channel width and wetted width were slightly smaller at the penstock crossing and especially downstream of the crossing post-construction, although, considering differences documented between the two pre-construction years, the difference between periods was relatively small. Some change in channel gradient was observed, but overall changes in gradient were small and were greatest for the upstream reach, which is suggestive of inter-observer differences or slight changes in measurement location. Embeddedness also differed little between periods, and the overall decrease in embeddedness recorded (more low embeddedness values were recorded post than pre-construction in all reaches) is not likely to be a negative change for Coastal Tailed Frogs that depend on interstitial spaces as refuges (Hayes and Quinn 2015). Proportions of riffles to cascades differed somewhat among years in the penstock crossing reach (the proportion of riffles to cascades increased post-construction); however, changes in the proportion of riffles to cascades were also noted in the upstream reach (though in the opposite direction), and little change was observed in the downstream reach. No change was evident in the proportion of pools in any reach. There was little change in substrate at either the penstock crossing reach or the downstream reach: gravel and fines were the dominant and subdominant materials both pre and post-construction. Substrate size, as estimated through a modified Wolman pebble count, was slightly larger in the impact and downstream reaches than during baseline data collection, although differences were not substantially greater than differences observed between 2012 and 2013 (Table 63). Estimates of substrate size also varied among years for the upstream reach; however, substrate size as estimated in 2018 was within the range of variation for substrate size measured in 2012 and 2013.

The instream restoration prescription called for compaction of subsurface materials, or another method (i.e., liner) to prevent the stream from going subsurface (Woodruff and Lacroix 2014). Geotextile was installed along the stream channel; however, it is not deep enough within the substrate and is exposed along a 1.5 m length of the impact reach (Figure 33). Although geotextile was installed to prevent the stream from going subsurface, if it is left exposed it can prevent Coastal Tailed Frogs from accessing potential subsurface flows or refugia. Furthermore, exposed geotextile does not provide a suitable substrate for Coastal Tailed Frog foraging or cover. Exposed geotextile was also observed in the adjacent riparian areas.

Two of the permanent revegetation monitoring plots established for riparian revegetation monitoring located within the riparian area of ULL-ASTR04IM (ULL-PRM08 and ULL-PRM09; see Section 4.2.1) were used to evaluate riparian restoration at ULL-ASTR04 and were given special consideration with regards to potential for erosion and the presence of CWD relative to other riparian revegetation monitoring plots. Although substantial exposed soil was documented at each of the permanent monitoring plots, this is expected during early stages of revegetation and no signs of erosion were documented in the riparian areas of ULL-ASTR04IM during riparian revegetation monitoring. Areas of exposed geotextile were observed within the riparian area at ULL-PRM09 that are likely to reduce riparian habitat suitability by restricting revegetation and availability of natural cover objects (Figure 33, Figure 34). ULL-PRM08 and ULL-PRM09 contained four and two pieces of class 2 CWD, respectively, and overall, CWD distribution and density within 30 m of the stream was confirmed to be in compliance with the restoration prescriptions (Woodruff and Lacroix 2014, Woodruff *et al.* 2017). As described in Section 4.2.1, there is good survival of planted stock along both sides of ULL-ASTR04 and good natural regeneration of vegetation within 1 – 2 m of the stream edge at ULL-PRM09 (Figure 35). Planted and naturally regenerating vegetation was approximately 1 m tall on average.

Figure 33. **Exposed geotextile within the stream channel at ULL-ASTR04IM on August 31, 2019.**

Figure 34. **Exposed geotextile along ULL-ASTR04 on August 31, 2018.**

Figure 35. Looking upstream along the impact reach of ULL-ASTR04 on September 6, 2018.

Table 62. Summary of Coastal Tailed Frog habitat restoration compliance monitoring at transmission line crossings.

Site	Location	Date	UTM Coordinates (Zone 10U)		Clearing Restricted to Topping Trees	Effective Sediment and Erosion Control (yes/no)	Cut Wood Left in Place	Comments
			Easting	Northing	(yes/no)		(yes/no)	
ULH-ASTRCM01	~ 500 m downstream of the Boulder Creek HEF powerhouse	31-Aug-2018	468990	5611094	n/a	yes	n/a	No clearing required. The stream was dry at the time of the assessment.
ULH-ASTRCM02	~ 3 km downstream of the Boulder Creek HEF powerhouse	31-Aug-2018	471205	5609206	yes	yes	yes	Trees are burnt but still topped with cut wood left in place.
ULH-ASTRCM03	~ 2.5 km northeast of Mount Morrison, and 100 m south of Lillooet River	21-Sep-2018	493120	5596474	yes	yes	yes	River left of the stream appears to be an old clear cut. Cut wood placed over the creek.
ULH-ASTRCM04	~ 6 km east of Mount Morrison, and 500 m southeast of Lillooet River	24-Sep-2018	497330	5594140	yes	yes	yes	Some topped trees visible, wood left in place, no erosion issues observed. Small patch of fallen trees on river right appear to be windfall.
ULH-ASTRCM05	~ 6 km east of Mount Morrison and 400 m south of ULH-ASTRCM04	24-Sep-2018	497499	5593905	yes	yes	yes	Topped trees visible, wood left in place, no erosion issues observed near transmission line. Small slide observed upstream of transmission line is unrelated to the transmission line.

Table 62. Continued.

Site	Location	Date	UTM Coordinates (Zone 10U)		Clearing Restricted to Topping Trees	Effective Sediment and Erosion Control (yes/no)	Cut Wood Left in Place	Comments
			Easting	Northing	(yes/no)		(yes/no)	
ULH-ASTRCM06	Ryan River	19-Jun-2018	499681	5591294	yes	yes	yes	Very little flow when assessed. It appears that a high flow deposited material upstream of the culvert but the culvert is still passable.
ULH-ASTRCM07	north of Miller Creek	n/a	505489	5581958	n/a	n/a	n/a	Assessment not required as this transmission line crossing is over a non-classified drainage. Coastal Tailed Frogs were only detected further downstream where the drainage is more defined (salvages at ULL-TBTFSA09 to ULL-TBTFSA13).
ULH-ASTRCM08	Miller Creek	24-Sep-2018	506391	5579361	n/a	yes	n/a	The transmission line is high enough here that no topping or clearing was necessary.
ULH-ASTRCM09	Pemberton Creek	24-Sep-2018	508747	5574484	yes	yes	yes	Topped trees visible, wood left in place, no erosion issues observed.

Table 63. Comparison of Coastal Tailed Frog instream habitat attributes at tributary ULL-ASTR04 between pre- and post-construction periods.

Reach	Year	Temperature (°C)	Average Channel Morphology Measurements			Embeddedness[1]			Average Mesohabitat Characteristics[2]			Substrate[3]		Wolman Pebble Count D_{50} (cm)[4]
			Wetted Width (m)	Channel Width (m)	Gradient (%)	0 m	50 m	100 m	Riffle (%)	Cascade (%)	Pool (%)	Dominant	Sub-dominant	
ULL-ASTR04US	2012	9	1.15	1.33	18	M	M	M	65	28	8	F	G	3 - 4
	2013	12	0.92	1.63	16	H	H	H	60	40	0	C	G	16 - 32
	2018	12	0.95	1.30	29	L	L	L	45	55	0	G	CO	11 - 16
ULL-ASTR04IM	2012	8	1.24	1.65	15	M	M	M	70	28	3	F	G	4
	2013	12	1.16	2.18	11	L	M	L	60	40	0	G	F	12 - 16
	2018	12	0.96	1.41	7	L	M	L	85	15	0	G	F	32 - 64
ULL-ASTR04DS	2012	7	1.05	1.45	8	L	M	M	80	15	10	G	F	3 - 4
	2013	10	0.97	1.72	13	L	L	M	80	20	0	G	F	16
	2018	12	0.73	1.29	7	L	L	L	75	15	10	G	F	32 - 64

[1] M: moderate, H: high, L: low. For ULL-ASTR04IM and ULL-ASTR04DS, embeddedness was evaluated at 0, 25, and 50 m rather than 0, 50, and 100 m.

[2] Average of upstream and downstream values.

[3] F: fines, G: gravel, C: cobble.

[4] Range of particle size categories that 50% of the samples are equal to or smaller than.

4.6.1.2. Avian Habitat

Harlequin Ducks

Clearing and revegetation characteristics documented post-construction at the four compliance monitoring sites (where the transmission line crossed over Harlequin Duck riparian breeding habitat) are shown in Table 64. At all monitoring sites, clearing had been either restricted to topping trees (three sites) or clearing and topping had not been necessary (at ULH-HADUCM02). Tree heights averaged between 4 and 6 m, and shrub heights averaged between 1 and 3 m. Coarse woody debris was documented naturally present at all sites except ULH-HADUCM03, and at this site coarse woody debris could not be placed close to shore without creating a potential hazard at high flow (Appendix Q).

Table 64. Clearing and vegetation characteristics of high quality riparian Harlequin Duck breeding habitat within 30 m of the Lillooet and Ryan rivers.

Site	Location	Clearing Restricted to Topping Trees[1]	Average Tree Height (m)	Average Shrub Height (m)	Coarse Woody Debris in Riparian Areas
ULH-HADUCM01	Lillooet River Transmission Line Crossing - north side (river left)	yes	6	2	yes
ULH-HADUCM02	Lillooet River Transmission Line Crossing - south side (river right)	clearing and topping were not necessary	5	3	yes
ULH-HADUCM03	Ryan River Transmission Line Crossing - north side (river left)	yes	5	1	no - not feasible
ULH-HADUCM04	Ryan River Transmission Line Crossing - south side (river right)	yes	4	1	yes

[1] If necessary the height of the shrub layer may have been reduced.

Peregrine Falcons

The vertical and horizontal distances between Peregrine Falcon nesting ledges and the nearest power pole of the transmission line are presented in Table 65 for the three nesting ledges identified. The smallest horizontal (150 m) and vertical distance (0 m) were both recorded for site ULH-PEFACM01 (habitat polygon ULH-PEFA01) (Figure 36). However, these minimum measurements did not consider orientation of the nesting ledge. When the nearest power pole facing the nesting ledge orientation (SE) was considered, horizontal and vertical distances increased to 287 m and ~75 m, respectively (see comments in Table 65). Vertical and horizontal distances measured for site ULH-PEFACM03 (habitat polygon ULH-PEF16) (Figure 37, Figure 38) are conservative, since nesting ledges are oriented to the east and the transmission line is north of the nesting ledges. Distances between nesting ledges and the nearest power pole for site ULH-PEFACM02 (habitat polygon ULH-PEF04) are intermediate, and as is apparent from Figure 39, the transmission line is well separated from the nesting ledges, both horizontally and vertically. Thus, in all cases, when vertical and horizontal distances are considered together, along with orientation of the nesting ledges relative to the power pole locations, the locations of the nearest poles are far enough away to not compromise the suitability of the nesting ledges for Peregrine Falcons. This evaluation is based on professional judgement and the classification of Peregrine Falcons as a species “moderately” tolerant of human activities near the nest site (MOE 2013).

Figure 36. Transmission line in the vicinity of Peregrine Falcon nesting ledges at ULH-PEFACM01, on September 24, 2018.

Figure 37. Transmission line below Peregrine Falcon nesting ledges at ULH-PEFACM03, on September 24, 2018. The nearest nesting ledges are approximately 300 m above the transmission line, not visible in this photo.

Figure 38. Peregrine Falcon nesting ledges within habitat polygon ULH-PEFA16, at least 300 m above where the transmission line crosses this ravine at ULH-PEFACM03, on August 12, 2011.

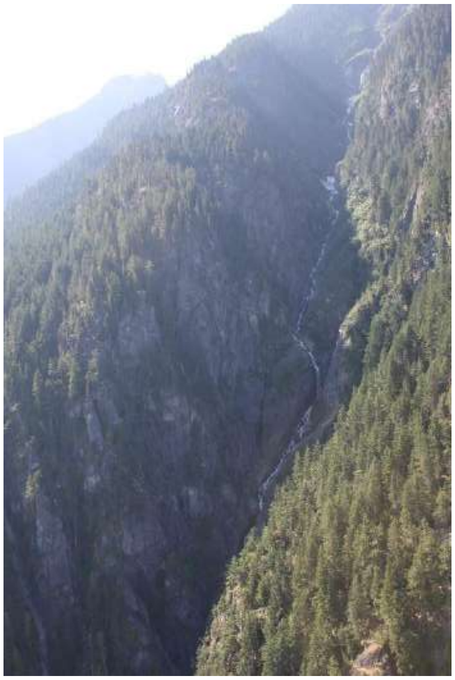

Figure 39. Transmission line below Peregrine Falcon nesting ledges at ULH-PEFACM02, on September 24, 2018.

Table 65. Assessment of vertical and horizontal distances between Peregrine Falcon nesting ledges and transmission line poles.

Site	Original Habitat Polygon ID	UTM Coordinates (Zone 10U)		Distance Between Pole and Nesting Ledge (m)		Comments
		Easting	Northing	vertical	horizontal	
ULH-PEFACM01	ULH-PEFA01	474260	5606281	0	150	Habitat polygon ULH-PEFA01 is on a slope oriented to the southeast, whereas the closest transmission line pole is to the southwest. To the southeast, the closest transmission line pole is 287 m away and between 50 and 100 m below the lowest portion of the habitat polygon.
ULH-PEFACM02	ULH-PEFA04	477972	5604026	150	280	Habitat polygon ULH-PEFA04 is oriented towards the transmission line; however the nearest potential nesting ledges are approximately 150 m higher than the base of the nearest transmission line pole.
ULH-PEFACM03	ULH-PEFA16	490705	5597376	440	300	Nesting ledges within habitat polygon ULH-PEFA16 are oriented to the east, whereas the transmission line is to the north. Furthermore, the nearest potential nesting ledges are approximately 300 m above the base of the nearest transmission line pole.

4.6.1.3. Mammal Habitat

Results of mammal habitat restoration compliance monitoring for Grizzly Bear, Moose, and Mule Deer is presented in Table 66 and the details of compliance monitoring results, along with photographs, are presented in Appendix T (Map 16).

For Grizzly Bear, prescriptions of habitat restoration differed by location (Table 5). In addition to results presented in Appendix C, two sites were monitored for WHA 2-399 (ULH-MAMCM14 and ULH-MAMCM16; Map 18). At both sites, greater than 50% planted vegetation composed of native fruit bearing shrubs was confirmed. The presence of a vegetated screen was also confirmed at both sites; however, the screen at ULH-MAMCM14 was only 3 m in height (both were 9 m wide). Thus, because a 5 m tall screen is desired, this site will need to be reassessed in Year 3.

For the South Lillooet River FSR and all other locations, only Grizzly Bear vegetated screen requirements were assessed as part of this report; species-specific planting requirements were assessed as part of the vegetation assessment conducted by Hedberg (Appendix C). Nineteen sites were monitored at these other locations, of which three were along the South Lillooet River FSR (Map 18). At all three of the South Lillooet River FSR sites (ULH-MAMCM17, ULH-MAMCM18, ULH-MAMCM19), the presence of a vegetated screen was confirmed but the height of the screen was less than the required 5 m (Appendix T).

Of the other 16 Grizzly Bear monitoring sites (Map 18), only at one site (ULH-MAMCM05) was the vegetated screen adequate and no further reassessment is required. At the remaining fifteen sites (ULH-MAMCM01, ULH-MAMCM02, ULH-MAMCM04A, ULH-MAMCM04B, ULH-MAMCM06, ULH-MAMCM07, ULH-MAMCM09, ULH-MAMCM21, ULH-MAMCM22, ULH-MAMCM23, ULH-MAMCM24, ULH-MAMCM25, ULH-MAMCM26, ULH-MAMCM27, ULH-MAMCM28) the screens had not yet attained the required width and/or height and reassessment is required. Growth of existing vegetation is expected to create an adequate screen over time at most of these sites, but the potential need for some future planting was identified for ULHMAMCM09 if this does not occur. At ULH-MAMCM02 the reason for the lack of screen was that the vegetation in this location had been destroyed in the 2015 Boulder wildfire, and although natural regeneration is anticipated, reassessment at a later date is required. The establishment of a vegetated screen at ULH-MAMCM07, along a 70 m wide scree slope, will likely not be feasible. Screen height may also be limited by the transmission line at ULH-MAMCM24 due to transmission line safety considerations.

An inspection was conducted at each of the facilities with waste management requirements (ULR HEF intake, ULR HEF powerhouse, Boulder Creek HEF intake and Boulder Creek HEF powerhouse) to evaluate if disposal of food waste at facilities with waste management requirements is occurring as per Grizzly Bear compliance monitoring prescriptions. Results of the inspections are summarized in Table 67. All areas were found to be generally neat and tidy. There were no garbage or waste bins outside at the ULR HEF intake or Boulder Creek HEF intake during the inspections on September 6 and November 30, 2018, respectively. Thus, there are no issues with food waste management at either of the Project intakes. During the inspections of the ULR HEF powerhouse and Boulder Creek HEF powerhouse on August 31, 2018, a few empty beverage containers, an empty candy wrapper and an empty oil container were observed in open waste containers (one at each powerhouse) outside, where they could potentially attract bears or other wildlife. The Project's Environment Supervisor was notified of the issue and Project operators were reminded of the requirement to store all food waste or other waste that could attract bears in a location not accessible to bears, such as inside or in an animal proof waste container outside, until it can be transported out of the Project area.

Six vegetated screen sites were monitored within Moose UWR (Map 19). For three of these sites (ULH-MAMCM13, ULH-MAMCM15, and ULH-MAMCM16), an adequate screen was confirmed and no further reassessment is required. At two sites (ULH-MAMCM12, ULH-MAMCM14), although the screen was present and screen width was adequate, the screen was not tall enough. The vegetation at these two sites is expected to increase in height over time to create an adequate screen. At ULH-MAMCM03, mature vegetation was retained (the site was not disturbed by construction).

Twelve vegetated screen sites were monitored within Mule Deer UWR (Map 20). At one of these sites (ULH-MAMCM05) adequacy of the vegetated screen was confirmed, thus no further reassessment is required (Appendix T). At all other sites, the vegetated screen was either not high enough (ULH-MAMCM06, ULH-MAMCM07, ULH-MAMCM08, ULH-MAMCM10, ULH-MAMCM11, ULH-MAMCM20, ULH-MAMCM24, ULH-MAMCM25, and ULH-MAMCM26), or both not high and not wide enough (ULH-MAMCM09, ULH-MAMCM21), and future reassessment is required. However, in all cases except ULH-MAMCM09, vegetation growth is anticipated to create an adequate screen over time. As noted for Grizzly Bear monitoring, at ULH-MAMCM09 the potential need for some planting was identified if natural regeneration is still not adequate during future monitoring, at ULH-MAMCM07 vegetation growth is not anticipated to occur along a scree slope, and at ULH-MAMCM24 the height of the screen may be limited by the transmission line.

Table 66. Summary of vegetated screen assessments and species composition of revegetated areas within high value mammal habitat along the transmission line.

Site	Species and Habitat[1]	Vegetated Screen (3 sites per screen)			Density of woody stems > 20 cm tall (stems/ha)	Recommendation to Reassess in Year 3?
		Average Width (m)	Average Height (m)	Average % Cover Through Screen		
ULH-MAMCM01	Grizzly Bear - High Value	7	4	13	37,800	yes
ULH-MAMCM02	Grizzly Bear - High Value	0	0	0	0	yes
ULH-MAMCM03	Moose - UWR	27	11	100	-	no
ULH-MAMCM04A	Grizzly Bear - High Value	14	4	100	32,800	no
ULH-MAMCM04B	Grizzly Bear - High Value	0	0	0	9,400	yes
ULH-MAMCM05	Grizzly Bear - High Value Mule Deer - UWR	17	5	93	48,600	no
ULH-MAMCM06	Grizzly Bear - High Value Mule Deer - UWR	17	2	30	23,000	yes
ULH-MAMCM07	Grizzly Bear - High Value Mule Deer - UWR	3	2	10	6,000	yes
ULH-MAMCM08	Mule Deer - UWR	17	3	47	49,200	yes
ULH-MAMCM09	Grizzly Bear - High Value Mule Deer - UWR	2	1	4	29,000	yes
ULH-MAMCM10	Mule Deer - UWR	9	1	10	18,800	yes

[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).

Table 66. Continued.

Site	Species and Habitat[1]	Vegetated Screen (3 sites per screen)			Density of woody stems > 20 cm tall (stems/ha)	Recommendation to Reassess in Year 3?
		Average Width (m)	Average Height (m)	Average % Cover Through Screen		
ULH-MAMCM11	Mule Deer - UWR	7	2	40	28,400	yes
ULH-MAMCM12	Moose - UWR	7	2	10	25,400	yes
ULH-MAMCM13	Moose - UWR	25	19	30	19,800	no
ULH-MAMCM14	Grizzly Bear - WHA 2-399 Moose - UWR	9	3	100	39,600[2]	yes
ULH-MAMCM15	Moose - UWR	11	5	100	12,000	no
ULH-MAMCM16	Grizzly Bear - WHA 2-399 Moose - UWR	9	5	57	23,200[2]	no
ULH-MAMCM17	Grizzly Bear - South Lillooet River FSR	8	3	87	31,800	yes
ULH-MAMCM18	Grizzly Bear - South Lillooet River FSR	20	2	30	22,000	yes
ULH-MAMCM19	Grizzly Bear - South Lillooet River FSR	10	3	20	80,200	yes
ULH-MAMCM20	Mule Deer - UWR	14	4	42	33,200	yes

[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] More than 50% of woody stems counted within the two plots within WHA 2-399 were preferred Grizzly Bear forage species (ULH-MAMCM14 : 67%, ULH-MAMCM16: 71%).

Table 66. Continued.

Site	Species and Habitat[1]	Vegetated Screen (3 sites per screen)			Density of woody stems > 20 cm tall (stems/ha)	Recommendation to Reassess in Year 3?
		Average Width (m)	Average Height (m)	Average % Cover Through Screen		
ULH-MAMCM21	Grizzly Bear - High Value Mule Deer - UWR	4	4	53	47,800	yes
ULH-MAMCM22	Grizzly Bear - High Value	7	3	53	54,400	yes
ULH-MAMCM23	Grizzly Bear - High Value	8	1	0	8,600	yes
ULH-MAMCM24	Grizzly Bear - High Value Mule Deer - UWR	n/a	1	0	0	yes
ULH-MAMCM25	Grizzly Bear - High Value Mule Deer - UWR	8	4	67	47,000	yes
ULH-MAMCM26	Grizzly Bear - High Value Mule Deer - UWR	40	2	50	38,800	yes
ULH-MAMCM27	Grizzly Bear - High Value	40	2	84	42,400	yes
ULH-MAMCM28	Grizzly Bear - High Value	40	1	3	29,400	yes

[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).

Table 67. Summary of inspections used to determine if disposal of food waste at facilities with waste management requirements is occurring in accordance with prescriptions for Grizzly Bears.

Location	Date	Comments
ULR HEF intake	6-Sep-2018	No garbage can outside, or garbage waste on site. Area is neat and tidy.
ULR HEF powerhouse	31-Aug-2018	No garbage can outside. Blue bin outside contains a clean spill kit, and no bear attractants. Open mesh metal recycling bin outside contained cardboard and a few empty soda cans. The Project's Environment Supervisor was notified of this observations and operators were reminded that empty soda cans and any other food or bear attractant waste stored at this location should be stored inside, or in an animal proof waste container outside, until it can be transported out of the Project area.
Boulder Creek HEF intake	30-Nov-2018	No garbage or waste bins on site.
Boulder Creek HEF powerhouse	31-Aug-2018	Open garbage can outside the crew house with beverage cans, an empty oil container, and a candy wrapper inside. The Project's Environment Supervisor was notified of this observation and operators were reminded that all food or bear attractant waste should be stored inside, or in an animal proof waste container outside. Powerhouse was clean and tidy, no food waste in the big metal bin.

4.6.2. Mitigation Effectiveness

4.6.2.1. Avian Collisions

Bird diversion markers were observed along the transmission line sections over the Lillooet River and Ryan River and no avian carcasses were found on transect surveys in spring and fall (Table 68). However, detection may have been hampered by dense vegetation during the spring survey at the south side of the Lillooet River transmission line crossing (Figure 40) and by high flows that may have removed any carcasses that fell along the shoreline during the fall survey at the Ryan River transmission line crossing (Figure 41). Visibility of the ground was good during most surveys (e.g., spring survey at the north side of the Lillooet River transmission line crossing; Figure 42). In all cases, surveys for carcasses provide only an indicator of potential avian losses, because any birds that collide with the power lines and fall to the ground are likely to be scavenged rapidly.

Table 68. Avian collision survey results for surveys conducted at the Lillooet River and Ryan River transmission line crossings.

Location	Survey Period	Date	Time		Area (m^2)	Results	Comments
			Start	End			
Lillooet River Transmission Line Crossing - north side (river left)	Spring	30-Apr-2018	13:25	13:40	1,050	no avian carcasses observed	good visibility of the ground
	Fall	21-Sep-2018	10:16	10:30	1,050	no avian carcasses observed	
Lillooet River Transmission Line Crossing - south side (river right)	Spring	23-May-2018	10:20	10:40	580	no avian carcasses observed	thick vegetation under the powerlines
	Fall	21-Sep-2018	11:52	12:15	580	no avian carcasses observed	
Ryan River Transmission Line Crossing - river right, river left and bridge	Spring	4-May-2018	11:23	11:50	2,420	no avian carcasses observed	bridge follows transmission line, good visibility of the ground
	Fall	2-Nov-2018	11:07	11:30	2,420	no avian carcasses observed	river was very high and turbid due to heavy rainfall the day before

Figure 40. **Avian collision transect along the Lillooet River transmission line crossing (south side), showing thick vegetation under the power line, on May 23, 2018.**

Figure 41. **Avian collision transect along the Ryan River transmission line crossing, showing high flows in the Ryan River, on November 2, 2018.**

Figure 42. Avian collision transect along the Lillooet River transmission line crossing (north side), showing good ground visibility, on April 30, 2018.

4.6.2.2. Mountain Goats

Upper Lillooet River HEF

Photographs taken from remote infrared cameras maintained along the Truckwash Creek Mountain Goat migration corridor during the post-construction period indicated that Mountain Goats were travelling along the Truckwash Creek migration corridor as they had been before and during construction.

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

. Wildlife cameras installed in the Truckwash Creek area also photographed a variety of other wildlife species (Appendix V).

Comparison to remote infrared camera results from baseline and construction periods suggests that Mountain Goat movement through the Truckwash Creek migration corridor has not been affected by Project construction. Direct comparison among years and time periods of numbers of individuals or groups detected is not possible because camera locations were moved out of active construction areas and to optimize detections, and survey effort differed (i.e., different numbers of cameras were functional at different times). However, Mountain Goats were only detected by remote infrared cameras [redacted] Sensitive location and timing information has been removed to protect this species.) on one occasion in the baseline period (Regehr *et al.* 2016), and on one occasion in each of the three construction years (Newbury *et al.* 2015, 2016, Regehr *et al.* 2017). Further, Mountain Goats were documented [redacted] both pre and post-construction.

Results from systematic winter ground-based surveys documented Mountain Goat sign on two occasions during Year 1 post-construction monitoring. Transects were surveyed on eight days in total between January 2018 and January 2019, and three transects were surveyed on each day (Table 70). Mountain Goat scat was seen on one occasion [redacted] and tracks from two individuals were seen on one other occasion [redacted] (Table 71). In both cases, the Mountain Goat sign was seen along transect [redacted] ([redacted]; Map 17). Fresh snow had occurred between 1.5 and > 14 days prior to surveys, and snow varied in hardness between soft and very hard and was at least 26 cm deep on all surveys (Table 70).

Comparison of post-construction systematic winter ground-based survey results to baseline results from ground-based and aerial surveys combined (see Section 4.3.1.1 of Regehr *et al.* (2016) for rationale for combining survey types) indicates that the amount of Mountain Goat sign detected per year was similar between the two periods. Mountain Goat sign was also detected during systematic winter ground-based surveys during construction (Newbury *et al.* 2015, 2016). During baseline surveys, only one detection (of sign) was recorded in both 2011/12 and 2012/13, and eight detections were recorded in 2010/11. Thus, the rate of Mountain Goat detections per survey differed little between pre (8 detections in 21 surveys) and post (2 detections in eight surveys) construction periods. Although sign from larger groups was detected during baseline surveys than during post-construction surveys (sign from groups of four were detected on two occasions during baseline surveys (once in 2010/11 and once in 2012/13)), the number of detections per year was too small to allow consideration of potential differences in group size. Overall, remote infrared cameras (the placement of which was refined over time to more specifically target wildlife trails and Mountain Goat movement routes) were found to be more effective than systematic ground-based winter (snow-tracking) surveys at detecting Mountain Goats moving through the Truckwash Creek migration corridor. Sign from other wildlife species was also recorded during post-construction systematic winter ground-based surveys (Appendix U).

Opportunistic monitoring of the Keyhole Falls Mountain Goat winter range (UWR u-2-002 UL 11) indicated that Mountain Goats, including nannies, are continuing to use this winter range post-construction. Mountain Goats were also observed continuing to use this winter range during construction (Newbury *et al.* 2015, 2016). The winter range was scanned on eight occasions between January 2018 and January 2019, and Mountain Goats were recorded during five of these scans (Table 72). Sensitive location and timing information has been removed to protect this species. [redacted] Adult females, which were a particular monitoring target, were seen on all occasions during which individuals were seen that could be identified to sex (three occasions).

In addition to observations of Mountain Goats and their sign recorded during surveys, Mountain Goat tracks were also incidentally observed [redacted] (Section 4.5.2).

Figure 43. Group of four Mountain Goats (one nanny, one kid, and two sub-adults) photographed by [redacted].

Table 69. Mountain Goats photographed by remote infrared cameras within the Truckwash Creek Mountain Goat migration corridor.

Date	Time	Location	Mountain Goats Photographed
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	
[redacted]	[redacted]	[redacted]	[redacted]

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

Table 70. Dates, times, and survey conditions for systematic winter ground-based surveys conducted along transects within the Truckwash Creek Mountain Goat migration corridor between January 2018 and January 2019.

Date	Transect	Start Time	End Time	Snow Depth (cm)	Snow Hardness[1]	Snow Cover (%)	Days Since 5 cm Snow
14-Jan-2018	ULL-SNTR01	13:20	15:35	26-50	Hard	76-100	1.5
	ULL-SNTR02	14:20	16:15	101-150	Medium	76-100	1.5
	ULL-SNTR03	14:50	15:25	101-150	Medium	76-100	1.5
15-Feb-2018	ULL-SNTR01	12:00	13:00	>150	Soft	76-100	2
	ULL-SNTR04	13:10	13:30	>150	Soft	76-100	2
	ULL-SNTR05	13:40	14:35	>150	Soft	76-100	2
7-Mar-2018	ULL-SNTR01	12:30	14:10	>150	Hard	76-100	5
	ULL-SNTR04	12:00	12:20	>150	Hard	76-100	5
	ULL-SNTR05	13:28	14:00	>150	Hard	76-100	5
9-Apr-2018	ULL-SNTR01	8:10	9:08	>150	Soft	76-100	7
	ULL-SNTR04	7:35	8:08	>150	Soft	76-100	7
	ULL-SNTR05	9:23	10:30	101-150	Soft	76-100	7
20-Apr-2018	ULL-SNTR01	12:20	13:20	76-100	Soft	76-100	> 14
	ULL-SNTR04	11:49	12:17	26-50	Soft	76-100	> 14
	ULL-SNTR05	13:30	14:18	76-100	Soft	76-100	> 14
3-May-2018	ULL-SNTR01	12:25	12:56	51-75	Soft	51-75	> 14
	ULL-SNTR04	11:42	12:13	51-75	Soft	51-75	> 14
	ULL-SNTR05	13:00	13:30	51-75	Soft	26-50	> 14
4-Dec-2018	ULL-SNTR01	10:38	11:28	26-50	Very Hard	76-100	12
	ULL-SNTR04	10:13	10:38	26-50	Very Hard	76-100	12
	ULL-SNTR05	9:50	10:11	26-50	Very Hard	76-100	12
30-Jan-2019	ULL-SNTR01	13:38	14:56	>150	Soft	76-100	7
	ULL-SNTR04	13:20	13:38	>150	Soft	76-100	7
	ULL-SNTR05	12:43	13:17	101-150	Soft	76-100	7

[1] Snow hardness was categorized as: Very Soft - fist penetrates top snow layer easily; Soft - tips of four fingers penetrate the top snow layer easily; Medium - tip of one finger penetrates the top snow layer easily; Hard - tip of a pencil penetrates the top snow layer easily; Very Hard - tip of a knife penetrates the top snow layer easily.

Table 71. Mountain Goat sign observed during systematic ground-based surveys within the Truckwash Creek Mountain Goat migration corridor between January 2018 and January 2019.

Date	Transect	UTM Coordinates (Zone 10U)		Comments
		Easting	Northing	
Sensitive location and timing information has been removed to protect this species.				

Table 72 Summary of Mountain Goats observed from the Keyhole Falls UWR viewpoint (ULL-MGOBS02) between January 2018 and January 2019.

Date	Mountain Goat Observations		
	Sex	Age	Number

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

Boulder Creek HEF

Photographs taken by the three remote infrared cameras installed along the Boulder Creek HEF intake access road indicated that one member of the public was able to travel past the gate on an ATV during the Year 1 monitoring period. A hunter on an ATV was photographed by BDR-CAM01 and BDR-CAM02 along the intake access road on November 19, 2018 (Figure 44). BDR-CAM03 was not functional on this date (Table 20); thus, the means by which the hunter travelled past the gate is not known (i.e., whether the gate was open or closed and if the ATV passed through it or around it). Later in the winter, the gate became non-functional due to snow height. During the camera maintenance trip on January 17, 2019, both the gate and the camera (BDR-CAM03) were completely buried in snow (Figure 45).

Results from predator monitoring identified a number of potential predators within the survey area in the vicinity of the Boulder Creek HEF intake (Sensitive location and timing information has been removed to protect this species. (Section 4.5.2)). Remote infrared cameras photographed American Black Bear (*Ursus americanus*), Bobcat (*Lynx rufus*), Grizzly

Bear (*Ursus arctos*), and Wolverine (*Gulo gulo*), between mid-May and mid-October in 2018 (Table 74, Map 5), all of which are considered occasional predators of Mountain Goats (Shackleton 1999). Predator sign documented during systematic ground-based surveys (Table 75) additionally identified Coyote (*Canis latrans*) presence (Table 76), which is also an occasional predator. Main predators of Mountain Goats (Cougars (*Puma concolor*) and Grey Wolves (*Canis lupus*); Shackleton (1999)) were not detected during either monitoring method and no kills were seen. All predator detections, whether by camera or by snow-tracking methods, identified a single individual per detection, with the exception of the Grizzly Bear detection which were of two individuals (either sow with a two-year old cub, or two two-year old siblings). The Bobcat track recorded on three occasions on February 26 on transect BDR-SNTR03 (Table 76) was likely to have been made by a single individual (Map 5).

Comparison of camera monitoring results pre and post-construction is difficult due to changes in cameras between time periods (two cameras were used during baseline surveys and three were used during Year 1 of post-construction monitoring; no camera locations used during baseline monitoring could be used post-construction). However, a crude comparison of results to date suggest that the amount and type of predator sign detected during the winter season for Mountain Goats (November 1 to June 15) was similar between the two periods. All potential predator species observed near the Boulder Creek HEF intake during the first year of operational monitoring were also observed in the area prior to construction. During baseline camera surveys, three American Black Bears were detected during the winter season in 2012 (one in May and two in the first half of June (Regehr *et al.* 2016; note that the definition of the winter period is slightly different for the presentation of baseline results)). During post-construction surveys (2018), a Wolverine was detected in January, a Bobcat and two Grizzly Bears were detected in June, and an American Black Bear was detected on eight separate occasions (by two cameras) in May, June, and November (Table 74, Map 5). Appearance of the American Black Bear photographed and detection dates suggested that four of these detections were of the same individual that passed by both BDR-CAM01 and BDR-CAM02 on May 12 and May 23.

Comparison of results from ground-based and aerial surveys between pre and post-construction periods (see Section 4.3.1.2 of Regehr *et al.* (2016) for rationale for combining survey types for baseline results) also do not support differences in the frequency of predator detections to date. Predators were detected on two occasions during the eight surveys conducted in Year 1 of post-construction monitoring (an average of 0.25 individuals per survey) (Table 76), and during the three baseline years of monitoring, 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). Thus, there is currently no evidence of changes in frequency of occurrence of predators in the Boulder Creek HEF intake area. Different predator species were detected during ground-based/aerial surveys between pre and post-construction periods (during baseline surveys only Wolverines were detected, whereas post-construction Wolverines were not detected; Table 76); however, a Wolverine was detected by camera in January 2018 along the access road (Table 74) and was also incidentally detected (see below). Further, only occasional predators of Mountain Goats were detected during baseline and post construction surveys. Owing to the low frequency of predator detections in general, continued camera monitoring (which will replace all ground-based surveys in future monitoring) in the following years will provide additional information on predator use (by species and frequency) of the area.

Mountain Goat predators were also detected incidentally during the Year 1 post-construction monitoring period, but few detections were in the Boulder Creek HEF intake area (Map 4, Appendix R). The only potential predator incidentally detected during the winter season in the Boulder Creek HEF intake area was Wolverine, for which tracks were observed near the Boulder Creek HEF diversion on March 14, 2018. Other predators, including main predators of Mountain Goats (Cougars and Grey Wolves) were detected only in other parts of the Project area. Mountain Goat sign was incidentally detected Sensitive location and timing information has been removed to protect this species.

Figure 44. **Hunter on ATV travelling along the Boulder Creek HEF intake access road northeast of the gate photographed by BDR-CAM02 on November 19, 2018.**

Figure 45. **Gate across the Boulder Creek HEF intake access road buried in snow and non-functional on January 17, 2019. Snowmobile in photo belongs to crew accessing the area for camera maintenance.**

Table 73. **Human activity that was not associated with the Project along the Boulder Creek HEF intake access road documented with remote infrared cameras in 2018.**

Human Activity [1]	Camera	Date	Comments
Hunter on ATV	BDR-CAM01	19-Nov-2018	same hunter observed on BDR-CAM02
	BDR-CAM02	19-Nov-2018	appears to notice and follow tracks from American Black Bear photographed November 18, 2018

[1] Several vehicles (i.e., pick-up trucks, a plow, a snow UTV and a Komatsu WA430, Ecofish snowmobiles) associated with the Project were also photographed travelling along the Boulder Creek HEF intake access road between November 1 and June 15, particularly in association with maintenance works at the Boulder Creek HEF intake in early December 2018. Tree planting crews working within the vicinity of the gate, but not in association with the Project, were also photographed in May 2018.

Table 74. **Potential predators of Mountain Goats photographed by remote infrared cameras near the Boulder Creek HEF intake and access road. Grey shading identifies detections that occurred in the Mountain Goat winter and spring seasons (November 1 to June 15).**

Species		Camera	Date	Comments
Common Name	Scientific Name			
American Black Bear	*Ursus americanus*	BDR-CAM01	12-May-2018	bear with bald patches, also observed on BDR-CAM02
			22-May-2018	
			23-May-2018	same bear with bald patches that was observed on May 12
			4-Jul-2018	
			8-Jul-2018	
			6-Aug-2018	
			4-Oct-2018	
			16-Oct-2018	
		BDR-CAM02	12-May-2018	bear with bald patches, also observed on BDR-CAM01
			23-May-2018	same bear with bald patches that was observed on May 12
			5-Jun-2018	
			11-Jun-2018	
			2-Jul-2018	
			31-Jul-2018	passed by the camera twice on July 31, likely same bear
			18-Nov-2018	
		BDR-CAM03	19-Jun-2018	
			23-Jun-2018	young adult
			8-Jul-2018	
Bobcat	*Lynx rufus*	BDR-CAM02	7-Jun-2018	
Grizzly Bear	*Ursus arctos*	BDR-CAM02	13-Jun-2018	two Grizzly Bears, possibly a sow with her two-year-old or two siblings
Wolverine	*Gulo gulo*	BDR-CAM02	11-Jan-2019	

Table 75. Dates, times, and survey conditions for systematic ground-based surveys conducted along transects near the Boulder Creek HEF intake in 2018.

Date	Transect	Start Time	End Time	Snow Depth (cm)	Snow Hardness[1]	Snow Cover (%)	Days Since 5 cm Snow
6-Feb-2018	BDR-SNTR01	11:25	11:45	>150	Hard	76-100	1
	BDR-SNTR02	11:45	12:46	>150	Hard	76-100	1
	BDR-SNTR03	12:50	14:35	>150	Hard	76-100	1
22-Feb-2018	BDR-SNTR01	13:06	13:40	>150	Soft	76-100	4
	BDR-SNTR02	12:10	12:56	>150	Very Soft	76-100	4
	BDR-SNTR03	10:57	12:07	>150	Very Soft	76-100	4
6-Mar-2018	BDR-SNTR01	13:14	13:47	>150	Soft	76-100	5
	BDR-SNTR02	11:30	12:11	>150	Soft	76-100	5
	BDR-SNTR03	12:15	13:05	>150	Soft	76-100	5
31-Mar-2018	BDR-SNTR01	10:50	11:15	>150	Very Hard	76-100	5
	BDR-SNTR02	11:15	11:50	>150	Very Hard	76-100	5
	BDR-SNTR03	11:50	12:30	>150	Very Hard	76-100	5
12-Apr-2018	BDR-SNTR01	14:05	14:20	>150	Soft	76-100	10
	BDR-SNTR02	12:50	13:30	101-150	Soft	76-100	10
	BDR-SNTR03	13:30	14:05	>150	Soft	76-100	10
30-Apr-2018	BDR-SNTR01	11:20	11:50	6-25	Soft	51-75	>14
	BDR-SNTR02	12:00	12:35	76-100	Soft	76-100	>14
	BDR-SNTR03	12:40	13:10	76-100	Soft	76-100	>14
8-May-2018	BDR-SNTR02	9:50	10:10	6-25	Soft	6-25	>14
	BDR-SNTR03	10:15	10:50	6-25	Soft	6-25	>14
30-Nov-2018	BDR-SNTR02	10:13	12:10	26-50	Hard	76-100	7
	BDR-SNTR03	12:30	14:12	26-50	Hard	76-100	7

[1] Snow hardness was categorized as: Very Soft - fist penetrates top snow layer easily; Soft - tips of four fingers penetrate the top snow layer easily; Medium - tip of one finger penetrates the top snow layer easily; Hard - tip of a pencil penetrates the top snow layer easily; Very Hard - tip of a knife penetrates the top snow layer easily.

Table 76. Sign of Mountain Goats and potential predators observed during systematic winter ground-based surveys near the Boulder Creek HEF intake.

Species		Date	Transect	UTM Coordinates (Zone 10U)		Comments
Common Name	Scientific Name			Easting	Northing	
Bobcat	*Lynx rufus*	26-Feb-2018	BDR-SNTR03	473009	5611095	1 set of tracks
				473145	5611230	1 set of tracks
				473191	5611373	1 set of tracks
Coyote	*Canis latrans*	12-Apr-2018	BDR-SNTR01	473363	5611406	1 set of tracks
Mountain Goat	*Oreamnos americanus*					

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

5. RECOMMENDATIONS

5.1. Aquatic and Riparian Habitat

5.1.1. Riparian Revegetation Assessment

Revegetation of woody vegetation is generally progressing well in the first year of this riparian monitoring program, and site conditions are generally favorable which will support ongoing natural regeneration. However, additional restoration actions are recommended for 2019 enhance and accelerate the condition of specific revegetation areas to meet the OEMP targets by the last year of planned monitoring in Year 5.

2019 Riparian Revegetation Actions:

- Add rocky material to cover areas of exposed geotextile at ULL-PRM09, by the Coastal Tailed Frog stream (ULL-ASTR04) crossed by the penstock (this recommendation also applies to amphibian habitat restoration monitoring). The area of exposed geotextile is small enough that this work can be accomplished by hand, using local materials already on site.

5.2. Water Temperature

We recommend that the monitoring program continue in 2019 (Year 2), based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017).

5.2.1. Frazil Ice

The frazil ice assessment protocol has been implemented since December 2017 and crews have responded to two alarms since this date. As stated in the OEMP, our understanding of the effect of flow on frazil ice development and effects on frazil ice on fish habitat is limited. Thus, given that only one year of monitoring data have been collected, during which fish habitat availability was assessed to have been reduced as a result of the frazil and anchor ice on one occasion, we recommend that future monitoring is continued in each of the Upper Lillooet River and Boulder Creek diversions in accordance with the protocols used in the first monitoring year. As specified in the OEMP, the effectiveness and suitability of this monitoring and management protocol should continue to be evaluated annually for the duration of the five-year monitoring period under the direction of an Ecofish QP. Recommendations for refinement of the protocol and thresholds will be provided once additional data are collected and analysed.

5.3. Fish Community

5.3.1. Juvenile Density and Biomass

Juvenile fish densities and biomass monitoring was successfully implemented in Year 1 using closed-site electrofishing surveys in the diversion and upstream reaches of the Upper Lillooet River and through mark re-sight snorkeling surveys within the diversion and downstream reaches of Boulder Creek. No changes to the juvenile fish density and biomass monitoring program are recommended at this time. Accordingly, monitoring will continue using the same methods used to date for Year 2 of operational monitoring, as specified in the OEMP.

5.3.2. Adult Fish Migration and Distribution

Adult Bull Trout and Cutthroat Trout migration and distribution monitoring was successfully implemented in Year 1 through a combination of angling surveys in the diversion and downstream reaches of the Upper Lillooet River and Boulder Creek, and spawning surveys in the reference streams (29.2 km Tributary and Alena Creek). Given the shutdowns that occurred during the spawning period of Bull Trout in 2018, it is recommended that angling surveys in the diversion and downstream reaches of the Upper Lillooet River and Boulder Creek and spawning surveys at three reference streams (29.2 km Tributary, Alena Creek and North Creek – the latter of which was not surveyed in 2018) continue in Year 2, but only if the HEFs are not shutdown during the mid-September to mid-October spawning period.

Results from the Cutthroat Trout tributary assessments in the lower diversion reach of Upper Lillooet River revealed that results from 2018 were similar to baseline conditions which showed Cutthroat Trout spawning in ULL-83.2 km and ULL-83.7 km, with similar access limitations. These results indicate that Cutthroat Trout spawning in 2018 occurred in the same tributaries as baseline and no further assessment is recommended as per the OEMP.

5.3.3. Assessment of Entrainment at the Upper Lillooet River Intake

Monitoring of the Headpond tributary at km 87.0 and ten upstream sites on the Upper Lillooet River through closed-site electrofishing surveys was successfully implemented in support of an assessment of fish entrainment at the Upper Lillooet River HEF intake in Year 1. No changes to this monitoring program are recommended at this time. Accordingly, monitoring of the fish community within this tributary will continue in Year 2.

5.4. Water Quality Monitoring

Year 1 (2018) operational data 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 WQG for the protection of aquatic life. A recent DFO (2016) publication regarding the results of on-going monitoring of similar projects, suggest that biologically significant effects of Project operations on water quality are not likely to occur. Therefore, we recommend that that the water quality monitoring component be removed from the OEMP in Years 2, 3, 4, and 5.

5.5. Wildlife Species Monitoring

5.5.1. Harlequin Ducks

Monitoring results from Year 1 indicated that Harlequin Ducks are still using the Project area but evidence of breeding in the vicinity of the Project area post-construction is inconclusive (i.e., the pair observation in spring and the two females[3] observed in fall were early and late in the breeding season, respectively; thus, they may have been passing through the Project area on the way to and from breeding locations). Continued annual monitoring for the next four years (with reporting in Years 3 and 5), in accordance with the Project's EAC (Condition #3 of the TOC) and as specified in the OEMP, is recommended to allow further evaluation of Harlequin Duck use of the immediate Project area post-construction.

5.5.2. Species at Risk and of Regional Concern

Incidental wildlife observations in Year 1 have provided valuable information on the timing and locations of species at risk and of regional concern within the Project area, that would otherwise not be available. Documenting incidental observations of these species will continue in Years 2 through 5, as specified in the OEMP.

5.6. Wildlife Habitat Monitoring

5.6.1. Habitat Restoration

5.6.1.1. Amphibian Habitat

Monitoring of transmission line crossings over suitable Coastal Tailed Frog streams indicated that in all locations clearing had been conducted in accordance with clearing prescriptions (restricted to topping trees, cut wood left in place, effective sediment and erosion control had been implemented). As such there are no recommendations for additional work or monitoring.

Comparison of instream habitat characteristics between pre and post-construction years within three reaches (one upstream control, one impact at the penstock crossing, and one downstream of the penstock crossing) of the Coastal Tailed Frog tributary ULL-ASTR04 demonstrate that the instream characteristics known to be important to Coastal Tailed Frogs are similar among reaches and years. These results confirm that key instream habitat restoration prescriptions were implemented in tributary ULL-ASTR04 following penstock installation and that the instream habitat has been effectively restored, with one exception. As an exception, geotextile has been left exposed within the impact reach and riparian area at the penstock crossing. Riparian habitat at ULL-ASTR04 will continue to be monitored in years 3 and 5, in conjunction with the riparian revegetation assessment (Table 1). Recommendations for further restoration work at ULL-ASTR04 include:

- Covering the areas of exposed geotextile within the riparian areas with additional rocky substrate (this recommendation also applies to riparian revegetation assessment monitoring); and
- Covering the area of exposed geotextile within the stream channel impact reach (ULL-ASTR04IM) with additional rocky substrate.

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[3] At the end of the breeding season it is difficult to distinguish adult females from juveniles of either sex.

The area of exposed geotextile is small enough that this work can be accomplished by hand, using local materials already on site. Given exposed geotextile within the stream channel the following monitoring action is also recommended:

- A spot check of instream Coastal Tailed Frog habitat at the ULR HEF penstock crossing should be conducted in coordination with riparian revegetation monitoring at this location in Year 3 to evaluate potential exposure of geotextile.

5.6.1.2. Avian Habitat

It was confirmed that clearing of riparian habitat within high quality Harlequin Duck breeding areas during transmission line construction had occurred in accordance with prescribed habitat restoration prescriptions. Clearing within 30 m of the high water mark in the transmission line RoW along the Lillooet and Ryan rivers was restricted to topping trees, coarse woody debris was present where feasible, and tree and shrub cover affected by the transmission line RoW were documented to be maintaining important riparian vegetation characteristics as required by Harlequin Ducks for nesting. As such, there are no recommendations for additional work or monitoring and this monitoring component is now complete.

Transmission line poles were confirmed to be located away from the three identified suitable Peregrine Falcon nesting ledges, as per requirements of the Project's EAC (Condition #24 of the TOC). As such, it was evaluated that the transmission line is not reducing habitat suitability of these nesting ledges and compliance with habitat restoration measures prescribed for Peregrine Falcons was confirmed. There are therefore no recommendations for additional work or monitoring and this monitoring component is now complete.

5.6.1.3. Mammal Habitat

Mammal habitat restoration compliance monitoring for Grizzly Bear, Moose, and Mule Deer indicated that for most of the restoration monitoring sites (23 of 29 sites), future reassessment in Year 3 will be required. Most of the screens requiring reassessment had not attained the required height (5 m), which is not unexpected given that these results are from the first year of monitoring. At some sites the screen also did not have the required width. For these sites, future reassessment will be required to confirm that the vegetated screen meets the requirements specified in the OEMP. Natural regeneration and vegetation growth are anticipated to create an adequate screen at most sites over time. At one site (ULH-MAMCM09), the potential need for planting was identified, and this will be re-evaluated in Year 3. Inspections of facilities with waste management requirements indicated that although garbage and food waste was generally disposed of properly, attractants were observed on one occasion in open waste containers outside of the ULR HEF powerhouse and Boulder Creek HEF powerhouse. Given the observations of bear attractants, and that vegetation screens in 23 locations have not yet attained the required height (5 m) and/or width (5 m), the following monitoring actions are recommended:

- All sites where vegetation screens had not yet attained the required height (5 m) and/or width (5 m) (as specified in the last column of Table 66) should be revisited in Year 3 to assess ongoing vegetation screen growth. At that time the need for measures to enhance vegetation growth will be assessed for any sites where requirements are not yet met; and
- Compliance with proper disposal of food waste at facilities with waste management requirements should be confirmed in Year 2.

5.6.2. Mitigation Effectiveness

5.6.2.1. Avian Collisions

The OEMP specified that the potential need for additional data collection to evaluate the effectiveness of bird diversion markers on the transmission lines (where they cross the Upper Lillooet and Ryan rivers) in preventing avian collisions will be reviewed after surveys have been conducted for one year. Bird diversion markers were confirmed to be installed on the transmission line to increase visibility where the transmission line crosses the Upper Lillooet River and the Ryan River. No avian carcasses were observed during a total of six surveys, one in spring and fall for each of three high risk locations. Ground visibility was limited by dense vegetation at one site and detection conditions were suboptimal due to high flows during the fall survey at the Ryan River transmission line crossing; however, avian carcasses were also not observed during surveys when conditions where vegetation was less dense or when flows were lower. Although a lack of observations does not mean that no birds are colliding with power lines (in addition to suboptimal conditions in some surveys, scavengers are likely to remove carcasses soon after they appear), the lack of observed carcasses during good conditions also suggests that additional years of surveys are unlikely to be useful. Thus, we are not recommending that additional surveys be conducted in future years.

5.6.2.2. Mountain Goats

Upper Lillooet River HEF

Results from mitigation effectiveness monitoring for Mountain Goats indicated that the Truckwash Creek migration corridor, in the vicinity of the ULR HEF downstream tunnel portal, is still being used by Mountain Goats post-construction. This was evident from all survey methods used: infrared cameras documented Mountain Goats of both sexes and all age classes along the migration corridor, systematic winter ground-based surveys documented the presence of Mountain Goat sign (tracks and sign) in the vicinity of the ULR HEF downstream portal, and opportunistic monitoring of the Keyhole Falls Mountain Goat winter range (UWR u-2-002 UL 11) indicated that Mountain Goats, including nannies, are continuing to use this winter range. Although systematic ground-based surveys were planned for up to three years post-construction, the OEMP specified that the potential need for additional data to evaluate the effectiveness of the partial visual and auditory barrier design at the ULR HEF downstream tunnel portal in maintaining use of the Truckwash Creek migration corridor by Mountain Goats (from systematic winter ground-based surveys or remote infrared cameras) would be evaluated after the first post-construction monitoring year. Given the success of Year 1 monitoring in demonstrating continued Mountain Goat use of the Truckwash Creek migration corridor and Keyhole Falls winter range (UWR u-2-002 UL 11), we recommend that Mountain Goat mitigation effectiveness monitoring at the ULR HEF be discontinued.

Boulder Creek HEF

Results from mitigation effectiveness monitoring conducted to evaluate the effectiveness of the gate in preventing public access to the Boulder Creek HEF intake area within the Mountain Goat winter range during winter indicated that the access road was accessible to the public by motorized vehicle on one occasion when the gate is required to be closed (preventing motorized public access). However, because the camera that was installed to provide a view of the gate (BDR-CAM03) was not functioning when the motorized vehicle (ATV) gained access to the intake area and winter range, it was not possible to determine how access was gained (i.e., whether the gate was open or closed, and if closed, how the vehicle passed by). Monitoring also indicated that the gate becomes non-functional during the winter months due to burial from snow and therefore will not impede snowmobile access.

If a motorized vehicle can pass the gate and continue along the access road to the winter range during the November 1 to June 15 period, the gate is not effective in preventing access, and corrective action needs to be taken. No incidents of the public passing the gate during mid-winter when the gate was buried in snow were documented, thus potential gate inadequacies during these conditions are not currently an issue. However, the cause of the problem during the snow-free period was not determined which is the first critical step in finding a solution. Posting a back-up camera at the gate (for if/when BDR-CAM03 becomes non-functional) is a possible means of identifying the problem; however, cameras are difficult to install in the location of the gate without being noticeable, in which case they may either deter entry until they are uninstalled at the end of the monitoring period (which would bias monitoring data) or encourage vandalism. Given these considerations, the following measures are recommended to help increase gate effectiveness:

- an automated electronic reminder and sign-off system is setup to confirm the gate is kept closed during the required period (November 1 to June 15), the effectiveness of which will be ensured through monitoring in future years;
- signage is posted at the base of the access road to inform 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; and
- a barricade will be installed on the upslope side of the gate to block the potential passage of smaller vehicles, in such as manner as not to impede drainage of the ditch on the upslope side of the road.

Predator Monitoring

Results from mitigation effectiveness monitoring conducted to evaluate predator presence and behavior within the Mountain Goat winter range post-construction, which will be used to assess potential access-related increase in risk to Mountain Goats, did not identify differences in predator use or activity between pre and post-construction. Comparison of remote infrared camera monitoring results and ground-based and/or aerial survey results to date suggest that the amount and type of predator sign detected during the Mountain Goat winter season (December through May) was similar between pre and post-construction. However, owing to the typically low frequency of predator detections, which makes it difficult to obtain adequate sample sizes for meaningful comparison, and in accordance with requirements of the OEMP, continued predator monitoring in the following years is needed to document whether or not a notable increase in predator use of the area is observed as the road receives less Project-related use during winter and predators potentially discover the road and adjust their habitat use.

5.7. Vegetation Monitoring

Vegetation monitoring is scheduled annually for Years 1-5 in the approved version of the OEMP (Harwood *et al.* 2017). Subsequent revisions to the OEMP were proposed to MFLNRORD in February 2018 (Harwood *et al.* 2018) that include reducing the frequency of the vegetation monitoring program to Years 1, 3 and 5 which would match the riparian vegetation monitoring schedule. Hedberg recommends following this revised monitoring schedule (Appendix C). However, a survival survey is recommended in Year 2 (2019) to assess the general survival rates of trees planted in civil works sites in 2018 (Appendix C). No further revegetation treatments are recommended at this time (Appendix C).

6. CLOSURE

The OEMP outlines the operational monitoring frequency and duration for each monitoring component. The monitoring objectives for Year 1 were achieved. There are no changes recommended to the monitoring programs being conducted under the Project's OEMP at this time, with the exceptions of the change to the Mountain Goat mitigation effectiveness monitoring program at the Boulder Creek HEF that was previously communicated to FLNRORD (Newbury *et al.* 2018, Katamay-Smith, pers. comm. 2018b), the removal of water quality monitoring in Years 2 - 5, and removal of vegetation monitoring in Year 2 and 4. For Year 2 of operations, the following will be completed, with all data collection following the methods outlined in the Project's OEMP (Harwood *et al.* 2017) and described in detail in Section 3 above.

- Juvenile fish density monitoring in the diversion and upstream reaches of the Upper Lillooet River and the diversion and downstream reaches of Boulder Creek will continue in Year 2 at established monitoring sites. Juvenile fish density monitoring will also continue within the tributary at km 87.0 in support of an assessment of fish entrainment at the Upper Lillooet River HEF intake.

- Adult fish distribution and migration will continue to be monitored through a mixture of angling surveys in the Upper Lillooet River and Boulder Creek, and spawning surveys in 29.2 km Tributary, North Creek, and Alena Creek in Year 2.
- Harlequin Duck use of the Upper Lillooet River HEF area will continue to be monitored through vantage point surveys along with the recording and compilation of incidental observations.
- Incidental observations of species at risk and of regional concern will continue to be recorded and compiled.
- Compliance with proper disposal of food waste and containers will be confirmed in Year 2 through a spot check at the ULR HEF powerhouse and the Boulder Creek powerhouse.
- Mountain Goat mitigation effectiveness monitoring will continue at the Boulder Creek HEF to: 1) evaluate the effectiveness of the gate in preventing public access during winter, and 2) to evaluate predator presence and behaviour within the winter range post-construction which will be used to assess potential access-related increase in risk to Mountain Goats through the strategic placement of remote infrared cameras.
- Tree seedling survival survey of civil works sites where planting occurred in 2018.

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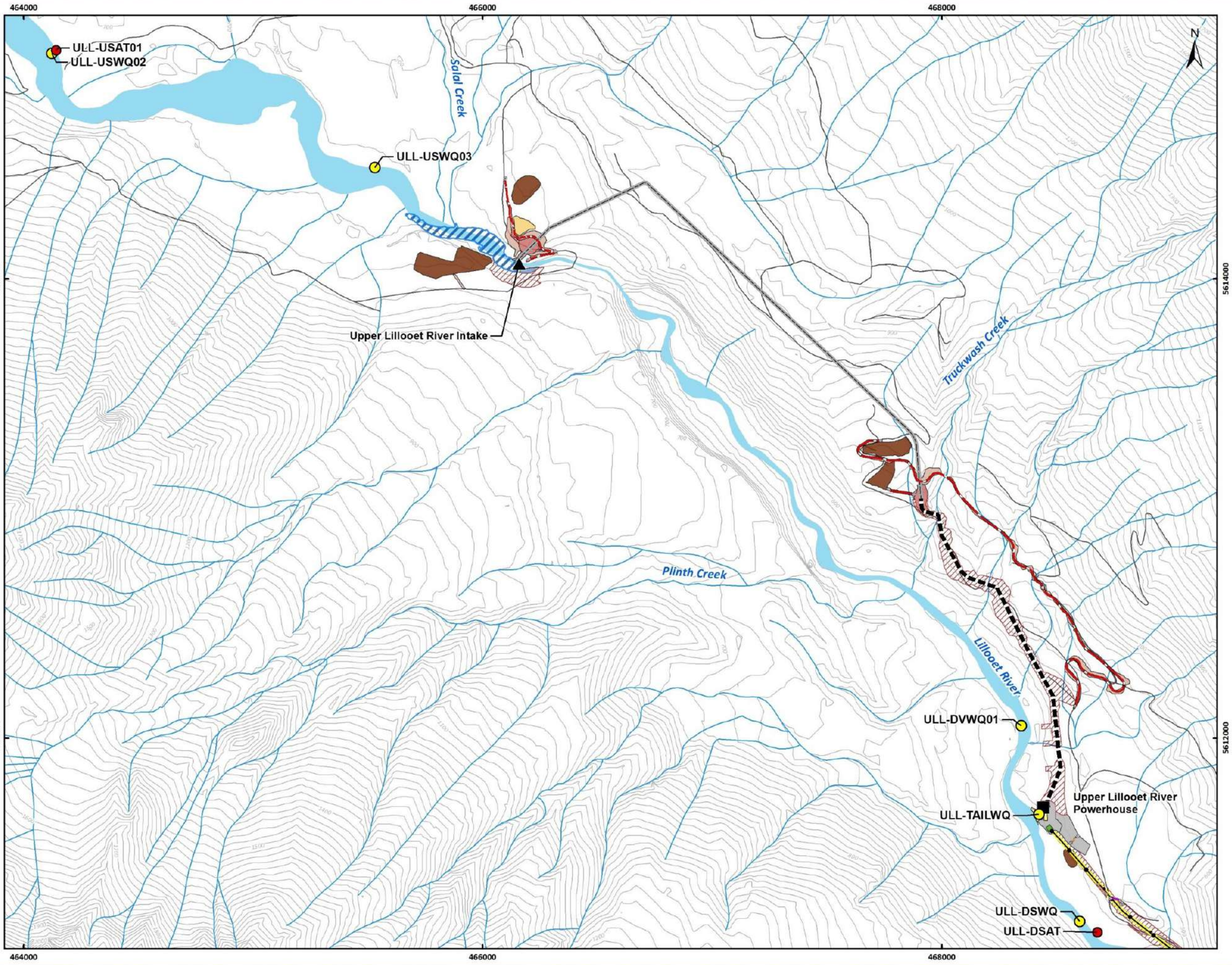
PROJECT MAPS

UPPER LILLOOET HYDROPOWER PROJECT

Upper Lillooet River Water Quality, Water Temperature and Air Temperature Monitoring Sites



Legend

- ● Air Temperature
- ● Water Quality and Water Temperature

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- New Facility Road
- New Tower Road
- Existing Road Upgraded
- Penstock
- Tunnel
- Transmission Line
- ▨ Headpond
- Rip Rap
- Intake Structure
- Temporary Diversion Channel
- Portal
- Powerhouse Building
- Switchyard
- Tailrace
- Spoil/Borrow Area
- Laydown Area
- Permanent Clearing Area
- ▨ Temporary Clearing Area
- New Road ROW
- Roads
- Forestry Service Road
- 20 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 100 200 400 600 800 Meters

Scale: 1:16,000

NO.	DATE	REVISION	BY
1	22/03/2019	1095_ULL_WQ_WT_AT_MonSites_2019Jan24	CGA
2			
3			
4			
5			

Date Saved: 22/03/2019
Coordinate System: NAD 1983 UTM Zone 10N

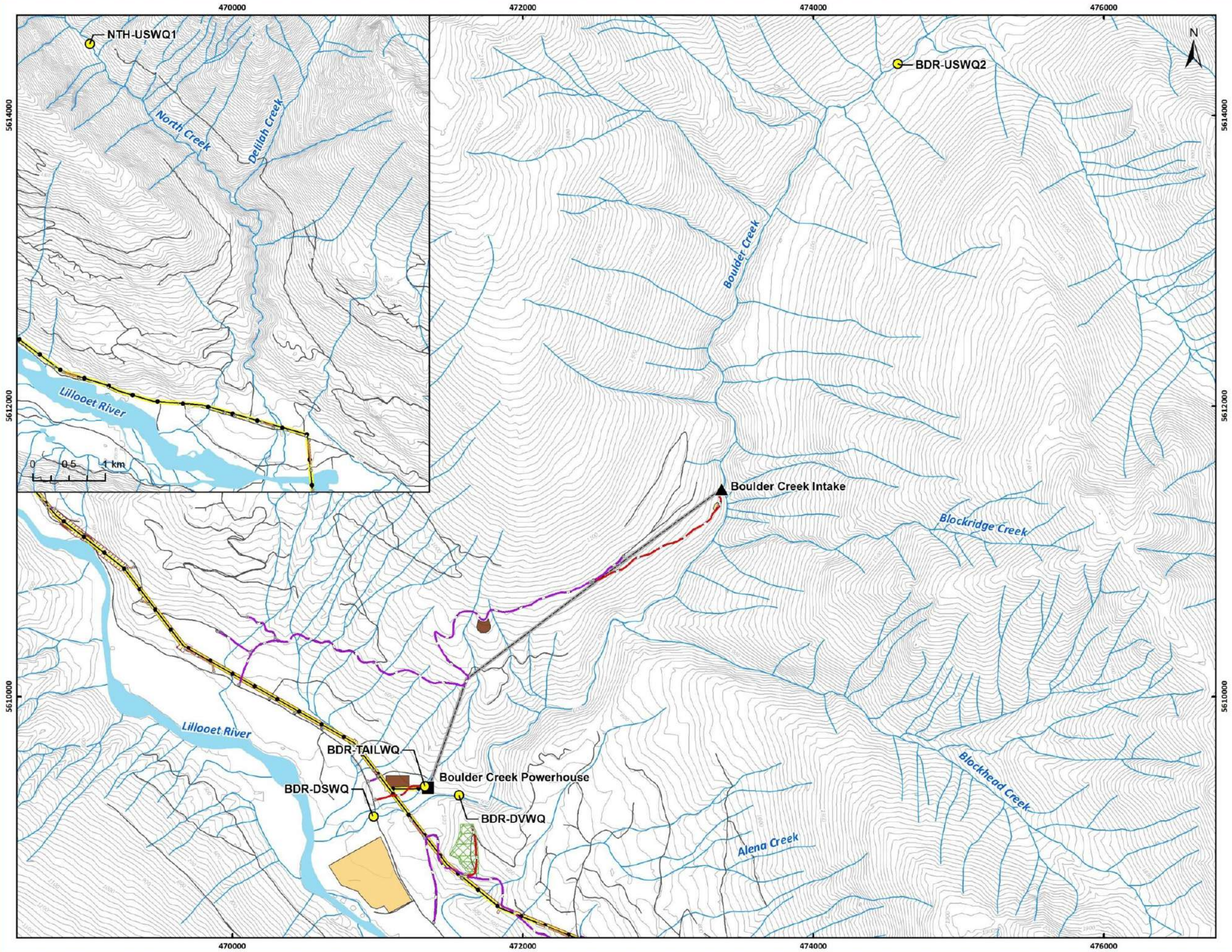
ECOFISH RESEARCH

Map 2

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\WaterQuality\1095_ULL_WQ_WT_AT_MonSites_2019Jan24.mxd

UPPER LILLOOET HYDROPOWER PROJECT

Boulder Creek Water Temperature Monitoring Sites



Legend

- ○ Water Temperature Monitoring Site

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- New Facility Road
- New Tower Road
- Existing Road Upgraded
- Penstock
- Tunnel
- Transmission Line
- 🟫 Spoil/Borrow Area
- 🟨 Laydown Area
- ▨ Temporary Clearing Area
- ▨ Camp
- Roads
- Forestry Service Road
- 20 m Contours

0 0.25 0.5 1 km

Scale: 1:25,000

NO.	DATE	REVISION	BY
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2			
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Date Saved: 22/03/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 3

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\WaterQuality\1095_BDR_WT_MonitoringSites_2019Feb26.mxd

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

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

UPPER LILLOOET HYDRO PROJECT

Riparian Revegetation Assessment Sites

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

Scale: 1:25,000

NO.	DATE	REVISION	BY
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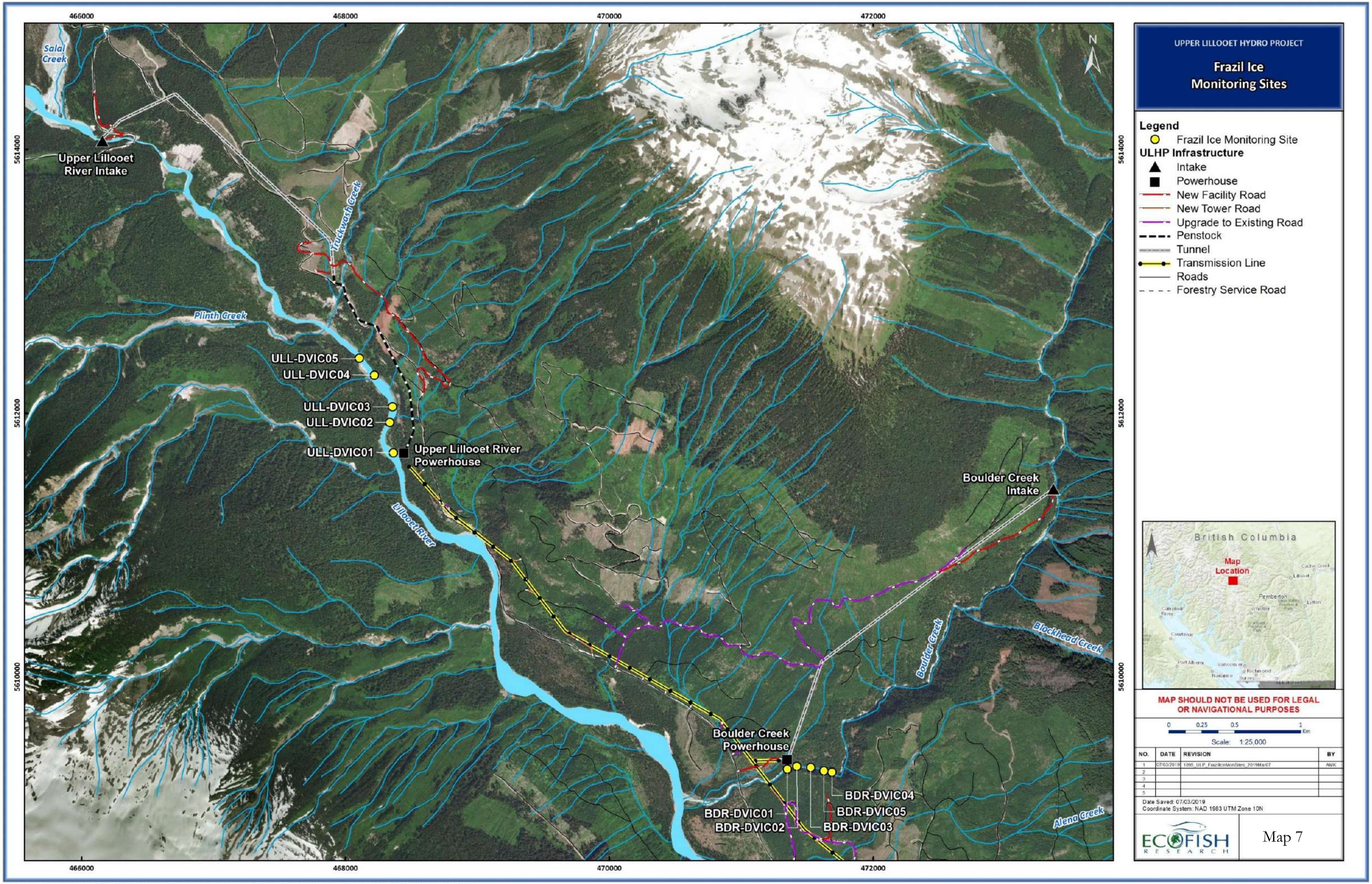
3			
4			
5			

Date Saved: 05/03/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 6

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Riparian\1095_ULP_RiparianRevegAssmtSites_2019Jan17.mxd



UPPER LILLOOET HYDRO PROJECT

Frazil Ice Monitoring Sites

Legend

● Frazil Ice Monitoring Site

ULHP Infrastructure

▲ Intake
■ Powerhouse
New Facility Road
New Tower Road
Upgrade to Existing Road
Penstock
Tunnel
Transmission Line
Roads
Forestry Service Road

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

Scale: 1:25,000

NO.	DATE	REVISION	BY
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2			
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Date Saved: 07/03/2019
Coordinate System: NAD 1983 UTM Zone 10N

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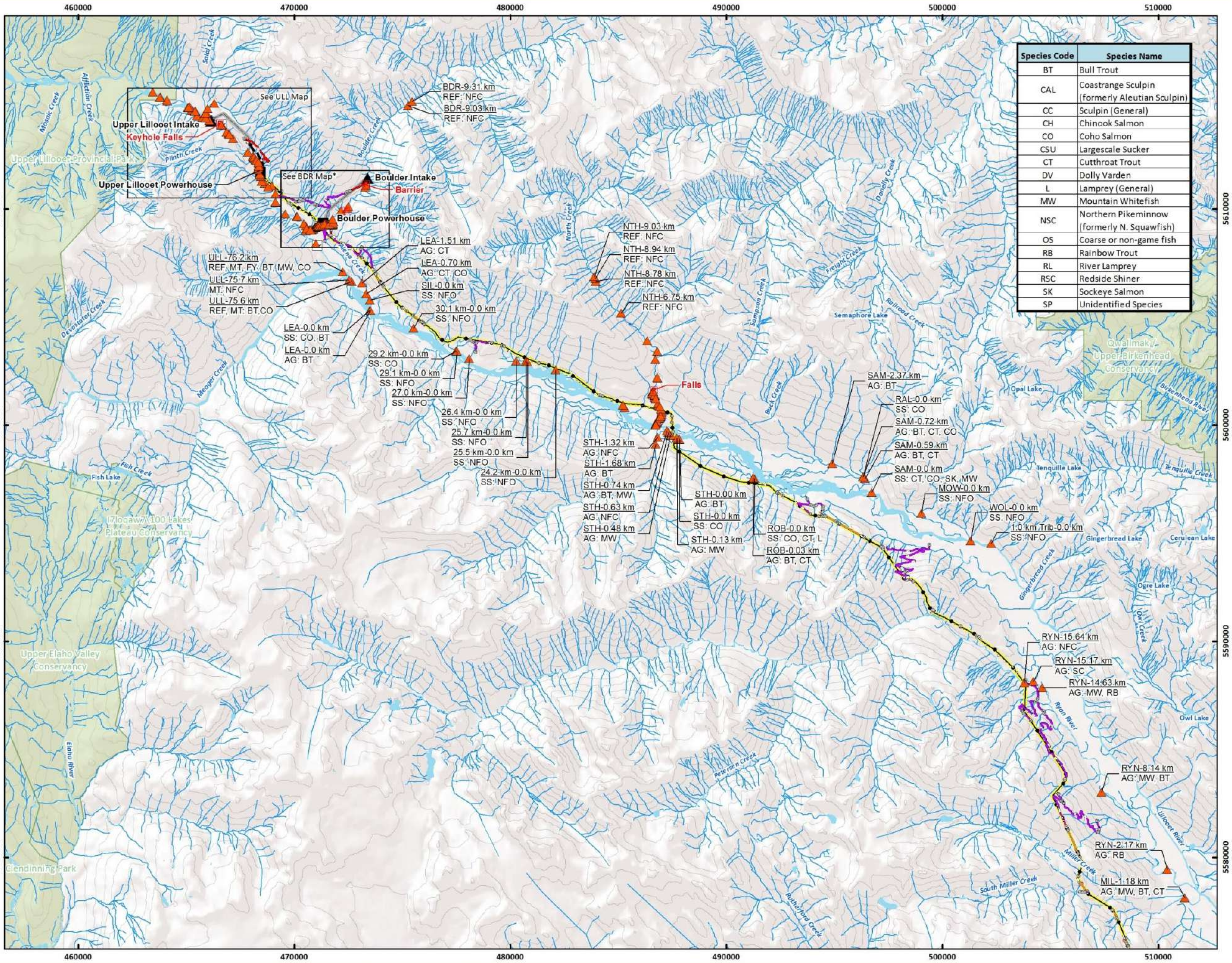
Map 7

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ULP_FrazilIceMonSites_2019Mar07.mxd

UPPER LILLOOET HYDRO PROJECT

Fish Sampling Sites Overview



Species Code	Species Name
BT	Bull Trout
CAL	Coastrange Sculpin (formerly Aleutian Sculpin)
CC	Sculpin (General)
CH	Chinook Salmon
CO	Coho Salmon
CSU	Largescale Sucker
CT	Cutthroat Trout
DV	Dolly Varden
L	Lamprey (General)
MW	Mountain Whitefish
NSC	Northern Pikeminnow (formerly N. Squawfish)
OS	Coarse or non-game fish
RB	Rainbow Trout
RL	River Lamprey
RSC	Redside Shiner
SK	Sockeye Salmon
SP	Unidentified Species

Legend

- ▲ Fish Sampling Sites

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- New Facility Road
- New Tower Road
- Upgrade Required to Existing Road
- Penstock
- Tunnel
- Transmission Line
- ▨ Headpond
- 🟩 Parks and Protected Areas
- 200m Contours

*Further details on fish sampling in BDR and NTH creeks are presented in Faulkner et al. (2011).

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 Km

Scale: 1:170,000

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Date Saved: 12/07/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

MAP: Map 8

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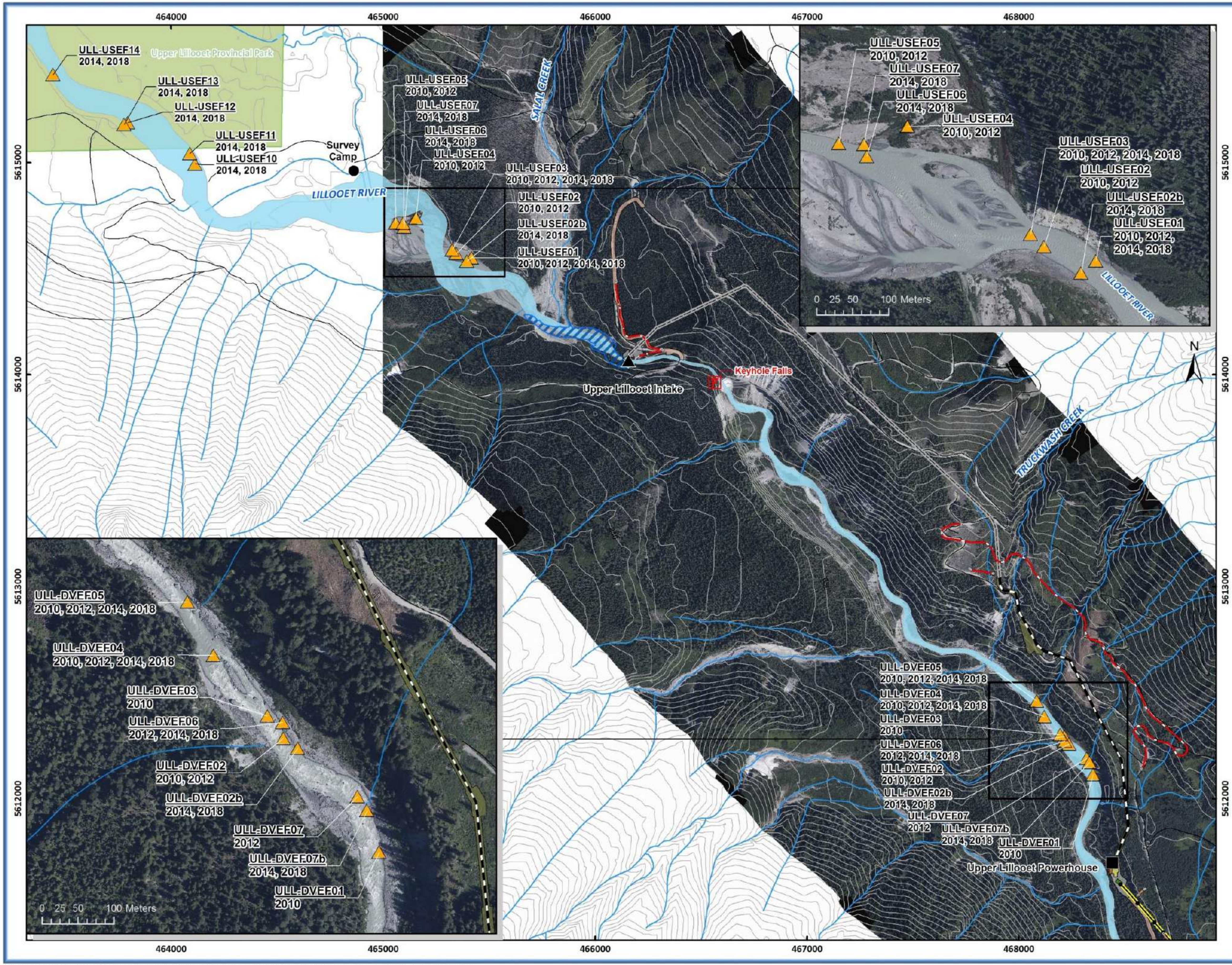

UPPER LILLOOET HYDRO PROJECT

Upper Lillooet River Electrofishing Sites

Legend

- ▲ Electrofishing Site
- **ULHP Infrastructure**
- ▲ Intake
- ■ Powerhouse
- ● Survey Camp
- New Facility Road
- New Tower Road
- Penstock
- Tunnel
- Transmission Line
- ▨ Headpond
- Rip Rap
- Intake Structure
- Powerhouse Building
- 🟩 Switchyard
- Tailrace
- Penstock RoW
- Permanent Clearing Area
- New Road RoW
- Parks and Protected Areas
- Existing Roads
- 20 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 100 200 400 600 800 m

Scale: 1:17,000

NO.	DATE	REVISION	BY
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3			
4			
5			

Date Saved: 17/04/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 9

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ULL_EFSites_2018Apr17.mxd

Map 10

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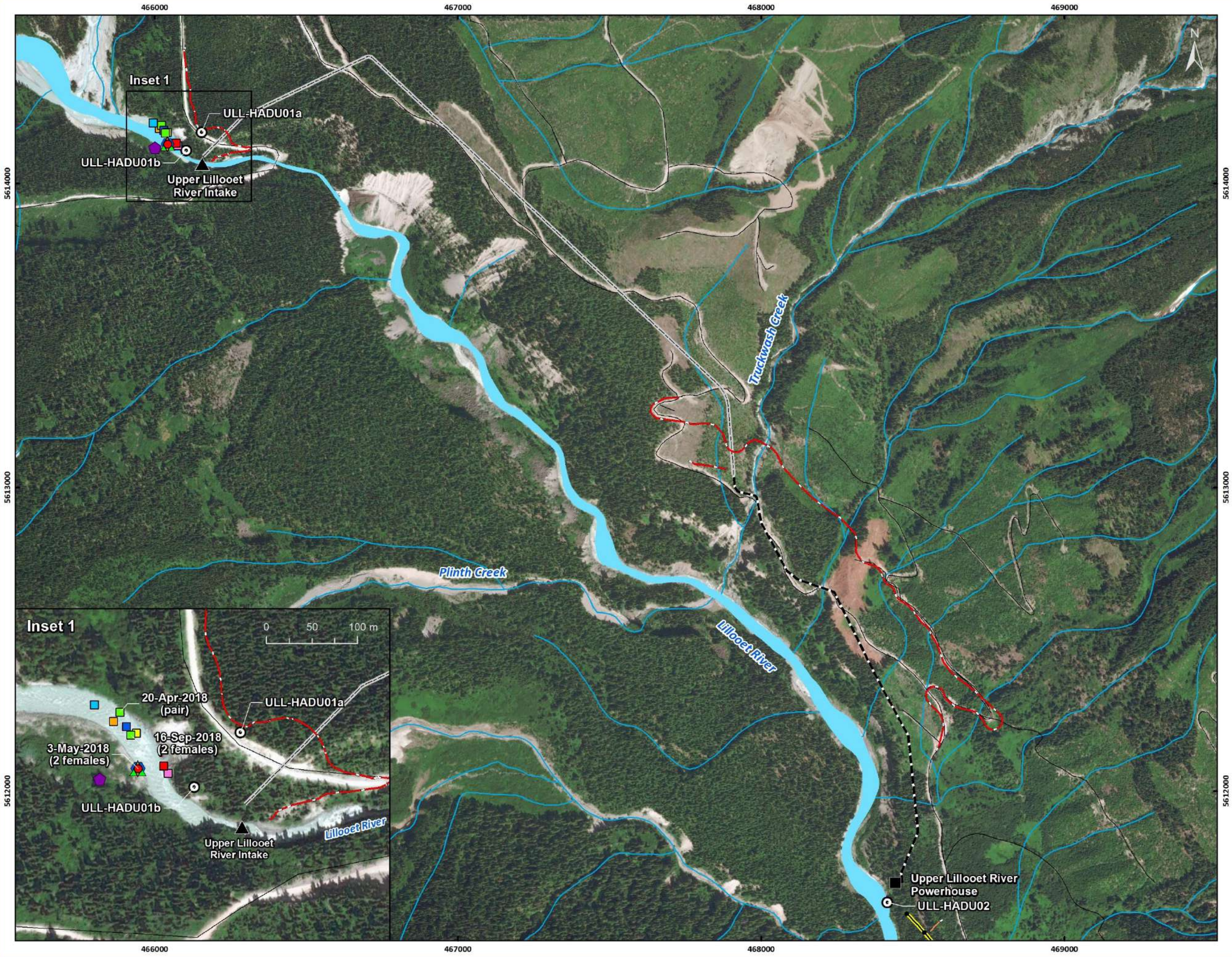

UPPER LILLOOET HYDRO PROJECT

Harlequin Duck Spot Check Surveys in 2018

Legend

⊙ Harlequin Duck Spot Check Survey Vantage Points

Riverine Bird Survey Observations

- ▲ Harlequin Duck
- ● American Wigeon
- ◆ Barrow's Goldeneye
- ⬢ Mallard
- ⬟ Spotted Sandpiper

Riverine Bird Incidental Observations

- 🟩 Harlequin Duck
- 🟥 American Wigeon
- 🟧 Barrow's Goldeneye
- 🟨 Bufflehead
- ■ Common Merganser
- 🟦 Duck
- 🟦 Mallard

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- — New Facility Road
- — New Tower Road
- — Upgrade to Existing Road
- - - Penstock
- — Tunnel
- — Transmission Line
- — Roads
- - - Forestry Service Road

0 50 100 200 300 400 500 Meters

Scale: 1:12,000

NO.	DATE	REVISION	BY
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3			
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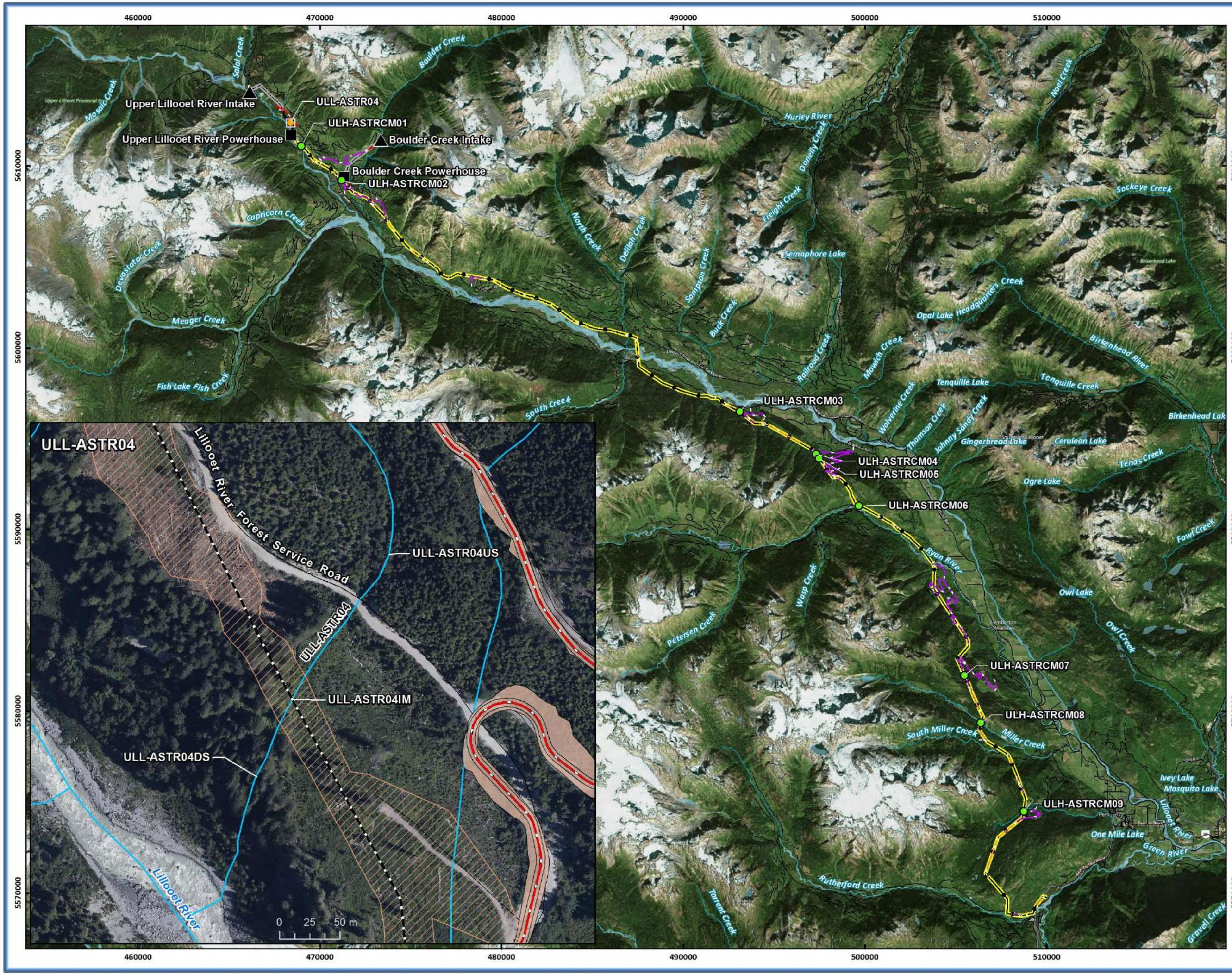
Date Saved: 06/03/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 11

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\HarlequinDuck\1095_ULP_HADU_SpotCheckSurveys2018_2019Jan22.mxd



UPPER LILLOOET HYDRO PROJECT

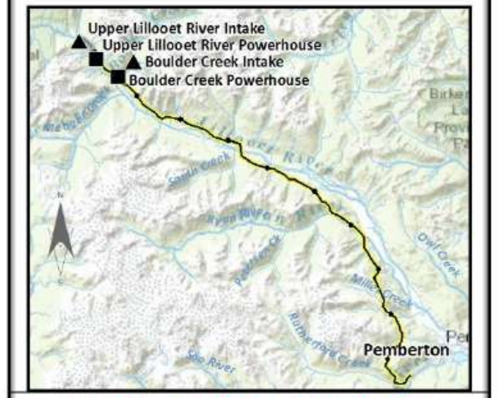
Coastal Tailed Frog Habitat Restoration Monitoring Locations

Legend

- 🟢 Coastal Tailed Frog streams at the Transmission Line Crossing
- 🟠 Coastal Tailed Frog stream at the Penstock Crossing

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- New Facility Road
- New Tower Road
- Upgrade to Existing Road
- Penstock
- Tunnel
- Transmission Line
- ▨ Temporary Clearing Area
- New Road ROW
- Roads
- Forestry Service Road



MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 Km

Scale: 1:200,000

NO.	DATE	REVISION	BY
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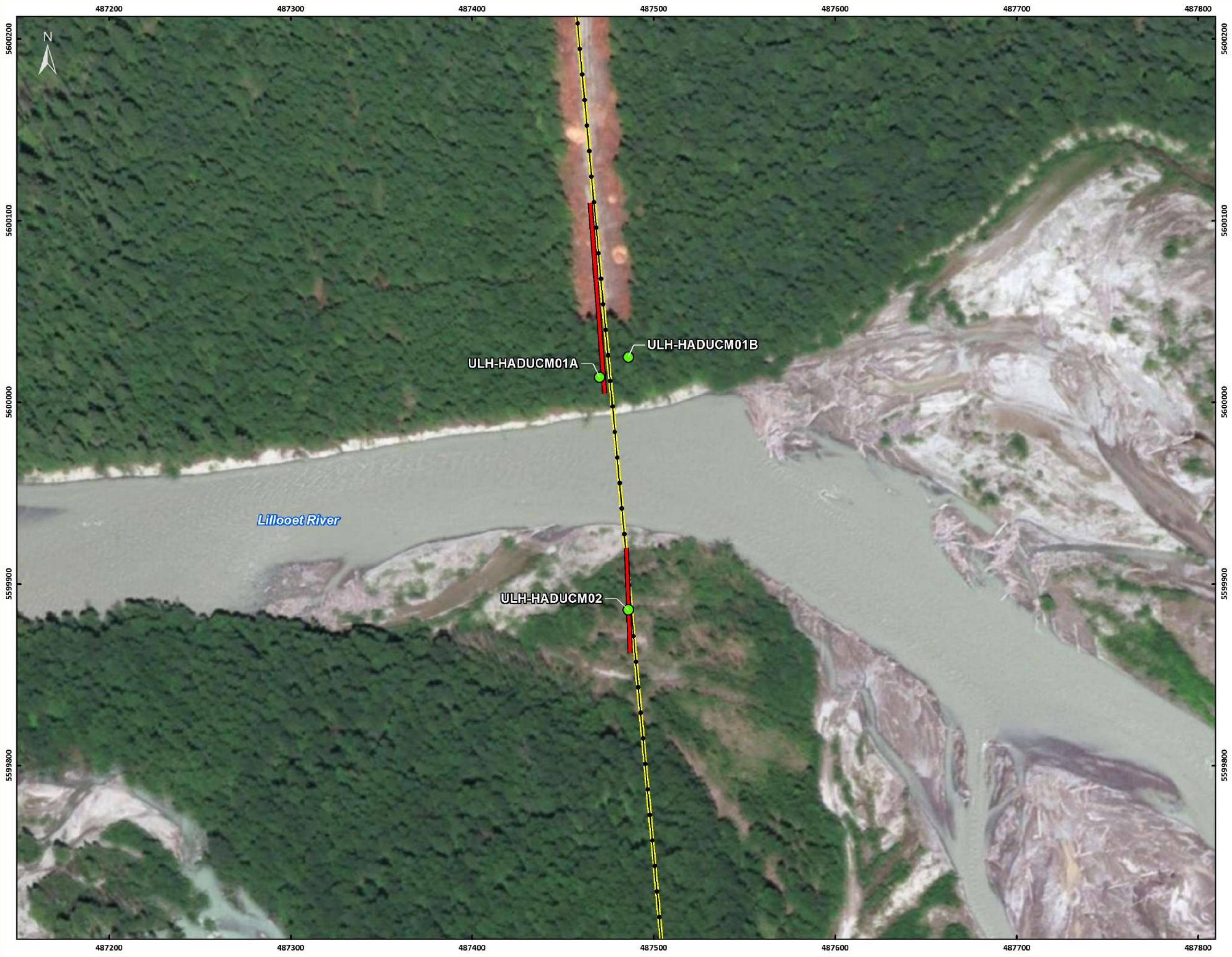
3			
4			
5			

Date Saved: 22/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 12

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\TailedFrogs\1095_ULL_ASTR_HabitatRestorationMonLocs_2019Feb22.mxd



UPPER LILLOOET HYDRO PROJECT

Avian Habitat Restoration and Mitigation Effectiveness Monitoring at the Lillooet River Transmission Line Crossing

Legend

●	Harlequin Duck Riparian Habitat Monitoring Locations
🟥	Avian Collision Survey Transects
●—	Transmission Line

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 10 20 40 60 80 100 Meters

Scale: 1:2,000

NO.	DATE	REVISION	BY
1	19/02/2019	1095_ULP_AvianHabRest_MitEffectMon_2019Feb19	CGA
2			
3			
4			
5			

Date Saved: 19/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 13

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\HarlequinDuck\1095_ULP_AvianHabRest_MitEffectMon_2019Feb19.mxd

UPPER LILLOOET HYDRO PROJECT

Avian Habitat Restoration and Mitigation Effectiveness Monitoring at the Ryan River Transmission Line Crossing

Legend

- ● Harlequin Duck Riparian Habitat Monitoring Locations
- 🟥 Avian Collision Survey Transect
- Transmission Line

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

Scale: 1:2,000

NO.	DATE	REVISION	BY
1	19/02/2019	1095_ULP_AvianHabRest_MitEffectMon_2019Feb19	CGA
2			
3			
4			
5			

Date Saved: 19/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

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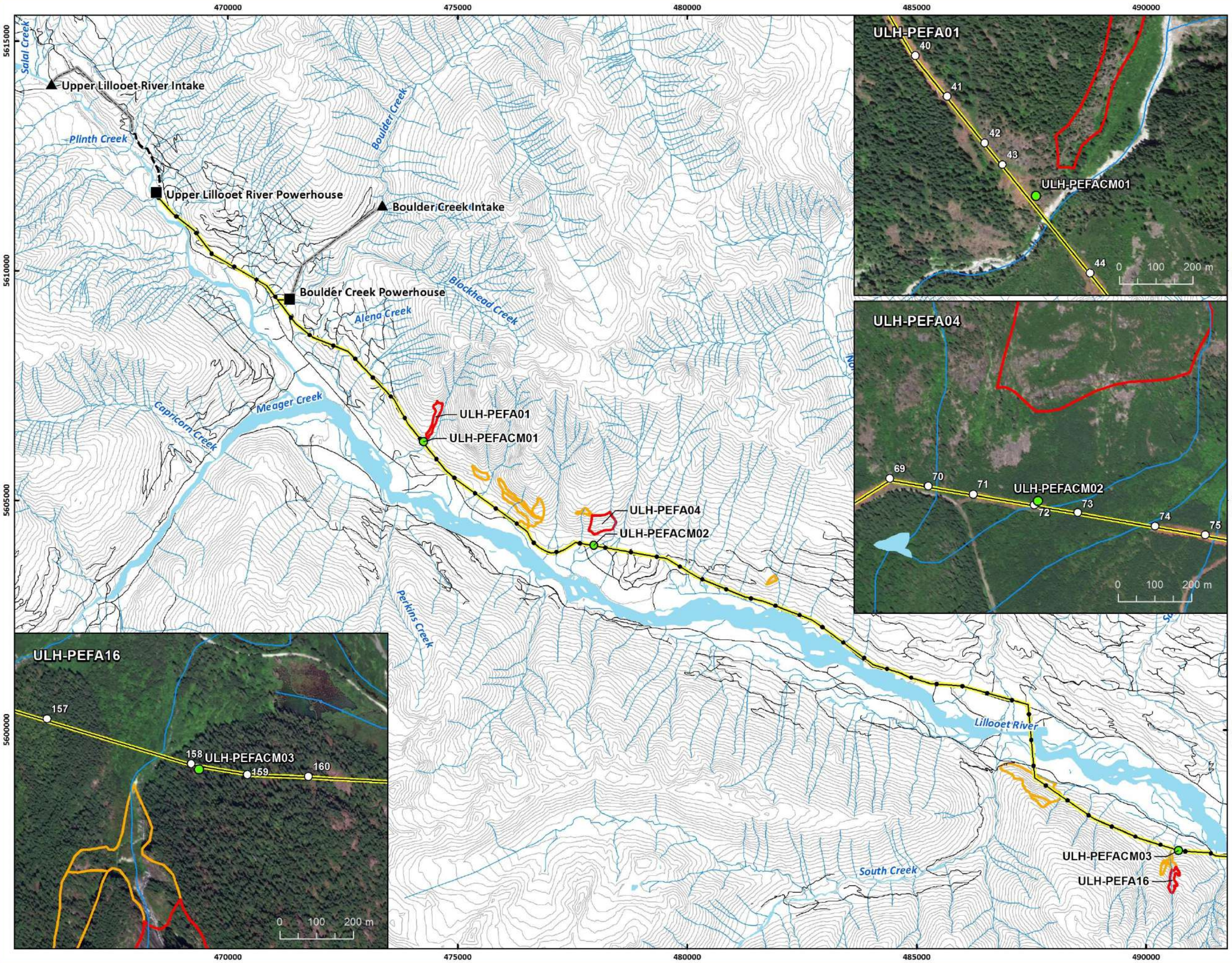
Map 14

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\HarlequinDuck\1095_ULP_AvianHabRest_MitEffectMon_2019Feb19.mxd

UPPER LILLOOET HYDRO PROJECT

Peregrine Falcon Habitat Monitoring Locations



Legend

- ● Peregrine Falcon Habitat Compliance Monitoring Sites

Peregrine Falcon Suitable Habitat

- 🟥 High
- 🟧 Moderate

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- Penstock
- Tunnel
- ○ Transmission Line Tower
- Transmission Line
- Roads
- Forestry Service Road
- 50 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.5 1 2 3 4 Km

Scale: 1:80,000

NO.	DATE	REVISION	BY
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3			
4			
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Date Saved: 22/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

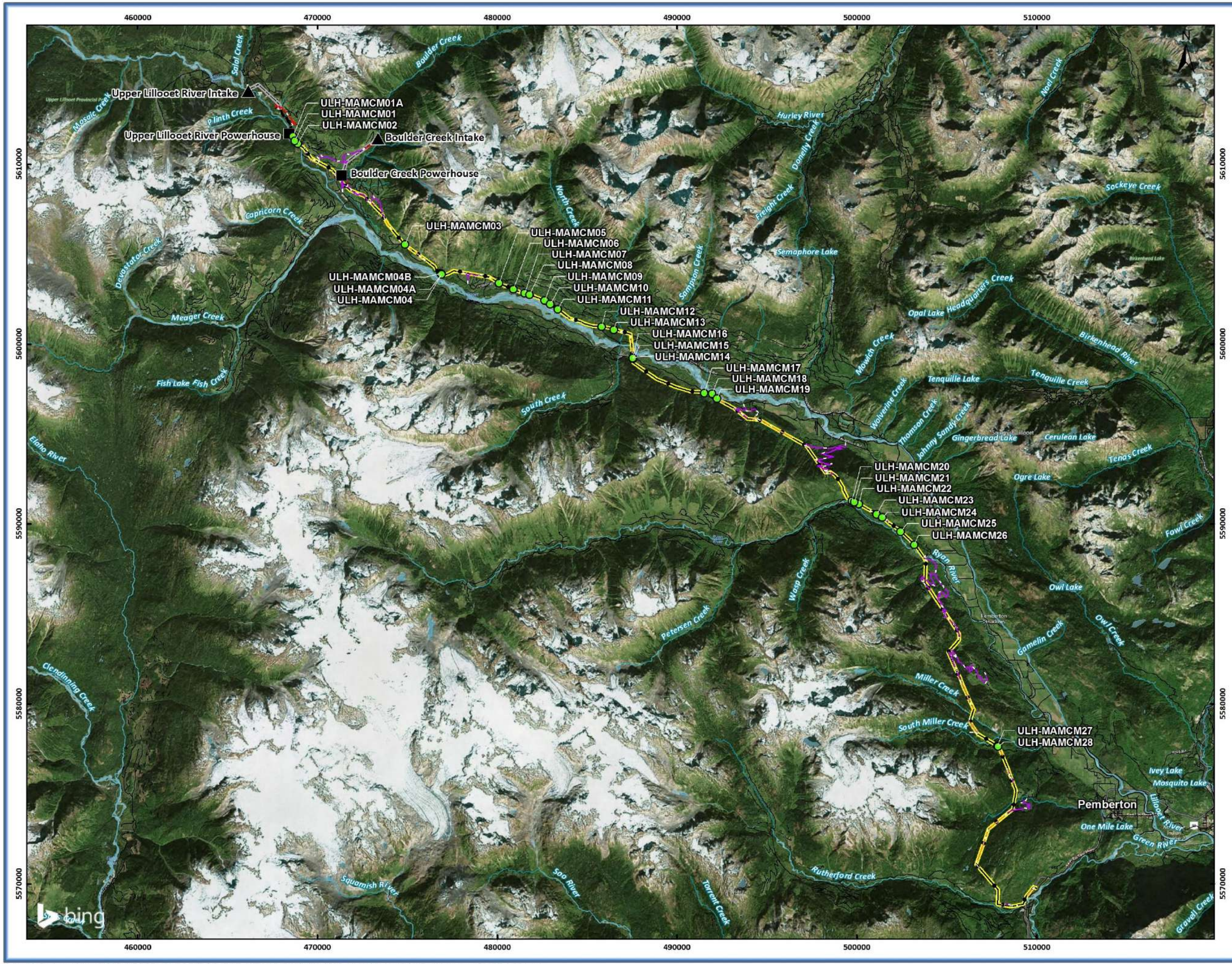
ECOFISH RESEARCH

Map 15

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\PeregrineFalcon\1095_ULP_PEFA_HabitatMonLocs_2019Feb22.mxd

UPPER LILLOOET HYDRO PROJECT

Mammal Habitat Restoration Monitoring Locations

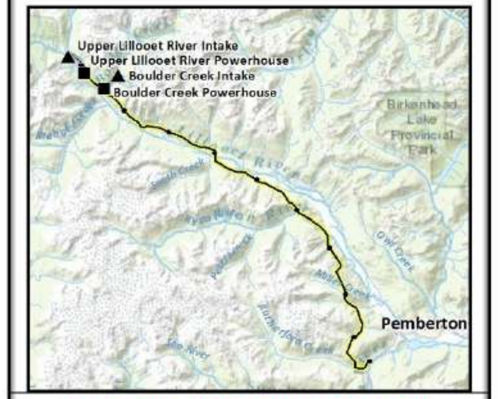


Legend

- ● Mammal Habitat Restoration Monitoring Locations

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- — New Facility Road
- — New Tower Road
- — Upgrade to Existing Road
- - - Penstock
- ═ Tunnel
- ●—● Transmission Line
- — Roads
- - - Forestry Service Road



MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 10 Km

Scale: 1:200,000

NO.	DATE	REVISION	BY
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2			
3			
4			
5			

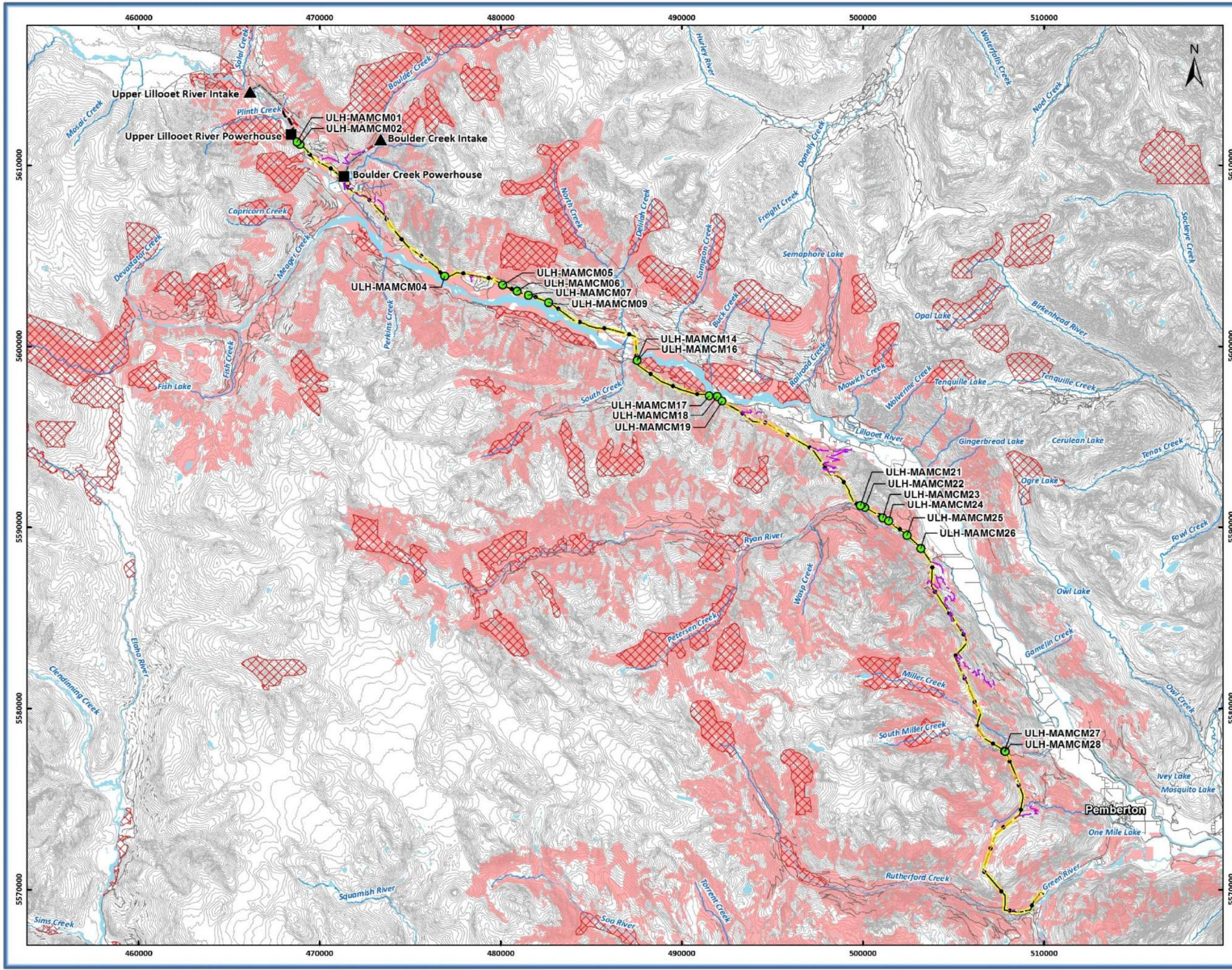
Date Saved: 22/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 16

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\1095_ULH_MammalHabResMonLocs_2019Feb22.mxd

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



UPPER LILLOOET HYDRO PROJECT

Mammal Habitat Restoration Monitoring Locations - Grizzly Bear

Legend

● Mammal Habitat Restoration Monitoring Locations - Grizzly Bear
▨ Grizzly Bear Wildlife Habitat Areas
🟥 Class 1 and 2 Suitable Grizzly Bear Habitat

ULHP Infrastructure

▲ Intake
■ Powerhouse
— New Facility Road
— New Tower Road
— Upgrade to Existing Road
- - Penstock
═ Tunnel
—●— Transmission Line
— Roads
- - Forestry Service Road
— 50 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 10 Km

Scale: 1:200,000

NO.	DATE	REVISION	BY
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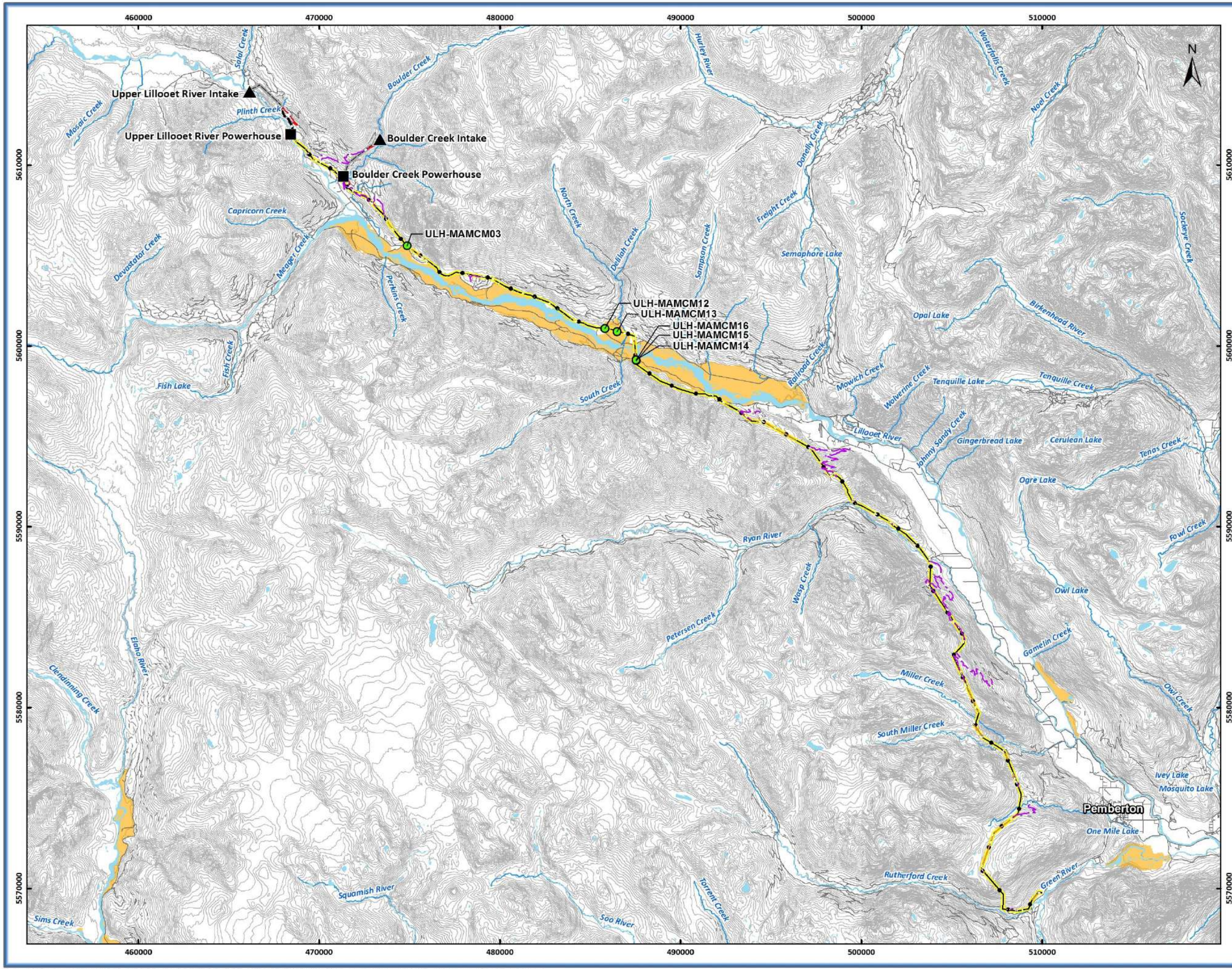
Date Saved: 27/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 18

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\1095_ULH_MammalHabResMonLocs_2019Feb26.mxd



UPPER LILLOOET HYDRO PROJECT

Mammal Habitat Restoration Monitoring Locations - Moose

Legend

● Mammal Habitat Restoration Monitoring Locations - Moose

🟧 Moose Winter Range

ULHP Infrastructure

▲ Intake

■ Powerhouse

— New Facility Road

— New Tower Road

— Upgrade to Existing Road

- - - Penstock

═ Tunnel

—●— Transmission Line

— Roads

- - Forestry Service Road

— 50 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 10 Km

Scale: 1:200,000

NO.	DATE	REVISION	BY
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Date Saved: 27/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 19

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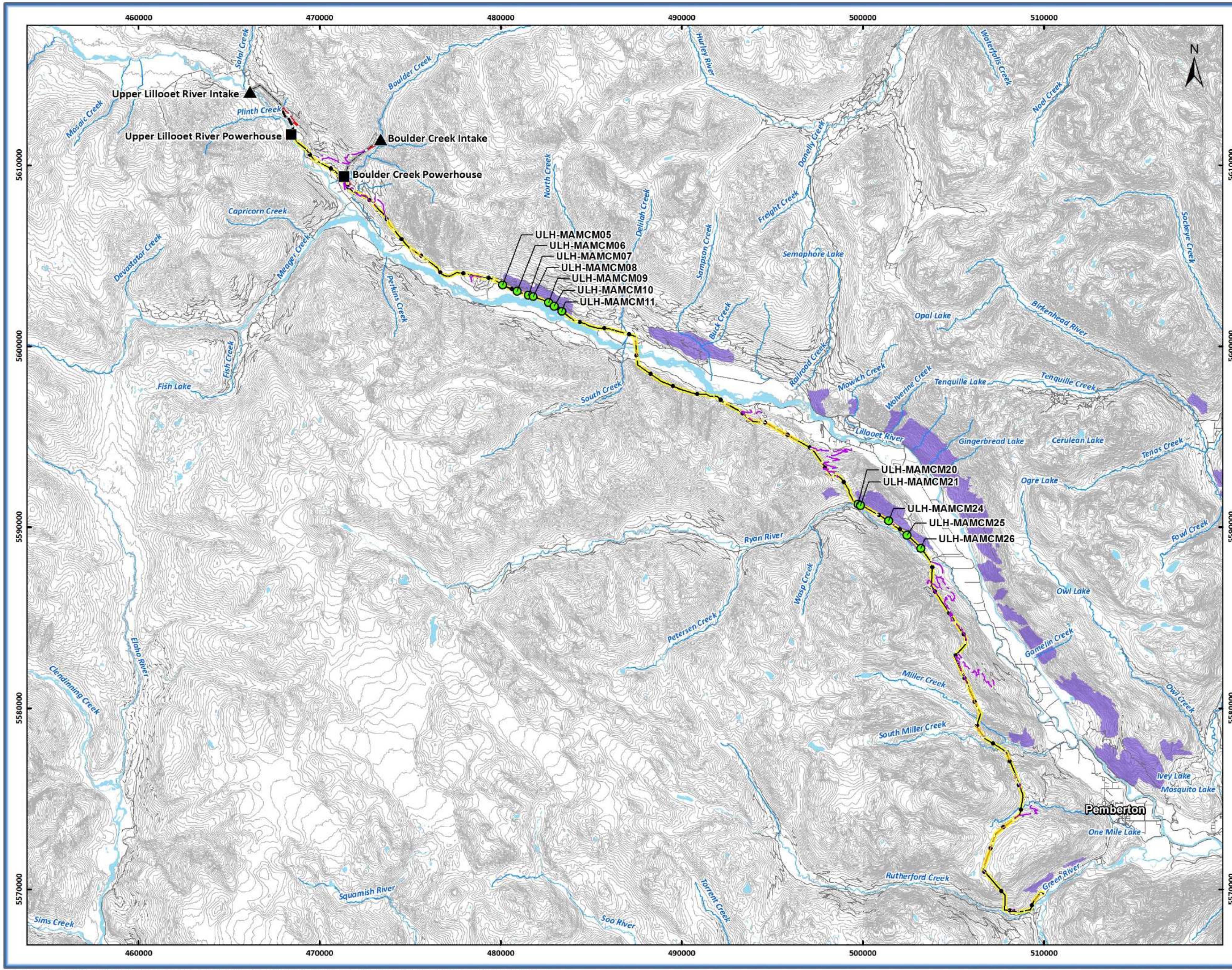

UPPER LILLOOET HYDRO PROJECT

Mammal Habitat Restoration Monitoring Locations - Mule Deer

Legend

- ● Mammal Habitat Restoration Monitoring Locations - Mule Deer
- ▨ Mule Deer Winter Range

ULHP Infrastructure

- ▲ Intake
- ■ Powerhouse
- — New Facility Road
- — New Tower Road
- — Upgrade to Existing Road
- - - Penstock
- — Tunnel
- —●— Transmission Line
- — Roads
- - - Forestry Service Road
- — 50 m Contours

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 1 2 4 6 8 10 Km

Scale: 1:200,000

NO.	DATE	REVISION	BY
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Date Saved: 27/02/2019
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 20

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Wildlife\1095_ULH_MammalHabResMonLocs_2019Feb26.mxd

APPENDICES

Appendix A. Alena Creek Fish Habitat Enhancement Project: Year 1 Monitoring Report

Alena Creek Fish Habitat Enhancement Project

Year 1 Monitoring Report

Prepared for:

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

March 12, 2019

Prepared by:

Ecofish Research Ltd.

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

For inquiries contact: Technical Lead documentcontrol@ecofishresearch.com 250-334-3042

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Certification: *stamped version on file.*

Senior Reviewer:

Sean Faulkner, M.Sc., R.P.Bio. No. 2242

Fisheries Scientist/Project Manager

Kevin Ganshorn, M.Sc., R.P.Bio. No. 2448

Biologist/Project Manager

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089

Wildlife Biologist/Project Manager

Technical Leads:

Andrew Harwood, Ph.D., R.P.Bio. No. 1652

Fisheries Scientist/Project Manager

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089

Wildlife Biologist/Project Manager

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EXECUTIVE SUMMARY

Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to conduct monitoring for the fish habitat enhancement constructed on Alena Creek (also known as Leanna Creek). The Fish Habitat Enhancement Project (FHEP) was designed to offset the footprint and operational habitat losses incurred by the Upper Lillooet Hydro Project (ULHP, the Project). Alena Creek is a tributary to the Upper Lillooet River located approximately 4.1 km downstream of Boulder Creek confluence with the Upper Lillooet River.

Historical fish and fish habitat data from Alena Creek and long-term monitoring requirements for the enhancement habitat were originally described in the Alena Creek Long-Term Monitoring Program (LTMP) (Harwood *et al.* 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2017). Results of Year 1 and 2 of Alena Creek baseline monitoring are documented in Harwood *et al.* (2016). The purpose of this report is to provide results of the first year of the long-term monitoring program to evaluate the effectiveness of the FHEP as per the *Fisheries Act* Authorization issued for the ULHP.

Hydrology

Post-construction monitoring of water levels in Alena Creek was conducted at the Lillooet River Forest Service Road (FSR) crossing at the downstream end of the Fish Habitat Enhancement Project (FHEP). Seasonal trends in the Alena Creek hydrograph are consistent with a coastal, snow dominated watershed. Stage remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, as well as from mid-July through the end of September when precipitation was minimal. Stage also increased through March and April associated with the spring snow melt as was observed during baseline. However, high water levels were observed at the Alena Bridge site in June and July 2017; these were atypical and not associated with precipitation. The high stage readings appear to be the result of backwatering caused by a new side channel of the Upper Lillooet River just downstream of the hydrometric gauge.

The daily peak in stage was recorded on November 9, 2016 (0.95 m) during a flood event that represented a 1-in-20 year flood event on the Upper Lillooet River. Overall, mean daily stage (± SD) in Alena Creek from November 2016 to September 2017 was 0.28 m ± 0.12 m and stage did not drop below 0.16 m. However, these results are skewed by the likely backwatering effect caused by the Upper Lillooet River side channel.

To account for the backwatering of the gauge at the FSR bridge over Alena Creek when flows in the Upper Lillooet River are high, and to ensure the stage data collected are representative of Alena Creek water levels, we recommend moving the gauge upstream.

Water Quality

Water Chemistry

The purpose of the long-term monitoring of water chemistry is to ensure the maintenance of suitable water quality for the protection of aquatic life, and monitor any improvements in water quality resulting from the construction of the habitat compensation features. Concerns were raised by DFO over potentially elevated concentrations of metals, particularly iron and arsenic thus these parameters were included in baseline monitoring and the first year of the LTMP (Harwood *et al.* 2013). Water chemistry data are collected at two sites; a control site (ALE-USWQ/ALE-USWQ1), upstream of the enhancement habitat, and at a second site (ALE-BDGWQ) located at the downstream end of the enhancement habitat.

Baseline water chemistry data were collected quarterly for general water quality parameters, nutrients and anions, dissolved oxygen, total metals and dissolved metals in 2013 and 2014. Baseline water quality data met the applicable BC Water Quality Guidelines (BC WQG) for the protection of aquatic life (MOE 2018) for all parameters with the exception of dissolved oxygen (which dropped below levels applicable to buried life stages only), total iron (T-Fe) and dissolved iron (D-Fe), which exceeded the BC WQG at both the upstream control site and the downstream bridge site during baseline sampling (Harwood *et al.* 2016). Dissolved arsenic was below the applicable BC WQG during baseline sampling and post-construction monitoring.

Water quality in Alena Creek has generally improved since baseline sampling began in 2013. In year 1 monitoring, no exceedances of the minimum BC WQG for dissolved oxygen were observed at the site in the enhancement habitat (ALE-BDGWQ), with data indicating a well aerated condition (dissolved oxygen concentrations ranging from 10.38 mg/L to 10.81 mg/L).

Concentrations of dissolved iron exceeded the short-term maximum BC WQG of 0.35 mg/L at the site in the enhancement habitat during all sampling periods, with the range of concentrations similar between baseline and year 1 monitoring. Total iron exceeded the short-term maximum BC WQG of 1 mg/L at one or both sites on all sampling dates during baseline sampling. However, only one exceedance occurred during year 1 sampling at the site in the enhancement habitat, and concentrations at this site in year 1 sampling were on average lower than observed during baseline sampling.

Considering these observations and that instream enhancement is not expected to result in adverse effects on water quality, it is recommended that water quality monitoring on Alena Creek be ceased.

Water Temperature

The objective of water temperature monitoring is to ensure that conditions within the enhancement habitat support functional use for spawning, incubation, and rearing by the fish species present. This report provides a summary of year 1 post-construction water temperature results, with discussion of results relative to the baseline monitoring period.

Water temperature data were collected at the two water quality sites: ALE-USWQ1, immediately upstream of the instream works, and ALE-BDGWQ, at the downstream end of the works. Pre-construction monitoring occurred from April 17, 2013 to December 31, 2014 and post-construction monitoring to date has occurred from November 23, 2016 to present (data up to November 10, 2017 are included in this report). 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), instantaneous and daily average, minimum and maximum temperature, number of days with extreme mean daily temperature (e.g., >18°C, >20°C, and <1°C), the length of the growing season, and the accumulated thermal units in the growing season (i.e., degree days), and mean weekly maximum temperature (MWMxT). In addition, instantaneous minimum and maximum temperatures within critical periods for Bull Trout were compared to guideline limits for this species.

During the year 1 (2017) monitoring period, both monitoring sites had complete data records, but data gaps did occur during pre-construction monitoring. In post-construction year 1, the pattern in daily temperature has been largely similar to pre-construction phase. There has been no substantial change in the pattern of inter-site differences in water temperature compared to the pre-construction phase. Temperatures at site ALE-BDGWQ are cooler in winter and warmer in summer than at site ALE-USWQ1.

The range of monthly average temperatures was similar between the pre- and post-construction phases at both sites. The coolest temperatures were observed between December to April, while the warmest months were July to September. Over the available data record, monthly average temperatures at the upstream site (ALE-USWQ1) ranged from 5.0°C to 8.1°C pre-construction, and from 4.0°C to 8.1°C post-construction. At the downstream site (ALE-BDGWQ) monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction, and from 3.2°C to 10.4°C post-construction.

There has been no apparent change to the growing season start dates (end of April) post-construction compared to pre-construction, but the growing season end dates (early November) during the post-construction phase are earlier than those observed during the pre-construction phase (between mid-November and mid-December) at both monitoring sites. As a result, there has been a decrease in cumulative degree days during the growing season at both sites during post-construction phase in year 1.

With respect to daily extreme temperatures, Alena Creek is classified as a cool stream based on there being no days with mean water temperatures >18°C in either pre or post-construction conditions, at either site and few days when the mean temperature was <1°C. The highest maximum instantaneous temperatures did not exceed the prescribed guideline upper threshold of daily temperature for Bull Trout (18°C) for the entire period of record at any site. The maximum (instantaneous) water temperature recorded within the Project area was 13.75°C, recorded at site ALE-BDGWQ in 2015.

In general, it appears site ALE-USWQ1 is more suitable than site ALE-BDGWQ for spawning and incubation of Bull Trout across the stated periodicity for this species. The highest maximum daily temperatures never exceeded the prescribed guideline upper threshold for spawning and incubation (10°C) at site ALE-USWQ1, but exceedances did occur at site ALE-BDGWQ under both pre and post-construction conditions. This occurred because of warm temperatures in August and September; in general, water temperatures at ALE-BDGWQ do not cool below 10°C until late September/October.

No exceedances of the daily mean temperature threshold occurred at the upstream site (ALE-USWQ1), although some instantaneous records were less than 2°C. Daily mean water temperatures did fall outside the lower threshold range for Bull Trout incubation (2°C) at site ALE-BDGWQ, under both pre- and post-construction conditions: the frequency of occurrence was lower post-construction.

In general, water temperature at the monitoring sites was optimal for the fish species and life stages present under both pre and post-construction periods, although some sub-optimally cool temperatures were recorded within most periods as well. Notable exceptions for both baseline and post-construction periods where MWMxTs were sub-optimally cool for the majority of, or the entire period, include: Coho Salmon rearing and Cutthroat Trout spawning and incubation at site ALE-USWQ1. Temperatures also were cooler than optimal at times for Coho Salmon rearing, Bull Trout spawning at site ALE-BDGWQ.

Sub-optimally warm temperatures were observed in August and September at both sites during Bull Trout spawning and incubation period and for a small proportion of the record at site ALE-BDGWQ during Cutthroat Trout incubation. Warm surface waters during incubation may be partially mitigated by the groundwater upwelling at site ALE-USWQ1, such that temperature within the redds may be lower.

Overall, the minimum and maximum MWMxT was greatest at site ALE-BDGWQ and more moderate at site ALE-USWQ1, perhaps due to a thermal buffering effect of groundwater at the upstream site. No substantial change in the range of MWMxTs was observed at site ALE-BDGWQ between pre and post-construction phases: MWMxT ranged from 2.1°C to 13.7°C pre-construction and from 2.8°C to 13.0°C post-construction. The range of MWMxTs observed at site ALE-USWQ1 was slightly greater post-construction (3.5°C to 10.5°C post vs. 4.4°C to 9.9°C pre) but was small enough to be explained by interannual variability.

Water temperature monitoring will continue in Year 2 of post-construction phase at the established monitoring sites to continue to build on a dataset that will facilitate the identification of any biologically significant differences between pre- and post-construction temperature regimes, and aid in the interpretation of key monitoring parameters, such as changes in fish abundance. Water temperature monitoring will continue in Year 2.

Fish Habitat

Stability Assessment

A stability assessment was conducted to monitor the structural integrity and functionality of each of the enhancement habitat features and ensure that any remedial action required to maintain the effectiveness of habitat features is taken in a timely manner. To assist in the stability assessments, photo-points were established during the as-built survey at a total of eight survey transects. At each of the transects a panorama of photographs was taken to facilitate an evaluation of changes in habitat conditions over time. Qualitative observations were also made along the entire FHEP enhanced reaches.

Reach 1 is located in the downstream reach of the FHEP starting at the Lillooet River FSR. Thirteen riffles were installed in Reach 1 and more than 120 pieces of large woody debris with total creation of 1,387 m^2 of enhanced fish habitat. In early November 2016, two months following Project completion, a significant rain-on-snow event occurred, resulting in a 1-in-20 year flood event on the Upper Lillooet River. As a result, there were some notable changes in some of the channel structures in Alena Creek, though none affected the overall quality or usability of the constructed habitat.

A total of 668 m^2 of new instream habitat and 1,139 m^2 of floodplain was created in the upstream enhanced reach, Reach 3. Twelve cobble riffles were installed with over 100 pieces of large woody debris. The high-water flood event in 2016 had a greater impact to the habitat features in Reach 3 than Reach 1; however, as in Reach 1, it has not diminished the overall function or usability of the constructed habitat. Three of the four surveyed cross-sections show evidence of erosion and deposition which has caused widening and some bank instability. We recommend undertaking repairs during the least risk timing window in August 2018. All repairs can be completed by hand. All areas experiencing bank erosion should be stabilized using materials like cobble and small boulders; willow and red-osier stakes should also be planted at select bank sites to aid in short-term stability.

Fish Habitat Assessment

A baseline Fish Habitat Assessment Procedure (FHAP) was completed in 2014, following the methodology described in Johnston and Slaney (1996). A follow-up FHAP was conducted on October 3, 2017 as part of year 1 monitoring. A total of 1,344 m of habitat was surveyed, consisting of 1,312 m of primary and 32 m of secondary habitat. The surveyed section of the Alena Creek mainstem consisted of 24 primary habitat units, with a total wetted area of 10,361 m^2 and a bankfull area of 13,012 m^2.

In 2017, the mainstem of Alena Creek was dominated by pool habitat (72%) followed by glide (18%) and riffle (6%). Overall, sands and fines were the dominant substrate in the mainstem, with 58% of mainstem habitat units having sand and fines as the dominant substrate. Gravel was the sub-dominant substrate in 44% of habitat units. Of the gravel available, there were 48 total patches of functional spawning gravel and 19 patches of non-functional (i.e., dry) spawning gravel. The majority of the area of functional spawning gravel (78%) was characterized as suitable for both resident and anadromous fish. Similarly, the majority of non-functional patches (88%) would be suitable for both resident and anadromous fish at higher flows. If all observed spawning patches were wetted, there would be 1,049 m^2 of spawning habitat available.

There was a relatively high amount of cover available for fish in the Alena Creek mainstem, representing 51.8% of the total area. The dominant cover type for fish was large woody debris (LWD) (19.4%), followed by other forms of available cover including overhanging vegetation, instream vegetation and deep pools. LWD was present in all 24 habitat units surveyed in the mainstem. Of the 315 pieces of LWD that were counted during the survey, all were characterized as functional except one piece, with most of them being >50 cm in diameter.

Riparian vegetation along Alena Creek is a mix of deciduous pole saplings and shrubs. Canopy closure was 0 to 20% in 67% of habitat units, and 20 to 40% in 21% of habitat units.

A total of nine off-channel habitats to the Alena Creek mainstem were observed. The majority (i.e. 89%) of these habitat units are side channels. It is estimated that 56% of these side channels are accessible at most flows. A further two side channels, and a wetland, are accessible at high flows only. The major side-channel affected by FHEP construction was surveyed in full as secondary habitat to the Alena Creek mainstem. This channel has a total wetted area of 45 m^2 and a bankfull area of 48 m^2. The average gradient of this habitat unit was 0.5. The average wetted width was 2.8 m and the average bankfull width was 3.0 m. This side channel contained only one glide habitat unit. Sand/fines was the dominant substrate type and gravel was the sub-dominant substrate type. Cover was present in 10% of the secondary habitat unit provided primarily provided by functional LWD.

A comparison of the FHAP conducted in Alena Creek during baseline studies and Year 1 monitoring showed two principal differences. The first was a change in the dominant habitat type from shallow glide habitat to deeper pool habitat. This change was a result of the enhancement work in Reaches 1 and 3 along with beaver activity in Reaches 2 and 4. The second major difference was a 785. 2 m^2 increase in the amount of functional spawning gravel available. This increase in spawning gravel was directly attributable to the enhancement work.

Fish Community

Spawner use of Alena Creek was assessed by bank walk spawner surveys focusing on Coho Salmon, the dominant species within Alena Creek, completed over three surveys between November and December in both 2016 and 2017. In both years, the peak counts of adult spawning Coho Salmon were greater than 100 individuals, with the peak count in 2017 being the same as that observed in 2011 during the baseline period. In contrast, the peak count in 2016 was 174, which represents a notable increase in the number of spawners compared to the two baseline years and 2017. A comparison of the 2016 and 2017 results also highlights the variability in run timing between years, with the peak count recorded on November 14, 2016 and similarly high numbers two weeks later

(November 27), whereas the peak count in 2017 was observed on November 26. Although surveys are not conducted at a frequency to allow total spawner abundance to be compared among years, and peak counts may be influenced by survey timing and spawner residence time and predation, the counts nevertheless provide an indication of use and demonstrate that Alena Creek supports equivalent or greater use by Coho spawners relative to pre-enhancement.

Minnow trapping surveys were conducted at six sites in Alena Creek on September 27, 2017. The objective of minnow trapping was to determine catch-per-unit-effort (CPUE) by species and life history stage so that relative juvenile fish abundance could be tracked for the duration of the monitoring period and compared to CPUE prior to enhancement. Sampling was conducted in the same sites sampled during baseline monitoring, of which two were located in newly created/enhanced habitat and four were in habitat not directly enhanced.

All fish captured by minnow trapping were identified to species, enumerated, measured with scale samples collected for aging. Biological data from Cutthroat Trout and Coho Salmon were analyzed to define the age structure, size structure, length-weight relationship, length at age, and condition factor by species. Relative abundance was evaluated using catch-per-unit-effort (CPUE) for minnow trap data, which was calculated as the number of fish captured per 100 trap hours.

In 2017 sampling, seven Cutthroat Trout were captured minnow trapping, which represents a decrease compared to 2013 and 2014. In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+. No Cutthroat Trout fry were captured in 2017, which is fairly consistent with baseline sampling when only four Cutthroat fry were captured during sampling 2013 and 2014. The lack of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence and the size of fry in late September / early October. In 2017, the combined condition factor for all age classes of Cutthroat Trout captured was 1.0, whereas average Cutthroat Trout condition was 1.1 in 2013 and 1.2 in 2014.

In 2017 sampling, 142 Coho Salmon were captured by minnow trapping, which represents a decrease compared to 2013 and 2014. During 2017 sampling, the average CPUE across all sites was 18.2 fish/100 hrs of minnow trapping which was lower than the CPUE values for 2013 and 2014. In all sampling years, the most abundant age class of Coho Salmon captured was 0+. In 2017, the combined condition factor for all age classes of Coho Salmon captured was 1.1, whereas average Coho Salmon condition was 1.2 in 2013 and 1.0 in 2014.

The reduced catch and CPUE for both Cutthroat Trout and Coho Salmon during year 1 monitoring may be the result of altered habitat conditions caused by beaver activity both at the minnow trap locations, which were selected during baseline studies, as well as in upstream locations. There was evidence of beaver activity along Alena Creek during baseline studies; however, all beaver dams appeared abandoned and dilapidated with no new activity observed. In 2016, Alena Creek saw a notable increase in beaver activity in reaches upstream of both enhanced FHEP reaches. Beaver activity resulted in a significant increase in the amount of rearing habitat available through the creation of extensive backwater areas and side channels in the unenhanced reaches of Alena Creek.

This increase in habitat availability, in conjunction with the creation of 668 m^2 of new instream habitat in Reach 3 as part of the FHEP, is likely a contributory factor to the lower catch and CPUE in 2017 as a similar number of fish dispersed over a larger area will result in lower CPUE.

The beaver dam activity affected habitat availability and/or accessibility to all of the six minnow trap sites. The backwatering resulted in a significant increase in the amount of rearing habitat available, but also restricted movement under the flow conditions observed at the time of minnow trapping. The restriction of downstream movement may have contributed to the reduced number of Coho captured in the enhanced Reach 1 compared to baseline sampling. Cutthroat would have been equally affected by the large dams which would have restricted movement by spawning adults and fry. As the dams were unpassable during low to moderate flows this would limit access to spawning areas such as those in the enhanced reaches. This in turn would affect distribution throughout Alena by rearing fry and parr.

Based on the habitat changes caused by beaver activity, we recommend adjusting and increasing the sites minnow trapped in September 2018. In Reach 2, we recommend adjusting the sites sampled to be more representative of the habitat sampled under baseline conditions. We also recommend adding two minnow trap sites in the enhanced Reach 3 to monitor juvenile fish use of the pools and large woody debris complexes installed. These changes will result in the sampling of eight sites in total, four in unenhanced habitat and four in enhanced habitat. This will allow a better comparison between CPUE in enhanced and unenhanced habitat, as well as improving the ability to demonstrate that the FHEP supports equivalent or greater fish usage relative to pre-project densities in Alena Creek, as per the requirements of the *Fisheries Act* Authorization.

Riparian Habitat

The Alena Creek FHEP detailed specific restoration and enhancement prescriptions for the 30 m Alena Creek riparian compensation area to increase vegetation diversity by clearing gaps within the regenerating red alder (*Alnus rubra*) stands and planting clusters of western redcedar (*Thuja plicata*). The objective of the riparian restoration monitoring program is to qualify and quantify re-growth and planting success and to confirm that a diversity of native tree and shrub species with low observed mortality rates becomes established. Successful replanting is defined as a survival of at least 80% of the planted western redcedar stock within the first year of planting (DFO 2006). Three distinct methods are employed to monitor the success of the riparian restoration works and the overall function of the riparian habitat. These methods are: (1) permanent vegetation density monitoring; (2) percent vegetation ground cover estimates; and (3) photopoint comparisons.

Prior to the Meager Creek slide in 2010, the Alena Creek riparian area was dominated by mature red alder and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), with patches of older shifting mosaic seral stage forest approximately 121-140 years old (Harwood *et al.* 2016). When vegetation was assessed in 2014, four years following the slide, vegetation had been regenerating naturally, with red alder densely colonizing the understory. Overall density of woody vegetation was estimated as 46,250 ± 32,469 stems/ha in 2014.

After the implementation of riparian restoration works in 2016, estimated density decreased to 5,700 ± 5,002 stems/ha. A total of 21 conifers, including western hemlock (*Tsuga heterophylla*), western redcedar and Douglas-fir (*Pseudotsuga menziesii*), were recorded within the monitoring plots, along with a relatively diverse assemblage of at least seven shrub species.

Between 2016 and 2017, vigorous regeneration of black cottonwood and red alder caused the estimated density to increase to 43,200 ± 36,210 stems/ha. The DFO and MELP (1998) guided revegetation effectiveness target of 2,309 stems/ha was exceeded within all four permanent vegetation monitoring plots in both years. Some differences were observed in woody vegetation composition. Since 2016, the total number of conifers (15) decreased slightly while shrub diversity remained relatively similar.

Three planted western redcedar were recorded as dead within the permanent monitoring plots in 2017. Nevertheless, the survival rate of the western redcedar recorded within the permanent monitoring plots was 83%, higher than the minimum target of 80%, thus replanting is not required. Standard photos, taken in 2016 and 2017, show an increase in vegetation abundance from 2016 to 2017. No regionally or provincially noxious or invasive plant species were detected within the compensation area.

Vegetation ground cover is important within riparian areas to minimize erosion and resulting sedimentation in adjacent watercourses during early successional stages. Average percent vegetation cover recorded in 2017 (61%) was higher than in 2016 (23%) but lower than 2014 (82%). The riparian compensation area was also built to have low gradients; thus, erosion is not a concern. Moreover, the extent of natural recruitment within the riparian compensation area has shown that soil condition is appropriate for native vegetation and no soil conditioning is required.

Results from year 1 monitoring indicate that vegetation within the Alena Creek riparian compensation area is on a trajectory to become similar to that prior to the Meager Creek slide. No additional planting or remediation measures are recommended at this time. However, the overall density and potential crowding of pioneer species, red alder and black cottonwood, will be monitored to determine whether additional restoration works (e.g. thinning) would be required to support the establishment of conifers. Monitoring will occur late in the growing season in years 3 and 5 to ensure diverse riparian vegetation continues to establish (Harwood *et al.* 2017).

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1. INTRODUCTION

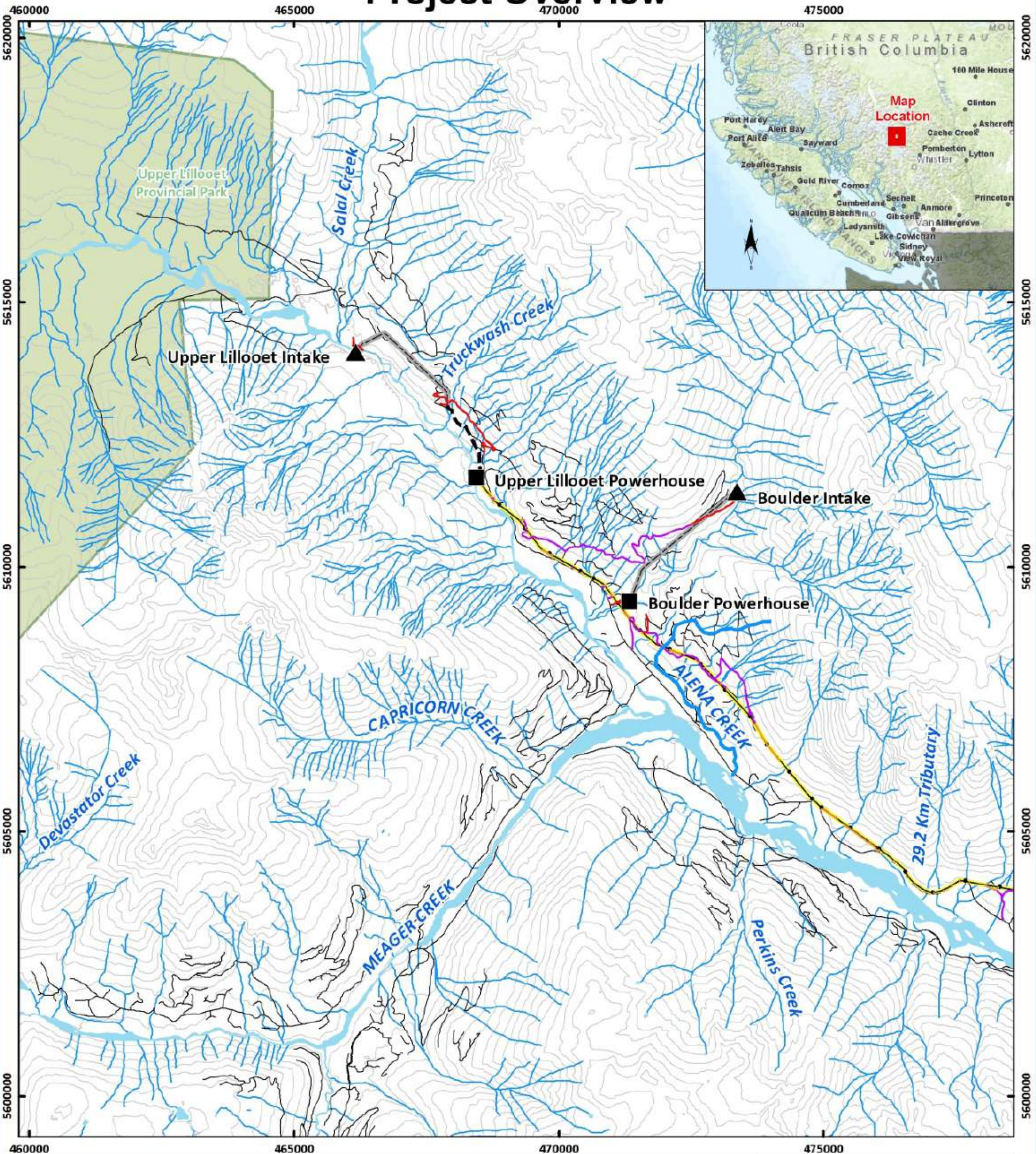
Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to conduct monitoring for the fish habitat enhancement constructed on Alena Creek (also known as Leanna Creek). The Fish Habitat Enhancement Project (FHEP) was designed by Hemmera Envirochem Inc. (Hemmera 2015) and Ecofish (Appendix A) to offset the footprint and operational habitat losses incurred by the Upper Lillooet Hydro Project (ULHP, the Project), which 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 Boulder Creek confluence with the Upper Lillooet River, and is therefore downstream of the two HEFs (Map 1).

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

The offsetting plan involved fish habitat enhancement in Alena Creek, which was heavily impacted by the Capricorn/Meager Creek slide (hereafter referred to as the Meager Creek slide); a natural, catastrophic event that occurred on August 6, 2010 and deposited a large amount of woody debris and thick heavy sediment in and around Alena Creek. In addition to heavily impacting aquatic habitat, the slide affected riparian habitat either by uprooting trees or by smothering root systems with heavy sediment. The FHEP created a new section of channel and enhanced both the aquatic and riparian habitat of Alena Creek and will therefore benefit Coho Salmon (*Oncorhynchus kisutch*), Cutthroat Trout (*Oncorhynchus clarki*) and Bull Trout (*Salvelinus confluentus*). The FHEP consisted 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 design features constructed 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 enhancement habitat were originally described in the Alena Creek Long-Term Monitoring Program (LTMP) (Harwood *et al.* 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2017). Results of Year 1 and 2 of Alena Creek baseline monitoring are documented in Harwood *et al.* (2016). The purpose of this report is to provide results of the first year of the long-term monitoring program to evaluate the effectiveness of the FHEP as per the *Fisheries Act* Authorization issued for the ULHP.

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. Hydrology

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

2.2. Water Quality

2.2.1. Water Chemistry

The purpose of the long-term monitoring of water chemistry is to ensure the maintenance of suitable water quality for the protection of aquatic life, and monitor any improvements in water quality resulting from the construction of the habitat compensation features. Concerns were raised by DFO over potentially elevated concentrations of metals, particularly iron and arsenic, thus these parameters were included in baseline monitoring and the first year of the LTMP (Harwood *et al.* 2013).

Baseline water chemistry data were collected quarterly for general water quality parameters, nutrients and anions, dissolved oxygen, total metals and dissolved metals for one year between 2013 and 2014, with additional periodic *in-situ* sampling conducted in 2014. Baseline water quality data met the applicable BC Water Quality Guidelines (BC WQG) for the protection of aquatic life (MOE 2018) for all parameters with the exception of dissolved oxygen (applicable to buried life stages only), total iron (T-Fe) and dissolved iron (D-Fe), which exceeded the BC WQG at both the upstream control site and the downstream bridge site during baseline sampling (Harwood *et al.* 2016). Dissolved arsenic was below the applicable BC WQG during baseline sampling.

The OEMP for the Upper Lillooet Hydro Project (Harwood *et al.* 2017) specified quarterly sampling for the first year followed by biannual sampling of a reduced list of parameters in Year 2 to 5 and evaluation by the QEP of whether this sampling program remains suitable, given results from Year 1. This report presents the water chemistry results for the baseline and first year of post-construction monitoring in 2016 and 2017 following completion of the habitat enhancement on Alena Creek.

2.2.2. Water Temperature

Small incremental changes in water temperature can potentially affect stream biota, including fish and their behaviour. Fish are vulnerable to both small increases and decreases in water temperature, with tolerance levels varying between species and life-history stages and dependent on existing conditions. The objective of water temperature monitoring is to ensure that conditions within the enhancement habitat support functional use for spawning, incubation, and rearing by the fish species present. Collection of continuous water temperature data will allow for a comparison of pre- and post-construction temperature data to track changes within the compensation habitat over time.

Water temperature may be influenced by the instream enhancement features and/or maturation of the riparian habitat restoration. This report provides a summary of Year 1 post-enhancement water temperature results, with discussion of results relative to the pre-construction monitoring period.

2.3. Fish Habitat

2.3.1. Stability Assessment

A stability assessment was conducted to monitor the structural integrity and functionality of each of the enhancement habitat features and ensure that any remedial action required to maintain the effectiveness of habitat features is taken in a timely manner.

2.3.2. Fish Habitat Assessment

A fish habitat assessment procedure (FHAP) was conducted over the enhanced section of Alena Creek to document changes in mesohabitat availability and to demonstrate the continued provision of spawning and rearing habitat for Coho Salmon and Cutthroat Trout.

2.4. Fish Community

The goal of enhancing Alena Creek aquatic and riparian habitat was to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout and support equivalent or greater fish usage relative to pre-project densities in Alena Creek. 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-enhancement conditions.

2.5. 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 Alena Creek FHEP detailed specific restoration and enhancement prescriptions for the 30 m Alena Creek riparian area to increase vegetation diversity by creating clearing gaps within the regenerating red alder (*Alnus rubra*) stands and by planting clusters of western redcedar (*Thuja plicata*) (Hemmera 2015).

The objective of the riparian restoration monitoring program is to qualify and quantify re-growth and planting success and to confirm that a diversity of well-established native tree and shrub species with low observed mortality rates is achieved within the riparian portion of the Alena Creek FHEP (Harwood *et al.* 2016). Successful replanting is defined as a survival of at least 80% of the stock within the first year of planting (DFO and MELP 1998). If more than 20% of the planted stock dies over one year, replanting will be required. Results of the first year of monitoring are compared against three scenarios: 1) prior to the Meager Creek slide, 2) four years after the slide prior to restoration work, and 3) immediately following restoration work in 2016 (Harwood *et al.* 2016).

3. METHODS

3.1. Hydrology

KPL commenced monitoring water level in Alena Creek in April 2013. Two water level loggers were originally installed in Alena Creek; one at the Lillooet River FSR crossing (Alena Bridge) and another at the upstream end of the project area (Alena Upstream) (Map 3). For post-construction monitoring, water level data were collected only at the Alena Bridge site.

3.2. Water Quality

3.2.1. Water Chemistry

3.2.1.1. Monitoring Sites, Schedule, and Parameters Monitored

In 2016 and 2017, year 1 of the LTMP, water chemistry monitoring was conducted at the same two sites as sampled during baseline: a control site (ALE-USWQ1) located approximately 1,070 m upstream of the Alena Creek bridge, and a second site located approximately 20 m upstream of the Alena Creek bridge at the downstream end of the instream enhancement (Table 1, Map 3). Note that the control site (ALE-USWQ) was originally 500 m upstream of the Alena Creek bridge during baseline sampling, and was moved in November 2013 to ALE-USWQ1 due to modifications to the proposed enhancement plan. Representative photos are provided in Appendix B.

Water quality data were collected using two methods: *in-situ* sampling (physical parameters and dissolved gases) and laboratory analysis (physical parameters, anions and nutrients, and total and dissolved metals). *In-situ* and laboratory sampling procedures and assignment of proper laboratory detection limits were determined following the guidelines of the Ambient Fresh Water and Effluent Sampling Manual within the British Columbia Field Sampling Manual (Clark 2013). Baseline lab and *in-situ* sampling was conducted on July 8, 2013, September 16, 2013, November 18, 2013, and February 27, 2014. Additional *in-situ* baseline sampling was conducted in 2014 on April 29, September 25, and November 25. Following construction of the enhancement habitat, one year of quarterly lab and *in-situ* sampling was completed (November 23, 2016, March 5, 2017, June 5, 2017 and September 13, 2017).

Table 1. Alena Creek water chemistry sampling sites.

Site	UTM Coordinates (Zone 10U)		Elevation (masl)[1]
	Easting	Northing	
ALE-USWQ1	472,976	5,606,870	391
ALE-BDGWQ	473,336	5,606,095	382

[1] Elevation was determined from Google Earth.

3.2.1.2. Quality Assurance/Quality Control and Data Analysis

QA/QC of the water quality data was ensured through equipment maintenance, data collection methods, sampling protocols, laboratory procedures, and the processing and interpretation of data. *In-situ* water quality meters were maintained following the manufacturers recommendations. Maintenance included calibration, cleaning, periodic replacement of components, and proper storage. In the event of equipment malfunction and/or inaccessibility due to inclement field conditions, particular parameters or sampling dates may be omitted. *In-situ* measurements were made in triplicate unless otherwise indicated.

In-situ readings were recorded in triplicate, while water quality samples were collected for laboratory analysis in triplicate (2013 to 2016 sampling dates) or duplicate (2017 sampling dates). Duplicate and triplicate data reduce the risk of erroneous data resulting from travel or field contamination. The BC field sampling manual recommends that 20% to 30% of samples are designated for QA/QC (Clark 2013), while the RISC manual recommends a less conservative minimum of 10% of samples (RISC 1998a). Exceeding the more stringent QA/QC requirements, 26 of a total of 42 laboratory samples were QA/QC replicates, and therefore 62% of the lab sampling program consisted of QA/QC samples. For samples collected for laboratory analysis, sampling procedures and assignment of detection limits were determined following the guidelines of the Ambient Fresh Water and Effluent Sampling Manual within the British Columbia Field Sampling Manual (Clark 2013).

Appropriate collection procedures and use of a laboratory with its own established QC procedures were important components of QA/QC. Operational water quality samples were collected in plastic or amber glass bottles as required, with sample containers and preservatives provided by ALS. Samples were packaged in clean coolers filled with ice packs and couriered to ALS in Burnaby. Standard Chain of Custody procedure was strictly adhered to. ALS also maintains a Quality Management System that adheres to the requirements of the ISO:IEC 17025:2005 standards. Laboratory QC procedures included replicate analysis of a subset of samples, analysis of standard reference materials, and method blanks. QA/QC qualifiers and comments from laboratory analysis are provided in Appendix C.

Hold times for water quality parameters were adhered to when possible, but were sometimes exceeded. Exceedance of pH hold times (0.25 hours) was unavoidable and was therefore observed for all samples; pH is also measured *in-situ*. The analytical results for any parameters with hold time exceedances were compared to previous data collected at each site to determine if the results were within historical ranges and to identify any unusual analytical results that may be attributed to hold time exceedances. The hold time exceedance summary is provided in Appendix D.

QA/QC measures during data analysis included methods of addressing values less than or near laboratory method detection limits (MDL), use of established protocols for data analysis, and screening of outliers. The MDL for a given parameter occasionally differs between samples due to matrix effects in the sample or variations in analytical instruments. It is a common occurrence in clear fast flowing mountain streams to have concentrations of a number of parameters that are less than, or near, the MDL. When this occurs, there are a number of different methods that can be used to analyze these values. In this report, any values that were less than the MDL were assigned the actual MDL values and averaged with the results of the other replicates. In such cases, the average is also considered to be less than the value reported.

The RISC manual "Guidelines for Interpreting Water Quality Data" (RISC 1998b) was referred to for data analysis as it provides detailed direction for screening, editing, compiling, presenting, analyzing, and interpreting water quality data. Precision was evaluated by calculating the percent relative difference (RPD) for duplicates (duplicate RPD should be less than 25%) and the percent relative standard deviation (RSD) for triplicates (triplicate RSD should be less than 18%) as per the guidance provided in RISC (1998b). Precision analysis was only completed if the analytical results were greater than five times the parameter MDL. Exceedances of the precision guidelines are summarized in Appendix D, and data were evaluated for accuracy if the RPD or RSD exceeded recommended thresholds. If data were within historical ranges then the high variability was likely due to natural variability in the stream at the time of sampling.

3.2.1.3. Guidelines for the Protection of Aquatic Life

Water quality guidelines for the protection of aquatic life and typical ranges of water quality parameters in BC waters that were considered for this report are provided in Appendix D. Results were compared to provincial water quality guidelines where they exist. Provincial guidelines do not exist for total phosphate, and results were therefore compared to federal guidelines. For parameters without provincial or federal guidelines (e.g., orthophosphate, alkalinity, and specific conductivity), results were compared to typical ranges found in BC streams (Appendix D). Any results for water quality parameters that approached or exceeded guidelines for the protection of aquatic life or ranges typical for BC are discussed.

3.2.2. Water Temperature

Water temperature data were collected at the two water quality sites: ALE-USWQ1, immediately upstream of the instream works, and ALE-BDGWQ, at the downstream end of the works (Map 3). Pre-construction monitoring occurred from April 17, 2013 to December 31, 2014 and post-construction monitoring to date has occurred from November 23, 2016 to present (data up to November 10, 2017 are included in this report).

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

The data underwent a thorough QA to ensure that any suspect or unreliable data were excluded from data analysis and presentation. Excluded data included, for example, data where the sensor was suspected of being out of the water, affected by snow or ice, or buried in sediment. Water temperature data were processed as follows. First, outliers were identified and removed. This was done for each logger by comparing temperature data from the duplicate site loggers and the loggers at the other sites. For example, occasional drops in water level which exposed the temperature loggers to the air were considered as outliers and removed from the dataset. Second, the records from duplicate loggers were averaged and records from different download dates were combined into a single time-series for each monitoring sites. The time series for both sites were then interpolated to a regular interval of 60 and 15 minutes (where data were not already logged on a 60 and 15-minute interval), starting at the full hour, for the pre- and post-construction phase, respectively.

Data were presented in plots that were generated from temperature data collected at, or interpolated to, 15 minute intervals. Plots were also generated for the hourly rates of change in water temperature as per the provincial guidelines for the protection of aquatic life (Oliver and Fidler 2001, see Table 1 in Appendix E).

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), instantaneous and daily average, minimum and maximum temperature, number of days with extreme mean daily temperature (e.g., >18°C, >20°C, and <1°C), the length of the growing season, and the accumulated thermal units in the growing season (i.e., degree days), and mean weekly maximum temperature (MWMxT). Table 2 defines these statistics and describes how they were calculated. Coho Salmon and Cutthroat Trout are target species for the Project (Section 2.4), and Bull Trout may also be present in the study area. Therefore, instantaneous minimum and maximum temperatures within critical periods for Bull Trout were compared to guideline limits for this species.

The length of the growing season and the number of degree days in the growing season are important indicators for the health of aquatic life. Here, the beginning of the growing season is defined 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 is defined as the last day of the first week that average stream temperature dropped below 5°C as per modified Coleman and Fausch (2007). Herein, the threshold of MWMxT for the end of the growing season was modified from 4°C (as per Coleman and Fausch 2007) to 5°C, because the available observed MWMxT data at ALE-USWQ1 (during pre- and post-construction phase) never dropped below 4°C due to buffered groundwater during winter season.

Table 2. Water temperature summary parameters and method of calculation.

Parameter	Description	Method of Calculation
Water temperature	Instantaneous and daily averaged, maximum, and minimum	Calculated from 15 minute data (interpolated where necessary) and presented in graphical form.
Water temperature	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	>18°C , >20°C , and <1°C	Total number of days with daily mean water temperature >18°C , >20°C , and <1°C.
MWMxT (Mean Weekly Maximum Temperature)	Mean, minimum, and maximum on a weekly 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; this is calculated for every day of the year.

3.2.2.1. Applicable Guidelines

Daily Extremes

Extreme cold or warm temperatures are monitored as part of the water temperature component. The number of days when the daily mean temperature was <1°C was calculated, along with the number of days when the daily mean temperature >18°C and >20°C.

Bull Trout / Dolly Varden Temperature Guidelines

Bull Trout are present throughout the Project area and their life history periodicity is provided in Section 1 of Appendix E. Additional Provincial water temperature guidelines exist specific to Bull Trout and Dolly Varden in streams (Table 1 of Appendix E). When either of these fish species are present, the guidelines state that:

- maximum daily water temperature is 15°C;
- maximum incubation temperature is 10°C;
- minimum incubation temperature is 2°C; and
- maximum spawning temperature is 10°C.

Thus, the incidence of extreme daily mean water temperatures, and instantaneous minimum and maximum temperatures were calculated, for comparison to the above thresholds.

Mean Weekly Maximum Temperature (MWMxT)

The mean weekly maximum water temperature (MWMxT) is an important indicator of prolonged periods of cold and warm water temperatures that fish are exposed to. The guideline 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). Accordingly, MWMxT values were compared to the optimum temperature ranges given in Table 2 of Appendix E (modified from Oliver and Fidler 2001) for the fish species present.

The timing of life history stages in the Upper Lillooet River as reported in the periodicity table (Section 1 of Appendix E), was used to define the temporal bounds of the MWMxT analysis for each life stage where thermal optima are given by Oliver and Fidler (2001). Within this period, the completeness of the data record (% complete for all years in either pre- or post-construction period), the overall minimum and maximum MWMxT, and distribution of MWMxT values (above or within the optimal temperature range) was calculated.

3.3. Fish Habitat

3.3.1. Stability Assessment

To assist in the stability assessments, photo-points were established during the as-built survey (West *et al.* 2017), which was completed immediately following construction. A total of eight transects were surveyed at that time, including the installation of the permanent photo-points. At each of the transects a panorama of photographs were taken to facilitate an evaluation of changes in habitat conditions over time. Photographs were taken looking downstream, upstream, from river left to river right, and from river right to river left. The photograph aspects were oriented to provide a full view of the bankfull channel and floodplain, with the transect tape included in the photo to provide a visual reference line to aid with analysis of the topographic transect surveys. Photos were recreated for a visual comparison. Qualitative observations were also made along the entire FHEP constructed reaches.

3.3.2. FHAP Assessment

The FHAP Level 1, as described by Johnston and Slaney (1996), was used to collect quantitative information on fish habitat at a mesohabitat scale. The main objectives of the assessment were to quantify the habitat unit composition, delineating units into pools, glides, runs, riffles, cascades, chutes and falls.

The FHAP was completed following the methods described in Lewis *et al.* (2004). Data collection procedures and survey design were consistent with methods in Johnston and Slaney (1996); however, some modifications were necessary to address the objectives of this study:

1. The primary objective was altered from identifying the impacts of forest harvesting and/or opportunities for restoration to the one listed above.
2. The overview assessment, initial planning exercise, and Level 2 FHAP as described in Johnston and Slaney (1996) were not completed, as these were deemed unnecessary for this study. The overview assessment was not completed because a more detailed survey (Level 1 FHAP) was performed.
3. The methods of habitat evaluation were modified to focus on limitations to production rather than forestry impacts. This included a detailed assessment of spawning habitat throughout the surveyed section of stream.

Table 3 lists the physical parameters surveyed along with the units of measure and the equipment used. Parameters were measured rather than estimated wherever possible. However, estimates were made for pool depths greater than 1.5 m, dominant and subdominant bed materials, percent cover, canopy closure, and amounts of spawning gravel. All field data were collected by a two-person crew and recorded onto FHAP site cards (1996 Edition).

Habitat units were classified as pools, glides, runs, riffles, cascades, chutes and falls. Johnston and Slaney (1996) recommend using only pools, glide, riffle, cascade and "other"; however, we added run, chute and falls habitat types to better define the habitat units. Units were additionally classified by location within the stream as primary, secondary, and tertiary. Primary habitat units encompass greater than 50% of the total wetted width. Secondary units occur in minor channels that are isolated from the main channel by a vegetated island with perennial plants greater than 1 m in height. Tertiary units are habitat units within the larger channel that occupy less than 50% of the wetted width (i.e., are nested within primary or secondary units) and are of a different classification than the main channel (e.g., a pool that is part of a cascade unit). The habitat unit composition of each reach was determined based on the proportion of wetted area occupied by each habitat type over the total wetted area of the reach. Total wetted areas and bankfull areas were determined by summing the wetted areas and bankfull areas of individual habitat units within a given reach. For each habitat unit type, excluding falls, the average wetted and bankfull areas, widths, depths, and gradients were determined by averaging data from individual units within a given reach. Photographs of each habitat unit were taken. Potential barriers or obstructions to fish migration (e.g., beaver dams) were photographed and waypoints were taken.

Off-channel habitat such as side channels, sloughs, ponds and seasonally flooded wetlands were noted, along with their accessibility for fish (not accessible, accessible at high flow only, or accessible) and estimated length. However, due to the number of side channels present, there were not fully assessed as secondary habitat units unless they were directly affected by FHEP construction.

Substrate was classified according to a modified Wentworth scale into the following categories: fines (<2 mm), gravel (2 to 64 mm), cobble (64 to 256 mm), boulder (256 to 4,000 mm) and bedrock (>4,000 mm) (Lewis *et al.* 2004). The dominant and subdominant substrate type within each habitat unit was estimated based on coverage area. Dominant and subdominant substrate types were then determined from the percentage of habitat units in which a particular substrate type was either dominant or subdominant.

Total spawning habitat was estimated and classified according to the FHAP methodology (Johnston and Slaney 1996). Individual patches of gravel were measured with a meter stick and classified as suitable for anadromous or resident fish, or both, based on gravel size and patch area. According to the definitions in Johnston and Slaney (1996), patches at least 1.5 m^2 in area with gravel between 10 and 150 mm in size are classified as suitable for anadromous fish. In contrast, resident spawning gravel was reported in the following categories: R) patches greater than 0.1 m^2 with gravel between 10 and 75 mm in size are classified as suitable for resident trout and char; and, AR) patches that were at least 1.5 m^2 and composed of gravel between 10 and 75 mm in size were classified as suitable for anadromous and resident fish. Patches were also classified as functional or non-functional based on location from wetted edge and extent of compaction and embeddedness.

For each spawning gravel patch, the average length, average width, and average water depth were measured and recorded. If multiple small gravel patches were located in close proximity or separated by only a few large cobble or boulders, they were included as a single composite patch. Johnston and Slaney (1996) describe functional spawning habitat as having water depths greater than 15 cm and water velocities between 0.3 to 1.0 m/s during the spawning season. During our assessment flows were relatively low; therefore, to avoid underestimating functional spawning gravel only dry substrate and areas with velocities estimated to be below 0.01 m/s were classified as non-functional.

Compaction was subjectively classified as low (L), moderate (M), or high (H) using the 'Boot Test', which is a relative measure of gravel compaction, in which the substrate is kicked with a wading boot and the degree of penetration of the boot into the substrate is used to grade compaction. Compaction is classified as low if the boot easily and deeply penetrates the gravel substrate (>4 cm), moderate if a portion of the boot penetrates the gravel (approximately 2 to 4 cm), and high if the boot only slightly enters or does not enter the substrate completely (<2 cm).

The embeddedness of the gravel is a measure of the amount of fines (<2 mm) that are present in the substrate in each spawning gravel patch. Embeddedness was subjectively classified as trace (T, <5%), low (L, 5 to 25%), medium (M, 25 to 50%), high (H, 50 to 75%) and very high (VH, >75%) based on visual assessment.

Photographs were taken of each spawning gravel patch including a photo taken from above the water, and a photo taken underwater (if water was deep enough). A reference photo was also taken that showed the location of the gravel patch in relation to a distinguishable stream bank feature so that each patch can be located in the future. Photographs were taken at the start and end point of the survey and of significant stream features (e.g., log jam, gradient change). Photographs at these locations included views looking upstream, downstream and cross-stream from bank to bank.

Table 3. Physical parameters, units of measure, and equipment used during the FHAP surveys.

Parameter	Unit	Measured or Estimated	Equipment Used
Bankfull depth	m	Measured	Metre stick (0.05 m increments)
Bankfull width	m	Measured	30 m fibreglass tape
Bed material type	n/a	Visual estimate	Visual
Canopy closure	%	Visual estimate	Visual
Cover proportions	%	Visual estimate	Visual
Cover types	n/a	Visual estimate	Visual
Disturbance indicators	n/a	Visual estimate	Visual
Gradient	%	Measured	Suunto clinometer
Habitat unit length	m	Measured	30 m fibreglass tape/rangefinder
Maximum pool depth (>1.5 m)	m	Visual estimate	Visual
Maximum pool depth (<1.5 m)	m	Measured	Metre stick (0.05 m increments)
Pool crest depth	m	Measured	Metre stick (0.05 m increments)
Reach length	m	Measured	30 m fibreglass tape/rangefinder
Residual pool depth	m	Measured	Metre stick (0.05 m increments)
Riparian structure	n/a	Visual estimate	Visual
Riparian vegetation type	n/a	Visual estimate	Visual
Spawning gravel abundance	n/a	Visual estimate	Visual
Spawning gravel amount	m^2	Measured	Metre stick (0.05 m increments)
Spawning gravel type	n/a	Visual estimate	Visual
Substrate type	n/a	Visual estimate	Visual
Water and air temperature	ºC	Measured	Alcohol thermometer
Wetted depth	m	Measured	Metre stick (0.05 m increments)
Wetted width	m	Measured	30 m fibreglass tape

3.4. Fish Community

3.4.1. Adult Spawner Abundance

Spawner surveys focused on Coho Salmon, the dominant species within Alena Creek, and consisted of bank walk surveys conducted every two weeks between early-November and early-December for a total of three surveys a year. Spawner surveys were completed between November 14 and

December 9, 2016, and between November 10 and December 5, 2017. Results of these surveys are summarized in Section 4.4.1.

3.4.2. Juvenile Abundance

3.4.2.1. Minnow Trapping

Minnow trapping surveys were conducted in Alena Creek commencing on September 27, 2017. The objective of minnow trapping was to determine catch-per-unit-effort (CPUE) by species and life history stage so that relative juvenile fish abundance could be tracked for the duration of the monitoring period and compared to CPUE prior to enhancement.

Six sites were selected with five traps set at each site except for ALE-MT06, where 10 traps were set because it was a large pool that required greater sampling effort. Sampling was conducted in the same sites sampled during baseline monitoring (Map 4) (Harwood *et al.* 2016), of which two (ALE-MT01 and 02) were located in newly created/enhanced habitat and four were in habitat not directly enhanced. The minnow traps were baited using salmon roe and left overnight. When the traps were retrieved, captured fish were identified and measured.

3.4.2.2. Biological Information

All captured fish were identified to species using standard field keys and enumerated. The fork length of each captured fish was determined using a measuring board (±1.0 mm); after which each fish was weighed using a field scale (±0.1 g). Aging samples were taken from a sub-sample of captured fish and these were aged at the Ecofish laboratory in Squamish.

Scale samples collected in the field were examined under a dissecting microscope for aging purposes: three representative scales were photographed and apparent annuli noted on a digital image. Fish age was determined by a biologist and QA'd by a senior biologist. Where discrepancies were identified, they were discussed and final age determination was based on the professional judgement of the senior biologist.

3.4.2.3. Data Analysis

Individual Fish Data

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

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

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

where W is the weight in grams, L is the length in millimeters, 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.

3.5. Riparian Habitat

Three distinct methods are employed to monitor the success of the riparian restoration works and the overall function of the riparian habitat. These methods are: (1) permanent vegetation density monitoring; (2) percent vegetation ground cover estimates; and (3) photopoint comparisons. Each of these techniques is discussed in more detail below. Any invasive species regionally or provincially designated as noxious were also documented when observed.

3.5.1. Permanent Vegetation Density Monitoring

Woody vegetation is the primary focus of riparian vegetation monitoring due to the long-term contribution to the maintenance and enhancement of riparian habitat and function. Consequently, the density (stems per hectare) of woody vegetation is an important metric and indicator of restored riparian habitat quality. Permanent vegetation monitoring plots were established to sample the density of perennial woody vegetation within a 50 m^2 circular plot, according to 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 vegetation monitoring plots were established in 2014, prior to construction of the compensation habitat; however, only one of these four plots (ALE-PRM03) ended up within the restored area, and was thus assessed in 2016 and 2017. Three additional plots were established in 2016 for a total of four plots that were assessed in 2016 and 2017. These permanent vegetation monitoring plots will be assessed for the duration of the monitoring program (Map 4).

Perennial woody vegetation includes long-lived species such as trees and shrubs, but excludes forbs, grasses, and mosses. The surveyors counted the number of stems of all native perennial woody plants, and conducted health and mortality checks. Plants showing signs of abiotic stress, insect damage, fungal blights, or other afflictions were all counted as living but incidences of the disease and the host plant species were noted. Stems were defined as those stems of a plant that were distinctly individual at ground level. Tree or shrub seedlings having secondary leaves that were at least the size of a quarter and that were established on site were counted as trees or shrubs and were considered the minimum tree or shrub size. No minimum height requirements were used.

The DFO and MELP effective revegetation criteria provide a general target density for vegetation planted 2.0 m apart (DFO and MELP 1998). This equates to a final minimum target density of 2,309 stems per hectare. This target density for all tree and shrub species combined was considered when assessing whether a diverse assemblage of native tree and shrub species is becoming established within the Alena Creek FHEP area. Survival rate was calculated for planted western redcedar as the proportion of live plants divided by the total of live and dead plants.

3.5.2. Percent Vegetation Cover Estimates

Measurement of percent vegetation ground cover, including herbaceous and small woody species, is a useful indicator of substrate stabilization early in the revegetation process. Quadrat sampling is employed to determine the percent ground cover of all herbaceous and woody vegetation, excluding lichens, fungi and mosses. The assessment describes the percent ground cover of both the woody vegetation, and the forb and grass layer not captured by counting perennial woody vegetation within the permanent monitoring plots. This method is most meaningful during the early vegetation re-establishment period before perennial woody vegetation has established. The method consists of counting the number of 10 x 10 cm quadrat squares that contain vegetation within ten 0.25 m^2 quadrat replicates. Quadrat replicates were randomly located within the vicinity of the permanent vegetation monitoring plots and results from the ten replicates were averaged for the overall site. Photos of each quadrat replicate were taken.

3.5.3. Photopoint Comparison

Standard photographs provide insight into how the riparian function provided by grasses, forbs and smaller shrubs and trees changes over time. Photographs were taken facing 0 degrees (north) from 1.3 m above each permanent monitoring plot centre to qualitatively document change over time. Additional descriptive photographs were also taken of the monitoring sites.

4. RESULTS

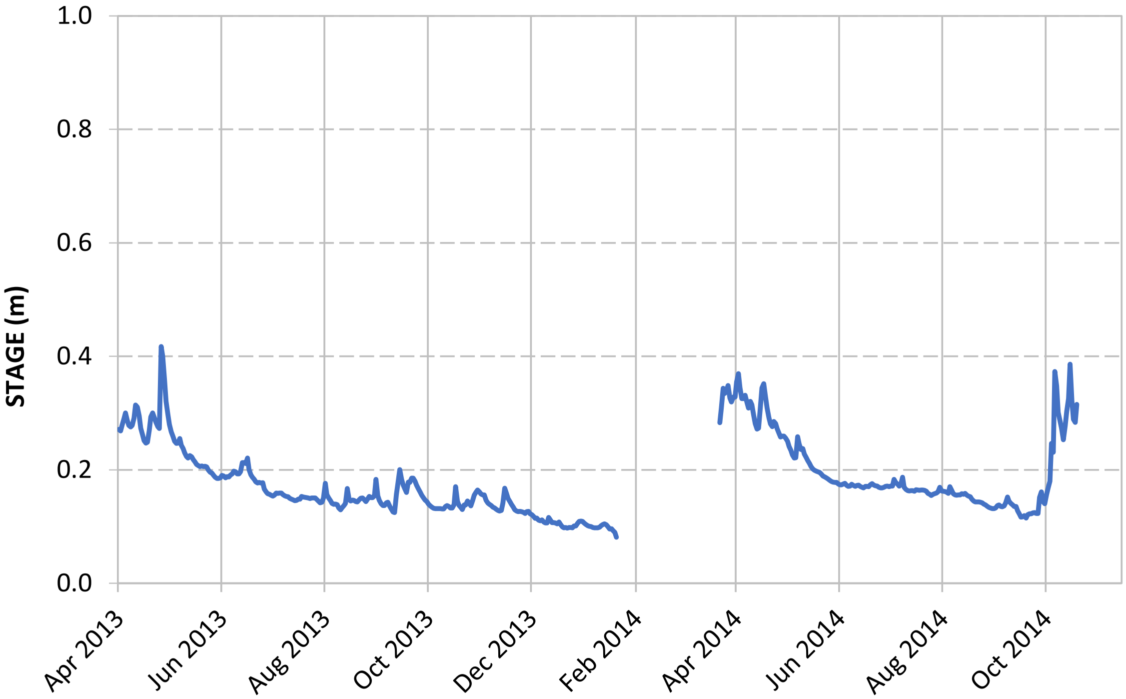
4.1. Hydrology

Seasonal trends in the Alena Creek hydrograph are consistent with a coastal, snow dominated watershed. Stage remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, as well as from mid-July through the end of September when precipitation was minimal (Figure 1). The daily peak in stage was recorded on November 9, 2016 (0.95 m) during a flood event that represented a 1-in-20 year flood event on the Upper Lillooet River (McCoy, pers. comm. 2016). Stage also increased through March and April associated with the spring snow melt as was observed during baseline (Figure 1a). However, the high water levels in June and July 2017 (Figure 1b) are atypical, and were not observed during the baseline years when stage steadily declined through June and July. The high stage readings at the FSR Bridge site on Alena Creek in summer 2017 appear to be the result of backwatering caused by a new side channel of the Upper Lillooet River just downstream of the hydrometric gauge (Figure 2 and Figure 3) because there was little precipitation during this period. The new side channel formed during the peak flow in November 2016. Evidence that backwatering caused exaggerated stage readings at the bridge on Alena Creek during high flows in the Upper Lillooet River can be seen in Figure 4, which shows the Alena Creek stage readings responding to the diurnal fluctuation in stage experienced by the Upper Lillooet River during snow melt in summer.

Overall, mean daily stage (± SD) in Alena Creek from November 2016 to September 2017 was 0.28 m ± 0.12 m and stage did not drop below 0.16 m. However, these results are skewed by the likely backwatering effect caused by the Upper Lillooet River side channel.

Figure 1. Stage in Alena Creek at the Lillooet River FSR bridge during a) baseline (Apr 2013 to Nov 2014) and b) year 1 monitoring (Nov 2016 to Oct 2017).

a) Baseline



b) Year 1 monitoring

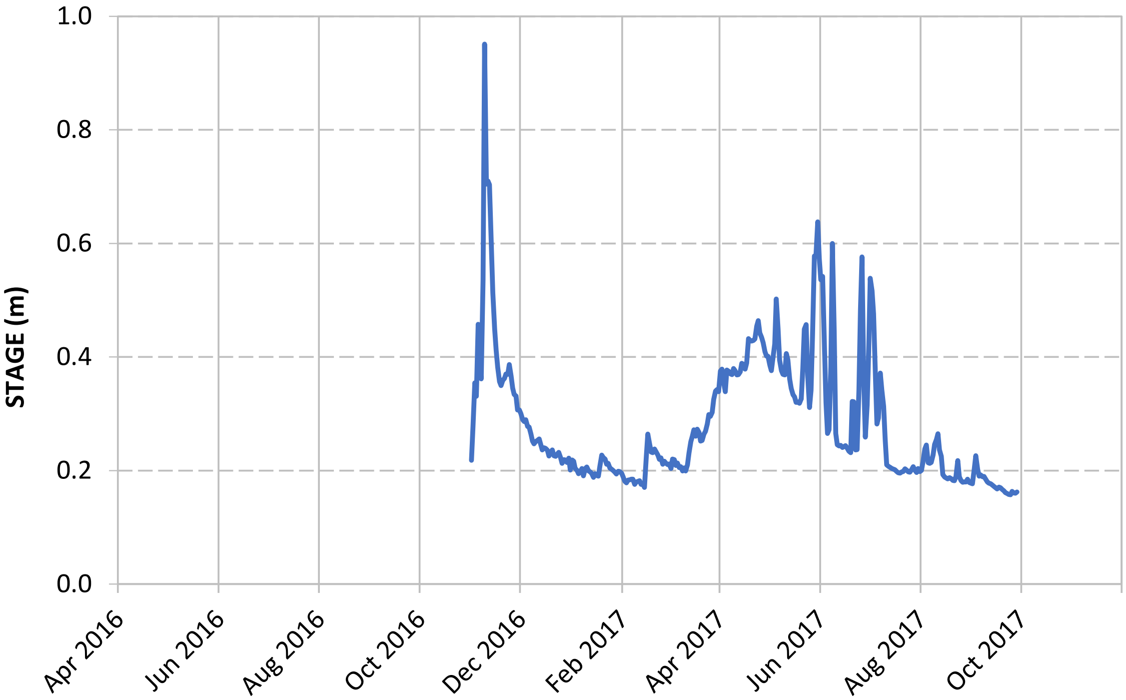
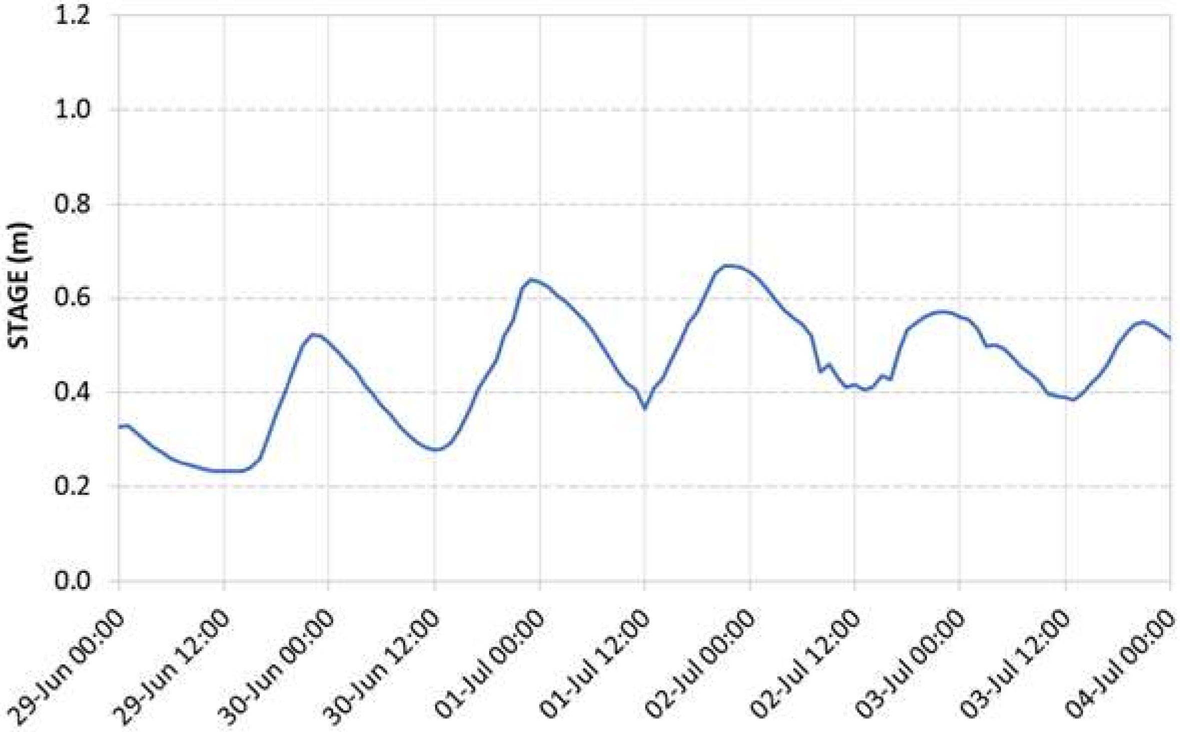


Figure 2. Looking upstream at a newly formed side channel of the Upper Lillooet River entering Alena Creek approximately 25 m downstream of the Lillooet FSR Bridge on November 14, 2016.

Figure 3. Looking downstream at Alena Creek from the Lillooet River FSR bridge in November 2016. The new Upper Lillooet River side channel is visible on river right.

Figure 4. Stage in Alena Creek at the Lillooet River FSR bridge in late June and early July 2017 showing the diurnal fluctuation experienced by the Upper Lillooet River during snow melt in summer.



4.2. Water Quality

4.2.1. Water Chemistry

Detailed data summary tables including baseline (2013 and 2014) and year 1 (2016 and 2017) data are provided in Appendix D along with applicable BC WQG (MOE 2017) for the protection of aquatic life (MOE 2018) and typical ranges of parameter values in BC watercourses (as provided in RISC 1998b). Laboratory reports from ALS including laboratory QA/QC results are provided in Appendix C.

Comparison of the range in concentration of water quality parameters between the baseline sampling period (2013 and 2014) and the first year of long term monitoring (2016 and 2017), and to BC WQG is provided in Table 4. During baseline and year 1 of long term monitoring, total iron, dissolved iron, and dissolved oxygen (applicable to buried life stages only) exceeded the BC short term water quality guidelines for the protection of aquatic life (MOE 2018). These exceedances are discussed in detail in the following sections.

Table 4. Summary of baseline and year 1 water quality data for key parameters. For metals, only parameters with BC WQG guideline exceedances are included.

Parameter	Range of parameter values				BC WQG
	Baseline (2013 - 2014)		Year 1 (2016 - 2017)		Instantaneous Min./Max.
	Min.	Max.	Min.	Max.	
Physical Tests (mg/L)					
Sp. Conductivity (*in-situ*, µS/cm)	37	70.8	50.1	85.9	
Sp. Conductivity (lab, µS/cm)	53.4	65.4	48.5	65.0	
Hardness (as $CaCO_3$)	22.6	27.3	18.4	25.5	
Dissolved Oxygen (*in-situ*, %)	65.0	84.5	54.6	94.7	
Dissolved Oxygen (*in-situ*)	7.89	11.24	6.54	10.81	< 9 (buried life stages)[1]; < 5 (other life stages)[1]
Temperature (*in-situ*, °C)	4.9	11.8	4.0	9.6	
Total Dissolved Solids	49	69	40	63	
Total Suspended Solids	<1.0	8.5	<1.0	5.6	EQ
Turbidity (lab, NTU)	0.72	8.68	0.23	4.69	
pH (*in-situ*, pH units)	5.87	8.30	6.41	7.17	n/a[2]
pH (lab, pH units)	7.28	7.59	7.11	7.45	n/a[2]
Biological Oxygen Demand	<2.00	<2.00	<2.00	<2.00	
Chemical Oxygen Demand	<20.0	<20.0	<20.0	<20.0	
Anions and Nutrients (mg/L)					
Alkalinity, Total (as $CaCO_3$)	22.9	29.9	16.1	26.8	
Ammonia, Total (as N)	<0.005	0.0383	<0.005	0.0416	0.68
Bromide (Br)	<0.05	<0.05	<0.05	<0.05	
Chloride (Cl)	<0.5	2.56	<0.5	0.58	600
Orthophosphate (as P)	<0.001	0.0039	<0.001	0.0033	
Fluoride (F)	0.023	0.031	0.022	0.032	EQ
Nitrate (as N)	0.0284	0.0495	0.0264	0.173	32
Nitrite (as N)	<0.001	0.0013	<0.001	<0.001	EQ
Sulfate (SO_4)	4.12	5.73	3.00	6.78	
Total Phosphate[3]	0.0024	0.0276	<0.002	0.0120	
Total Metals (mg/L)					
Iron (Fe)	0.329	3.610	0.065	1.340	1
Dissolved Metals (mg/L)					
Iron (Fe)	0.161	1.02	0.040	1.280	0.35

Yellow shading indicates exceedance of the instantaneous minimum BC WQG (MOE 2018).

EQ indicates that the applicable guideline is an equation as per MOE (2018). Total suspended solids data at the bridge site were compared to data collected at the upstream site on the same sample date; because data were available for total suspended solids, data were not screened against turbidity guidelines.

[1] Dissolved oxygen data were screened against the BC WQG for the instantaneous minimum water column concentration for both buried embryo/alevin life stages (9 mg/L) and other life stages (5 mg/L).

[2] When baseline values are between 6.5 and 9 there is no restriction on changes within this range (lethal effects observed below 4.5 and above 9.5). When baseline pH is < 6.5, there should be no statistically significant decrease in pH from background, and there is no restriction on the increase in pH except in boggy areas that have a unique fauna or flora.

[3] Total Phosphate measured during baseline, Total Phosphorus measured during Year 1.

4.2.1.1. Physical Parameters, Dissolved Oxygen and Nutrients

No discernable changes in the range of general physical water quality parameters are evident for specific conductivity, alkalinity, hardness, TDS, TSS, turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD), and anions (fluoride, chloride, and sulfate) (Appendix D). Furthermore, these parameter values do not exceed BC WQGs where applicable.

Alkalinity values in Alena Creek are typical of BC coastal waters and indicate a moderate sensitivity to acidic inputs (RISC 1998b). Alena Creek exhibited predominantly clear flow conditions (TSS <25 mg/L and turbidity <8 NTU) in all cases during year 1 sampling. During baseline and year 1 monitoring, turbidity and TSS were typically slightly higher at the bridge site (ALE-BDGWQ) compared to the upstream site and varied between seasons at both sites (Appendix D).

In-situ pH was less than 6.5 on a number of occasions with the lowest pH measured at the ALE-USWQ1 site during both baseline (pH was 6.21) and year 1 monitoring (pH was 6.41). Coastal streams in BC commonly have pH values ranging from 5.5 to 6.5 and natural variation in pH is a common occurrence (RISC 1998b). Laboratory analyzed pH was between 7.11 and 7.59 in all cases. The BC WQG indicate that if pH is less than 6.5 then no statistically significant decrease from background pH should occur (MOE 2018). The ALE-USWQ1 site represents background conditions as no instream habitat enhancement work was conducted this far upstream (Map 3).

Biochemical oxygen demand and chemical oxygen demand were below the respective MDLs of 2.0 mg/L and 20 mg/L at all sites on all sample occasions during both baseline and year 1 sampling. The non-detectable concentrations of BOD and COD in Alena Creek suggest that the concentration of organic matter in the water is low.

In BC, surface waters generally have dissolved oxygen concentrations greater than 10 mg/L, with saturations that are close to equilibrium with the atmosphere (i.e., close to 100%) (RISC 1998b). Dissolved oxygen concentrations measured *in-situ* ranged from 7.89 mg/L to 11.24 mg/L during baseline sampling and from 6.54 mg/L to 10.81 mg/L during year 1 sampling (Table 5). During baseline and year 1 sampling, dissolved oxygen levels in the water column were less than the BC WQG minimum instantaneous value for the water column of 9 mg/L for the protection of buried life stages (eggs and alevin) on a number of occasions, predominantly at the upstream site (Table 5). The BC WQG for dissolved oxygen are more stringent when applied to buried life stages given that the dissolved oxygen in the interstitial water (in the spawning gravel) is expected to be less than that measured in the water column. Following the enhancement works, no exceedances of the minimum BC WQG at the bridge site were observed, with data indicating a well aerated condition with dissolved oxygen concentrations ranging from 10.38 mg/L to 10.81 mg/L at ALE-BDGWQ in 2016 and 2017 (Table 5).

Nutrient concentrations were within typical values for BC watercourses and well below the applicable BC WQG for the protection of aquatic life (Appendix D). Ammonia is expected to be present at concentrations of <0.100 mg/L in waters not affected by waste discharges

(Nordin and Pommen 1986). In general, ammonia concentrations were higher at the bridge site during both baseline and year 1 sampling (Appendix D). Nitrate concentrations were also slightly higher at the bridge site during both baseline and year 1 sampling (Appendix D).

Orthophosphate concentrations were often below detection limits at the upstream site and slightly higher at the bridge site. Very low orthophosphate concentrations are expected as it is a biologically readily available form of phosphorus and quickly utilized by biota. Coastal BC streams typically have orthophosphate concentrations <0.0001 mg/L (Slaney and Ward 1993, Ashley and Slaney 1997).

Table 5. Summary of dissolved oxygen data collected during baseline and year 1 monitoring.

Year	Date	Site[1]	Dissolved Oxygen %				Dissolved Oxygen[3] mg/L			
			Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD
2013	08-Jul	ALE-USWQ	79.1	79.0	79.1	0.1	8.20	8.20	8.21	0.01
		ALE-BDGWQ	82.8	82.7	82.9	0.1	8.76	8.75	8.77	0.01
	16-Sep	ALE-USWQ	80.4	79.9	81.1	0.6	9.04	8.95	9.16	0.11
		ALE-BDGWQ	82.6	80.1	84.5	2.3	9.20	9.06	9.29	0.12
	18-Nov	ALE-USWQ1	65.4	65.0	66.1	0.6	7.93	7.89	7.97	0.04
		ALE-BDGWQ	76.9	76.5	77.3	0.4	9.67	9.64	9.71	0.04
2014	27-Feb	ALE-USWQ1	79.4	79.3	79.4	0.1	9.20	9.20	9.21	0.01
		ALE-BDGWQ	82.5	82.5	82.6	0.1	10.01	10.00	10.01	0.01
	29-Apr	ALE-USWQ1	88.2	88.1	88.3	0.1	10.90	10.89	10.91	0.01
		ALE-BDGWQ	95.4	95.3	95.5	0.1	11.23	11.22	11.24	0.01
	25-Nov	ALE-BDGWQ	86.6	86.5	86.6	0.1	10.95	10.95	10.96	0.01
2016	23-Nov	ALE-USWQ1	71.8	71.7	72.0	0.2	8.87	8.86	8.88	0.01
		ALE-BDGWQ	83.5	83.4	83.6	0.1	10.55	10.55	10.56	0.01
2017	05-Mar	ALE-USWQ1	78.7	78.4	78.9	0.3	-	-	-	-
		ALE-BDGWQ	85.8	85.8	85.8	0.0	-	-	-	-
	05-Jun	ALE-USWQ1	74.6	74.5	74.7	0.1	8.77	8.74	8.80	0.03
		ALE-BDGWQ	89.4	89.3	89.5	0.1	10.38	10.38	10.39	0.01
	13-Sep	ALE-USWQ1	55.0	54.6	55.7	0.6	6.56	6.54	6.58	0.02
		ALE-BDGWQ	94.7	94.6	94.7	0.1	10.80	10.80	10.81	0.01

[1] ALE-USWQ was moved 570 m upstream to ALE-USWQ1 in November 2013 to ensure the site was sufficiently upstream of the instream enhancement works.

[2] Average of three replicate *in-situ* measurements (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

[3] DO data were screened against the BC WQG for the instantaneous minimum water quality concentration for both buried embryo / alevin life stages (9 mg/L) and other life stages (5 mg/L). Yellow shading indicates an exceedance of the instantaneous minimum water column concentration of 9 mg/L for buried embryo / alevin life stages (MOE 2018).

4.2.1.2. Total and Dissolved Metals

The baseline and year 1 total and dissolved metals results are provided in summary tables in Appendix D and the ALS lab reports for 2016 and 2017 are provided in Appendix C (ALS lab reports for the baseline period are provided in Appendix B of Harwood *et al.* 2016). Note that dissolved metals results for November 2016 are not available due to an error where samples were not filtered prior to analysis. With the exception of iron (Table 6), total and dissolved metals concentrations were not in exceedance of the short-term maximum BC WQG (MOE 2018) during baseline or year 1 sampling. Due to the exceedance of the BC WQGs for iron, these results are discussed in more detail below.

Total and Dissolved Iron

The consequences of high background iron concentrations on the Alena Creek fish populations were evaluated in detail in the baseline report (Harwood *et al.* 2016). Several studies have demonstrated that fish can acclimatize to moderately high total iron concentrations within four to six weeks exposure at concentrations ranging from 1.8 mg/L to 18.6 mg/L (Phippen *et al.* 2008). Total iron concentrations in Alena Creek are either below or within the lower end of the range used in these acclimatization studies (Table 6). This, combined with the presence of a well-established, self-sustaining fish population in Alena Creek, suggests that iron concentrations are not high enough to be toxic to fish present in Alena Creek. In addition, the Ministry of Environment recognizes that the total iron water quality guideline of 1 mg/L may be over-protective in many cases (Phippen *et al.* 2008). This is in part due to the reliance on bioassay data, which in the case of iron may be confounded by the complexity of iron chemistry that includes pH shifts, changes from Fe^{2+} and Fe^{3+}, and changes from the dissolved to particulate phase (Phippen *et al.* 2008). In all situations, Phippen *et al.* (2008) recommends that dissolved iron concentrations are the most appropriate way to measure risk; however, they also acknowledge that the development of a guideline for dissolved iron is difficult due to the lack of clear data specifically differentiating between the effects of dissolved and total iron.

Dissolved iron exceeded the BC WQG less frequently during year 1 sampling than during baseline sampling because exceedances were only observed at the bridge site. Concentrations of dissolved iron exceeded the short-term maximum BC WQG of 0.35 mg/L at the bridge site during all sampling periods, with the range of concentrations similar between baseline and year 1 monitoring (Table 6).

Total iron exceeded the short-term maximum BC WQG of 1 mg/L at one or both sites on all sampling dates during baseline sampling, however only one exceedance occurred during year 1 sampling (ALE-BDGWQ on Sep 13, 2017). The frequency of exceedances and concentration of total iron decreased during year 1 in comparison to baseline values (Table 6) at both sites.

Fish, including young-of-the-year, are distributed throughout the area sampled for water quality (Section 4.4.2) and do not appear to be adversely affected by the iron concentrations observed.

Table 6. Summary of total and dissolved iron (Fe) results during baseline (2013 and 2014) and year 1 (2016 and 2017) sampling.

Year	Date	Site	n	Iron (Fe) - Dissolved mg/L				Iron (Fe) - Total mg/L			
				Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2013	08-Jul	ALE-USWQ	3	0.596	0.589	0.600	0.006	1.06	1.04	1.09	0.03
		ALE-BDGWQ	3	1.013	1.010	1.020	0.006	1.96	1.95	1.98	0.02
	16-Sep	ALE-USWQ	3	0.772	0.740	0.801	0.031	1.19	1.15	1.22	0.04
		ALE-BDGWQ	3	0.821	0.811	0.832	0.011	2.11	2.08	2.13	0.03
	18-Nov	ALE-USWQ1	3	0.207	0.204	0.209	0.003	0.34	0.33	0.35	0.01
		ALE-BDGWQ	3	0.809	0.783	0.829	0.024	1.18	1.16	1.21	0.03
2014	27-Feb	ALE-USWQ1	3	0.172	0.161	0.183	0.011	1.45	0.34	3.61	1.87
		ALE-BDGWQ	3	0.456	0.452	0.460	0.004	0.80	0.77	0.82	0.03
Baseline Summary			*24*	*0.606*	*0.161*	*1.020*	-	*1.26*	*0.33*	*3.61*	-
2016	23-Nov	ALE-USWQ1	3	0.197	0.191	0.201	0.005	0.22	0.22	0.23	0.01
		ALE-BDGWQ	3	0.871	0.857	0.887	0.015	0.93	0.91	0.94	0.02
2017	05-Mar	ALE-USWQ1	2	0.109	0.105	0.112	0.005	0.11	0.11	0.11	0.00
		ALE-BDGWQ	2	0.877	0.871	0.882	0.008	0.90	0.88	0.93	0.03
	05-Jun	ALE-USWQ1	2	0.070	0.066	0.074	0.006	0.07	0.07	0.07	0.00
		ALE-BDGWQ	2	0.669	0.660	0.678	0.013	0.65	0.64	0.65	0.01
	13-Sep	ALE-USWQ1	2	0.041	0.040	0.042	0.001	0.19	0.17	0.20	0.02
		ALE-BDGWQ	2	1.007	0.733	1.280	0.387	1.34	1.34	1.34	0.00
Year 1 Summary			*18*	*0.480*	*0.040*	*1.280*	-	*0.55*	*0.07*	*1.34*	-

[1] Average of three (n=3) or two (n=2) replicates on each date.

Yellow shading indicates exceedance of the short-term maxiumum (0.35 mg/L for dissovled iron and 1.0 mg/L for total iron, MOE 2018).

4.2.2. Water Temperature

4.2.2.1. Overview

The period of record for post-construction analysis in Year 1 was from November 23, 2016 to November 10, 2017 (Table 7). Data availability is based on the most recent download of water temperature loggers. During the Year 1 monitoring period, both monitoring sites had complete data records, but data gaps did occur during pre-construction monitoring (Table 7). Data gaps can occur due to equipment failure or loss, and out-of-water events during low flows, or if sensors become buried in sediment.

For the pre-construction phase, the processed record corresponded to a period of 568 days from April 17, 2014 to December 31, 2014 at ALE-USWQ1, and 460 days from August 27, 2013 to December 31, 2014 at ALE-BDGWQ, with the sizes of gaps in the records ranging from 6.3% to 8.9% of this period (Table 7). For the post-construction phase, the processed record to date corresponded to a period of 352 days with zero gaps in the records (Table 7).

Detailed plots of water temperature at both sites for all monitoring years (pre- and post-construction) are shown in Figure 5. Detailed plots of annual water temperature for each site during pre- and post-construction phase are provided in Section 2 of Appendix E. The water temperature records from the monitoring sites show seasonal and interannual variability. This variability is displayed in Section 3 of Appendix E and summarized in Section 4 of Appendix E for the pre- and post-construction phase, respectively, which provides the mean, minimum, and maximum water temperatures for each month of the period of record.

In post-construction Year 1, the pattern in daily temperature has been largely similar to pre-construction phase. There has been no substantial change in the pattern of inter-site differences in water temperature compared to pre-construction phase (Section 3 of Appendix E). In general, water temperature at ALE-USWQ1 varied in a narrower range than observed at ALE-BDGWQ. Typically, water temperatures at upstream sites are cooler (58% and 54% of the data record during pre- and post-construction phase) than that of downstream site. However, this is not the case for all months of the year in Alena Creek where the upstream site is observed to be warmer (42% and 46% of the data record during pre- and post-construction phase) than the downstream site, possibly due to buffered groundwater, during the late fall and winter months.

There are differences in water temperature between the ALE-USWQ1 and ALE-BDGWQ sites during the winter and summer seasons, despite the short distance (~1 km) and elevation (11 m) difference between the two sites. There are likely two main reasons for these differences. First, the narrow range of temperatures observed at ALE-USWQ1 suggests that surface water temperature is buffered by groundwater at this site. Second, a tributary flows into Alena Creek between the two sites and this alters the influence of the groundwater entering Alena Creek near ALE-USWQ1. Some heating and cooling of the water will also occur along the 1 km reach between the two gauges.

Table 7. Period of record and source of water temperature data collected from Alena Creek sites.

Site	Project Phase	Periods of Record		No of Datapoints	Logging Interval	Number of Days with Valid Data	Gaps in Record (%)
		Start Date	End Date				
ALE-USWQ1	Pre-construction[1]	4/17/2013	12/31/2014	13,627	60 minute	568	8.9
	Post-construction[2]	11/23/2016	11/10/2017	33,780	15 minute	352	0
ALE-BDGWQ	Pre-construction[1]	8/27/2013	12/31/2014	11,049	60 minute	460	6.3
	Post-construction[2]	11/23/2016	11/10/2017	33,780	15 minute	352	0

[1] Pre-construction (2013-2014) water temperature was monitored via hydrometric gauges maintained by KPL.

[2] Post-construction water temperature Tidbit monitoring commenced on November 23, 2016.

Figure 5. Pre-construction and Post- Construction daily (a) average, (b) maximum, and (c) minimum water temperature data at all monitoring sites in the Alena Creek from May 2013 to December 2017. Note that the monitoring period does not include the construction period.

(a) Daily Average

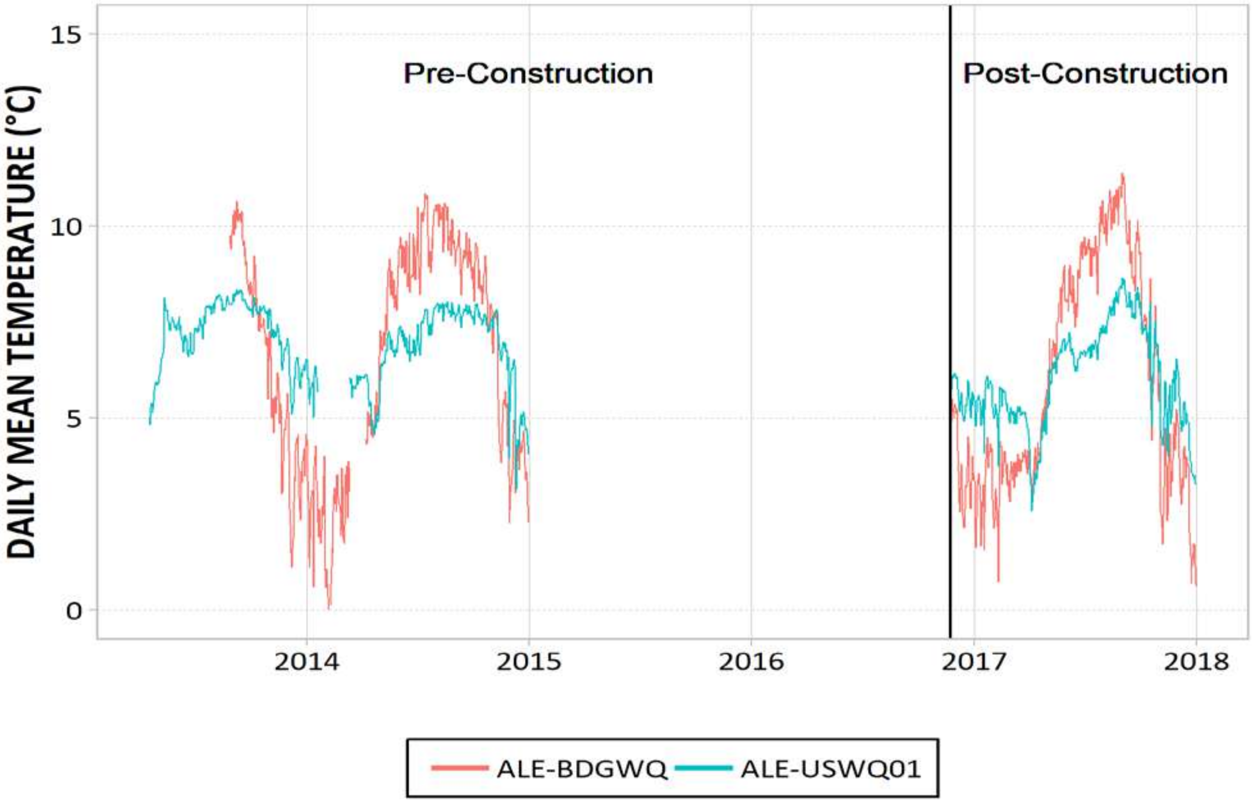


Table 5. Continued.

(b) Daily Maximum

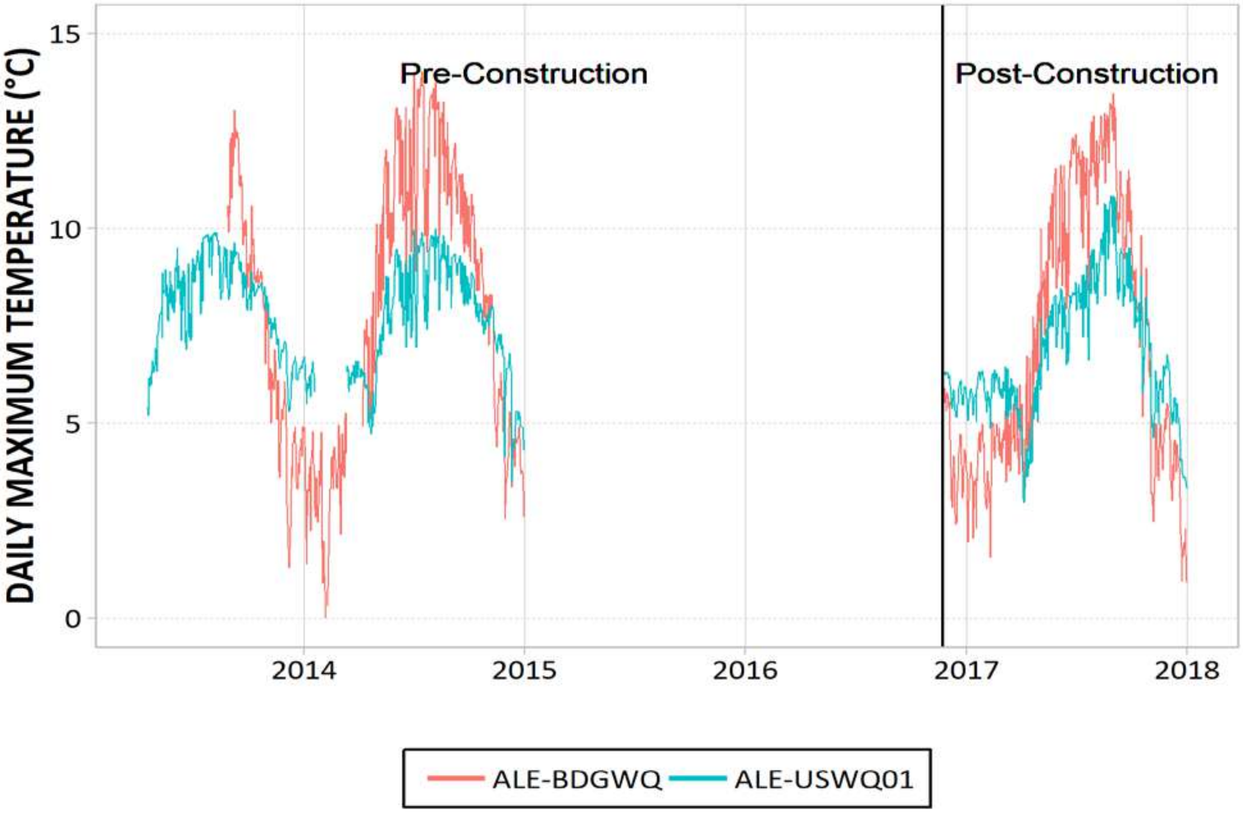
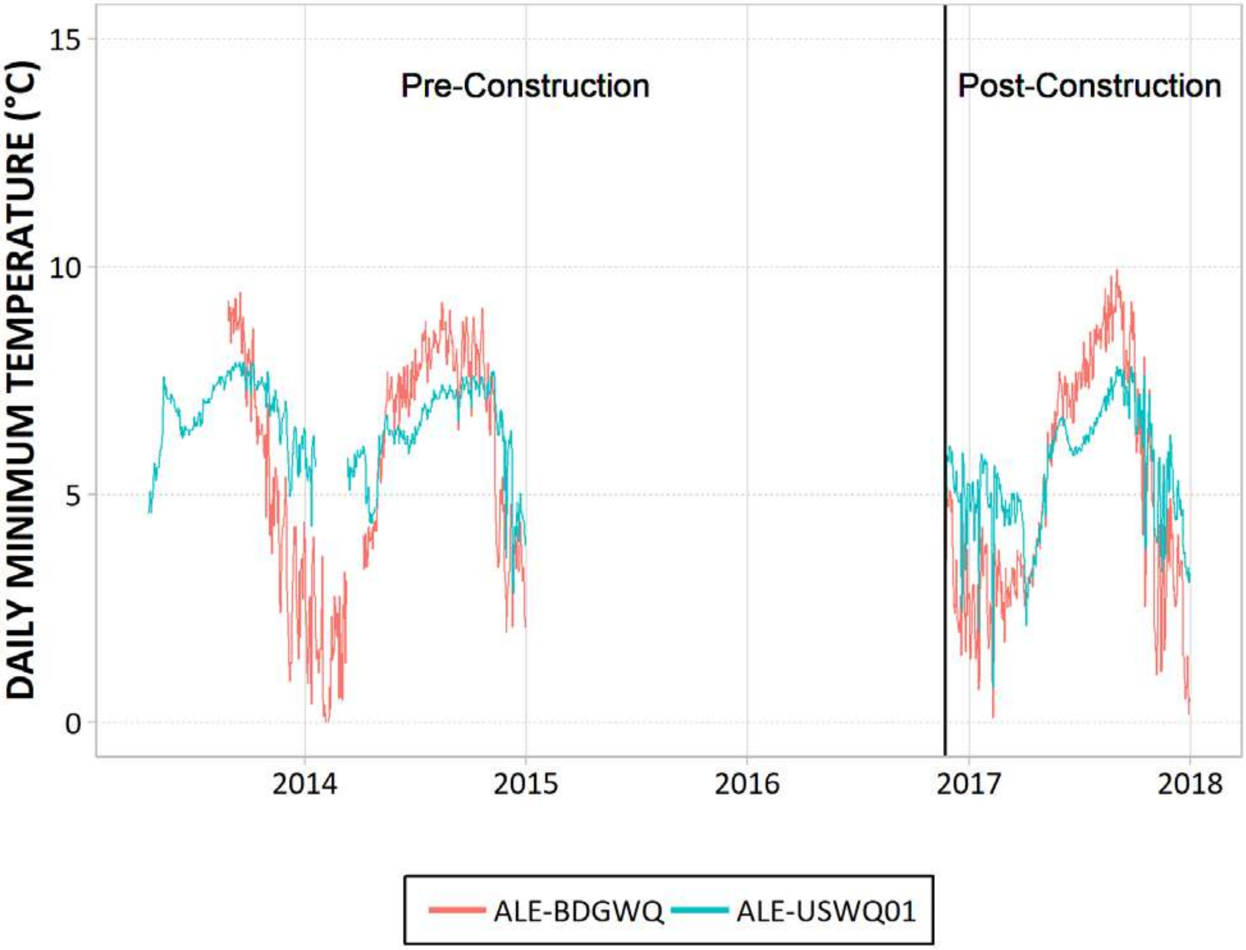


Table 5. Continued.

(c) Daily Minimum



4.2.2.1. Monthly Statistics, Growing Season, and Daily Extremes

The range of monthly average temperatures was similar between the pre- and post-construction phases at both sites. The coolest temperatures were observed between December to April, while the warmest months were July to September. Over the available data record, monthly average temperatures at the upstream site (ALE-USWQ1) ranged from 5.0°C to 8.1°C pre-construction, and from 4.0°C to 8.1°C post-construction (Section 4 of Appendix E). At the downstream site (ALE-BDGWQ) monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction, and from 3.2°C to 10.4°C post-construction.

Post-construction monthly minimum and maximum temperatures at site ALE-BDGWQ were within the range observed during pre-construction monitoring (0°C to 14°C), while the minimum and maximum values were slightly different at site ALE-USWQ1 under post-construction (0.8°C vs. 2.8°C and 10.8°C vs. 10.0°C). Note that a data gap occurred during pre-construction monitoring in February/March 2014, so there is some uncertainty in whether the coolest temperatures were captured during this phase. Nevertheless, no substantial change in monthly temperature statistics has been observed within the available pre and post-construction data period of record.

There has been no apparent change to the growing season start dates post-construction compared to pre-construction; the growing season started at the end of April during pre- and post-construction phase at both sites (Table 8). However, the growing season end dates (early November) during the post-construction phase are earlier than those observed during pre-construction phase (between mid-November and mid-December) at both monitoring sites. As a result, a decrease in cumulative degree days during the growing season at both sites during post-construction phase. Additional post-construction data are required to confirm growing season trends.

With respect to daily extreme temperatures, Alena Creek is classified as a cool stream based on there being no days with mean water temperatures >18°C in either pre or post-construction conditions, at either site (Table 9). The highest hourly temperature was 14.0°C, which occurred at the downstream site, ALE-BDGWQ, on July 15, 2014. At ALE-USWQ1, no days when the mean temperature was <1°C were observed pre-construction; however, this excludes a period in early February 2014 that was removed from the dataset due to suspected icing conditions when water temperature approached -2°C (Section 2.2.2) (McCarthy, pers. comm. 2014). Only one day was observed when the mean temperature was <1°C at ALE-BDGWQ.

In the post-construction phase, the number of days where the mean temperature was <1°C ranged from 0 days (ALE-USWQ1) to 1 days (ALE-BDGWQ). Note that, the post-construction record does not yet cover a complete year; the temperature extremes for a complete post-construction year for both sites will be reported in the Year 2 report, following additional data collection.

Table 8. Degree days in the growing season at ALE-USWQ1 and ALE-BDGWQ.

Site	Project Phase	Year	Number of days with valid data	Growing Season				
				Start Date	End Date	Length (day)	Gap (day)	Accumulated Thermal Units
ALE-USWQ1	Pre-construction	2013†	256	-	-	-	-	-
		2014	306	24-Apr	12-Dec	233	3	1,665
	Post-construction	2016‡	38	-	-	-	-	-
		2017	312	26-Apr	7-Nov	196	1	1,375
ALE-BDGWQ	Pre-construction	2013†	125	-	24-Nov	-	-	-
		2014	328	20-Apr	16-Nov	211	1	1,833
	Post-construction	2016‡	38	-	-	-	-	-
		2017	312	20-Apr	4-Nov	199	1	1,675

† Growing season could not be estimated because data are not available for complete year.

‡ Temperature monitoring began on November 23, 2016, limiting the ability to estimate the start date and accumulated thermal units.

Table 9. Summary of the number of days with mean daily water temperatures >20°C, >18°C , and <1°C at ALE-USWQ1 and ALE-BDGWQ.

Site	Project Phase	Year	*n* (days)±	Days T_{water} > 18°C	Days T_{water} > 20°C	Days T_{water} < 1°C
ALE-USWQ1	Pre-construction	2013	256	0	0	0
		2014†	306	0	0	0
	Post-construction‡	2016	38	0	0	0
		2017	312	0	0	0
ALE-BDGWQ	Pre-construction	2013	125	0	0	0
		2014	328	0	0	1
	Post-construction‡	2016	38	0	0	0
		2017	312	0	0	1

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

† Value excludes the period in February 2014 that was excluded from the dataset based on suspected ice conditions.

‡ To date, post-construction water temperature Tidbit monitoring commenced on November 23, 2016 and ended on November 10, 2017.

4.2.2.2. Bull Trout / Dolly Varden Temperature Guidelines

Provincial water temperature guidelines specific to Bull Trout and/or Dolly Varden in streams (Table 1 of Appendix E) were compared to the observed temperature at each monitoring site (ALE-USWQ1 and ALE-BDGWQ), as Bull Trout are present throughout the Alena Creek Project area. The incidence of extreme daily mean water temperatures compared to Bull Trout/Dolly

Varden water temperature guidelines is presented in Table 10. In addition, minimum and maximum instantaneous water temperature statistics at ALE-USWQ1 and ALE-BDGWQ monitoring site compared to guideline limits are presented in Section 5 of Appendix E.

The maximum (instantaneous) water temperature recorded within the Project area was 13.75°C, recorded at site ALE-BDGWQ in 2015 (Section 5 of Appendix E). Therefore, the highest maximum instantaneous temperatures did not exceed the prescribed guideline upper threshold of daily temperature for Bull Trout for the entire period of record at any site.

In addition, at site ALE-USWQ1 the highest maximum daily temperatures did not exceed the prescribed guideline upper threshold for spawning and incubation (i.e. 10°C), under pre or post-construction conditions (Table 10). However, the highest instantaneous maximum temperature observed at ALE-USWQ01 was 10.8°C in 2017. At site ALE-BDGWQ, the upper temperature threshold for spawning and incubation was exceeded under both pre- and post-construction conditions (Table 10). This occurred because of warm temperatures in August and September; in general, water temperatures at this site do not cool below 10°C until late September/October at this site.

Daily mean water temperatures did fall outside the lower threshold range for incubation (2°C) at site ALE-BDGWQ, under both pre- and post-construction conditions (Table 10): the frequency of occurrence was lower post-construction. No exceedances of the daily mean temperature threshold occurred at the upstream site (ALE-USWQ1), although some instantaneous records were less than 2°C (Section 5 of Appendix E).

In general, it appears site ALE-USWQ1 is more suitable for spawning and incubation of Bull Trout across the stated periodicity for this species, than site ALE-BDGWQ.

Table 10. Summary of incidence of extreme daily mean water temperatures compared to Bull Trout/Dolly Varden water temperature guidelines.

Site	Project Phase	Year	*n* (days)*	Days T_{water} > 15°C (Year Round)	Days T_{water} > 10°C (i.e., max spawning temperature, Aug 01 -Dec 08)	Days T_{water} > 10°C (i.e., max incubation temperature, Aug 01 -Mar 01)	Days T_{water} < 2°C (i.e., min incubation temperature, Aug 01 -Mar 01)
ALE-USWQ1	Pre-construction	2013	256	0	0	0	0
		2014†	306	0	0	0	0
	Post-construction	2016	38	0	0	0	0
		2017	312	0	0	0	0
ALE-BDGWQ	Pre-construction	2013	125	0	14	14	25
		2014	328	0	20	20	0
	Post-construction	2016	38	0	0	0	5
		2017	312	0	32	32	1

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

[†] Value excludes the period in February 2014 that was excluded from the dataset based on suspected ice conditions.

[‡] Post-construction water temperature monitoring commenced on November 23, 2016 and data are available to November 10, 2017.

4.2.2.3. Mean Weekly Maximum Temperatures (MWMxT)

A comparison of MWMxT temperature data to optimum temperature ranges was completed for each fish species using pre- and post-construction data collected at both sites. Results for upstream and downstream baseline water temperature data for all years combined is presented in Table 11 and Table 12. Post-construction data are presented in Table 13 and Table 14. The tables show the percent complete of the data record as well as the minimum and maximum MWMxT during the life stages of each fish species. For each life stage, the table also shows the percentage of MWMxT data that were above, within, and below the optimum ranges for fish life stages during baseline monitoring, as well as the percentage of MWMxT data more than 1°C above and below the optimum ranges.

Complete temperature records are not available for all life stages for each year, thus for each life history stage the percentage of data available is also provided in the summary tables. If the percent complete for a particular life stage is less than 50%, comparisons to the provincial guidelines were not calculated. Note that post-construction monitoring began near the end of 2016, and the MWMxT data during 2016 does not cover the complete life stage of any fish species (except for incubation for Coho Salmon). In addition, the current post-construction monitoring ended on November 2017; thus the spawning and incubation periods for Coho Salmon and incubation period for Bull Trout data are missing during 2017. MWMxT statistics for incubation will be calculated in Year 2, when a more complete period of record is available.

In general, water temperature at the monitoring sites was optimal for the fish species and life stages present under both pre- and post-construction periods, although some sub-optimally cool temperatures were recorded within most periods as well. Notable exceptions for both baseline and post-construction periods where MWMxTs were sub-optimally cool for the majority of, or the entire period, include: Coho Salmon rearing and Cutthroat Trout spawning and incubation at site ALE-USWQ1. Temperatures were also cooler than optimal at times for Coho Salmon rearing, Bull Trout spawning at site ALE-BDGWQ.

Sub-optimally warm temperatures were observed in August and September at both sites during Bull Trout spawning and incubation periods and for a small proportion of the record at site ALE-BDGWQ during Cutthroat Trout incubation. Warm surface waters during incubation may be partially mitigated by the groundwater upwelling at site ALE-USWQ1, such that temperature within the redds may be lower.

Overall, the minimum and maximum MWMxT was greatest at site ALE-BDGWQ and more moderate at site ALE-USWQ1, perhaps due to a thermal buffering effect of groundwater at the upstream site. No substantial change in the range of MWMxTs was observed at site ALE-BDGWQ between pre- and post-construction phases: MWMxT ranged from 2.1°C to 13.7°C pre-construction and from 2.8°C to 13.0°C post-construction. The range of MWMxTs observed at site ALE-USWQ1 was slightly greater post-construction (3.5°C to 10.5°C post vs. 4.4°C to 9.9°C pre) but was small enough to be explained by inter-annual variability.

Post-construction conditions will be assessed further following the collection of Year 2 data as a longer period of record will complete the period of record for all life history stages.

Table 11. Pre-construction mean weekly maximum water temperatures for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-USWQ1.

Species	Life Stage			Year	Percent Complete	MWMxT (°C)		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min.	Max.	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	98.4	5.6	9.4	6.7	37.5	62.5	0.0	0.0
			122	2014	98.4	4.4	9.3	25.0	39.2	60.8	0.0	0.0
	Spawning* (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	97.5	5.6	8.5	0.0	0.0	100.0	0.0	0.0
			79	2014	96.2	4.4	7.9	0.0	1.3	98.7	0.0	0.0
	Incubation* (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	53.8	5.6	8.5	0.0	0.0	100.0	0.0	0.0
			169	2014	45	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	70.1	5.6	9.8	36.3	77.3	22.7	0.0	0.0
			365	2014	83.8	4.4	9.7	53.9	81.7	18.3	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	81.5	5.8	8.9	45.3	100.0	0.0	0.0	0.0
			92	2014	100	5.0	9.2	56.5	94.6	5.4	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	100	6.8	9.8	16.9	65.3	34.7	0.0	0.0
			124	2014	100	6.3	9.7	17.7	62.9	37.1	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	70.1	5.6	9.8	3.5	22.7	77.3	0.0	0.0
			365	2014	83.8	4.4	9.7	16.0	34.6	65.4	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	98.5	5.6	9.8	0.0	0.0	75.0	25.0	0.0
			130	2014	98.5	5.7	9.7	0.0	0.0	71.1	28.9	0.0
	Incubation* (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	77.9	5.6	9.8	0.0	0.0	6.0	94.0	64.5
			213	2014	70.9	4.4	9.7	0.0	0.0	18.5	81.5	76.2
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	70.1	5.6	9.8	0.0	3.5	96.5	0.0	0.0
			365	2014	83.8	4.4	9.7	4.2	16.0	84.0	0.0	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).
Grey shading indicates the percent complete is less than 50%, comparisons to the provincial guidelines are not included for <50% of data.
* statistics presented are for the calendar year in which the period started, and include data for the following calendar year when period lasts through the winter.

Table 12. **Pre-construction mean weekly maximum water temperatures for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-BDGWQ.**

Species	Life Stage			Year	Percent Complete	MWMxT (°C)			% of MWMxT			
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min.	Max.	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	99.2	2.1	12.5	43.8	49.6	50.4	0.0	0.0
			122	2014	99.2	3.2	11.7	40.5	42.1	57.9	0.0	0.0
	Spawning* (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	98.7	2.1	8.8	10.3	30.8	69.2	0.0	0.0
			79	2014	97.5	3.2	9.1	3.9	28.6	71.4	0.0	0.0
	Incubation* (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	82.2	2.1	8.8	13.7	52.5	47.5	0.0	0.0
			169	2014	45.6	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	34.2	-	-	-	-	-	-	-
			365	2014	89.9	2.2	13.7	44.8	50.3	49.7	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	0	-	-	-	-	-	-	-
			92	2014	92.4	5.9	12.7	24.7	31.8	60.0	8.2	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	4.0	-	-	-	-	-	-	-
			124	2014	99.2	8.5	13.7	0.0	3.3	61.0	35.8	13.8
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	34.2	-	-	-	-	-	-	-
			365	2014	89.9	2.2	13.7	34.5	40.2	59.8	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	78.5	2.1	12.5	5.9	13.7	46.1	40.2	26.5
			130	2014	99.2	3.5	13.3	3.9	11.6	30.2	58.1	48.1
	Incubation* (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	83.1	2.1	12.5	0.0	0.0	55.4	44.6	37.9
			213	2014	70.9	3.2	13.3	0.0	0.0	32.5	67.5	66.2
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	34.2	-	-	-	-	-	-	-
			365	2014	89.9	2.2	13.7	30.2	34.5	65.5	0.0	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).
Grey shading indicates the percent complete is less than 50%, comparisons to the provincial guidelines are not included for <50% of data.
* statistics presented are for the calendar year in which the period started, and include data for the following calendar year when period lasts through the winter.

Table 13. **Post-construction mean weekly maximum water temperatures for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-USWQ1.**

Species	Life Stage			Year	Percent Complete	MWMxT (°C)		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min.	Max.	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2016	30.3	-	-	-	-	-	-	-
			122	2017	57.4	5.2	10.4	11.4	22.9	77.1	0.0	0.0
	Spawning* (Oct. 15 to Jan. 01)	4.4-12.8	79	2016	49.4	-	-	-	-	-	-	-
			79	2017	32.9	-	-	-	-	-	-	-
	Incubation* (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	76.3	4.6	6.3	0.0	0.0	100.0	0.0	0.0
			169	2017	15.4							
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	3.5	10.5	66.3	87.2	12.8	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2016	0	-	-	-	-	-	-	-
			92	2017	98.9	3.5	8.3	90.1	100.0	0.0	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2016	0	-	-	-	-	-	-	-
			124	2017	99.2	6.2	10.5	43.1	77.2	22.8	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	3.5	10.5	34.3	47.1	52.9	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2016	10.8	-	-	-	-	-	-	-
			130	2017	77.7	5.2	10.5	0.0	0.0	64.4	35.6	10.9
	Incubation* (Aug. 01 to Mar. 01)	2.0-6.0	213	2016	46.0	-	-	-	-	-	-	-
			213	2017	47.4	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	3.5	10.5	7.1	34.3	65.7	0.0	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).
Grey shading indicates the percent complete is less than 50%, comparisons to the provincial guidelines are not included for <50% of data.
* statistics presented are for the calendar year in which the period started, and include data for the following calendar year when period lasts through the winter.

Table 14. Post-construction mean weekly maximum water temperatures for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-BDGWQ.

Species	Life Stage			Year	Percent Complete	MWMxT (°C)		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min.	Max.	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2016	30.3	-	-	-	-	-	-	-
			122	2017	57.4	3.3	12.9	12.9	22.9	77.1	0.0	0.0
	Spawning* (Oct. 15 to Jan. 01)	4.4-12.8	79	2016	49.4	-	-	-	-	-	-	-
			79	2017	32.9	-	-	-	-	-	-	-
	Incubation* (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	76.3	2.8	5.7	1.6	41.9	58.1	0.0	0.0
			169	2017	15.4	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	2.8	13.0	49.4	56.1	43.9	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2016	0	-	-	-	-	-	-	-
			92	2017	98.9	4.3	12.2	39.6	52.7	42.9	4.4	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2016	0.0	-	-	-	-	-	-	-
			124	2017	99.2	7.4	13.0	4.9	14.6	60.2	25.2	0.8
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	2.8	13.0	37.8	41.3	58.7	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2016	10.8	-	-	-	-	-	-	-
			130	2017	77.7	3.3	13.0	5.9	7.9	28.7	63.4	53.5
	Incubation* (Aug. 01 to Mar. 01)	2.0-6.0	213	2016	46.0	-	-	-	-	-	-	-
			213	2017	47.4	-	-	-	-	-	-	-
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2016	10.1	-	-	-	-	-	-	-
			365	2017	85.5	2.8	13.0	34.6	37.8	62.2	0.0	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).
Grey shading indicates the percent complete is less than 50%, comparisons to the provincial guidelines are not included for <50% of data.
* statistics presented are for the calendar year in which the period started, and include data for the following calendar year when period lasts through the winter.

4.3. Fish Habitat

4.3.1. Stability Assessment

4.3.1.1. Reach 1

Reach 1 is located in the downstream reach of the FHEP starting at the Lillooet River Forest Service Road (FSR) (Figure 6). Thirteen riffles were installed in Reach 1 and more than 120 pieces of large woody debris with total creation of 1,387 m^2 of enhanced fish habitat. In early November 2016, two months following Project completion, a significant rain-on-snow event occurred, resulting in a 1-in-20 year flood event on the Upper Lillooet River (McCoy, pers. comm. 2016) (Figure 1b). As a result, there were some notable changes in some of the channel structures in Alena Creek, though none affected the overall quality or usability of the constructed habitat. A comparison of photos is available in Appendix F; however, a selection of comparison photos is presented below.

Figure 6 shows a plan view of the enhancements conducted in Reach 1, with Figure 7 and Figure 9 showing a comparison of the furthest downstream cross-section (ALE-XS1). The stream channel at this location has widened slightly with wetted access to the constructed floodplain on river left, as intended. Just upstream of this cross-section the river bends to the right and a series of root wads were installed along the outside left bank (Figure 9). Following the high water in November 2016, the bank at 0+185 has eroded up to 0.85 cm back from its original configuration (Figure 10). Currently, the root wads and woody debris are stable; however, this bank should be monitored over the duration of the LTMP term to note any changes. There were no other significant changes along the other transects in Reach 1 (ALE-XS2, ALE-XS3 and ALE-XS4; Figure 6).

Figure 6. Alena Creek Reach 1, UAV imagery from the as-built Survey (West *et al.* 2017).

Figure 7. Looking RR-RL at ALE-XS1 on Sep 19, 2016.

Figure 8. Looking RL-RR at ALE-XS1 on Nov 10, 2017.

Figure 9. Looking upstream at bend at installed rootwads on Oct 26, 2016.

Figure 10. Looking upstream at bend at installed rootwads where bank has eroded on Nov 10, 2017.

4.3.1.2. Reach 3

A total of 668 m^2 of new instream habitat and 1,139 m^2 of floodplain was created in the upstream reach, Reach 3 (Figure 11). Twelve cobble riffles were installed with over 100 pieces of large woody debris. The flood event in 2016 had a greater impact to the habitat features in Reach 3 than Reach 1; however, as in Reach 1, it has not diminished the overall function or usability of the constructed habitat. Downcutting is evident at ALE-XS5 (Figure 12, Figure 13). This is because the further downstream riffle crest at 0+185 has been eroded along the river right bank (Figure 14, Figure 15). The gradient downstream of this constructed riffle crest to the confluence of the existing habitat was the greatest of all the constructed riffles. Further upstream downcutting is prevented by the stable riffle crest constructed at 0+165.

At transect ALE-XS6, the channel has remained unchanged from construction. However, just upstream of the transect, a mid-channel bar has formed as the result of erosion along the right bank (Figure 16, Figure 17). The bank erosion is caused by a new storm water channel that flows into Alena Creek from the Lillooet FSR.

At transect ALE-XS7, the cross-sectional geometry has changed significantly following the high flow in 2016. Immediately following construction, the bankfull width was measured at 5.3 m and the wetted width at 4.4m. The current bankfull and wetted width are greater, respectively, at 6.2 m and 5.7 m. The widening of the channel is caused by a deposition of gravel just upstream of the transect (Figure 18). The deposition is caused by a small breach in the riffle crest along the left bank at 0+0.050 (Figure 19).

Beaver activity has created significant damming upstream of both Reach 1 and Reach 3. This activity has not affected either of the constructed reaches to date; however, the backwatered areas and new channel formation has the potential to affect both constructed reaches in the future. For example, immediately upstream of ALE-XS8, a new side channel has formed that has the potential to create erosion at this site if it becomes more established.

Figure 11. **Alena Creek Reach 3, UAV imagery from the as-built Survey (West *et al.* 2017).**

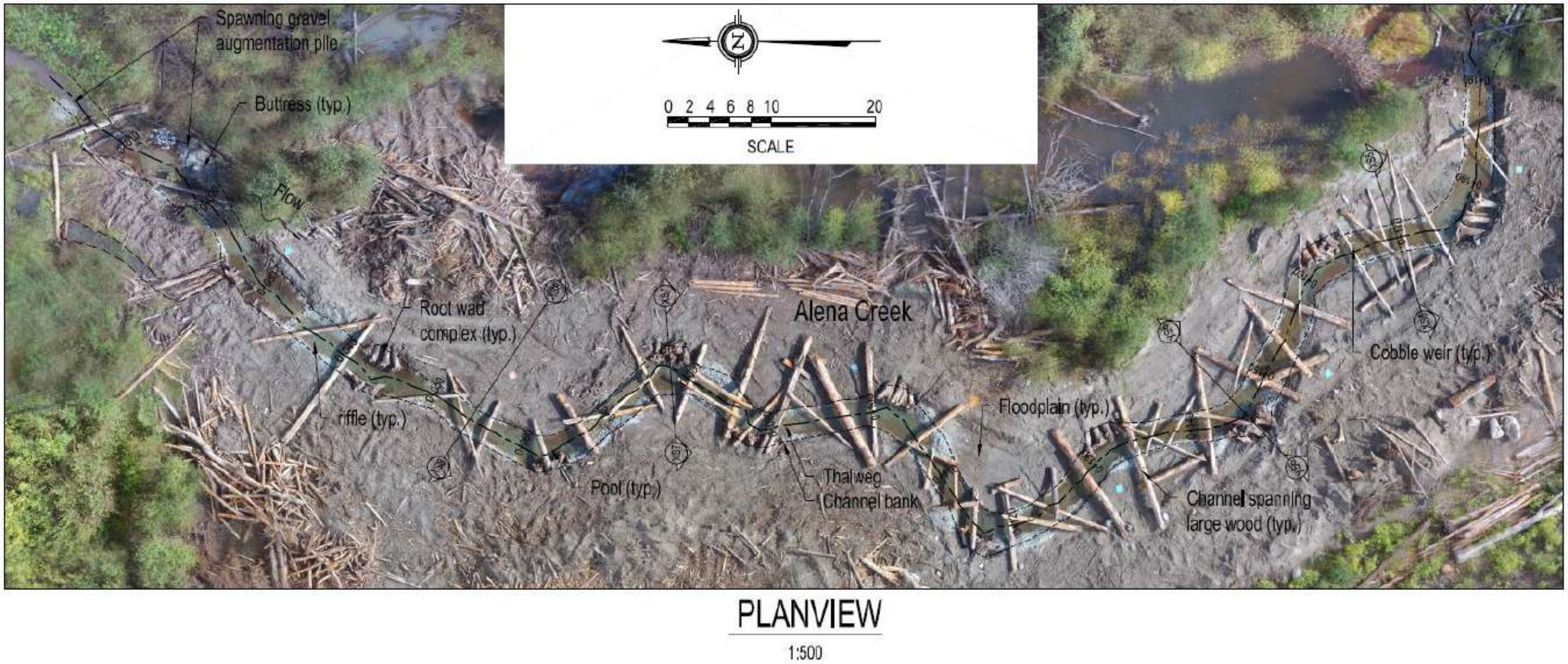


Figure 12. Looking RL-RR at ALE-XS5 on Sep 19, 2016. Note wetted width at yellow arrow.

Figure 13. Looking RL-RR at ALE-XS5 on Nov 10, 2017. Note wetted width at yellow arrow.

Figure 14. Looking upstream at riffle crest (0+185, Reach 3) on Sep 16, 2016.

Figure 15. Looking upstream at riffle crest (0+185, Reach 3) at right bank erosion on Nov 10, 2017.

Figure 16. Looking upstream of ALE-XS6 at the formation of a mid-channel bar on Nov 10, 2017.

Figure 18. Looking RR-RL at ALE-XS7 on Nov 10, 2017. Note upstream mid-channel bar formation.

Figure 17. Looking upstream at ALE-XS7 on Nov 10, 2017.

Figure 19. Looking upstream at riffle crest at 0+050 at breach along the RL bank on Nov 10, 2017.

4.3.2. Fish Habitat Assessment

The FHAP was conducted on October 3, 2017. A total of 1,344 m of habitat was surveyed, consisting of 1,312 m of primary and 32 m of secondary habitat. The mesohabitat units identified in the FHAP were digitized and a detailed map of the surveyed area was created (Map 2). FHAP information collected for the Alena Creek mainstem (primary units) and secondary units are provided below. The one secondary unit (side channel) that was directly associated with the construction activities was surveyed in full. All other off-channel habitat was assessed for access only. A summary table of the FHAP data is provided in Appendix G and photographs for individual units are presented in Appendix H.

The surveyed section of the Alena Creek mainstem consisted of 24 primary habitat units, with a total wetted area of 10,361 m^2 and a bankfull area of 13,012 m^2 (Table 15, Map 2). The average gradient of the primary units was 0.6% (SD = 0.5). Average wetted width was 7.2 m (SD = 8.3) and average bankfull width was 9.0 m (SD = 10.1).

The mainstem of Alena Creek is dominated by pool habitat (72%) followed by glide (18%) and riffle (6%) (Table 15). Numerically, total wetted area of different habitat types follows the same order as habitat units; pool habitat has a total wetted area of 7,505 m^2 followed by glide habitat with a total of 2,227 m^2 of total wetted area (Table 15). One tertiary pool with a depth of 0.7 m was identified within the primary channel (Table 16).

Overall, sands and fines were the dominant substrate in the mainstem, with 58% of mainstem habitat units having sand and fines as the dominant substrate (Table 17). Gravel was the sub-dominant substrate in 44% of habitat units. Of the gravel available, there were 48 total patches of functional spawning gravel and 19 patches of non-functional (i.e., dry) spawning gravel (Table 18). The majority of the area of functional spawning gravel (78%) was characterized as suitable for both resident and anadromous fish. Similarly, the majority of non-functional patches (88%) would be suitable for both resident and anadromous fish at higher flows. Total area of functional spawning habitat was 991.0 m^2. If all observed spawning patches were wetted, there would be 1,049 m^2 of spawning habitat available.

There was a relatively high amount of cover available for fish in the Alena Creek mainstem, representing 51.8% of the total area (Table 17). The dominant cover type for fish was large woody debris (LWD) (19.4%), followed by other forms of available cover including overhanging vegetation, instream vegetation and deep pools (Table 17). LWD was present in all 24 habitat units surveyed in the mainstem (Table 19). Of the 315 pieces of LWD that were counted during the survey, all were characterized as functional except one piece, with most of them being >50 cm in diameter.

Riparian vegetation along Alena Creek is a mix of deciduous pole saplings and shrubs (Table 20). Canopy closure was 0 to 20% in 67% of habitat units, and 20 to 40% in 21% of habitat units (Table 21).

A total of nine off-channel habitats to the Alena Creek mainstem were observed. The majority (i.e. 89%) of these habitat units are side channels. It is estimated that 56% of these side channels are accessible at most flows (Table 22). A further two side channels, and a wetland, are accessible at high flows only. The major side-channel affected by FHEP construction was surveyed in full as secondary habitat to the Alena Creek mainstem (Table 23). This channel has a total wetted area of 45 m^2 and a bankfull area of 48 m^2. The average gradient of this habitat unit was 0.5. The average wetted width was 2.8 m and the average bankfull width was 3.0 m. This side channel contained only one glide habitat unit (Table 23). Sand/fines was the dominant substrate type and gravel was the sub-dominant substrate type (Table 24). Cover was present in 10% of the secondary habitat unit (Table 24) and was primarily provided by LWD, all of which was classified as functional (Table 25).

A comparison of the FHAP conducted in Alena Creek during baseline studies in 2014 (Harwood *et al.* 2016) and Year 1 monitoring (conducted in 2017) showed two principal differences. The first was a change in the dominant habitat type from shallow glide habitat (mean ± SD depth of 0.3 m ± 0.2 m) to deeper (0.8 m ± 0.5 m) pool habitat (0.8 m ± 0.5 m). This change was a result of the enhancement work in Reaches 1 and 3 along with beaver activity in Reaches 2 and 4. The second major difference was a significant increase in the amount of functional spawning gravel available (an increase from 205.8 m^2 in 2014 to 991.0 m^2 in 2017). This increase in spawning gravel was directly attributable to the enhancement work.

Table 15. Summary of fish habitat assessment results for Alena Creek primary units, October 3, 2017.

Habitat Type	Number of Units	% of Total Habitat	Total Wetted Area (m^2)	Total Bankfull Area (m^2)	Mean Wetted Area (m^2)	Wetted Width (m)		Bankfull Width (m)		Wetted Depth (m)		Bankfull Depth (m)		Total Length (m)	Individual Length (m)		Gradient (%)		Weighted Gradient (%)
						Mean	SD[1]	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]		Mean	SD[1]	Mean	SD[1]	
Pool	8	72%	7,505	9,438	938	16.1	9.2	19.8	11.4	0.8	0.5	1.4	0.8	422	53	43	0.2	0.2	0.3
Riffle	6	6%	641	960	107	2.1	0.8	3.0	1.2	0.2	0.0	0.5	0.1	317	53	55	1.2	0.3	1.3
Run	3	3%	307	387	102	3.3	0.5	4.1	0.7	0.2	0.1	0.4	0.1	88	29	25	1.2	0.3	1.1
Glide	7	18%	1,908	2,227	273	3.0	1.7	3.7	1.7	0.4	0.3	1.0	0.4	485	69	65	0.4	0.2	0.3
Total	24	100%	10,361	13,012	432	7.2	8.3	9.0	10.1	0.5	0.4	0.9	0.6	1,312	55	50	0.6	0.5	0.6

[1] There are no standard deviation when habitat data was collected for only one unit

Table 16. Tertiary pool in the Alena Creek mainstem identified during FHAP, October 3, 2017.

Category	Number of Units	Length (m)		Width (m)		Water Depth (m)		Area (m^2)		Total Area (m^2)	% of Wetted Area
		Average	SD[1]	Average	SD[1]	Average	SD[1]	Average	SD[1]		
Primary	1	8.0	-	3.5	-	0.7	-	28.0	-	28.0	0.3

[1] There are no standard deviation when habitat data was collected for only one unit

Table 17. Summary of substrate and cover available in the mainstem habitat units of Alena Creek, October 3, 2017.

Substrate		Cover							
Dominant	**Sub-dominant**	**% Boulder**	**% Deep Pool**	**% LWD**	**%SWD**	**% Undercut Banks**	**% Instream Vegetation**	**% Overhanging Vegetation**	**% Total**
Sands/Fines (58%)	Gravel (44%)	0.0	10.0	19.4	0.0	0.7	10.3	11.3	51.8

Substrate percentages represent the percentage of habitat units in which the substrate type was dominant or sub-dominant.

Cover percentages represent percentages of total habitat area.

Table 18. Summary of the gravel habitat in the Alena Creek mainstem, October 3, 2017.

Spawner Type	Functional[a]				Non-functional[a]			
	# of Patches	Total Area (m^2)	Mean Area (m^2)	Standard Deviation (m^2)[b]	# of Patches	Total Area (m^2)	Mean Area (m^2)	Standard Deviation (m^2)[b]
Resident (R)	19	214.6	11.3	34.3	7	6.8	1.0	0.4
Both (AR)	29	776.4	26.8	51.1	12	50.8	4.2	4.6
Total	***48***	***991.0***	***20.6***	***45.4***	***19***	***57.6***	***3.0***	***4.0***

[a] Functional = wetted at time of survey, Non-functional = dry at time of survey.

[b] There are no standard deviation values when less than two patches were present.

AR = Suitable for both anadromous salmon and resident trout and char (10-75 mm, at least 1.5 m^2).

R = Suitable for resident trout and char (10-75 mm, at least 0.1 m^2).

A = Suitable for anadromous salmon (10-150 mm, at least 1.5 m^2).

Table 19. Summary of the LWD characteristics in Alena Creek mainstem, October 3, 2017.

Reach	Habitat Units Total	Habitat Units with LWD	Total LWD Tally	Functional LWD (Tally)			Non-Functional LWD (Tally)
				10-20 cm Diameter	20-50 cm Diameter	>50 cm Diameter	
Total	24	24	315	112	87	115	1

Table 20. Summary of the riparian characteristics for Alena Creek mainstem (number of habitat units with specified riparian vegetation), October 3, 2017.

Riparian Vegetation	Stage					Total
	Initial	Shrub	Pole Saplings	Young Forest	Mature Forest	
Mixed Conifer-Deciduous	0	1	0	0	0	*1*
Deciduous	0	6	14	0	0	*20*
Shrub/Herb	0	3	0	0	0	*3*
Total	*0*	*10*	*14*	*0*	*0*	*24*

Table 21. Canopy closure data for Alena Creek mainstem, October 3, 2017.

Reach	Canopy Closure				
	0 to 20 %	20 to 40 %	40 to 70 %	70 to 90 %	> 90%
Total	16	5	3	0	0

Table 22. Summary of Off Channel Habitat associated with the Alena Creek Mainstem, October 3, 2017.

Type	Access	n	Length (m)	
			Average[1]	S.D.[2]
Side Channel	Accessible at Most Flows	5	40	n/a
	No Access	1	nc	-
	Accessible at High Flows Only	2	20	n/a
Wetland	Accessible at High Flows Only	1	0	-

[1] nc = not collected

[2] There are no standard deviation when length data was collected for only one unit

Table 23. Fish habitat assessment results summary for Alena Creek secondary units, October 3, 2017.

Habitat Type	Number of Units	% of Total Habitat	Total Wetted Area (m^2)	Total Bankfull Area (m^2)	Mean Wetted Area (m^2)	Wetted Width (m)		Bankfull Width (m)		Wetted Depth (m)		Bankfull Depth (m)		Total Length (m)	Individual Length		Gradient (%)		Weighted Gradient (%)
						Mean	SD[1]	Mean	SD[1]	Mean	SD[1]	Mean	SD[1]		Mean	SD[1]	Mean	SD[1]	
Glide	1	100%	45	48	45	2.8	n/a	3.0	n/a	0.1	n/a	0.5	n/a	16	16	n/a	0.5	n/a	0.5
Total	1	100%	45	48	45	2.8	n/a	3.0	n/a	0.1	n/a	0.5	n/a	16	16	n/a	0.5	n/a	0.5

[1] There are no standard deviation when habitat data was collected for only one unit

Table 24. Substrate and cover summary for Alena Creek secondary units, October 3, 2017.

Substrate		Cover							
Dominant	Sub-dominant	% Boulder	% Deep Pool	% LWD	%SWD	% Undercut Banks	% Instream Vegetation	% Overhanging Vegetation	% Total
Sands/Fines (100%)	Gravel (100%)	0.0	0.0	10.0	0.0	0.0	0.0	0.0	10.0

Substrate percentages represent the percentage of habitat units in which the substrate type was dominant or sub-dominant.

Cover percentages represent percentages of total habitat area.

Table 25. Summary of the LWD characteristics in Alena Creek secondary units, October 3, 2017

Reach	Habitat Units Total	Habitat Units with LWD	Total LWD Tally	Functional LWD (Tally)			Non-Functional LWD (Tally)
				10-20 cm Diameter	20-50 cm Diameter	>50 cm Diameter	
Total	1	1	4	2	0	2	0

4.4. Fish Community

4.4.1. Adult Spawner Abundance

Observations of Coho Salmon during fall spawner surveys were made in 2016 (Table 26) and 2017 (Table 27). In both years, the peak counts of adult spawning Coho Salmon (Figure 20) were greater than 100 individuals, with the peak count in 2017 being the same as that observed in 2011 during the baseline period (Table 27). In contrast, the peak count in 2016 was 174, which represents a notable increase in the number of spawners compared to the two baseline years and 2017. A comparison of the 2016 and 2017 results also highlights the variability in run timing between years, with the peak count recorded on November 14, 2016 and similarly high numbers two weeks later (November 27), whereas the peak count in 2017 was observed on November 26. Although surveys are not conducted at a frequency to allow total spawner abundance to be compared among years, and peak counts may be influenced by survey timing and spawner residence time and predation, the counts nevertheless provide an indication of use and demonstrate that Alena Creek supports equivalent or greater use by Coho spawners relative to pre-enhancement.

Table 26. Number of Coho Salmon observed during fall spawner surveys in 2016.

Stream	Sampling Event 1 (Nov 14, 2016)	Sampling Event 2 (Nov 27, 2016)	Sampling Event 3 (Dec 9, 2016)	2010 Peak Count	2011 Peak Count
Alena Creek	174	168	3	127	110

Table 27. Number of Coho Salmon observed during fall spawner surveys in 2017.

Stream	Sampling Event 1 (Nov 10, 2017)	Sampling Event 2 (Nov 26, 2017)	Sampling Event 3 (Dec 05, 2017)	2010 Peak Count	2011 Peak Count	2016 Peak Count
Alena Creek	3	110	76	127	110	174

Figure 20. **Spawning Coho Salmon observed spawning in enhanced habitat on November 14, 2016.**

4.4.2. Juvenile Abundance

In September 2017, 35 minnow traps were set overnight in riffle, pool and glide habitat ranging in depth from 0.23 to 1.5 m (Table 28). Raw data tables and representative photos of the minnow trap sites are presented in Appendix I. A total of 150 fish were captured during minnow trap sampling consisting of 142 Coho Salmon, seven Cutthroat Trout and one Bull Trout. Due to the high number of Coho Salmon captured, in some cases only a portion of the captured fish were measured (Table 29).

The distribution of species and age classes throughout Alena Creek is evaluated by breaking the sampled portion of Alena Creek into Reach 1 (enhanced, ALE-MT01 and 02), Reach 2 (ALE-MT03, 04 and 06), Reach 3 (enhanced), and Reach 4 (ALE-MT05) sections (Map 4).

Table 28. Summary of minnow trapping habitat characteristics and catch in Alena Creek on September 27, 2017.

Site	Enhancement Status	# of Traps	Total Soak Time (hrs)	Mesh Size (mm)	Habitat Type	Cover Types	Trap Depth Range (m)	Avg Water Temp (°C)	Total Catch BT	Total Catch CO	Total Catch CT
ALE-MT01	Enhanced	5	117.3	3-6	Riffle	BO	0.23 - 0.41	8.5	0	6	1
ALE-MT02	Enhanced	5	118.5	6	Riffle	LWD	0.23 - 0.46	8.5	0	15	0
ALE-MT03	Unenhanced	5	116.4	3-6	Glide	LWD, OV	0.38 - 0.73	8.5	0	69	0
ALE-MT04	Unenhanced	5	126.0	3-6	Riffle	LWD	0.25 - 0.39	8.5	0	18	2
ALE-MT05	Unenhanced	5	126.8	3-6	Glide	DP, LWD, OV, SWD	0.30 - 0.83	8.5	0	13	2
ALE-MT06	Unenhanced	10	282.0	3-6	Pool	DP, LWD, OV, SWD	0.43 - 1.50	9.0	1	21	2
								Total	**1**	**142**	**7**
								Average	**0.2**	**23.7**	**1.2**

Table 29. Catch and processed fish counts for 2017 sampling.

Site	Date	Enhancement Status	# of Coho Salmon Captured	# of Coho Salmon Measured
ALE-MT01	27-Sep-17	Enhanced	6	6
ALE-MT02	27-Sep-17	Enhanced	15	15
ALE-MT03	27-Sep-17	Unenhanced	69	30
ALE-MT04	27-Sep-17	Unenhanced	18	18
ALE-MT05	27-Sep-17	Unenhanced	13	12
ALE-MT06	27-Sep-17	Unenhanced	21	21
	Total		**142**	**102**

4.4.2.1. Cutthroat Trout

Seven Cutthroat Trout, ranging in length from 90 to 140 mm in length, were captured during 2017 sampling. Raw data tables are presented in Appendix I. Scale samples were collected and analysed from all Cutthroat Trout. The length-at-age data from the scale analyses are presented Figure 21. Based on a review of the aging data and length-frequency histogram, discrete fork length ranges were defined for each age class (Table 30). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 31. The length-frequency histogram and length-weight regression for the fish captured in 2017 sampling are presented in in Figure 22 and Figure 23, respectively. Summary statistics of fish length, weight, and condition factor are presented for these age classes in Table 31.

Cutthroat Trout Fry (0+)

No Cutthroat Trout fry (0+) were captured at any of the sampling sites in 2017 (Table 32).

Cutthroat Trout Parr (1+)

Cutthroat Trout parr (1+) were captured at ALE-MT01 in Reach 1 (enhanced), ALE-MT04 and 06 in Reach 2 (unenhanced), and ALE-MT05 in Reach 4 (unenhanced) (Table 32). A total of five Cutthroat Trout 1+ parr were captured, with an average CPUE of 0.6 fish/100 hrs. CPUE ranged from 0.0 to 1.6 fish/100 hrs. Based on the CPUE data, Cutthroat Trout parr were distributed mostly in the unenhanced Reaches 2 and 4 (Table 32), which is consistent with the distribution observed during baseline sampling (Section 4.4.2.4).

Cutthroat Trout Parr (2+)

Only two Cutthroat Trout 2+ parr were captured in 2017, resulting in an average CPUE of 0.2 fish/100 hrs (Table 32). The 2+ parr were captured at ALE-MT04 and ALE-MT06 in the unenhanced Reach 2.

Figure 21. Fork length versus age for Cutthroat Trout captured during the 2017 abundance sampling in Alena Creek.

Table 30. Age breaks for Cutthroat Trout captured during the 2017 sampling in Alena Creek.

Age Class	Fork Length Range (mm)
Fry (0+)	-
Parr (1+)	90-120
Parr (2+)	131-140

Figure 22. Fork length frequency for Cutthroat Trout captured in Alena Creek, during the 2017 sampling in Alena Creek.

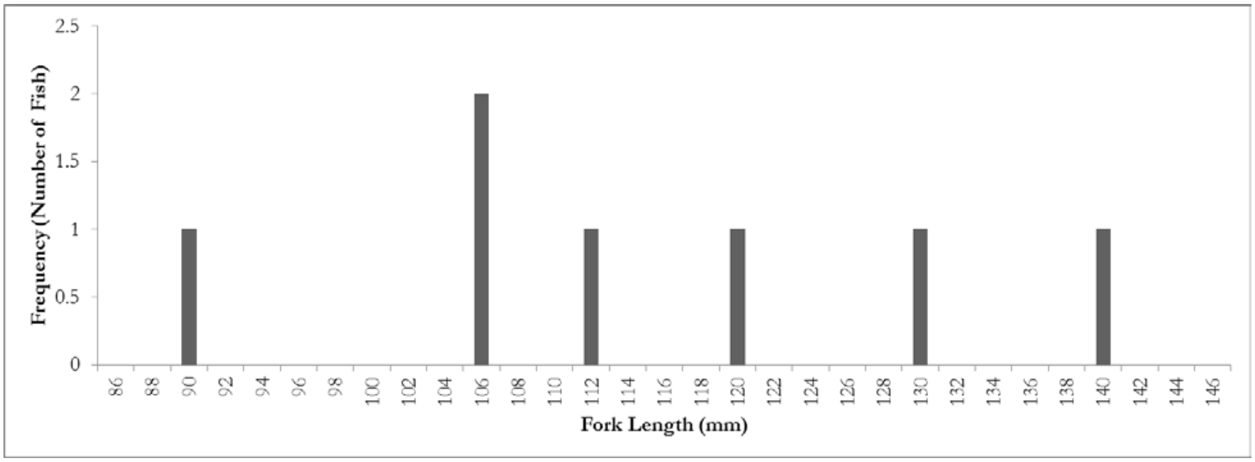


Figure 23. **Length-weight regression Cutthroat Trout captured in Alena Creek, during the 2017 sampling in Alena Creek.**

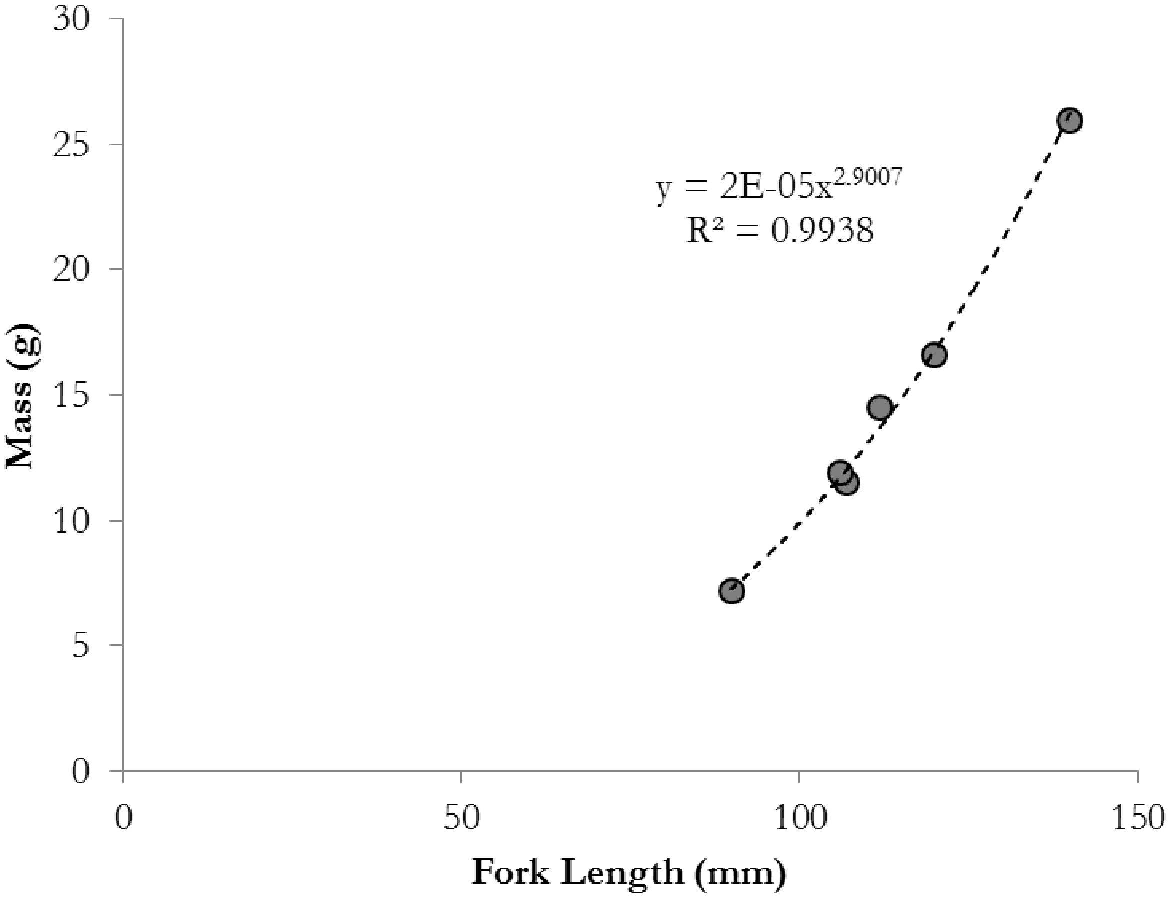


Table 31. **Summary of fork length, weight and condition for Cutthroat Trout captured during the 2017 sampling in Alena Creek.**

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+)	5	107	90	120	5	12.3	7.2	16.6	5	0.98	0.94	1.03
Parr (2+)	1	140	140	140	1	25.9	25.9	25.9	1	0.94	0.94	0.94
All	6	113	90	140	6	14.6	7.2	25.9	6	0.98	0.94	1.03

Table 32. Catch and CPUE for Cutthroat Trout during minnow trapping in 2017.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Minnow Trap Catch (# of Fish)				Minnow Trap CPUE (# of Fish/100 Trap hrs)			
					0+	1+	2+	All	0+	1+	2+	All
ALE-MT01	27-Sep-17	Enhanced	5	117.3	0	1	0	1	0.0	0.9	0.0	0.9
ALE-MT02	27-Sep-17	Enhanced	5	118.5	0	0	0	0	0.0	0.0	0.0	0.0
ALE-MT03	27-Sep-17	Unenhanced	5	116.4	0	0	0	0	0.0	0.0	0.0	0.0
ALE-MT04	27-Sep-17	Unenhanced	5	126.0	0	1	1	2	0.0	0.8	0.8	1.6
ALE-MT05	27-Sep-17	Unenhanced	5	126.8	0	2	0	2	0.0	1.6	0.0	1.6
ALE-MT06	27-Sep-17	Unenhanced	10	282.0	0	1	1	2	0.0	0.4	0.4	0.7
		Total	35	**886.9**	**0.0**	**5.0**	**2.0**	**7.0**	**0.0**	**3.6**	**1.1**	**4.7**
		Average	n/a	**147.8**	**0.0**	**0.8**	**0.3**	**1.2**	**0.0**	**0.6**	**0.2**	**0.8**
		SD	n/a	**65.9**	**0.0**	**0.8**	**0.5**	**1.0**	**0.0**	**0.6**	**0.3**	**0.7**

4.4.2.2. Coho Salmon

A total of 142 Coho Salmon, ranging in length from 42 to 104 mm were captured minnow trapping in Alena Creek in September 2017. Raw data tables are presented in Appendix I. The length-at-age data from the scale analyses are presented in Figure 24. Based on a review of the aging data and length-frequency histogram, discrete fork length ranges were defined for each age class (Table 33). The length-frequency histogram for Coho Salmon captured during 2017 sampling is presented in Figure 25; the length-weight regression is presented in Figure 26. Summary statistics of fish length, weight, and condition factor are presented for these age classes in Table 34.

Coho Salmon Fry (0+)

Coho Salmon fry (0+) were captured at all sampling sites in 2017 and are distributed throughout the sampled portion of Alena Creek (Table 35). Coho Salmon fry were most abundant at ALE-MT03 in the unenhanced Reach 2. In total, 140 Coho Salmon fry were captured, with an average CPUE of 17.9 fish/100 hrs of minnow trapping. Coho Salmon fry CPUE ranged from 5.1 fish/100 hrs (at ALE-MT01) to 58.4 fish/100 hrs (at ALE-MT03).

Coho Salmon Parr (1+)

Coho Salmon 1+ parr were only captured at ALE-MT03 and ALE-MT05 in Reaches 2 and 4, respectively (Table 35). Average CPUE at these two sites was 1.0 fish/100 hrs of minnow trapping.

Figure 24. **Fork length versus age for Coho Salmon captured during the 2017 abundance sampling in Alena Creek.**

Table 33. **Age breaks for Coho Salmon captured during the 2017 abundance sampling in Alena Creek.**

Age Class	Fork Length Range (mm)
Fry (0+)	42-87
Parr (1+)	96-104

Figure 25. Fork length frequency for Coho Salmon captured in Alena Creek during 2017 sampling.

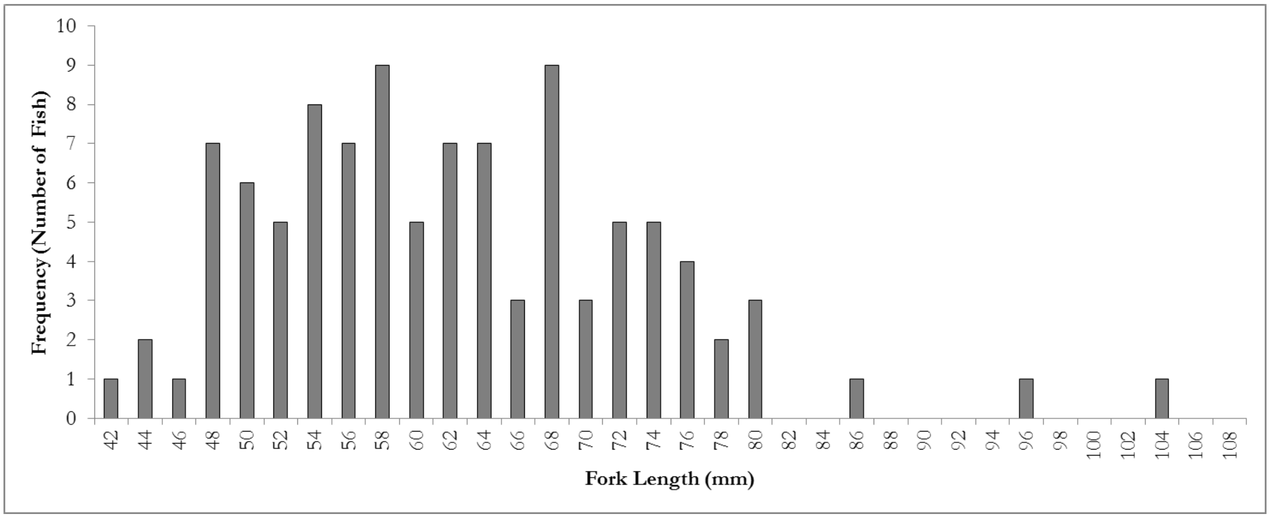


Figure 26. Length-weight regression for Coho Salmon captured in Alena Creek in 2017.

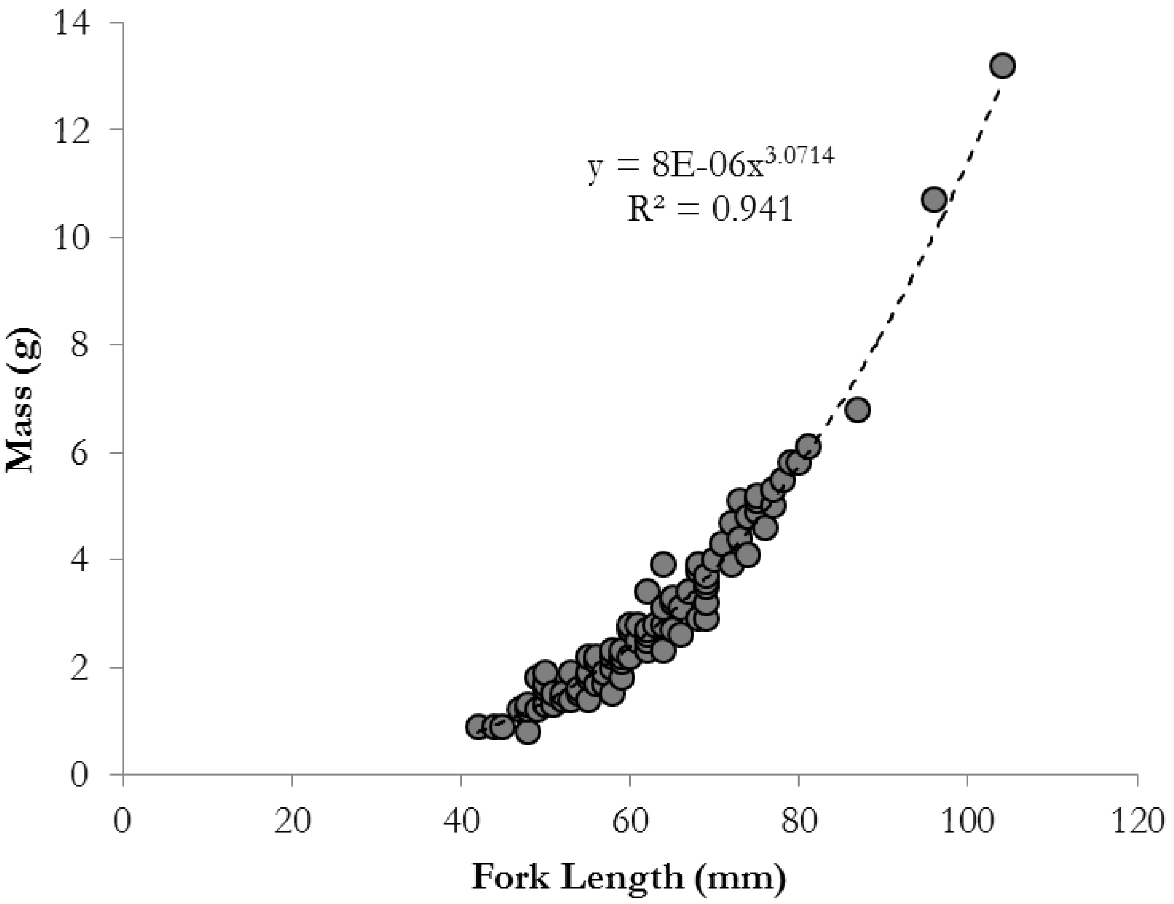


Table 34. Summary of fork length, weight and condition for Coho Salmon captured during the 2017 sampling in Alena Creek.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	99	62	42	87	99	2.8	0.8	6.8	99	1.11	0.72	1.53
Parr (1+)	2	100	96	104	2	12.0	10.7	13.2	2	1.19	1.17	1.21
All	101	63	42	104	101	3.0	0.8	13.2	101	1.11	0.72	1.53

Table 35. Catch and CPUE for Coho Salmon during minnow trapping in 2017.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Minnow Trap Catch (# of Fish)			Minnow Trap CPUE (# of Fish/100 Trap hrs)		
					0+	1+	All	0+	1+	All
ALE-MT01	27-Sep-17	Enhanced	5	117.3	6	0	6	5.1	0.0	5.1
ALE-MT02	27-Sep-17	Enhanced	5	118.5	15	0	15	12.7	0.0	12.7
ALE-MT03	27-Sep-17	Unenhanced	5	116.4	68	1	69	58.4	0.9	59.3
ALE-MT04	27-Sep-17	Unenhanced	5	126.0	18	0	18	14.3	0.0	14.3
ALE-MT05	27-Sep-17	Unenhanced	5	126.8	12	1	13	9.5	0.8	10.3
ALE-MT06	27-Sep-17	Unenhanced	10	282.0	21	0	21	7.4	0.0	7.4
			Total	**886.9**	**140.0**	**2.0**	**142.0**	**107.4**	**1.6**	**109.1**
			Average	**147.8**	**23.3**	**0.3**	**23.7**	**17.9**	**0.3**	**18.2**
			SD	**65.9**	**22.5**	**0.5**	**22.8**	**20.1**	**0.4**	**20.4**

4.4.2.3. Bull Trout

A single Bull Trout with a fork length of 130 mm was captured at ALE-MT06 in the unenhanced Reach 2 during 2017 sampling.

4.4.2.4. Comparison between Years

Cutthroat Trout

In 2017 sampling, seven Cutthroat Trout were captured minnow trapping, which represents a decrease compared to 2013 (27 Cutthroat captured during two sampling events: 14 on September 21, and 13 on September 22) and 2014 (16 Cutthroat captured). In 2017, most Cutthroat Trout were captured in Reach 2 (ALE-MT03, 04 and 06) and Reach 4 (ALE-MT05), which is similar to 2013 and 2014 sampling results (Figure 27). Cutthroat Trout CPUE in the enhanced Reach 1 (ALE-MT01 and 02) was lower in 2017 compared to pre-enhancement in 2013 and 2014.

During 2017 sampling, the average CPUE across all sites was 0.8 fish/100 hrs of minnow trapping (± 0.7 SD) (Table 32, Figure 28), which was lower than the CPUE values for 2013 (1.7 fish/100 hrs minnow trapping (± 1.1 SD) on September 21, and 1.9 fish/100 hrs minnow trapping (± 1.0 SD) on September 22) and 2014 (7.4 fish/100 hrs minnow trapping (± 7.0 SD)) (Harwood *et al* 2016). However, the 2014 CPUE results are biased high by the short daytime sets and the likelihood that catchability is not constant throughout the trap's soak time, with a high initial catch rate that diminishes over time (Harwood *et al.* 2016).

In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+. No Cutthroat Trout fry were captured in 2017, which is fairly consistent with baseline sampling when only three Cutthroat fry were captured during two sampling events in September 2013, and only one fry was captured in October 2014. The lack of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence and the size of fry in late September / early October.

In 2017, the combined condition factor for all age classes of Cutthroat Trout captured was 1.0 (Table 31), whereas average Cutthroat Trout condition was 1.1 in 2013 and 1.2 in 2014 (Harwood *et al.* 2016).

Coho Salmon

In 2017 sampling, 142 Coho Salmon were captured by minnow trapping, which represents a decrease compared to 2013 (485 Coho captured during two sampling events: 291 on September 21, and 194 on September 22) and 2014 (336 Coho captured) (Harwood *et al* 2016). In 2017, the highest Coho Salmon catch was observed in Reach 2, specifically at ALE-MT03, whereas in 2013 most fish were captured at ALE-MT06 (Figure 29). In 2014, Coho Salmon CPUE was highest at ALE-MT03, 04 and 06, although CPUE at ALE-MT03 and 04 was biased high in 2014 due to the need to employ short daytime sets due to bear activity (Harwood *et al* 2016). Within the enhanced Reach 1, Coho CPUE in 2017 was similar to that in 2013 and 2014 at ALE-MT02, but lower than baseline CPUE at ALE-MT01 (Figure 29). The distribution of Coho Salmon in 2017 may have been affected by beaver activity in Reaches 2 and 4, as discussed in more detail in the following section.

During 2017 sampling, the average CPUE across all sites was 18.2 fish/100 hrs of minnow trapping (± 20.4 SD) (Table 35, Figure 30), which was lower than the CPUE values for 2013 (24.2 fish/100 hrs minnow trapping (± 16.9 SD) on September 21, and 22.5 fish/100 hrs minnow trapping (± 19.7 SD) on September 22) and 2014 (62.6 fish/100 hrs minnow trapping (± 34.0 SD)) (Harwood *et al* 2016). However, the 2014 CPUE results are biased high by the short daytime sets and the likelihood that catchability is not constant throughout the trap's soak time, with a high initial catch rate that diminishes over time (Harwood *et al.* 2016). The 2017 CPUE was highly variable, with the largest reduction compared to baseline sampling observed at ALE-MT06 at the upstream end of Reach 2.

In all sampling years, the most abundant age class of Coho Salmon captured was 0+. In 2017, the combined condition factor for all age classes of Coho Salmon captured was 1.1, whereas average Coho Salmon condition was 1.2 in 2013 and 1.0 in 2014.

Changes in Site Conditions

The reduced catch and CPUE for both Cutthroat Trout and Coho Salmon during year 1 monitoring may be the result of altered habitat conditions caused by beaver activity both at the minnow trap locations, which were selected during baseline studies, as well as in upstream locations. There was evidence of beaver activity along Alena Creek during baseline studies; however, all beaver dams appeared abandoned and dilapidated with no new activity observed.

In 2016, Alena Creek saw a notable increase in beaver activity in Reach 2, in which ALE-MT03, 04 and 06 are located (Map 4). The largest dam was located approximately 100 m upstream of the upper extent of the enhancement work conducted in Reach 1. This dam was approximately 50 m in length and up to 1.8 m high (Figure 31). This was the key dam responsible for the backwatering seen throughout Reach 2, though there were other large dams constructed, including ones that diverted water away from the primary channel surveyed during baseline studies. The beavers were trapped and removed from the area in late 2016, though the dams remained intact. The 1-in-20 year flow on November 9, 2016 allowed enough water over the key dam to allow Coho Salmon access to upstream spawning areas, though the dam was undamaged (Figure 32). The dam(s) resulted in a significant increase in the amount of rearing habitat available at ALE-MT03, but also restricted movement downstream to Reach 1 under the flow conditions observed at the time of sampling in September 2017. This likely contributed to the higher catch of Coho Salmon observed at ALE-MT03 in 2017 compared to 2013; the higher catch observed in 2014 is biased high by the short daytime sets and the likelihood that catchability is not constant throughout the trap's soak time, with a high initial catch rate that diminishes over time (Figure 29, Harwood *et al.* 2016). The restriction of downstream movement may also have contributed to the reduced number of Coho captured in the enhanced Reach 1 compared to baseline sampling. The key dam in Reach 2 was breached during a rain event on November 26, 2017, and a new channel was carved around the dam (Figure 33). This rain event allowed spawning Coho access through Reach 2 into the upstream reaches, including the enhancement work in Reach 3. This breach ultimately resulted in a dewatering of the channels throughout Reach 2 and a change of channel configuration compared to baseline years.

In 2017, beaver activity upstream of the enhancement work in Reach 4 increased drastically (see large pool in Map 2). A series of large dams ranging from approximately 20-70 m in length, and of various heights, were constructed creating significant areas of backwater (Figure 34). Extensive damming was constructed approximately every 50 m. Beaver activity resulted in a significant increase in the amount of rearing habitat available through the creation of extensive backwater areas and side channels. This increase in habitat availability, in conjunction with the creation of 668 m^2 of new instream habitat in Reach 3 as part of the FHEP, is likely a contributory factor to the lower catch and CPUE at ALE-MT05 in 2017 as a similar number of fish dispersed over a larger area will result in lower CPUE.

Overall, the beaver dam activity in Reaches 2 and 4 affected habitat availability and accessibility at ALE-MT03, 04 and 06, which were the three sites that had the highest catch and CPUE during baseline studies (Figure 27, Figure 29, Harwood *et al.* 2016). Coho Salmon CPUE at ALE-MT06 was much lower in 2017 than in 2013 and 2014 (Figure 29) and this may have been affected by the series of beaver dams in Reach 4, which increased the availability of rearing pool habitat in Reach 4 and restricted access throughout the reach and downstream to Reaches 2 and 3. At ALE-MT04, most of the flow was directed away from the site by an upstream dam and access into the site was restricted by both an upstream and downstream dam.

Cutthroat Trout would have been equally affected by the large beaver dams, which would have restricted movement by spawning adults and rearing fry and parr. As the dams were unpassable during low to moderate flows this would have limited access for fish resident in Reach 2 to spawning areas such as those constructed in Reach 1 and 3, and the distribution of rearing fish throughout Alena.

Based on these habitat changes, we recommend adjusting and increasing the sites minnow trapped in September 2018 (Section 5.4).

Figure 27. Comparison of minnow trap CPUE for Cutthroat Trout at each site in 2013, 2014 and 2017. Error bars represent standard error.

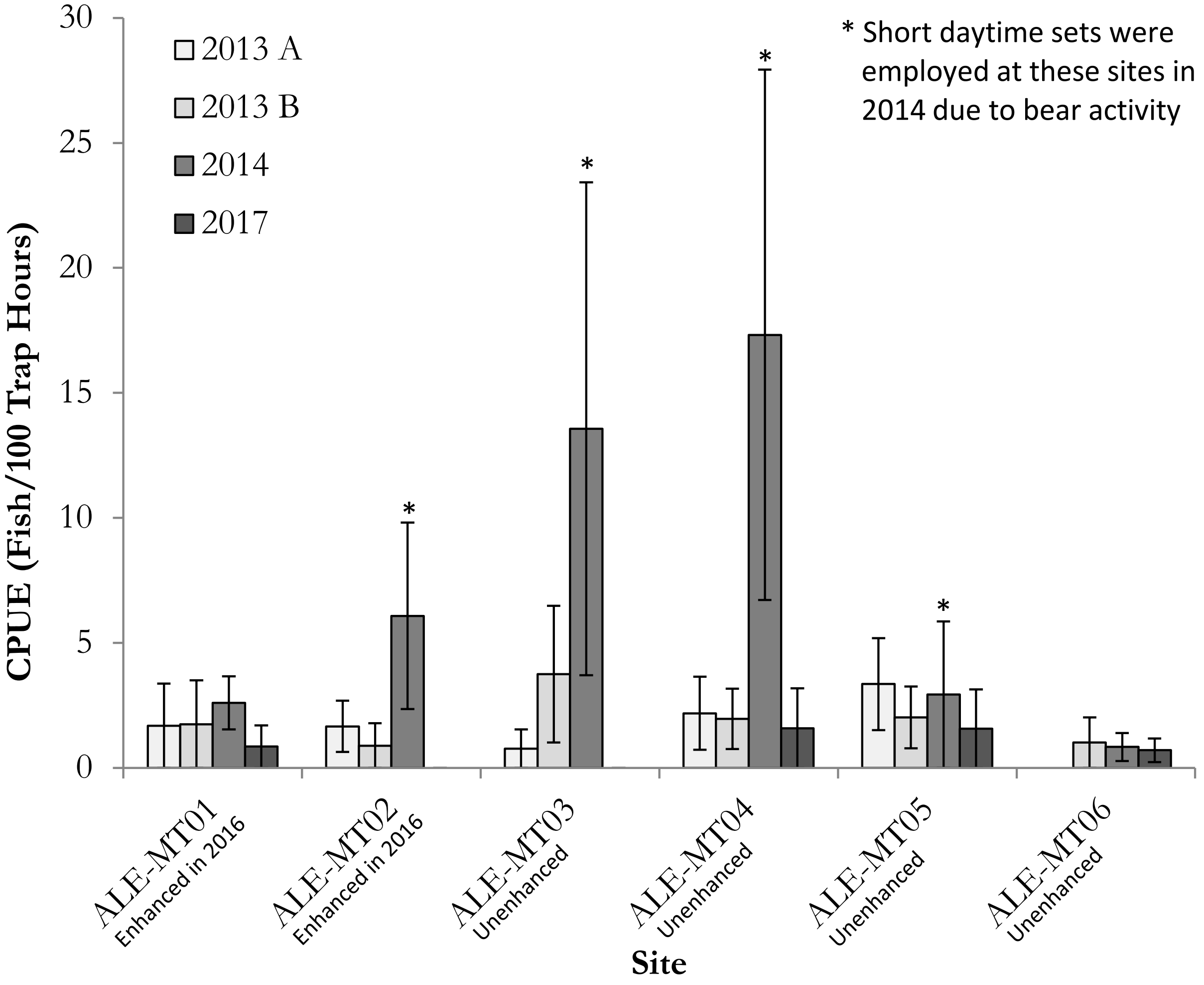


Figure 28. **Comparison of minnow trap CPUE for Cutthroat Trout from 2013, 2014 and 2017. Error bars represent standard error among sites. Note that 2014 CPUE is biased high by short daytime sets at some sites.**

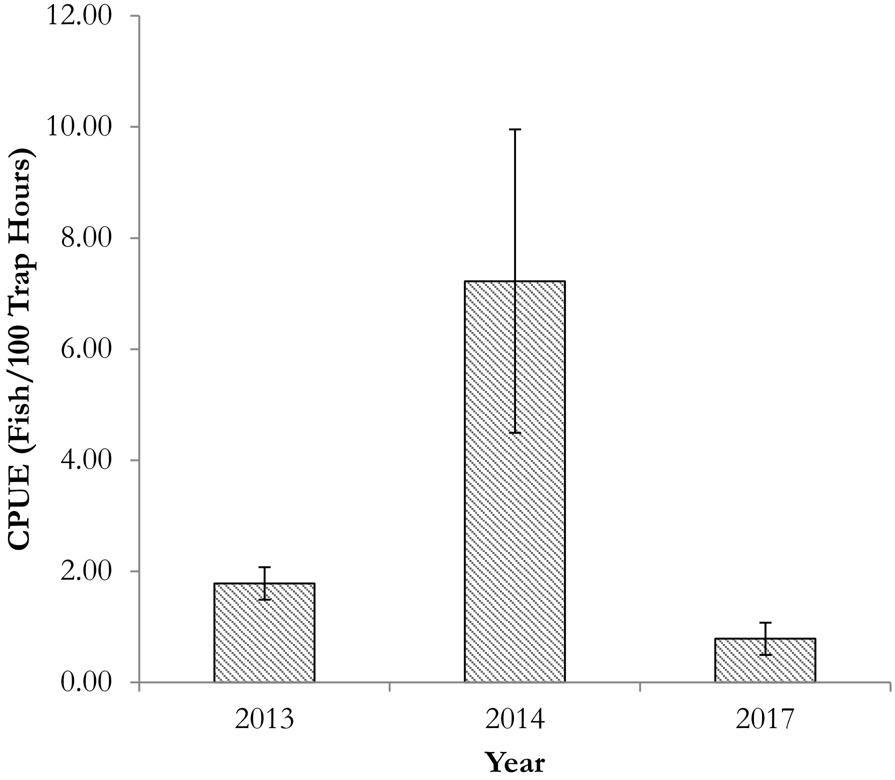


Figure 29. **Comparison of minnow trap CPUE for Coho Salmon at each site in 2013, 2014 and 2017. Error bars represent standard error.**

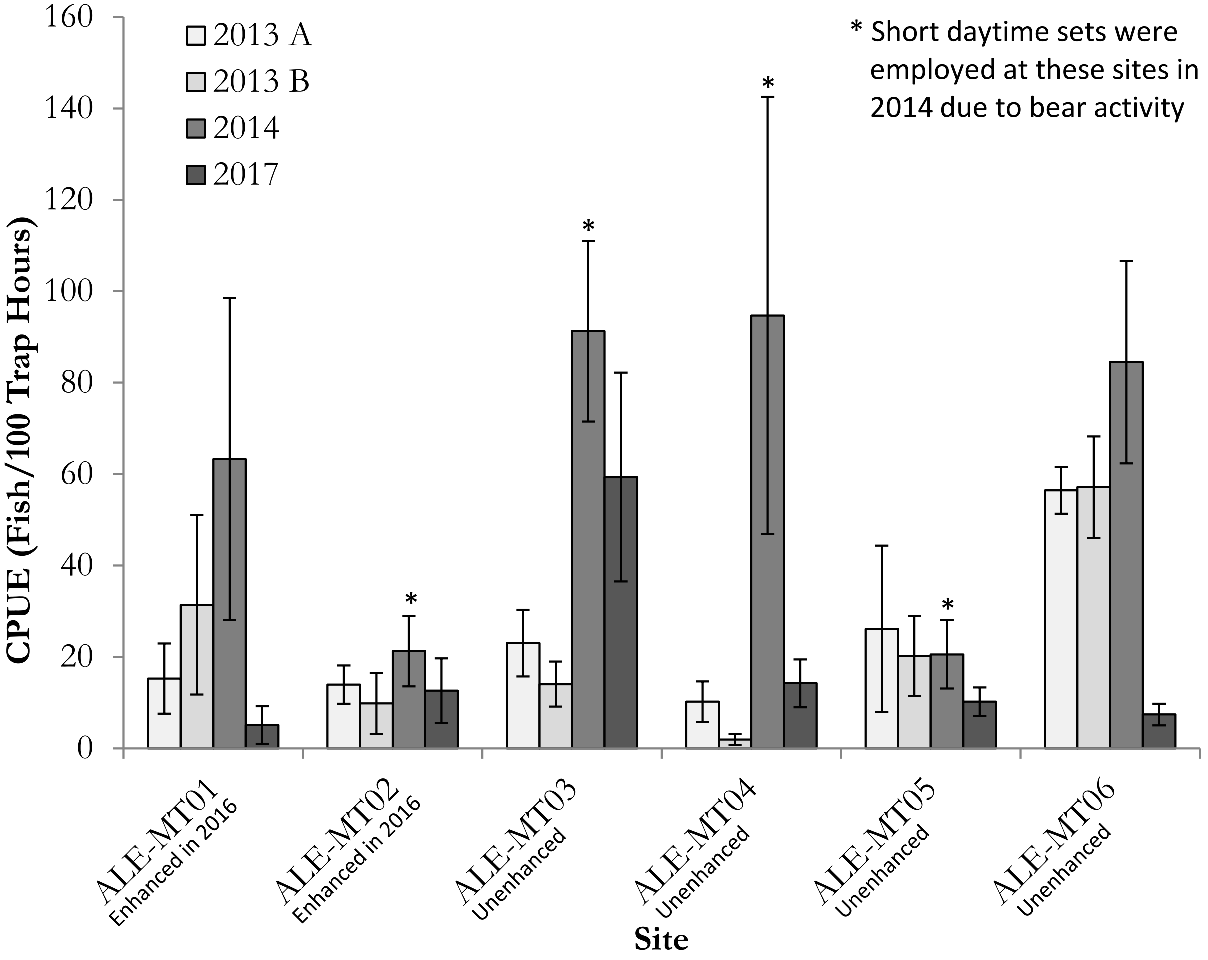


Figure 30. Comparison of minnow trap CPUE for Coho Salmon from 2013, 2014 and 2017. Error bars represent standard error among sites. Note that 2014 CPUE is biased high by short daytime sets at some sites.

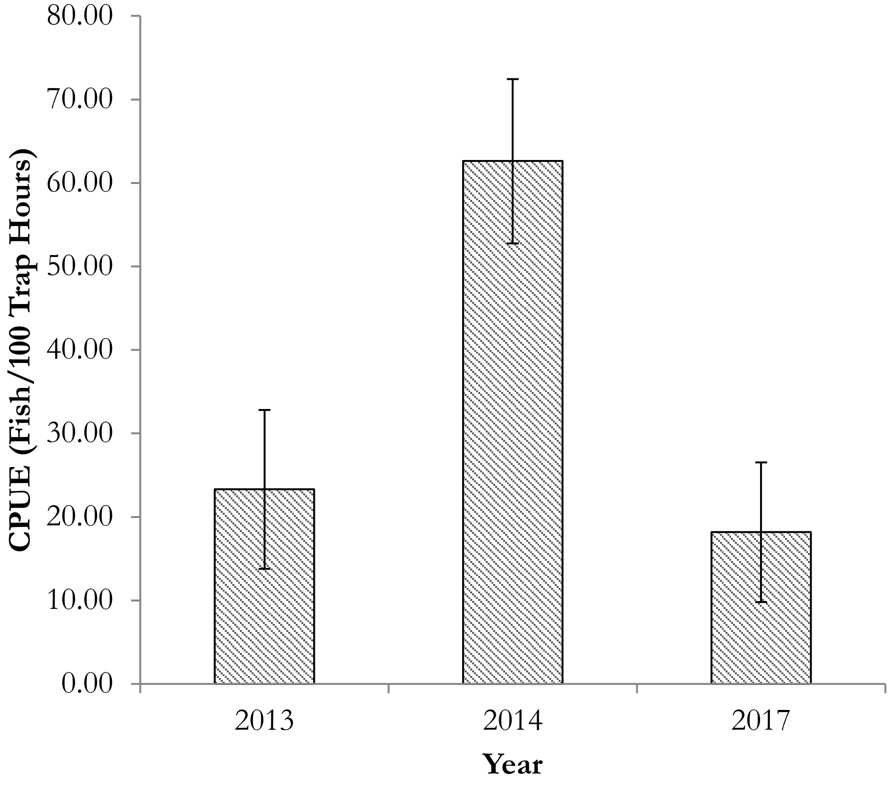


Figure 31. **Panoramic view looking upstream at the primary dam 100 m upstream of Reach 1 on December 9. 2016.**

Figure 32. Looking river right to left at the dam 100 m upstream of Reach 1 showing sufficient overflow to allow Coho Salmon migration on November 10, 2016.

Figure 33. **Looking upstream at the primary dam 100 m upstream of Reach 1 showing the formation of a new channel on river right (photo left) on November 26, 2017.**

Figure 34. Comparison of water levels at ALE-MT05 site on a) February 27, 2014 and b) November 10, 2017.

a)

b)

4.5. Riparian Habitat

4.5.1. Permanent Vegetation Density Monitoring

Prior to the Meager Creek slide in 2010, the Alena Creek riparian area was dominated by mature red alder and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*), with patches of older shifting mosaic seral stage forest approximately 121-140 years old (Harwood *et al.* 2016). When vegetation was assessed in 2014, four years following the slide, vegetation had been regenerating naturally, with red alder densely colonizing the understory and at least ten different shrub species recorded within the permanent vegetation monitoring plots established in 2014. A single conifer, a western redcedar, was recorded within the monitoring plots (in ALE-PRM01) in 2014. Overall density of woody vegetation was estimated as 46,250 ± 32,469 stems/ha in 2014 (Harwood *et al.* 2016).

Shortly after clearing and creating gaps within the regenerating red alder stands and planting clusters of western redcedar in 2016, estimated density decreased to 5,700 ± 5,002 stems/ha (Table 36, Table 37). A total of 21 conifers, including western hemlock, western redcedar and Douglas-fir (*Pseudotsuga menziesii*), were recorded within the monitoring plots in 2016, along with a relatively diverse assemblage of eight shrub species. Devil's club (*Oplopanax horridus*) stems were most abundant, followed by red-osier dogwood (*Cornus stolonifera*), Sitka willow, salmonberry (*Rubus spectabilis*), thimbleberry (*Rubus parviflorus*), black raspberry (*Rubus leucodermis*), an unknown species of willow (*Salix sp.*) and red elderberry (*Sambucus racemosa*).

Between 2016 and 2017, vigorous regeneration of black cottonwood and red alder was observed (Figure 35). These floodplain pioneer species, with high initial growth rates, rapidly recolonized and infilling the compensation area (Figure 35, Figure 36, Appendix J). The estimated density for the four monitoring plots increased to 43,200 ± 36,210 stems/ha, with 90% certainty that the density of trees and shrubs ranges from 6,900 to 79,410 stems/ha (Table 36, Table 38). The DFO and MELP (1998) guided revegetation effectiveness target of 2,309 stems/ha was exceeded within all four permanent vegetation monitoring plots in 2016 and 2017 (Table 36).

Between 2016 and 2017, the total number of conifers species decreased slightly and the diversity of shrub species recorded within the monitoring plots also differed (Table 37, Table 38). Similar to 2016, western hemlock and western redcedar were recorded within the monitoring plots in 2017; however, no live Douglas-fir was detected in 2017. In 2017, thimbleberry stems followed by devil's club were the most abundant within the plots whereas in 2016 devil's club was the most abundant shrub followed by red-osier dogwood. In 2017, no black raspberries were observed. This species was only observed in ALE-PRM03 (Table 38). However, in 2017 an additional species, trailing blackberry (*Rubus ursinus*), was observed in the monitoring plot. ALE-PRM03 also supported the greatest diversity of shrubs in 2016. However, in 2017, most species of shrubs were observed at ALE-PRM06. Results from plots assessed in 2014 cannot be directly compared to results from plots assessed in 2016 and 2017 as only one of the plots established in 2014 (ALE-PRM03) fell within the construction area and was assessed again in 2016 and 2017; nevertheless, the density of woody vegetation within the plots decreased following thinning between 2014 and 2016 and rebounded to

2014 levels again in 2017. Conifer density recorded in 2016 and 2017 was higher than in 2014 and shrub species diversity was relatively similar between all three years.

Red alder is recognized for its ability to fix nitrogen, and thus increase soil quality in preparation for later successional stage species. Early successional stands of red alder and black cottonwood are commonly replaced with western redcedar and western hemlock in later successional stages within the Coastal Western Hemlock southern dry submaritime variant (CWHds1) biogeoclimatic zone (MFR 2000). If conifer density continues to decrease in future monitoring years, additional thinning of red alder and black cottonwood and/or additional planting of conifers, may be recommended to increase the diversity of woody vegetation and accelerate the transition to a later successional stage.

Permanent monitoring plot data was employed to estimate survival of planted western redcedar. Standing dead woody vegetation was recorded within only two of the four permanent vegetation monitoring plots in 2017 (Table 39). A total of three dead planted western redcedars were recorded, two in ALE-PRM05, within the Meager Creek slide path where the substrate has a low organic component, and one in ALE-PRM03. The survival rate of the planted western redcedars within the permanent monitoring plots was 83%, higher than the minimum target of 80%, thus replanting is not required (DFO and MELP 1998). Other dead woody vegetation was also recorded, one dead Douglas-fir and one large dead red alder was recorded in ALE-PRM03 (Table 39).

No regionally or provincially noxious or invasive plant species were detected within the compensation area. Although riparian monitoring is focused on the permanent vegetation monitoring plots, Ecofish crews have been looking out for noxious plant species while conducting other fieldwork within the compensation area, particularly in the vicinity of access roads, construction areas, and riparian areas.

Table 36. Summary of riparian habitat data collected in 2014 four years after the Meager Creek slide, 2016 immediately after restoration works, and in 2017 one year after riparian restoration works, as part of Alena FHEP.

Permanent Vegetation Monitoring Plot	UTM Coordinates			Year	Woody Vegetation Density			Estimated Vegetation Cover (%)	Comments
	Zone	Easting	Northing		Count of Live Stems/Plot	Count of Dead Stems/Plot	Estimated Live Vegetation Density (stems/ha)		
ALE-PRM03	10U	473335	5606225	2014[1]	305	0	61,000	88	Extensive regeneration of red alder under a mostly dead red alder overstory, with a few large living red alder.
				2016	60	0	12,000	30	
				2017	62	3	12,400	80	Good revegetation with horsetail, grass, and ferns. Most of the planted plugs have survived.
ALE-PRM05	10U	473014	5606707	2016	18	0	3,600	8	
				2017	107	2	21,400	37	Some natural revegetation occurring, especially along and within 10 m of the streambank.
ALE-PRM06	10U	473348	5606089	2016	22	0	4,400	16	
				2017	327	0	65,400	59	Good natural regeneration, good survival rate for planted vegetation.
ALE-PRM07	10U	473338	5606166	2016	14	0	2,800	39	
				2017	368	0	73,600	66	Good regeneration of horsetail, grass, bunchberry, fireweed, ferns, red alder and black cottonwood, especially in the ground divots.
Expected Density (stems/ha)				**2016**			**5,700**		
				2017			**43,200**		
Confidence Interval ± per ha				**2016**			**5,002**		
				2017			**36,210**		

[1] ALE-PRM03 was the only plot (of four) established in 2014 that fell within the construction area and was thus sampled again in 2016 and 2017.

Table 37. Live species counted within each of the permanent vegetation monitoring plots in 2016, immediately following riparian restoration works, as part of the Alena Creek FHEP.

Permanent Vegetation Monitoring Plot	Trees					Shrubs								Total
	black cottonwood *(Populus balsamifera ssp. trichocarpa)*	coastal Douglas-fir *(Pseudotsuga menziesii var. menziesii)*	red alder *(Alnus rubra)*	western hemlock *(Tsuga heterophylla)*	western redcedar *(Thuja plicata)*	black raspberry *(Rubus leucodermis)*	devil's club *(Oplopanax horridus)*	red elderberry *(Sambucus racemosa)*	red-osier dogwood *(Cornus stolonifera)*	salmonberry *(Rubus spectabilis)*	Sitka willow *(Salix sitchensis)*	thimbleberry *(Rubus parviflorus)*	willow (unknown species) *(Salix sp.)*	
ALE-PRM03	4	2	27	0	2	4	14	1	0	0	0	3	3	60
ALE-PRM05	0	0	0	2	3	0	1	0	8	2	0	2	0	18
ALE-PRM06	1	0	0	1	7	0	2	0	4	5	2	0	0	22
ALE-PRM07	0	0	0	0	4	0	0	0	2	0	8	0	0	14
Mean	1.25	0.50	6.75	0.75	4.00	1.00	4.25	0.25	3.50	1.75	2.50	1.25	0.75	28.50
Standard Deviation	1.89	1.00	13.50	0.96	2.16	2.00	6.55	0.50	3.42	2.36	3.79	1.50	1.50	21.25
Standard error of the mean	0.95	0.50	6.75	0.48	1.08	1.00	3.28	0.25	1.71	1.18	1.89	0.75	0.75	10.63
t-value_90%	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353
Confidence Interval	2.23	1.18	15.89	1.13	2.54	2.35	7.71	0.59	4.02	2.78	4.45	1.77	1.77	25.01
Expected Density (stems/ha)	**250**	**100**	**1,350**	**150**	**800**	**200**	**850**	**50**	**700**	**350**	**500**	**250**	**150**	**5,700**
Confidence Interval ± per ha	**445**	**235**	**3,177**	**225**	**508**	**471**	**1,542**	**118**	**804**	**556**	**891**	**353**	**353**	**5,002**

Table 38. Live species counted within each of the permanent vegetation monitoring plots in 2017, one year after riparian restoration works, as part of Alena Creek FHEP.

Permanent Vegetation Monitoring Plot	Trees				Shrubs							Total
	black cottonwood (*Populus balsamifera ssp. trichocarpa*)	red alder (*Alnus rubra*)	western hemlock (*Tsuga heterophylla*)	western redcedar (*Thuja plicata*)	devil's club (*Oplopanax horridus*)	red elderberry (*Sambucus racemosa*)	red-osier dogwood (*Cornus stolonifera*)	salmonberry (*Rubus spectabilis*)	thimbleberry (*Rubus parviflorus*)	trailing blackberry (*Rubus ursinus*)	willow (unknown species) (*Salix sp.*)	
ALE-PRM03	18	14	0	0	12	3	0	0	10	5	0	62
ALE-PRM05	72	16	0	3	1	0	4	2	9	0	0	107
ALE-PRM06	169	129	1	8	0	1	7	7	3	0	2	327
ALE-PRM07	203	157	0	3	0	3	2	0	0	0	0	368
Mean	115.50	79.00	0.25	3.50	3.25	1.75	3.25	2.25	5.50	1.25	0.50	216.00
Standard Deviation	85.47	74.78	0.50	3.32	5.85	1.50	2.99	3.30	4.80	2.50	1.00	153.86
Standard error of the mean	42.74	37.39	0.25	1.66	2.93	0.75	1.49	1.65	2.40	1.25	0.50	76.93
t-value_90%	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353	2.353
Confidence Interval	100.58	88.00	0.59	3.90	6.89	1.77	3.51	3.89	5.64	2.94	1.18	181.05
Expected Density (stems/ha)	**23,100**	**15,800**	**50**	**700**	**650**	**350**	**650**	**450**	**1,100**	**250**	**100**	**43,200**
Confidence Interval ±/ha	**20,115**	**17,600**	**118**	**781**	**1,377**	**353**	**703**	**778**	**1,129**	**588**	**235**	**36,210**

Table 39. Dead tree species counted within each of the permanent vegetation monitoring plots one year after riparian restoration works, as part of Alena Creek FHEP.

Permanent Vegetation Monitoring Plot	Douglas-fir (*Pseudotsuga menziesii*)	red alder (*Alnus rubra*)	western redcedar (*Thuja plicata*)	Total
ALE-PRM03	1	1	1	3
ALE-PRM05	0	0	2	2
ALE-PRM06	0	0	0	0
ALE-PRM07	0	0	0	0
Mean	0.25	0.25	0.75	1.25
Standard Deviation	0.50	0.50	0.96	1.50
Standard error of the mean	0.25	0.25	0.48	0.75
t-value_90%	2.353	2.353	2.353	2.353
Confidence Interval	0.59	0.59	1.13	1.77
Expected Density (stems/ha)	50	50	150	250
Confidence Interval ±/ha	118	118	225	353

Figure 35. **Natural regeneration observed at ALE-PRM07. Photo is representative of vigorous re-establishment of red alder and black cottonwood, within the Alena Creek FHEP, on October 5, 2017.**

Figure 36. Photo of ALE-PRM07 after the implementation of riparian restoration works, on October 25, 2016.

4.5.2. Percent Vegetation Cover Estimates

The percent vegetation ground cover was relatively high in 2014, ranging from 64 to 98% with an average of 82%. Immediately following riparian restoration works in 2016, the average percent vegetation cover was lower, ranging from 8 to 30% with an average of 23%, to permit the establishment of planted western redcedar and promote tree and shrub diversity. Average percent vegetation cover recorded in 2017 (61%) was higher than in 2016 but lower than 2014, likely due to the shorter recovery time since establishing and creating the clearing gaps (i.e., one year between restoration works and 2017 data collection versus four years between the Meager Creek slide and 2014 data collection).

In 2017, vegetation cover was relatively high at three of the four sites surrounding the permanent vegetation monitoring plots. Vegetation cover ranged from 37% to 80%, with an average of 61% cover across all sites (Table 36). Vegetation cover was highest around the plot at ALE-PRM03 (Figure 37), where the substrate is dominated by native soils, and lowest around the plot at

ALE-PRM05. As previously noted, ALE-PRM05 is situated within the Meager Creek slide path; where the substrate is primarily mineral soil and sand, with a low organic component (Figure 38, Map 4). Vegetation ground cover is important within riparian areas to minimize erosion and resulting sedimentation in adjacent watercourses during early successional stages. Establishment of herbaceous vegetation also aids in the later establishment of woody vegetation, the ultimate goal in riparian habitat restoration.

The LTMP stated that additional erosion control and soil conditioning may be required to stabilize vegetation on steep, erodible soils and ensure successful long-term vegetation survival. In consideration of erosion risk, the final grade and structure of the riparian compensation area was constructed to have a shallow, low gradient. Consequently, erosion is not a current concern. Although the Meager Creek slide dramatically changed soil conditions within the slide path, the extent of natural vegetation recruitment between 2016 and 2017 has shown that the soil condition is generally appropriate for native vegetation and no soil conditioning is required.

Figure 37. Higher percent vegetation cover (80%), primarily horsetail, grass and ferns, at ALE-PRM03, October 5, 2017.

Figure 38. **Lower percent vegetation cover (37%), primarily horsetail, at ALE-PRM05 located within the Meager Creek slide path, October 5, 2017.**

4.5.3. Photopoint Comparison

Standard photos taken in 2016 and 2017 at 1.3 m above the plot centre, facing 0 degrees (north) are presented in Appendix J to compare vegetation condition in 2016 and 2017 at each plot. Representative photos of the general site condition surrounding each permanent monitoring plot is also provide. The photos show an increase in vegetation abundance from 2016 to 2017.

5. RECOMMENDATIONS

The success of the enhancement habitat will be judged according to the criteria in the *Fisheries Act* Authorization, namely that the habitat enhancement is physically stable, maintains suitable flows, has been demonstrated to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout of not less than 2,310 m^2, and supports equivalent or greater fish usage relative to pre-project densities in Alena Creek. Details of the monitoring to be conducted to evaluate the effectiveness of the enhancement habitat were described in the Project's OEMP (Harwood *et al.* 2017), but based on the results of year 1 monitoring we recommend the following adjustments be made.

5.1. Hydrology

To account for the backwatering of the gauge at the FSR bridge over Alena Creek when flows in the Upper Lillooet River are high, and to ensure the stage data collected are representative of Alena Creek water levels, we recommend moving the gauge upstream. A suitable location will need to be confirmed in the field, but there is a large boulder near the temporary crossing that was used during enhancement works (10U 472240 5606169) that may provide a suitable location.

5.2. Water Quality

5.2.1. Water Chemistry

Water quality in Alena Creek has generally improved since baseline sampling began in 2013. The only parameters that have exceedances of BC WQG for the protection of aquatic life over the course of baseline and year 1 monitoring are dissolved oxygen (buried life stage guideline only), total iron, and dissolved iron.

In year 1 monitoring, no exceedances of the minimum BC WQG for dissolved oxygen were observed at the site in the enhancement habitat, with data indicating a well aerated condition (dissolved oxygen concentrations ranging from 10.38 mg/L to 10.81 mg/L).

Concentrations of dissolved iron exceeded the short-term maximum BC WQG of 0.35 mg/L at the site in the enhancement habitat during all sampling periods, with the range of concentrations similar between baseline and year 1 monitoring. Total iron exceeded the short-term maximum BC WQG of 1 mg/L at one or both sites on all sampling dates during baseline sampling. However, only one exceedance occurred during year 1 sampling at the site in the enhancement habitat, and concentrations at this site in year 1 were on average lower than observed during baseline sampling.

Considering these observations and that instream enhancement is not expected to result in adverse effects on water quality, it is recommended that water quality monitoring on Alena Creek be ceased.

5.2.2. Water Temperature

Monitoring of water temperature will continue in Alena Creek in Year 2 using temperature dataloggers installed upstream and downstream of the habitat compensation features.

5.3. Fish Habitat

The overall function and quality of the constructed habitats remains high despite the flood flows experienced in Alena Creek since construction. In the downstream reach, Reach 1, we recommend continued monitoring of the bank erosion at 0+185 just upstream of ALE-XS1. In Reach 3, we recommend undertaking repairs during the least risk timing window in August 2018. All repairs can be completed by a hand, utilizing a crew of four. At ALE-XS5, material from the constructed riffle crest that is currently dewatered can be utilized to reconstruct the weir in the wetted width. This will alleviate all upstream concerns with further channel incision. The erosion issues upstream of both ALE-XS6 and ALE-XS7 should also be repaired. It may be possible to complete the repairs utilizing materials on site, or it may need to be sourced locally and brought into site. This could be done using small equipment, such as an ATV with a trailer and manual labor. In addition to using materials like cobble and small boulder, willow and red-osier stakes should be planted at select bank sites to aid in short-term stability.

We also recommend that beaver activity continue to be monitored and controlled to ensure the enhanced habitat remains functional.

5.4. Fish Community

Based on the habitat changes caused by beaver activity in Reach 2, we recommend adjusting the sites sampled in this reach to be more representative of the habitat sampled under baseline conditions. We recommend replacing ALE-MT04 with a site just upstream of Reach 1 at the gravel augmentation pile installed as part of the enhancement works. Habitat conditions at this site are similar to conditions during baseline studies at ALE-MT03 and ALE-MT04, prior to the backwatering and braiding of the channels. This location is situated within the primary flow of Alena Creek, downstream of where all side channels converge again into a single channel. There is little risk that this location will be affected by beavers or braiding in the future based on the nature of the steep banks at the gravel augmentation pile and further upstream. To the extent feasible based on habitat alterations caused by beaver activity, the precise location sampled at ALE-MT03 should also be adjusted to be representative of the habitat sampled during baseline (i.e., the new primary channel at ALE-MT03 should be sampled).

We also recommend adding two minnow trap sites in the enhanced Reach 3 to monitor juvenile fish use of the pools and large woody debris complexes installed. These changes will result in the sampling of eight sites in total, four in unenhanced habitat and four in enhanced habitat. This will allow a better comparison between CPUE in enhanced and unenhanced habitat, as well as improving the ability to demonstrate that the FHEP supports equivalent or greater fish usage relative to pre-project densities in Alena Creek, as per the requirements of the *Fisheries Act* Authorization.

5.5. Riparian Habitat

Results from year 1 monitoring indicate that vegetation within the Alena Creek riparian compensation area is on a trajectory to become similar to that prior to the Meager Creek slide. No additional planting or remediation measures are recommended at this time. However, the overall density and potential crowding of pioneer species, red alder and black cottonwood, will be monitored to determine whether additional restoration works (e.g., thinning) are required. We will continue to monitor vegetation density, composition, and diversity late in the growing season in years 3 and 5 (Harwood *et al.* 2018).

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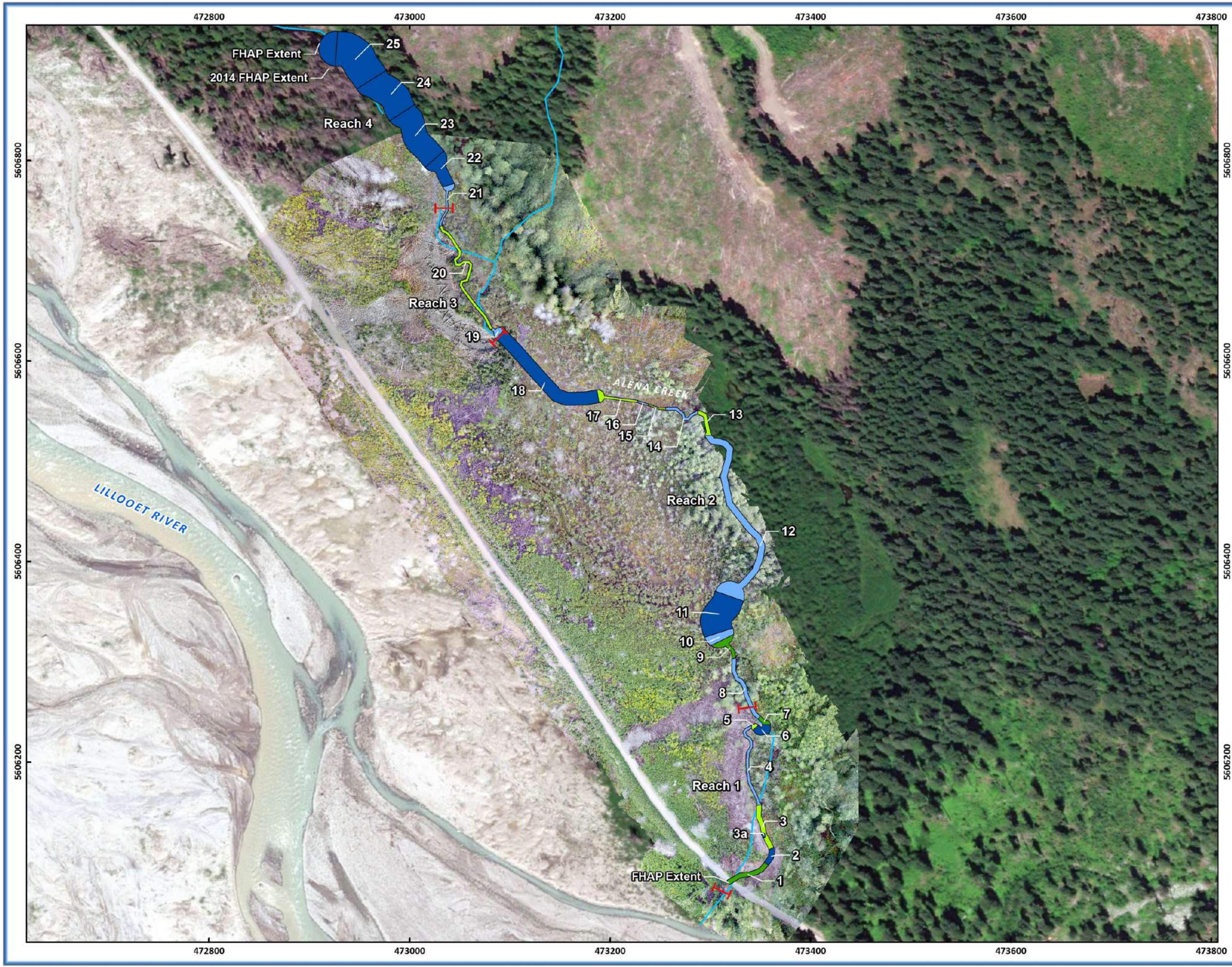
PROJECT MAPS



UPPER LILLOOET HYDRO PROJECT

Alena Creek
Fish Habitat Assessment

Legend

FHAP Type

🟦	Glide
🟦	Pool
🟩	Riffle
🟩	Run
I	Reach Break The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
—	Streams

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:3,600

NO.	DATE	REVISION	BY
1	17/04/2018	1095_ALN_FHAP_2017Oct24	SPK
2			
3			
4			
5			

Date Saved: 17/04/2018
Coordinate System: NAD 1983 UTM Zone 10N

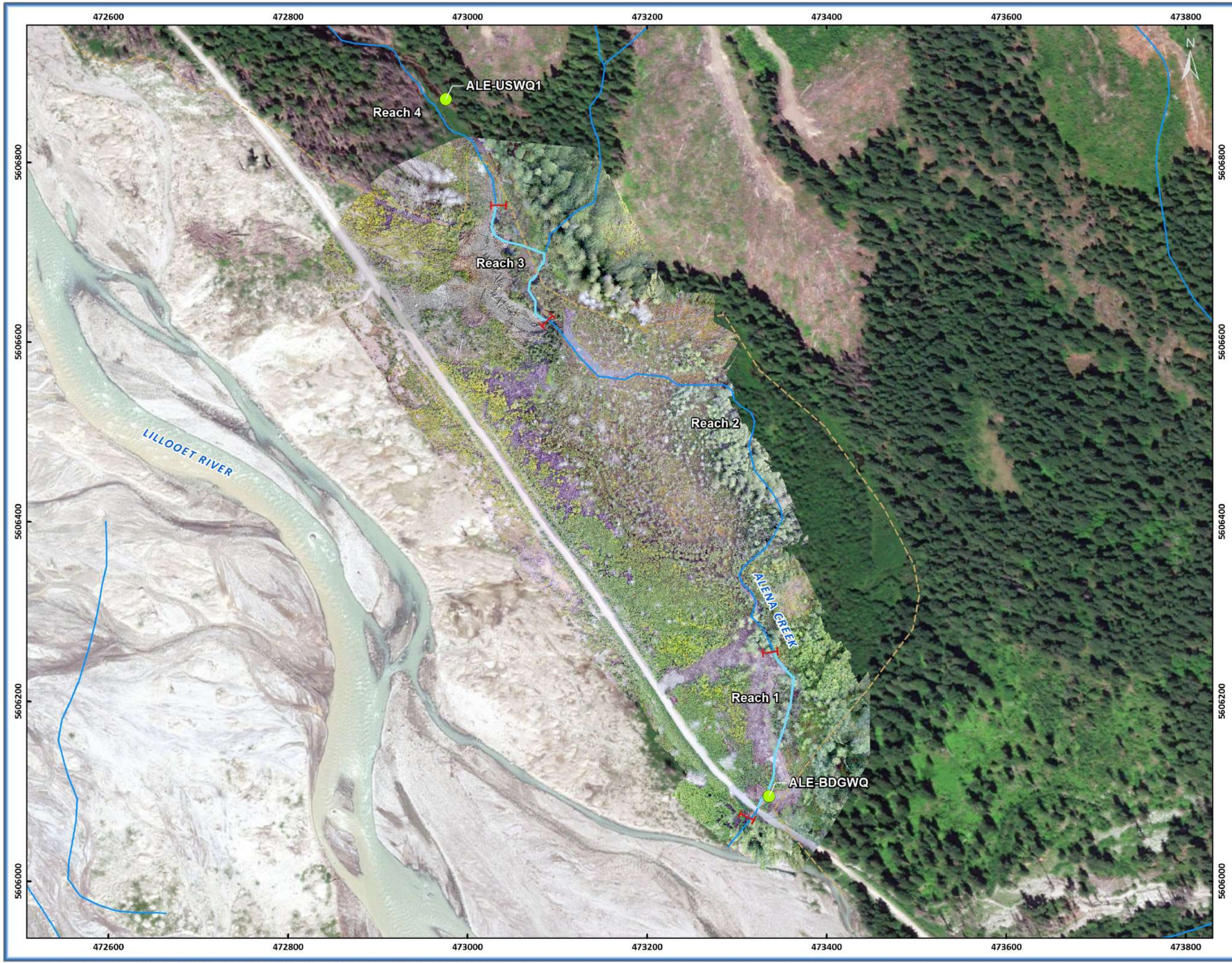
ECOFISH RESEARCH

Map 2

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ALN_FHAP_2017Oct24.mxd

UPPER LILLOOET HYDRO PROJECT

Alena Creek
Water Quality Sites



Legend

- 🟢 Water Quality Sample Site
- Reach Break
- I The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- --- Meager Creek Slide Extent
- — Streams

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:4,000

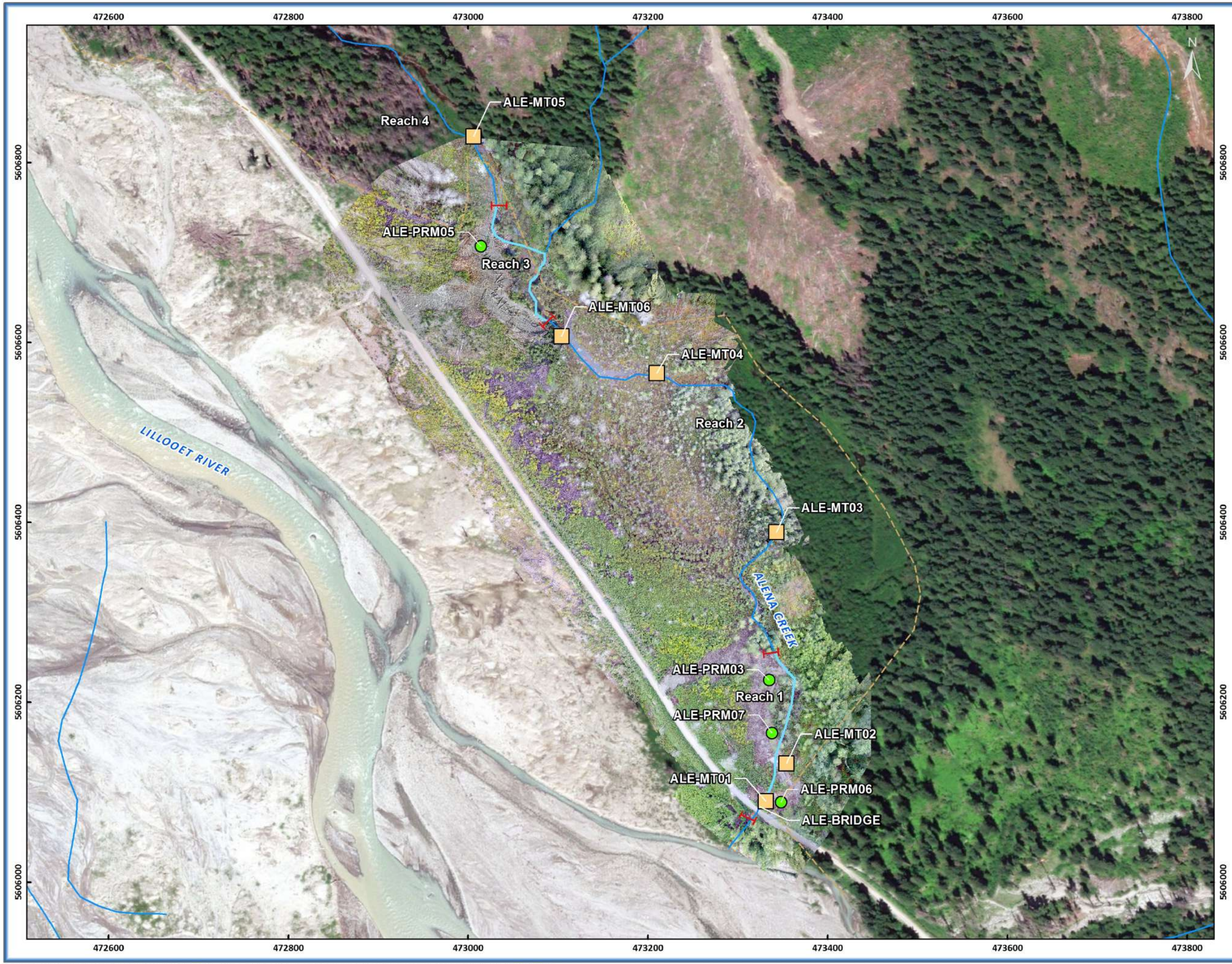
NO.	DATE	REVISION	BY
1	17/04/2018	1095_ALN_WQSamplingSites_2018Mar15	SPK
2			
3			
4			
5			

Date Saved: 17/04/2018
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 3

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\WaterQuality\1095_ALN_WQSamplingSites_2018Mar15.mxd



UPPER LILLOOET HYDRO PROJECT

Alena Creek Fish Abundance Sampling and Riparian Monitoring Sites

Legend

🟧	Minnow Traps
●	Permanent Vegetation Monitoring Plots
I	Reach Break The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- - -	Meager Creek Slide Extent
—	Streams

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:4,000

NO.	DATE	REVISION	BY
1	17/04/2018	1095_ALN_FishAbundanceRipMonSites_2018Apr12	SPK
2			
3			
4			
5			

Date Saved: 17/04/2018
Coordinate System: NAD 1983 UTM Zone 10N

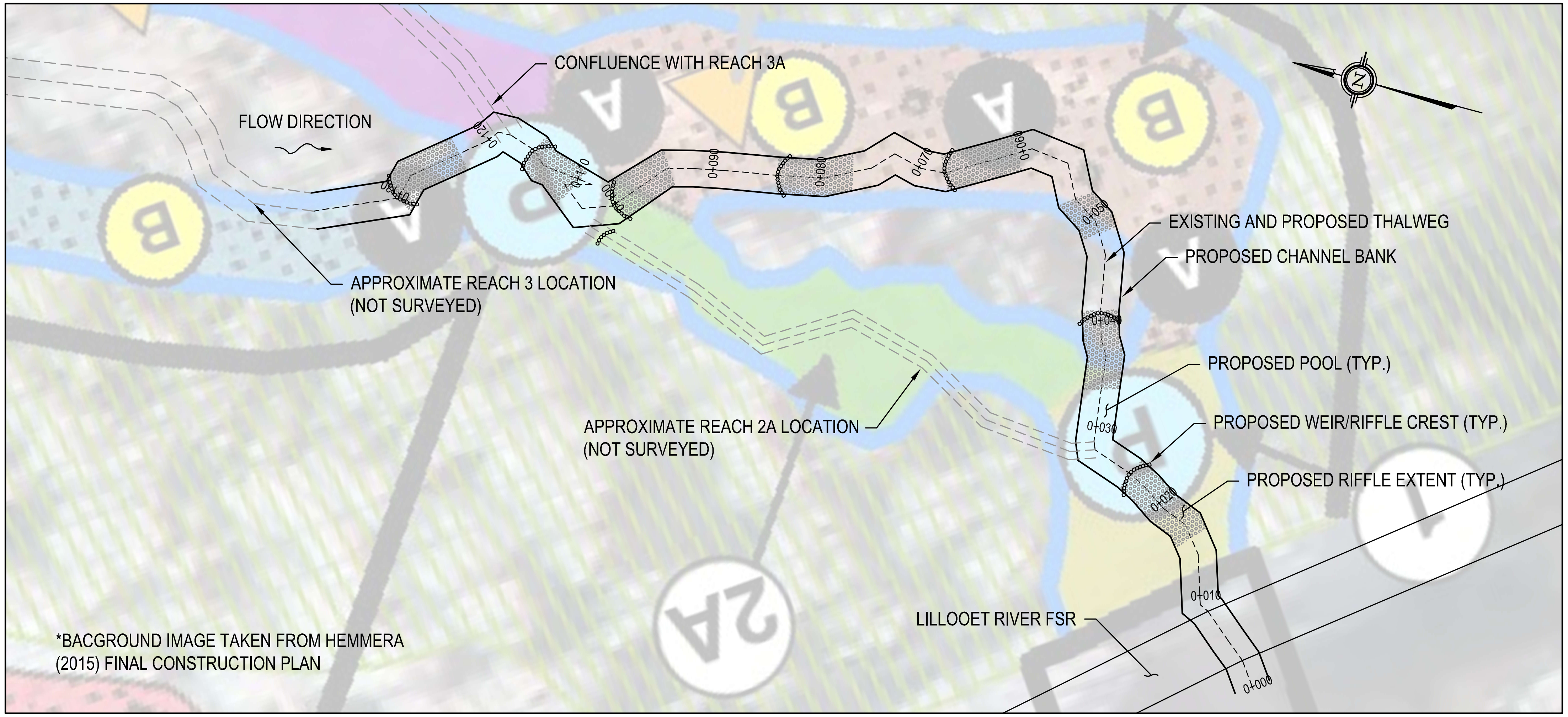
ECOFISH RESEARCH

Map 4

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ALN_FishAbundanceRipMonSites_2018Apr12.mxd

APPENDICES

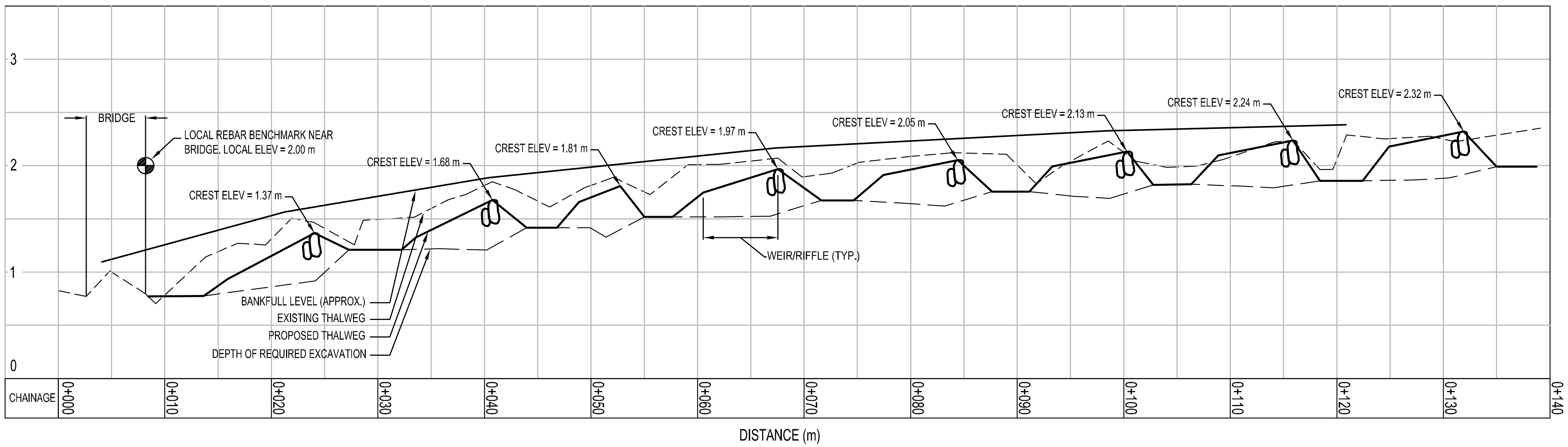
Appendix A. Final Design Drawings of the Alena Creek Fish Habitat Enhancement Project



*BACGROUND IMAGE TAKEN FROM HEMMERA (2015) FINAL CONSTRUCTION PLAN

REACH 1, 2, & 2A PLANVIEW

1:500



REACH 1, 2, & 2A PROFILE

1:500

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.
4. ALL MEASUREMENTS FOR THIS PROJECT ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE INDICATED.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR LAYOUT, SURVEY AND LOCATION OF ALL UTILITIES.
6. LOCATION OF FEATURES AND EXTENT OF WORKS SHALL BE REVIEWED AND APPROVED BY ENVIRONMENTAL MONITOR.
7. ALL WORKS SHALL BE SUPERVISED, INSPECTED AND APPROVED BY A ENVIRONMENTAL MONITOR.
8. ALL WORKS AND MATERIALS SHALL BE IN ACCORDANCE WITH APPLICABLE MUNICIPAL AND/OR PROVINCIAL STANDARD SPECIFICATIONS AND DRAWINGS.
9. ALL GENERAL BACKFILL SHALL BE APPROVED MATERIAL COMPACTED TO 85% STANDARD PROCTOR DENSITY.
10. ALL UNSUITABLE AND/OR EXCESS MATERIALS SHALL BE DEPOSITED IN A SPOIL AREA DETERMINED BYENVIRONMENTAL MONITOR.
11. IMMEDIATELY AFTER CONSTRUCTION, ALL DISTURBED AREAS SHALL BE STABILIZED AND/OR RESTORED TO ORIGINAL CONDITION.
12. THE CONTRACTOR SHALL REMOVE ALL SEDIMENT CONTROLS AFTER VEGETATION HAS ESTABLISHED. WORKS WILL NOT BE CONSIDERED COMPLETE UNTIL ALL TEMPORARY SEDIMENT CONTROLS ARE REMOVED.

WATERCOURSE PROTECTION

1. MITIGATION MEASURES SECTION OF HEMMERA (2015) FINAL CONSTRUCTION PLAN TO BE REVIEWED AND ADHERED TO.
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3. ADDITIONAL EROSION AND SEDIMENT CONTROLS SHALL BE INSTALLED IF IT IS DETERMINED THAT APPROVED CONTROLS DO NOT ADEQUATELY PREVENT EROSION AND RELEASE OF SEDIMENT.
4. WHERE WORK IN A WATERCOURSE OR ON WATERCOURSE BANKS IS NOT REQUIRED, EQUIPMENT SHALL NOT BE OPERATED IN SUCH AREAS.
5. WHERE WORK IN A WATERCOURSE OR ON WATERCOURSE BANKS IS REQUIRED, THE USE OF EQUIPMENT WITHIN THE WATERCOURSE SHALL BE MINIMIZED.
6. WORK IN A WATERCOURSE AND ON WATERCOURSE BANKS SHALL BE COMPLETED IN THE DRY IN AN ISOLATED WORK AREA DURING LOW-FLOW CONDITIONS.
7. THE WEATHER FORECAST SHALL BE CONTINUALLY MONITORED TO ENSURE THAT CONSTRUCTION ACTIVITIES MAY PROCEED UNDER FAVOURABLE CONDITIONS.
8. EXCAVATION OF THE WATERCOURSE BED AND PLACEMENT OF MATERIALS SHALL BE STAGED SO THAT NO EXCAVATED AREAS REMAIN EXPOSED AT THE END OF EACH WORKING DAY.
9. IF FLOWS WITHIN A WATERCOURSE ARE OBSERVED TO RISE TO A LEVEL APPROACHING THE PUMPING CAPACITY, PLACEMENT OF MATERIALS IN EXCAVATED AREAS MUST BE COMPLETED AS SOON AS POSSIBLE, AFTER WHICH WORK MUST BE SHUT DOWN UNTIL THE FLOW RETURNS TO A LEVEL WITHIN THE PROVIDED PUMPING CAPACITY.
10. ALL EQUIPMENT SHALL BE CLEAN AND FREE OF PETROLEUM PRODUCTS.
11. ALL MAINTENANCE, REFUELING AND STORAGE OF EQUIPMENT SHALL BE CONTROLLED SO AS TO PREVENT ANY DISCHARGE OF PETROLEUM PRODUCTS. VEHICULAR MAINTENANCE AND REFUELING SHALL BE CONDUCTED AWAY FROM WATERCOURSES AND WATERCOURSE BANKS.
12. CONSTRUCTION MATERIAL, EXCESS MATERIAL, CONSTRUCTION DEBRIS AND EMPTY CONTAINERS SHALL BE STORED AWAY FROM WATERCOURSES AND WATERCOURSE BANKS.

	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

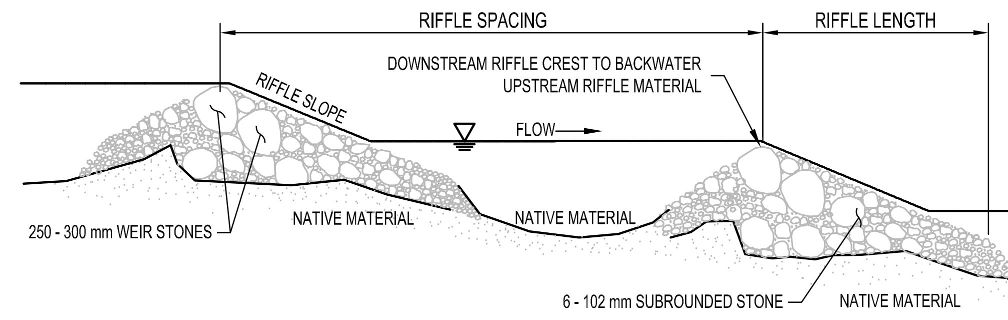
July 10, 2016
PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA
D. T. WEST
41242

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

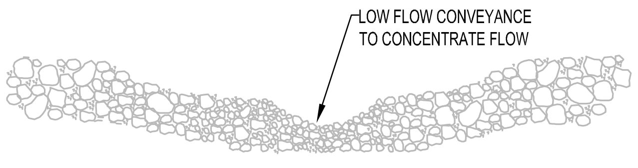


TYPICAL RIFFLE SEQUENCE PROFILE

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.

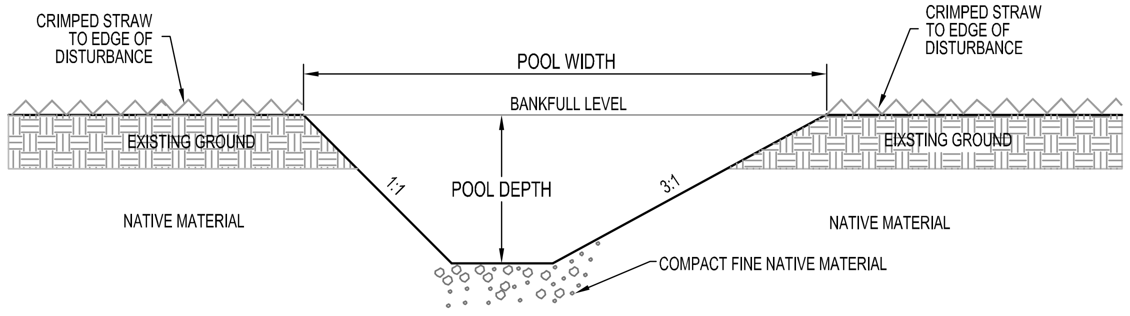


CROSS-SECTION

N.T.S.

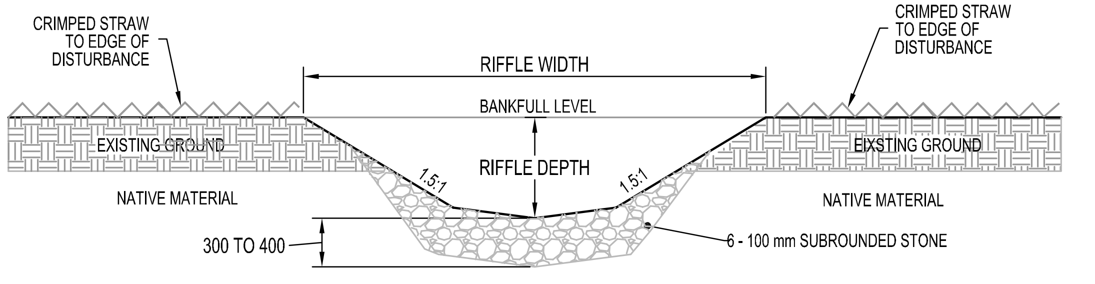
WEIR/RIFFLE CONSTRUCTION DETAILS

N.T.S.



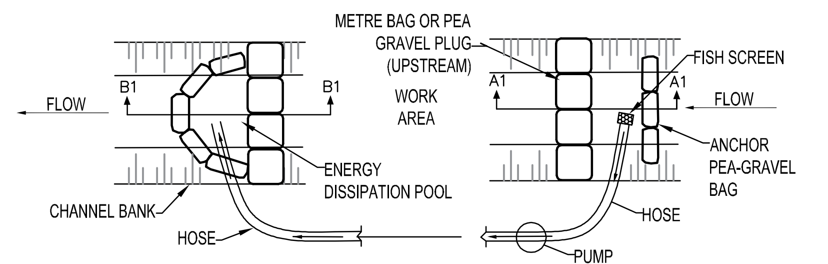
TYPICAL POOL CROSS SECTION

N.T.S.

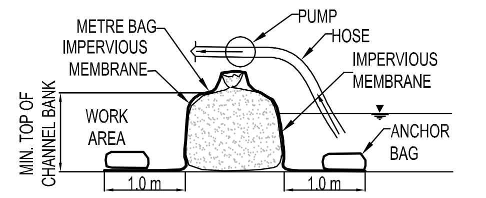


TYPICAL RIFFLE CROSS SECTION

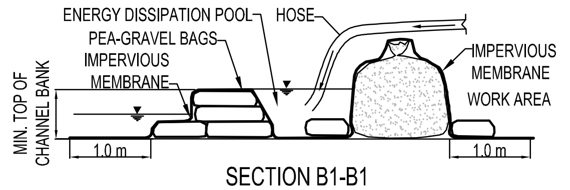
N.T.S.



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

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	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

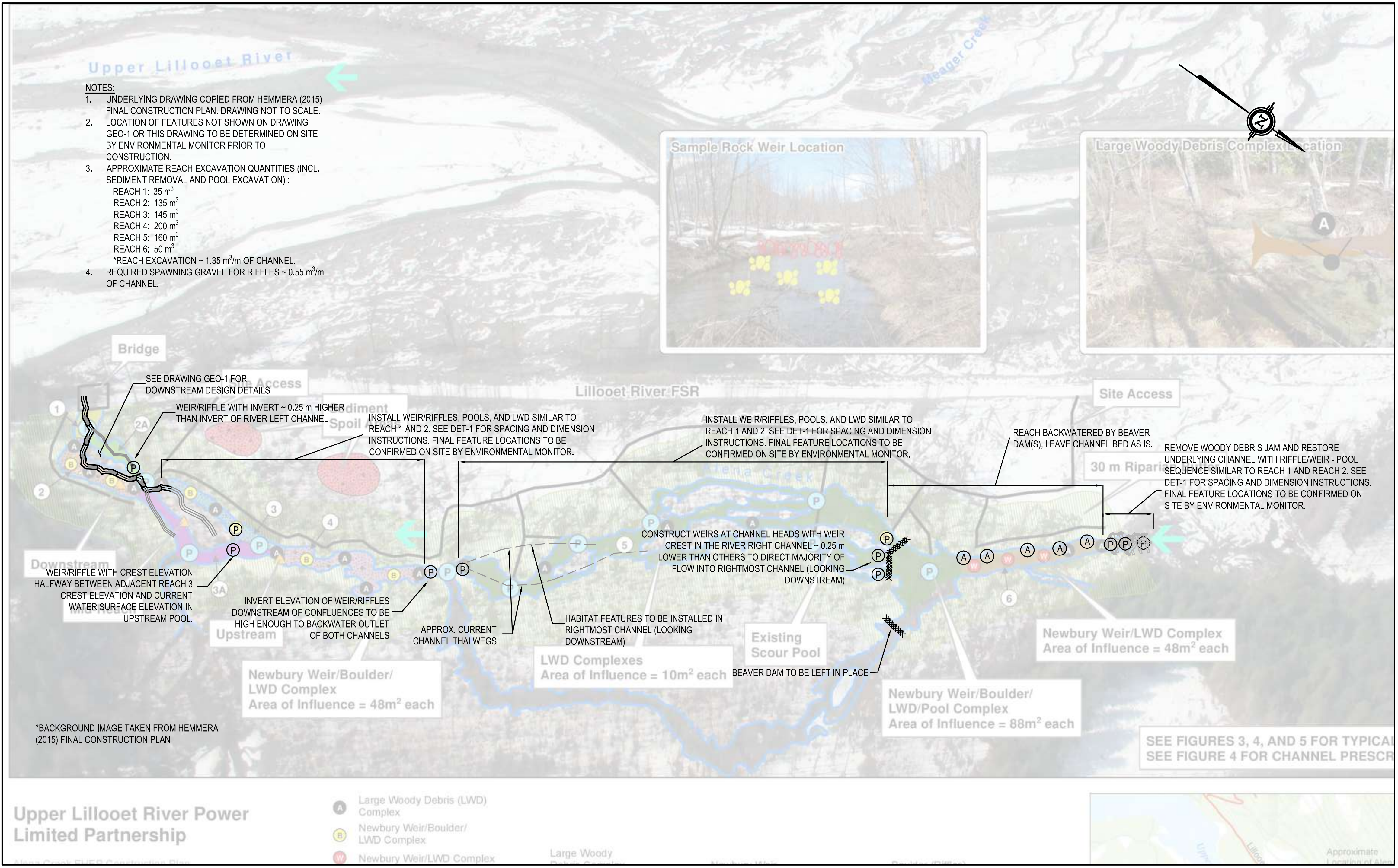
July 10, 2016
D. T. WEST
41242

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



NOTES:

1. UNDERLYING DRAWING COPIED FROM HEMMERA (2015) FINAL CONSTRUCTION PLAN. DRAWING NOT TO SCALE.
2. LOCATION OF FEATURES NOT SHOWN ON DRAWING GEO-1 OR THIS DRAWING TO BE DETERMINED ON SITE BY ENVIRONMENTAL MONITOR PRIOR TO CONSTRUCTION.
3. APPROXIMATE REACH EXCAVATION QUANTITIES (INCL. SEDIMENT REMOVAL AND POOL EXCAVATION) :
   - REACH 1: 35 m^3
   - REACH 2: 135 m^3
   - REACH 3: 145 m^3
   - REACH 4: 200 m^3
   - REACH 5: 160 m^3
   - REACH 6: 50 m^3
   - *REACH EXCAVATION ~ 1.35 m^3/m OF CHANNEL.
4. REQUIRED SPAWNING GRAVEL FOR RIFFLES ~ 0.55 m^3/m OF CHANNEL.

SEE DRAWING GEO-1 FOR DOWNSTREAM DESIGN DETAILS

WEIR/RIFFLE WITH INVERT ~ 0.25 m HIGHER THAN INVERT OF RIVER LEFT CHANNEL

INSTALL WEIR/RIFFLES, POOLS, AND LWD SIMILAR TO REACH 1 AND 2. SEE DET-1 FOR SPACING AND DIMENSION INSTRUCTIONS. FINAL FEATURE LOCATIONS TO BE CONFIRMED ON SITE BY ENVIRONMENTAL MONITOR.

INSTALL WEIR/RIFFLES, POOLS, AND LWD SIMILAR TO REACH 1 AND 2. SEE DET-1 FOR SPACING AND DIMENSION INSTRUCTIONS. FINAL FEATURE LOCATIONS TO BE CONFIRMED ON SITE BY ENVIRONMENTAL MONITOR.

REACH BACKWATERED BY BEAVER DAM(S), LEAVE CHANNEL BED AS IS.

REMOVE WOODY DEBRIS JAM AND RESTORE UNDERLYING CHANNEL WITH RIFFLE/WEIR - POOL SEQUENCE SIMILAR TO REACH 1 AND REACH 2. SEE DET-1 FOR SPACING AND DIMENSION INSTRUCTIONS. FINAL FEATURE LOCATIONS TO BE CONFIRMED ON SITE BY ENVIRONMENTAL MONITOR.

WEIR/RIFFLE WITH CREST ELEVATION HALFWAY BETWEEN ADJACENT REACH 3 CREST ELEVATION AND CURRENT WATER SURFACE ELEVATION IN UPSTREAM POOL.

INVERT ELEVATION OF WEIR/RIFFLES DOWNSTREAM OF CONFLUENCES TO BE HIGH ENOUGH TO BACKWATER OUTLET OF BOTH CHANNELS

APPROX. CURRENT CHANNEL THALWEGS

HABITAT FEATURES TO BE INSTALLED IN RIGHTMOST CHANNEL (LOOKING DOWNSTREAM)

CONSTRUCT WEIRS AT CHANNEL HEADS WITH WEIR CREST IN THE RIVER RIGHT CHANNEL ~ 0.25 m LOWER THAN OTHERS TO DIRECT MAJORITY OF FLOW INTO RIGHTMOST CHANNEL (LOOKING DOWNSTREAM)

BEAVER DAM TO BE LEFT IN PLACE

*BACKGROUND IMAGE TAKEN FROM HEMMERA (2015) FINAL CONSTRUCTION PLAN

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.

	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

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

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. Representative Photos of Water Quality Monitoring Sites in 2016-2017

LIST OF FIGURES

Figure 1. Looking upstream ALE-USWQ1 on November 23, 2016.

Figure 2. Looking downstream ALE-USWQ1 on November 23, 2016.

Figure 3. River right to river left ALE-USWQ1 on November 23, 2016.

Figure 4. Looking upstream ALE-BDGWQ on November 23, 2016.

Figure 5. Looking downstream ALE-BDGWQ on November 23, 2016.

Figure 6. River left to river right ALE-BDGWQ on November 23, 2016.

Figure 7. Looking upstream ALE-USWQ1 on March 5, 2017

Figure 8. Looking downstream ALE-USWQ1 on March 5, 2017.

Figure 9. River right to river left ALE-USWQ1 on March 5, 2017.

Figure 10. Looking upstream ALE-BDGWQ on March 5, 2017.

Figure 11. Looking downstream ALE-BDGWQ on March 5, 2017.

Figure 12. River left to river right ALE-BDGWQ on March 5, 2017.

Figure 13. Looking upstream ALE-USWQ1 on September 13, 2017.

Figure 14. Looking downstream ALE-USWQ1 on September 13, 2017.

Figure 15. River right to river left ALE-USWQ1 on September 13, 2017.

Figure 16. Looking upstream ALE-BDGWQ on September 13, 2017.

Figure 17. Looking downstream ALE-BDGWQ on September 13, 2017.

Appendix C. Water Quality ALS Laboratory Reports

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Sute 906, 595 Howe Street,
Sute 1000
Vancouver BC V6C 2T5

Date Received: 24-NOV-16
Report Date: 29-DEC-16 20:18 (MT)
Version: FINAL

Client Phone: 604-608-6180

Certificate of Analysis

Lab Work Order #: L1862248

Project P.O. #: 1095-49.40
Job Reference:
C of C Numbers: OL-2183
Legal Site Desc: British Columbia

Ariel McDonnell, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1862248-1	L1862248-2	L1862248-3	L1862248-4	L1862248-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16
	Sampled Time	10:30	10:30	10:30	12:29	12:29
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-BDGWQ C	ALE-USWQ1A	ALE-USWQ1B
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	48.6	48.5	48.5	50.2	50.1
	Hardness (as CaCO3) (mg/L)	19.3	19.4	19.4	20.0	20.2
	pH (pH)	7.45	7.44	7.41	7.38	7.36
	Total Suspended Solids (mg/L)	4.6	5.6	5.1	3.3	2.9
	Total Dissolved Solids (mg/L)	44	47	50	47	51
	Turbidity (NTU)	1.51	1.85	1.91	0.81	0.88
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	16.1	19.5	19.1	19.5	19.4
	Ammonia, Total (as N) (mg/L)	0.0311	0.0313	0.0310	0.0115	0.0112
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Fluoride (F) (mg/L)	0.024	0.025	0.025	0.024	0.024
	Nitrate (as N) (mg/L)	0.127	0.127	0.127	0.0477	0.0478
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Orthophosphate-Dissolved (as P) (mg/L)	0.0029	0.0033	0.0032	0.0024	0.0025
	Phosphorus (P)-Total Dissolved (mg/L)	0.0035	0.0057	0.0050	0.0044	0.0051
	Phosphorus (P)-Total (mg/L)	0.0115	0.0109	0.0092	0.0076	0.0073
	Sulfate (SO4) (mg/L)	3.00	3.00	3.00	3.72	3.73
Total Metals	Aluminum (Al)-Total (mg/L)	0.133	0.122	0.133	0.0850	0.0739
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00016	0.00014	0.00015	<0.00010	<0.00010
	Barium (Ba)-Total (mg/L)	0.0142	0.0140	0.0142	0.0109	0.0107
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	0.0000087	0.0000091	0.0000072	0.0000077	0.0000085
	Calcium (Ca)-Total (mg/L)	5.90	5.82	5.80	6.03	6.07
	Chromium (Cr)-Total (mg/L)	0.00019	0.00013	0.00022	0.00011	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00029	0.00029	0.00029	0.00017	0.00014
	Copper (Cu)-Total (mg/L)	0.00107	0.00100	0.00105	0.00068	0.00065
	Iron (Fe)-Total (mg/L)	0.944	0.912	0.942	0.225	0.217
	Lead (Pb)-Total (mg/L)	0.000070	0.000056	0.000059	<0.000050	<0.000050
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.97	0.96	0.99	0.92	0.90
	Manganese (Mn)-Total (mg/L)	0.0717	0.0709	0.0725	0.0202	0.0187
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.000476	0.000479	0.000472	0.000485	0.000485
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1862248-6				
	Description	Water				
	Sampled Date	23-NOV-16				
	Sampled Time	12:29				
	Client ID	ALE-USWQ1C				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	49.7				
	Hardness (as CaCO3) (mg/L)	20.2				
	pH (pH)	7.36				
	Total Suspended Solids (mg/L)	3.8				
	Total Dissolved Solids (mg/L)	48				
	Turbidity (NTU)	0.82				
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	19.9				
	Ammonia, Total (as N) (mg/L)	0.0112				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	0.024				
	Nitrate (as N) (mg/L)	0.0477				
	Nitrite (as N) (mg/L)	<0.0010				
	Orthophosphate-Dissolved (as P) (mg/L)	0.0022				
	Phosphorus (P)-Total Dissolved (mg/L)	0.0045				
	Phosphorus (P)-Total (mg/L)	0.0063				
	Sulfate (SO4) (mg/L)	3.74				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0833				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	<0.00010				
	Barium (Ba)-Total (mg/L)	0.0108				
	Beryllium (Be)-Total (mg/L)	<0.000020				
	Bismuth (Bi)-Total (mg/L)	<0.000050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	0.0000058				
	Calcium (Ca)-Total (mg/L)	6.06				
	Chromium (Cr)-Total (mg/L)	<0.00010				
	Cobalt (Co)-Total (mg/L)	0.00016				
	Copper (Cu)-Total (mg/L)	0.00068				
	Iron (Fe)-Total (mg/L)	0.228				
	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	<0.0010				
	Magnesium (Mg)-Total (mg/L)	0.92				
	Manganese (Mn)-Total (mg/L)	0.0193				
	Mercury (Hg)-Total (mg/L)	<0.0000050				
	Molybdenum (Mo)-Total (mg/L)	0.000486				
	Nickel (Ni)-Total (mg/L)	<0.00050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1862248-1	L1862248-2	L1862248-3	L1862248-4	L1862248-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16
	Sampled Time	10:30	10:30	10:30	12:29	12:29
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-BDGWQ C	ALE-USWQ1A	ALE-USWQ1B
WATER						
Total Metals	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Total (mg/L)	0.95	0.94	0.96	0.87	0.84
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	6.17	6.08	6.13	6.45	6.37
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	1.50	1.48	1.50	1.60	1.56
	Strontium (Sr)-Total (mg/L)	0.0319	0.0316	0.0315	0.0333	0.0333
	Sulfur (S)-Total (mg/L)	0.93	0.81	0.92	1.08	1.05
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00533	0.00476	0.00495	0.00266	0.00269
	Uranium (U)-Total (mg/L)	0.000025	0.000026	0.000027	0.000021	0.000020
	Vanadium (V)-Total (mg/L)	0.00108	0.00097	0.00101	0.00063	0.00058
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0660	0.0705	0.0686	0.0423	0.0469
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00013	0.00014	0.00013	<0.00010	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0132	0.0141	0.0134	0.0109	0.0109
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000071	0.0000058	0.0000058	0.0000066
	Calcium (Ca)-Dissolved (mg/L)	6.22	6.20	6.23	6.46	6.57
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00026	0.00028	0.00027	0.00015	0.00014
	Copper (Cu)-Dissolved (mg/L)	0.00094	0.00125	0.00095	0.00067	0.00059
	Iron (Fe)-Dissolved (mg/L)	0.857	0.887	0.869	0.191	0.201
	Lead (Pb)-Dissolved (mg/L)	0.000053	0.000058	0.000052	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	0.93	0.95	0.93	0.93	0.92
	Manganese (Mn)-Dissolved (mg/L)	0.0669	0.0708	0.0680	0.0187	0.0187
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000405	0.000399	0.000418	0.000425	0.000458
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

	Sample ID	L1862248-6
	Description	Water
	Sampled Date	23-NOV-16
	Sampled Time	12:29
	Client ID	ALE-USWQ1C
Grouping	**Analyte**	
WATER		
Total Metals	Phosphorus (P)-Total (mg/L)	<0.050
	Potassium (K)-Total (mg/L)	0.86
	Selenium (Se)-Total (mg/L)	<0.000050
	Silicon (Si)-Total (mg/L)	6.52
	Silver (Ag)-Total (mg/L)	<0.000010
	Sodium (Na)-Total (mg/L)	1.59
	Strontium (Sr)-Total (mg/L)	0.0335
	Sulfur (S)-Total (mg/L)	1.24
	Thallium (Tl)-Total (mg/L)	<0.000010
	Tin (Sn)-Total (mg/L)	<0.00010
	Titanium (Ti)-Total (mg/L)	0.00274
	Uranium (U)-Total (mg/L)	0.000020
	Vanadium (V)-Total (mg/L)	0.00062
	Zinc (Zn)-Total (mg/L)	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD
	Dissolved Metals Filtration Location	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0466
	Antimony (Sb)-Dissolved (mg/L)	<0.00010
	Arsenic (As)-Dissolved (mg/L)	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0113
	Beryllium (Be)-Dissolved (mg/L)	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	0.0000082
	Calcium (Ca)-Dissolved (mg/L)	6.50
	Chromium (Cr)-Dissolved (mg/L)	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00015
	Copper (Cu)-Dissolved (mg/L)	0.00064
	Iron (Fe)-Dissolved (mg/L)	0.199
	Lead (Pb)-Dissolved (mg/L)	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	0.96
	Manganese (Mn)-Dissolved (mg/L)	0.0191
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000435
	Nickel (Ni)-Dissolved (mg/L)	<0.00050

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1862248-1	L1862248-2	L1862248-3	L1862248-4	L1862248-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16	23-NOV-16
	Sampled Time	10:30	10:30	10:30	12:29	12:29
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-BDGWQ C	ALE-USWQ1A	ALE-USWQ1B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	1.07	1.09	1.07	1.00	0.96
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Dissolved (mg/L)	6.01	5.82	5.86	6.31	6.30
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	1.43	1.48	1.45	1.61	1.59
	Strontium (Sr)-Dissolved (mg/L)	0.0333	0.0335	0.0336	0.0352	0.0360
	Sulfur (S)-Dissolved (mg/L)	1.26	1.17	1.22	1.48	1.57
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00190	0.00199	0.00189	0.00114	0.00150
	Uranium (U)-Dissolved (mg/L)	0.000026	0.000025	0.000027	0.000019	0.000021
	Vanadium (V)-Dissolved (mg/L)	0.00083	0.00090	0.00089	0.00050	0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0014	0.0018	0.0017	0.0017	0.0014
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Aggregate Organics	BOD (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	COD (mg/L)	<20	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1862248-6				
	Description	Water				
	Sampled Date	23-NOV-16				
	Sampled Time	12:29				
	Client ID	ALE-USWQ1C				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050				
	Potassium (K)-Dissolved (mg/L)	1.02				
	Selenium (Se)-Dissolved (mg/L)	<0.000050				
	Silicon (Si)-Dissolved (mg/L)	6.32				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	1.66				
	Strontium (Sr)-Dissolved (mg/L)	0.0356				
	Sulfur (S)-Dissolved (mg/L)	1.66				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	0.00126				
	Uranium (U)-Dissolved (mg/L)	0.000021				
	Vanadium (V)-Dissolved (mg/L)	0.00054				
	Zinc (Zn)-Dissolved (mg/L)	0.0021				
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030				
Aggregate Organics	BOD (mg/L)	<2.0				
	COD (mg/L)	<20				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Boron (B)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Sulfur (S)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Orthophosphate-Dissolved (as P)	MS-B	L1862248-1, -2, -3, -4, -5, -6
Matrix Spike	Orthophosphate-Dissolved (as P)	MS-B	L1862248-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ALS Test Code	Matrix	Test Description	Method Reference**
BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

ALS Test Code	Matrix	Test Description	Method Reference**
BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Reference Information

BOD5-VA Water Biochemical Oxygen Demand- 5 day APHA 5210 B- "BIOCHEMICAL OXYGEN DEMAND"

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

BOD5-VA Water Biochemical Oxygen Demand- 5 day APHA 5210 B- BIOCHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

BR-L-IC-N-VA Water Bromide in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-VA Water Chloride in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA Water Chemical Oxygen Demand by Colorimetric APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA Water Fluoride in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA Water Diss. Mercury in Water by CVAAS or CVAFS APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA Water Total Mercury in Water by CVAAS or CVAFS EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA Water Total Dissolved P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA Water Total Suspended Solids by Grav. (1 mg/L) APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	**Laboratory Location**
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2183

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1862248   Report Date: 29-DEC-16

Client: ECOFISH RESEARCH LTD
Sute 906, 595 Howe Street, Sute 1000
Vancouver BC V6C 2T5

Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-COL-VA	**Water**							
Batch R3609149								
WG2444186-2 LCS								
Alkalinity, Total (as CaCO3)			104.0		%		85-115	01-DEC-16
WG2444186-1 MB								
Alkalinity, Total (as CaCO3)			<2.0		mg/L		2	01-DEC-16
BE-D-L-CCMS-VA	**Water**							
Batch R3603226								
WG2440199-2 LCS								
Beryllium (Be)-Dissolved			101.5		%		80-120	25-NOV-16
WG2440199-1 MB		**NP**						
Beryllium (Be)-Dissolved			<0.000020		mg/L		0.00002	25-NOV-16
BE-T-L-CCMS-VA	**Water**							
Batch R3607047								
WG2442833-2 LCS								
Beryllium (Be)-Total			111.4		%		80-120	29-NOV-16
WG2442833-1 MB								
Beryllium (Be)-Total			<0.000020		mg/L		0.00002	29-NOV-16
BOD5-VA	**Water**							
Batch R3607084								
WG2440372-2 LCS								
BOD			95.2		%		85-115	25-NOV-16
WG2440372-6 LCS								
BOD			86.3		%		85-115	25-NOV-16
WG2440372-1 MB								
BOD			<2.0		mg/L		2	25-NOV-16
WG2440372-5 MB								
BOD			<2.0		mg/L		2	25-NOV-16
BR-L-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-2 LCS								
Bromide (Br)			98.6		%		85-115	25-NOV-16
WG2440212-21 LCS								
Bromide (Br)			99.0		%		85-115	25-NOV-16
WG2440212-1 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-10 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-13 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BR-L-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-13 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-16 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-19 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-4 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-7 MB								
Bromide (Br)			<0.050		mg/L		0.05	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Bromide (Br)			103.7		%		75-125	25-NOV-16
CL-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-2 LCS								
Chloride (Cl)			98.9		%		90-110	25-NOV-16
WG2440212-21 LCS								
Chloride (Cl)			99.0		%		90-110	25-NOV-16
WG2440212-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-10 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-13 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-16 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-19 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-4 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-7 MB								
Chloride (Cl)			<0.50		mg/L		0.5	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Chloride (Cl)			104.1		%		75-125	25-NOV-16
COD-COL-VA	**Water**							

Quality Control Report

Test		Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
COD-COL-VA		**Water**							
Batch	**R3608231**								
WG2444026-2	**DUP**		**L1862248-4**						
COD			<20	<20	RPD-NA	mg/L	N/A	20	01-DEC-16
WG2444026-3	**LCS**								
COD				100.9		%		85-115	01-DEC-16
WG2444026-6	**LCS**								
COD				100.1		%		85-115	01-DEC-16
WG2444026-1	**MB**								
COD				<20		mg/L		20	01-DEC-16
WG2444026-5	**MB**								
COD				<20		mg/L		20	01-DEC-16
WG2444026-4	**MS**		**L1862248-3**						
COD				99.4		%		75-125	01-DEC-16
EC-PCT-VA		**Water**							
Batch	**R3605323**								
WG2440106-19	**CRM**		**VA-EC-PCT-CONTROL**						
Conductivity				100.3		%		90-110	25-NOV-16
WG2440106-24	**CRM**		**VA-EC-PCT-CONTROL**						
Conductivity				99.7		%		90-110	25-NOV-16
WG2440106-16	**MB**								
Conductivity				<2.0		uS/cm		2	25-NOV-16
WG2440106-21	**MB**								
Conductivity				<2.0		uS/cm		2	25-NOV-16
F-IC-N-VA		**Water**							
Batch	**R3603245**								
WG2440212-2	**LCS**								
Fluoride (F)				96.4		%		90-110	25-NOV-16
WG2440212-21	**LCS**								
Fluoride (F)				97.0		%		90-110	25-NOV-16
WG2440212-1	**MB**								
Fluoride (F)				<0.020		mg/L		0.02	25-NOV-16
WG2440212-10	**MB**								
Fluoride (F)				<0.020		mg/L		0.02	25-NOV-16
WG2440212-13	**MB**								
Fluoride (F)				<0.020		mg/L		0.02	25-NOV-16
WG2440212-16	**MB**								
Fluoride (F)				<0.020		mg/L		0.02	25-NOV-16
WG2440212-19	**MB**								
Fluoride (F)				<0.020		mg/L		0.02	25-NOV-16

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-4 MB								
Fluoride (F)			<0.020		mg/L		0.02	25-NOV-16
WG2440212-7 MB								
Fluoride (F)			<0.020		mg/L		0.02	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Fluoride (F)			102.1		%		75-125	25-NOV-16
HG-D-CVAA-VA	**Water**							
Batch R3603376								
WG2440152-2 LCS								
Mercury (Hg)-Dissolved			101.1		%		80-120	25-NOV-16
WG2440152-1 MB		**NP**						
Mercury (Hg)-Dissolved			<0.000005		mg/L		0.000005	25-NOV-16
WG2440152-10 MS		**L1862248-2**						
Mercury (Hg)-Dissolved			96.5		%		70-130	25-NOV-16
HG-T-CVAA-VA	**Water**							
Batch R3603376								
WG2440628-2 LCS								
Mercury (Hg)-Total			99.7		%		80-120	25-NOV-16
WG2440628-1 MB								
Mercury (Hg)-Total			<0.000005		mg/L		0.000005	25-NOV-16
MET-D-CCMS-VA	**Water**							
Batch R3603226								
WG2440199-2 LCS								
Aluminum (Al)-Dissolved			104.7		%		80-120	25-NOV-16
Antimony (Sb)-Dissolved			98.1		%		80-120	25-NOV-16
Arsenic (As)-Dissolved			98.3		%		80-120	25-NOV-16
Barium (Ba)-Dissolved			100.1		%		80-120	25-NOV-16
Bismuth (Bi)-Dissolved			99.7		%		80-120	25-NOV-16
Boron (B)-Dissolved			95.4		%		80-120	25-NOV-16
Cadmium (Cd)-Dissolved			99.0		%		80-120	25-NOV-16
Calcium (Ca)-Dissolved			100.2		%		80-120	25-NOV-16
Chromium (Cr)-Dissolved			98.0		%		80-120	25-NOV-16
Cobalt (Co)-Dissolved			98.4		%		80-120	25-NOV-16
Copper (Cu)-Dissolved			96.4		%		80-120	25-NOV-16
Iron (Fe)-Dissolved			93.2		%		80-120	25-NOV-16
Lead (Pb)-Dissolved			101.7		%		80-120	25-NOV-16

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3603226								
WG2440199-2 LCS								
Lithium (Li)-Dissolved			101.4		%		80-120	25-NOV-16
Magnesium (Mg)-Dissolved			99.3		%		80-120	25-NOV-16
Manganese (Mn)-Dissolved			101.4		%		80-120	25-NOV-16
Molybdenum (Mo)-Dissolved			104.0		%		80-120	25-NOV-16
Nickel (Ni)-Dissolved			98.8		%		80-120	25-NOV-16
Phosphorus (P)-Dissolved			118.8		%		80-120	25-NOV-16
Potassium (K)-Dissolved			103.6		%		80-120	25-NOV-16
Selenium (Se)-Dissolved			98.4		%		80-120	25-NOV-16
Silicon (Si)-Dissolved			104.8		%		80-120	25-NOV-16
Silver (Ag)-Dissolved			97.7		%		80-120	25-NOV-16
Sodium (Na)-Dissolved			102.5		%		80-120	25-NOV-16
Strontium (Sr)-Dissolved			107.6		%		80-120	25-NOV-16
Sulfur (S)-Dissolved			98.0		%		80-120	25-NOV-16
Thallium (Tl)-Dissolved			99.6		%		80-120	25-NOV-16
Tin (Sn)-Dissolved			96.1		%		80-120	25-NOV-16
Titanium (Ti)-Dissolved			96.1		%		80-120	25-NOV-16
Uranium (U)-Dissolved			99.3		%		80-120	25-NOV-16
Vanadium (V)-Dissolved			100.6		%		80-120	25-NOV-16
Zinc (Zn)-Dissolved			96.1		%		80-120	25-NOV-16
Zirconium (Zr)-Dissolved			90.7		%		80-120	25-NOV-16
WG2440199-1 MB		**NP**						
Aluminum (Al)-Dissolved			<0.0010		mg/L		0.001	25-NOV-16
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Barium (Ba)-Dissolved			<0.000050		mg/L		0.00005	25-NOV-16
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	25-NOV-16
Boron (B)-Dissolved			<0.010		mg/L		0.01	25-NOV-16
Cadmium (Cd)-Dissolved			<0.0000050		mg/L		0.000005	25-NOV-16
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	25-NOV-16
Chromium (Cr)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	25-NOV-16
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	25-NOV-16
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	25-NOV-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3603226								
WG2440199-1 MB		**NP**						
Lithium (Li)-Dissolved			<0.0010		mg/L		0.001	25-NOV-16
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	25-NOV-16
Manganese (Mn)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	25-NOV-16
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	25-NOV-16
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	25-NOV-16
Potassium (K)-Dissolved			<0.050		mg/L		0.05	25-NOV-16
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	25-NOV-16
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	25-NOV-16
Silver (Ag)-Dissolved			<0.000010		mg/L		0.00001	25-NOV-16
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	25-NOV-16
Strontium (Sr)-Dissolved			<0.00020		mg/L		0.0002	25-NOV-16
Sulfur (S)-Dissolved			<0.50		mg/L		0.5	25-NOV-16
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	25-NOV-16
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	25-NOV-16
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	25-NOV-16
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	25-NOV-16
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	25-NOV-16
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	25-NOV-16
Zirconium (Zr)-Dissolved			<0.00030		mg/L		0.0003	25-NOV-16
MET-T-CCMS-VA	**Water**							
Batch R3607047								
WG2442833-2 LCS								
Aluminum (Al)-Total			112.3		%		80-120	29-NOV-16
Antimony (Sb)-Total			109.0		%		80-120	29-NOV-16
Arsenic (As)-Total			114.3		%		80-120	29-NOV-16
Barium (Ba)-Total			107.9		%		80-120	29-NOV-16
Bismuth (Bi)-Total			109.5		%		80-120	29-NOV-16
Boron (B)-Total			104.9		%		80-120	29-NOV-16
Cadmium (Cd)-Total			103.9		%		80-120	29-NOV-16
Calcium (Ca)-Total			108.8		%		80-120	29-NOV-16
Chromium (Cr)-Total			112.6		%		80-120	29-NOV-16
Cobalt (Co)-Total			110.4		%		80-120	29-NOV-16
Copper (Cu)-Total			108.3		%		80-120	29-NOV-16

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3607047								
WG2442833-2 LCS								
Iron (Fe)-Total			103.3		%		80-120	29-NOV-16
Lead (Pb)-Total			106.9		%		80-120	29-NOV-16
Lithium (Li)-Total			109.7		%		80-120	29-NOV-16
Magnesium (Mg)-Total			111.8		%		80-120	29-NOV-16
Manganese (Mn)-Total			111.8		%		80-120	29-NOV-16
Molybdenum (Mo)-Total			110.2		%		80-120	29-NOV-16
Nickel (Ni)-Total			111.5		%		80-120	29-NOV-16
Phosphorus (P)-Total			111.3		%		80-120	29-NOV-16
Potassium (K)-Total			112.7		%		80-120	29-NOV-16
Selenium (Se)-Total			107.1		%		80-120	29-NOV-16
Silicon (Si)-Total			110.7		%		80-120	29-NOV-16
Silver (Ag)-Total			101.5		%		80-120	29-NOV-16
Sodium (Na)-Total			112.4		%		80-120	29-NOV-16
Strontium (Sr)-Total			115.1		%		80-120	29-NOV-16
Sulfur (S)-Total			109.3		%		80-120	29-NOV-16
Thallium (Tl)-Total			106.5		%		80-120	29-NOV-16
Tin (Sn)-Total			105.0		%		80-120	29-NOV-16
Titanium (Ti)-Total			106.1		%		80-120	29-NOV-16
Uranium (U)-Total			104.0		%		80-120	29-NOV-16
Vanadium (V)-Total			112.4		%		80-120	29-NOV-16
Zinc (Zn)-Total			105.1		%		80-120	29-NOV-16
Zirconium (Zr)-Total			100.7		%		80-120	29-NOV-16
WG2442833-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	29-NOV-16
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Arsenic (As)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Barium (Ba)-Total			<0.000050		mg/L		0.00005	29-NOV-16
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	29-NOV-16
Boron (B)-Total			<0.010		mg/L		0.01	29-NOV-16
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	29-NOV-16
Calcium (Ca)-Total			<0.050		mg/L		0.05	29-NOV-16
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Copper (Cu)-Total			<0.00050		mg/L		0.0005	29-NOV-16

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3607047								
WG2442833-1 MB								
Iron (Fe)-Total			<0.010		mg/L		0.01	29-NOV-16
Lead (Pb)-Total			<0.000050		mg/L		0.00005	29-NOV-16
Lithium (Li)-Total			<0.0010		mg/L		0.001	29-NOV-16
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	29-NOV-16
Manganese (Mn)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	29-NOV-16
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	29-NOV-16
Phosphorus (P)-Total			<0.050		mg/L		0.05	29-NOV-16
Potassium (K)-Total			<0.050		mg/L		0.05	29-NOV-16
Selenium (Se)-Total			<0.000050		mg/L		0.00005	29-NOV-16
Silicon (Si)-Total			<0.050		mg/L		0.05	29-NOV-16
Silver (Ag)-Total			<0.000010		mg/L		0.00001	29-NOV-16
Sodium (Na)-Total			<0.050		mg/L		0.05	29-NOV-16
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	29-NOV-16
Sulfur (S)-Total			<0.50		mg/L		0.5	29-NOV-16
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	29-NOV-16
Tin (Sn)-Total			<0.00010		mg/L		0.0001	29-NOV-16
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	29-NOV-16
Uranium (U)-Total			<0.000010		mg/L		0.00001	29-NOV-16
Vanadium (V)-Total			<0.00050		mg/L		0.0005	29-NOV-16
Zinc (Zn)-Total			<0.0030		mg/L		0.003	29-NOV-16
Zirconium (Zr)-Total			<0.00030		mg/L		0.0003	29-NOV-16
NH3-F-VA	**Water**							
Batch R3606498								
WG2442096-2 LCS								
Ammonia, Total (as N)			103.8		%		85-115	29-NOV-16
WG2442096-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	29-NOV-16
NO2-L-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-2 LCS								
Nitrite (as N)			97.5		%		90-110	25-NOV-16
WG2440212-21 LCS								
Nitrite (as N)			98.2		%		90-110	25-NOV-16
WG2440212-1 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-10 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-13 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-19 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Nitrite (as N)			102.7		%		75-125	25-NOV-16
NO3-L-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-2 LCS								
Nitrate (as N)			99.8		%		90-110	25-NOV-16
WG2440212-21 LCS								
Nitrate (as N)			99.8		%		90-110	25-NOV-16
WG2440212-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-10 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-13 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-19 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Nitrate (as N)			104.5		%		75-125	25-NOV-16

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
P-T-PRES-COL-VA	**Water**							
Batch R3618614								
WG2452588-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			99.1		%		80-120	16-DEC-16
WG2452588-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			106.6		%		80-120	16-DEC-16
WG2452588-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	16-DEC-16
WG2452588-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	16-DEC-16
P-TD-COL-VA	**Water**							
Batch R3603140								
WG2440148-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			110.0		%		80-120	25-NOV-16
WG2440148-1 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	25-NOV-16
WG2440148-4 MS		**L1862248-1**						
Phosphorus (P)-Total Dissolved			104.0		%		70-130	25-NOV-16
PH-PCT-VA	**Water**							
Batch R3605323								
WG2440106-17 CRM		**VA-PH7-BUF**						
pH			7.02		pH		6.9-7.1	25-NOV-16
WG2440106-22 CRM		**VA-PH7-BUF**						
pH			7.03		pH		6.9-7.1	25-NOV-16
PO4-DO-COL-VA	**Water**							
Batch R3602793								
WG2440116-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			96.5		%		80-120	25-NOV-16
WG2440116-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			100.9		%		80-120	25-NOV-16
WG2440116-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	25-NOV-16
WG2440116-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	25-NOV-16
SO4-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-2 LCS								
Sulfate (SO4)			99.8		%		90-110	25-NOV-16
WG2440212-21 LCS								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-VA	**Water**							
Batch R3603245								
WG2440212-21 LCS								
Sulfate (SO4)			99.9		%		90-110	25-NOV-16
WG2440212-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-10 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-13 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-16 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-19 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-4 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-7 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	25-NOV-16
WG2440212-8 MS		**L1862248-6**						
Sulfate (SO4)			103.9		%		75-125	25-NOV-16
TDS-VA	**Water**							
Batch R3607113								
WG2442199-3 DUP		**L1862248-1**						
Total Dissolved Solids		44	43		mg/L	3.4	20	29-NOV-16
WG2442199-2 LCS								
Total Dissolved Solids			99.3		%		85-115	29-NOV-16
WG2442199-1 MB								
Total Dissolved Solids			<10		mg/L		10	29-NOV-16
TSS-LOW-VA	**Water**							
Batch R3606821								
WG2442432-2 LCS								
Total Suspended Solids			98.8		%		85-115	29-NOV-16
WG2442432-1 MB								
Total Suspended Solids			<1.0		mg/L		1	29-NOV-16
TURBIDITY-VA	**Water**							
Batch R3603525								
WG2440599-11 CRM		**VA-FORM-40**						
Turbidity			103.8		%		85-115	25-NOV-16
WG2440599-10 MB								
Turbidity			<0.10		NTU		0.1	25-NOV-16

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	23-NOV-16 10:30	25-NOV-16 16:49	0.25	54	hours	EHTR-FM
	2	23-NOV-16 10:30	25-NOV-16 16:49	0.25	54	hours	EHTR-FM
	3	23-NOV-16 10:30	25-NOV-16 16:49	0.25	54	hours	EHTR-FM
	4	23-NOV-16 12:29	25-NOV-16 16:49	0.25	52	hours	EHTR-FM
	5	23-NOV-16 12:29	25-NOV-16 16:49	0.25	52	hours	EHTR-FM
	6	23-NOV-16 12:29	25-NOV-16 16:49	0.25	52	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1862248 were received on 24-NOV-16 13:00.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Short Holding Time

Rush Processing

ALS En

Chain of Custody / Analytical Request
Canada Toll Free : 1 800 668 987
www.alsglobal.com

L1862248-COFC

COC #: OL-2163

Page 1 of 2

Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite 1000 Suite 906 - 595 Howe Street Vancouver, BC Canada, V6C 2T5
Phone:	604-608-6180
Fax:	604-608-6163
Invoice To	☑Email ☐Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	

Reporting	
Distribution:	☐Fax ☐Mail ☑Email
☑Criteria on Report (select from Guidelines below)	
Report Type:	☑Excel ☐Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
EDD Format:	
EDD Email(s):	
Project Info	
Job #:	
PO/AFE:	1095-49.40
LSD:	British Columbia
Quote #:	
ALS Contact: Ariel McDonnell	Sampler: sarah kennedy

Service Requested

- ● Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests — Please indicate below Filtered, Preserved or both(F, P, F/P) — (See page 2 for further requests)

Sample #	Sample Identification (This will appear on the report)	Coordinates Longitude	Coordinates Latitude	Date	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Anions by Ion Chromatography	Biochemical Oxygen Demand- 5 day	Chemical Oxygen Demand by Colorimetric	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Dissolved Metals in Water + Hg (BC MDG)	Sample Prep (Filtration for Metals)	Total Dissolved P in Water by Colour	Total Dissolved Solids by Gravimetric	Total Metals in Water + Hg (BC MDG)	Total P in Water by Colour
									P											P
	ALE-BDGWQ A -123	.377159	50.610045	23.NOV.16	10:30	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R
	ALE-BDGWQ B					Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R
	ALE-BDGWQ C					Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R
	ALE-USWQ1A -123	.381958	50.613091	23.Nov.16	12:29	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R
	ALE-USWQ1B					Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R
	ALE-USWQ1C					Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R

Special Instructions/Comments

DISSOLVED METALS WAS NOT FILTERED

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐Yes ☑No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐Yes ☑No

Guidelines

British Columbia Approved and Working Water Quality Guidelines (MAY, 2015) - BCAWWQG - Freshwater Aquatic Life

SAMPLE CONDITION (lab use only)

☐Frozen ☐Cold ☐Ambient ☐Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:
V. WOODRUFF	24.NOV 2016	8:00 am		Nov 24	1 Pm	2 °C				☐Yes If Yes add SIF

COC #: OL-2183

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

Page 2 of 2

Sample #	Sample Identification (This will appear on the report)	Coordinates		Date	Time	Sample Type	Analysis Requests														
		Longitude	Latitude				Number of Containers	Total Suspended Solids by Grav. (1 mg/L)	Turbidity by Meter	pH by Meter (Automated)											
								Please indicate below Filtered, Preserved or both(F, P, F/P)													
[redacted]	ALE-BDGWQ A	-123.37759	50.60015	23 Nov	10:30	Water	7	R	R	R											
[redacted]	ALE-BDGWQ B	"	"	"	"	Water	7	R	R	R											
[redacted]	ALE-BDGWQ C	"	"	"	"	Water	7	R	R	R											
[redacted]	ALE-USWQ1A	-123.38958	50.62081	23 Nov	12:29	Water	7	R	R	R											
[redacted]	ALE-USWQ1B	"	"	"	"	Water	7	R	R	R											
[redacted]	ALE-USWQ1C	"	"	"	"	Water	7	R	R	R											
[redacted]																					
[redacted]																					
[redacted]																					

Short Holding Time
Rush Processing

L1862248-COFC

lady Nov-24 1PM 2°C

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5

Date Received: 06-MAR-17
Report Date: 16-MAR-17 18:48 (MT)
Version: FINAL

Client Phone: 604-608-6180

Certificate of Analysis

Lab Work Order #: L1897855

Project P.O. #: 1095-49.40
Job Reference:
C of C Numbers: OL-2306
Legal Site Desc: BRITISH COLUMBIA

Shane Stack
Account Manager

	Sample ID	L1897855-1	L1897855-2	L1897855-3	L1897855-4
	Description	WATER	WATER	WATER	WATER
	Sampled Date	05-MAR-17	05-MAR-17	05-MAR-17	05-MAR-17
	Sampled Time	13:00	13:00	12:00	12:00
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	56.2	55.4	55.9	54.8
	Hardness (as CaCO3) (mg/L)	22.0	22.7	21.2	21.6
	pH (pH)	7.27	7.23	7.11	7.23
	Total Suspended Solids (mg/L)	1.3	<1.0	1.8	<1.0
	Total Dissolved Solids (mg/L)	48	47	43	45
	Turbidity (NTU)	2.76	2.69	4.46	0.53
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	24.0	24.5	23.1	23.5
	Ammonia, Total (as N) (mg/L)	0.0338	0.0319	<0.0050	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	<0.50	<0.50
	Fluoride (F) (mg/L)	0.024	0.025	0.022	0.022
	Nitrate (as N) (mg/L)	0.0678	0.0691	0.0551	0.0551
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Orthophosphate-Dissolved (as P) (mg/L)	0.0031	0.0031	<0.0010	<0.0010
	Phosphorus (P)-Total Dissolved (mg/L)	0.0044	0.0051	<0.0020	<0.0020
	Phosphorus (P)-Total (mg/L)	0.012	0.010	<0.0020	0.0021
	Sulfate (SO4) (mg/L)	3.90	3.91	4.65	4.65
Total Metals	Aluminum (Al)-Total (mg/L)	0.0192	0.0182	0.0120	0.0110
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	0.00011	0.00011	<0.00010	<0.00010
	Barium (Ba)-Total (mg/L)	0.0139	0.0140	0.0106	0.0105
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	0.0000053	<0.0000050	0.0000064	0.0000064
	Calcium (Ca)-Total (mg/L)	7.20	7.15	7.03	6.97
	Chromium (Cr)-Total (mg/L)	0.00014	0.00069	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00016	0.00016	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	0.880	0.929	0.110	0.109
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	1.09	1.11	0.99	0.98
	Manganese (Mn)-Total (mg/L)	0.0811	0.0833	0.0152	0.0151
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.000530	0.000493	0.000452	0.000460
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1897855-1	L1897855-2	L1897855-3	L1897855-4	
	Description	WATER	WATER	WATER	WATER	
	Sampled Date	05-MAR-17	05-MAR-17	05-MAR-17	05-MAR-17	
	Sampled Time	13:00	13:00	12:00	12:00	
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B	
Grouping	**Analyte**					
WATER						
Total Metals	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Potassium (K)-Total (mg/L)	0.98	0.99	0.88	0.88	
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Silicon (Si)-Total (mg/L)	6.73	6.66	7.01	7.02	
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Total (mg/L)	1.69	1.72	1.75	1.67	
	Strontium (Sr)-Total (mg/L)	0.0361	0.0354	0.0369	0.0366	
	Sulfur (S)-Total (mg/L)	1.32	1.35	1.52	1.64	
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Total (mg/L)	0.00042	0.00046	<0.00030	<0.00030	
	Uranium (U)-Total (mg/L)	0.000013	0.000013	0.000012	0.000012	
	Vanadium (V)-Total (mg/L)	0.00068	0.00070	<0.00050	<0.00050	
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0163	0.0172	0.0102	0.0110	
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00010	<0.00010	<0.00010	
	Barium (Ba)-Dissolved (mg/L)	0.0137	0.0138	0.0107	0.0108	
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000051	0.0000070	0.0000074	
	Calcium (Ca)-Dissolved (mg/L)	7.05	7.23	6.80	7.02	
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	0.00021	<0.00010	<0.00010	
	Cobalt (Co)-Dissolved (mg/L)	0.00015	0.00015	<0.00010	<0.00010	
	Copper (Cu)-Dissolved (mg/L)	0.00033	0.00034	0.00027	0.00028	
	Iron (Fe)-Dissolved (mg/L)	0.871	0.882	0.112	0.105	
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Magnesium (Mg)-Dissolved (mg/L)	1.08	1.13	1.02	0.99	
	Manganese (Mn)-Dissolved (mg/L)	0.0777	0.0802	0.0157	0.0148	
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
	Molybdenum (Mo)-Dissolved (mg/L)	0.000468	0.000502	0.000467	0.000432	
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1897855-1	L1897855-2	L1897855-3	L1897855-4
	Description	WATER	WATER	WATER	WATER
	Sampled Date	05-MAR-17	05-MAR-17	05-MAR-17	05-MAR-17
	Sampled Time	13:00	13:00	12:00	12:00
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B
Grouping	**Analyte**				
WATER					
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050
	Potassium (K)-Dissolved (mg/L)	0.92	0.95	0.90	0.86
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Dissolved (mg/L)	6.86	7.05	7.08	7.49
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	1.68	1.72	1.85	1.76
	Strontium (Sr)-Dissolved (mg/L)	0.0353	0.0360	0.0375	0.0363
	Sulfur (S)-Dissolved (mg/L)	1.27	1.26	1.31	1.43
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	0.00042	0.00045	<0.00030	<0.00030
	Uranium (U)-Dissolved (mg/L)	0.000011	0.000014	0.000010	0.000011
	Vanadium (V)-Dissolved (mg/L)	0.00062	0.00063	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0018	<0.0010	<0.0010	0.0014
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030
Aggregate Organics	BOD (mg/L)	<2.0	<2.0	<2.0	<2.0
	COD (mg/L)	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Barium (Ba)-Total	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Total	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Total	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Total	MS-B	L1897855-1, -2, -3, -4
Matrix Spike	Sulfur (S)-Total	MS-B	L1897855-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

BOD5-VA	Water	Biochemical Oxygen Demand- 5 day	APHA 5210 B- BIOCHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Reference Information

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA Water Total Mercury in Water by CVAAS or CVAFS EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA Water Total Dissolved P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA Water Total Suspended Solids by Grav. (1 mg/L) APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

Reference Information

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2306

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1897855 Report Date: 16-MAR-17

Client: ECOFISH RESEARCH LTD
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-TITR-VA	**Water**							
Batch R3672778								
WG2491225-13 CRM		**VA-ALK-TITR-CONTROL**						
Alkalinity, Total (as CaCO3)			101.8		%		85-115	10-MAR-17
WG2491225-11 MB								
Alkalinity, Total (as CaCO3)			<1.0		mg/L		1	10-MAR-17
BE-D-L-CCMS-VA	**Water**							
Batch R3669143								
WG2489898-2 LCS								
Beryllium (Be)-Dissolved			98.5		%		80-120	07-MAR-17
WG2489898-1 MB		**NP**						
Beryllium (Be)-Dissolved			<0.000020		mg/L		0.00002	07-MAR-17
Batch R3672821								
WG2489898-4 MS		**L1897855-1**						
Beryllium (Be)-Dissolved			109.2		%		70-130	09-MAR-17
BE-T-L-CCMS-VA	**Water**							
Batch R3673405								
WG2491812-2 LCS								
Beryllium (Be)-Total			95.9		%		80-120	10-MAR-17
WG2491812-1 MB								
Beryllium (Be)-Total			<0.000020		mg/L		0.00002	10-MAR-17
BOD5-VA	**Water**							
Batch R3673932								
WG2490284-2 LCS								
BOD			95.9		%		85-115	07-MAR-17
WG2490284-1 MB								
BOD			<2.0		mg/L		2	07-MAR-17
BR-L-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Bromide (Br)		<0.050	<0.050	RPD-NA	mg/L	N/A	20	07-MAR-17
WG2490044-2 LCS								
Bromide (Br)			100.4		%		85-115	07-MAR-17
WG2490044-9 LCS								
Bromide (Br)			99.5		%		85-115	07-MAR-17
WG2490044-1 MB								
Bromide (Br)			<0.050		mg/L		0.05	07-MAR-17
WG2490044-4 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BR-L-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-4 MB								
Bromide (Br)			<0.050		mg/L		0.05	07-MAR-17
WG2490044-7 MB								
Bromide (Br)			<0.050		mg/L		0.05	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Bromide (Br)			98.4		%		75-125	07-MAR-17
CL-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Chloride (Cl)		<0.50	<0.50	RPD-NA	mg/L	N/A	20	07-MAR-17
WG2490044-2 LCS								
Chloride (Cl)			101.1		%		90-110	07-MAR-17
WG2490044-9 LCS								
Chloride (Cl)			100.9		%		90-110	07-MAR-17
WG2490044-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	07-MAR-17
WG2490044-4 MB								
Chloride (Cl)			<0.50		mg/L		0.5	07-MAR-17
WG2490044-7 MB								
Chloride (Cl)			<0.50		mg/L		0.5	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Chloride (Cl)			100.2		%		75-125	07-MAR-17
COD-COL-VA	**Water**							
Batch R3674854								
WG2493768-3 LCS								
COD			100.2		%		85-115	14-MAR-17
WG2493768-7 LCS								
COD			100.3		%		85-115	14-MAR-17
WG2493768-1 MB								
COD			<20		mg/L		20	14-MAR-17
WG2493768-5 MB								
COD			<20		mg/L		20	14-MAR-17
EC-PCT-VA	**Water**							
Batch R3670083								
WG2489846-10 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			99.0		%		90-110	07-MAR-17
WG2489846-4 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.3		%		90-110	07-MAR-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
EC-PCT-VA	**Water**							
Batch R3670083								
WG2489846-6 DUP		**L1897855-4**						
Conductivity		54.8	54.3		uS/cm	0.9	10	07-MAR-17
WG2489846-1 MB								
Conductivity			<2.0		uS/cm		2	07-MAR-17
WG2489846-7 MB								
Conductivity			<2.0		uS/cm		2	07-MAR-17
F-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Fluoride (F)		0.022	0.021		mg/L	0.3	20	07-MAR-17
WG2490044-2 LCS								
Fluoride (F)			98.8		%		90-110	07-MAR-17
WG2490044-9 LCS								
Fluoride (F)			98.7		%		90-110	07-MAR-17
WG2490044-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	07-MAR-17
WG2490044-4 MB								
Fluoride (F)			<0.020		mg/L		0.02	07-MAR-17
WG2490044-7 MB								
Fluoride (F)			<0.020		mg/L		0.02	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Fluoride (F)			99.0		%		75-125	07-MAR-17
HG-D-CVAA-VA	**Water**							
Batch R3668939								
WG2489900-2 LCS								
Mercury (Hg)-Dissolved			97.9		%		80-120	07-MAR-17
WG2489900-1 MB		**NP**						
Mercury (Hg)-Dissolved			<0.000005		mg/L		0.000005	07-MAR-17
WG2489900-4 MS		**L1897855-1**						
Mercury (Hg)-Dissolved			97.3		%		70-130	07-MAR-17
HG-T-CVAA-VA	**Water**							
Batch R3668939								
WG2490150-3 DUP		**L1897855-2**						
Mercury (Hg)-Total		<0.0000050	<0.000005	RPD-NA	mg/L	N/A	20	07-MAR-17
WG2490150-2 LCS								
Mercury (Hg)-Total			96.8		%		80-120	07-MAR-17
WG2490150-1 MB								
Mercury (Hg)-Total			<0.000005		mg/L		0.000005	07-MAR-17

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3669143								
WG2489898-2 LCS								
Aluminum (Al)-Dissolved			100.3		%		80-120	07-MAR-17
Antimony (Sb)-Dissolved			91.4		%		80-120	07-MAR-17
Arsenic (As)-Dissolved			98.3		%		80-120	07-MAR-17
Barium (Ba)-Dissolved			99.0		%		80-120	07-MAR-17
Bismuth (Bi)-Dissolved			97.5		%		80-120	07-MAR-17
Boron (B)-Dissolved			93.2		%		80-120	07-MAR-17
Cadmium (Cd)-Dissolved			96.8		%		80-120	07-MAR-17
Calcium (Ca)-Dissolved			96.5		%		80-120	07-MAR-17
Chromium (Cr)-Dissolved			95.9		%		80-120	07-MAR-17
Cobalt (Co)-Dissolved			97.7		%		80-120	07-MAR-17
Copper (Cu)-Dissolved			95.0		%		80-120	07-MAR-17
Iron (Fe)-Dissolved			92.5		%		80-120	07-MAR-17
Lead (Pb)-Dissolved			98.8		%		80-120	07-MAR-17
Lithium (Li)-Dissolved			96.5		%		80-120	07-MAR-17
Magnesium (Mg)-Dissolved			100.4		%		80-120	07-MAR-17
Manganese (Mn)-Dissolved			100.0		%		80-120	07-MAR-17
Molybdenum (Mo)-Dissolved			98.7		%		80-120	07-MAR-17
Nickel (Ni)-Dissolved			97.9		%		80-120	07-MAR-17
Phosphorus (P)-Dissolved			104.8		%		80-120	07-MAR-17
Potassium (K)-Dissolved			100.5		%		80-120	07-MAR-17
Selenium (Se)-Dissolved			92.3		%		80-120	07-MAR-17
Silicon (Si)-Dissolved			98.6		%		80-120	07-MAR-17
Silver (Ag)-Dissolved			94.7		%		80-120	07-MAR-17
Sodium (Na)-Dissolved			98.9		%		80-120	07-MAR-17
Strontium (Sr)-Dissolved			104.0		%		80-120	07-MAR-17
Sulfur (S)-Dissolved			90.7		%		80-120	07-MAR-17
Thallium (Tl)-Dissolved			96.7		%		80-120	07-MAR-17
Tin (Sn)-Dissolved			96.4		%		80-120	07-MAR-17
Titanium (Ti)-Dissolved			92.7		%		80-120	07-MAR-17
Uranium (U)-Dissolved			99.1		%		80-120	07-MAR-17
Vanadium (V)-Dissolved			97.9		%		80-120	07-MAR-17
Zinc (Zn)-Dissolved			95.7		%		80-120	07-MAR-17
Zirconium (Zr)-Dissolved			90.1		%		80-120	07-MAR-17
WG2489898-1 MB		**NP**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3669143								
WG2489898-1 MB		**NP**						
Aluminum (Al)-Dissolved			<0.0010		mg/L		0.001	07-MAR-17
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Barium (Ba)-Dissolved			<0.000050		mg/L		0.00005	07-MAR-17
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	07-MAR-17
Boron (B)-Dissolved			<0.010		mg/L		0.01	07-MAR-17
Cadmium (Cd)-Dissolved			<0.0000050		mg/L		0.000005	07-MAR-17
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	07-MAR-17
Chromium (Cr)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	07-MAR-17
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	07-MAR-17
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	07-MAR-17
Lithium (Li)-Dissolved			<0.0010		mg/L		0.001	07-MAR-17
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	07-MAR-17
Manganese (Mn)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	07-MAR-17
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	07-MAR-17
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	07-MAR-17
Potassium (K)-Dissolved			<0.050		mg/L		0.05	07-MAR-17
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	07-MAR-17
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	07-MAR-17
Silver (Ag)-Dissolved			<0.000010		mg/L		0.00001	07-MAR-17
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	07-MAR-17
Strontium (Sr)-Dissolved			<0.00020		mg/L		0.0002	07-MAR-17
Sulfur (S)-Dissolved			<0.50		mg/L		0.5	07-MAR-17
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	07-MAR-17
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	07-MAR-17
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	07-MAR-17
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	07-MAR-17
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	07-MAR-17
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	07-MAR-17
Zirconium (Zr)-Dissolved			<0.00030		mg/L		0.0003	07-MAR-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3672821								
WG2489898-4 MS		**L1897855-1**						
Aluminum (Al)-Dissolved			100.9		%		70-130	09-MAR-17
Antimony (Sb)-Dissolved			105.7		%		70-130	09-MAR-17
Arsenic (As)-Dissolved			95.9		%		70-130	09-MAR-17
Barium (Ba)-Dissolved			99.3		%		70-130	09-MAR-17
Bismuth (Bi)-Dissolved			95.4		%		70-130	09-MAR-17
Boron (B)-Dissolved			105.4		%		70-130	09-MAR-17
Cadmium (Cd)-Dissolved			100.3		%		70-130	09-MAR-17
Calcium (Ca)-Dissolved			N/A	MS-B	%		-	09-MAR-17
Chromium (Cr)-Dissolved			99.3		%		70-130	09-MAR-17
Cobalt (Co)-Dissolved			96.1		%		70-130	09-MAR-17
Copper (Cu)-Dissolved			96.5		%		70-130	09-MAR-17
Iron (Fe)-Dissolved			94.1		%		70-130	09-MAR-17
Lead (Pb)-Dissolved			104.2		%		70-130	09-MAR-17
Lithium (Li)-Dissolved			109.8		%		70-130	09-MAR-17
Magnesium (Mg)-Dissolved			N/A	MS-B	%		-	09-MAR-17
Manganese (Mn)-Dissolved			N/A	MS-B	%		-	09-MAR-17
Molybdenum (Mo)-Dissolved			106.0		%		70-130	09-MAR-17
Nickel (Ni)-Dissolved			99.2		%		70-130	09-MAR-17
Phosphorus (P)-Dissolved			100.8		%		70-130	09-MAR-17
Potassium (K)-Dissolved			98.7		%		70-130	09-MAR-17
Selenium (Se)-Dissolved			101.3		%		70-130	09-MAR-17
Silicon (Si)-Dissolved			98.1		%		70-130	09-MAR-17
Silver (Ag)-Dissolved			101.5		%		70-130	09-MAR-17
Sodium (Na)-Dissolved			99.9		%		70-130	09-MAR-17
Strontium (Sr)-Dissolved			N/A	MS-B	%		-	09-MAR-17
Sulfur (S)-Dissolved			99.99		%		70-130	09-MAR-17
Thallium (Tl)-Dissolved			104.6		%		70-130	09-MAR-17
Tin (Sn)-Dissolved			96.5		%		70-130	09-MAR-17
Titanium (Ti)-Dissolved			90.8		%		70-130	09-MAR-17
Uranium (U)-Dissolved			106.2		%		70-130	09-MAR-17
Vanadium (V)-Dissolved			100.2		%		70-130	09-MAR-17
Zinc (Zn)-Dissolved			99.2		%		70-130	09-MAR-17
Zirconium (Zr)-Dissolved			105.1		%		70-130	09-MAR-17
MET-T-CCMS-VA	**Water**							

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3673405								
WG2491812-2 LCS								
Aluminum (Al)-Total			104.6		%		80-120	10-MAR-17
Antimony (Sb)-Total			101.7		%		80-120	10-MAR-17
Arsenic (As)-Total			101.2		%		80-120	10-MAR-17
Barium (Ba)-Total			101.9		%		80-120	10-MAR-17
Bismuth (Bi)-Total			104.6		%		80-120	10-MAR-17
Boron (B)-Total			89.3		%		80-120	10-MAR-17
Cadmium (Cd)-Total			98.2		%		80-120	10-MAR-17
Calcium (Ca)-Total			96.1		%		80-120	10-MAR-17
Chromium (Cr)-Total			99.1		%		80-120	10-MAR-17
Cobalt (Co)-Total			100.0		%		80-120	10-MAR-17
Copper (Cu)-Total			97.0		%		80-120	10-MAR-17
Iron (Fe)-Total			98.8		%		80-120	10-MAR-17
Lead (Pb)-Total			105.9		%		80-120	10-MAR-17
Lithium (Li)-Total			104.4		%		80-120	10-MAR-17
Magnesium (Mg)-Total			104.1		%		80-120	10-MAR-17
Manganese (Mn)-Total			102.1		%		80-120	10-MAR-17
Molybdenum (Mo)-Total			99.2		%		80-120	10-MAR-17
Nickel (Ni)-Total			100.3		%		80-120	10-MAR-17
Phosphorus (P)-Total			108.5		%		80-120	10-MAR-17
Potassium (K)-Total			102.8		%		80-120	10-MAR-17
Selenium (Se)-Total			97.6		%		80-120	10-MAR-17
Silicon (Si)-Total			104.4		%		80-120	10-MAR-17
Silver (Ag)-Total			101.5		%		80-120	10-MAR-17
Sodium (Na)-Total			105.7		%		80-120	10-MAR-17
Strontium (Sr)-Total			107.7		%		80-120	10-MAR-17
Sulfur (S)-Total			102.2		%		80-120	10-MAR-17
Thallium (Tl)-Total			96.8		%		80-120	10-MAR-17
Tin (Sn)-Total			97.7		%		80-120	10-MAR-17
Titanium (Ti)-Total			97.6		%		80-120	10-MAR-17
Uranium (U)-Total			106.8		%		80-120	10-MAR-17
Vanadium (V)-Total			103.5		%		80-120	10-MAR-17
Zinc (Zn)-Total			95.0		%		80-120	10-MAR-17
Zirconium (Zr)-Total			95.2		%		80-120	10-MAR-17
WG2491812-1 MB								

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3673405								
WG2491812-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	10-MAR-17
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Arsenic (As)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Barium (Ba)-Total			<0.000050		mg/L		0.00005	10-MAR-17
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	10-MAR-17
Boron (B)-Total			<0.010		mg/L		0.01	10-MAR-17
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	10-MAR-17
Calcium (Ca)-Total			<0.050		mg/L		0.05	10-MAR-17
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Copper (Cu)-Total			<0.00050		mg/L		0.0005	10-MAR-17
Iron (Fe)-Total			<0.010		mg/L		0.01	10-MAR-17
Lead (Pb)-Total			<0.000050		mg/L		0.00005	10-MAR-17
Lithium (Li)-Total			<0.0010		mg/L		0.001	10-MAR-17
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	10-MAR-17
Manganese (Mn)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	10-MAR-17
Phosphorus (P)-Total			<0.050		mg/L		0.05	10-MAR-17
Potassium (K)-Total			<0.050		mg/L		0.05	10-MAR-17
Selenium (Se)-Total			<0.000050		mg/L		0.00005	10-MAR-17
Silicon (Si)-Total			<0.050		mg/L		0.05	10-MAR-17
Sodium (Na)-Total			<0.050		mg/L		0.05	10-MAR-17
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	10-MAR-17
Sulfur (S)-Total			<0.50		mg/L		0.5	10-MAR-17
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	10-MAR-17
Tin (Sn)-Total			<0.00010		mg/L		0.0001	10-MAR-17
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	10-MAR-17
Uranium (U)-Total			<0.000010		mg/L		0.00001	10-MAR-17
Vanadium (V)-Total			<0.00050		mg/L		0.0005	10-MAR-17
Zinc (Zn)-Total			<0.0030		mg/L		0.003	10-MAR-17
Zirconium (Zr)-Total			<0.00030		mg/L		0.0003	10-MAR-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3674264								
WG2491812-1 MB								
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	10-MAR-17
Silver (Ag)-Total			<0.000010		mg/L		0.00001	10-MAR-17
NH3-F-VA	**Water**							
Batch R3673619								
WG2492543-7 DUP		**L1897855-1**						
Ammonia, Total (as N)		0.0338	0.0332		mg/L	1.6	20	11-MAR-17
WG2492543-6 LCS								
Ammonia, Total (as N)			95.0		%		85-115	11-MAR-17
WG2492543-5 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	11-MAR-17
WG2492543-8 MS		**L1897855-1**						
Ammonia, Total (as N)			100.9		%		75-125	11-MAR-17
NO2-L-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Nitrite (as N)		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	07-MAR-17
WG2490044-2 LCS								
Nitrite (as N)			98.6		%		90-110	07-MAR-17
WG2490044-9 LCS								
Nitrite (as N)			98.3		%		90-110	07-MAR-17
WG2490044-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	07-MAR-17
WG2490044-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	07-MAR-17
WG2490044-7 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Nitrite (as N)			97.4		%		75-125	07-MAR-17
NO3-L-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Nitrate (as N)		0.0551	0.0529		mg/L	4.0	20	07-MAR-17
WG2490044-2 LCS								
Nitrate (as N)			101.3		%		90-110	07-MAR-17
WG2490044-9 LCS								
Nitrate (as N)			101.4		%		90-110	07-MAR-17
WG2490044-1 MB								

Quality Control Report

Workorder: L1897855 Report Date: 16-MAR-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	07-MAR-17
WG2490044-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	07-MAR-17
WG2490044-7 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Nitrate (as N)			100.7		%		75-125	07-MAR-17
P-T-PRES-COL-VA	**Water**							
Batch R3668750								
WG2489885-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			104.8		%		80-120	07-MAR-17
WG2489885-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	07-MAR-17
Batch R3670527								
WG2490446-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			109.7		%		80-120	08-MAR-17
WG2490446-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	08-MAR-17
P-TD-COL-VA	**Water**							
Batch R3668735								
WG2489882-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			100.7		%		80-120	07-MAR-17
WG2489882-3 DUP		**L1897855-1**						
Phosphorus (P)-Total Dissolved		0.0044	0.0046		mg/L	2.4	20	07-MAR-17
WG2489882-1 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	07-MAR-17
WG2489882-4 MS		**L1897855-2**						
Phosphorus (P)-Total Dissolved			98.8		%		70-130	07-MAR-17
PH-PCT-VA	**Water**							
Batch R3670083								
WG2489846-2 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	07-MAR-17
WG2489846-8 CRM		**VA-PH7-BUF**						
pH			7.04		pH		6.9-7.1	07-MAR-17
WG2489846-6 DUP		**L1897855-4**						
pH		7.23	7.25	J	pH	0.02	0.3	07-MAR-17
PO4-DO-COL-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3668715								
WG2489881-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			85.5		%		80-120	07-MAR-17
WG2489881-3 DUP		**L1897855-1**						
Orthophosphate-Dissolved (as P)		0.0031	0.0029		mg/L	5.3	20	07-MAR-17
WG2489881-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	07-MAR-17
WG2489881-4 MS		**L1897855-2**						
Orthophosphate-Dissolved (as P)			100.1		%		70-130	07-MAR-17
SO4-IC-N-VA	**Water**							
Batch R3669070								
WG2490044-3 DUP		**L1897855-3**						
Sulfate (SO4)		4.65	4.66		mg/L	0.2	20	07-MAR-17
WG2490044-2 LCS								
Sulfate (SO4)			101.4		%		90-110	07-MAR-17
WG2490044-9 LCS								
Sulfate (SO4)			101.5		%		90-110	07-MAR-17
WG2490044-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	07-MAR-17
WG2490044-4 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	07-MAR-17
WG2490044-7 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	07-MAR-17
WG2490044-5 MS		**L1897855-2**						
Sulfate (SO4)			100.3		%		75-125	07-MAR-17
TDS-VA	**Water**							
Batch R3669042								
WG2489799-5 LCS								
Total Dissolved Solids			101.4		%		85-115	06-MAR-17
WG2489799-4 MB								
Total Dissolved Solids			<10		mg/L		10	06-MAR-17
TSS-LOW-VA	**Water**							
Batch R3669025								
WG2489849-2 LCS								
Total Suspended Solids			95.5		%		85-115	06-MAR-17
WG2489849-1 MB								
Total Suspended Solids			<1.0		mg/L		1	06-MAR-17
TURBIDITY-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TURBIDITY-VA	**Water**							
Batch R3669241								
WG2490410-2 CRM		**VA-FORM-40**						
Turbidity			104.0		%		85-115	07-MAR-17
WG2490410-5 CRM		**VA-FORM-40**						
Turbidity			103.0		%		85-115	07-MAR-17
WG2490410-1 MB								
Turbidity			<0.10		NTU		0.1	07-MAR-17
WG2490410-4 MB								
Turbidity			<0.10		NTU		0.1	07-MAR-17

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	05-MAR-17 13:00	07-MAR-17 14:14	0.25	49	hours	EHTR-FM
	2	05-MAR-17 13:00	07-MAR-17 14:14	0.25	49	hours	EHTR-FM
	3	05-MAR-17 12:00	07-MAR-17 14:14	0.25	50	hours	EHTR-FM
	4	05-MAR-17 12:00	07-MAR-17 14:14	0.25	50	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1897855 were received on 06-MAR-17 12:38.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Short Holding Time

Rush Processing

ALS En

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

L1897855-COFC

COC #: OL-2306

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Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite 906, 595 Howe Street, Suite 1000 Vancouver, BC CANADA, V6C 2T5
Phone:	604-608-6180
Fax:	604-608-6163
Invoice To	☑ Email ☐ Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	[redacted]

Reporting	
Distribution:	☐ Fax ☐ Mail ☑ Email
☐ Criteria on Report (select from Guidelines below)	
Report Type:	☑ Excel ☑ Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com vwoodruff@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	kganshorn@ecofishresearch.com bbennett@ecofishresearch.com tkasubuchi@ecofishresearch.com
Project Info	
Job #:	
PO/AFE:	1095-49.40
LSD:	British Columbia
Quote #:	
ALS Contact:	Ariel McDonnell, B.Sc.
Sampler:	Sarah Kennedy

Service Requested

- ● Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests

Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Coordinates Longitude	Coordinates Latitude	Date MAR 5, 2017	Time	Sample Type	Number of Containers	Alkalinity by Colourimetric (Automated)	Ammonia in Water by Fluorescence	Anions by Ion Chromatography	Biochemical Oxygen Demand- 5 day	Chemical Oxygen Demand by Colorimetric	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Dissolved Metals in Water + Hg (BC MDG).	Total Dissolved P in Water by Colour	Total Dissolved Solids by Gravimetric	Total Metals in Water + Hg (BC MDG)	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	(See page 2 for further requests)
[redacted]	ALE-BDGWQ A	123°22'36"	50°36'21"	~~Feb-20-2017~~	~~12:00 PM~~ 13:00	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
[redacted]	ALE-BDGWQ B	"	"	~~Feb-20-2017~~	12:00 PM 13:30	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
[redacted]	ALE-USWQ1A	123°22'53"	50°36'45"	~~Feb-20-2017~~	12:00 PM	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
[redacted]	ALE-USWQ1B	"	"	~~Feb-20-2017~~	12:00 PM	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
[redacted]																					
[redacted]																					
[redacted]																					
[redacted]																					
[redacted]																					

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐ Yes ☒ No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐ Yes ☒ No

Guidelines

SAMPLE CONDITION (lab use only)

☐ Frozen ☐ Cold ☐ Ambient ☐ Cooling Initiated

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations:
V. Woodruff	Mar 6/17	7:00 AM	JC	MAR - 6 2017	12:38pm	1 °C				☐ Yes If Yes add SIF

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2306

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Sample #	Sample Identification (This will appear on the report)	Coordinates		Date	Time	Sample Type	Analysis Requests														
		Longitude	Latitude				Number of Containers	Turbidity by Meter	pH by Meter (Automated)												
				MARS 2017				Please indicate below Filtered, Preserved or both(F, P, F/P)													
[redacted]	ALE-BDGWQ A	123° 22' 36"	50° 36' 21'	~~Feb-20-2017~~	~~12:00 PM~~ 13:00	Water	7	R	R												
[redacted]	ALE-BDGWQ B	"	"	~~Feb-20-2017~~	~~12:00 PM~~ 13:20	Water	7	R	R												
[redacted]	ALE-USWQ1A	123°22'53	50°36'45"	~~Feb-20-2017~~	12:00 PM	Water	7	R	R												
[redacted]	ALE-USWQ1B			~~Feb-20-2017~~	12:00 PM	Water	7	R	R												
[redacted]																					
[redacted]																					
[redacted]																					
[redacted]																					
[redacted]																					

L1897855-COFC

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 06-JUN-17
Report Date: 16-JUN-17 16:55 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1937465
Project P.O. #: 1095-49.40
Job Reference:
C of C Numbers: OL-2485
Legal Site Desc: British Columbia

Shane Stack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1937465-1	L1937465-2	L1937465-3	L1937465-4
	Description	Water	Water	Water	Water
	Sampled Date	05-JUN-17	05-JUN-17	05-JUN-17	05-JUN-17
	Sampled Time	12:00	12:00	11:00	11:00
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B
Grouping	**Analyte**				
WATER					
Physical Tests	Conductivity (uS/cm)	52.5	51.6	48.9	48.6
	Hardness (as CaCO3) (mg/L)	19.3	19.3	19.2	18.4
	pH (pH)	7.27	7.26	7.22	7.24
	Total Suspended Solids (mg/L)	1.6	1.2	<1.0	<1.0
	Total Dissolved Solids (mg/L)	49	45	40	44
	Turbidity (NTU)	2.78	2.13	0.23	0.35
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	22.5	21.9	21.4	21.2
	Ammonia, Total (as N) (mg/L)	0.0217	0.0254	<0.0050	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	<0.50	<0.50
	Fluoride (F) (mg/L)	0.032	0.032	0.030	0.030
	Nitrate (as N) (mg/L)	0.173	0.173	0.0579	0.0571
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Orthophosphate-Dissolved (as P) (mg/L)	0.0023	0.0022	<0.0010	0.0013
	Phosphorus (P)-Total Dissolved (mg/L)	0.0037	0.0036	0.0021	<0.0020
	Phosphorus (P)-Total (mg/L)	0.0046	0.0044	<0.0020	0.0026
	Sulfate (SO4) (mg/L)	3.21	3.21	3.71	3.70
Total Metals	Aluminum (Al)-Total (mg/L)	0.0175	0.0189	0.0155	0.0153
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Barium (Ba)-Total (mg/L)	0.0120	0.0115	0.00899	0.00907
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.0000050	<0.0000050	0.0000062	0.0000056
	Calcium (Ca)-Total (mg/L)	6.36	6.37	6.17	6.07
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00014	0.00015	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	0.641	0.653	0.065	0.067
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Total (mg/L)	0.91	0.91	0.83	0.84
	Manganese (Mn)-Total (mg/L)	0.0662	0.0669	0.0109	0.0111
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Total (mg/L)	0.000470	0.000479	0.000501	0.000497
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

	Sample ID	L1937465-1	L1937465-2	L1937465-3	L1937465-4	
	Description	Water	Water	Water	Water	
	Sampled Date	05-JUN-17	05-JUN-17	05-JUN-17	05-JUN-17	
	Sampled Time	12:00	12:00	11:00	11:00	
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B	
Grouping	**Analyte**					
WATER						
Total Metals	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Potassium (K)-Total (mg/L)	0.83	0.83	0.77	0.80	
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Silicon (Si)-Total (mg/L)	6.20	6.06	6.21	6.27	
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Total (mg/L)	1.43	1.43	1.46	1.50	
	Strontium (Sr)-Total (mg/L)	0.0331	0.0330	0.0322	0.0321	
	Sulfur (S)-Total (mg/L)	1.08	1.12	1.26	1.27	
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Total (mg/L)	0.00036	0.00032	<0.00030	<0.00030	
	Uranium (U)-Total (mg/L)	0.000013	0.000013	0.000014	0.000013	
	Vanadium (V)-Total (mg/L)	0.00063	0.00063	<0.00050	<0.00050	
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0037	<0.0030	
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0177	0.0167	0.0147	0.0156	
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00010	<0.00010	<0.00010	
	Barium (Ba)-Dissolved (mg/L)	0.0124	0.0125	0.00925	0.00943	
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	0.0000052	
	Calcium (Ca)-Dissolved (mg/L)	6.17	6.15	6.24	5.94	
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Cobalt (Co)-Dissolved (mg/L)	0.00016	0.00016	<0.00010	<0.00010	
	Copper (Cu)-Dissolved (mg/L)	0.00051	0.00049	0.00042	0.00061	
	Iron (Fe)-Dissolved (mg/L)	0.678	0.660	0.074	0.066	
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Magnesium (Mg)-Dissolved (mg/L)	0.95	0.96	0.89	0.86	
	Manganese (Mn)-Dissolved (mg/L)	0.0722	0.0721	0.0116	0.0117	
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
	Molybdenum (Mo)-Dissolved (mg/L)	0.000423	0.000436	0.000477	0.000470	
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1937465-1	L1937465-2	L1937465-3	L1937465-4	
	Description	Water	Water	Water	Water	
	Sampled Date	05-JUN-17	05-JUN-17	05-JUN-17	05-JUN-17	
	Sampled Time	12:00	12:00	11:00	11:00	
	Client ID	ALE-BDGWQ A	ALE-BDGWQ B	ALE-USWQ1A	ALE-USWQ1B	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Potassium (K)-Dissolved (mg/L)	0.89	0.88	0.84	0.83	
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Silicon (Si)-Dissolved (mg/L)	6.14	6.07	5.98	6.17	
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Dissolved (mg/L)	1.53	1.53	1.55	1.54	
	Strontium (Sr)-Dissolved (mg/L)	0.0319	0.0321	0.0325	0.0306	
	Sulfur (S)-Dissolved (mg/L)	0.97	0.91	1.15	0.99	
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Dissolved (mg/L)	0.00034	0.00032	<0.00030	<0.00030	
	Uranium (U)-Dissolved (mg/L)	0.000011	0.000012	0.000013	0.000013	
	Vanadium (V)-Dissolved (mg/L)	0.00059	0.00057	<0.00050	<0.00050	
	Zinc (Zn)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Aggregate Organics	BOD (mg/L)	<2.0	<2.0	<2.0	<2.0	
	COD (mg/L)	<20	<20	<20	<20	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Manganese (Mn)-Total	MB-LOR	L1937465-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Iron (Fe)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Manganese (Mn)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Sodium (Na)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Sulfur (S)-Total	MS-B	L1937465-1, -2, -3, -4
Matrix Spike	Uranium (U)-Total	MS-B	L1937465-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**	
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity	This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
BOD5-VA	Water	Biochemical Oxygen Demand- 5 day	APHA 5210 B- BIOCHEMICAL OXYGEN DEMAND	This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.
BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND	This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.	This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510	Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.
F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B	Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.
HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)	

Reference Information

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA Water Total Mercury in Water by CVAAS or CVAFS EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

P-TD-COL-VA Water Total Dissolved P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA Water Total Suspended Solids by Grav. (1 mg/L) APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

Reference Information

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2485

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-TITR-VA	**Water**							
Batch R3746899								
WG2546640-3 CRM		**VA-ALK-TITR-CONTROL**						
Alkalinity, Total (as CaCO3)			98.1		%		85-115	13-JUN-17
WG2546640-1 MB								
Alkalinity, Total (as CaCO3)			<1.0		mg/L		1	13-JUN-17
BE-D-L-CCMS-VA	**Water**							
Batch R3743035								
WG2543338-14 LCS								
Beryllium (Be)-Dissolved			112.1		%		80-120	07-JUN-17
WG2543338-13 MB		**NP**						
Beryllium (Be)-Dissolved			<0.000020		mg/L		0.00002	07-JUN-17
BE-T-L-CCMS-VA	**Water**							
Batch R3747604								
WG2547832-2 LCS								
Beryllium (Be)-Total			102.5		%		80-120	13-JUN-17
WG2547832-1 MB								
Beryllium (Be)-Total			<0.000020		mg/L		0.00002	13-JUN-17
Batch R3748473								
WG2547832-3 DUP		**L1937465-4**						
Beryllium (Be)-Total		<0.000020	<0.000020	RPD-NA	mg/L	N/A	20	14-JUN-17
BOD5-VA	**Water**							
Batch R3745813								
WG2543443-2 LCS								
BOD			97.0		%		85-115	07-JUN-17
WG2543443-1 MB								
BOD			<2.0		mg/L		2	07-JUN-17
BR-L-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Bromide (Br)		<0.050	<0.050	RPD-NA	mg/L	N/A	20	06-JUN-17
WG2542750-13 LCS								
Bromide (Br)			101.0		%		85-115	06-JUN-17
WG2542750-17 LCS								
Bromide (Br)			99.6		%		85-115	06-JUN-17
WG2542750-2 LCS								
Bromide (Br)			98.6		%		85-115	06-JUN-17
WG2542750-22 LCS								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BR-L-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-22 LCS								
Bromide (Br)			98.1		%		85-115	06-JUN-17
WG2542750-5 LCS								
Bromide (Br)			99.7		%		85-115	06-JUN-17
WG2542750-9 LCS								
Bromide (Br)			99.3		%		85-115	06-JUN-17
WG2542750-1 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
WG2542750-12 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
WG2542750-16 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
WG2542750-20 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
WG2542750-4 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
WG2542750-8 MB								
Bromide (Br)			<0.050		mg/L		0.05	06-JUN-17
CL-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Chloride (Cl)		<0.50	<0.50	RPD-NA	mg/L	N/A	20	06-JUN-17
WG2542750-13 LCS								
Chloride (Cl)			98.9		%		90-110	06-JUN-17
WG2542750-17 LCS								
Chloride (Cl)			98.9		%		90-110	06-JUN-17
WG2542750-2 LCS								
Chloride (Cl)			98.8		%		90-110	06-JUN-17
WG2542750-22 LCS								
Chloride (Cl)			98.9		%		90-110	06-JUN-17
WG2542750-5 LCS								
Chloride (Cl)			99.0		%		90-110	06-JUN-17
WG2542750-9 LCS								
Chloride (Cl)			99.3		%		90-110	06-JUN-17
WG2542750-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
WG2542750-12 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
WG2542750-16 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-16 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
WG2542750-20 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
WG2542750-4 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
WG2542750-8 MB								
Chloride (Cl)			<0.50		mg/L		0.5	06-JUN-17
COD-COL-VA	**Water**							
Batch R3743892								
WG2544957-3 LCS								
COD			100.4		%		85-115	09-JUN-17
WG2544957-1 MB								
COD			<20		mg/L		20	09-JUN-17
EC-PCT-VA	**Water**							
Batch R3746334								
WG2545176-14 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			98.6		%		90-110	12-JUN-17
WG2545176-11 MB								
Conductivity			<2.0		uS/cm		2	12-JUN-17
F-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Fluoride (F)		0.030	0.030		mg/L	0.7	20	06-JUN-17
WG2542750-13 LCS								
Fluoride (F)			98.9		%		90-110	06-JUN-17
WG2542750-17 LCS								
Fluoride (F)			99.7		%		90-110	06-JUN-17
WG2542750-2 LCS								
Fluoride (F)			99.1		%		90-110	06-JUN-17
WG2542750-22 LCS								
Fluoride (F)			99.0		%		90-110	06-JUN-17
WG2542750-5 LCS								
Fluoride (F)			98.7		%		90-110	06-JUN-17
WG2542750-9 LCS								
Fluoride (F)			99.1		%		90-110	06-JUN-17
WG2542750-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-12 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17
WG2542750-16 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17
WG2542750-20 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17
WG2542750-4 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17
WG2542750-8 MB								
Fluoride (F)			<0.020		mg/L		0.02	06-JUN-17
HG-D-CVAA-VA	**Water**							
Batch R3742358								
WG2542888-73 MB		**NP**						
Mercury (Hg)-Dissolved			<0.0000050		mg/L		0.000005	07-JUN-17
WG2542888-76 MS		**L1937465-2**						
Mercury (Hg)-Dissolved			101.9		%		70-130	07-JUN-17
Batch R3743120								
WG2542888-74 LCS								
Mercury (Hg)-Dissolved			99.0		%		80-120	08-JUN-17
HG-T-CVAA-VA	**Water**							
Batch R3742358								
WG2543576-2 LCS								
Mercury (Hg)-Total			97.9		%		80-120	07-JUN-17
WG2543576-1 MB								
Mercury (Hg)-Total			<0.0000050		mg/L		0.000005	07-JUN-17
WG2543576-8 MS		**L1937465-2**						
Mercury (Hg)-Total			101.5		%		70-130	07-JUN-17
MET-D-CCMS-VA	**Water**							
Batch R3743035								
WG2543338-14 LCS								
Aluminum (Al)-Dissolved			97.5		%		80-120	07-JUN-17
Antimony (Sb)-Dissolved			109.5		%		80-120	07-JUN-17
Arsenic (As)-Dissolved			101.4		%		80-120	07-JUN-17
Barium (Ba)-Dissolved			96.7		%		80-120	07-JUN-17
Bismuth (Bi)-Dissolved			111.2		%		80-120	07-JUN-17
Boron (B)-Dissolved			102.9		%		80-120	07-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3743035								
WG2543338-14 LCS								
Cadmium (Cd)-Dissolved			96.8		%		80-120	07-JUN-17
Calcium (Ca)-Dissolved			110.4		%		80-120	07-JUN-17
Chromium (Cr)-Dissolved			97.9		%		80-120	07-JUN-17
Cobalt (Co)-Dissolved			96.7		%		80-120	07-JUN-17
Copper (Cu)-Dissolved			97.8		%		80-120	07-JUN-17
Iron (Fe)-Dissolved			92.9		%		80-120	07-JUN-17
Lead (Pb)-Dissolved			112.8		%		80-120	07-JUN-17
Lithium (Li)-Dissolved			114.7		%		80-120	07-JUN-17
Magnesium (Mg)-Dissolved			100.6		%		80-120	07-JUN-17
Manganese (Mn)-Dissolved			101.6		%		80-120	07-JUN-17
Molybdenum (Mo)-Dissolved			112.4		%		80-120	07-JUN-17
Nickel (Ni)-Dissolved			96.2		%		80-120	07-JUN-17
Phosphorus (P)-Dissolved			104.8		%		80-120	07-JUN-17
Potassium (K)-Dissolved			97.9		%		80-120	07-JUN-17
Selenium (Se)-Dissolved			94.7		%		80-120	07-JUN-17
Silicon (Si)-Dissolved			92.8		%		80-120	07-JUN-17
Silver (Ag)-Dissolved			113.6		%		80-120	07-JUN-17
Sodium (Na)-Dissolved			96.2		%		80-120	07-JUN-17
Strontium (Sr)-Dissolved			111.8		%		80-120	07-JUN-17
Sulfur (S)-Dissolved			91.2		%		80-120	07-JUN-17
Thallium (Tl)-Dissolved			111.9		%		80-120	07-JUN-17
Tin (Sn)-Dissolved			99.9		%		80-120	07-JUN-17
Titanium (Ti)-Dissolved			98.5		%		80-120	07-JUN-17
Uranium (U)-Dissolved			113.1		%		80-120	07-JUN-17
Vanadium (V)-Dissolved			98.3		%		80-120	07-JUN-17
Zinc (Zn)-Dissolved			94.3		%		80-120	07-JUN-17
Zirconium (Zr)-Dissolved			106.6		%		80-120	07-JUN-17
WG2543338-13 MB		**NP**						
Aluminum (Al)-Dissolved			<0.0010		mg/L		0.001	07-JUN-17
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Barium (Ba)-Dissolved			<0.000050		mg/L		0.00005	07-JUN-17
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	07-JUN-17
Boron (B)-Dissolved			<0.010		mg/L		0.01	07-JUN-17

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3743035								
WG2543338-13 MB		**NP**						
Cadmium (Cd)-Dissolved			<0.0000050		mg/L		0.000005	07-JUN-17
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	07-JUN-17
Chromium (Cr)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	07-JUN-17
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	07-JUN-17
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	07-JUN-17
Lithium (Li)-Dissolved			<0.0010		mg/L		0.001	07-JUN-17
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	07-JUN-17
Manganese (Mn)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	07-JUN-17
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	07-JUN-17
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	07-JUN-17
Potassium (K)-Dissolved			<0.050		mg/L		0.05	07-JUN-17
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	07-JUN-17
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	07-JUN-17
Silver (Ag)-Dissolved			<0.000010		mg/L		0.00001	07-JUN-17
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	07-JUN-17
Strontium (Sr)-Dissolved			<0.00020		mg/L		0.0002	07-JUN-17
Sulfur (S)-Dissolved			<0.50		mg/L		0.5	07-JUN-17
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	07-JUN-17
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	07-JUN-17
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	07-JUN-17
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	07-JUN-17
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	07-JUN-17
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	07-JUN-17
Zirconium (Zr)-Dissolved			<0.000060		mg/L		0.00006	07-JUN-17
MET-T-CCMS-VA	**Water**							
Batch R3747604								
WG2547832-2 LCS								
Aluminum (Al)-Total			105.2		%		80-120	13-JUN-17
Antimony (Sb)-Total			105.1		%		80-120	13-JUN-17
Arsenic (As)-Total			104.4		%		80-120	13-JUN-17
Barium (Ba)-Total			106.0		%		80-120	13-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3747604								
WG2547832-2 LCS								
Bismuth (Bi)-Total			97.3		%		80-120	13-JUN-17
Boron (B)-Total			95.6		%		80-120	13-JUN-17
Cadmium (Cd)-Total			102.5		%		80-120	13-JUN-17
Calcium (Ca)-Total			99.0		%		80-120	13-JUN-17
Chromium (Cr)-Total			100.4		%		80-120	13-JUN-17
Cobalt (Co)-Total			100.4		%		80-120	13-JUN-17
Copper (Cu)-Total			100.9		%		80-120	13-JUN-17
Iron (Fe)-Total			93.6		%		80-120	13-JUN-17
Lead (Pb)-Total			98.3		%		80-120	13-JUN-17
Lithium (Li)-Total			100.1		%		80-120	13-JUN-17
Magnesium (Mg)-Total			101.6		%		80-120	13-JUN-17
Manganese (Mn)-Total			101.9		%		80-120	13-JUN-17
Molybdenum (Mo)-Total			99.5		%		80-120	13-JUN-17
Nickel (Ni)-Total			102.9		%		80-120	13-JUN-17
Phosphorus (P)-Total			101.1		%		80-120	13-JUN-17
Potassium (K)-Total			103.3		%		80-120	13-JUN-17
Selenium (Se)-Total			98.3		%		80-120	13-JUN-17
Silicon (Si)-Total			114.5		%		80-120	13-JUN-17
Silver (Ag)-Total			99.2		%		80-120	13-JUN-17
Sodium (Na)-Total			96.9		%		80-120	13-JUN-17
Strontium (Sr)-Total			98.7		%		80-120	13-JUN-17
Sulfur (S)-Total			114.8		%		80-120	13-JUN-17
Thallium (Tl)-Total			98.7		%		80-120	13-JUN-17
Tin (Sn)-Total			99.7		%		80-120	13-JUN-17
Titanium (Ti)-Total			102.0		%		80-120	13-JUN-17
Uranium (U)-Total			93.9		%		80-120	13-JUN-17
Vanadium (V)-Total			101.9		%		80-120	13-JUN-17
Zinc (Zn)-Total			99.3		%		80-120	13-JUN-17
Zirconium (Zr)-Total			89.4		%		80-120	13-JUN-17
WG2547832-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	13-JUN-17
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	13-JUN-17
Arsenic (As)-Total			<0.00010		mg/L		0.0001	13-JUN-17
Barium (Ba)-Total			<0.000050		mg/L		0.00005	13-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3747604								
WG2547832-1 MB								
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	13-JUN-17
Boron (B)-Total			<0.010		mg/L		0.01	13-JUN-17
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	13-JUN-17
Calcium (Ca)-Total			<0.050		mg/L		0.05	13-JUN-17
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	13-JUN-17
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	13-JUN-17
Copper (Cu)-Total			<0.00050		mg/L		0.0005	13-JUN-17
Iron (Fe)-Total			<0.010		mg/L		0.01	13-JUN-17
Lead (Pb)-Total			<0.000050		mg/L		0.00005	13-JUN-17
Lithium (Li)-Total			<0.0010		mg/L		0.001	13-JUN-17
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	13-JUN-17
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	13-JUN-17
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	13-JUN-17
Phosphorus (P)-Total			<0.050		mg/L		0.05	13-JUN-17
Potassium (K)-Total			<0.050		mg/L		0.05	13-JUN-17
Selenium (Se)-Total			<0.000050		mg/L		0.00005	13-JUN-17
Silicon (Si)-Total			<0.10		mg/L		0.1	13-JUN-17
Silver (Ag)-Total			<0.000010		mg/L		0.00001	13-JUN-17
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	13-JUN-17
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	13-JUN-17
Tin (Sn)-Total			<0.00010		mg/L		0.0001	13-JUN-17
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	13-JUN-17
Uranium (U)-Total			<0.000010		mg/L		0.00001	13-JUN-17
Vanadium (V)-Total			<0.00050		mg/L		0.0005	13-JUN-17
Zinc (Zn)-Total			<0.0030		mg/L		0.003	13-JUN-17
Zirconium (Zr)-Total			<0.000060		mg/L		0.00006	13-JUN-17
Batch R3748473								
WG2547832-3 DUP		**L1937465-4**						
Aluminum (Al)-Total		0.0153	0.0161		mg/L	4.8	20	14-JUN-17
Antimony (Sb)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	14-JUN-17
Arsenic (As)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	14-JUN-17
Barium (Ba)-Total		0.00907	0.00889		mg/L	2.0	20	14-JUN-17
Bismuth (Bi)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	14-JUN-17
Boron (B)-Total		<0.010	<0.010	RPD-NA	mg/L	N/A	20	14-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3748473								
WG2547832-3 DUP		**L1937465-4**						
Cadmium (Cd)-Total		0.0000056	0.0000052		mg/L	7.8	20	14-JUN-17
Calcium (Ca)-Total		6.07	6.15		mg/L	1.3	20	14-JUN-17
Chromium (Cr)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	14-JUN-17
Cobalt (Co)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	14-JUN-17
Copper (Cu)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	14-JUN-17
Iron (Fe)-Total		0.067	0.064		mg/L	3.5	20	14-JUN-17
Lead (Pb)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	14-JUN-17
Lithium (Li)-Total		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	14-JUN-17
Magnesium (Mg)-Total		0.84	0.84		mg/L	0.6	20	14-JUN-17
Manganese (Mn)-Total		0.0111	0.0108		mg/L	2.7	20	14-JUN-17
Molybdenum (Mo)-Total		0.000497	0.000510		mg/L	2.5	20	14-JUN-17
Nickel (Ni)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	14-JUN-17
Phosphorus (P)-Total		<0.050	<0.050	RPD-NA	mg/L	N/A	20	14-JUN-17
Potassium (K)-Total		0.80	0.77		mg/L	4.0	20	14-JUN-17
Selenium (Se)-Total		<0.000050	<0.000050	RPD-NA	mg/L	N/A	20	14-JUN-17
Silicon (Si)-Total		6.27	6.17		mg/L	1.6	20	14-JUN-17
Silver (Ag)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	14-JUN-17
Sodium (Na)-Total		1.50	1.47		mg/L	2.0	20	14-JUN-17
Strontium (Sr)-Total		0.0321	0.0324		mg/L	1.0	20	14-JUN-17
Sulfur (S)-Total		1.27	1.13		mg/L	12	20	14-JUN-17
Thallium (Tl)-Total		<0.000010	<0.000010	RPD-NA	mg/L	N/A	20	14-JUN-17
Tin (Sn)-Total		<0.00010	<0.00010	RPD-NA	mg/L	N/A	20	14-JUN-17
Titanium (Ti)-Total		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	14-JUN-17
Uranium (U)-Total		0.000013	0.000014		mg/L	1.5	20	14-JUN-17
Vanadium (V)-Total		<0.00050	<0.00050	RPD-NA	mg/L	N/A	20	14-JUN-17
Zinc (Zn)-Total		<0.0030	<0.0030	RPD-NA	mg/L	N/A	20	14-JUN-17
Zirconium (Zr)-Total		<0.00030	<0.00030	RPD-NA	mg/L	N/A	20	14-JUN-17
Batch R3748722								
WG2547832-1 MB								
Manganese (Mn)-Total			0.00022	MB-LOR	mg/L		0.0001	14-JUN-17
Sodium (Na)-Total			<0.050		mg/L		0.05	14-JUN-17
Sulfur (S)-Total			<0.50		mg/L		0.5	14-JUN-17
NH3-F-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NH3-F-VA	**Water**							
Batch R3742729								
WG2543801-2 LCS								
Ammonia, Total (as N)			98.3		%		85-115	08-JUN-17
WG2543801-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	08-JUN-17
NO2-L-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Nitrite (as N)		<0.0010	<0.0010	RPD-NA	mg/L	N/A	20	06-JUN-17
WG2542750-13 LCS								
Nitrite (as N)			98.6		%		90-110	06-JUN-17
WG2542750-17 LCS								
Nitrite (as N)			97.5		%		90-110	06-JUN-17
WG2542750-2 LCS								
Nitrite (as N)			98.6		%		90-110	06-JUN-17
WG2542750-22 LCS								
Nitrite (as N)			99.0		%		90-110	06-JUN-17
WG2542750-5 LCS								
Nitrite (as N)			99.6		%		90-110	06-JUN-17
WG2542750-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	06-JUN-17
WG2542750-12 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	06-JUN-17
WG2542750-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	06-JUN-17
WG2542750-20 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	06-JUN-17
WG2542750-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	06-JUN-17
NO3-L-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Nitrate (as N)		0.0571	0.0578		mg/L	1.2	20	06-JUN-17
WG2542750-13 LCS								
Nitrate (as N)			99.4		%		90-110	06-JUN-17
WG2542750-17 LCS								
Nitrate (as N)			99.3		%		90-110	06-JUN-17
WG2542750-2 LCS								
Nitrate (as N)			99.2		%		90-110	06-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-22 LCS								
Nitrate (as N)			99.5		%		90-110	06-JUN-17
WG2542750-5 LCS								
Nitrate (as N)			99.4		%		90-110	06-JUN-17
WG2542750-9 LCS								
Nitrate (as N)			99.5		%		90-110	06-JUN-17
WG2542750-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
WG2542750-12 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
WG2542750-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
WG2542750-20 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
WG2542750-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
WG2542750-8 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	06-JUN-17
P-T-PRES-COL-VA	**Water**							
Batch R3747625								
WG2548066-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			101.4		%		80-120	14-JUN-17
WG2548066-6 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			96.6		%		80-120	14-JUN-17
WG2548066-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	14-JUN-17
WG2548066-5 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	14-JUN-17
P-TD-COL-VA	**Water**							
Batch R3742070								
WG2542940-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			102.5		%		80-120	07-JUN-17
WG2542940-1 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	07-JUN-17
PH-PCT-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH-PCT-VA	**Water**							
Batch R3746334								
WG2545176-12 CRM		**VA-PH7-BUF**						
pH			7.00		pH		6.9-7.1	12-JUN-17
PO4-DO-COL-VA	**Water**							
Batch R3741158								
WG2542885-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			94.4		%		80-120	07-JUN-17
WG2542885-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			97.4		%		80-120	07-JUN-17
WG2542885-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			101.6		%		80-120	07-JUN-17
WG2542885-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	07-JUN-17
WG2542885-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	07-JUN-17
WG2542885-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	07-JUN-17
SO4-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-19 DUP		**L1937465-4**						
Sulfate (SO4)		3.70	3.69		mg/L	0.1	20	06-JUN-17
WG2542750-13 LCS								
Sulfate (SO4)			99.97		%		90-110	06-JUN-17
WG2542750-17 LCS								
Sulfate (SO4)			99.97		%		90-110	06-JUN-17
WG2542750-2 LCS								
Sulfate (SO4)			99.8		%		90-110	06-JUN-17
WG2542750-22 LCS								
Sulfate (SO4)			99.99		%		90-110	06-JUN-17
WG2542750-5 LCS								
Sulfate (SO4)			99.99		%		90-110	06-JUN-17
WG2542750-9 LCS								
Sulfate (SO4)			100.1		%		90-110	06-JUN-17
WG2542750-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
WG2542750-12 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
WG2542750-16 MB								

Quality Control Report

Workorder: L1937465 Report Date: 16-JUN-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-VA	**Water**							
Batch R3741093								
WG2542750-16 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
WG2542750-20 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
WG2542750-4 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
WG2542750-8 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	06-JUN-17
TDS-VA	**Water**							
Batch R3745791								
WG2544681-3 DUP		**L1937465-1**						
Total Dissolved Solids		49	45		mg/L	7.9	20	08-JUN-17
WG2544681-2 LCS								
Total Dissolved Solids			95.9		%		85-115	08-JUN-17
WG2544681-1 MB								
Total Dissolved Solids			<10		mg/L		10	08-JUN-17
TSS-LOW-VA	**Water**							
Batch R3743549								
WG2544673-4 LCS								
Total Suspended Solids			95.8		%		85-115	08-JUN-17
WG2544673-3 MB								
Total Suspended Solids			<1.0		mg/L		1	08-JUN-17
TURBIDITY-VA	**Water**							
Batch R3741164								
WG2542886-2 CRM		**VA-FORM-40**						
Turbidity			104.5		%		85-115	07-JUN-17
WG2542886-1 MB								
Turbidity			<0.10		NTU		0.1	07-JUN-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	05-JUN-17 12:00	12-JUN-17 15:22	0.25	171	hours	EHTR-FM
	2	05-JUN-17 12:00	12-JUN-17 15:22	0.25	171	hours	EHTR-FM
	3	05-JUN-17 11:00	12-JUN-17 15:22	0.25	172	hours	EHTR-FM
	4	05-JUN-17 11:00	12-JUN-17 15:22	0.25	172	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1937465 were received on 06-JUN-17 13:15.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Short Holding Time

Rush Processing

Chain of Custody / Analytical Reques
Canada Toll Free : 1 800 668 987
www.alsglobal.com

L1937465-COFC

COC #: OL-2485

Page 1 of 2

Report To

Company: ECOFISH RESEARCH LTD
Contact: Kevin Ganshorn
Address: Suite 906 - 595 Howe Street
Vancouver, BC
CANADA, V6C 2T5
Phone: 604-608-6180
Fax:

Invoice To ☑ Email ☐ Mail
Company: ECOFISH RESEARCH LTD
Contact: Accounts Payable
Address: Suite F, 450 - 8th Street
Courtenay, BC
Canada, V9N 1N5
Email: accountspayable@ecofishresearch.com
Phone: 250-334-3042

Lab Work Order # (lab use only)

Reporting

Distribution: ☐ Fax ☐ Mail ☑ Email
☐ Ciriteria on Report (select from Guidelines below)
Report Type: ☑ Excel ☑ Digital
Report Format: CROSSTAB_ALSQC
Report Email(s): kganshorn@ecofishresearch.com
tkasubuchi@ecofishresearch.com
vwoodruff@ecofishresearch.com
EDD Format: ECF100
EDD Email(s): kganshorn@ecofishresearch.com
bbennett@ecofishresearch.com
tkasubuchi@ecofishresearch.com

Project Info

Job #:
PO/AFE: 1095-49.40
LSD: BRITISH COLUMBIA
Quote #:
ALS Contact: Shane Stack
Sampler: SARAH KENNEDY

Service Requested

- ● Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests

Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Coordinates Longitude	Coordinates Latitude	Date	Time	Sample Type	Number of Containers	Ammonia in Water by Fluorescence	Anions by Ion Chromatography	Biochemical Oxygen Demand- 5 day	Chemical Oxygen Demand by Colorimetric	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Dissolved Metals in Water + Hg (BC MDG)	Total Alkalinity by Titration	Total Dissolved P in Water by Colour	Total Dissolved Solids by Gravimetric	Total Metals in Water + Hg (BC MDG)	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	(See page 2 for further requests)
	ALE-BDGWQ A			JUN 5, 17	12:00 pm	WATER	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-BDGWQ B			"	12:00 pm	WATER	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-USWQ1A			"	11:00 am	WATER	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-USWQ1B			"	11:00 AM	WATER	7	R	R	R	R	R	R	R	R	R	R	R	R	R	

Special Instructions/Comments

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐ Yes ☒ No
If yes, please use an authorized drinking water COC
Is the water sampled intended to be potable for human consumption? ☐ Yes ☒ No

Guidelines

SAMPLE CONDITION (lab use only)

☐ Frozen ☐ Cold ☐ Ambient ☐ Cooling Initiated

SHIPMENT RELEASE (client use)		
Released by: V. Woodruff	Date: 6 JUN	Time: 6.00 AM

SHIPMENT RECEPTION (lab use only)			
Received by: lady	Date: June 6	Time: 1:45PM	Temperature: 9 °C

SHIPMENT VERIFICATION (lab use only)			
Verified by:	Date:	Time:	Observations: ☐ Yes If Yes add SIF

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2485

Page 2 of 2

Sample #	Sample Identification (This will appear on the report)	Coordinates		Date	Time	Sample Type	Analysis Requests														
		Longitude	Latitude				Number of Containers	Turbidity by Meter	pH by Meter (Automated)												
								Please indicate below Filtered, Preserved or both(F, P, F/P)													
	ALE-BDGWQ A					WATER	7	R	R												
	ALE-BDGWQ B					WATER	7	R	R												
	ALE-USWQ1A					WATER	7	R	R												
	ALE-USWQ1B					WATER	7	R	R												

lady June 6 1:15PM 9°c

L1937465-COFC

ECOFISH RESEARCH LTD
ATTN: Kevin Ganshorn
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5

Date Received: 14-SEP-17
Report Date: 26-SEP-17 17:35 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L1991689

Project P.O. #:	1095-49.40
Job Reference:	
C of C Numbers:	OL-2678
Legal Site Desc:	British Columbia

Shane Stack
Account Manager

	Sample ID	L1991689-1	L1991689-4	L1991689-5	L1991689-8	
	Description	Water	Water	Water	Water	
	Sampled Date	13-SEP-17	13-SEP-17	13-SEP-17	13-SEP-17	
	Sampled Time	13:07	11:56	13:07	11:56	
	Client ID	ALE-BDGWQ-A	ALE-USWQ1-A	ALE-BDGWQ-B	ALE-USWQ1-B	
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	65.0	60.7	63.8	61.2	
	Hardness (as CaCO3) (mg/L)	24.7	25.5	25.1	25.3	
	Total Suspended Solids (mg/L)	2.8	<1.0	2.1	<1.0	
	Total Dissolved Solids (mg/L)	63	55	62	53	
	Turbidity (NTU)	4.61	0.50	4.69	0.34	
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	26.6	23.7	26.8	23.5	
	Ammonia, Total (as N) (mg/L)	0.0416	<0.0050	0.0405	<0.0050	
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Chloride (Cl) (mg/L)	0.58	<0.50	0.58	<0.50	
	Fluoride (F) (mg/L)	0.031	0.022	0.028	0.022	
	Nitrate (as N) (mg/L)	0.0267	0.0273	0.0264	0.0270	
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Orthophosphate-Dissolved (as P) (mg/L)	0.0024	<0.0010	0.0025	<0.0010	
	Phosphorus (P)-Total Dissolved (mg/L)	0.0043	<0.0020	0.0038	<0.0020	
	Phosphorus (P)-Total (mg/L)	0.0079	0.0027	0.0065	0.0030	
	Sulfate (SO4) (mg/L)	6.04	6.75	6.03	6.78	
Total Metals	Aluminum (Al)-Total (mg/L)	0.0230	0.0154	0.0262	0.0245	
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Arsenic (As)-Total (mg/L)	0.00019	<0.00010	0.00020	<0.00010	
	Barium (Ba)-Total (mg/L)	0.0178	0.0138	0.0179	0.0140	
	Beryllium (Be)-Total (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Boron (B)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Cadmium (Cd)-Total (mg/L)	<0.0000050	0.0000078	<0.0000050	<0.0000050	
	Calcium (Ca)-Total (mg/L)	7.99	7.58	7.93	7.72	
	Chromium (Cr)-Total (mg/L)	0.00011	<0.00010	0.00014	<0.00010	
	Cobalt (Co)-Total (mg/L)	0.00020	0.00013	0.00020	0.00017	
	Copper (Cu)-Total (mg/L)	0.00051	<0.00050	0.00057	<0.00050	
	Iron (Fe)-Total (mg/L)	1.34	0.174	1.34	0.202	
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Magnesium (Mg)-Total (mg/L)	1.29	1.09	1.31	1.12	
	Manganese (Mn)-Total (mg/L)	0.124	0.0248	0.125	0.0262	
	Mercury (Hg)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
	Molybdenum (Mo)-Total (mg/L)	0.000471	0.000435	0.000491	0.000467	
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Phosphorus (P)-Total (mg/L)	<0.050	<0.050	<0.050	<0.050	

	Sample ID	L1991689-1	L1991689-4	L1991689-5	L1991689-8
	Description	Water	Water	Water	Water
	Sampled Date	13-SEP-17	13-SEP-17	13-SEP-17	13-SEP-17
	Sampled Time	13:07	11:56	13:07	11:56
	Client ID	ALE-BDGWQ-A	ALE-USWQ1-A	ALE-BDGWQ-B	ALE-USWQ1-B
Grouping	**Analyte**				
WATER					
Total Metals	Potassium (K)-Total (mg/L)	1.10	0.93	1.13	0.95
	Selenium (Se)-Total (mg/L)	<0.000050	0.000055	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	7.20	6.91	7.28	6.94
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	1.99	1.95	2.04	1.98
	Strontium (Sr)-Total (mg/L)	0.0455	0.0433	0.0453	0.0441
	Sulfur (S)-Total (mg/L)	1.96	2.13	1.94	2.13
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	<0.0012 DLM	0.00033	0.00120	<0.00060 DLM
	Uranium (U)-Total (mg/L)	0.000012	<0.000010	0.000011	0.000011
	Vanadium (V)-Total (mg/L)	0.00099	<0.00050	0.00104	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030
	Zirconium (Zr)-Total (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0135	0.0060	0.0211	0.0069
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00013	<0.00010	0.00017	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0155	0.0146	0.0176	0.0139
	Beryllium (Be)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	0.0000095	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	8.04	8.29	7.94	8.25
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00017	0.00015	0.00018	0.00013
	Copper (Cu)-Dissolved (mg/L)	0.00029	0.00024	0.00046	0.00026
	Iron (Fe)-Dissolved (mg/L)	0.733	0.042	1.28	0.040
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	1.12	1.17	1.27	1.13
	Manganese (Mn)-Dissolved (mg/L)	0.105	0.0259	0.121	0.0249
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.000401	0.000350	0.000427	0.000376
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1991689-1	L1991689-4	L1991689-5	L1991689-8	
	Description	Water	Water	Water	Water	
	Sampled Date	13-SEP-17	13-SEP-17	13-SEP-17	13-SEP-17	
	Sampled Time	13:07	11:56	13:07	11:56	
	Client ID	ALE-BDGWQ-A	ALE-USWQ1-A	ALE-BDGWQ-B	ALE-USWQ1-B	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Potassium (K)-Dissolved (mg/L)	1.04	1.12	1.18	1.10	
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	
	Silicon (Si)-Dissolved (mg/L)	6.78	6.93	7.02	6.78	
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Dissolved (mg/L)	1.75	2.08	2.00	2.05	
	Strontium (Sr)-Dissolved (mg/L)	0.0442	0.0461	0.0447	0.0457	
	Sulfur (S)-Dissolved (mg/L)	1.69	2.07	1.79	1.92	
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Dissolved (mg/L)	0.00033	<0.00030	DLM <0.00090	<0.00030	
	Uranium (U)-Dissolved (mg/L)	0.000011	<0.000010	0.000014	<0.000010	
	Vanadium (V)-Dissolved (mg/L)	0.00060	<0.00050	0.00102	<0.00050	
	Zinc (Zn)-Dissolved (mg/L)	0.0016	0.0010	<0.0010	0.0013	
	Zirconium (Zr)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
Aggregate Organics	BOD (mg/L)	<2.0	<2.0	<2.0	<2.0	
	COD (mg/L)	<20	<20	<20	<20	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client Sample ID	Qualifier	Description
L1991689-1	ALE-BDGWQ-A	WSMT	Water sample(s) for total mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
		WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
L1991689-4	ALE-USWQ1-A	WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
L1991689-5	ALE-BDGWQ-B	WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.
L1991689-8	ALE-USWQ1-B	WSMD	Water sample(s) for dissolved mercury analysis was not submitted in glass or PTFE container with HCl preservative. Results may be biased low.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sulfate (SO4)	MS-B	L1991689-1, -4, -5, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BE-D-L-CCMS-VA	Water	Diss. Be (low) in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

BE-T-L-CCMS-VA	Water	Total Be (Low) in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

BOD5-VA	Water	Biochemical Oxygen Demand- 5 day	APHA 5210 B- BIOCHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5210 B - "Biochemical Oxygen Demand (BOD)". All forms of biochemical oxygen demand (BOD) are determined by diluting and incubating a sample for a specified time period, and measuring the oxygen depletion using a dissolved oxygen meter. Dissolved BOD (SOLUBLE) is determined by filtering the sample through a glass fibre filter prior to dilution. Carbonaceous BOD (CBOD) is determined by adding a nitrification inhibitor to the diluted sample prior to incubation.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA	Water	Diss. Mercury in Water by CVAAS or CVAFS	APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA Water Total Mercury in Water by CVAAS or CVAFS EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

P-TD-COL-VA Water Total Dissolved P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TSS-LOW-VA Water Total Suspended Solids by Grav. (1 mg/L) APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

Reference Information

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2678

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1991689 Report Date: 26-SEP-17

Client: ECOFISH RESEARCH LTD
Suite F, 450 - 8th Street
Courtenay BC V9N 1N5
Contact: Kevin Ganshorn

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-TITR-VA	**Water**							
Batch R3836891								
WG2623547-3 CRM		**VA-ALK-TITR-CONTROL**						
Alkalinity, Total (as CaCO3)			98.3		%		85-115	24-SEP-17
WG2623547-1 MB								
Alkalinity, Total (as CaCO3)			<1.0		mg/L		1	24-SEP-17
BE-D-L-CCMS-VA	**Water**							
Batch R3837736								
WG2622544-6 LCS								
Beryllium (Be)-Dissolved			99.7		%		80-120	22-SEP-17
WG2622544-5 MB		**NP**						
Beryllium (Be)-Dissolved			<0.000020		mg/L		0.00002	22-SEP-17
BE-T-L-CCMS-VA	**Water**							
Batch R3836275								
WG2622218-2 LCS								
Beryllium (Be)-Total			89.0		%		80-120	22-SEP-17
WG2622218-1 MB								
Beryllium (Be)-Total			<0.000020		mg/L		0.00002	22-SEP-17
BOD5-VA	**Water**							
Batch R3833259								
WG2617117-2 LCS								
BOD			93.7		%		85-115	15-SEP-17
WG2617117-6 LCS								
BOD			91.7		%		85-115	15-SEP-17
WG2617117-1 MB								
BOD			<2.0		mg/L		2	15-SEP-17
WG2617117-5 MB								
BOD			<2.0		mg/L		2	15-SEP-17
BR-L-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Bromide (Br)			102.4		%		85-115	16-SEP-17
WG2617644-17 LCS								
Bromide (Br)			103.2		%		85-115	16-SEP-17
WG2617644-2 LCS								
Bromide (Br)			98.7		%		85-115	16-SEP-17
WG2617644-21 LCS								
Bromide (Br)			99.8		%		85-115	16-SEP-17
WG2617644-26 LCS								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
BR-L-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-26 LCS								
Bromide (Br)			99.4		%		85-115	16-SEP-17
WG2617644-5 LCS								
Bromide (Br)			100.5		%		85-115	16-SEP-17
WG2617644-9 LCS								
Bromide (Br)			101.6		%		85-115	16-SEP-17
WG2617644-1 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-12 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-16 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-20 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-24 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-4 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
WG2617644-8 MB								
Bromide (Br)			<0.050		mg/L		0.05	16-SEP-17
CL-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Chloride (Cl)			101.3		%		90-110	16-SEP-17
WG2617644-17 LCS								
Chloride (Cl)			101.5		%		90-110	16-SEP-17
WG2617644-2 LCS								
Chloride (Cl)			101.2		%		90-110	16-SEP-17
WG2617644-21 LCS								
Chloride (Cl)			101.3		%		90-110	16-SEP-17
WG2617644-26 LCS								
Chloride (Cl)			101.2		%		90-110	16-SEP-17
WG2617644-5 LCS								
Chloride (Cl)			101.2		%		90-110	16-SEP-17
WG2617644-9 LCS								
Chloride (Cl)			101.4		%		90-110	16-SEP-17
WG2617644-1 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-12 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-12 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-16 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-20 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-24 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-4 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
WG2617644-8 MB								
Chloride (Cl)			<0.50		mg/L		0.5	16-SEP-17
COD-COL-VA	**Water**							
Batch R3836794								
WG2623473-2 DUP		**L1991689-1**						
COD		<20	<20	RPD-NA	mg/L	N/A	20	23-SEP-17
WG2623473-10 LCS								
COD			102.5		%		85-115	23-SEP-17
WG2623473-3 LCS								
COD			102.3		%		85-115	23-SEP-17
WG2623473-6 LCS								
COD			102.9		%		85-115	23-SEP-17
WG2623473-1 MB								
COD			<20		mg/L		20	23-SEP-17
WG2623473-5 MB								
COD			<20		mg/L		20	23-SEP-17
WG2623473-9 MB								
COD			<20		mg/L		20	23-SEP-17
EC-PCT-VA	**Water**							
Batch R3831986								
WG2618511-9 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			100.5		%		90-110	19-SEP-17
WG2618511-6 MB								
Conductivity			<2.0		uS/cm		2	19-SEP-17
F-IC-N-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
F-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Fluoride (F)			100.3		%		90-110	16-SEP-17
WG2617644-17 LCS								
Fluoride (F)			100.6		%		90-110	16-SEP-17
WG2617644-2 LCS								
Fluoride (F)			100.4		%		90-110	16-SEP-17
WG2617644-21 LCS								
Fluoride (F)			100.2		%		90-110	16-SEP-17
WG2617644-26 LCS								
Fluoride (F)			100.1		%		90-110	16-SEP-17
WG2617644-5 LCS								
Fluoride (F)			100.2		%		90-110	16-SEP-17
WG2617644-9 LCS								
Fluoride (F)			100.4		%		90-110	16-SEP-17
WG2617644-1 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-12 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-16 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-20 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-24 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-4 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
WG2617644-8 MB								
Fluoride (F)			<0.020		mg/L		0.02	16-SEP-17
HG-D-CVAA-VA	**Water**							
Batch R3830890								
WG2617840-10 LCS								
Mercury (Hg)-Dissolved			100.7		%		80-120	17-SEP-17
Batch R3832943								
WG2617840-9 MB		**NP**						
Mercury (Hg)-Dissolved			<0.0000050		mg/L		0.000005	19-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-D-CVAA-VA	**Water**							
Batch R3838189								
WG2625563-2 LCS								
Mercury (Hg)-Dissolved			93.7		%		80-120	26-SEP-17
WG2625563-1 MB		**NP**						
Mercury (Hg)-Dissolved			<0.000005C		mg/L		0.000005	26-SEP-17
HG-T-CVAA-VA	**Water**							
Batch R3831214								
WG2618774-2 LCS								
Mercury (Hg)-Total			97.8		%		80-120	18-SEP-17
WG2618774-1 MB								
Mercury (Hg)-Total			<0.000005C		mg/L		0.000005	18-SEP-17
Batch R3835215								
WG2621648-8 DUP		**L1991689-4**						
Mercury (Hg)-Total		<0.0000050	<0.000005C	RPD-NA	mg/L	N/A	20	21-SEP-17
WG2621648-2 LCS								
Mercury (Hg)-Total			99.9		%		80-120	21-SEP-17
WG2621648-1 MB								
Mercury (Hg)-Total			<0.000005C		mg/L		0.000005	21-SEP-17
Batch R3838189								
WG2625278-4 DUP		**L1991689-1**						
Mercury (Hg)-Total		<0.0000050	<0.000005C	RPD-NA	mg/L	N/A	20	26-SEP-17
WG2625278-2 LCS								
Mercury (Hg)-Total			96.6		%		80-120	26-SEP-17
WG2625278-1 MB								
Mercury (Hg)-Total			<0.000005C		mg/L		0.000005	26-SEP-17
MET-D-CCMS-VA	**Water**							
Batch R3837736								
WG2622544-6 LCS								
Aluminum (Al)-Dissolved			100.8		%		80-120	22-SEP-17
Antimony (Sb)-Dissolved			98.0		%		80-120	22-SEP-17
Arsenic (As)-Dissolved			99.1		%		80-120	22-SEP-17
Barium (Ba)-Dissolved			97.8		%		80-120	22-SEP-17
Bismuth (Bi)-Dissolved			99.4		%		80-120	22-SEP-17
Boron (B)-Dissolved			96.6		%		80-120	22-SEP-17
Cadmium (Cd)-Dissolved			97.9		%		80-120	22-SEP-17
Calcium (Ca)-Dissolved			94.8		%		80-120	22-SEP-17
Chromium (Cr)-Dissolved			96.7		%		80-120	22-SEP-17
Cobalt (Co)-Dissolved			97.5		%		80-120	22-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3837736								
WG2622544-6 LCS								
Copper (Cu)-Dissolved			96.4		%		80-120	22-SEP-17
Iron (Fe)-Dissolved			95.6		%		80-120	22-SEP-17
Lead (Pb)-Dissolved			99.0		%		80-120	22-SEP-17
Lithium (Li)-Dissolved			96.8		%		80-120	22-SEP-17
Magnesium (Mg)-Dissolved			102.3		%		80-120	22-SEP-17
Manganese (Mn)-Dissolved			100.5		%		80-120	22-SEP-17
Molybdenum (Mo)-Dissolved			97.7		%		80-120	22-SEP-17
Nickel (Ni)-Dissolved			97.6		%		80-120	22-SEP-17
Phosphorus (P)-Dissolved			102.8		%		80-120	22-SEP-17
Potassium (K)-Dissolved			95.4		%		80-120	22-SEP-17
Selenium (Se)-Dissolved			93.4		%		80-120	22-SEP-17
Silicon (Si)-Dissolved			101.1		%		80-120	22-SEP-17
Silver (Ag)-Dissolved			96.9		%		80-120	22-SEP-17
Sodium (Na)-Dissolved			100.7		%		80-120	22-SEP-17
Strontium (Sr)-Dissolved			97.3		%		80-120	22-SEP-17
Sulfur (S)-Dissolved			98.7		%		80-120	22-SEP-17
Thallium (Tl)-Dissolved			99.5		%		80-120	22-SEP-17
Tin (Sn)-Dissolved			98.6		%		80-120	22-SEP-17
Titanium (Ti)-Dissolved			89.2		%		80-120	22-SEP-17
Uranium (U)-Dissolved			99.9		%		80-120	22-SEP-17
Vanadium (V)-Dissolved			99.1		%		80-120	22-SEP-17
Zinc (Zn)-Dissolved			91.0		%		80-120	22-SEP-17
Zirconium (Zr)-Dissolved			98.1		%		80-120	22-SEP-17
WG2622544-5 MB		**NP**						
Aluminum (Al)-Dissolved			<0.0010		mg/L		0.001	22-SEP-17
Antimony (Sb)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17
Arsenic (As)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17
Barium (Ba)-Dissolved			<0.000050		mg/L		0.00005	22-SEP-17
Bismuth (Bi)-Dissolved			<0.000050		mg/L		0.00005	22-SEP-17
Boron (B)-Dissolved			<0.010		mg/L		0.01	22-SEP-17
Cadmium (Cd)-Dissolved			<0.0000050		mg/L		0.000005	22-SEP-17
Calcium (Ca)-Dissolved			<0.050		mg/L		0.05	22-SEP-17
Chromium (Cr)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17
Cobalt (Co)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-D-CCMS-VA	**Water**							
Batch R3837736								
WG2622544-5 MB		**NP**						
Copper (Cu)-Dissolved			<0.00020		mg/L		0.0002	22-SEP-17
Iron (Fe)-Dissolved			<0.010		mg/L		0.01	22-SEP-17
Lead (Pb)-Dissolved			<0.000050		mg/L		0.00005	22-SEP-17
Lithium (Li)-Dissolved			<0.0010		mg/L		0.001	22-SEP-17
Magnesium (Mg)-Dissolved			<0.0050		mg/L		0.005	22-SEP-17
Manganese (Mn)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17
Molybdenum (Mo)-Dissolved			<0.000050		mg/L		0.00005	22-SEP-17
Nickel (Ni)-Dissolved			<0.00050		mg/L		0.0005	22-SEP-17
Phosphorus (P)-Dissolved			<0.050		mg/L		0.05	22-SEP-17
Potassium (K)-Dissolved			<0.050		mg/L		0.05	22-SEP-17
Selenium (Se)-Dissolved			<0.000050		mg/L		0.00005	22-SEP-17
Silicon (Si)-Dissolved			<0.050		mg/L		0.05	22-SEP-17
Silver (Ag)-Dissolved			<0.000010		mg/L		0.00001	22-SEP-17
Sodium (Na)-Dissolved			<0.050		mg/L		0.05	22-SEP-17
Strontium (Sr)-Dissolved			<0.00020		mg/L		0.0002	22-SEP-17
Sulfur (S)-Dissolved			<0.50		mg/L		0.5	22-SEP-17
Thallium (Tl)-Dissolved			<0.000010		mg/L		0.00001	22-SEP-17
Tin (Sn)-Dissolved			<0.00010		mg/L		0.0001	22-SEP-17
Titanium (Ti)-Dissolved			<0.00030		mg/L		0.0003	22-SEP-17
Uranium (U)-Dissolved			<0.000010		mg/L		0.00001	22-SEP-17
Vanadium (V)-Dissolved			<0.00050		mg/L		0.0005	22-SEP-17
Zinc (Zn)-Dissolved			<0.0010		mg/L		0.001	22-SEP-17
Zirconium (Zr)-Dissolved			<0.000060		mg/L		0.00006	22-SEP-17
MET-T-CCMS-VA	**Water**							
Batch R3836275								
WG2622218-2 LCS								
Aluminum (Al)-Total			90.1		%		80-120	22-SEP-17
Antimony (Sb)-Total			88.8		%		80-120	22-SEP-17
Arsenic (As)-Total			91.1		%		80-120	22-SEP-17
Barium (Ba)-Total			88.8		%		80-120	22-SEP-17
Bismuth (Bi)-Total			89.5		%		80-120	22-SEP-17
Boron (B)-Total			88.0		%		80-120	22-SEP-17
Cadmium (Cd)-Total			90.6		%		80-120	22-SEP-17
Calcium (Ca)-Total			88.5		%		80-120	22-SEP-17

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3836275								
WG2622218-2 LCS								
Chromium (Cr)-Total			86.3		%		80-120	22-SEP-17
Cobalt (Co)-Total			89.2		%		80-120	22-SEP-17
Copper (Cu)-Total			88.3		%		80-120	22-SEP-17
Iron (Fe)-Total			86.2		%		80-120	22-SEP-17
Lead (Pb)-Total			90.3		%		80-120	22-SEP-17
Lithium (Li)-Total			91.2		%		80-120	22-SEP-17
Magnesium (Mg)-Total			90.8		%		80-120	22-SEP-17
Manganese (Mn)-Total			85.8		%		80-120	22-SEP-17
Molybdenum (Mo)-Total			87.4		%		80-120	22-SEP-17
Nickel (Ni)-Total			88.1		%		80-120	22-SEP-17
Phosphorus (P)-Total			86.2		%		80-120	22-SEP-17
Potassium (K)-Total			88.6		%		80-120	22-SEP-17
Selenium (Se)-Total			84.4		%		80-120	22-SEP-17
Silicon (Si)-Total			89.4		%		80-120	22-SEP-17
Silver (Ag)-Total			85.5		%		80-120	22-SEP-17
Sodium (Na)-Total			90.1		%		80-120	22-SEP-17
Strontium (Sr)-Total			87.0		%		80-120	22-SEP-17
Sulfur (S)-Total			86.7		%		80-120	22-SEP-17
Thallium (Tl)-Total			88.2		%		80-120	22-SEP-17
Tin (Sn)-Total			90.9		%		80-120	22-SEP-17
Titanium (Ti)-Total			82.7		%		80-120	22-SEP-17
Uranium (U)-Total			89.9		%		80-120	22-SEP-17
Vanadium (V)-Total			88.8		%		80-120	22-SEP-17
Zinc (Zn)-Total			81.7		%		80-120	22-SEP-17
Zirconium (Zr)-Total			89.7		%		80-120	22-SEP-17
WG2622218-1 MB								
Aluminum (Al)-Total			<0.0030		mg/L		0.003	22-SEP-17
Antimony (Sb)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Arsenic (As)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Barium (Ba)-Total			<0.000050		mg/L		0.00005	22-SEP-17
Bismuth (Bi)-Total			<0.000050		mg/L		0.00005	22-SEP-17
Boron (B)-Total			<0.010		mg/L		0.01	22-SEP-17
Cadmium (Cd)-Total			<0.0000050		mg/L		0.000005	22-SEP-17
Calcium (Ca)-Total			<0.050		mg/L		0.05	22-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-T-CCMS-VA	**Water**							
Batch R3836275								
WG2622218-1 MB								
Chromium (Cr)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Cobalt (Co)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Copper (Cu)-Total			<0.00050		mg/L		0.0005	22-SEP-17
Iron (Fe)-Total			<0.010		mg/L		0.01	22-SEP-17
Lead (Pb)-Total			<0.000050		mg/L		0.00005	22-SEP-17
Lithium (Li)-Total			<0.0010		mg/L		0.001	22-SEP-17
Magnesium (Mg)-Total			<0.0050		mg/L		0.005	22-SEP-17
Manganese (Mn)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Molybdenum (Mo)-Total			<0.000050		mg/L		0.00005	22-SEP-17
Nickel (Ni)-Total			<0.00050		mg/L		0.0005	22-SEP-17
Phosphorus (P)-Total			<0.050		mg/L		0.05	22-SEP-17
Potassium (K)-Total			<0.050		mg/L		0.05	22-SEP-17
Selenium (Se)-Total			<0.000050		mg/L		0.00005	22-SEP-17
Silicon (Si)-Total			<0.10		mg/L		0.1	22-SEP-17
Silver (Ag)-Total			<0.000010		mg/L		0.00001	22-SEP-17
Sodium (Na)-Total			<0.050		mg/L		0.05	22-SEP-17
Strontium (Sr)-Total			<0.00020		mg/L		0.0002	22-SEP-17
Sulfur (S)-Total			<0.50		mg/L		0.5	22-SEP-17
Thallium (Tl)-Total			<0.000010		mg/L		0.00001	22-SEP-17
Tin (Sn)-Total			<0.00010		mg/L		0.0001	22-SEP-17
Titanium (Ti)-Total			<0.00030		mg/L		0.0003	22-SEP-17
Uranium (U)-Total			<0.000010		mg/L		0.00001	22-SEP-17
Vanadium (V)-Total			<0.00050		mg/L		0.0005	22-SEP-17
Zinc (Zn)-Total			<0.0030		mg/L		0.003	22-SEP-17
Zirconium (Zr)-Total			<0.000060		mg/L		0.00006	22-SEP-17
NH3-F-VA	**Water**							
Batch R3834193								
WG2620973-2 LCS								
Ammonia, Total (as N)			100.3		%		85-115	20-SEP-17
WG2620973-1 MB								
Ammonia, Total (as N)			<0.0050		mg/L		0.005	20-SEP-17
NO2-L-IC-N-VA	**Water**							

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-L-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Nitrite (as N)			101.1		%		90-110	16-SEP-17
WG2617644-17 LCS								
Nitrite (as N)			101.3		%		90-110	16-SEP-17
WG2617644-2 LCS								
Nitrite (as N)			101.0		%		90-110	16-SEP-17
WG2617644-21 LCS								
Nitrite (as N)			101.0		%		90-110	16-SEP-17
WG2617644-26 LCS								
Nitrite (as N)			100.4		%		90-110	16-SEP-17
WG2617644-5 LCS								
Nitrite (as N)			101.1		%		90-110	16-SEP-17
WG2617644-9 LCS								
Nitrite (as N)			101.0		%		90-110	16-SEP-17
WG2617644-1 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-12 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-16 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-20 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-24 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-4 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
WG2617644-8 MB								
Nitrite (as N)			<0.0010		mg/L		0.001	16-SEP-17
NO3-L-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Nitrate (as N)			101.9		%		90-110	16-SEP-17
WG2617644-17 LCS								
Nitrate (as N)			101.9		%		90-110	16-SEP-17
WG2617644-2 LCS								
Nitrate (as N)			101.5		%		90-110	16-SEP-17
WG2617644-21 LCS								
Nitrate (as N)			101.8		%		90-110	16-SEP-17
WG2617644-26 LCS								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO3-L-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-26 LCS								
Nitrate (as N)			101.7		%		90-110	16-SEP-17
WG2617644-5 LCS								
Nitrate (as N)			101.5		%		90-110	16-SEP-17
WG2617644-9 LCS								
Nitrate (as N)			101.8		%		90-110	16-SEP-17
WG2617644-1 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-12 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-16 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-20 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-24 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-4 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
WG2617644-8 MB								
Nitrate (as N)			<0.0050		mg/L		0.005	16-SEP-17
P-T-PRES-COL-VA	**Water**							
Batch R3834868								
WG2620845-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total			100.1		%		80-120	21-SEP-17
WG2620845-1 MB								
Phosphorus (P)-Total			<0.0020		mg/L		0.002	21-SEP-17
P-TD-COL-VA	**Water**							
Batch R3835139								
WG2621263-2 CRM		**VA-ERA-PO4**						
Phosphorus (P)-Total Dissolved			107.3		%		80-120	21-SEP-17
WG2621263-1 MB								
Phosphorus (P)-Total Dissolved			<0.0020		mg/L		0.002	21-SEP-17
PO4-DO-COL-VA	**Water**							
Batch R3829944								
WG2617525-10 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			92.7		%		80-120	16-SEP-17
WG2617525-14 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			93.4		%		80-120	16-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PO4-DO-COL-VA	**Water**							
Batch R3829944								
WG2617525-18 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			90.2		%		80-120	16-SEP-17
WG2617525-2 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			97.0		%		80-120	16-SEP-17
WG2617525-6 CRM		**VA-OPO4-CONTROL**						
Orthophosphate-Dissolved (as P)			97.6		%		80-120	16-SEP-17
WG2617525-11 DUP		**L1991689-1**						
Orthophosphate-Dissolved (as P)		0.0024	0.0022		mg/L	9.1	20	16-SEP-17
WG2617525-1 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-SEP-17
WG2617525-13 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-SEP-17
WG2617525-17 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-SEP-17
WG2617525-5 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-SEP-17
WG2617525-9 MB								
Orthophosphate-Dissolved (as P)			<0.0010		mg/L		0.001	16-SEP-17
WG2617525-12 MS		**L1991689-4**						
Orthophosphate-Dissolved (as P)			100.6		%		70-130	16-SEP-17
SO4-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-13 LCS								
Sulfate (SO4)			102.1		%		90-110	16-SEP-17
WG2617644-17 LCS								
Sulfate (SO4)			102.3		%		90-110	16-SEP-17
WG2617644-2 LCS								
Sulfate (SO4)			102.2		%		90-110	16-SEP-17
WG2617644-21 LCS								
Sulfate (SO4)			102.2		%		90-110	16-SEP-17
WG2617644-26 LCS								
Sulfate (SO4)			102.1		%		90-110	16-SEP-17
WG2617644-5 LCS								
Sulfate (SO4)			102.0		%		90-110	16-SEP-17
WG2617644-9 LCS								
Sulfate (SO4)			102.4		%		90-110	16-SEP-17
WG2617644-1 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-12 MB								

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-VA	**Water**							
Batch R3830252								
WG2617644-12 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-16 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-20 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-24 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-4 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
WG2617644-8 MB								
Sulfate (SO4)			<0.30		mg/L		0.3	16-SEP-17
TDS-VA	**Water**							
Batch R3834980								
WG2620000-5 LCS								
Total Dissolved Solids			100.8		%		85-115	19-SEP-17
WG2620000-8 LCS								
Total Dissolved Solids			103.5		%		85-115	19-SEP-17
WG2620000-4 MB								
Total Dissolved Solids			<10		mg/L		10	19-SEP-17
WG2620000-7 MB								
Total Dissolved Solids			<10		mg/L		10	19-SEP-17
TSS-LOW-VA	**Water**							
Batch R3835200								
WG2621083-2 LCS								
Total Suspended Solids			88.3		%		85-115	20-SEP-17
WG2621083-1 MB								
Total Suspended Solids			<1.0		mg/L		1	20-SEP-17
TURBIDITY-VA	**Water**							
Batch R3829859								
WG2617159-11 CRM		**VA-FORM-40**						
Turbidity			103.5		%		85-115	15-SEP-17
WG2617159-14 CRM		**VA-FORM-40**						
Turbidity			103.0		%		85-115	15-SEP-17
WG2617159-17 CRM		**VA-FORM-40**						
Turbidity			103.0		%		85-115	15-SEP-17
WG2617159-2 CRM		**VA-FORM-40**						
Turbidity			102.8		%		85-115	15-SEP-17

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TURBIDITY-VA	**Water**							
Batch R3829859								
WG2617159-5 CRM		**VA-FORM-40**						
Turbidity			103.3		%		85-115	15-SEP-17
WG2617159-8 CRM		**VA-FORM-40**						
Turbidity			103.8		%		85-115	15-SEP-17
WG2617159-1 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17
WG2617159-10 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17
WG2617159-13 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17
WG2617159-16 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17
WG2617159-4 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17
WG2617159-7 MB								
Turbidity			<0.10		NTU		0.1	15-SEP-17

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Anions and Nutrients							
Total Dissolved P in Water by Colour							
	1	13-SEP-17 13:07	20-SEP-17 23:00	3	7	days	EHT
	4	13-SEP-17 11:56	20-SEP-17 23:00	3	7	days	EHT
	5	13-SEP-17 13:07	20-SEP-17 23:00	3	7	days	EHT
	8	13-SEP-17 11:56	20-SEP-17 23:00	3	7	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1991689 were received on 14-SEP-17 12:40.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L1991689-COFC

COC #: OL-2678

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ALS Environmental

Report To	
Company:	ECOFISH RESEARCH LTD
Contact:	Kevin Ganshorn
Address:	Suite F, 450 - 8th Street Courtenay, BC CANADA, V9N 1N5
Phone:	250-334-3042
Fax:	250-334-3097
Invoice To	☑ Email ☐ Mail
Company:	ECOFISH RESEARCH LTD
Contact:	Accounts Payable
Address:	Suite F, 450 - 8th Street Courtenay, BC Canada, V9N 1N5
Email:	accountspayable@ecofishresearch.com
Phone:	250-334-3042
Lab Work Order # (lab use only)	

Reporting	
Distribution:	☐ Fax ☐ Mail ☑ Email
☐ Ciriteria on Report (select from Guidelines below)	
Report Type:	☑ Excel ☑ Digital
Report Format:	CROSSTAB_ALSQC
Report Email(s):	kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com vwoodruff@ecofishresearch.com
EDD Format:	ECF100
EDD Email(s):	bbennett@ecofishresearch.com kganshorn@ecofishresearch.com tkasubuchi@ecofishresearch.com
Project Info	
Job #:	
PO/AFE:	1095-49.40
LSD:	British Columbia
Quote #:	
ALS Contact:	Shane Stack
Sampler:	Sarah Kennedy

Service Requested

- ● Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests

Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Coordinates Longitude	Coordinates Latitude	Date	Time	Sample Type	Number of Containers	Ammonia in Water by Fluorescence	Anions by Ion Chromatography	Biochemical Oxygen Demand- 5 day	Chemical Oxygen Demand by Colorimetric	Conductivity (Automated)	Diss. Orthophosphate in Water by Colour	Dissolved Metals in Water + Hg (BC MDG)	Total Alkalinity by Titration	Total Dissolved P in Water by Colour	Total Dissolved Solids by Gravimetric	Total Metals in Water + Hg (BC MDG)	Total P in Water by Colour	Total Suspended Solids by Grav. (1 mg/L)	(See page 2 for further requests)
	ALE-BDGWQ A			13 Sep. 17	13:05	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-BDGWQ B			"	"	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-USWQ1A			"	11:50	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-USWQ1B			"	11:50	Water	7	R	R	R	R	R	R	R	R	R	R	R	R	R	
	ALE-BDGWQ A Dup			"	13:10	Water	7	R	R	R	R	R	R	R	R	R	R		R	R	
	ALE-BDGWQ B Dup			"	"	Water	7	R	R	R	R	R	R	R	R	R	R		R	R	
	ALE-USWQ1A Dup			"	"	Water	7	R	R	R	R	R	R	R	R	R	R		R	R	
	ALE-USWQ1B Dup			"	"	Water	7	R	R	R	R	R	R	R	R	R	R		R	R	

Special Instructions/Comments

[redacted]

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐ Yes ☐ No

If yes, please use an authorized drinking water COC

Is the water sampled intended to be potable for human consumption? ☐ Yes ☐ No

Guidelines

SAMPLE CONDITION (lab use only)

☐ Frozen ☐ Cold ☐ Ambient ☐ Cooling Initiated

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:
V. Woodruff	14 SEP. 17	6:00AM

SHIPMENT RECEPTION (lab use only)

Received by:	Date:	Time:	Temperature:
Shayan	Sep. 14	1240	16.6 °C

SHIPMENT VERIFICATION (lab use only)

Verified by:	Date:	Time:	Observations:
			☐ Yes If Yes add SIF

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free : 1 800 668 9878
www.alsglobal.com

COC #: OL-2678

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Sample #	Sample Identification (This will appear on the report)	Coordinates		Date	Time	Sample Type	Analysis Requests															
		Longitude	Latitude				Number of Containers	Turbidity by Meter	pH by Meter (Automated)	Total Metals in Water + Hg (BC MDG)												
								Please indicate below Filtered, Preserved or both(F, P, F/P)														
	ALE-BDGWQ A			13-SEP-17	13:10	Water	7	R	R													
	ALE-BDGWQ B			"	"	Water	7	R	R													
	ALE-USWQ1A			"	11:50	Water	7	R	R													
	ALE-USWQ1B			,	"	Water	7	R	R													
	ALE-BDGWQ A Dup			"	13:10	Water	7	R	R	R												
	ALE-BDGWQ B Dup			"	"	Water	7	R	R	R												
	ALE-USWQ1A Dup			"	1:50	Water	7	R	R	R												
	ALE-USWQ1B Dup			"	"	Water	7	R	R	R												
				"																		

L1991689-COFC

Shayan Sep.14 1240 16.6 c

Some of the bottles were not labeled correctly
for example, heavy metals were labeled on plastic on
certain sites, & glass on others.
The label on the bottles are correct for sample type.
For any clarification please email
vdimma @ ecofishresearch.com

Appendix D. Water Quality Guidelines and Data Summary Tables

TABLE OF CONTENTS

LIST OF TABLES

1. WATER CHEMISTRY

1.1. BC Water Quality Guidelines

For many of the water quality parameters measured in the current study, there are short term (maximum) and long term (30-day average) Provincial water quality guidelines for the protection of aquatic life (MOE 2017). Applicable guidelines are provided in the data summary tables and exceedances of the BC WQG are highlighted. For dissolved oxygen, two sets of the guidelines for the protection of aquatic life are applicable: 1) guidelines for buried life stage (eggs and alevin) and 2) all other life stages (juvenile, adult) (Table 1) more stringent minimum BC WQG are applicable to the buried life stages since the concentration of dissolved oxygen in the water column is assumed to be ~ 3 mg/L higher than that experienced in the interstitial waters by the buried life stages (MOE 2017).

Typical ranges of water quality parameters in British Columbia watercourses are provided in Table 2 and where applicable the range in concertation of each parameter is compared to the typical values.

Total and dissolved metal guidelines for the protection of aquatic life (MOE 2017) often depend on the pH or hardness of the watercourse at the time of sampling. Guideline values and equations are identified in the data summary tables and exceedances are highlighted.

Table 1. Dissolved oxygen guidelines for the protection of aquatic life in British Columbia.

	Life Stages Other Than Buried Embryo/Alevin	**Buried Embryo/Alevin**[2]	**Buried Embryo/Alevin**[2]
Dissolved Oxygen Concentration	Water column mg/L O_2	Water column mg/L O_2	Interstitial Water mg/L O_2
Instantaneous minimum[3]	5	9	6
30-day mean[4]	8	11	8

[1] MOE (1997a) and MOE (1997b)

[2] For the buried embryo / alevin life stages these are in-stream concentrations from spawning to the point of yolk sac absorption or 30 days post-hatch for fish; the water column concentrations recommended to achieve interstitial dissolved oxygen values when the latter are unavailable. Interstitial oxygen measurements would supersede water column measurements in comparing to criteria.

[3] The instantaneous minimum level is to be maintained at all times.

[4] The mean is based on at least five approximately evenly spaced samples. If a diurnal cycle exists in the water body, measurements should be taken when oxygen levels are lowest (usually early morning).

Table 2. Typical values for water quality parameters in British Columbia waters.

Parameter	Unit	Typical range in BC streams and rivers	Reference
Specific Conductivity	µS/cm	The typical value in coastal British Columbia streams is 100 µS/cm	RISC (1998)
pH	pH units	Natural fresh waters have a pH range from 4 to 10, lakes tend to have a pH ≥ 7.0 and coastal streams commonly have pH values of 5.5 to 6.5	RISC (1998)
Alkalinity	mg/L	Natural waters almost always have concentrations less than 500 mg/L, with waters in coastal BC typically ranging from 0 to 10 mg/L; waters in interior BC can have values greater than 100 mg/L	RISC (1998)
Total Suspended Solids	mg/L	In British Columbia natural concentrations of suspended solids vary extensively from waterbody to waterbody and can have large variation within a day and among seasons	Singleton (1985) in Caux *et al.* (1997)
Turbidity	NTU	In British Columbia natural concentrations of suspended solids vary extensively from waterbody to waterbody and can have large variation within a day and among seasons	Singleton (1985) in Caux *et al.* (1997)
Dissolved Oxygen	mg/L	In BC surface waters are generally well aerated and have DO concentrations > 10 mg/L	MOE (1997a)
Dissolved Oxygen	% saturation	In BC surface waters are generally well aerated and have DO concentrations close to equilibrium with the atmosphere (i.e., close to 100% saturation)	MOE (1997b)
Total Ammonia (N)	µg/L	<100 µg/L for waters not affected by waste discharges	Nordin and Pommen (1986)
Nitrite (N)	µg/L	Due to its unstable nature, nitrite concentrations are very low, typically present in surface waters at concentrations of <1 µg/L	RISC (1998)
Nitrate (N)	µg/L	In oligotrophic lakes and streams, nitrate concentrations are expected to be <100 µg/L	Nordin and Pommen (1986)
Orthophosphate (P)	µg/L	Coastal BC streams have concentrations <1 µg/L	Slaney and Ward (1993); Ashley and Slaney (1997)
Total Phosphorus (P)	µg/L	Oligotrophic water bodies have total phosphorus concentrations that are between 4 to 10 µg/L while concentrations are typically between 10 to 20 µg/L in mesotrophic water bodies.	CCME (2004)

1.2. Data Summary Tables – general parameters, anions and nutrients

Table 3. Summary of *in-situ* water quality data during baseline (2013 and 2014) and year 1 (2016 and 2017) long term monitoring.

Year	Date	Site[1]	pH				Specific Conductivity				Water Temperature				Air Temperature				Dissolved Oxygen				Dissolved Oxygen[3]			
			pH units				µS/cm				°C				°C				%				mg/L			
			Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD
2013	08-Jul	ALE-USWQ	6.77	6.76	6.77	0.01	58.2	58.2	58.2	0.0	11.7	11.7	11.8	0.1	25.8	25.5	26.0	0.3	79.1	79.0	79.1	0.1	8.20	8.20	8.21	0.01
		ALE-BDGWQ	6.64	6.61	6.66	0.03	64.5	64.5	64.6	0.1	10.9	10.9	10.9	0.0	25.0	25.0	25.0	0.0	82.8	82.7	82.9	0.1	8.76	8.75	8.77	0.01
	16-Sep	ALE-USWQ	-	-	-	-	67.2	67.0	67.5	0.3	10.2	10.1	10.2	0.1	15.1	15.1	15.2	0.1	80.4	79.9	81.1	0.6	9.04	8.95	9.16	0.11
		ALE-BDGWQ	-	-	-	-	55.0	37.0	64.0	15.6	10.7	10.7	10.7	0.0	14.9	14.9	15.0	0.1	82.6	80.1	84.5	2.3	9.20	9.06	9.29	0.12
	18-Nov	ALE-USWQ1	-	-	-	-	63.8	63.7	63.8	0.1	7.2	7.2	7.2	0.0	3.5	3.5	3.5	0.0	65.4	65.0	66.1	0.6	7.93	7.89	7.97	0.04
		ALE-BDGWQ	-	-	-	-	60.2	60.1	60.2	0.1	5.5	5.5	5.5	0.0	3.0	3.0	3.0	0.0	76.9	76.5	77.3	0.4	9.67	9.64	9.71	0.04
2014	27-Feb	ALE-USWQ1	5.96	5.87	6.04	0.09	63.4	63.4	63.4	0.0	6.7	6.7	6.7	0.0	5.0	-	-	-	79.4	79.3	79.4	0.1	9.20	9.20	9.21	0.01
		ALE-BDGWQ	6.36	6.33	6.38	0.03	59.6	59.5	59.6	0.1	4.9	4.9	4.9	0.0	5.0	-	-	-	82.5	82.5	82.6	0.1	10.01	10.00	10.01	0.01
	29-Apr	ALE-USWQ1	6.11	6.09	6.12	0.02	43.3	43.3	43.3	0.0	5.3	5.3	5.3	0.0	16.0	16.0	16.0	0.0	88.2	88.1	88.3	0.1	10.90	10.89	10.91	0.01
		ALE-BDGWQ	6.19	6.12	6.23	0.06	42.2	42.1	42.2	0.1	7.2	7.2	7.2	0.0	14.0	14.0	14.0	0.0	95.4	95.3	95.5	0.1	11.23	11.22	11.24	0.01
	25-Sep	ALE-USWQ1	6.21	6.21	6.21	0.00	66.8	66.8	66.8	0.0	7.5	7.5	7.5	0.0	13.0	13.0	13.0	0.0	-	-	-	-	-	-	-	-
		ALE-BDGWQ	6.37	6.36	6.37	0.01	70.8	70.8	70.8	0.0	8.9	8.9	8.9	0.0	14.0	14.0	14.0	0.0	-	-	-	-	-	-	-	-
	25-Nov	ALE-BDGWQ	8.30	-	-	-	35.9	-	-	-	5.3	5.3	5.3	0.0	-	-	-	-	86.6	86.5	86.6	0.1	10.95	10.95	10.96	0.01
2016	23-Nov	ALE-USWQ1	-	-	-	-	85.2	85.1	85.4	0.2	6.3	6.3	6.3	0.0	0.5	0.5	0.5	0.0	71.8	71.7	72.0	0.2	8.87	8.86	8.88	0.01
		ALE-BDGWQ	-	-	-	-	85.7	85.5	85.9	0.2	5.6	5.6	5.6	0.0	-	-	-	-	83.5	83.4	83.6	0.1	10.55	10.55	10.56	0.01
2017	05-Mar	ALE-USWQ1	6.41	6.41	6.41	0.00	54.5	54.4	54.5	0.1	5.8	5.8	5.8	0.0	-1.0	-1.0	-1.0	0.0	78.7	78.4	78.9	0.3	-	-	-	-
		ALE-BDGWQ	6.45	6.43	6.48	0.03	57.9	57.7	58.0	0.2	4.0	4.0	4.0	0.0	-	-	-	-	85.8	85.8	85.8	0.0	-	-	-	-
	05-Jun	ALE-USWQ1	6.81	6.80	6.82	0.01	50.2	50.1	50.2	0.1	8.3	8.3	8.3	0.0	18.0	-	-	-	74.6	74.5	74.7	0.1	8.77	8.74	8.80	0.03
		ALE-BDGWQ	7.09	7.09	7.09	0.00	53.6	53.6	53.6	0.0	8.8	8.8	8.8	0.0	20.0	20.0	20.0	0.0	89.4	89.3	89.5	0.1	10.38	10.38	10.39	0.01
	13-Sep	ALE-USWQ1	6.49	6.48	6.50	0.01	63.7	63.2	64.3	0.6	7.5	7.5	7.5	0.0	20.0	20.0	20.0	0.0	55.0	54.6	55.7	0.6	6.56	6.54	6.58	0.02
		ALE-BDGWQ	7.16	7.16	7.17	0.01	68.4	68.3	68.4	0.1	9.6	9.6	9.6	0.0	20.0	20.0	20.0	0.0	94.7	94.6	94.7	0.1	10.80	10.80	10.81	0.01

[1] ALE-USWQ was moved 570 m upstream to ALE-USWQ1 in November 2013 to ensure the site was sufficiently upstream of the instream enhancement works.

[2] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

[3] DO data were screened against the BC WQG for the instantaneous minimum water column concentration for both bureid embryo/alevin life stages (9 mg/L) and other life stages (5 mg/L). Yellow shading indicates an exceedance of the instantaneous minimum water column concentration of 9 mg/L for buried embryo/alevin life stages (MOE 2018).

Table 4. Summary of laboratory water quality data (general parameters) during baseline (2013 and 2014) and year 1 (2016 and 2017) long term monitoring.

Year	Date	Site[1]	pH				Specific Conductivity				Total Suspended Solids				Turbidity				Total Dissolved Solids				Alkalinity, Total (as $CaCO_3$)			
			pH units				µS/cm				mg/L				NTU				mg/L				mg/L			
			Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD
2013	08-Jul	ALE-USWQ	7.39	7.37	7.41	0.02	53.6	53.4	53.7	0.2	<3.4	<3.0	3.7	0.4	1.43	1.36	1.48	0.06	51	49	55	3	23.0	22.9	23.1	0.1
		ALE-BDGWQ	7.43	7.40	7.48	0.04	58.8	58.3	59.3	0.5	5.7	4.9	6.1	0.7	3.42	3.03	4.20	0.67	57	55	62	4	25.5	25.3	25.7	0.2
	16-Sep	ALE-USWQ	7.56	7.55	7.57	0.01	64.6	64.4	64.7	0.2	4.8	4.5	5.1	0.3	5.72	4.92	6.48	0.78	63	60	65	3	28.9	28.4	29.9	0.9
		ALE-BDGWQ	7.56	7.53	7.59	0.03	65.3	65.1	65.4	0.2	7.2	5.5	8.5	1.5	7.05	5.91	8.68	1.45	64	61	69	4	29.0	28.5	29.3	0.4
	18-Nov	ALE-USWQ	7.30	7.28	7.33	0.03	63.8	63.7	63.9	0.1	<1.0	<1.0	<1.0	0.0	0.76	0.72	0.80	0.04	51	50	53	2	26.4	26.3	26.6	0.2
		ALE-BDGWQ	7.35	7.33	7.38	0.03	58.8	58.4	59.2	0.4	1.6	1.4	1.8	0.2	2.29	2.11	2.58	0.25	51	50	52	1	25.9	25.8	26.1	0.2
2014	27-Feb	ALE-USWQ	7.39	7.39	7.39	0.00	62.6	62.4	62.8	0.2	<1.0	<1.0	<1.0	0.0	1.39	0.73	2.34	0.84	55	55	55	0	26.4	26.2	26.6	0.2
		ALE-BDGWQ	7.49	7.47	7.51	0.02	58.6	58.3	59.1	0.4	<1.0	<1.0	<1.0	0.0	2.61	2.56	2.64	0.05	52	51	54	2	25.3	25.3	25.4	0.1
	25-Sep	ALE-USWQ1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.8	24.7	24.9	0.1
		ALE-BDGWQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.8	27.4	28.2	0.4
2016	23-Nov	ALE-USWQ1	7.37	7.36	7.38	0.01	50.0	49.7	50.2	0.3	3.3	2.9	3.8	0.5	0.84	0.81	0.88	0.04	49	47	51	2	19.6	19.4	19.9	0.3
		ALE-BDGWQ	7.43	7.41	7.45	0.02	48.5	48.5	48.6	0.1	5.1	4.6	5.6	0.5	1.76	1.51	1.91	0.22	47	44	50	3	18.2	16.1	19.5	1.9
2017	05-Mar	ALE-USWQ1	7.17	7.11	7.23	0.08	55.4	54.8	55.9	0.8	<1.4	<1.0	1.8	0.6	2.50	0.53	4.46	2.78	44	43	45	1	23.3	23.1	23.5	0.3
		ALE-BDGWQ	7.25	7.23	7.27	0.03	55.8	55.4	56.2	0.6	<1.2	<1.0	1.3	0.2	2.73	2.69	2.76	0.05	48	47	48	1	24.3	24.0	24.5	0.4
	05-Jun	ALE-USWQ1	7.23	7.22	7.24	0.01	48.8	48.6	48.9	0.2	<1.0	<1.0	<1.0	0.0	0.29	0.23	0.35	0.08	42	40	44	3	21.3	21.2	21.4	0.1
		ALE-BDGWQ	7.27	7.26	7.27	0.01	52.1	51.6	52.5	0.6	1.4	1.2	1.6	0.3	2.46	2.13	2.78	0.46	47	45	49	3	22.2	21.9	22.5	0.4
	13-Sep	ALE-USWQ1	-	-	-	-	61.0	60.7	61.2	0.4	<1.0	<1.0	<1.0	0.0	0.42	0.34	0.50	0.11	54	53	55	1	23.6	23.5	23.7	0.1
		ALE-BDGWQ	-	-	-	-	64.4	63.8	65.0	0.8	2.5	2.1	2.8	0.5	4.65	4.61	4.69	0.06	63	62	63	1	26.7	26.6	26.8	0.1

[1] ALE-USWQ was moved 570 m upstream to ALE-USWQ1 in November 2013 to ensure the site was sufficiently upstream of the instream enhancement works.

[2] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 5. Summary of laboratory water quality data (nutrients) during baseline (2013 and 2014) and year 1 (2016 and 2017) long term monitoring.

Year	Date	Site[1]	Ammonia, Total (as N) mg/L				Nitrate (as N) mg/L				Nitrite (as N) mg/L				Total Phosphorus (P) mg/L				Dissolved Orthophosphate (as P) mg/L			
			Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD
2013	08-Jul	ALE-USWQ	0.0211	0.0196	0.0227	0.0016	0.0287	0.0285	0.0290	0.0003	<0.001	<0.001	<0.001	0.000	0.0076	0.0054	0.0114	0.0033	0.0022	0.0013	0.0039	0.0014
		ALE-BDGWQ	0.0371	0.0364	0.0383	0.0010	0.0290	0.0284	0.0301	0.0009	<0.001	<0.001	<0.001	0.000	0.0109	0.0083	0.0129	0.0024	0.0021	0.0019	0.0023	0.0002
	16-Sep	ALE-USWQ	0.0258	0.0240	0.0269	0.0016	0.0330	0.0329	0.0332	0.0002	<0.001	<0.001	<0.001	0.000	0.0138	0.0130	0.0143	0.0007	0.0016	0.0015	0.0017	0.0001
		ALE-BDGWQ	0.0292	0.0290	0.0295	0.0003	0.0287	0.0284	0.0289	0.0003	<0.001	<0.001	<0.001	0.000	0.0250	0.0228	0.0276	0.0024	0.0026	0.0025	0.0026	0.0001
	18-Nov	ALE-USWQ1	<0.0068	<0.0050	0.0105	0.0032	0.0356	0.0347	0.0363	0.0008	<0.001	<0.001	<0.001	0.000	0.0026	0.0024	0.0028	0.0002	<0.0010	<0.0010	<0.0010	0.0000
		ALE-BDGWQ	0.0323	0.0310	0.0349	0.0022	0.0375	0.0375	0.0376	0.0001	<0.001	<0.001	<0.001	0.000	0.0069	0.0064	0.0074	0.0005	0.0018	0.0017	0.0018	0.0001
2014	27-Feb	ALE-USWQ1	0.0064	0.0062	0.0067	0.0003	0.0430	0.0428	0.0434	0.0003	<0.001	<0.001	<0.001	0.000	0.0056	0.0028	0.0092	0.0033	<0.0010	<0.0010	0.0011	0.0001
		ALE-BDGWQ	0.0197	0.0196	0.0200	0.0002	0.0490	0.0487	0.0495	0.0005	<0.001	<0.001	0.001	0.000	0.0050	0.0048	0.0053	0.0003	0.0019	0.0018	0.0021	0.0002
	25-Sep	ALE-USWQ1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ALE-BDGWQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	23-Nov	ALE-USWQ1	0.0113	0.0112	0.0115	0.0002	0.0477	0.0477	0.0478	0.0001	<0.001	<0.001	<0.001	0.000	0.0071	0.0063	0.0076	0.0007	0.0024	0.0022	0.0025	0.0002
		ALE-BDGWQ	0.0311	0.0310	0.0313	0.0002	0.1270	0.1270	0.1270	0.0000	<0.001	<0.001	<0.001	0.000	0.0105	0.0092	0.0115	0.0012	0.0031	0.0029	0.0033	0.0002
2017	05-Mar	ALE-USWQ1	<0.0050	<0.0050	<0.0050	0.0000	0.0551	0.0551	0.0551	0.0000	<0.001	<0.001	<0.001	0.000	<0.0021	<0.0020	0.0021	0.0001	<0.0010	<0.0010	<0.0010	0.0000
		ALE-BDGWQ	0.0329	0.0319	0.0338	0.0013	0.0685	0.0678	0.0691	0.0009	<0.001	<0.001	<0.001	0.000	<0.0110	<0.0100	0.0120	0.0014	0.0031	0.0031	0.0031	0.0000
	05-Jun	ALE-USWQ1	<0.0050	<0.0050	<0.0050	0.0000	0.0575	0.0571	0.0579	0.0006	<0.001	<0.001	<0.001	0.000	<0.0023	<0.0020	0.0026	0.0004	<0.0012	<0.0010	0.0013	0.0002
		ALE-BDGWQ	0.0236	0.0217	0.0254	0.0026	0.1730	0.1730	0.1730	0.0000	<0.001	<0.001	<0.001	0.000	0.0045	0.0044	0.0046	0.0001	0.0023	0.0022	0.0023	0.0001
	13-Sep	ALE-USWQ1	<0.0050	<0.0050	<0.0050	0.0000	0.0272	0.0270	0.0273	0.0002	<0.001	<0.001	<0.001	0.000	0.0029	0.0027	0.0030	0.0002	<0.0010	<0.0010	<0.0010	0.0000
		ALE-BDGWQ	0.0411	0.0405	0.0416	0.0008	0.0266	0.0264	0.0267	0.0002	<0.001	<0.001	<0.001	0.000	0.0072	0.0065	0.0079	0.0010	0.0025	0.0024	0.0025	0.0001

[1] ALE-USWQ was moved 570 m upstream to ALE-USWQ1 in November 2013 to ensure the site was sufficiently upstream of the instream enhancement works.

[2] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

Table 6. Summary of laboratory water quality data (COD, BOD and anions) during baseline (2013 and 2014) and year 1 (2016 and 2017) long term monitoring.

Year	Date	Site[1]	BOD mg/L				COD mg/L				Chloride (Cl) mg/L				Fluoride (F) mg/L				Sulfate (SO4) mg/L			
			Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD	Avg[2]	Min	Max	SD
2013	08-Jul	ALE-USWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	-	-	-	-	-	-	-	-	-	-	-	-
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	-	-	-	-	-	-	-	-	-	-	-	-
	16-Sep	ALE-USWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.026	0.025	0.026	0.001	5.69	5.64	5.73	0.05
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.026	0.026	0.027	0.001	5.60	5.58	5.62	0.02
	18-Nov	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.023	0.023	0.024	0.001	5.39	5.36	5.42	0.03
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	1.44	0.78	2.56	0.97	0.027	0.027	0.027	0.000	4.18	4.12	4.26	0.07
2014	27-Feb	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.025	0.025	0.026	0.001	5.07	5.07	5.07	0.00
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.030	0.029	0.031	0.001	4.18	4.18	4.18	0.00
	25-Sep	ALE-USWQ1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		ALE-BDGWQ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	23-Nov	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.024	0.024	0.024	0.000	3.73	3.72	3.74	0.01
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.025	0.024	0.025	0.001	3.00	3.00	3.00	0.00
2017	05-Mar	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.022	0.022	0.022	0.000	4.65	4.65	4.65	0.00
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.025	0.024	0.025	0.001	3.91	3.90	3.91	0.01
	05-Jun	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.030	0.030	0.030	0.000	3.71	3.70	3.71	0.01
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.032	0.032	0.032	0.000	3.21	3.21	3.21	0.00
	13-Sep	ALE-USWQ1	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	<0.50	<0.50	<0.50	0.00	0.022	0.022	0.022	0.000	6.77	6.75	6.78	0.02
		ALE-BDGWQ	<2.0	<2.0	<2.0	0.0	<20	<20	<20	0	0.58	0.58	0.58	0.00	0.030	0.028	0.031	0.002	6.04	6.03	6.04	0.01

[1] ALE-USWQ was moved 570 m upstream to ALE-USWQ1 in November 2013 to ensure the site was sufficiently upstream of the instream enhancement works.

[2] Average of three replicates (n=3) on each date unless otherwise indicated. A single data listed under Avg. indicates n=1.

Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes.

1.3. Data Summary Tables – total and dissolved metals

Table 7. Summary of laboratory water quality data (total metals) during baseline monitoring (2013 and 2014).

Date	8-Jul-2013						16-Sep-2013						BC WQG
Site	**ALE-USWQ**			**ALE-BDGWQ**			**ALE-USWQ**			**ALE-BDGWQ**			**Max**
Replicate	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	
Total Metals													
Aluminum (Al)	0.0395	0.037	0.0393	0.0476	0.0489	0.047	0.188	0.178	0.184	0.193	0.196	0.205	
Antimony (Sb)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Arsenic (As)	0.00013	0.00014	0.00015	0.00019	0.00016	0.00018	0.00021	0.0014	0.00024	0.00028	0.00029	0.00028	0.005
Barium (Ba)	0.0138	0.0139	0.014	0.0171	0.0172	0.0167	0.019	0.0189	0.02	0.0218	0.0215	0.0214	
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Boron (B)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.2
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Calcium (Ca)	7.33	7.43	7.53	8.06	7.96	7.93	8.74	8.39	9.09	8.75	8.87	8.9	
Chromium (Cr)	0.00011	0.00013	0.00012	0.00016	0.00015	0.00015	0.00033	0.00041	0.00032	0.00037	0.00037	0.00038	
Cobalt (Co)	0.00046	0.00047	0.00046	0.0005	0.00049	0.00048	0.00053	0.00056	0.00054	0.00053	0.00054	0.00055	0.11
Copper (Cu)	0.00051	0.0009	0.00053	0.0005	0.00089	0.0005	0.00085	0.00087	0.00087	0.0009	0.00103	0.00113	EQ
Iron (Fe)	1.04	1.06	1.09	1.95	1.95	1.98	1.2	1.15	1.22	2.13	2.08	2.11	1
Lead (Pb)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.000126	<0.00005	0.000102	0.000102	0.00011	EQ
Lithium (Li)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Magnesium (Mg)	1.04	1.05	1.07	1.22	1.21	1.2	1.27	1.2	1.32	1.34	1.34	1.36	
Manganese (Mn)	0.142	0.144	0.145	0.174	0.173	0.172	0.15	0.145	0.152	0.181	0.177	0.181	EQ
Mercury (Hg)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Molybdenum (Mo)	0.000503	0.000502	0.000511	0.000532	0.000477	0.000478	0.000489	0.000517	0.000513	0.000515	0.000498	0.000517	2
Nickel (Ni)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Phosphorus (P)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Potassium (K)	0.93	0.91	0.94	1.07	1.03	1.01	1.35	1.24	1.38	1.82	1.77	1.86	
Selenium (Se)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Silicon (Si)	6.8	6.83	6.9	7.03	6.97	6.93	7.25	6.8	7.42	7.04	7.04	7.23	
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	EQ
Sodium (Na)	1.56	1.56	1.57	1.67	1.64	1.65	1.83	1.9	1.85	1.8	1.85	1.95	
Strontium (Sr)	0.0384	0.0385	0.0388	0.0425	0.0418	0.0404	0.0482	0.0468	0.0485	0.0466	0.0472	0.0482	
Sulfur (S)	1.09	1.1	1.09	1.15	1.15	1.11	1.99	1.95	2.03	2.02	2.04	2.05	
Thallium (Tl)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Tin (Sn)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Titanium (Ti)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Uranium (U)	0.00001	0.00002	0.00001	0.00002	0.00002	0.00002	0.00002	0.00004	0.00002	0.00003	0.00003	0.00002	
Vanadium (V)	0.001	0.001	0.001	0.0013	0.0012	0.0013	0.001	0.0011	0.001	0.0015	0.0015	0.0015	
Zinc (Zn)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.0033	<0.003	0.0032	<0.003	<0.003	EQ

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 7. Continued.

Date	18-Nov-2013						27-Feb-2014						BC WQG
Site	ALE-USWQ1			ALE-BDGWQ			ALE-USWQ1			ALE-BDGWQ			Max
Replicate	A	B	C	A	B	C	A	B	C	A	B	C	
Total Metals													
Aluminum (Al)	0.0159	0.0159	0.0166	0.0391	0.0405	0.0386	0.0953	0.017	0.0149	0.0163	0.0184	0.0167	
Antimony (Sb)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Arsenic (As)	0.00013	0.0001	0.00013	0.00024	0.0003	0.00022	0.00028	0.0001	0.0001	0.00013	0.00013	0.00014	0.005
Barium (Ba)	0.0135	0.0132	0.0137	0.0157	0.0166	0.0157	0.014	0.0134	0.0118	0.0134	0.0136	0.0135	
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Boron (B)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.2
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Calcium (Ca)	8.81	8.66	8.87	8	7.96	7.62	8.62	8.41	8.77	7.96	7.95	7.94	
Chromium (Cr)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.00019	0.00011	0.0001	0.0001	0.0001	0.0001	
Cobalt (Co)	0.00016	0.00016	0.00018	0.00033	0.00035	0.00033	0.00043	0.00012	0.00012	0.00013	0.00013	0.00012	0.11
Copper (Cu)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00093	0.0005	0.0005	0.0005	0.0005	0.0005	EQ
Iron (Fe)	0.329	0.332	0.345	1.18	1.21	1.16	3.61	0.344	0.397	0.799	0.824	0.769	1
Lead (Pb)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	EQ
Lithium (Li)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Magnesium (Mg)	1.22	1.2	1.22	1.22	1.23	1.2	1.18	1.15	1.19	1.2	1.17	1.19	
Manganese (Mn)	0.0548	0.057	0.0575	0.109	0.112	0.11	0.129	0.0512	0.0456	0.0527	0.0532	0.0523	EQ
Mercury (Hg)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Molybdenum (Mo)	0.000444	0.000444	0.000446	0.000529	0.000519	0.000498	0.000609	0.000431	0.000451	0.0005	0.000518	0.000525	2
Nickel (Ni)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Phosphorus (P)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Potassium (K)	1.14	1.11	1.13	1.21	1.22	1.18	0.99	0.98	0.99	1.05	0.99	1.01	
Selenium (Se)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Silicon (Si)	8.01	7.89	8.04	7.23	7.27	6.98	7.71	7.39	7.7	7.04	6.92	6.98	
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	EQ
Sodium (Na)	1.9	1.92	2	1.75	1.82	1.73	1.78	2.03	1.81	1.74	1.73	1.72	
Strontium (Sr)	0.0441	0.046	0.0452	0.0408	0.0393	0.0382	0.0417	0.0409	0.0423	0.0392	0.0387	0.039	
Sulfur (S)	1.86	1.82	1.86	1.44	1.4	1.38	1.71	1.71	1.75	1.5	1.47	1.47	
Thallium (Tl)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Tin (Sn)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Titanium (Ti)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Uranium (U)	0.00002	0.00001	0.00001	0.00002	0.00002	0.00002	0.00004	0.00001	0.00001	0.00001	0.00001	0.00001	
Vanadium (V)	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	
Zinc (Zn)	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	EQ

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 8. Summary of laboratory water quality data (dissolved metals) during baseline monitoring (2013 and 2014).

Date	8-Jul-2013						16-Sep-2013						BC WQG
Site	ALE-USWQ			ALE-BDGWQ			ALE-USWQ			ALE-BDGWQ			Max
Replicate	A	B	C	A	B	C	A	B	C	A	B	C	
Dissolved Metals (mg/L)													
Aluminum (Al)	0.0116	0.012	0.0121	0.0138	0.0132	0.0128	0.0246	0.0241	0.0239	0.0216	0.0221	0.0216	EQ
Antimony (Sb)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Arsenic (As)	<0.0001	<0.0001	<0.0001	0.00014	<0.0001	<0.0001	0.00018	0.00017	0.00019	0.00018	0.00018	0.00018	
Barium (Ba)	0.0131	0.0132	0.0132	0.0161	0.0163	0.0161	0.0173	0.0175	0.0176	0.0188	0.0188	0.019	
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Boron (B)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	EQ
Calcium (Ca)	7.36	7.38	7.43	7.89	7.99	8.08	8.75	8.86	8.88	8.63	8.63	8.67	
Chromium (Cr)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00025	0.00024	0.00021	0.00025	0.00024	0.00025	
Cobalt (Co)	0.00039	0.00038	0.0004	0.00041	0.00041	0.00041	0.00045	0.00047	0.00046	0.00044	0.00041	0.00042	
Copper (Cu)	0.00025	0.00024	0.00024	0.00027	0.00023	0.00025	0.00041	0.00039	0.00041	0.00044	0.00043	0.00042	
Iron (Fe)	0.6	0.589	0.598	1.01	1.01	1.02	0.74	0.775	0.801	0.811	0.821	0.832	0.35
Lead (Pb)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
Lithium (Li)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Magnesium (Mg)	1.04	1.04	1.04	1.18	1.19	1.22	1.22	1.25	1.25	1.27	1.27	1.28	
Manganese (Mn)	0.129	0.129	0.13	0.156	0.155	0.156	0.141	0.144	0.147	0.151	0.155	0.155	
Mercury (Hg)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Molybdenum (Mo)	0.000466	0.000444	0.000435	0.000416	0.000429	0.000431	0.000445	0.00043	0.000444	0.000415	0.00041	0.000421	
Nickel (Ni)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Phosphorus (P)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Potassium (K)	0.92	0.95	0.96	1.03	1.03	1.05	1.2	1.28	1.27	1.67	1.7	1.67	
Selenium (Se)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Silicon (Si)	6.69	6.62	6.74	6.74	6.73	6.93	6.79	6.92	6.92	6.56	6.56	6.58	
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Sodium (Na)	1.55	1.55	1.56	1.63	1.62	1.63	1.88	1.85	1.83	1.76	1.81	1.78	
Strontium (Sr)	0.0365	0.0365	0.037	0.0398	0.0395	0.0394	0.0455	0.0483	0.046	0.0461	0.0443	0.045	
Thallium (Tl)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Tin (Sn)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Titanium (Ti)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Uranium (U)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Vanadium (V)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc (Zn)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	0.0015	0.0014	0.0011	0.0013	0.0015	

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 8. Continued.

Date	18-Nov-2013						27-Feb-2014						BC WQG
Site	**ALE-USWQ1**			**ALE-BDGWQ**			**ALE-USWQ1**			**ALE-BDGWQ**			**Max**
Replicate	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	
Dissolved Metals (mg/L)													
Aluminum (Al)	0.0102	0.0099	0.0098	0.0187	0.0176	0.0167	0.0098	0.0112	0.008	0.0096	0.0097	0.0095	EQ
Antimony (Sb)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Arsenic (As)	<0.0001	<0.0001	<0.0001	0.00019	0.00018	0.00017	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Barium (Ba)	0.0129	0.013	0.0131	0.0159	0.0158	0.0159	0.0141	0.0126	0.0118	0.0133	0.0143	0.0144	
Beryllium (Be)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (Bi)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Boron (B)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Cadmium (Cd)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	EQ
Calcium (Ca)	8.57	8.51	8.5	7.84	7.75	7.67	8.72	8.77	8.81	8.1	8.06	8.06	
Chromium (Cr)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Cobalt (Co)	0.00016	0.00016	0.00016	0.00031	0.0003	0.0003	0.00011	0.00013	0.00011	0.00011	0.00011	0.00011	
Copper (Cu)	0.0002	0.00021	0.0002	0.00029	0.00031	0.00027	0.00033	0.00073	0.00026	0.0003	0.0003	0.00031	
Iron (Fe)	0.209	0.204	0.208	0.815	0.829	0.783	0.183	0.171	0.161	0.46	0.452	0.456	0.35
Lead (Pb)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	
Lithium (Li)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Magnesium (Mg)	1.16	1.14	1.15	1.17	1.18	1.16	1.16	1.16	1.16	1.17	1.18	1.18	
Manganese (Mn)	0.053	0.053	0.054	0.107	0.105	0.104	0.045	0.045	0.045	0.05	0.05	0.05	
Mercury (Hg)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Molybdenum (Mo)	0.000433	0.0004	0.000423	0.000473	0.00051	0.0005	0.000411	0.00042	0.000397	0.000469	0.00047	0.000473	
Nickel (Ni)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	
Phosphorus (P)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Potassium (K)	1.03	0.99	1.01	1.1	1.1	1.08	0.92	0.93	0.94	0.96	0.97	0.97	
Selenium (Se)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Silicon (Si)	7.7	7.6	7.66	7.03	6.99	6.87	7.56	7.57	7.6	7	7.02	7.09	
Silver (Ag)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Sodium (Na)	1.96	1.87	1.88	1.74	1.79	1.71	1.86	1.85	1.82	1.71	1.74	1.74	
Strontium (Sr)	0.0442	0.0426	0.044	0.0385	0.0397	0.039	0.0414	0.0415	0.041	0.0378	0.0377	0.037	
Thallium (Tl)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Tin (Sn)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Titanium (Ti)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Uranium (U)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	
Vanadium (V)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc (Zn)	0.0011	0.0013	0.0011	0.0013	0.0012	0.001	0.0013	0.0077	0.0028	0.001	<0.001	0.0014	

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 9. Summary of laboratory water quality data (total metals) during year 1 (2016 and 2017) long term monitoring.

Date	**23-Nov-2016**						**5-Mar-2017**				**BC WQG**
Site	**ALE-USWQ1**			**ALE-BDGWQ**			**ALE-USWQ1**		**ALE-BDGWQ**		**Max**
Replicate	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**A**	**B**	
Total Metals (mg/L)											
Aluminum (Al)	0.0850	0.0739	0.0833	0.133	0.122	0.133	0.0120	0.0110	0.0192	0.0182	
Antimony (Sb)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Arsenic (As)	<0.00010	<0.00010	<0.00010	0.00016	0.00014	0.00015	<0.00010	<0.00010	0.00011	0.00011	0.005
Barium (Ba)	0.0109	0.0107	0.0108	0.0142	0.0140	0.0142	0.0106	0.0105	0.0139	0.0140	5
Beryllium (Be)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	
Bismuth (Bi)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Boron (B)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	1.2
Cadmium (Cd)	0.0000077	0.0000085	0.0000058	0.0000087	0.0000091	0.0000072	0.0000064	0.0000064	0.0000053	<0.0000050	
Calcium (Ca)	6.03	6.07	6.06	5.90	5.82	5.80	7.03	6.97	7.20	7.15	
Chromium (Cr)	0.00011	<0.00010	<0.00010	0.00019	0.00013	0.00022	<0.00010	<0.00010	0.00014	0.00069	
Cobalt (Co)	0.00017	0.00014	0.00016	0.00029	0.00029	0.00029	<0.00010	<0.00010	0.00016	0.00016	0.11
Copper (Cu)	0.00068	0.00065	0.00068	0.00107	0.00100	0.00105	<0.00050	<0.00050	<0.00050	<0.00050	EQ
Iron (Fe)	0.225	0.217	0.228	0.944	0.912	0.942	0.110	0.109	0.880	0.929	1
Lead (Pb)	<0.000050	<0.000050	<0.000050	0.000070	0.000056	0.000059	<0.000050	<0.000050	<0.000050	<0.000050	EQ
Lithium (Li)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	
Magnesium (Mg)	0.92	0.90	0.92	0.97	0.96	0.99	0.99	0.98	1.09	1.11	
Manganese (Mn)	0.0202	0.0187	0.0193	0.0717	0.0709	0.0725	0.0152	0.0151	0.0811	0.0833	EQ
Mercury (Hg)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
Molybdenum (Mo)	0.000485	0.000485	0.000486	0.000476	0.000479	0.000472	0.000452	0.000460	0.000530	0.000493	2
Nickel (Ni)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	
Phosphorus (P)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	
Potassium (K)	0.87	0.84	0.86	0.95	0.94	0.96	0.88	0.88	0.98	0.99	
Selenium (Se)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Silicon (Si)	6.45	6.37	6.52	6.17	6.08	6.13	7.01	7.02	6.73	6.66	
Silver (Ag)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	EQ
Sodium (Na)	1.60	1.56	1.59	1.50	1.48	1.50	1.75	1.67	1.69	1.72	
Strontium (Sr)	0.0333	0.0333	0.0335	0.0319	0.0316	0.0315	0.0369	0.0366	0.0361	0.0354	
Sulfur (S)	1.08	1.05	1.24	0.93	0.81	0.92	1.52	1.64	1.32	1.35	
Thallium (Tl)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	
Tin (Sn)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Titanium (Ti)	0.00266	0.00269	0.00274	0.00533	0.00476	0.00495	<0.00030	<0.00030	0.00042	0.00046	
Uranium (U)	0.000021	0.000020	0.000020	0.000025	0.000026	0.000027	0.000012	0.000012	0.000013	0.000013	
Vanadium (V)	0.00063	0.00058	0.00062	0.00108	0.00097	0.00101	<0.00050	<0.00050	0.00068	0.00070	
Zinc (Zn)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	EQ
Zirconium (Zr)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 9. Continued.

Date	5-Jun-2017				13-Sep-2017				BC WQG
Site	ALE-USWQ1		ALE-BDGWQ		ALE-USWQ1		ALE-BDGWQ		Max
Replicate	A	B	A	B	A	B	A	B	
Total Metals (mg/L)									
Aluminum (Al)	0.0155	0.0153	0.0175	0.0189	0.0154	0.0245	0.0230	0.0262	
Antimony (Sb)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Arsenic (As)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00019	0.00020	0.005
Barium (Ba)	0.00899	0.00907	0.0120	0.0115	0.0138	0.0140	0.0178	0.0179	5
Beryllium (Be)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	
Bismuth (Bi)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Boron (B)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	1.2
Cadmium (Cd)	0.0000062	0.0000056	<0.0000050	<0.0000050	0.0000078	<0.0000050	<0.0000050	<0.0000050	
Calcium (Ca)	6.17	6.07	6.36	6.37	7.58	7.72	7.99	7.93	
Chromium (Cr)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	0.00014	
Cobalt (Co)	<0.00010	<0.00010	0.00014	0.00015	0.00013	0.00017	0.00020	0.00020	0.11
Copper (Cu)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00051	0.00057	EQ
Iron (Fe)	0.065	0.067	0.641	0.653	0.174	0.202	1.34	1.34	1
Lead (Pb)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	EQ
Lithium (Li)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	
Magnesium (Mg)	0.83	0.84	0.91	0.91	1.09	1.12	1.29	1.31	
Manganese (Mn)	0.0109	0.0111	0.0662	0.0669	0.0248	0.0262	0.124	0.125	EQ
Mercury (Hg)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
Molybdenum (Mo)	0.000501	0.000497	0.000470	0.000479	0.000435	0.000467	0.000471	0.000491	2
Nickel (Ni)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	
Phosphorus (P)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	
Potassium (K)	0.77	0.80	0.83	0.83	0.93	0.95	1.10	1.13	
Selenium (Se)	<0.000050	<0.000050	<0.000050	<0.000050	0.000055	<0.000050	<0.000050	<0.000050	
Silicon (Si)	6.21	6.27	6.20	6.06	6.91	6.94	7.20	7.28	
Silver (Ag)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	EQ
Sodium (Na)	1.46	1.50	1.43	1.43	1.95	1.98	1.99	2.04	
Strontium (Sr)	0.0322	0.0321	0.0331	0.0330	0.0433	0.0441	0.0455	0.0453	
Sulfur (S)	1.26	1.27	1.08	1.12	2.13	2.13	1.96	1.94	
Thallium (Tl)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	
Tin (Sn)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Titanium (Ti)	<0.00030	<0.00030	0.00036	0.00032	0.00033	<0.00060	<0.0012	0.00120	
Uranium (U)	0.000014	0.000013	0.000013	0.000013	<0.000010	0.000011	0.000012	0.000011	
Vanadium (V)	<0.00050	<0.00050	0.00063	0.00063	<0.00050	<0.00050	0.00099	0.00104	
Zinc (Zn)	0.0037	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	EQ
Zirconium (Zr)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	

EQ indicates that the applicable guideline is an equation as per MOE (2018).
Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Table 10. Summary of laboratory water quality data (dissolved metals) during year 1 (2016 and 2017) long term monitoring.

Date	5-Mar-2017				5-Jun-2017				13-Sep-2017				BC WQG
Site	ALE-USWQ1		ALE-BDGWQ		ALE-USWQ1		ALE-BDGWQ		ALE-USWQ1		ALE-BDGWQ		Max
Replicate	A	B	A	B	A	B	A	B	A	B	A	B	
Dissolved Metals (mg/L)													
Aluminum (Al)	0.0102	0.0110	0.0163	0.0172	0.0147	0.0156	0.0177	0.0167	0.0060	0.0069	0.0135	0.0211	EQ
Antimony (Sb)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Arsenic (As)	<0.00010	<0.00010	<0.00010	0.00010	<0.00010	<0.00010	<0.00010	0.00010	<0.00010	<0.00010	0.00013	0.00017	
Barium (Ba)	0.0107	0.0108	0.0137	0.0138	0.00925	0.00943	0.0124	0.0125	0.0146	0.0139	0.0155	0.0176	
Beryllium (Be)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	
Bismuth (Bi)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Boron (B)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
Cadmium (Cd)	0.0000070	0.0000074	<0.0000050	0.0000051	<0.0000050	0.0000052	<0.0000050	<0.0000050	0.0000095	<0.0000050	<0.0000050	<0.0000050	EQ
Calcium (Ca)	6.80	7.02	7.05	7.23	6.24	5.94	6.17	6.15	8.29	8.25	8.04	7.94	
Chromium (Cr)	<0.00010	<0.00010	<0.00010	0.00021	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Cobalt (Co)	<0.00010	<0.00010	0.00015	0.00015	<0.00010	<0.00010	0.00016	0.00016	0.00015	0.00013	0.00017	0.00018	
Copper (Cu)	0.00027	0.00028	0.00033	0.00034	0.00042	0.00061	0.00051	0.00049	0.00024	0.00026	0.00029	0.00046	
Iron (Fe)	0.112	0.105	0.871	0.882	0.074	0.066	0.678	0.660	0.042	0.040	0.733	1.28	0.35
Lead (Pb)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Lithium (Li)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	
Magnesium (Mg)	1.02	0.99	1.08	1.13	0.89	0.86	0.95	0.96	1.17	1.13	1.12	1.27	
Manganese (Mn)	0.0157	0.0148	0.0777	0.0802	0.0116	0.0117	0.0722	0.0721	0.0259	0.0249	0.105	0.121	
Mercury (Hg)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	
Molybdenum (Mo)	0.000467	0.000432	0.000468	0.000502	0.000477	0.000470	0.000423	0.000436	0.000350	0.000376	0.000401	0.000427	
Nickel (Ni)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	
Phosphorus (P)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	
Potassium (K)	0.90	0.86	0.92	0.95	0.84	0.83	0.89	0.88	1.12	1.10	1.04	1.18	
Selenium (Se)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	
Silicon (Si)	7.08	7.49	6.86	7.05	5.98	6.17	6.14	6.07	6.93	6.78	6.78	7.02	
Silver (Ag)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	
Sodium (Na)	1.85	1.76	1.68	1.72	1.55	1.54	1.53	1.53	2.08	2.05	1.75	2.00	
Strontium (Sr)	0.0375	0.0363	0.0353	0.0360	0.0325	0.0306	0.0319	0.0321	0.0461	0.0457	0.0442	0.0447	
Sulfur (S)	1.31	1.43	1.27	1.26	1.15	0.99	0.97	0.91	2.07	1.92	1.69	1.79	
Thallium (Tl)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	
Tin (Sn)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	
Titanium (Ti)	<0.00030	<0.00030	0.00042	0.00045	<0.00030	<0.00030	0.00034	0.00032	<0.00030	<0.00030	0.00033	<0.00090	
Uranium (U)	0.000010	0.000011	0.000011	0.000014	0.000013	0.000013	0.000011	0.000012	<0.000010	<0.000010	0.000011	0.000014	
Vanadium (V)	<0.00050	<0.00050	0.00062	0.00063	<0.00050	<0.00050	0.00059	0.00057	<0.00050	<0.00050	0.00060	0.00102	
Zinc (Zn)	<0.0010	0.0014	0.0018	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0010	0.0013	0.0016	<0.0010	
Zirconium (Zr)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	

EQ indicates that the applicable guideline is an equation as per MOE (2018).

Yellow shading indicates exceedance of the short term (maximum) BC WQG.

Dissolved metals results for November 2016 are not available due to an error where samples were not filtered prior to analysis.

1.4. Quality Assurance/Quality Control

Table 11. Duplicate relative % difference (RPD) for lab samples collected in 2017.

Parameter	Method Detection Limit	Date Sampled	Sample Site	Replicate A	Replicate B	Relative % Difference
Aluminum (Al) - Dissolved	0.001	13-Sep-2017	ALE-BDGWQ	0.0135	0.0211	43.9
Aluminum (Al) - Total	0.003	13-Sep-2017	ALE-USWQ1	0.0154	0.0245	45.6
Chromium (Cr) - Total	0.0001	5-Mar-2017	ALE-BDGWQ	0.00014	0.00069	133
Iron (Fe) - Dissolved	0.01	13-Sep-2017	ALE-BDGWQ	0.733	1.28	54.3
Turbidity (lab, NTU)	0.1	5-Mar-2017	ALE-USWQ1	4.46	0.53	158
Turbidity (lab, NTU)	0.1	5-Jun-2017	ALE-BDGWQ	2.78	2.13	26.5

RPD is calculated as follows: (difference of two replicates/average of two replicates)*100. This metric is only calculated if the analytical results are >5x the MDL.

Table 12. Triplicate relative standard deviation (RSD) for lab samples collected in 2013, 2014, and 2016, and *in-situ* samples collected during all years.

Parameter	Method Detection Limit	Date Sampled	Sample Site	Mean	SD	Relative Standard Deviation
Aluminum (Al) - Total	0.003	27-Feb-2014	ALE-USWQ1	0.0424	0.0458	108
Arsenic (As) - Total	0.0001	16-Sep-2013	ALE-USWQ	0.0006	0.00068	110
Iron (Fe) - Total	0.01	27-Feb-2014	ALE-USWQ1	1.45	1.87	129
Manganese (Mn) - Total	0.00005	27-Feb-2014	ALE-USWQ1	0.0753	0.0466	61.9
Molybdenum (Mo) - Total	0.00005	27-Feb-2014	ALE-USWQ1	0.0005	9.8E-05	19.6
Specific Conductivity (In Situ, µS/cm)	NA	16-Sep-2013	ALE-BDGWQ	55.0	15.6	28.3
Total Phosphate	0.002	08-Jul-2013	ALE-BDGWQ	0.0109	0.00237	21.7
Total Suspended Solids	1	16-Sep-2013	ALE-BDGWQ	7.20	1.54	21.4
Turbidity (lab, NTU)	0.1	08-Jul-2013	ALE-BDGWQ	3.42	0.673	19.6
Turbidity (lab, NTU)	0.1	16-Sep-2013	ALE-BDGWQ	7.05	1.45	20.6
Turbidity (lab, NTU)	0.1	27-Feb-2014	ALE-USWQ1	1.39	0.842	60.4

RSD is calculated as SD/Mean*100. The metric is only calculated if the analytical results are >5x the MDL.

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Appendix E. Water Temperature Guidelines and Data

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1. WATER TEMPERATURE GUIDELINES AND FISH PERIODICITY

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

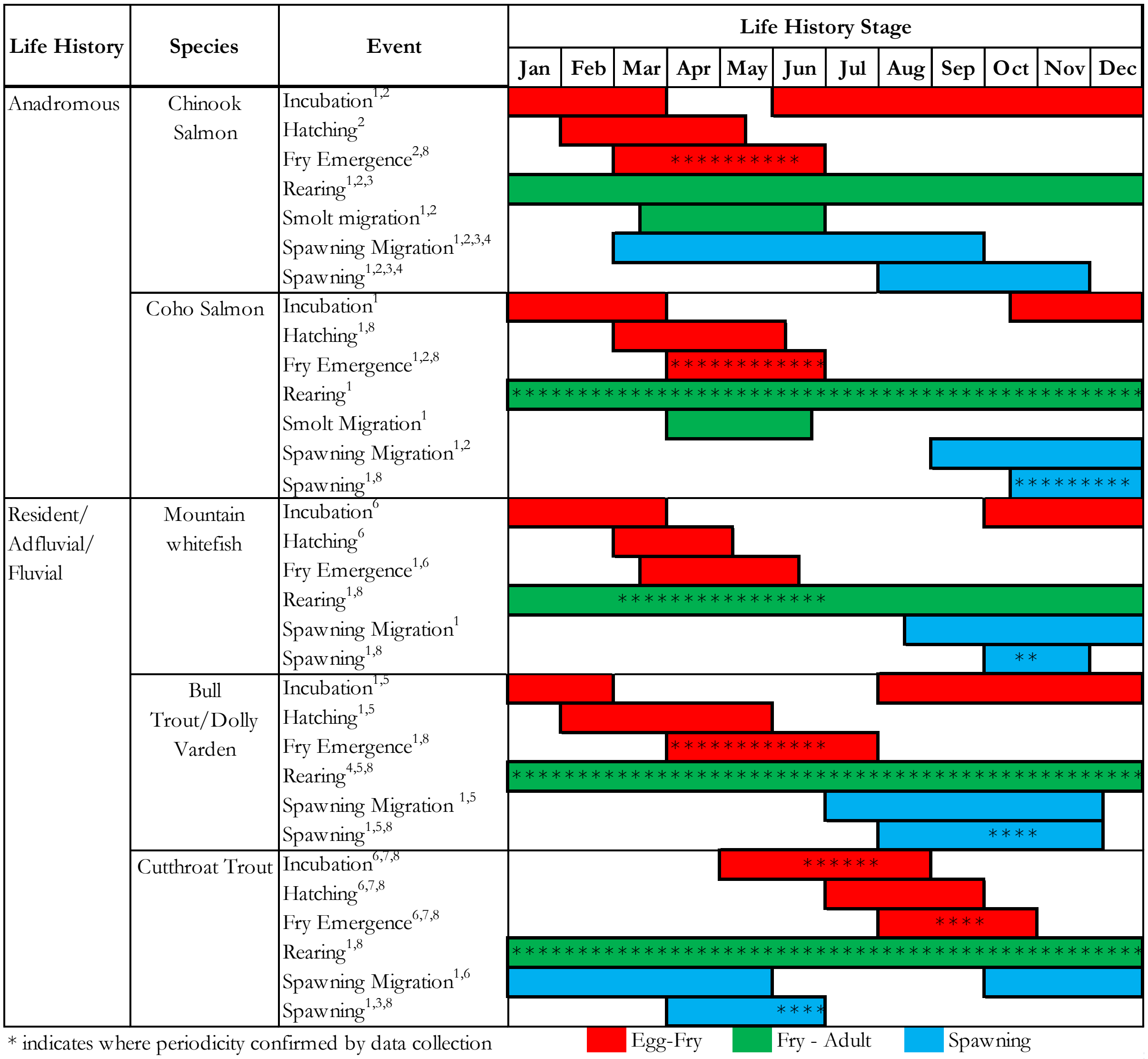
Category	Guideline[1]
All Streams	the rate of temperature change in natural water bodies not to exceed 1°C/hr
	temperature metrics to be described by the mean weekly maximum temperature (MWMxT)
Streams with Known Fish Presence	mean weekly maximum water temperatures should not exceed ±1°C beyond the optimum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

Table 2. Optimum water temperature ranges of specific life history stages of Coho Salmon, Cutthroat Trout and Bull Trout for MWMxT guideline application (modified from Oliver and Fidler 2001).

Species	Optimum Water Temperature (ºC) Range by Life History Stage			
	Incubation	Rearing	Migration	Spawning
Coho Salmon	4.0-13.0	9.0-16.0	7.2-15.6	4.4-12.8
Cutthroat Trout	9.0-12.0	7.0-16.0	—	9.0-12.0
Bull Trout	2.0-6.0	6.0-14.0	—	5.0-9.0

Table 3. Fish life history and periodicity for species present in the Upper Lillooet River (Faulkner *et al.* 2011).



Life History	Species	Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anadromous	Chinook Salmon	Incubation[1,2]	🟥	🟥	🟥			🟥	🟥	🟥	🟥	🟥	🟥	🟥
		Hatching[2]		🟥	🟥	🟥	🟥							
		Fry Emergence[2,8]			🟥	🟥*	🟥*	🟥*						
		Rearing[1,2,3]	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
		Smolt migration[1,2]			🟩	🟩	🟩	🟩						
		Spawning Migration[1,2,3,4]			🟦	🟦	🟦	🟦	🟦	🟦				
		Spawning[1,2,3,4]								🟦	🟦	🟦	🟦	
	Coho Salmon	Incubation[1]	🟥	🟥	🟥							🟥	🟥	🟥
		Hatching[1,8]			🟥	🟥	🟥	🟥						
		Fry Emergence[1,2,8]				🟥*	🟥*	🟥*						
		Rearing[1]	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*
		Smolt Migration[1]				🟩	🟩	🟩						
		Spawning Migration[1,2]									🟦	🟦	🟦	🟦
		Spawning[1,8]										🟦*	🟦*	🟦*
Resident/ Adfluvial/ Fluvial	Mountain whitefish	Incubation[6]	🟥	🟥	🟥							🟥	🟥	🟥
		Hatching[6]			🟥	🟥	🟥							
		Fry Emergence[1,6]			🟥	🟥	🟥	🟥						
		Rearing[1,8]	🟩	🟩	🟩*	🟩*	🟩*	🟩*	🟩	🟩	🟩	🟩	🟩	🟩
		Spawning Migration[1]								🟦	🟦	🟦	🟦	🟦
		Spawning[1,8]										🟦*	🟦*	
	Bull Trout/Dolly Varden	Incubation[1,5]	🟥	🟥						🟥	🟥	🟥	🟥	🟥
		Hatching[1,5]		🟥	🟥	🟥	🟥							
		Fry Emergence[1,8]				🟥*	🟥*	🟥*	🟥					
		Rearing[4,5,8]	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*
		Spawning Migration [1,5]							🟦	🟦	🟦	🟦	🟦	🟦
		Spawning[1,5,8]								🟦	🟦	🟦*	🟦	🟦
	Cutthroat Trout	Incubation[6,7,8]					🟥	🟥*	🟥*	🟥				
		Hatching[6,7,8]							🟥	🟥	🟥			
		Fry Emergence[6,7,8]								🟥	🟥*	🟥		
		Rearing[1,8]	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*	🟩*
		Spawning Migration[1,6]	🟦	🟦	🟦	🟦	🟦					🟦	🟦	🟦
		Spawning[1,3,8]				🟦	🟦	🟦*						

* indicates where periodicity confirmed by data collection

🟥 Egg-Fry 🟩 Fry - Adult 🟦 Spawning

1 McPhail 2007
2 Groot and Margolis 1991
3 Scott and Crossman 1973
4 DFO 2011b
5 Lewis et al. 2006
6 Ford et al. 1995
7 Province of BC 2010
8 Ecofish field observations

2. WATER TEMPERATURE DATA

Figure 1. **Pre-construction water temperature at ALE-USWQ1 from 2013 to 2014. Temperature data are shown at 60 min intervals.**

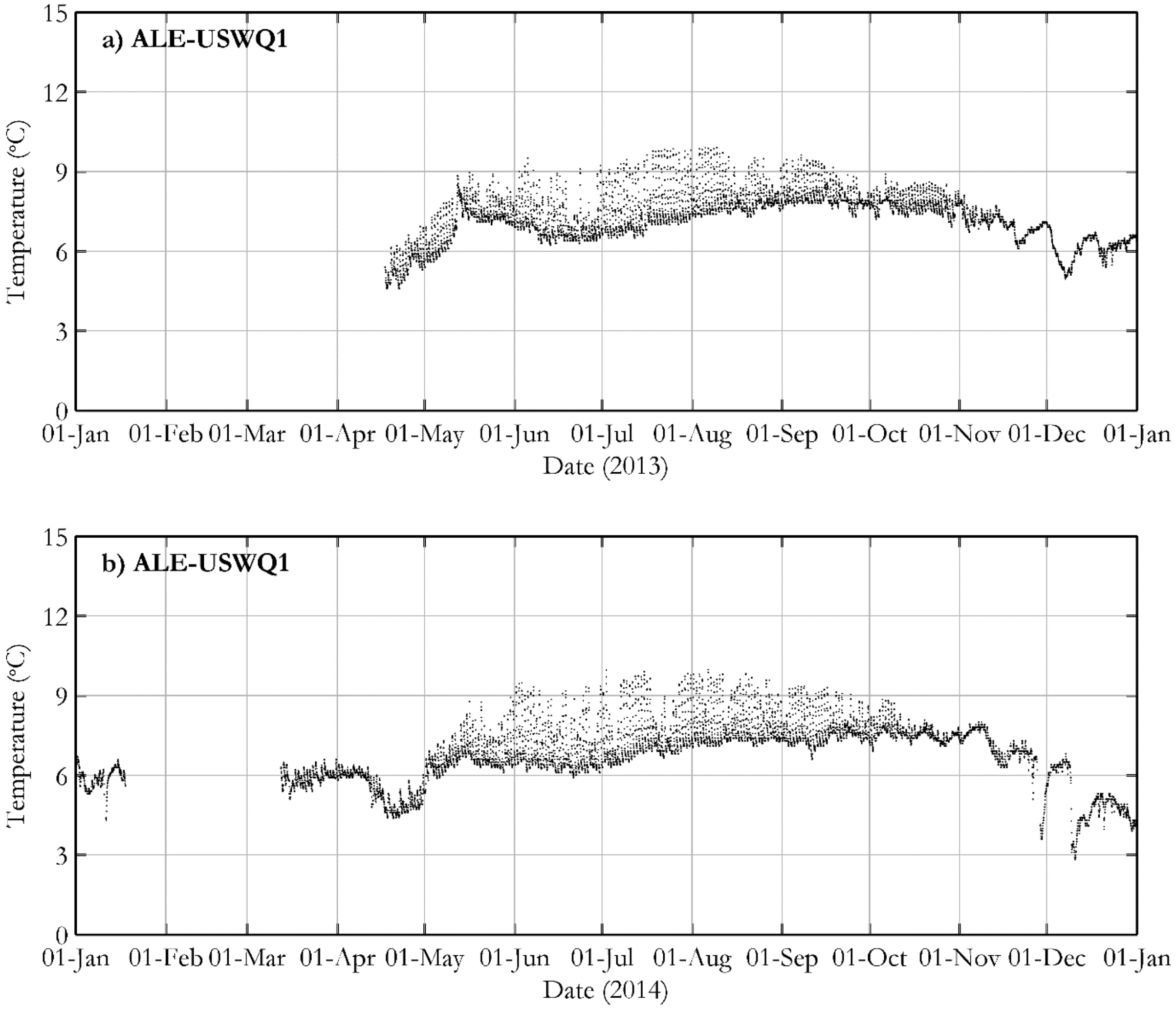


Figure 2. Post-construction water temperature at ALE-USWQ1 from November 2016 to November 2017. Temperature data are shown at 15 min intervals.

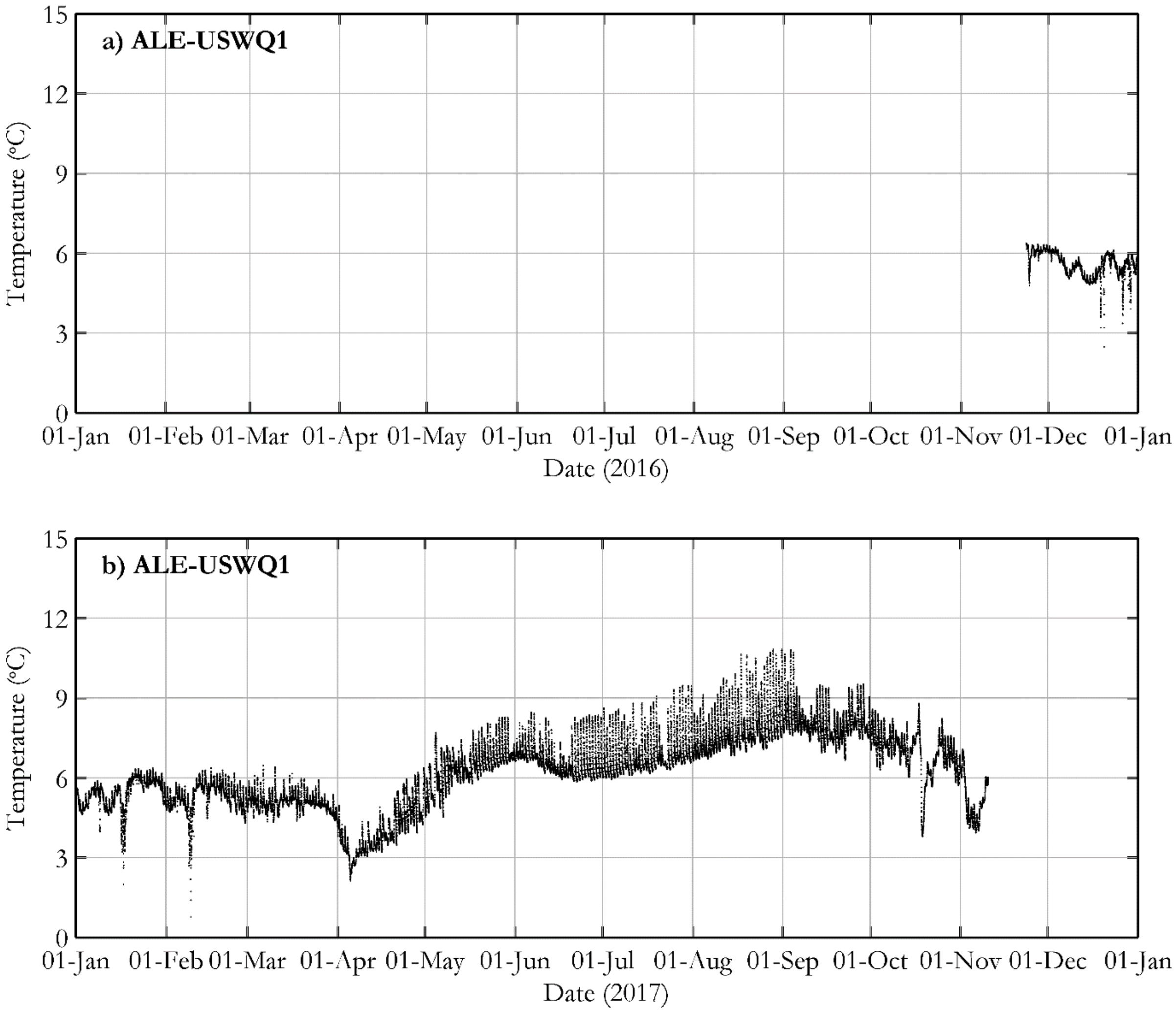


Figure 3. **Pre-construction water temperature at ALE-BDGWQ from 2013 to 2014. Temperature data are shown at 60 min intervals.**

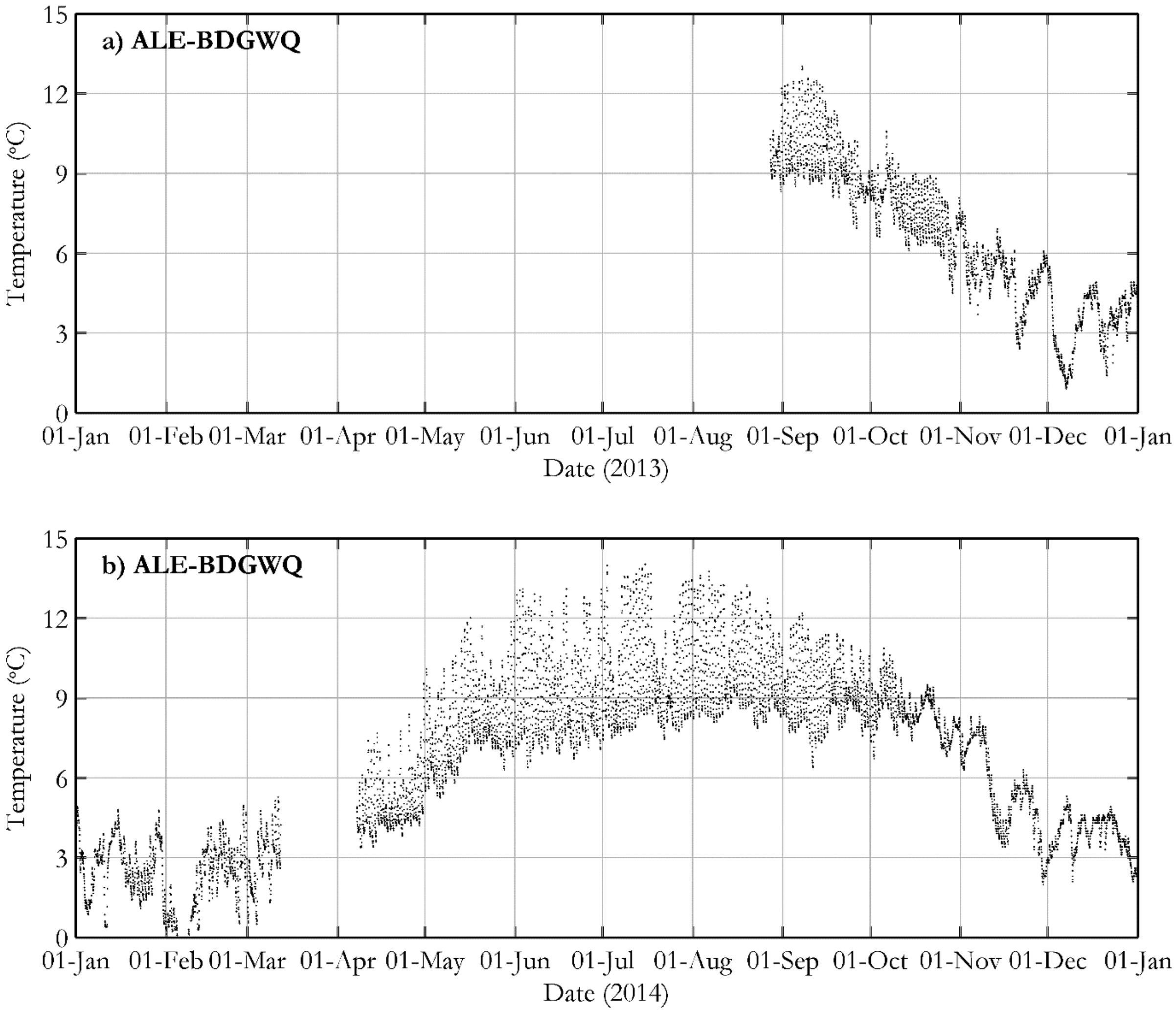
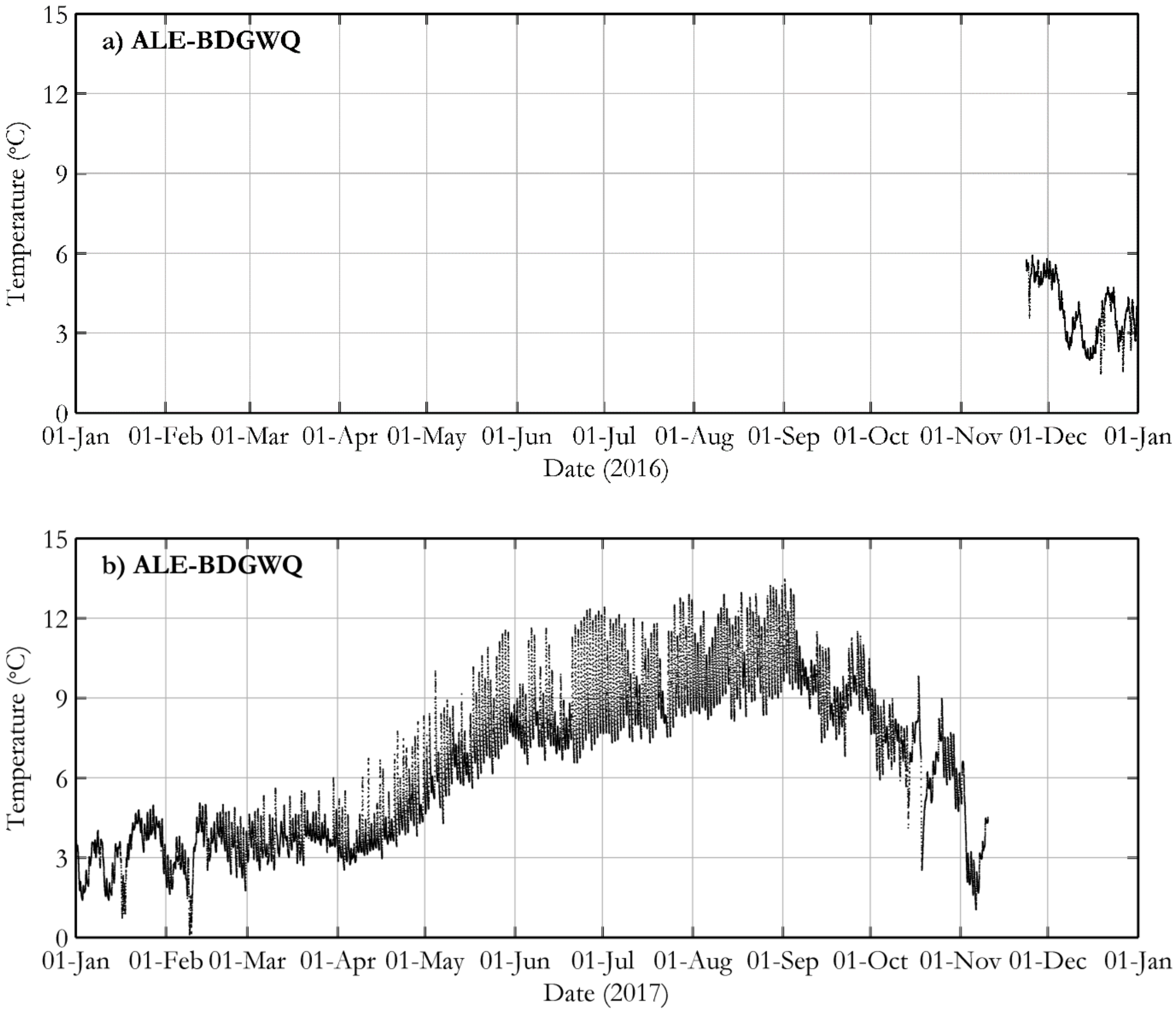
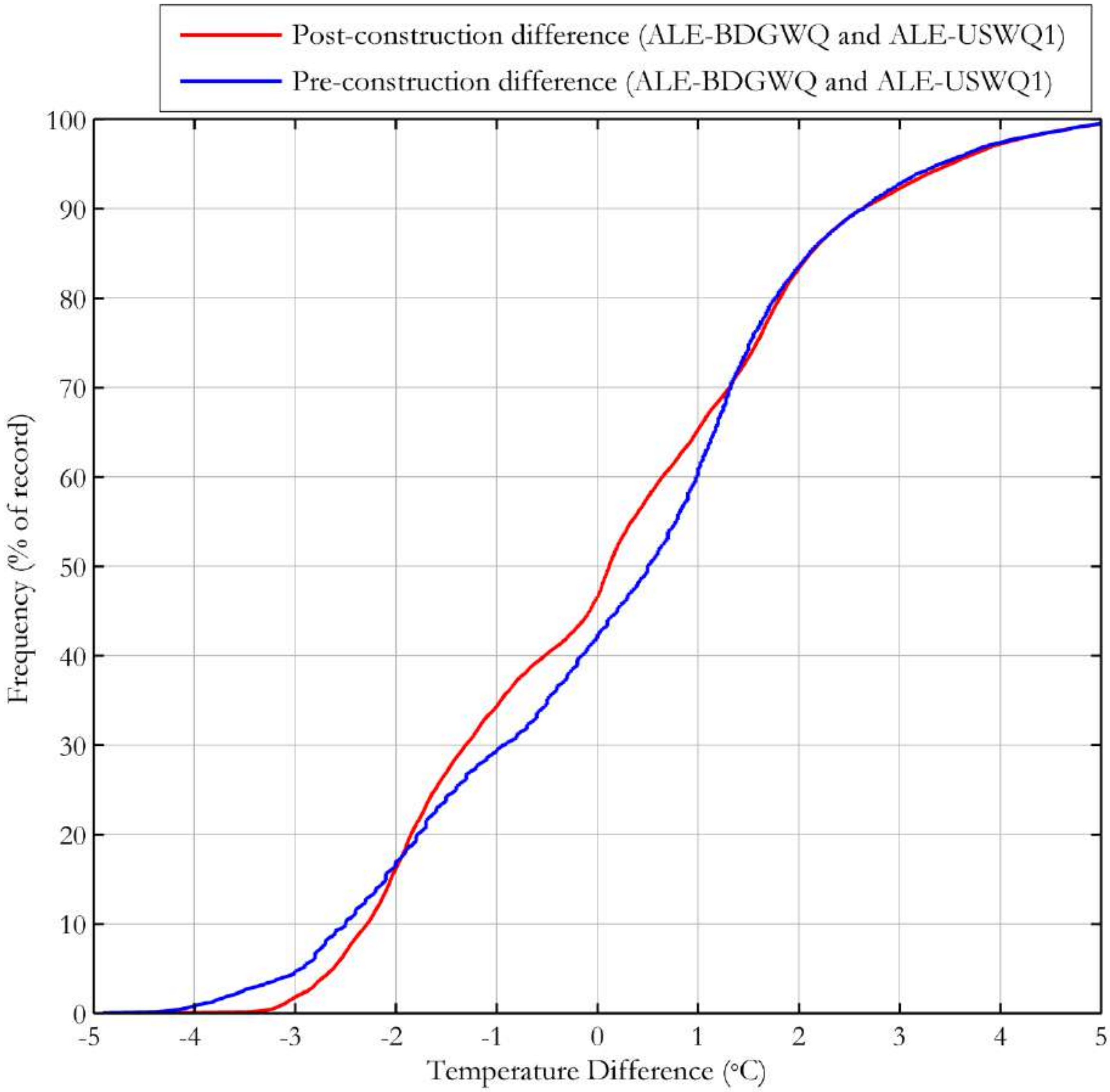


Figure 4. **Post-construction water temperature at ALE-BDGWQ from November 2016 to November 2017. Temperature data are shown at 15 min intervals.**



3. INTER-STATION COMPARISON

Figure 5. **Cumulative frequency distribution of differences in pre- and post-construction (blue and red line) instantaneous water temperature between a site at bridge (ALE-BDGWQ) and an upstream site (ALE-USWQ1) (positive values indicate colder temperatures at ALE-USWQ1).**



4. MONTHLY STATISTICS

Table 4. Pre-construction monthly statistics for water temperature observed at monitoring sites in Alena Creek from 2013 to 2014. "Avg", "Min", "Max", and "SD" denote the monthly- average, minimum, maximum and standard deviation of water temperatures (°C). Blue and red shadings highlight minimum and maximum temperatures, respectively.

Year	Month	Water Temperature[1] (°C)							
		ALE-USWQ1				ALE-BDGWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2013	Apr	-	-	-	-	-	-	-	-
	May	7.2	5.4	9.0	0.8	-	-	-	-
	Jun	7.0	6.2	9.5	0.6	-	-	-	-
	Jul	7.6	6.5	9.9	0.9	-	-	-	-
	Aug	8.0	7.3	9.9	0.6	-	-	-	-
	Sep	8.1	7.3	9.6	0.4	9.6	6.9	13.0	1.2
	Oct	7.8	6.9	8.9	0.3	7.5	4.5	10.6	1.0
	Nov	7.0	6.1	8.1	0.4	5.2	2.4	7.6	1.0
	Dec	6.1	5.0	7.1	0.5	3.4	0.9	5.5	1.1
2014	Jan	5.8	4.2	6.5	0.5	2.7	0.4	4.9	1.1
	Feb	-	-	-	-	2.2	0.0	5.0	1.2
	Mar	-	-	-	-	-	-	-	-
	Apr	5.4	4.4	6.4	0.6	5.0	3.4	9.6	1.1
	May	6.7	5.3	8.9	0.6	7.9	5.3	12.0	1.4
	Jun	7.0	5.9	9.5	0.8	9.1	6.4	13.1	1.6
	Jul	7.4	6.3	10.0	0.9	9.9	7.4	14.0	1.7
	Aug	7.9	7.1	10.0	0.7	10.1	7.9	13.8	1.4
	Sep	7.7	6.6	9.4	0.5	9.2	6.4	12.2	1.1
	Oct	7.6	6.9	8.9	0.3	8.4	6.7	10.9	0.8
	Nov	6.9	3.6	8.1	0.9	5.4	2.0	8.3	1.6
	Dec	5.0	2.8	6.8	0.9	3.8	2.1	5.3	0.7

[1] Statistics based on hourly data and were not generated for months with less than three weeks of data.

Table 5. **Post-construction monthly statistics for water temperature observed at monitoring stations in Alena Creek from November 2016 to November 2017. "Avg", "Min", "Max", and "SD" denote the monthly- average, minimum, maximum and standard deviation of water temperatures (°C). Blue and red shadings highlight minimum and maximum temperatures, respectively.**

Year	Month	Water Temperature[1] (°C)							
		ALE-USWQ1[†]				ALE-BDGWQ[†]			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2016	Nov	-	-	-	-	-	-	-	-
	Dec	5.5	2.5	6.3	0.4	3.5	1.5	5.7	0.9
2017	Jan	5.4	2.0	6.4	0.5	3.2	0.7	5.0	1.0
	Feb	5.3	0.8	6.4	0.5	3.2	0.1	5.1	0.9
	Mar	5.1	4.3	6.5	0.3	3.8	2.5	6.0	0.6
	Apr	4.0	2.1	6.4	0.9	4.3	2.5	8.3	1.1
	May	6.4	4.5	8.3	0.7	7.3	4.3	11.5	1.4
	Jun	6.7	5.8	8.5	0.6	8.5	6.5	12.3	1.4
	Jul	6.9	5.9	9.5	0.8	9.5	7.3	12.9	1.4
	Aug	7.9	6.6	10.8	0.9	10.4	8.1	13.2	1.3
	Sep	8.1	6.7	10.8	0.7	9.7	6.8	13.5	1.1
	Oct	6.9	3.8	8.8	0.8	6.9	2.5	9.8	1.2
	Nov	-	-	-	-	-	-	-	-

[1] Statistics based on 15 minutes data and were not generated for months with less than three weeks of data.

[†] Post-construction water temperature Tidbit monitoring commenced on November 23, 2016.

5. BULL TROUT/DOLLY VARDEN WATER TEMPERATURE GUIDELINES

Table 6. Comparison between provincial water temperature guidelines specific to Bull Trout and/or Dolly Varden and observed instantaneous water temperature at ALE-USWQ1 and ALE-BDGWQ under pre and post-construction conditions.

Site	Life Stage (Bull Trout)	Optimum Temperature (°C)	Project Phase	Year	Instantaneous Temperature (°C)	
					Min	Max
ALE-USWQ1	Spawning (Aug. 01 to Dec. 08)	10	Pre-construction	2013	-	9.9
				2014	-	10.0
			Post-construction	2016	-	6.4
				2017	-	10.8
	Incubation (Aug. 01 to Mar. 01)	2-10	Pre-construction	2013	4.3	9.9
				2014	2.8	10.0
			Post-construction	2016	0.8	6.4
				2017	3.8	10.8
ALE-BDGWQ	Spawning (Aug. 01 to Dec. 08)	10	Pre-construction	2013	-	13.0
				2014	-	13.8
			Post-construction	2016	-	5.9
				2017	-	13.5
	Incubation (Aug. 01 to Mar. 01)	2-10	Pre-construction	2013	0.0	13.0
				2014	2.0	13.8
			Post-construction	2016	0.1	5.9
				2017	1.0	13.5

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Appendix F. Photographs of Alena Creek Fish Habitat Enhancement Project Stability Assessment Year 1 Monitoring

LIST OF FIGURES

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

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

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

a) Looking upstream.

c) Looking RR-RL.

b) Looking downstream.

d) Looking RL-RR.

Figure 3. ALE-XS2 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 4. ALE-XS2 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 5. ALE-XS3 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 6. ALE-XS3 on November 10, 2017.

a) Looking upstream.

c) Looking RR-RL.

b) Looking downstream.

d) Looking RL-RR.

Figure 7. ALE-XS4 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 8. ALE-XS4 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 9. ALE-XS5 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 10. ALE-XS5 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 11. ALE-XS6 on September 19, 2016.

a) Looking upstream.

c) Looking RR-RL.

b) Looking downstream.

d) Looking RL-RR.

Figure 12. ALE-XS6 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 13. ALE-XS7 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 14. ALE-XS7 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 15. ALE-XS8 on September 19, 2016.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Figure 16. ALE-XS8 on November 10, 2017.

a) Looking upstream.

b) Looking downstream.

c) Looking RR-RL.

d) Looking RL-RR.

Appendix G. FHAP Summary

LIST OF TABLES

Table 1. FHAP Survey Results.

Unit	Habitat				Mean Depth				Mean Width		Pools Only				Bed Material[1]			Cover Type[3]				Off-channel Habitat		Disturbance	Riparian Vegetation			Barrier[9]
	Type	Category	Length (m)	Gradient (%)	Bankfull (m)	Water (m)	Water (m)	Water (m)	Bankfull (m)	Wetted (m)	Max. Depth (m)	Crest (m)	Residual (m)	Pool Type	Dom.	Sub-Dom.	Spawning Gravel?[2]	Cover Type	%	Cover Type	%	Type[4]	Length (m)	Indicators[5]	Type[6]	Structure[7]	Canopy Closure[8]	
1	Run	Primary	57	1.0	0.37	0.15	0.23	0.25	4.8	3.8					GR	CO	AR	LWD	30						D	SHR	1	N
2	Pool	Primary	10	0.2	1.20	0.70	0.65	0.60	5.5	4.8	0.80	0.15	0.60	unk	S/FI			LWD	10	DP	20	WL	10		D	SHR	1	N
3	Riffle	Primary	48	1.0	0.32	0.10	0.21	0.15	5.0	3.5					GR	CO	AR	LWD	40	OV	10				D	SHR	1	N
4	Glide	Primary	90	0.5	0.55	0.18	0.10	0.27	2.8	2.0					S/FI	GR	AR	LWD	40	OV	20	SC			D	PS	2	N
5	Riffle	Primary	10	1.0	0.47	0.12	0.07	0.13	2.5	1.9					GR	S/FI	AR	LWD	10						D	PS	1	N
6	Pool	Primary	10	0.2	0.80	0.61	0.59	0.58	8.0	6.1	0.61	0.11	0.40	unk	S/FI	GR	AR	LWD	20	DP	20	SC			D	PS	1	N
7	Run	Primary	10	1.0	0.35	0.17	0.09	0.15	4.0	3.2					GR	CO	AR	LWD	30						D	PS	1	N
8	Glide	Primary	79	0.5	0.80	0.30	0.52	0.44	4.2	3.5					S/FI	GR	AR	LWD	30	OV	30	SC	10		D	PS	2	N
9	Run	Primary	21	1.5	0.55	0.40	0.25	0.31	3.5	2.8					S/FI	GR	R	LWD	20	OV	30				D	PS	1	N
10	Glide	Primary	16	0.5	1.30	0.56	0.10	0.69	5.5	4.0					S/FI			OV	10	LWD	10	SC			D	PS	1	N
11	Pool	Primary	33	0.1	2.50	2.00	2.00	1.80	30.0	30.0					S/FI			DP	50	LWD	50				D	PS	1	BD
12	Glide	Primary	201	0.1	1.50	0.80	0.64	0.55	6.5	6.0					S/FI		AR	OV	20	LWD	10				D	PS	3	BD
13	Riffle	Primary	30	1.0	0.45	0.20	0.33	0.17	3.8	2.2					S/FI	GR	AR	OV	40	LWD	20				D	PS	3	N
14	Glide	Primary	51	0.5	0.73	0.29	0.46	0.40	2.9	2.3					S/FI	GR	AR	LWD	20	OV	20				D	PS	3	N
15	Riffle	Primary	19	1.0	0.75	0.22	0.29	0.30	1.5	1.1					S/FI	GR	AR	OV	50	CU	10				D	PS	2	N
16	Glide	Primary	13	0.1	1.20	0.80	0.80	0.70	2.1	2.0					S/FI			CU	50	OV	50				D	SHR	2	N
17	Riffle	Primary	49	1.5	0.53	0.15	0.18	0.18	2.4	1.9					GR	S/FI	R	OV	20	LWD	20	SC			D	SHR	1	N
18	Pool	Primary	136	0.5	2.70	0.62	2.00	3.00	13.0	12.0					S/FI			LWD	20	DP	50	SC			D	PS	1	N
19	Glide	Secondary	16	0.5	0.45	0.12	0.20	0.19	3.0	2.8					S/FI	GR	R	LWD	10			SC			S	SHR	1	BD
20	Riffle	Primary	161	1.5	0.50	0.20	0.17	0.32	2.7	1.7					GR	CO	AR	LWD	25			SC			S	SHR	1	N
21	Glide	Primary	35	0.5	0.61	0.20	0.06	0.14	2.1	1.1					GR	S/FI	R	LWD	10	OV	30	SC	40		D	PS	2	N
22	Pool	Primary	35	0.5	0.80	0.34	0.58	0.28	12.0	10.0					GR	S/FI	R	DP	20	LWD	25				D	SHR	1	N
23	Pool	Primary	42	0.1	0.75	0.48	0.54	0.38	25.0	20.0					GR	S/FI	AR	IV	70	LWD	10				S	SHR	1	N
24	Pool	Primary	77	0.1	1.30	0.67	0.72	1.05	30.0	25.0					GR	S/FI	AR	IV	70	DP	20				S	SHR	1	N
25	Pool	Primary	79	0.1	0.85	0.68	0.57	0.77	35.0	21.0					S/FI	GR	R	IV	60	DP	20				M	SHR	1	N
3a	Pool	Tertiary	8	0.2	0.82	0.57	0.61	0.48	5.0	3.5	0.7	0.11	0.6	unk	S/FI			LWD	10						D	SHR	1	N

[1] F = Fines, G = Gravels, C = Cobbles, B = Boulders, R = Rock, A = Anthropogenic. [2] R = suitable for resident trout and char, AR = suitable for both resident trout and anadromous salmon. [3] SWD = Small Woody Debris, LWD = Large Woody Debris, B = Boulders, CU = Undercut Banks, DP = Deep Pools, OV = Overhanging Vegetation, IV = Instream Vegetation. [4] SC = Side channel, SL = Slough, WL = Wetland. [5] BC = Isolated sidechannels or backchannels, MC = Multiple channels (braiding), JM = Recently formed LWD jams. [6] S = Shrub, D = Deciduous. [7] SHR = Shrub/herb, PS = Pole-sapling. [8] 0 = 0%, 1 = 1-20%, 3 = 41-70%, 4 = 71-90%, 5 = >90%. [9] N = No barriers.

Appendix H. FHAP Photographs

LIST OF FIGURES

Figure 1. Looking upstream at Unit 1 on October 3, 2017.

Figure 2. Looking downstream at Unit 1 on October 3, 2017.

Figure 3. Looking upstream at Unit 2 on October 3, 2017.

Figure 4. Looking downstream at Unit 2 on October 3, 2017.

Figure 5. Looking upstream at Unit 3 on October 3, 2017.

Figure 6. Looking downstream at Unit 3 on October 3, 2017.

Figure 7. Looking upstream at Tertiary Unit 3a on October 3, 2017.

Figure 8. Looking downstream at Tertiary Unit 3a on October 3, 2017.

Figure 9. **Looking upstream at Unit 4 on October 3, 2017.**

Figure 10. **Looking downstream at Unit 4 on October 3, 2017.**

Figure 11. Looking upstream at Unit 5 on October 3, 2017.

Figure 12. Looking downstream at Unit 5 on October 3, 2017.

Figure 13. Looking upstream at Unit 6 on October 3, 2017.

Figure 14. Looking river right to river left at Unit 6 on October 3, 2017.

Figure 15. Looking downstream at Unit 7 on October 3, 2017.

Figure 16. Looking river right to river left at Unit 7 on October 3, 2017.

Figure 17. Looking upstream at Unit 8 on October 3, 2017.

Figure 18. Looking downstream at Unit 8 on October 3, 2017.

Figure 19. Looking upstream at Unit 9 on October 3, 2017.

Figure 20. Looking downstream at Unit 9 on October 3, 2017.

Figure 21. Looking upstream at Unit 10 on October 3, 2017.

Figure 22. Looking downstream at Unit 10 on October 3, 2017.

Figure 23. Looking upstream at Unit 11 on October 3, 2017.

Figure 24. Looking downstream at Unit 11 on October 3, 2017.

Figure 25. Looking upstream at Unit 12 on October 3, 2017.

Figure 26. Looking downstream at Unit 12 on October 3, 2017.

Figure 27. Looking upstream at Unit 13 on October 3, 2017.

Figure 28. Looking downstream at Unit 13 on October 3, 2017.

Figure 29. Looking upstream at Unit 14 on October 3, 2017.

Figure 30. Looking from river right to river left at Unit 14 on October 3, 2017.

Figure 31. Looking upstream at Unit 15 on October 3, 2017.

Figure 32. Looking downstream at Unit 15 on October 3, 2017.

Figure 33. Looking upstream at Unit 16 on October 3, 2017.

Figure 34. Looking downstream at Unit 16 on October 3, 2017.

Figure 35. Looking upstream at Unit 17 on October 3, 2017.

Figure 36. Looking downstream at Unit 17 on October 3, 2017.

Figure 37. Looking upstream at Unit 18 on October 3, 2017.

Figure 38. Looking downstream at Unit 18 on October 3, 2017.

Figure 39. Looking upstream at Unit 19 on October 3, 2017.

Figure 40. Looking downstream at Unit 19 on October 3, 2017.

Figure 41. Looking upstream at Unit 20 on October 3, 2017.

Figure 42. Looking downstream at Unit 20 on October 3, 2017.

Figure 43. Looking upstream at Unit 21 on October 3, 2017.

Figure 44. Looking downstream at Unit 21 on October 3, 2017.

Figure 45. Looking upstream at Unit 22 on October 3, 2017.

Figure 46. Looking downstream at Unit 22 on October 3, 2017.

Figure 47. Looking upstream at Unit 23 on October 3, 2017.

Figure 48. Looking downstream at Unit 23 on October 3, 2017.

Figure 49. Looking upstream at Unit 24 on October 3, 2017.

Figure 50. Looking downstream at Unit 24 on October 3, 2017.

Figure 51. Looking upstream at Unit 25 on October 3, 2017.

Figure 52. Looking downstream at Unit 25 on October 3, 2017.

Appendix I. Raw Data Tables and Representative Photographs from Minnow Trap Sampling

LIST OF FIGURES

LIST OF TABLES

1. ADULT SPAWNER ABUNDANCE

Table 1. Number of Coho Salmon observed during fall spawner surveys in 2010.

	Sampling Event 1 (Nov 4, 2010)		Sampling Event 2 (Nov 5, 2010)		Sampling Event 3 (Nov 23, 2010)		Sampling Event 4 (Dec 7, 2010)	
	Live	**Dead**	**Live**	**Dead**	**Live**	**Dead**	**Live**	**Dead**
	21	4	102	0	8	67	1	1
Total	**25**		**102**		**75**		**2**	

Table 2. Number of Coho Salmon observed during fall spawner surveys in 2011.

	Sampling Event 1 (Oct 3, 2011)		Sampling Event 2 (Nov 16, 2011)		Sampling Event 3 (Nov 27, 2011)	
	Live	**Dead**	**Live**	**Dead**	**Live**	**Dead**
	0	0	0	0	110	1
Total	**0**		**0**		**111**	

2. JUVENILE ABUNDANCE

Table 3. Minnow trapping habitat and catch in Alena Creek during 2017 sampling.

Site	Date	Trap #	Mesh Size (mm)	Date In	Time In	Date Out	Time Out	Habitat	Trap Depth (m)	Soak Time (hrs)	Catch[1]		
											CO	CT	BT
ALE-MT01	27-Sep-17	1	3	27-Sep-17	10:31:00	28-Sep-17	09:58:00	Riffle	0.41	23.5	1	0	0
ALE-MT01	27-Sep-17	2	3	27-Sep-17	10:31:00	28-Sep-17	10:00:00	Riffle	0.32	23.5	0	0	0
ALE-MT01	27-Sep-17	3	6	27-Sep-17	10:32:00	28-Sep-17	10:00:00	Riffle	0.32	23.5	5	1	0
ALE-MT01	27-Sep-17	4	3	27-Sep-17	10:32:00	28-Sep-17	09:58:00	Riffle	0.23	23.4	0	0	0
ALE-MT01	27-Sep-17	5	6	27-Sep-17	10:32:00	28-Sep-17	09:58:00	Riffle	0.35	23.4	0	0	0
ALE-MT02	27-Sep-17	1	3	27-Sep-17	10:50:00	28-Sep-17	10:28:00	Riffle	0.23	23.6	0	0	0
ALE-MT02	27-Sep-17	2	6	27-Sep-17	10:45:00	28-Sep-17	10:28:00	Riffle	0.43	23.7	0	0	0
ALE-MT02	27-Sep-17	3	6	27-Sep-17	10:50:00	28-Sep-17	10:30:00	Riffle	0.37	23.7	2	0	0
ALE-MT02	27-Sep-17	4	6	27-Sep-17	10:50:00	28-Sep-17	10:33:00	Riffle	0.46	23.7	9	0	0
ALE-MT02	27-Sep-17	5	6	27-Sep-17	10:50:00	28-Sep-17	10:33:00	Riffle	0.46	23.7	4	0	0
ALE-MT03	27-Sep-17	1	3	27-Sep-17	12:35:00	28-Sep-17	11:50:00	Glide	0.73	23.3	5	0	0
ALE-MT03	27-Sep-17	2	3	27-Sep-17	12:35:00	28-Sep-17	11:50:00	Glide	0.73	23.3	29	0	0
ALE-MT03	27-Sep-17	3	6	27-Sep-17	12:37:00	28-Sep-17	11:58:00	Glide	0.43	23.4	8	0	0
ALE-MT03	27-Sep-17	4	6	27-Sep-17	12:37:00	28-Sep-17	11:50:00	Glide	0.38	23.2	24	0	0
ALE-MT03	27-Sep-17	5	6	27-Sep-17	12:40:00	28-Sep-17	11:58:00	Glide	0.61	23.3	3	0	0
ALE-MT04	27-Sep-17	1	3	27-Sep-17	12:05:00	28-Sep-17	13:08:00	Riffle	0.25	25.1	4	0	0
ALE-MT04	27-Sep-17	2	6	27-Sep-17	12:00:00	28-Sep-17	13:08:00	Riffle	0.39	25.1	0	0	0
ALE-MT04	27-Sep-17	3	6	27-Sep-17	12:05:00	28-Sep-17	13:29:00	Riffle	0.28	25.4	8	0	0
ALE-MT04	27-Sep-17	4	3	27-Sep-17	12:05:00	28-Sep-17	13:15:00	Riffle	0.31	25.2	4	2	0
ALE-MT04	27-Sep-17	5	6	27-Sep-17	12:00:00	28-Sep-17	13:15:00	Riffle	0.3	25.3	2	0	0
ALE-MT05	27-Sep-17	1	3	27-Sep-17	13:23:00	28-Sep-17	14:30:00	Glide	0.83	25.1	1	0	0
ALE-MT05	27-Sep-17	2	3	27-Sep-17	13:25:00	28-Sep-17	14:30:00	Glide	0.3	25.1	1	0	0
ALE-MT05	27-Sep-17	3	6	27-Sep-17	13:25:00	28-Sep-17	14:50:00	Glide	0.41	25.4	2	0	0
ALE-MT05	27-Sep-17	4	6	27-Sep-17	13:20:00	28-Sep-17	14:50:00	Glide	0.45	25.5	5	2	0
ALE-MT05	27-Sep-17	5	3	27-Sep-17	13:20:00	28-Sep-17	14:59:00	Glide	0.46	25.7	4	0	0
ALE-MT06	27-Sep-17	1	3	27-Sep-17	11:28:00	28-Sep-17	15:39:00	Pool	1.5	28.2	1	0	0
ALE-MT06	27-Sep-17	2	6	27-Sep-17	11:35:00	28-Sep-17	15:39:00	Pool	0.43	28.1	0	0	0
ALE-MT06	27-Sep-17	3	6	27-Sep-17	11:28:00	28-Sep-17	15:45:00	Pool	1.48	28.3	2	0	0
ALE-MT06	27-Sep-17	4	6	27-Sep-17	11:20:00	28-Sep-17	15:50:00	Pool	1.1	28.5	7	0	0
ALE-MT06	27-Sep-17	5	6	27-Sep-17	11:33:00	28-Sep-17	15:45:00	Pool	0.52	28.2	4	0	0
ALE-MT06	27-Sep-17	6	6	27-Sep-17	11:32:00	28-Sep-17	15:50:00	Pool	1.5	28.3	1	0	0
ALE-MT06	27-Sep-17	7	6	27-Sep-17	11:35:00	28-Sep-17	15:35:00	Pool	0.71	28.0	0	0	0
ALE-MT06	27-Sep-17	8	6	27-Sep-17	11:30:00	28-Sep-17	15:40:00	Pool	1.02	28.2	3	1	1
ALE-MT06	27-Sep-17	9	3	27-Sep-17	11:30:00	28-Sep-17	15:40:00	Pool	1.35	28.2	1	1	0
ALE-MT06	27-Sep-17	10	3	27-Sep-17	11:32:00	28-Sep-17	15:40:00	Pool	1.27	28.1	2	0	0

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

Table 3. Continued.

Site	Date	Trap #	Species¹	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Mark Type	Mark Location	Recapture (Y/N)
ALE-MT01	27-Sep-17	1	CO	74	4.8	1.18	SC	2			0			No
ALE-MT01	27-Sep-17	2	NFC											
ALE-MT01	27-Sep-17	3	CO	58	2.2	1.13					0			No
ALE-MT01	27-Sep-17	3	CO	59	1.8	0.88					0			No
ALE-MT01	27-Sep-17	3	CO	68	2.9	0.92	SC	5			0			No
ALE-MT01	27-Sep-17	3	CO	69	3.2	0.97	SC	4			0			No
ALE-MT01	27-Sep-17	3	CO	81	6.1	1.15	SC	3			0			No
ALE-MT01	27-Sep-17	3	CT	112	14.5	1.03	SC	1			1			No
ALE-MT01	27-Sep-17	4	NFC											
ALE-MT01	27-Sep-17	5	NFC											
ALE-MT02	27-Sep-17	1	NFC											
ALE-MT02	27-Sep-17	2	NFC											
ALE-MT02	27-Sep-17	3	CO	56	2.1	1.2					0			
ALE-MT02	27-Sep-17	3	CO	62	3.4	1.43					0			
ALE-MT02	27-Sep-17	4	CO	44	0.9	1.06					0			
ALE-MT02	27-Sep-17	4	CO	49	1.8	1.53					0			
ALE-MT02	27-Sep-17	4	CO	50	1.7	1.36					0			
ALE-MT02	27-Sep-17	4	CO	55	2.2	1.32					0			
ALE-MT02	27-Sep-17	4	CO	56	1.7	0.97					0			
ALE-MT02	27-Sep-17	4	CO	56	2.2	1.25					0			
ALE-MT02	27-Sep-17	4	CO	57	1.7	0.92					0			
ALE-MT02	27-Sep-17	4	CO	58	1.5	0.77					0			
ALE-MT02	27-Sep-17	4	CO	73	4.4	1.13	SC	5			0			
ALE-MT02	27-Sep-17	5	CO	61	2.8	1.23	SC	2			0			
ALE-MT02	27-Sep-17	5	CO	67	3.4	1.13	SC	4			0			
ALE-MT02	27-Sep-17	5	CO	68	3.8	1.21	SC	3			0			
ALE-MT02	27-Sep-17	5	CO	78	5.5	1.16	SC	1			0			
ALE-MT03	27-Sep-17	1	CO	48	1.2	1.09					0			
ALE-MT03	27-Sep-17	1	CO	49	1.8	1.53					0			
ALE-MT03	27-Sep-17	1	CO	59	2.2	1.07					0			
ALE-MT03	27-Sep-17	1	CO								0			
ALE-MT03	27-Sep-17	1	CO								0			
ALE-MT03	27-Sep-17	2	CO	57	1.9	1.03					0			
ALE-MT03	27-Sep-17	2	CO	64	3.9	1.49					0			
ALE-MT03	27-Sep-17	2	CO	65	3.3	1.2					0			
ALE-MT03	27-Sep-17	2	CO	68	3.9	1.24	SC	7			0			
ALE-MT03	27-Sep-17	2	CO	69	2.9	0.88					0			
ALE-MT03	27-Sep-17	2	CO	72							0			
ALE-MT03	27-Sep-17	2	CO	73	5.1	1.31	SC	4			0			
ALE-MT03	27-Sep-17	2	CO	75	5.2	1.23					0			

¹CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 3. Continued.

Site	Date	Trap #	Species¹	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Mark Type	Mark Location	Recapture (Y/N)
ALE-MT03	27-Sep-17	2	CO	77	5.3	1.16	SC	6			0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	2	CO								0			
ALE-MT03	27-Sep-17	3	CO	54	1.6	1.02					0			
ALE-MT03	27-Sep-17	3	CO	69	2.9	0.88					0			
ALE-MT03	27-Sep-17	3	CO	70	4	1.17					0			
ALE-MT03	27-Sep-17	3	CO	77	5	1.1					0			
ALE-MT03	27-Sep-17	3	CO	80	5.8	1.13					0			
ALE-MT03	27-Sep-17	3	CO								0			
ALE-MT03	27-Sep-17	3	CO								0			
ALE-MT03	27-Sep-17	3	CO								0			
ALE-MT03	27-Sep-17	4	CO	48	1.2	1.09					0			
ALE-MT03	27-Sep-17	4	CO	48	1.3	1.18					0			
ALE-MT03	27-Sep-17	4	CO	50	1.9	1.52					0			
ALE-MT03	27-Sep-17	4	CO	52	1.5	1.07					0			
ALE-MT03	27-Sep-17	4	CO	53	1.4	0.94					0			
ALE-MT03	27-Sep-17	4	CO	56	1.7	0.97					0			
ALE-MT03	27-Sep-17	4	CO	57	1.9	1.03					0			
ALE-MT03	27-Sep-17	4	CO	62	2.6	1.09	SC	3			0			
ALE-MT03	27-Sep-17	4	CO	69	3.7	1.13	SC	5			0			
ALE-MT03	27-Sep-17	4	CO	70	4	1.17					0			
ALE-MT03	27-Sep-17	4	CO	79	5.8	1.18	SC	2			0			

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 3. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Mark Type	Mark Location	Recapture (Y/N)
ALE-MT03	27-Sep-17	4	CO	96	10.7	1.21	SC	1			1			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	4	CO								0			
ALE-MT03	27-Sep-17	5	CO	42	0.9	1.21					0			
ALE-MT03	27-Sep-17	5	CO								0			
ALE-MT03	27-Sep-17	5	CO								0			
ALE-MT04	27-Sep-17	1	CO	50	1.6	1.28					0			
ALE-MT04	27-Sep-17	1	CO	55	1.8	1.08					0			
ALE-MT04	27-Sep-17	1	CO	61	2.5	1.1	SC	2			0			
ALE-MT04	27-Sep-17	1	CO	63	2.8	1.12	SC	1			0			
ALE-MT04	27-Sep-17	2	NFC											
ALE-MT04	27-Sep-17	3	CO	53	1.9	1.28					0			
ALE-MT04	27-Sep-17	3	CO	58	2	1.03					0			
ALE-MT04	27-Sep-17	3	CO	62	2.6	1.09					0			
ALE-MT04	27-Sep-17	3	CO	62	2.7	1.13					0			
ALE-MT04	27-Sep-17	3	CO	65	2.7	0.98					0			
ALE-MT04	27-Sep-17	3	CO	69	3.5	1.07					0			
ALE-MT04	27-Sep-17	3	CO	75	4.9	1.16					0			
ALE-MT04	27-Sep-17	3	CO	75	5.1	1.21	SC	5			0			
ALE-MT04	27-Sep-17	4	CO	59	2.1	1.02					0			
ALE-MT04	27-Sep-17	4	CO	60	2.7	1.25					0			
ALE-MT04	27-Sep-17	4	CO	65	3.2	1.17					0			
ALE-MT04	27-Sep-17	4	CO	74	4.1	1.01					0			
ALE-MT04	27-Sep-17	4	CT	90	7.2	0.99	SC	6			1			
ALE-MT04	27-Sep-17	4	CT	131			SC	7			2			
ALE-MT04	27-Sep-17	5	CO	58	2.3	1.18	SC	3			0			
ALE-MT04	27-Sep-17	5	CO	76	4.6	1.05	SC	4			0			
ALE-MT05	27-Sep-17	1	CO	77	5	1.1					0			
ALE-MT05	27-Sep-17	2	CO	87	6.8	1.03	SC	6			0			
ALE-MT05	27-Sep-17	3	CO	62	2.3	0.97					0			

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 3. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Mark Type	Mark Location	Recapture (Y/N)
ALE-MT05	27-Sep-17	3	CO	64	3.1	1.18					0			
ALE-MT05	27-Sep-17	4	CO	64	2.3	0.88					0			
ALE-MT05	27-Sep-17	4	CO	66	2.6	0.9					0			
ALE-MT05	27-Sep-17	4	CO	71	4.3	1.2	SC	4			0			
ALE-MT05	27-Sep-17	4	CO	104	13.2	1.17	SC	3			1			
ALE-MT05	27-Sep-17	4	CO								0			
ALE-MT05	27-Sep-17	4	CT	106	11.9	1	SC	1			1			
ALE-MT05	27-Sep-17	4	CT	107	11.5	0.94	SC	2			1			
ALE-MT05	27-Sep-17	5	CO	66	3.1	1.08					0			
ALE-MT05	27-Sep-17	5	CO	69	3.6	1.1					0			
ALE-MT05	27-Sep-17	5	CO	72	3.9	1.04					0			
ALE-MT05	27-Sep-17	5	CO	72	4.7	1.26	SC	5			0			
ALE-MT06	27-Sep-17	1	CO	55	1.8	1.08					0			
ALE-MT06	27-Sep-17	2	NFC											
ALE-MT06	27-Sep-17	3	CO	59	2.3	1.12					0			
ALE-MT06	27-Sep-17	3	CO	60	2.8	1.3					0			
ALE-MT06	27-Sep-17	4	CO	48	0.8	0.72					0			
ALE-MT06	27-Sep-17	4	CO	49	1.2	1.02					0			
ALE-MT06	27-Sep-17	4	CO	51	1.3	0.98					0			
ALE-MT06	27-Sep-17	4	CO	52	1.4	1					0			
ALE-MT06	27-Sep-17	4	CO	53	1.4	0.94					0			
ALE-MT06	27-Sep-17	4	CO	54	1.5	0.95					0			
ALE-MT06	27-Sep-17	4	CO	60	2.2	1.02					0			
ALE-MT06	27-Sep-17	5	CO	47	1.2	1.16					0			
ALE-MT06	27-Sep-17	5	CO	50	1.3	1.04					0			
ALE-MT06	27-Sep-17	5	CO	55	1.9	1.14					0			
ALE-MT06	27-Sep-17	5	CO	62	2.5	1.05					0			
ALE-MT06	27-Sep-17	6	CO	81	6.1	1.15	SC	4			0			
ALE-MT06	27-Sep-17	7	NFC											
ALE-MT06	27-Sep-17	8	BT	130	23.3	1.06	SC	2						
ALE-MT06	27-Sep-17	8	CO	51	1.5	1.13					0			
ALE-MT06	27-Sep-17	8	CO	55	1.8	1.08					0			
ALE-MT06	27-Sep-17	8	CO	59	2.1	1.02					0			
ALE-MT06	27-Sep-17	8	CT	120	16.6	0.96	SC	3			1			
ALE-MT06	27-Sep-17	9	CO	45	0.9	0.99					0			
ALE-MT06	27-Sep-17	9	CT	140	25.9	0.94	SC	1			2			
ALE-MT06	27-Sep-17	10	CO	55	1.4	0.84					0			
ALE-MT06	27-Sep-17	10	CO	64	2.8	1.07	SC	5			0			

[1] CO -= Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Figure 1. Looking upstream at ALE-MT01 sampling site on September 27, 2017.

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Figure 5. Looking upstream at ALE-MT03 sampling site on September 27, 2017.

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Figure 9. Looking upstream at ALE-MT05 sampling site on September 27, 2017.

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Figure 8. Standard photo of ALE-PRM06, taken from plot centre at 0 degrees on October 5, 2017.

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Figure 11. **Standard photo of ALE-PRM07, taken from plot centre at 0 degrees on October 5, 2017.**

Figure 12. **Representative photo of ALE-PRM07 on October 5, 2017.**

Appendix B. Alena Creek Fish Habitat Enhancement Project: Year 2 Monitoring Report

Alena Creek Fish Habitat Enhancement Project

Year 2 Monitoring Report

Prepared for:

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

April 25, 2019

Prepared by:

Ecofish Research Ltd.

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

For inquiries contact: Technical Lead documentcontrol@ecofishresearch.com 250-334-3042

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Certification: *stamped version on file.*

Senior Reviewers:

Sean Faulkner, M.Sc., R.P.Bio. No. 2242
Fisheries Scientist/Project Manager

Kevin Ganshorn, M.Sc., R.P.Bio. No. 2448
Biologist/Project Manager

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089
Wildlife Biologist/Project Manager

Technical Leads:

Andrew Harwood, Ph.D., R.P.Bio. No. 1652
Fisheries Scientist/Project Manager

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089
Wildlife Biologist/Project Manager

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EXECUTIVE SUMMARY

Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to conduct monitoring for the fish habitat enhancement constructed on Alena Creek (also known as Leanna Creek). The Fish Habitat Enhancement Project (FHEP) was designed to offset the footprint and operational habitat losses incurred by the Upper Lillooet Hydro Project (ULHP, the Project). Alena Creek is a tributary to the Upper Lillooet River located approximately 4.1 km downstream of Boulder Creek confluence with the Upper Lillooet River.

Historical fish and fish habitat data from Alena Creek and long-term monitoring requirements for the enhancement habitat were originally described in the Alena Creek Long-Term Monitoring Program (LTMP) (Harwood et al. 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood et al. 2017). Results of Year 1 and 2 of Alena Creek baseline monitoring are documented in Harwood et al. (2016). Results of Year 1 (2017) of post-construction monitoring are presented in Harwood et al. (2019). The purpose of this report is to provide results of Year 2 (2018) of the long-term monitoring program to evaluate the effectiveness of the FHEP as per the Fisheries Act Authorization issued for the ULHP.

Hydrology

Post-construction monitoring of water levels in Alena Creek was conducted at the Lillooet River Forest Service Road (FSR) crossing at the downstream end of the Fish Habitat Enhancement Project (FHEP). Seasonal trends in the Alena Creek hydrograph in 2018 are consistent with that of a coastal, snow dominated watershed. Stage remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, and increased through March and April during snow melt. The stage then decreases at late-summer and early fall (mid-July to the end of September) when precipitation was minimal. This is consistent with observations at the baseline monitoring.

The daily peak in stage during the 2018 monitoring period was recorded on April 27, 2018 (0.44 m), which corresponded with spring snowmelt. This is similar to baseline monitoring when daily peak stage was measured in May 2014. However, it is unknown if a larger peak may have occurred later because an equipment malfunction resulted in data gap from May 3 to August 23, 2018. Overall mean daily stage in 2018 was 0.23 ± 0.07 m, and did not drop below 0.16 m, which was consistent with Year 1 post-construction monitoring from November 2016 to September 2017.

Based on recommendations from the Year 1 Monitoring Report (Harwood *et al.*, 2018), a second gauge (R1) was installed on August 23, 2018 approximately 125 m upstream of the gauge at the FSR bridge to assess any influence of backwatering effects that may be caused by the Upper Lillooet River side channel during high flows. However, these effects could not be accurately assessed in this monitoring period because stage data was only collected during low flow conditions when backwatering was not evident and diurnal fluctuations were minimal. We recommend continued stage monitoring at both the FSR bridge and the upstream R1 gauge.

Water Temperature

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

Water temperature data were collected at the two water quality sites: ALE-USWQ1 located immediately upstream of the instream works, and ALE-BDGWQ located at the downstream end of the works. Pre-construction monitoring occurred from April 2013 to December 2014 and post-construction monitoring to date has occurred from November 23, 2016 to present (data up to January 1, 2019 are included in this report). No significant water temperature data gaps were observed during post-construction monitoring.

Analysis of the data included computing the following temperature metrics: monthly statistics (average, minimum, and maximum water temperatures for each month of record), differences in water temperature between the upstream and downstream monitoring sites, number of days with extreme mean daily temperature (e.g., >18°C, >20°C, and <1°C), the length of the growing season, exceedance of Bull Trout temperature thresholds, and mean weekly maximum temperature (MWMxT). These metrics are compared to water temperature BC WQG (Oliver and Fidler 2001, MOE 2018) to assess suitability of the water temperature for aquatic life and specifically, Coho Salmon, Cutthroat Trout, and Bull Trout.

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

Overall, considering inter-annual variably in temperature, no substantial change in monthly temperature statistics has been observed in Year 2 in comparison to Year 1 and pre-construction data. The range in monthly average temperatures at the upstream site was 5.0°C to 8.1°C pre-construction and 4.0°C to 8.1°C post-construction. No pre-construction data are available for the upstream site from mid-January to mid-March, therefore the monthly minimum of 5.0°C measured in December 2014 may not be representative of the coolest monthly average at this site pre-construction.

At the downstream site monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction, and from 2.5°C to 11.1°C post-construction. Minimum monthly temperatures in each year occurred in December or February.

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

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

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

Overall, no substantial differences were observed in the pre- and post-construction temperature regimes. We recommend that the monitoring program continue for 5 years post-construction based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017). It is recommended that post-construction water temperature data from the water level sensor at the upstream site be obtained should it exist in order to provide additional QA for the single Tidbit sensor present at this site. It is recommended that a second Tidbit be installed at this site for data redundancy as fully submerged Tidbits are less susceptible to icing issues compared to water level sensors that are housed in standpipes that are exposed to the atmosphere.

Fish Habitat

Stability Assessment

A stability assessment was conducted to monitor the structural integrity and functionality of each of the enhancement habitat features and ensure that any remedial action required to maintain the effectiveness of habitat features is taken in a timely manner. To assist in the stability assessments, photo-points were established during the as-built survey in 2016 at a total of eight survey transects. At each of the transects a panorama of photographs was taken to facilitate an evaluation of changes in habitat conditions over time. Qualitative observations were also made along the entire FHEP enhanced reaches.

There appears to be the potential for channel migration in the upper reach as a result of previous beaver dam activity, which will be assessed by a QP in 2019, with repairs completed as recommended during the August 2019 instream work window. There were no immediate stability issues observed in the downstream enhanced reach. Generally, the on-site assessments and photopoint assessments show a healthy watercourse with stable complex fish habitat. Beaver activity impacts on the enhancement reaches will continue to be monitored in 2019.

Fish Community

Fish community in Alena Creek was assessed by bank walk spawner surveys focusing on Coho Salmon, the dominant species within Alena Creek, completed over three surveys between November and December in 2018. The peak count of adult spawning Coho Salmon was 130 in 2018, which was slightly higher than the baseline years (127 and 111), less than 2016 (192) but similar to 2017 (132). A comparison of the results across years highlights the variability in run timing between years, with the peak live count recorded on November 14 in 2016, December 5 in 2017, and November 5 in 2010 and 2018. Although surveys are not conducted at a frequency to allow total spawner abundance to be compared among years (i.e., peak counts may be influenced by survey timing and spawner residence time and predation), the counts provide an indication of use and demonstrate that Alena Creek supports equivalent or greater use by Coho Salmon spawners relative to pre-enhancement.

Minnow trapping surveys were conducted at eight sites in Alena Creek on September 24, 2018. The objective of minnow trapping was to measure catch-per-unit-effort (CPUE) by species and life history stage to continue monitoring juvenile fish abundance and compare to CPUE prior to enhancement. Of the eight sites, five are in the enhanced reaches of Alena Creek, including three new sites. All fish captured by minnow trapping were identified to species, enumerated, measured with scale samples collected for aging. Biological data from Cutthroat Trout and Coho Salmon were analyzed to define the age structure, size structure, length-weight relationship, length at age, and condition factor by species.

In 2018, 13 Cutthroat Trout were captured representing an increase compared to 2017, but similar to 2013 and 2014. The average Cutthroat Trout CPUE was 1.4 fish per 100 trap hours (S.D. = 0.9 fish per hundred trap hours). In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+, with a general lack of fry. The lack of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence and the small size of fry in late September / early October when sampling occurs.

In 2018, 850 Coho Salmon were captured, representing a large increase from 2017 but similar to 2013 and 2014. The average CPUE across all sites was 74.5 fish per 100 trap hours, the highest of all years. The majority of Coho Salmon captured in all years are 0+; however, 1+ have also been detected in Alena Creek each year. The relatively high captures in the newly established site in the enhanced reach supports the notion that the enhanced reach is high quality habitat for both juvenile Cutthroat trout and Coho Salmon.

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1. INTRODUCTION

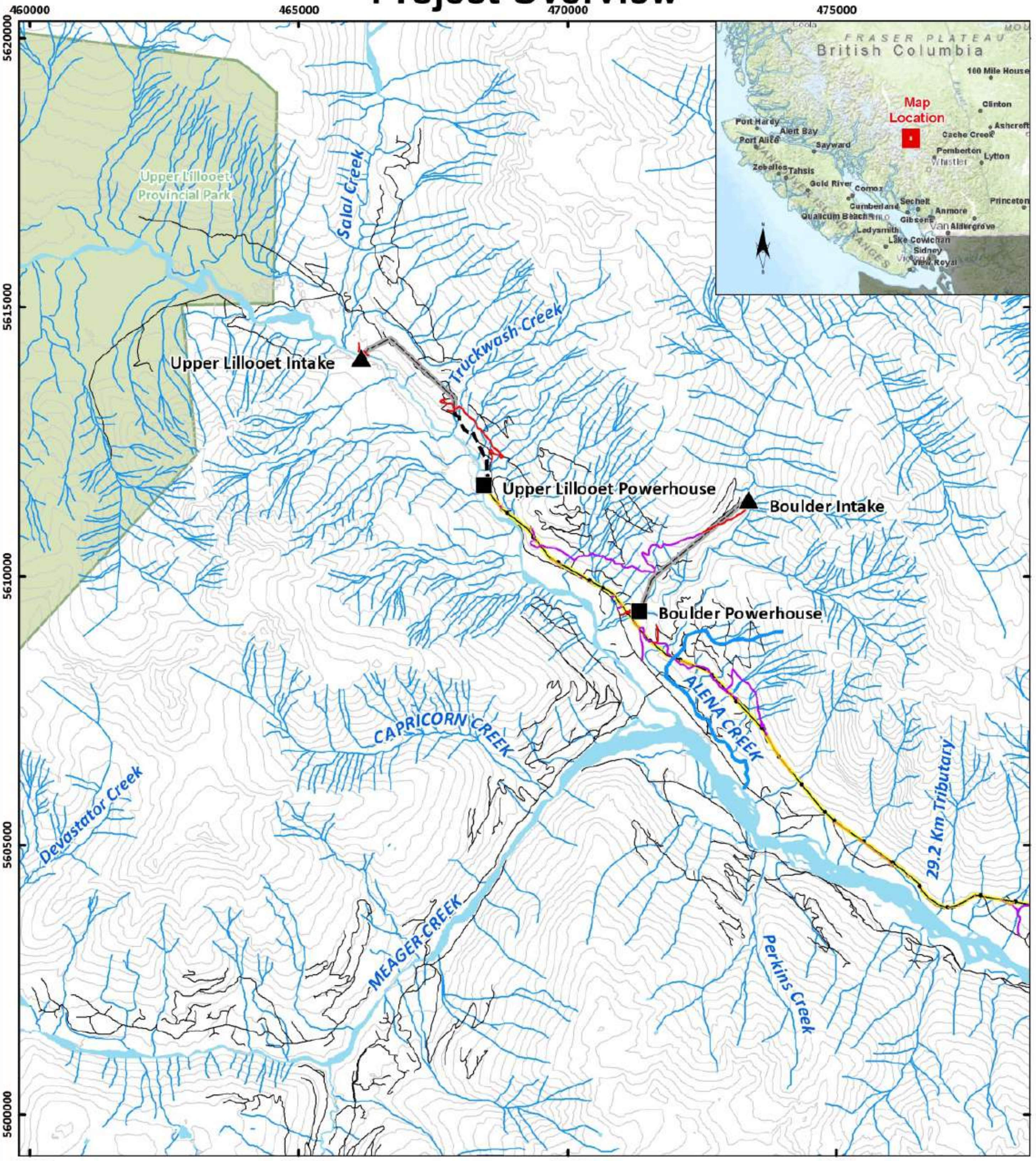
Ecofish Research Limited (Ecofish) was retained by the Upper Lillooet River Power Limited Partnership (ULRPLP) to conduct monitoring for the fish habitat enhancement constructed on Alena Creek (also known as Leanna Creek). The Fish Habitat Enhancement Project (FHEP) was designed by Hemmera Envirochem Inc. (Hemmera 2015) and Ecofish (Appendix A) to offset the footprint and operational habitat losses incurred by the Upper Lillooet Hydro Project (ULHP, the Project), which 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 Boulder Creek confluence with the Upper Lillooet River, and is therefore downstream of the two HEFs (Map 1).

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

The offsetting plan involved fish habitat enhancement in Alena Creek, which was heavily impacted by the Capricorn/Meager Creek slide (hereafter referred to as the Meager Creek slide); a natural, catastrophic event that occurred on August 6, 2010 and deposited a large amount of woody debris and thick heavy sediment in and around Alena Creek. In addition to heavily impacting aquatic habitat, the slide affected riparian habitat either by uprooting trees or by smothering root systems with heavy sediment. The FHEP constructed in the summer of 2016, created a new section of channel and enhanced both the aquatic and riparian habitat of Alena Creek and will therefore benefit Coho Salmon (*Oncorhynchus kisutch*), Cutthroat Trout (*Oncorhynchus 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 design features constructed 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 enhancement habitat were originally described in the Alena Creek Long-Term Monitoring Program (LTMP) (Harwood *et al.* 2013). Long-term monitoring requirements were subsequently revised and integrated into Project's Operational Environmental Monitoring Plan (OEMP) (Harwood *et al.* 2017). Results of Years 1 and 2 of Alena Creek pre-construction monitoring are documented in Harwood *et al.* (2016). Results of Year 1 (2017) of post-construction monitoring are presented in Harwood *et al.* (2019). The purpose of this report is to provide results of Year 2 (2018) of the long-term monitoring program to evaluate the effectiveness of the FHEP as per the *Fisheries Act* Authorization issued for the ULHP.

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

Map 1

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

2. OBJECTIVES AND BACKGROUND

2.1. Hydrology

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

2.2. Water Quality

The purpose of the long-term monitoring of water chemistry is to ensure the maintenance of suitable water quality for the protection of aquatic life, and monitor any improvements in water quality resulting from the construction of the habitat compensation features. Concerns were raised by DFO over potentially elevated concentrations of metals, particularly iron and arsenic, thus these parameters were included in pre-construction monitoring and the Year 1 of the LTMP (Harwood *et al.* 2013, Harwood *et al.* 2018). Water chemistry data were collected at two sites; a control site (ALE-USWQ/ALE-USWQ1), upstream of the enhancement habitat, and at a second site (ALE-BDGWQ) located at the downstream end. The OEMP for the Upper Lillooet Hydro Project (Harwood *et al.* 2017) specified quarterly sampling for the first year followed by biannual sampling of a reduced list of parameters in subsequent years and evaluation of the suitability of the sampling program by the QP.

Pre-construction water chemistry data were collected quarterly for general water quality parameters, nutrients and anions, dissolved oxygen, total metals and dissolved metals in 2013 and 2014. Pre-construction water quality data met the applicable BC Water Quality Guidelines (BC WQG) for the protection of aquatic life (MOE 2018) for all parameters with the exception of dissolved oxygen (applicable to buried life stages only), total iron (T-Fe) and dissolved iron (D-Fe), which exceeded the BC WQG at both the upstream control site and the downstream bridge site during pre-construction sampling (Harwood *et al.* 2016). Dissolved arsenic was below the applicable BC WQG during pre-construction sampling and post-construction monitoring.

As presented in the Alena Creek Year 1 monitoring report (Harwood *et al.* 2019), water quality in Alena Creek has generally improved since pre-construction sampling began in 2013 (Harwood *et al.* 2013, Harwood *et al.* 2018). In Year 1 (2016 and 2017) following completion of the habitat enhancement on Alena Creek, no exceedances of the minimum BC WQG for dissolved oxygen were observed at the site in the enhancement habitat (ALE-BDGWQ), with data indicating a well aerated condition (dissolved oxygen concentrations ranging from 10.38 mg/L to 10.81 mg/L).

Concentrations of dissolved iron exceeded the short-term maximum BC WQG of 0.35 mg/L at the site in the enhancement habitat during all sampling periods, with the range of concentrations similar between pre-construction and Year 1 monitoring. Total iron exceeded the short-term maximum BC WQG of 1 mg/L at one or both sites on all sampling dates during pre-construction sampling. However, only one exceedance occurred during Year 1 sampling at the site in the enhancement habitat, and concentrations at this site in Year 1 sampling were on average lower than observed during pre-construction sampling.

Considering these observations and that instream habitat enhancement is not expected to result in adverse effects on water quality, it was recommended in the Alena Creek Fish Habitat Enhancement Project Year 1 Monitoring Report that water quality monitoring on Alena Creek be ceased (Harwood *et al.* 2018). Accordingly, water quality sampling was not conducted in Year 2 of monitoring.

2.3. Water Temperature

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

The OEMP for the Upper Lillooet Hydro Project (Harwood *et al.* 2017) calls for five years of water temperature monitoring. A revised version of the OEMP (Harwood *et al.* 2018) was presented to MFLNRORD in February 2018 which included the recommendation to hold off reporting on water temperature results after Year 1 if no issues were identified, with final results reported following Year 5. This report provides a summary of Year 2 post-construction water temperature results, and evaluation of the need for additional annual reporting of the water temperature component.

2.4. Fish Habitat

2.4.1. Stability Assessment

A stability assessment was conducted to annually monitor the structural integrity and functionality of each of the enhancement habitat features and ensure that any remedial action required to maintain the effectiveness of habitat features is taken in a timely manner.

2.5. Fish Community

The goal of enhancing Alena Creek aquatic and riparian habitat was to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout and support equivalent or greater fish usage relative to pre-project densities in Alena Creek. 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-enhancement conditions. The adults were sampled by spawning bank walks during the Coho Salmon spawning season, early November to early December. The juveniles were sampled by minnow trap at eight sites in Alena Creek. The catch per unit effort (CPUE) for minnow trapping can be compared among years to assess the fish community health over time.

3. METHODS

3.1. Hydrology

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

3.2. Water Temperature

3.2.1. Study Design

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

Water temperature data were collected at the two water temperature sites: ALE-USWQ1, located immediately upstream of the enhancement works, and ALE-BDGWQ, located at the downstream end of the works (Table 1, Appendix B, Map 3). Pre-construction monitoring occurred from April 17, 2013 to December 31, 2014 at the upstream site and from August 27, 2013 to December 31, 2014 at the downstream site. Post-construction monitoring to date commenced at both sites on November 23, 2016. Data were available up to January 30, 2019 for the upstream site and to November 1, 2018 for the downstream site.

Table 1. Summary of water temperature site names, logging details and period of data record in Alena Creek pre-construction (2013, 2014) and post-construction (November 2016 through 2018).

Type	Site	UTM Coordinates (10U)		Elevation	Project Phase[2]	Periods of Record		No. of Datapoints	Logging Interval (min.)	No. of Days with Valid Data	Data Gaps in Record (%)[3]
		Easting	Northing	(masl)[1]		Start Date	End Date				
Upstream	ALE-USWQ1	472,976	5,606,870	391	Pre-construction	17-Apr-13	31-Dec-14	13,627	60	568	8.9
					Post-construction	23-Nov-16	30-Jan-19	76,624	15	799	0
Downstream	ALE-BDGWQ	473,336	5,606,095	382	Pre-construction	27-Aug-13	31-Dec-14	11,049	60	460	6.3
					Post-construction	23-Nov-16	1-Nov-18	67,984	15	709	0

[1] Estimated from Google Earth.

[2] Pre-construction (2013-2014) water temperature was monitored via hydrometric gauges maintained by KPL.

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

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

3.2.2. Fish Species Distribution

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

Table 2. Optimum water temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout life history stages (MOE 2018).

Species	Optimum Water Temperature (°C) Range (MOE 2018)[1]			
	Incubation	Rearing	Migration	Spawning
Coho Salmon	4.0-13.0	9.0-16.0	7.2-15.6	4.4-12.8
Cutthroat Trout	9.0-12.0	7.0-16.0	—	9.0-12.0
Bull Trout	2.0-6.0	6.0-14.0	—	5.0-9.0

[1] Optimal temperature ranges for water quality guideline application are provided in the BC WQG for the protection of aquatic life (MOE 2018). The water quality guideline range is ± 1 °C change beyond optimum temperature range for each life history phase of the most sensitive salmonid species present.

Table 3. Fish species periodicity.

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

3.2.3. Quality Assurance / Quality Control

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

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

During the pre-construction period of monitoring, there are gaps in the datasets from January 18 to March 12, 2014 at ALE-USWQ1, and from the end of March through early April 2014 at ALE-BDGWQ (Table 1). Considering that the data from January 18 to March 12, 2014 at the upstream site were excluded from the analysis due to the suspected build-up of ice (McCarthy, pers. comm. 2014), winter minimum temperatures were likely not captured at this site during pre-construction monitoring.

There were sufficient data to calculate February statistics at the downstream location and pre-construction winter minimum temperatures were recorded, however pre-construction data for March are missing at this site.

3.2.4. Data Analysis and Collection

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

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

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

The calculation of the end date of the length of the growing season (as defined in Table 4) was modified from 4°C (as per Coleman and Fausch 2007) to 5°C, because the mean weekly maximum water temperatures at the upstream site were >4°C in the winter data set for the first year of pre-construction monitoring (due to a data gap caused by ice conditions).

3.2.4.1. Applicable Guidelines

Water temperature BC WQG for the protection of aquatic life (as per Oliver and Fidler 2001, MOE 2018) are discussed below.

Hourly Rates of Water Temperature Change

Large, rapid changes in water temperature (greater than ±1.0°C/hr) can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specify that the hourly rate of water temperature change should not exceed ±1.0°C/hr (MOE 2018).

Daily Temperature Extremes

Extreme cold or warm temperatures are monitored as part of the water temperature component. The number of days when the daily mean temperature was <1°C was calculated, along with the number of days when the daily mean temperature >18°C and >20°C. The maximum optimum temperature for the fish species present in the Project area is 16°C (Coho Salmon and Cutthroat Trout rearing life stage, Table 2)

Mean Weekly Maximum Temperature (MWMxT)

The MWMxT is an important indicator of prolonged periods of cold and warm water temperatures that fish are exposed to. The water temperature BC WQG for the protection of aquatic life states "Where fish distribution information is available, then mean weekly maximum water temperatures should only vary by ±1.0°C beyond the optimum temperature range of each life history phase (incubation, rearing, migration and spawning) for the most sensitive salmonid species present" (Oliver and Fidler 2001, MOE 2018). Accordingly, MWMxT values were compared to the optimum temperature ranges or the fish species present based on the life history and periodicity (Table 2, Table 3).

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

Bull Trout Temperature Guidelines

Additional BC WQG (MOE 2018) water temperature guidelines are specified for streams with Bull Trout and Dolly Varden (Oliver and Fidler 2001; Table 1 in Appendix C). When either of these fish species are present, the guidelines state that:

- maximum daily water temperature is 15°C;
- maximum incubation temperature is 10°C;

- minimum incubation temperature is 2°C; and
- maximum spawning temperature is 10°C.

The number of days where these thresholds are exceeded are calculated using the appropriate daily maximum or minimum temperature values for each site where Bull Trout are present (Table 4).

Table 4. Water temperature metrics and method of calculation.

Metric	Description	Method of Calculation
Water temperature	Hourly or 15 minute data	Data (interpolated to 15 minute intervals where necessary) presented in graphical form.
Monthly statistics	Mean, minimum, and maximum on a monthly basis	Calculated from 15 minute data (interpolated where necessary) and presented in tabular format.
Rate of water temperature change	Hourly rate of change	Calculated from 15 minute data (interpolated where necessary); presented in summary tables and graphical form.
Degree days in growing season	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.

* See text in Section 3.2.3 discussing modification to the temperature criteria that defines the end of growing season.

3.3. Fish Habitat

3.3.1. Stability Assessment

Reach 1 and 3 of Alena Creek were enhanced as a part of the FHEP. To assess the stability in the enhanced reaches, photos were taken at photo-points established during the as-built survey (completed immediately following the construction in 2016). A total of eight transects were surveyed at that time. At each transect a panorama of photographs were taken to facilitate an evaluation of changes in habitat conditions over time. Photographs were taken looking downstream, upstream, from river left (RL) to river right (RR), and from river right to river left. The photograph aspects were oriented to provide a full view of the bankfull channel and floodplain, with the transect tape included in the photo to provide a visual reference line to aid with analysis of the topographic transect surveys. Photos were used for a visual comparison.

3.4. Fish Community

3.4.1. Adult Spawner Abundance

Coho Salmon (*Oncorhynchus kisutch*), Bull Trout (*Salvelinus confluentus*) and Cutthroat Trout (*O. clarkii*) were captured in Alena Creek during the monitoring studies. However, spawner surveys in Alena Creek focused on Coho Salmon, the dominant species within Alena Creek. Spawner surveys consisted of bank walks conducted every two weeks between November 5 and December 5, 2018 (a total of three surveys). Consistent with previous years, bank walks to count both live fish and carcasses occurred from the downstream confluence with the Upper Lillooet River to the upstream end of Alena Creek at the groundwater spring at the Lillooet River FSR crossing (~36.5km). Due to the meandering nature of the Upper Lillooet River, the downstream confluence with Alena Creek has varied over the survey years by up to ~1km. It is important to note that the carcasses counted in Alena Creek, are quickly consumed by wildlife in the area, as evidenced by the fact that they are not often whole and show signs of being eaten by wildlife. Often only the pyloric caeca, which animals prefer not to eat, is left behind. Carcasses are therefore easily distinguishable and double counting during the surveys is not a concern.

3.4.2. Juvenile Abundance

3.4.2.1. Minnow Trapping

Minnow trapping surveys were conducted in Alena Creek commencing on September 24, 2018. The objective of minnow trapping was to monitor the relative abundance by using catch-per-unit-effort (CPUE) by species and life stage so that the relative juvenile abundance could be tracked and compared between years.

A total of eight sites were selected in 2018, compared to six in previous years. Four to 10 traps were installed at each site. At ALE-MT06 site, 10 traps were set because it was a large pool that required a higher level of sampling effort. Sampling was conducted in five of the 6 sites sampled in previous years (ALE-MT01, ALE-MT02, ALE-MT03, ALE-MT05 and ALE-MT06); however, due to beaver activity in previous years sampling at ALE-MT04 was discontinued in 2018 as recommended in the Year 1 report (Harwood *et al.* 2019). Additionally, a total of three new sites were established in 2018 in enhanced habitat, specifically one site in Reach 1 (ALE-MT07) and two sites in Reach 3 (ALE-MT08 and ALE-09; Map 4). The Year 1 report had recommended that one of the additional sites be located just upstream of Reach 1 at the gravel augmentation pile installed as part of the enhancement works; however, due to beaver dam and stability issues at this location the site was located just downstream of the gravel augmentation pile and in the Reach 1 enhancement area (ALE-MT07). The minnow traps were baited using salmon roe and left overnight. When the traps were retrieved, captured fish were identified and measured.

3.4.2.2. Biological Information

All captured fish were enumerated and identified to species using standard field keys. The fork length of each captured fish was determined using a measuring board (±1.0 mm); after which each fish was weighed using a field scale (±0.1 g). Aging samples were taken from a sub-sample of captured fish and these were aged at the Ecofish laboratory in Squamish.

Scale samples collected in the field were examined under a dissecting microscope for aging purposes: three representative scales were photographed and apparent annuli noted on a digital image. Fish age was determined by a biologist and QA'd by a senior biologist. Where discrepancies were identified, they were discussed and final age determination was based on the professional judgement of the senior biologist.

3.4.2.3. Data Analysis

Individual Fish Data

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

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

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

where W is the weight in grams, L is the length in millimeters, 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.

4. RESULTS

4.1. Hydrology

Seasonal trends in the Alena Creek hydrograph in 2018 were consistent with a coastal, snow dominated watershed. Seasonal hydrograph patterns remained broadly consistent with observations from baseline and Year 1 post-construction monitoring. Stage readings in 2018 remained relatively low throughout the winter (January to mid-March) when precipitation was snow dominated, then increased during snow melt in spring (March and April). Stage remained low during monitoring in late-summer and early fall (August 23 to October) when precipitation was minimal (Figure 1).

The daily peak in stage during 2018 was recorded on April 27, 2018 (0.44 m) corresponding with the rising hydrograph limb during spring snowmelt. This was below the largest peak recorded on November 9, 2016 (0.95 m) during a 1-in-20 year probability flood event on the Upper Lillooet River (McCoy, pers. comm. 2016), but consistent with peak values recorded during baseline monitoring (Figure 1). Several higher stage values were also recorded in 2017 between mid-May to early-July (Figure 1), however a malfunction with the logger's vent tube resulted in missing data from May 3 to August 23, 2018. As a result, it is unknown if a larger peak event may have occurred during this time. Overall mean daily stage at the FSR bridge measured in January to May and August-October of 2018 was 0.23 ± 0.07 m, and did not drop below 0.16 m consistent with previous monitoring from November 2016 to September 2017. However, these results are likely skewed by missing data and the continued effect of backwatering caused by the Upper Lillooet River side channel.

High stage readings at the FSR Bridge site on Alena Creek in June and July of 2017 were suggested to be a possible result of backwatering caused by a new side channel of the Upper Lillooet River just downstream of the hydrometric gauge because there was little precipitation during this period (Harwood *et al.*, 2018). The new side channel was formed during the peak flow event in November 2016. Evidence that backwatering caused exaggerated stage readings at the bridge on Alena Creek during high flows in the Upper Lillooet River can be seen in Figure 2, which shows the Alena Creek stage readings responding to the diurnal fluctuation in stage experienced by the Upper Lillooet River during snow melt in summer. A second gauge (R1) installed on August 23, 2018 approximately 125 m upstream of the Alena Bridge gauge for comparison to assess the backwater effects, but was not effective in the 2018 monitoring period because data were only collected during later summer/early fall low flow conditions when backwatering was not evident and diurnal fluctuations were minimal. Water level readings at the upstream R1 site location were referenced to a different datum than those at the bridge, so a stage adjustment value was calculated using the initial difference in stage between the two points measured on August 23, 2018 to directly compare the two time series. After the adjustment, data show that stage reading at each gauge are highly similar, although appear to fluctuate more greatly at the Bridge (Figure 1). Continued monitoring at both gauges during seasonal high flow periods is necessary to evaluate the degree to which stage at the FSR bridge site is affected by from backwatering from the Upper Lillooet River side channel.

Figure 1. Stage in Alena Creek at the Lillooet River FSR bridge during baseline (Apr 2013 to Nov 2014), and Year 1 and Year 2 of post-construction monitoring (Nov 2016 to Oct 2018).

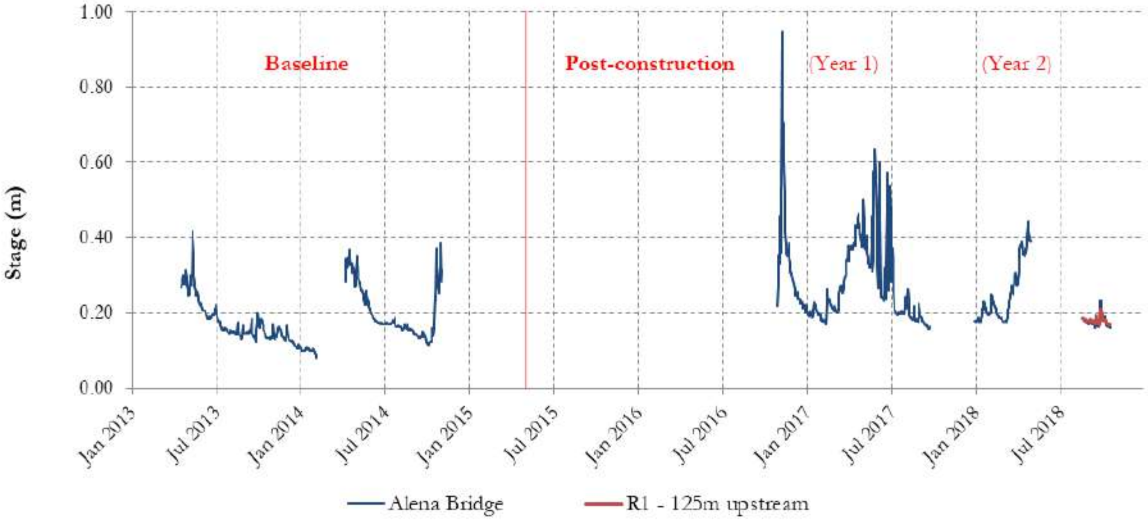
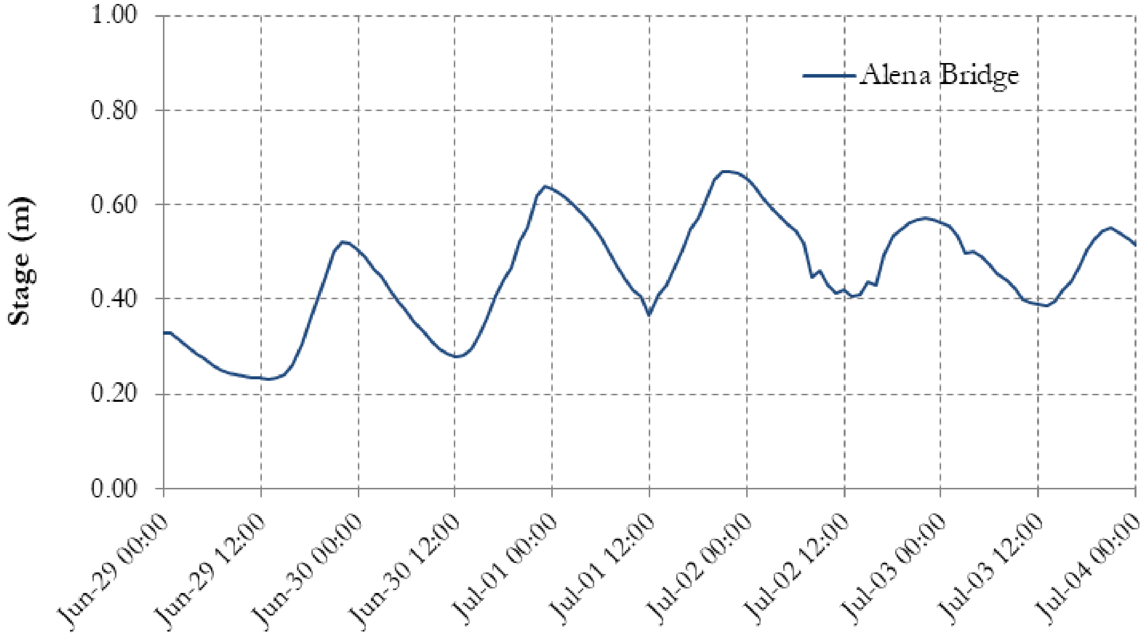


Figure 2. **Stage in Alena Creek at the Lillooet River FSR bridge in late June and early July 2017 showing the diurnal fluctuation experienced by the Upper Lillooet River during snow melt in summer.**



4.2. Water Temperature

4.2.1. Overview

Year 1 (2017) and Year 2 (2018) data complete two full years of post-construction water temperature data collection at the upstream site and nearly two full years of data collection at the downstream site; the period of record for post-construction analysis was from November 23, 2016 to January 30, 2019 (Table 1). Data availability is based on the most recent download of water temperature loggers. Data gaps occurred pre-construction due to icing issues and out of water events. There are no data gaps in the post-construction data set to date (Table 1).

The temperature regime is presented for the pre-construction and post-construction monitoring using a) daily average temperature data, b) daily maximum temperature data and c) daily minimum temperature data (Figure 3). In general, water temperature upstream (ALE-USWQ1) varied over a narrower range than observed downstream (ALE-BDGWQ) (Figure 3). The moderation of the water temperature regime upstream is attributed to the presence of groundwater inflow at this site. The daily average temperatures recorded at both sites were higher post-construction than pre-construction in the warmer months suggesting this increase is due to natural inter-annual temperature variation (Figure 3).

The pattern of differences in water temperature between the two sites during the winter and summer seasons is largely the same pre- and post-construction, as depicted in the cumulative frequency distribution between the sites (Figure 4). Despite the short distance (~1 km) and small difference in elevation (11 m) between the sites, the downstream site is generally warmer than the upstream site in the summer and cooler in the winter (Figure 3, Figure 4).

In addition to the influence of groundwater upstream, there is a tributary that enters Alena Creek between the two sites which may account for some of the cooler temperatures downstream in the winter and warmer temperatures downstream in the summer (Figure 3, Figure 4, Map 3).

Overall, no substantial difference is observed in the overall temperature regime (Figure 3) or the cumulative frequency distribution between sites (Figure 4). Data will be evaluated with a BACI analysis following 5 years of post-construction data collection.

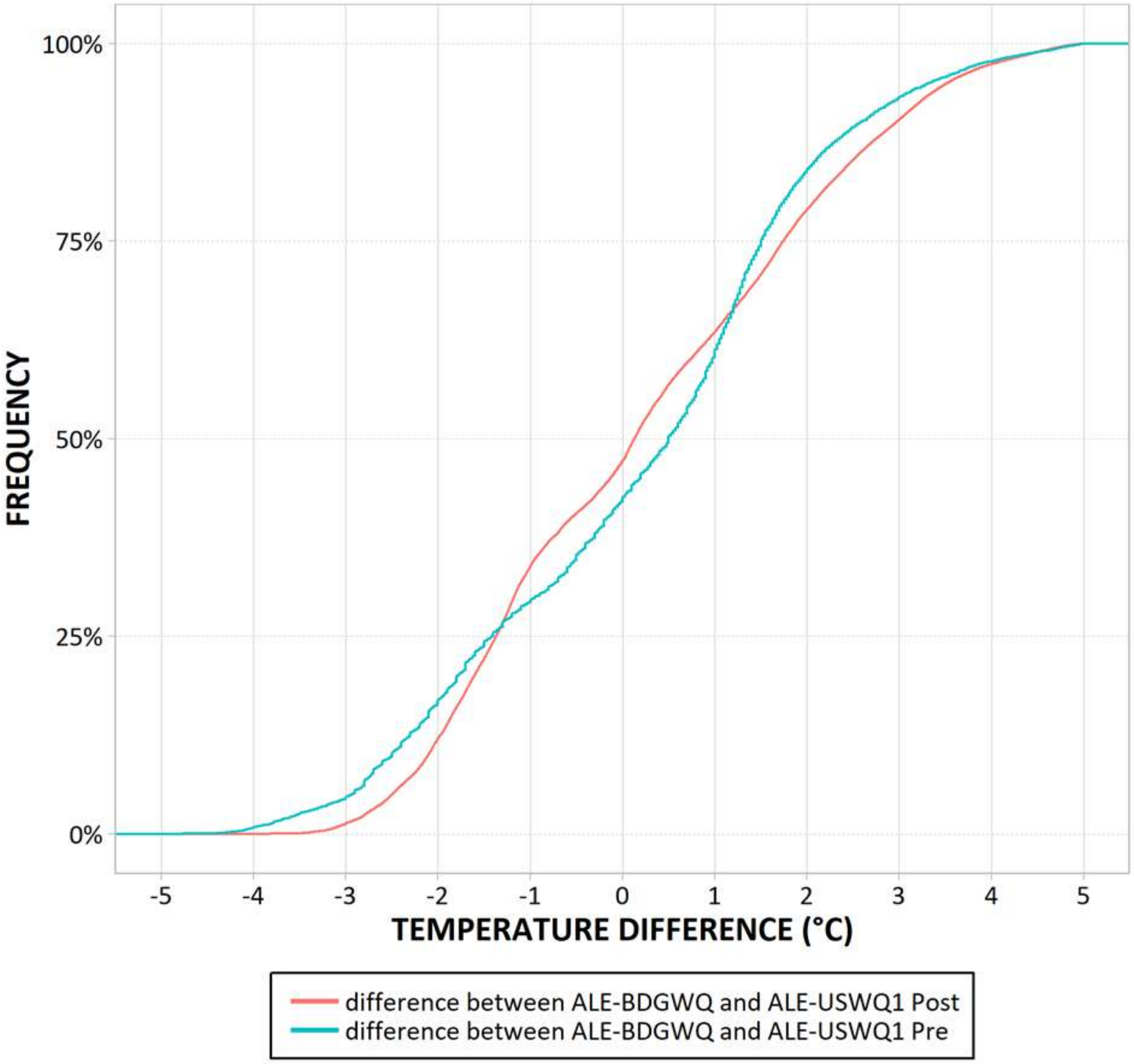
Figure 3. Overall average, maximum and minimum temperature regime in Alena Creek pre-construction (2014 to 2015) and post-construction (2017 to 2019).

(a) Daily Average

(b) Daily Maximum

(c) Daily Minimum

Figure 4. **Cumulative frequency distribution of differences in pre-construction and post-construction instantaneous water temperature between the downstream site (ALE-BDGWQ) and the upstream site (ALE-USWQ1) (positive values indicate colder temperatures at ALE-USWQ1).**



4.2.2. Monthly Summary Statistics

The mean, instantaneous minimum, instantaneous maximum, and standard deviation for water temperature for each month of the record are summarized in Appendix C.

Overall, no substantial change in monthly temperature statistics has been observed in Year 2 in comparison to Year 1 and the available pre-construction data. The range in monthly average temperatures at the upstream site was 5.0°C to 8.1°C pre-construction and 4.0°C to 8.1°C post-construction. No data are available for February or March pre-construction at the upstream site, therefore the monthly average minimum of 5.0°C measured in December 2014 may not be representative of the coolest monthly average pre-construction (Appendix C).

At the downstream site monthly average temperatures ranged from 2.2°C to 10.1°C pre-construction, and from 2.5°C to 11.1°C post-construction (Appendix C). Minimum monthly temperatures in each year occurred from December to February.

Pre-construction minimum and maximum instantaneous temperatures ranged from 2.8°C to 10°C at the upstream site, and 0.0°C to 14°C at the downstream site. Post-construction, instantaneous minimum and maximum temperatures ranged from 0.8°C to 10.8°C at the upstream site and 0.1°C to 13.9°C at the downstream site (Appendix C).

4.2.3. Growing Season Degree Days

The fall, early winter (October to December 31) weekly and maximum average temperatures upstream of the enhancement area are relatively mild, remaining above 4°C during the pre- and post-construction monitoring periods. Therefore, the growing season end date was calculated based on weekly average temperatures reaching 5°C rather than 4°C (see Section 3.2.4).

The start of the growing season based on the water temperature record at each site is consistently observed at the middle to end of April both pre- and post-construction (Table 5). The growing season end dates varied from early November to the end of December.

Considering both sites which define the downstream and upstream extent of the enhanced habitat, the growing season varied from 1,667 to 1,836 degree days pre-construction to 1,375 to 1,799 degree days post-construction. The shortest growing season occurred upstream in 2017 (1,375 days: Table 5).

Table 5. Growing season length and degree days upstream and downstream of the enhancement habitat in Alena Creek pre- and post-construction.

Site	Project Phase	Year	No. of days with valid data	Growing Season[1,2]				
				Start Date	End Date	Length (day)	Gap (day)	Degree Days
Upstream (ALE-USWQ1)	Pre-construction	2013	256	18-Apr	31-Dec	258	2	1,836
		2014	306	24-Apr	12-Dec	233	3	1,667
	Post-construction	2017	364	26-Apr	7-Nov	196	1	1,375
		2018	365	17-Apr	13-Dec	241	0	1,704
Downstream (ALE-BDGWQ)	Pre-construction[1]	2013	125	-	21-Nov	-	-	-
		2014	329	20-Apr	16-Nov	211	1	1,833
	Post-construction	2017	364	20-Apr	4-Nov	199	1	1,674
		2018	304	14-Apr	1-Nov	202	1	1,799

[1] Days with less than 23 hours of data are considered data gaps. Degree days are accumulated thermal units.

[2] 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 5°C (modified from Coleman and Fausch (2007)).

4.2.4. Hourly Rates of Water Temperature Change

Large, rapid temperature changes in temperature (greater than ±1.0°C/hr) can affect fish growth and survival (Oliver and Fidler 2001). Hourly rates of change in water temperature were compared to the BC WQG, which specify that the hourly rate of water temperature change should not exceed ±1.0°C/hr (Table 6).

Based on Ecofish's experience collecting pre-construction data on several other streams in British Columbia (file data), it is normal for a small percentage of data points to have hourly rates of water temperature change that exceed ±1.0°C/hr.

During pre- and post-construction, the percentage (%) of record where exceedances were observed was low (<0.50%), and exceedances occurred less often post-construction at both sites. Post-construction, the % exceedances varied from 0.01% at the downstream site to 0.20% at the upstream site (Table 6).

The magnitude of the water temperature increase/decrease was highest at the upstream site post-construction, which may be a consequence of groundwater inflow at this location or the possible influence of ice conditions at low flows. Only data that were definitively ice-affected were removed prior to analysis, and there is some uncertainty about ice effects in the data set from December 2016 to January 2017, which is included in the analysis.

Table 6. **Hourly rate of change statistics and frequency of occurrence of rates of temperature change exceeding a magnitude of 1.0°C/hr in Alena Creek.**

Site	Project Phase	Period of Record		n	Occurrence		Max-ve	Percentile				Max+ve
		Start	End		No.	% of Record		1st	5th	95th	99th	
ALE-USWQ1	Pre-Construction	17-Apr-13	31-Dec-14	13627	47	0.34	-1.15	-0.48	-0.27	0.33	0.85	1.45
	Post-Construction	23-Nov-16	30-Jan-19	76608	151	0.20	-3.32	-0.48	-0.25	0.35	0.73	2.63
ALE-BDGWQ	Pre-Construction	27-Aug-13	31-Dec-14	11049	52	0.47	-1.15	-0.63	-0.40	0.57	0.90	1.23
	Post-Construction	23-Nov-16	1-Nov-18	67973	9	0.01	-1.09	-0.52	-0.33	0.50	0.75	1.06

n = number of datapoints.

4.2.5. Daily Temperature Extremes

Alena Creek is classified as a cool stream based on the lack of days with average water temperatures >18°C observed in either pre- or post-construction conditions (Table 7). Considering all sites and dates, the maximum temperature was 14.0°C, which occurred in July 2014 at the downstream site (Appendix C). A similar maximum temperature of 13.9°C at the downstream site post-construction in August 2018.

Upstream of the enhancement habitat, there were no days when the daily average temperature was <1°C pre- or post-construction. Downstream of the enhancement habitat between 1-3 days per year with temperatures <1°C were observed during pre-construction (1 day per year in 2014) and post-construction (3 days per year in 2017 and 2018).

Table 7. **Summary of daily average water temperature extremes (number of days >20°C, >18°C and <1°C) at ALE-USWQ1 and ALE-BDGWQ.**

Site	Project Phase	Year[1]	n (days)	Days T_{water} > 18°C	Days T_{water} > 20°C	Days T_{water} < 1°C
ALE-USWQ1	Pre-construction	2013	256	0	0	0
		2014	306	0	0	0
	Post-construction	2016	38	0	0	0
		2017	364	0	0	0
		2018	365	0	0	0
ALE-BDGWQ	Pre-construction	2013	125	0	0	0
		2014	328	0	0	1
	Post-construction	2016	38	0	0	0
		2017	364	0	0	3
		2018	304	0	0	3

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

[1] Data gaps occurred in the February 2014 dataset due to suspected ice conditions in the river.

4.2.6. Mean Weekly Maximum Temperatures (MWMxT)

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

A comparison of MWMxT temperature data to optimum temperature ranges for Coho Salmon, Cutthroat Trout, and Bull Trout was completed for each species using pre- and post-construction data collected for the upstream site (Table 8, Table 9) and the downstream site (Table 10, Table 11).

Each of the tables provides the percent complete of the data record for each life stage along with the minimum and maximum MWMxT range in each period. The percentage of data within the optimum temperature ranges is provided to evaluate the overall suitability of the temperate range for each fish species life stage. Exceedance of the BC WQG range (greater than ±1°C outside the optimum ranges) are highlighted in each summary table.

The year-round range in MWMxT temperature corresponds to the rearing life stage for all the fish species (Table 10, Table 11). During 2018, the MWMxT values ranged from 3.5°C to 10.4°C at the upstream site, which is similar to the 2017 range (3.5°C to 10.5°C) and also similar to the pre-construction range of 4.4°C to 9.8°C if we consider that the lower range does not include the February 2014 data (Table 8, Table 9). At the downstream site, during 2018, the MWMxT values ranged from 1.8°C to 13.4°C, similar to the 2017 range (1.6°C to 12.9°C) and also similar to the pre-construction range of 2.1°C to 13.7°C.

MWMxT values in relation to species-specific optimal temperature ranges differed by species and location. Bull Trout prefer cooler temperatures overall in comparison to Cutthroat Trout and Coho Salmon (Table 2), therefore fewer exceedances of the cooler temperature limits are observed for this species. At the upstream site MWMxT values were generally sub-optimally cool for all species and life history stages except spawning and incubation for Coho Salmon and Bull Trout (Table 8, Table 9). At the downstream site MWMxT values were sub-optimally cool with the exception of Cutthroat Trout and Bull Trout incubation periods where no exceedances were observed (Table 10, Table 11)

The exceedances of the cooler temperature limits were generally more prevalent at the downstream site (ALE-BDGWQ); the upstream location (ALE-USWQ) was somewhat warmer during the winter months likely due to the influence of groundwater at this location.

Considering exceedances of the higher temperature ranges, exceedances are observed for Bull Trout spawning and incubation periods at both sites, while the other species do not encounter any exceedances of the higher temperature range with the exception of Cutthroat Trout during the incubation period (2018 only) at the downstream site. Warmer surface waters during Bull Trout incubation at the upstream site may be partially mitigated by the groundwater upwelling which would result in lower temperature within the redds (Table 8, Table 9).

No substantial change in the range of MWMxTs were observed between pre- and post-construction phases considering natural inter-annual variability in water temperature and considering that there were data gaps during the cooler months in the pre-construction data set.

Table 8. Pre-construction MWMxT for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-USWQ1.

Species	Life Stage Data			Year	%	MWMxT		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)		Complete[1]	Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	98.4	5.6	9.4	6.7	37.5	62.5	0.0	0.0
				2014	98.4	4.4	9.3	25.0	39.2	60.8	0.0	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	97.5	5.6	8.5	0.0	0.0	100.0	0.0	0.0
				2014	96.2	4.4	7.9	0.0	1.3	98.7	0.0	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	53.8	5.6	8.5	0.0	0.0	100.0	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2013	70.1	5.6	9.8	36.3	77.3	22.7	0.0	0.0
				2014	83.8	4.4	9.7	53.9	81.7	18.3	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2013	81.5	5.8	8.9	45.3	100.0	0.0	0.0	0.0
				2014	100	5.0	9.2	56.5	94.6	5.4	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2013	100	6.8	9.8	16.9	65.3	34.7	0.0	0.0
				2014	100	6.3	9.7	17.7	62.9	37.1	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2013	70.1	5.6	9.8	3.5	22.7	77.3	0.0	0.0
				2014	83.8	4.4	9.7	16.0	34.6	65.4	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	98.5	5.6	9.8	0.0	0.0	75.0	25.0	0.0
				2014	98.5	5.7	9.7	0.0	0.0	71.1	28.9	0.0
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	77.9	5.6	9.8	0.0	0.0	6.0	94.0	64.5
				2014	70.9	4.4	9.7	0.0	0.0	18.5	81.5	76.2
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2013	70.1	5.6	9.8	0.0	3.5	96.5	0.0	0.0
				2014	83.8	4.4	9.7	4.2	16.0	84.0	0.0	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 9. Post-construction MWMxT for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-USWQ1.

Species	Life Stage Data			Year	%	MWMxT		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)		Complete[1]	Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2017	100	3.5	10.4	43.4	56.6	43.4	0.0	0.0
				2018	100	5.3	9.3	23.8	44.3	55.7	0.0	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2017	100	3.5	7.8	0.0	15.2	84.8	0.0	0.0
				2018	100	5.2	8.5	0.0	0.0	100.0	0.0	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	76.3	4.6	6.3	0.0	0.0	100.0	0.0	0.0
				2017	100	3.5	7.8	0.0	8.9	91.1	0.0	0.0
				2018	62.1	4.8	8.5	0.0	0.0	100.0	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2017	99.7	3.5	10.5	71.4	89.0	11.0	0.0	0.0
				2018	100	3.5	10.4	57.0	80.5	19.5	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2017	98.9	3.5	8.3	90.1	100.0	0.0	0.0	0.0
				2018	100.0	5.3	9.6	45.7	78.3	21.7	0.0	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2017	99.2	6.2	10.5	43.9	77.2	22.8	0.0	0.0
				2018	100.0	7.3	10.4	10.5	45.2	54.8	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2017	99.7	3.5	10.5	40.9	54.9	45.1	0.0	0.0
				2018	100.0	3.5	10.4	33.7	44.9	55.1	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2017	100	5.2	10.5	0.0	0.0	72.3	27.7	8.5
				2018	100	5.7	10.2	0.0	0.0	77.7	22.3	1.5
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2017	100.0	3.5	10.5	0.0	0.0	50.7	49.3	41.3
				2018	84.5	4.8	10.2	0.0	0.0	30.6	69.4	56.1
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2017	99.7	3.5	10.5	9.9	40.9	59.1	0.0	0.0
				2018	100.0	3.5	10.4	15.3	33.7	66.3	0.0	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 10. Pre-construction MWMxT for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-BDGWQ.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2013	99.2	2.1	12.5	43.8	49.6	50.4	0.0	0.0
				2014	99.2	3.2	11.7	40.5	42.1	57.9	0.0	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2013	98.7	2.1	8.8	10.3	30.8	69.2	0.0	0.0
				2014	97.5	3.2	9.1	3.9	28.6	71.4	0.0	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2013	82.2	2.1	8.8	13.7	52.5	47.5	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2014	89.9	2.2	13.7	44.8	50.3	49.7	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2014	92.4	5.9	12.7	24.7	31.8	60.0	8.2	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2014	99.2	8.5	13.7	0.0	3.3	61.0	35.8	13.8
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2014	89.9	2.2	13.7	34.5	40.2	59.8	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2013	78.5	2.1	12.5	5.9	13.7	46.1	40.2	26.5
				2014	99.2	3.5	13.3	3.9	11.6	30.2	58.1	48.1
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2013	83.1	2.1	12.5	0.0	0.0	55.4	44.6	37.9
				2014	70.9	3.2	13.3	0.0	0.0	32.5	67.5	66.2
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2014	89.9	2.2	13.7	30.2	34.5	65.5	0.0	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 11. Post-construction MWMxT for Bull Trout, Cutthroat Trout, and Coho Salmon life stages at ALE-BDGWQ.

Species	Life Stage Data			Year	% Complete[1]	MWMxT		% of MWMxT				
	Periodicity	Optimum Temperature Range (°C)	Duration (days)			Min. (°C)	Max. (°C)	Below Lower Bound by >1°C	Below Lower Bound	Between Bounds	Above Upper Bound	Above Upper Bound by >1°C
Coho Salmon	Migration (Sep. 01 to Dec. 31)	7.2-15.6	122	2017	100	1.6	12.8	50.0	55.7	44.3	0.0	0.0
	Spawning (Oct. 15 to Jan. 01)	4.4-12.8	79	2017	100	1.6	8.1	19.0	55.7	44.3	0.0	0.0
	Incubation (Oct. 15 to Apr. 01)	4.0-13.0	169	2016	76.3	2.8	5.7	1.6	41.9	58.1	0.0	0.0
				2017	100.0	1.6	8.1	14.2	47.9	52.1	0.0	0.0
	Rearing (Jan. 01 to Dec. 31)	9.0-16.0	365	2017	99.7	1.6	12.9	56.6	62.4	37.6	0.0	0.0
				2018	82.7	1.8	13.4	44.4	49.7	50.3	0.0	0.0
Cutthroat Trout	Spawning (Apr. 01 to Jul. 01)	9.0-12.0	92	2017	98.9	4.3	12.2	39.6	52.7	42.9	4.4	0.0
				2018	100.0	5.7	12.6	23.9	33.7	59.8	6.5	0.0
	Incubation (May. 01 to Sep. 01)	9.0-12.0	124	2017	99.2	7.4	12.9	4.9	14.6	61.8	23.6	0.0
				2018	100.0	8.7	13.4	0.0	3.2	58.9	37.9	10.5
	Rearing (Jan. 01 to Dec. 31)	7.0-16.0	365	2017	99.7	1.6	12.9	47.0	49.7	50.3	0.0	0.0
				2018	82.7	1.8	13.4	31.8	35.4	64.6	0.0	0.0
Bull Trout	Spawning (Aug. 01 to Dec. 08)	5.0-9.0	130	2017	100	3.3	12.9	7.7	23.8	26.9	49.2	41.5
				2018	69.2	7.5	13.4	0.0	0.0	32.2	67.8	48.9
	Incubation (Aug. 01 to Mar. 01)	2.0-6.0	213	2017	100.0	1.6	12.9	0.0	5.2	51.6	43.2	40.8
	Rearing (Jan. 01 to Dec. 31)	6.0-14.0	365	2017	99.7	1.6	12.9	42.3	47.0	53.0	0.0	0.0
				2018	82.7	1.8	13.4	22.5	31.8	68.2	0.0	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.

4.2.7. Bull Trout Temperature Guidelines

Bull Trout specific water temperate guidelines (see Section 3.2.4.1) were applied to the pre- and post-construction water temperature records by calculating the number of days of exceedance of the minimum and maximum temperature thresholds (Table 12). In BC, Bull Trout are considered to have the highest thermal sensitivity of the native salmonids evaluated in Oliver and Fiddler (2001), therefore more restrictive guidelines are applied to streams with this species.

During both pre- and post-construction monitoring periods, the highest maximum daily temperatures did not exceed the prescribed thresholds for rearing (15°C) at either site (Table 12).

The number of day where daily maximum water temperatures were outside the Bull Trout thresholds for spawning and incubation (i.e., >10°C) were higher overall at the downstream site (ALE-BDGWQ) in comparison to the upstream site (ALE-USWQ1), due to warmer temperatures in August and September at the downstream site (Table 12, Figure 3). In general, water temperatures at the downstream site do not cool below 10°C until late September/October (Section 3 in Appendix C). Warmer temperatures (i.e., more days with exceedances of the 10°C limit) post-construction in comparison to pre-construction were observed at both the upstream and downstream sites suggesting this is due to natural inter-annual variability.

The number of days where the minimum temperature was less than the incubation threshold (i.e., <2°C) were also higher at the downstream site due to cooler temperatures during the winter months (Figure 3). These results suggest that temperature regime may be more suitable for Bull Trout at the upper end of the enhancement habitat area during spawning and incubation (Table 12).

Table 12. Summary of incidence (number of days) where the daily minimum or maximum water temperature exceeds the Bull Trout BC WQG (MOE 2018).

Site	Project Phase	Year	n (days)[1]	Rearing (Year Round)	Spawning (Aug.1 - Dec. 8)	Incubation (Aug. 1 - Mar. 1)	
				T_{water} > 15°C	T_{water} > 10°C	T_{water} < 2°C	T_{water} > 10°C
ALE-USWQ1	Pre-construction	2013	256	0	0	0	0
		2014[2]	306	0	0	0	0
	Post-construction	2017	364	0	14	2	14
		2018	365	0	10	0	10
ALE-BDGWQ	Pre-construction	2013	125	0	28	9	28
		2014	329	0	58	33	58
	Post-construction	2017	364	0	53	39	53
		2018	304	0	47	26	47

[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 (2018).

[2] Value excludes February 2014 data based on suspected ice conditions.

4.3. Fish Habitat

4.3.1. Stability Assessment

Photos were taken at established photo-point locations in the enhanced reaches (Reach 1 and Reach 3) of Alena Creek on November 5, 2018. A comparison of all photos is available in Appendix D; however, a selection of comparison photos is presented below. Overall, the riparian vegetation has increased since 2016 and the channel has remained stable over this time. No substantial changes to the stream channel where noted that were not anticipated as part of the dynamic stability criteria of the design. Some erosion of the right channel bank was noted as a result of a water bar that has been installed to convey run-off across and away from the Lillooet River FSR. The run-off flows to toward Reach 3 and has eroded a section of bank at the discharge point.

4.3.1.1. Reach 1

Reach 1 is the most downstream reach of Alena Creek and was enhanced under the FHEP and starts at the Lillooet River Forest Service Road (FSR, Map 4) bridge. In 2016, thirteen riffles and more than 120 pieces of large woody debris were installed in Reach 1 with total creation of 1,387 m^2 of enhanced fish habitat. The stream channel at ALE-XS1 has widened slightly with wetted access to the constructed floodplain on river left, as seen in 2017 and as intended in the design (Figure 5 to Figure 7). There were no other significant changes along Reach 1.

Figure 5. Looking from river right to river left at ALE-XS1 on September 19, 2016.

Figure 6. Looking from river left to river right at ALE-XS1 on November 10, 2017.

Figure 7. Looking from river left to river right at ALE-XS1 on November 5, 2018.

4.3.1.2. Reach 3

A total of 668 m^2 of new instream habitat and 1,139 m^2 of floodplain was created in Reach 3 in 2016. Twelve cobble riffles and over 100 pieces of large woody debris were installed in this reach as under the FHEP. However, a mid-channel bar formed in 2017 just upstream of the ALE-XS6 as the result of erosion along the right bank (Figure 8 to Figure 10). In 2018, the mid-channel bar was still present but did not appear to impede flows or limit the potential fish habitat. Bank erosion has also caused channel widening and down-cutting in section at the riffle-crest downstream of ALE-XS5 (Figure 11). Repairs are recommended in Section 5.3.

Beaver activity has created significant damming upstream of both Reach 1 and Reach 3 but these dams were removed in accordance with dam removal best management practices by a licensed trapper from EBB Environmental Consulting Inc. in September 2018. Reconstruction of beaver dams at these locations may restrict fish migration and downstream gravel migration and will be monitored in 2019. Beaver dams that temporarily created backwatered areas, appear to have caused new channel formation at the upper enhanced reach and have the potential to affect both enhanced reaches in the future.

Figure 8. Looking upstream at ALE-XS6 on November 10, 2016.

Figure 9. Looking upstream at ALE-XS6 on November 10, 2017

Figure 10. Looking upstream of ALE-XS6 on November 5, 2018.

Figure 11. **Looking upstream at the riffle crest located downstream of ALE-XS5 showing band erosion (yellow arrow) and down-cutting. The red arrow shows dewatered riffle crest. November 10, 2017.**

4.4. Fish Community

4.4.1. Adult Spawner Abundance

The peak count of Coho Salmon spawners observed in 2018 was 126 alive and 4 carcasses on November 5, 2018 (Table 13). The peak count was similar to that of 2017 but lower than 2016 (Table 14). A comparison of observations among years also highlights the variability in run timing, with the peak live count recorded on November 14 in 2016, December 5 in 2017, and November 5 in 2010 and 2018. Although surveys are not conducted at a frequency to allow total spawner abundance to be compared among years (i.e., peak counts may be influenced by survey timing and spawner residence time and predation), the counts provide an indication of use and demonstrate that Alena Creek supports equivalent or potentially greater use by Coho Salmon spawners compared to pre-enhancement. An example photograph of a Coho Salmon on a redd in enhanced habitat during 2018 is provided in Figure 12.

Table 13. Summary of adult fish observed during fall spawner surveys in 2018.

Stream	Date	Survey Time (hrs)	Survey Distance (m)	# of Live Adults Observed[1]			# of Adult Carcasses Observed[1]		
				CO	BT	CT	CO	BT	CT
Alena Creek	05-Nov-18	2.7	1,703	126	1	1	4	0	0
Alena Creek	15-Nov-18	2.4	1,911	49	0	0	18	0	0
Alena Creek	05-Dec-18	1.9	584	10	0	0	4	0	0
Alena Creek Total:		**6.9**	**4,197**	**185**	**1**	**1**	**26**	**0**	**0**

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

Table 14. Peak Coho Salmon spawner counts during baseline (2010, 2011) and post-construction monitoring (2016, 2017 and 2018).

	2010 Peak Count (05-Nov-10)		2011 Peak Count (02-Dec-11)		2016 Peak Count (27-Nov-16)		2017 Peak Count (05-Dec-17)		2018 Peak Count (05-Nov-18)	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
	127	0	110	1	174	18	110	22	126	4
Total	**127**		**111**		**192**		**132**		**130**	

Figure 12. Spawning Coho Salmon observed in the enhanced habitat in Reach 1 on November 5, 2018.

4.4.2. Juvenile Abundance

In September 24, 2018, 44 minnow traps were set overnight in riffle, pool, and glide habitat ranging in depth from 0.2 to 1.0 m (Table 15). A total of 866 fish were captured during minnow trap sampling consisting of 850 Coho Salmon and 16 Cutthroat Trout (Table 15). No juvenile Bull Trout were captured in 2018. Due to the high number of captured fish, at some sites a subsample of the captured fish were measured. Raw data tables and representative photographs of minnow trapping sites are presented in Appendix E.

Table 15. Summary of minnow trapping habitat characteristics and fish captures in Alena Creek on September 24, 2018.

Site	Date	Enhancement Status	# of Traps	Total Soak Time (hrs)	Mesh Size (mm)	Trap Depth Range (m)	Total Captures		
							BT	CO	CT
ALE-MT01	24-Sep-18	Enhanced	5	110.5	6	0.2 - 0.4	0	47	2
ALE-MT02	24-Sep-18	Enhanced	5	113.2	6	0.2 - 0.3	0	53	2
ALE-MT07	24-Sep-18	Enhanced	5	117.4	6	0.2 - 1.0	0	162	3
ALE-MT03	24-Sep-18	Unenhanced	4	97.1	6	0.2 - 0.6	0	135	2
ALE-MT06	24-Sep-18	Unenhanced	10	242.6	3-6	0.3 - 1.0	0	134	2
ALE-MT08	24-Sep-18	Enhanced	5	128.6	3-6	0.2 - 0.4	0	122	0
ALE-MT09	24-Sep-18	Enhanced	5	127.5	3	0.2 - 0.3	0	98	2
ALE-MT05	24-Sep-18	Unenhanced	5	128.8	3-6	0.5 - 0.7	0	99	3
Grand Total:			**44**	**1,065.6**			**0**	**850**	**16**
Grand Average:			**5.5**	**133.2**			**0**	**106**	**2**

4.4.2.1. Cutthroat Trout

A total of 13 Cutthroat Trout, ranging in length from 85 to 140 mm in length, were captured during the 2018 sampling program (Table 18). Based on a review of the length-frequency histogram (Figure 13) and aging data from scale analysis (Figure 15), discrete fork length ranges were defined for each age class (Table 18). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 19. Catch per unit effort (CPUE) ranged from 0 fish per 100 trap hours at ALE-MT08 to 2.6 fish per 100 trap hours in ALE-MT07 in the enhanced reach (Table 20). The average CPUE was 1.6 fish per 100 trap hours and the standard deviation was 0.8 fish per 100 trap hours.

Cutthroat Trout Fry (0+)

No Cutthroat Trout fry (0+) were captured at any of the sampling sites in 2018.

Cutthroat Trout Parr (1+)

Cutthroat Trout parr (1+) were distributed throughout Alena Creek and were captured at all sites except for ALE-MT06 and ALE-MT08, both in unenhanced reaches (Table 20). A total of 11 Cutthroat Trout 1+ parr were captured, with the highest captures in ALE-MT07.

Cutthroat Trout Parr (2+)

Only two Cutthroat Trout 2+ parr were captured in 2018, both of which captured in ALE-MT06 in Reach 2 (unenhanced reach).

Figure 13. **Fork length frequency for juvenile Cutthroat Trout captured (minnow trapping) in Alena Creek in 2018.**

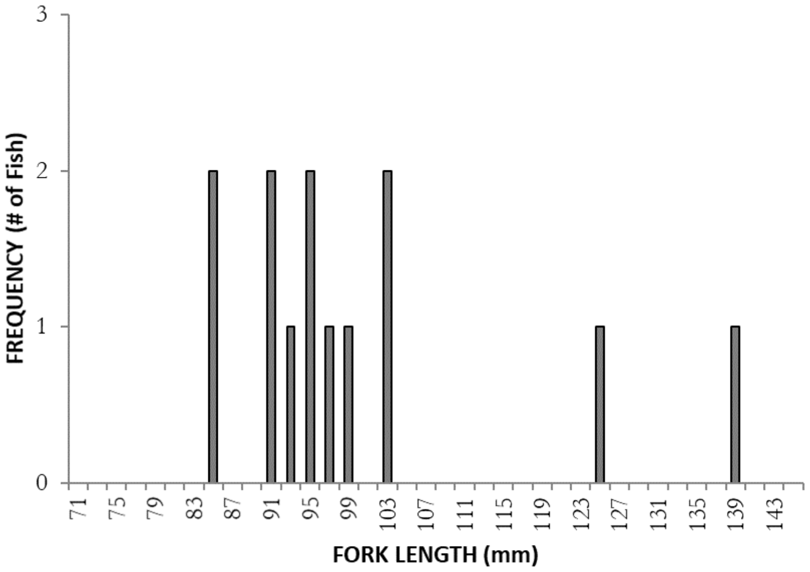


Figure 14. Fork length versus age for juvenile Cutthroat Trout captured in Alena Creek in 2018.

Table 16. Age size bins for juvenile Cutthroat Trout captured in Alena Creek in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	-
Parr (1+)	85-104
Parr (2+)	125-140

Table 17. Summary of fork length, weight and condition for juvenile Cutthroat Trout captured in Alena Creek in 2018.

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+)	11	95	85	104	11	9.1	6.0	11.0	11	1.06	0.94	1.17
Parr (2+)	2	133	125	140	2	25.5	21.0	30.0	2	1.08	1.08	1.09
All	**13**	**101**	**85**	**140**	**13**	**11.6**	**6.0**	**30.0**	**16**	**1.06**	**0.94**	**1.17**

Table 18. Catch and CPUE for Cutthroat Trout captured by minnow trapping in Alena Creek in 2018.

Site	Date	Enhancement Status	# of Traps	Total Soak Time	Total CT Catch (# of Fish)[1]	CPUE (# of Fish/100 Trap hrs)	Aged CT Catch (# of Fish)[2] 0+	1+	2+	All
ALE-MT01	24-Sep-18	Enhanced	5	110.5	2	1.8	0	2	0	**2**
ALE-MT02	24-Sep-18	Enhanced	5	113.2	2	1.8	0	1	0	**1**
ALE-MT07	24-Sep-18	Enhanced	5	117.4	3	2.6	0	3	0	**3**
ALE-MT03	24-Sep-18	Unenhanced	4	97.1	2	2.1	0	2	0	**2**
ALE-MT06	24-Sep-18	Unenhanced	10	242.6	2	0.8	0	0	2	**2**
ALE-MT08	24-Sep-18	Enhanced	5	128.6	0	0.0	0	0	0	**0**
ALE-MT09	24-Sep-18	Enhanced	5	127.5	2	1.6	0	2	0	**2**
ALE-MT05	24-Sep-18	Unenhanced	5	128.8	3	2.3	0	1	0	**1**
Grand Total:			**44**	**1,065.6**	**16**	**1.5**	**0**	**11**	**2**	**13**
Grand Average:			**5.5**	**133.2**	**2**	**1.6**	**0**	**1**	**0**	**2**
Grand Standard Deviation:				**45.5**	**1**	**0.8**	**0**	**1**	**1**	**2**

[1] Includes all captured fish in the minnow traps

[2] Only includes fish measured for fork length and assigned an age.

4.4.2.2. Coho Salmon

A total of 850 juvenile Coho Salmon were captured during minnow trap sampling in Alena Creek on September 24, 2018. Based on a review of the length-frequency histogram (Figure 15) and aging data from scale analysis (Table 19), discrete fork length ranges were defined for each age class (Table 20). Summary statistics of fish length, weight, and condition factor are presented for each age class in Table 20. CPUE ranged from 42.5 fish per 100 trap hours at ALE-MT01 (Reach 1, enhanced reach) to 139 fish per 100 trap hours in ALE-MT03 (Reach 2, unenhanced, Table 21). The total average CPUE was 83.8 fish per 100 trap hours and the standard deviation was 38 fish per 100 trap hours (Table 21).

Coho Salmon Fry (0+)

Coho Salmon fry (0+) were captured at all sampling sites in 2018 and are distributed throughout the sampled reaches of Alena Creek (Table 21). Coho Salmon fry were most abundant at ALE-MT03 in the unenhanced reach (Reach 2) and ALE-MT07 in the enhanced reach (Reach 1). In total, 68 Coho Salmon fry were processed in the field but it is likely that most of the Coho salmon released without processing were also fry.

Coho Salmon Parr (1+)

Coho Salmon 1+ parr were captured at all sites in 2018 except for ALE-MT09 (Table 21). They were most abundant in ALE-MT06, in the unenhanced reach (Reach 2).

Figure 15. Fork length frequency for juvenile Coho Salmon captured (minnow trapping) in Alena Creek in 2018.

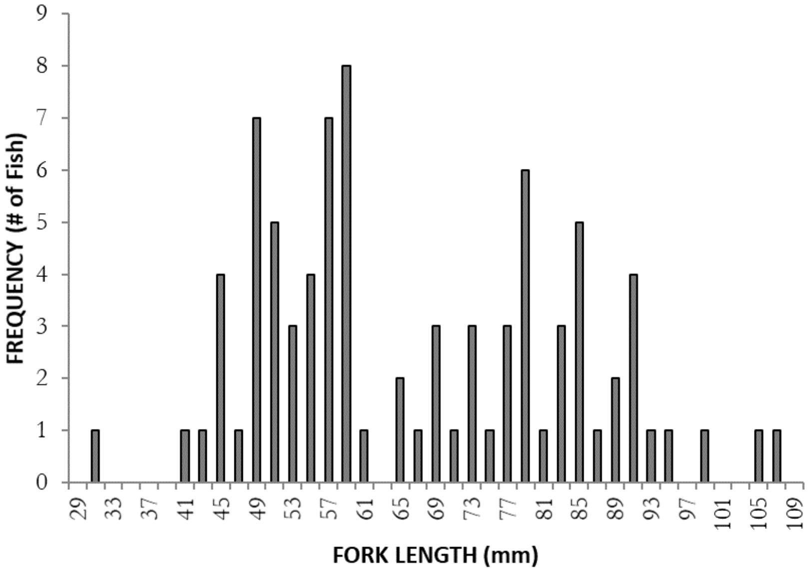


Figure 16. Fork length versus age for Coho Salmon captured in Alena Creek in 2018.

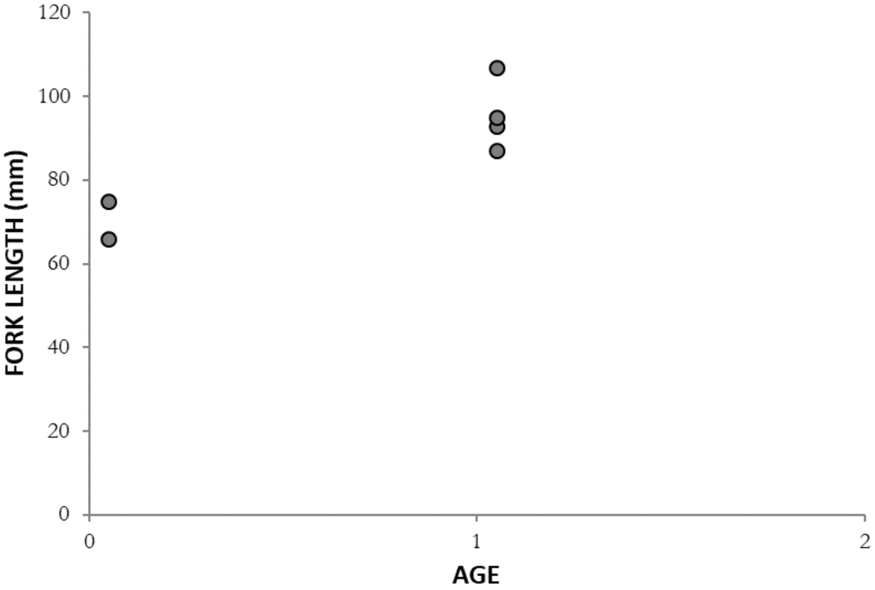


Table 19. Age size bins for Coho Salmon captured in Alena Creek in 2018.

Age Class	Fork Length Range (mm)
Fry (0+)	31-85
Parr (1+)	86-107

Table 20. Summary of fork length, weight and condition for Coho Salmon captured in Alena Creek in 2018.

Age Class	Fork Length (mm)				Weight (g)				Condition Factor (K)			
	n	Average	Min	Max	n	Average	Min	Max	n	Average	Min	Max
Fry (0+)	68	61	31	85	49	3.1	1.0	7.0	68	1.05	0.34	1.42
Parr (1+)	16	92	86	107	15	8.8	6.5	15.0	16	1.12	0.76	1.41
All	**84**	**67**	**31**	**107**	**64**	**4.4**	**1.0**	**15.0**	**850**	**1.06**	**0.34**	**1.42**

Table 21. Catch and CPUE for Coho Salmon captured in Alena Creek in 2018.

Site	Date	Enhancement Status	# of Traps	Total Soak Time	Total CO Catch (# of Fish)[1]	CPUE (# of Fish/100 Trap hrs)	Aged CO Catch (# of Fish)[2]		
							0+	1+	All
ALE-MT01	24-Sep-18	Enhanced	5	110.5	47	42.5	11	2	**13**
ALE-MT02	24-Sep-18	Enhanced	5	113.2	53	46.8	15	1	**16**
ALE-MT07	24-Sep-18	Enhanced	5	117.4	162	138.0	5	1	**6**
ALE-MT03	24-Sep-18	Unenhanced	4	97.1	135	139.0	8	3	**11**
ALE-MT06	24-Sep-18	Unenhanced	10	242.6	134	55.2	4	6	**10**
ALE-MT08	24-Sep-18	Enhanced	5	128.6	122	94.9	9	1	**10**
ALE-MT09	24-Sep-18	Enhanced	5	127.5	98	76.9	10	0	**10**
ALE-MT05	24-Sep-18	Unenhanced	5	128.8	99	76.9	6	2	**8**
Grand Total:			**44**	**1,065.6**	**850**	**79.8**	**68**	**16**	**84**
Grand Average:			**5.5**	**133.2**	**106**	**83.8**	**9**	**2**	**11**
Grand Standard Deviation:				**45.5**	**40**	**38.0**	**4**	**2**	**3**

[1] Includes all captured fish in the minnow traps

[2] Only includes fish measured for fork length and assigned an age.

4.4.2.3. Bull Trout

No Bull Trout were captured in Alena Creek minnow traps in 2018.

4.4.2.4. Comparison between Years

Cutthroat Trout

The 13 Cutthroat Trout captured in minnow traps in 2018 represents an increase from the seven captured in 2017, but a decrease from the 27 captured in 2013 and the 16 captured in 2014. While there were more sites sampled in 2018 (eight sites versus six sites in previous years), the average CPUE across sites in 2018 (1.6 fish per 100 trap hours) was greater than that of 2017 (0.8 fish per 100 trap hours) and similar to 2013 (1.8 fish per 100 trap hours) (Figure 17). The average CPUE in 2014 (7.2 fish per 100 trap hours) was much higher than other years; however, the 2014 CPUE results are biased high by the short daytime sets and the likelihood that catchability is not constant throughout the trap's soak time, with a high initial catch rate that diminishes over time (Harwood *et al.* 2016).

In 2018, Cutthroat Trout were relatively evenly distributed in relatively low numbers throughout Alena Creek, similar to previous years (Figure 18). The standard deviation of CPUE among sites was 0.8 fish per 100 trap hours compared to 0.7 fish per 100 trap hours in 2017 and 2013.

In all sampling years, the most abundant age class of Cutthroat Trout captured was 1+ parr. No Cutthroat Trout fry were captured in 2017 and 2018. Only three fry were captured during two sampling events in September 2013 and only one fry was captured in October 2014. The lack of Cutthroat Trout fry captured during sampling is likely a result of the timing of emergence and the size of fry in late September / early October.

Figure 17. **Comparison of minnow trap CPUE for Cutthroat Trout during baseline (2013 and 2014) and post-construction (2017 and 2018). Error bars represent standard error. Note that 2014 CPUE may be an overestimation due to shorter soak time at some sites due to bear activity.**

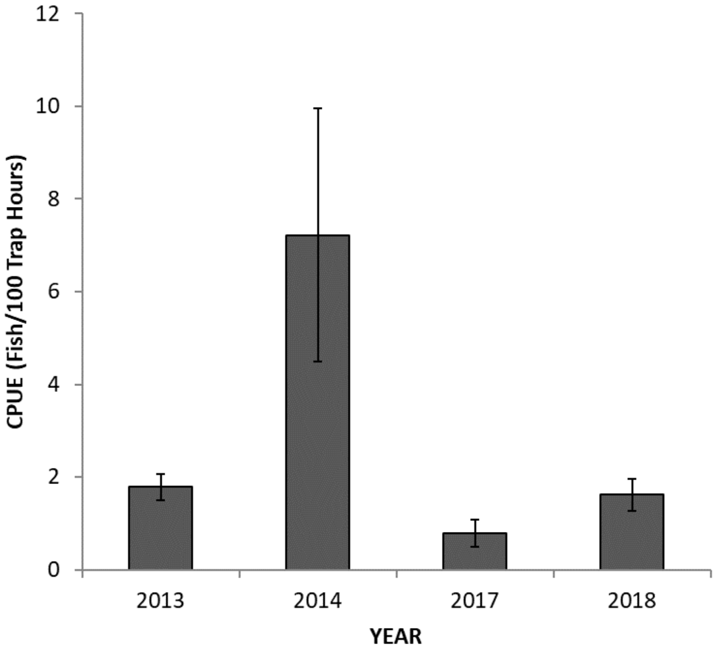
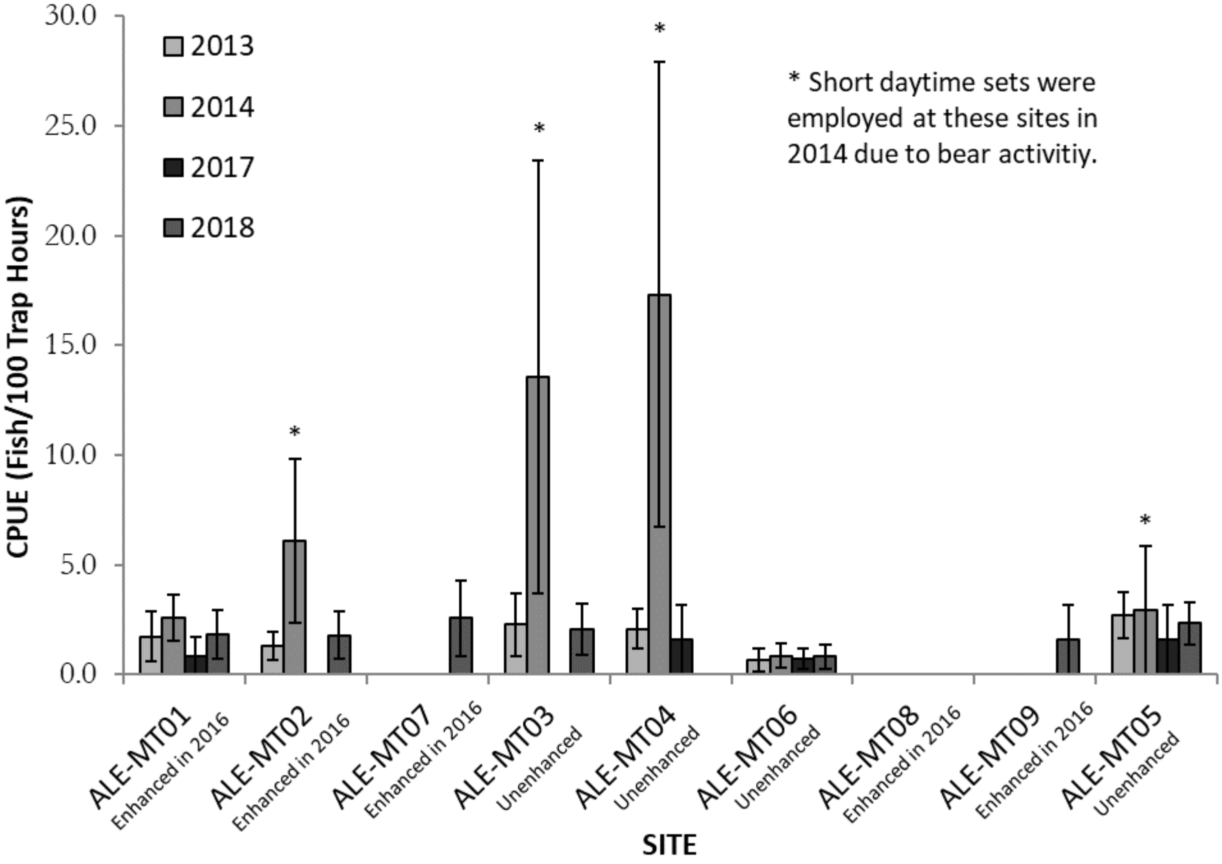


Figure 18. **Comparison of minnow trap CPUE for Cutthroat Trout at each site during baseline (2013 and 2014) and post-construction (2017 and 2018). Error bars represent standard error.**



Coho Salmon

The 850 Coho Salmon fry and parr captured in minnow traps in 2018 is higher than all previous sampling years (Figure 19). While there were more sites sampled in 2018 (eight sites versus six sites in previous years), the average CPUE across sites in 2018 (83.8 fish per 100 trap hours) was higher than all previous years (Figure 20).

In 2018, Coho Salmon fry and parr were found in all sites and were roughly distributed throughout Alena Creek similar to previous years (Figure 20). The standard deviation of CPUE among sites was 38.0 fish per 100 trap hours compared to 17.7 fish per 100 trap hours in 2013, 34.1 fish per 100 trap hours in 2014, and 20.4 fish per 100 trap hours in 2017.

Figure 19. **Comparison of minnow trap CPUE for Coho Salmon during baseline (2013 and 2014) and post-construction (2017 and 2018). Error bars represent standard error. Note that 2014 CPUE may be an overestimation due to shorter soak time at some sites due to bear activity.**

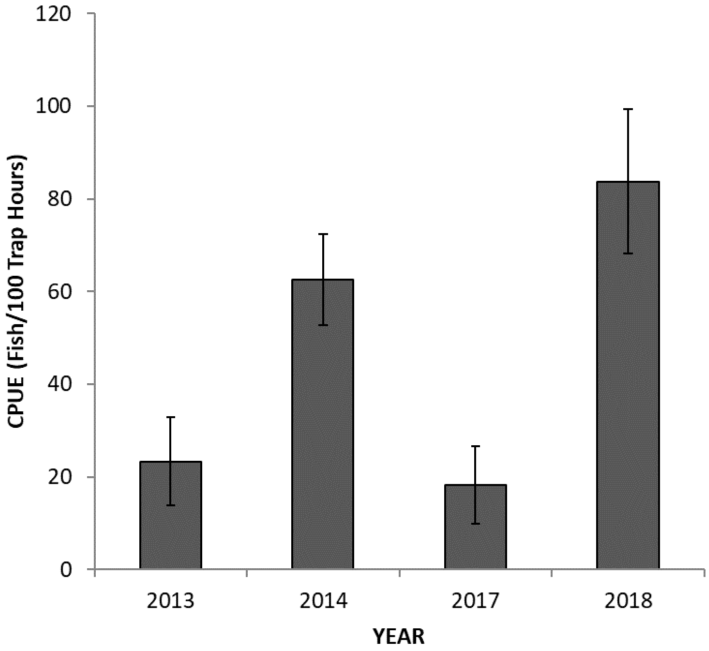
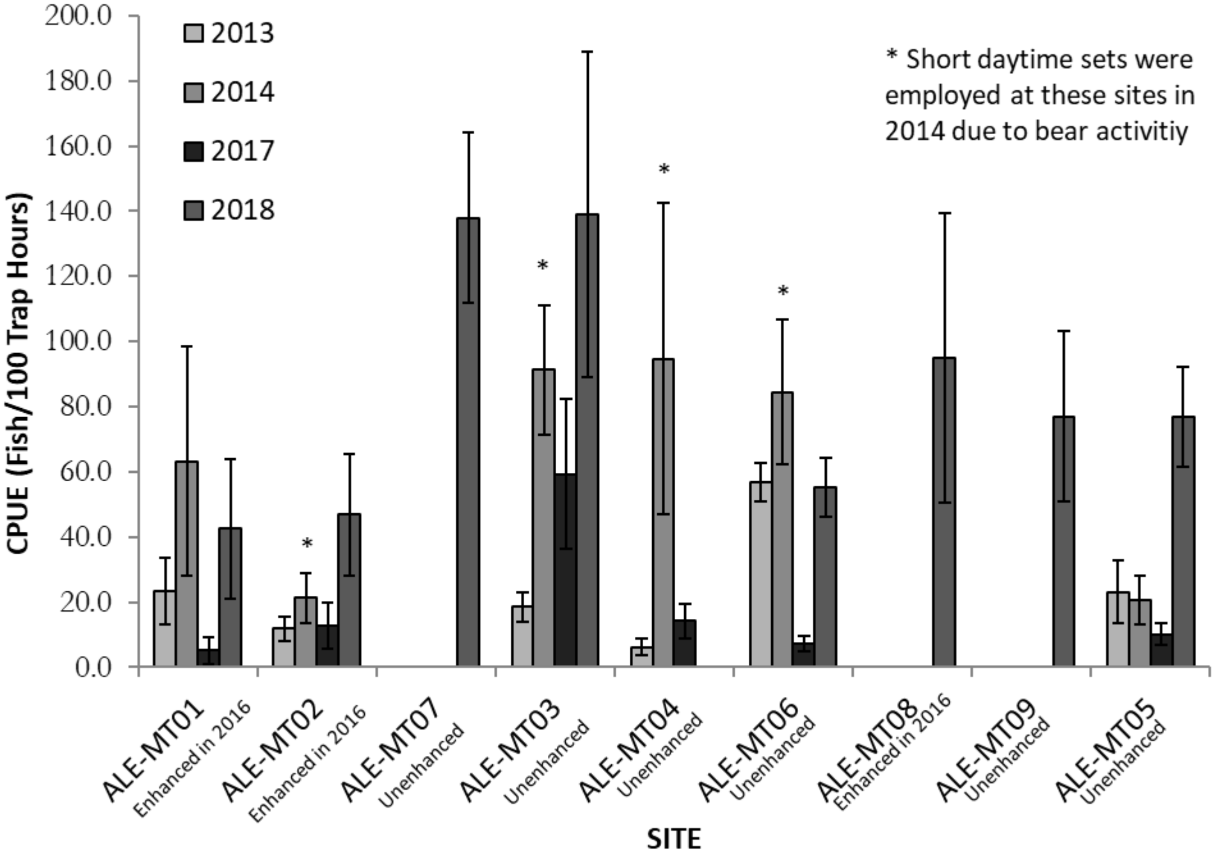


Figure 20. **Comparison of minnow trap CPUE for Coho Salmon at each site during baseline (2013 and 2014) and post-construction (2017 and 2018). Error bars represent standard error.**



5. RECOMMENDATIONS

The success of the enhancement habitat will be judged according to the criteria in the *Fisheries Act* Authorization, namely that the habitat enhancement is physically stable, maintains suitable flows, has been demonstrated to provide spawning and rearing habitat for Coho Salmon and Cutthroat Trout of not less than 2,310 m^2, and supports equivalent or greater fish usage relative to pre-project densities in Alena Creek. Details of the monitoring to be conducted to evaluate the effectiveness of the enhancement habitat were described in the Project's OEMP (Harwood *et al.* 2017), but based on the results of year 2 monitoring we recommend the following adjustments be made.

5.1. Hydrology

Simultaneous monitoring of stage at FSR bridge and R1 upstream locations during spring and summer (April to the end of July) is needed to accurately account for the backwatering of the gauge at the FSR bridge over Alena Creek when flows in the Upper Lillooet River are high, and to ensure the stage data collected are representative of Alena Creek water levels. We recommend continuing hydrometric monitoring at both locations. Future monitoring efforts should also include standard practice of gauge maintenance recommended by RISC (2009) prior to spring snowmelt and throughout monitoring period to avoid future issues with missing data during this critical period.

5.2. Water Temperature

Close to two full years (2017 and 2018) of water temperature data have been collected post-construction upstream and downstream of the enhancement habitat. Results to date indicate that the enhancement habitat provides water temperatures typical of the area, with beneficial moderating effects due to groundwater inflow upstream of the habitat. Overall temperatures are more suitable for Bull Trout than Coho Salmon and Cutthroat Trout due to the generally cooler optimum temperature ranges for Bull Trout.

Overall, no substantial differences were observed in the pre- and post-construction temperature regimes. We recommend that the monitoring program continue for 5 years post-construction based on the methodologies and schedule prescribed in the Project OEMP (Harwood *et al.* 2017). It is recommended that post-construction water temperature data from the water level sensor at the upstream site be obtained should it exist in order to provide additional QA for the single Tidbit sensor present at this site. It is recommended that a second Tidbit be installed at this site for data redundancy as fully submerged Tidbits are less susceptible to icing issues compared to water level sensors that are housed in standpipes that are exposed to the atmosphere.

5.3. Fish Habitat

The overall function and quality of the constructed habitats remains high despite the flood events experienced in Alena Creek since construction. In the downstream reach, Reach 1, we recommend continued monitoring of the bank erosion at 0+185 just upstream of ALE-XS1. In Reach 3, we recommend undertaking instream repairs during the least risk timing window in August 2019; however, we recognize that cutting and live-staking should be completed in late September. We anticipate that all repairs can be completed by hand, utilizing a crew of four over 1-2 days of work. At ALE-XS5, material from the constructed riffle crest that is currently dewatered can be utilized to reconstruct the weir in the wetted width. This will alleviate all upstream concerns with further channel incision. The erosion issues upstream of both ALE-XS6 and ALE-XS7 should also be repaired. It may be possible to complete the repairs utilizing materials on site, or it may need to be sourced locally and brought into site. This could be done using small equipment, such as an ATV with a trailer and manual labor. In addition to using materials like cobble and small boulder, locally cut willow and red-osier stakes should be planted at select bank sites to aid in short-term stability.

Beavers were trapped within the Alena Creek enhancement area and dams were removed in the fall of 2018 by a licensed trapper from EBB Environmental Consulting Inc. We recommend that beaver activity continue to be monitored and assessed to ensure the enhancement habitat remains functional. Recommendations for further beaver and beaver dam management will be provided following the 2019 channel stability assessment.

5.4. Fish Community

The fish community component of the Alena Creek FHEP monitoring was successfully implemented in 2018, which included an increase in the number of minnow trapping sites compared to previous years. We recommend that the monitoring program continue in 2019 following the methods used in 2018.

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McCoy, D. 2016. Engineering Manager, Innergex Renewable Energy Inc. Email communication with J. Mancinelli, Innergex Renewable Energy Inc., November 14, 2016.

PROJECT MAPS

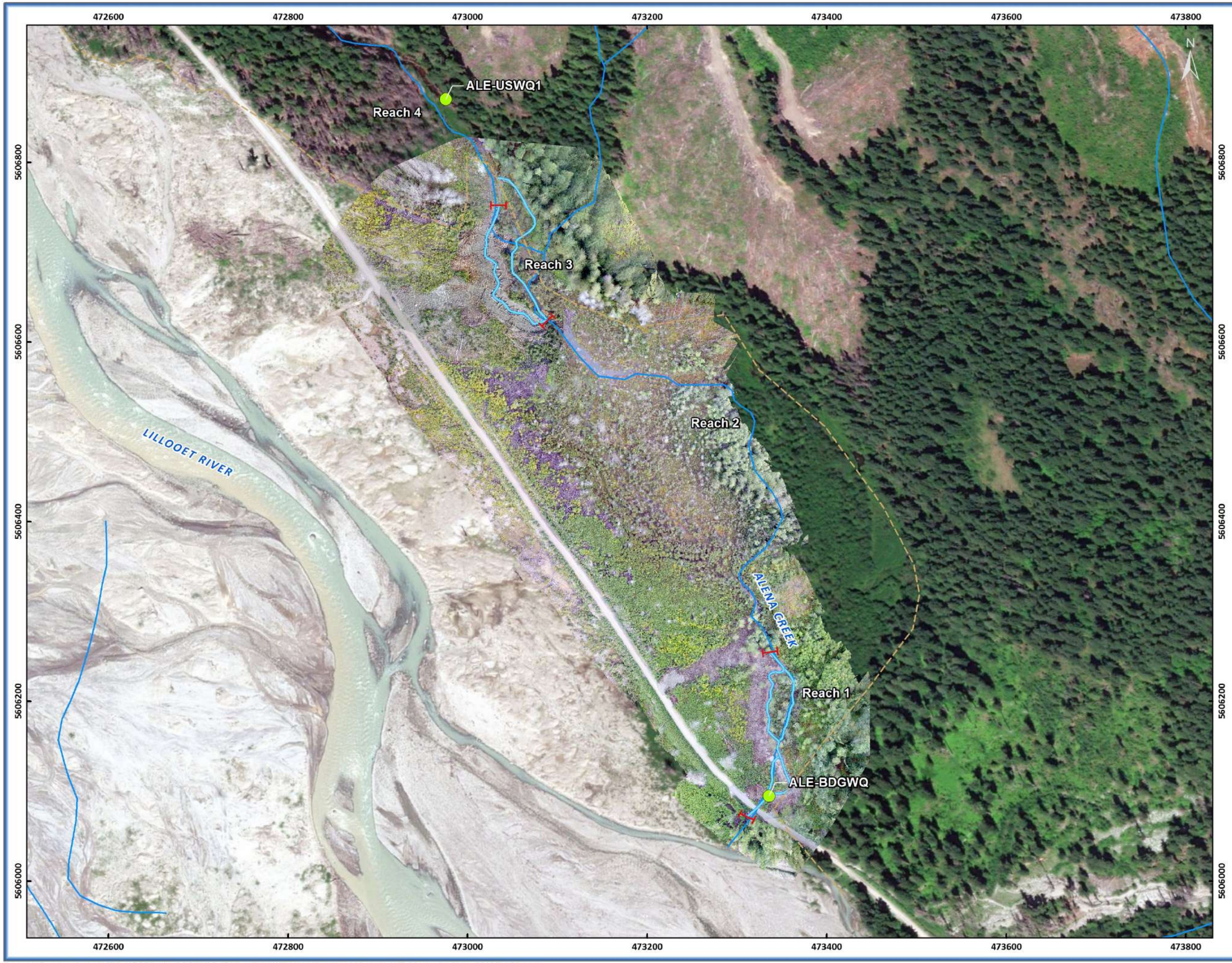
NO.	DATE	REVISION	BY
1	17/04/2018	1095_ALN_FHAP_2017Oct24	SPK
2			
3			
4			
5			

Map 2

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ALN_FHAP_2017Oct24.mxd

UPPER LILLOOET HYDRO PROJECT

Alena Creek Water Temperature Monitoring Sites



Legend

- ● Water Temperature Monitoring Site
- Reach Break
- I The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- - - Meager Creek Slide Extent
- ━ Enhanced Reaches
- ─ Streams (Hedberg)

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:4,000

NO.	DATE	REVISION	BY
1	24/04/2019	1095_ALN_WT_MonitoringSites_2019Feb25	SPK
2			
3			
4			
5			

Date Saved: 24/04/2019
Coordinate System: NAD 1983 UTM Zone 10N

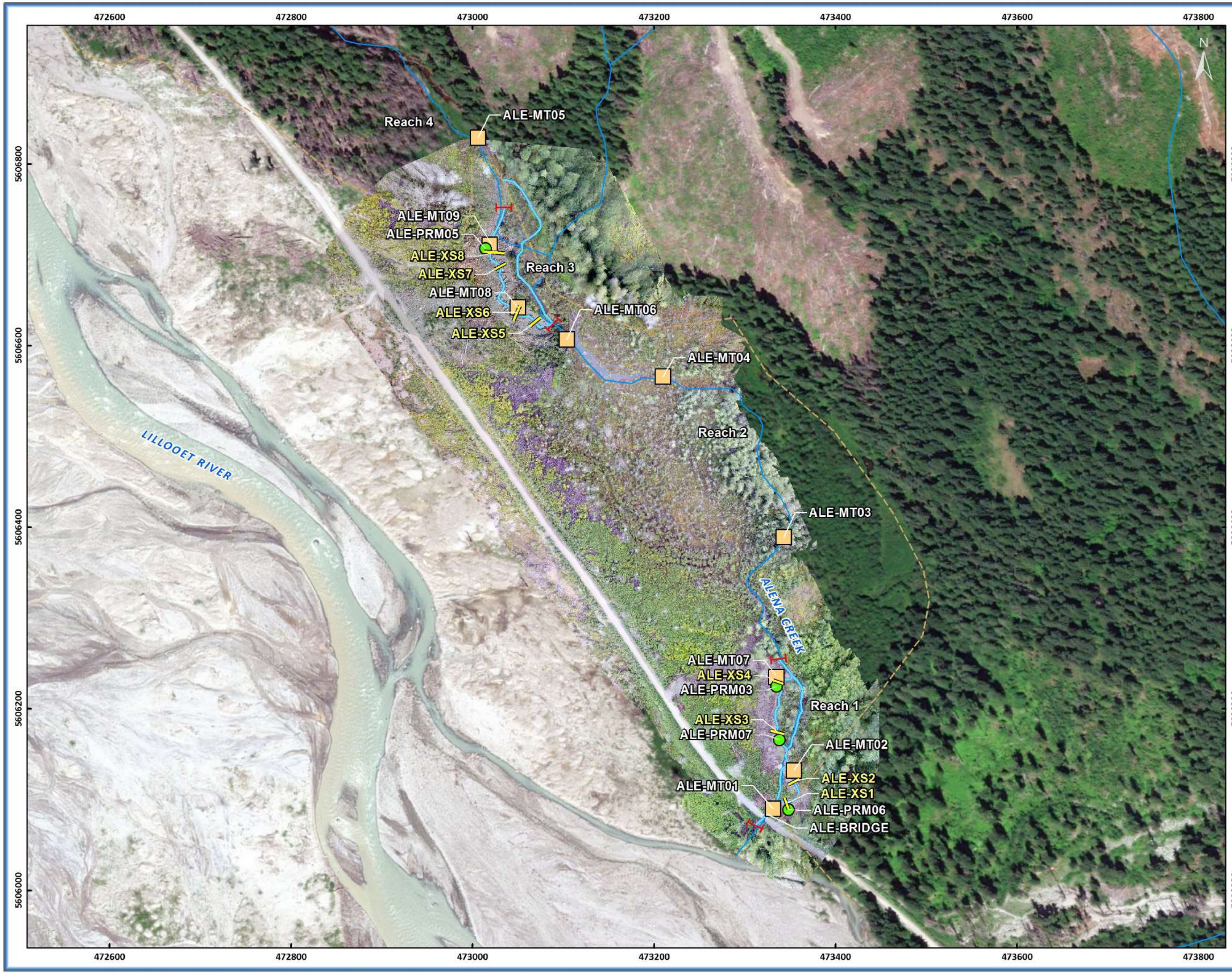
ECOFISH RESEARCH

Map 3

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\WaterQuality\1095_ALN_WT_MonitoringSites_2019Feb25.mxd

UPPER LILLOOET HYDRO PROJECT

Alena Creek Fish Abundance Sampling and Riparian Monitoring Sites



Legend

- 🟧 Minnow Traps
- ● Permanent Vegetation Monitoring Plots
- I Reach Break
The extent of enhanced habitat is delineated by Reach 1 (downstream) and Reach 3 (upstream)
- ═ Transect Sites
- - - Meager Creek Slide Extent
- ═ Enhanced Reaches
- — Streams (Hedberg)

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 25 50 100 150 200 m

Scale: 1:4,000

NO.	DATE	REVISION	BY
1	24/04/2019	1095_ALN_FishAbundanceRipMonSites_2019Mar26	SPK
2			
3			
4			
5			

Date Saved: 24/04/2019
Coordinate System: NAD 1983 UTM Zone 10N

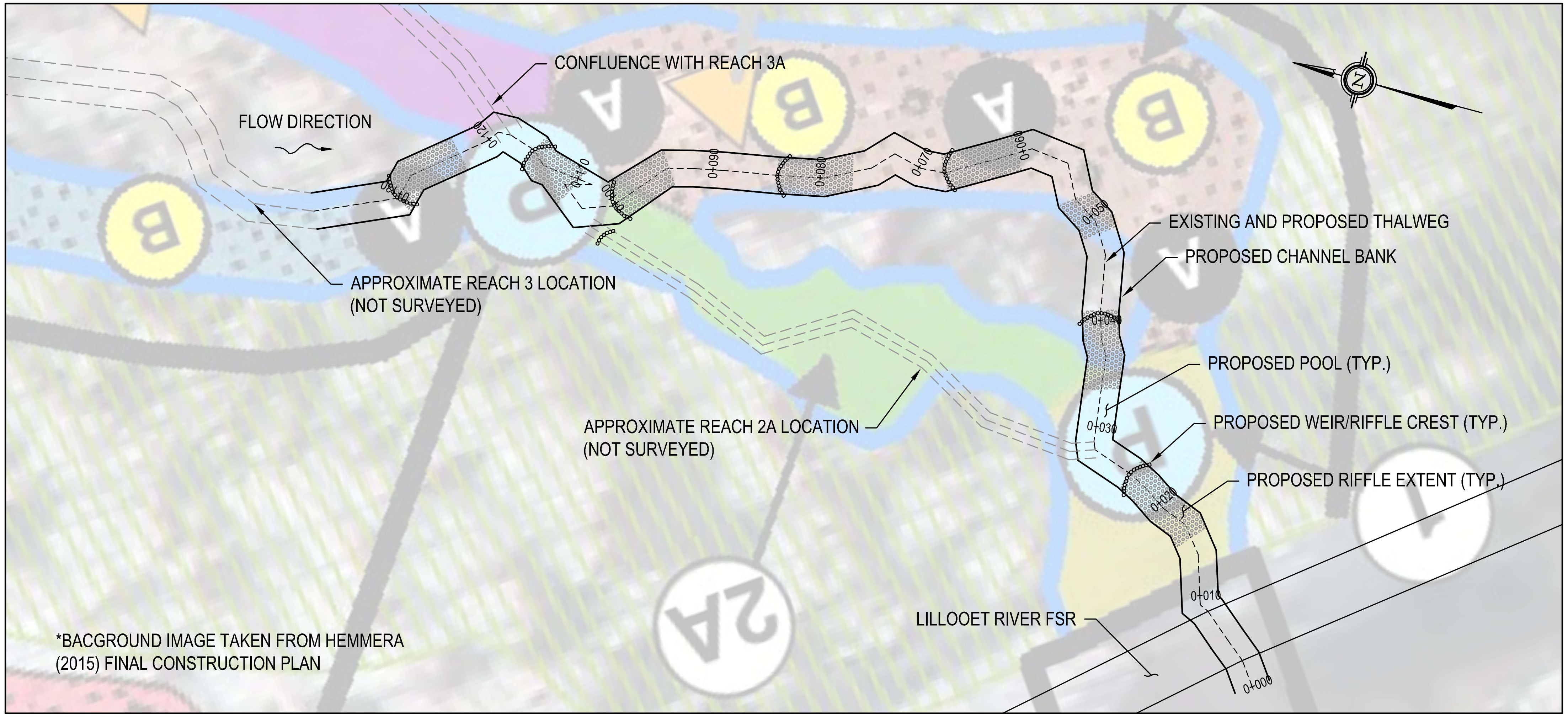
ECOFISH RESEARCH

Map 4

Path: M:\Projects-Active\1095_UPPERLILLOOETPROJECT_NEW\MXD\Fisheries\1095_ALN_FishAbundanceRipMonSites_2019Mar26.mxd

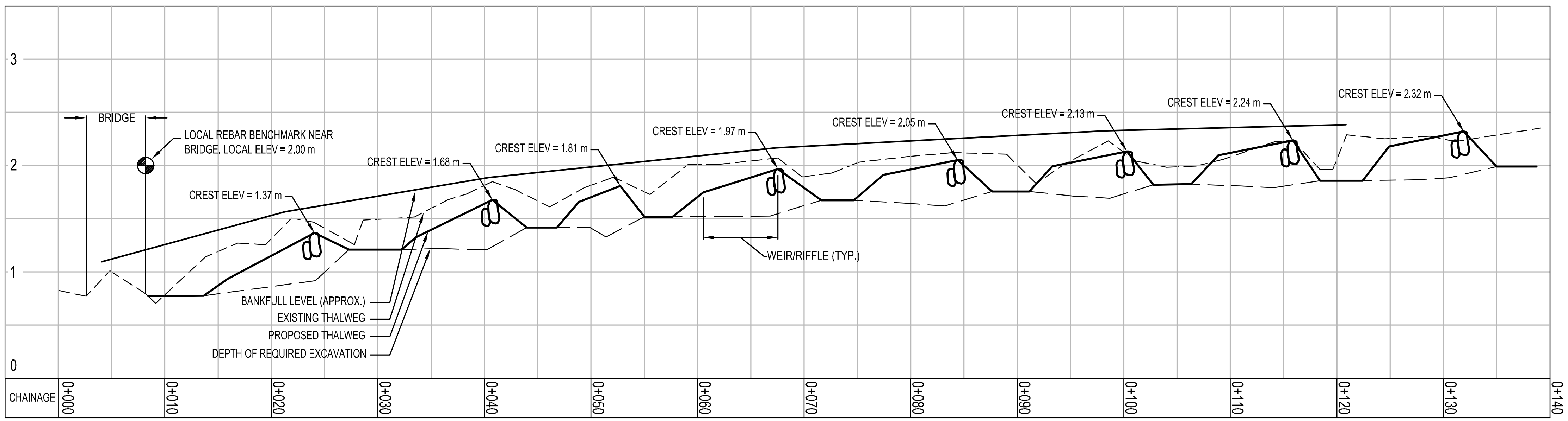
APPENDICES

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



REACH 1, 2, & 2A PLANVIEW

1:500



REACH 1, 2, & 2A PROFILE

1:500

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.
4. ALL MEASUREMENTS FOR THIS PROJECT ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE INDICATED.
5. THE CONTRACTOR SHALL BE RESPONSIBLE FOR LAYOUT, SURVEY AND LOCATION OF ALL UTILITIES.
6. LOCATION OF FEATURES AND EXTENT OF WORKS SHALL BE REVIEWED AND APPROVED BY ENVIRONMENTAL MONITOR.
7. ALL WORKS SHALL BE SUPERVISED, INSPECTED AND APPROVED BY A ENVIRONMENTAL MONITOR.
8. ALL WORKS AND MATERIALS SHALL BE IN ACCORDANCE WITH APPLICABLE MUNICIPAL AND/OR PROVINCIAL STANDARD SPECIFICATIONS AND DRAWINGS.
9. ALL GENERAL BACKFILL SHALL BE APPROVED MATERIAL COMPACTED TO 85% STANDARD PROCTOR DENSITY.
10. ALL UNSUITABLE AND/OR EXCESS MATERIALS SHALL BE DEPOSITED IN A SPOIL AREA DETERMINED BYENVIRONMENTAL MONITOR.
11. IMMEDIATELY AFTER CONSTRUCTION, ALL DISTURBED AREAS SHALL BE STABILIZED AND/OR RESTORED TO ORIGINAL CONDITION.
12. THE CONTRACTOR SHALL REMOVE ALL SEDIMENT CONTROLS AFTER VEGETATION HAS ESTABLISHED. WORKS WILL NOT BE CONSIDERED COMPLETE UNTIL ALL TEMPORARY SEDIMENT CONTROLS ARE REMOVED.

WATERCOURSE PROTECTION

1. MITIGATION MEASURES SECTION OF HEMMERA (2015) FINAL CONSTRUCTION PLAN TO BE REVIEWED AND ADHERED TO.
2. ALL EROSION AND SEDIMENT CONTROLS SHALL BE INSTALLED AS PER APPLICABLE PLANS.
3. ADDITIONAL EROSION AND SEDIMENT CONTROLS SHALL BE INSTALLED IF IT IS DETERMINED THAT APPROVED CONTROLS DO NOT ADEQUATELY PREVENT EROSION AND RELEASE OF SEDIMENT.
4. WHERE WORK IN A WATERCOURSE OR ON WATERCOURSE BANKS IS NOT REQUIRED, EQUIPMENT SHALL NOT BE OPERATED IN SUCH AREAS.
5. WHERE WORK IN A WATERCOURSE OR ON WATERCOURSE BANKS IS REQUIRED, THE USE OF EQUIPMENT WITHIN THE WATERCOURSE SHALL BE MINIMIZED.
6. WORK IN A WATERCOURSE AND ON WATERCOURSE BANKS SHALL BE COMPLETED IN THE DRY IN AN ISOLATED WORK AREA DURING LOW-FLOW CONDITIONS.
7. THE WEATHER FORECAST SHALL BE CONTINUALLY MONITORED TO ENSURE THAT CONSTRUCTION ACTIVITIES MAY PROCEED UNDER FAVOURABLE CONDITIONS.
8. EXCAVATION OF THE WATERCOURSE BED AND PLACEMENT OF MATERIALS SHALL BE STAGED SO THAT NO EXCAVATED AREAS REMAIN EXPOSED AT THE END OF EACH WORKING DAY.
9. IF FLOWS WITHIN A WATERCOURSE ARE OBSERVED TO RISE TO A LEVEL APPROACHING THE PUMPING CAPACITY, PLACEMENT OF MATERIALS IN EXCAVATED AREAS MUST BE COMPLETED AS SOON AS POSSIBLE, AFTER WHICH WORK MUST BE SHUT DOWN UNTIL THE FLOW RETURNS TO A LEVEL WITHIN THE PROVIDED PUMPING CAPACITY.
10. ALL EQUIPMENT SHALL BE CLEAN AND FREE OF PETROLEUM PRODUCTS.
11. ALL MAINTENANCE, REFUELING AND STORAGE OF EQUIPMENT SHALL BE CONTROLLED SO AS TO PREVENT ANY DISCHARGE OF PETROLEUM PRODUCTS. VEHICULAR MAINTENANCE AND REFUELING SHALL BE CONDUCTED AWAY FROM WATERCOURSES AND WATERCOURSE BANKS.
12. CONSTRUCTION MATERIAL, EXCESS MATERIAL, CONSTRUCTION DEBRIS AND EMPTY CONTAINERS SHALL BE STORED AWAY FROM WATERCOURSES AND WATERCOURSE BANKS.

	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

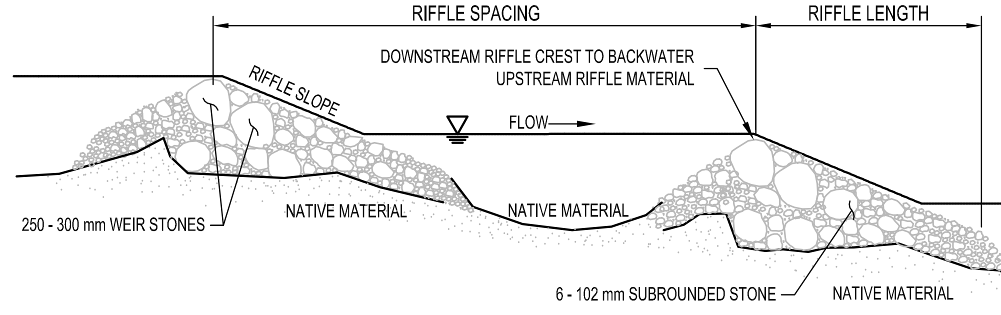
July 10, 2016
PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
D. T. WEST
41242

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

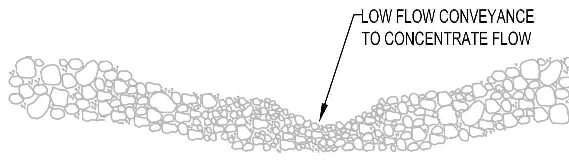


TYPICAL RIFFLE SEQUENCE PROFILE

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.

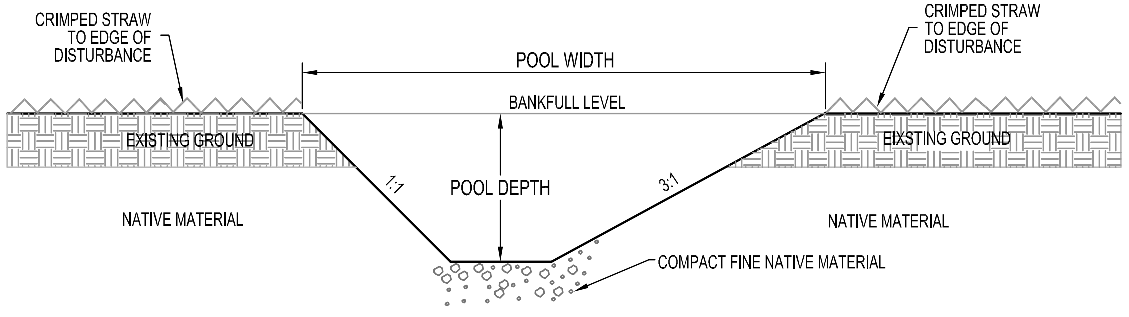


CROSS-SECTION

N.T.S.

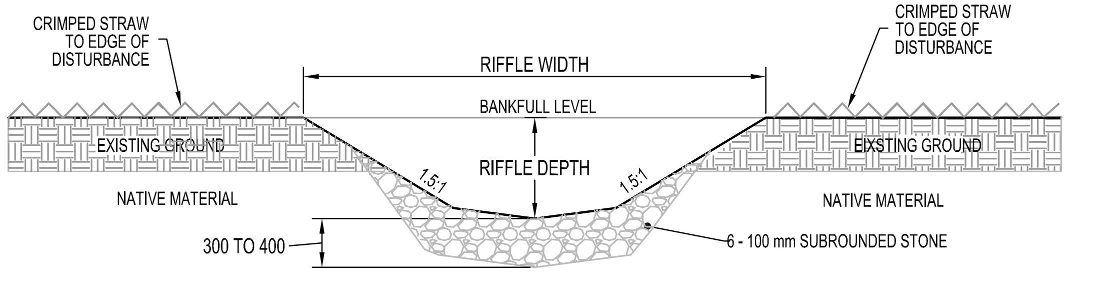
WEIR/RIFFLE CONSTRUCTION DETAILS

N.T.S.



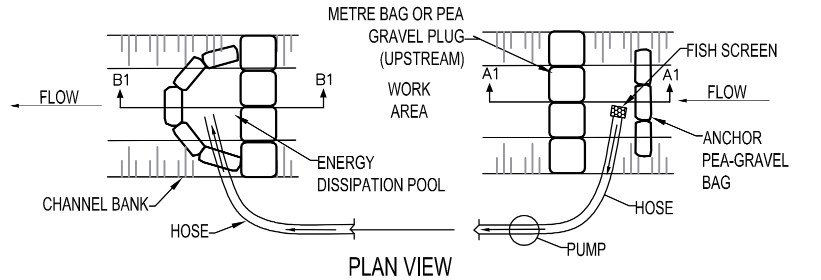
TYPICAL POOL CROSS SECTION

N.T.S.

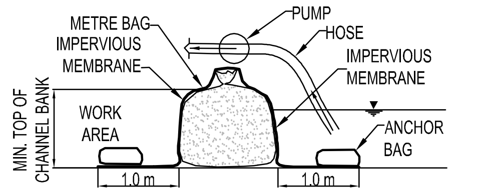


TYPICAL RIFFLE CROSS SECTION

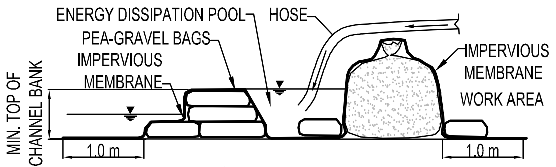
N.T.S.



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

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	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

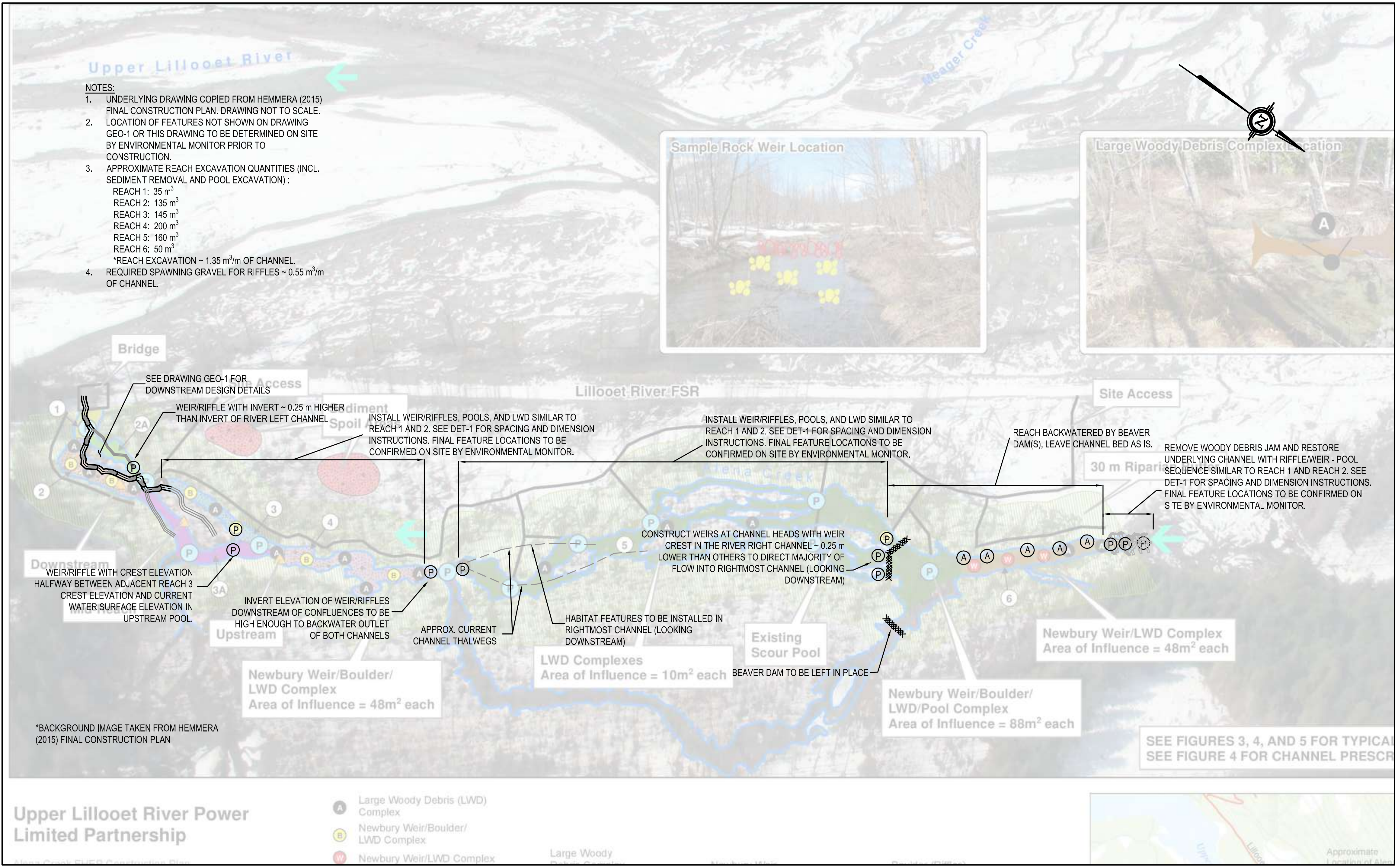
July 10, 2016
D. T. WEST
41242

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



NOTES:

1. UNDERLYING DRAWING COPIED FROM HEMMERA (2015) FINAL CONSTRUCTION PLAN. DRAWING NOT TO SCALE.
2. LOCATION OF FEATURES NOT SHOWN ON DRAWING GEO-1 OR THIS DRAWING TO BE DETERMINED ON SITE BY ENVIRONMENTAL MONITOR PRIOR TO CONSTRUCTION.
3. APPROXIMATE REACH EXCAVATION QUANTITIES (INCL. SEDIMENT REMOVAL AND POOL EXCAVATION) :
   REACH 1: 35 m^3
   REACH 2: 135 m^3
   REACH 3: 145 m^3
   REACH 4: 200 m^3
   REACH 5: 160 m^3
   REACH 6: 50 m^3
   *REACH EXCAVATION ~ 1.35 m^3/m OF CHANNEL.
4. REQUIRED SPAWNING GRAVEL FOR RIFFLES ~ 0.55 m^3/m OF CHANNEL.

*BACKGROUND IMAGE TAKEN FROM HEMMERA (2015) FINAL CONSTRUCTION PLAN

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

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

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. Representative Water Temperature Site Photographs.

LIST OF FIGURES

Figure 1. Looking RR to RL at ALE-USWQ1 on January 30, 2019.

Figure 2. Looking RR to RL at ALE-USWQ1 on January 30, 2019.

Figure 3. Looking downstream at ALE-BDGWQ on September 13, 2017.

Figure 4. Looking upstream of ALE-BDGWQ on September 13, 2017.

Appendix C. Water Temperature Guidelines and Data Summary.

LIST OF TABLES

1. WATER TEMPERATURE GUIDELINES

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

Category	Guideline
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
Streams with Bull Trout or Dolly Varden	maximum daily temperatures should not exceed 15°C
	maximum spawning temperature should not exceed 10°C
	preferred incubation temperatures should range from 2°C to 6°C
	±1°C change from natural condition[1]
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] Provided natural conditions are within these guidelines, if they are not, natural conditions should not be altered (Deniseger, pers. comm. 2009).

---

[1] Deniseger, J. 2009. Section Head, Environmental Quality, Ministry of Environment, Nanaimo, BC. Personal Communication. Telephone conversation with Kevin Ganshorn, June 2009.

2. MONTHLY SUMMARY STATISTICS

Table 2. Pre-construction (2013-2014) water temperature monthly statistics in Alena Creek. Blue and red shadings highlight minimum and maximum temperatures, respectively.

Year	Month	Water Temperature[1] (°C)							
		ALE-USWQ1				ALE-BDGWQ			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2013	Apr	-	-	-	-	-	-	-	-
	May	7.2	5.4	9.0	0.8	-	-	-	-
	Jun	7.0	6.2	9.5	0.6	-	-	-	-
	Jul	7.6	6.5	9.9	0.9	-	-	-	-
	Aug	8.0	7.3	9.9	0.6	-	-	-	-
	Sep	8.1	7.3	9.6	0.4	9.6	6.9	13.0	1.2
	Oct	7.8	6.9	8.9	0.3	7.5	4.5	10.6	1.0
	Nov	7.0	6.1	8.1	0.4	5.2	2.4	7.6	1.0
	Dec	6.1	5.0	7.1	0.5	3.4	0.9	5.5	1.1
2014	Jan	5.8	4.2	6.5	0.5	2.7	0.4	4.9	1.1
	Feb	-	-	-	-	2.2	0.0	5.0	1.2
	Mar	-	-	-	-	-	-	-	-
	Apr	5.4	4.4	6.4	0.6	5.0	3.4	9.6	1.1
	May	6.7	5.3	8.9	0.6	7.9	5.3	12.0	1.4
	Jun	7.0	5.9	9.5	0.8	9.1	6.4	13.1	1.6
	Jul	7.4	6.3	10.0	0.9	9.9	7.4	14.0	1.7
	Aug	7.9	7.1	10.0	0.7	10.1	7.9	13.8	1.4
	Sep	7.7	6.6	9.4	0.5	9.2	6.4	12.2	1.1
	Oct	7.6	6.9	8.9	0.3	8.4	6.7	10.9	0.8
	Nov	6.9	3.6	8.1	0.9	5.4	2.0	8.3	1.6
	Dec	5.0	2.8	6.8	0.9	3.8	2.1	5.3	0.7

[1] Statistics based on hourly data and were not generated for months with less than three weeks of data.

Table 3. **Post-construction (2016-2019) water temperature monthly statistics in Alena Creek. Blue and red shadings highlight minimum and maximum temperatures, respectively.**

Year	Month	Water Temperature[1] (°C)							
		ALE-USWQ1†				ALE-BDGWQ†			
		Avg	Min	Max	SD	Avg	Min	Max	SD
2016	Nov	-	-	-	-	-	-	-	-
	Dec	5.5	2.5	6.3	0.4	3.5	1.5	5.7	0.9
2017	Jan	5.4	2.0	6.4	0.5	3.2	0.7	5.0	1.0
	Feb	5.3	0.8	6.4	0.5	3.2	0.1	5.1	0.9
	Mar	5.1	4.3	6.5	0.3	3.8	2.5	6.0	0.6
	Apr	4.0	2.1	6.4	0.9	4.3	2.5	8.3	1.1
	May	6.4	4.5	8.3	0.7	7.3	4.3	11.5	1.4
	Jun	6.7	5.8	8.5	0.6	8.5	6.5	12.3	1.4
	Jul	6.9	5.9	9.5	0.8	9.5	7.3	12.9	1.4
	Aug	7.9	6.6	10.8	0.9	10.4	8.1	13.2	1.3
	Sep	8.1	6.7	10.8	0.7	9.7	6.8	13.5	1.1
	Oct	6.9	3.8	8.8	0.8	6.9	2.5	9.8	1.2
	Nov	5.4	3.3	7.1	0.8	3.8	1.0	6.6	1.2
	Dec	4.6	3.1	6.6	0.9	2.8	0.2	5.3	1.3
2018	Jan	4.2	3.2	5.2	0.5	2.9	0.4	4.3	0.9
	Feb	4.3	3.6	5.6	0.4	2.5	0.1	4.5	1.1
	Mar	5.0	3.8	6.8	0.6	3.8	1.0	7.1	1.0
	Apr	5.1	3.4	8.5	1.0	5.2	2.4	9.9	1.4
	May	7.3	5.5	9.8	0.8	8.3	5.4	11.5	1.3
	Jun	6.9	5.7	9.8	0.8	9.0	6.4	12.9	1.5
	Jul	7.6	5.9	10.8	1.1	10.8	7.7	13.6	1.4
	Aug	8.0	6.8	10.4	0.8	11.1	8.3	13.9	1.1
	Sep	7.6	6.7	9.8	0.6	9.7	7.4	11.9	0.8
	Oct	7.2	5.6	9.0	0.6	7.2	5.0	8.8	0.8
	Nov	6.4	3.9	8.4	0.6	-	-	-	-
	Dec	5.2	2.9	6.8	0.6	-	-	-	-
2019	Jan	5.0	2.7	6.6	0.6	-	-	-	-

[1] Statistics based on 15 minutes data were not generated for months with less than three weeks of data.

Appendix D. Photographs of Alena Creek Fish Habitat Enhancement Project Stability Assessment Year 2 Monitoring.

LIST OF FIGURES

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-XS2 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 5. ALE-XS2 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 6. 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 7. ALE-XS3 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 8. ALE-XS3 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 9. 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 10. 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 11. 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 12. 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 13. 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 14. 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 15. 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 16. 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 17. ALE-XS6 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 18. 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 19. ALE-XS7 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-XS7 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 21. 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 22. 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 23. 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 24. 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.

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

LIST OF FIGURES

LIST OF TABLES

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 (m)	Soak Time (hrs)	Catch[1]		
									CO	CT	BT
ALE-MT01	1	6	24-Sep-18	10:10	25-Sep-18	08:20	0.40	22.17	1	0	0
	2	6	24-Sep-18	10:10	25-Sep-18	08:20	0.36	22.17	24	0	0
	3	6	24-Sep-18	10:10	25-Sep-18	08:12	0.35	22.03	0	0	0
	4	6	24-Sep-18	10:10	25-Sep-18	08:12	0.27	22.03	17	1	0
	5	6	24-Sep-18	10:10	25-Sep-18	08:10	0.21	22.00	5	1	0
ALE-MT02	1	6	24-Sep-18	10:32	25-Sep-18	09:10	0.26	22.63	12	0	0
	2	6	24-Sep-18	10:32	25-Sep-18	09:10	0.31	22.63	7	1	0
	3	6	24-Sep-18	10:32	25-Sep-18	09:10	0.25	22.63	7	0	0
	4	6	24-Sep-18	10:32	25-Sep-18	09:10	0.22	22.63	1	1	0
	5	6	24-Sep-18	10:32	25-Sep-18	09:10	0.24	22.63	26	0	0
ALE-MT03	1	6	24-Sep-18	11:28	25-Sep-18	11:45	0.58	24.28	64	1	0
	3	6	24-Sep-18	11:28	25-Sep-18	11:45	0.38	24.28	5	0	0
	4	6	24-Sep-18	11:28	25-Sep-18	11:45	0.21	24.28	36	0	0
	5	6	24-Sep-18	11:28	25-Sep-18	11:45	0.22	24.28	30	1	0
ALE-MT05	1	6	24-Sep-18	13:55	25-Sep-18	15:40	0.59	25.75	27	0	0
	2	3	24-Sep-18	13:55	25-Sep-18	15:40	0.74	25.75	7	1	0
	3	6	24-Sep-18	13:55	25-Sep-18	15:40	0.49	25.75	22	2	0
	4	3	24-Sep-18	13:55	25-Sep-18	15:40	0.55	25.75	15	1	0
	5	6	24-Sep-18	13:55	25-Sep-18	15:40	0.54	25.75	28	0	0
ALE-MT06	1	3	24-Sep-18	12:58	25-Sep-18	13:15	0.66	24.28	7	0	0
	2	3	24-Sep-18	12:59	25-Sep-18	13:15	0.40	24.27	3	0	0
	3	6	24-Sep-18	13:00	25-Sep-18	13:15	0.80	24.25	22	1	0
	4	6	24-Sep-18	13:02	25-Sep-18	13:15	0.50	24.22	12	0	0
	5	3	24-Sep-18	12:58	25-Sep-18	13:15	0.90	24.28	7	0	0
	6	3	24-Sep-18	12:58	25-Sep-18	13:15	0.95	24.28	8	0	0
	7	3	24-Sep-18	12:59	25-Sep-18	13:15	1.00	24.27	17	1	0
	8	3	24-Sep-18	12:59	25-Sep-18	13:15	1.00	24.27	22	0	0
	9	3	24-Sep-18	12:59	25-Sep-18	13:15	0.94	24.27	21	0	0
	10	6	24-Sep-18	13:00	25-Sep-18	13:15	0.26	24.25	15	0	0
ALE-MT07	1	6	24-Sep-18	10:55	25-Sep-18	10:24	0.20	23.48	34	0	0
	2	6	24-Sep-18	10:55	25-Sep-18	10:24	0.90	23.48	34	0	0
	3	6	24-Sep-18	10:55	25-Sep-18	10:24	0.90	23.48	25	2	0
	4	6	24-Sep-18	10:55	25-Sep-18	10:24	0.90	23.48	16	1	0
	5	6	24-Sep-18	10:55	25-Sep-18	10:24	0.95	23.48	53	0	0
ALE-MT08	1	6	24-Sep-18	12:33	25-Sep-18	14:16	0.24	25.72	69	0	0
	2	6	24-Sep-18	12:33	25-Sep-18	14:16	0.20	25.72	9	0	0
	3	6	24-Sep-18	12:33	25-Sep-18	14:16	0.26	25.72	20	0	0
	4	6	24-Sep-18	12:33	25-Sep-18	14:16	0.42	25.72	17	0	0
	5	3	24-Sep-18	12:33	25-Sep-18	14:16	0.25	25.72	7	0	0
ALE-MT09	1	3	24-Sep-18	13:30	25-Sep-18	15:00	0.22	25.50	59	0	0
	2	3	24-Sep-18	13:30	25-Sep-18	15:00	0.30	25.50	0	2	0
	3	3	24-Sep-18	13:30	25-Sep-18	15:00	0.26	25.50	34	0	0
	4	3	24-Sep-18	13:30	25-Sep-18	15:00	0.30	25.50	33	0	0
	5	3	24-Sep-18	13:30	25-Sep-18	15:00	0.21	25.50	9	0	0

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

Table 2. Detailed fish capture, fork length and aging data.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT01	24-Sep-18	1	CO	70							0	No
ALE-MT01	24-Sep-18	2	CO	45							0	No
ALE-MT01	24-Sep-18	2	CO	49	1.0	0.85	FC	7	FC	7	0	No
ALE-MT01	24-Sep-18	2	CO	60							0	No
ALE-MT01	24-Sep-18	2	CO	70							0	No
ALE-MT01	24-Sep-18	2	CO	90							1	No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	2	CO									No
ALE-MT01	24-Sep-18	3	NFC									
ALE-MT01	24-Sep-18	4	CO	73	3.0	0.77	SC	6	FC	6	0	No
ALE-MT01	24-Sep-18	4	CO	91	7.2	0.96	SC	4	FC	4	1	No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CO									No
ALE-MT01	24-Sep-18	4	CT	92	7.3	0.94	SC	5	FC	5	1	No
ALE-MT01	24-Sep-18	5	CO	46	1.2	1.23	SC	3	FC	3	0	No
ALE-MT01	24-Sep-18	5	CO	57	1.4	0.76	SC	2	FC	2	0	No
ALE-MT01	24-Sep-18	5	CO	57							0	No
ALE-MT01	24-Sep-18	5	CO	57							0	No
ALE-MT01	24-Sep-18	5	CO	57							0	No
ALE-MT01	24-Sep-18	5	CT	95	9.0	1.05	SC	1	FC	1	1	No
ALE-MT02	24-Sep-18	1	CO	49	1.0	0.85					0	No
ALE-MT02	24-Sep-18	1	CO	51	1.6	1.21					0	No
ALE-MT02	24-Sep-18	1	CO	52	1.6	1.14					0	No
ALE-MT02	24-Sep-18	1	CO	62	2.6	1.09					0	No
ALE-MT02	24-Sep-18	1	CO	75	5.0	1.19	SC	2	FC	2	0	No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	1	CO									No
ALE-MT02	24-Sep-18	2	CO	60	2.0	0.93					0	No
ALE-MT02	24-Sep-18	2	CO	60	2.0	0.93					0	No
ALE-MT02	24-Sep-18	2	CO									No
ALE-MT02	24-Sep-18	2	CO									No
ALE-MT02	24-Sep-18	2	CO									No
ALE-MT02	24-Sep-18	2	CO									No
ALE-MT02	24-Sep-18	2	CO									No
ALE-MT02	24-Sep-18	2	CT	85	6.0	0.98	SC	6	FC	6	1	No
ALE-MT02	24-Sep-18	3	CO	58	2.3	1.18					0	No
ALE-MT02	24-Sep-18	3	CO	60	2.5	1.16					0	No
ALE-MT02	24-Sep-18	3	CO	78	3.8	0.80	SC	1	FC	1	0	No
ALE-MT02	24-Sep-18	3	CO									No
ALE-MT02	24-Sep-18	3	CO									No
ALE-MT02	24-Sep-18	3	CO									No
ALE-MT02	24-Sep-18	3	CO									No
ALE-MT02	24-Sep-18	4	CO	86	6.5	1.02					1	No
ALE-MT02	24-Sep-18	4	CT									No
ALE-MT02	24-Sep-18	5	CO	50	1.6	1.28					0	No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT02	24-Sep-18	5	CO	54	1.7	1.08	SC	4	FC	4	0	No
ALE-MT02	24-Sep-18	5	CO	59	2.0	0.97	SC	5	FC	5	0	No
ALE-MT02	24-Sep-18	5	CO	73	4.0	1.03					0	No
ALE-MT02	24-Sep-18	5	CO	80	5.1	1.00	SC	3	FC	3	0	No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT02	24-Sep-18	5	CO									No
ALE-MT03	24-Sep-18	1	CO	92	7.0	0.90					1	
ALE-MT03	24-Sep-18	1	CO	95	7.8	0.91	SC	5	FC	5	1	
ALE-MT03	24-Sep-18	1	CO	100	8.4	0.84					1	
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CO									
ALE-MT03	24-Sep-18	1	CT	103	11.0	1.01	SC	4	FC	4	1	
ALE-MT03	24-Sep-18	3	CO	41							0	
ALE-MT03	24-Sep-18	3	CO	51							0	
ALE-MT03	24-Sep-18	3	CO	56	2.0	1.14					0	
ALE-MT03	24-Sep-18	3	CO	57	2.0	1.08					0	
ALE-MT03	24-Sep-18	3	CO	66	3.3	1.15	SC	1	FC	1	0	
ALE-MT03	24-Sep-18	4	CO	54	2.0	1.27					0	
ALE-MT03	24-Sep-18	4	CO	68							0	
ALE-MT03	24-Sep-18	4	CO	70	3.0	0.87	SC	3	FC	3	0	
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	4	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CO									
ALE-MT03	24-Sep-18	5	CT	95	10.0	1.17	SC	2	FC	2	1	
ALE-MT05	24-Sep-18	1	CO	52	1.0	0.71					0	No
ALE-MT05	24-Sep-18	1	CO	85	6.0	0.98					0	No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	1	CO									No
ALE-MT05	24-Sep-18	2	CO	80	5.0	0.98					0	No
ALE-MT05	24-Sep-18	2	CO	92	10.0	1.28					1	No
ALE-MT05	24-Sep-18	2	CO									No
ALE-MT05	24-Sep-18	2	CO									No
ALE-MT05	24-Sep-18	2	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT05	24-Sep-18	2	CO									No
ALE-MT05	24-Sep-18	2	CO									No
ALE-MT05	24-Sep-18	2	CT	92	9.0	1.16		1	FC	1	1	No
ALE-MT05	24-Sep-18	3	CO	80	6.0	1.17					0	No
ALE-MT05	24-Sep-18	3	CO	86	9.0	1.41					1	No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									No
ALE-MT05	24-Sep-18	3	CO									
ALE-MT05	24-Sep-18	3	CO									
ALE-MT05	24-Sep-18	3	CT	135	25.0	1.02		4	FC	4	2	No
ALE-MT05	24-Sep-18	3	CT									
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CO									No
ALE-MT05	24-Sep-18	4	CT									No
ALE-MT05	24-Sep-18	5	CO	54	1.0	0.64		2	FC	2	0	No
ALE-MT05	24-Sep-18	5	CO	83	5.0	0.87		3	FC	3	0	No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT05	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No
ALE-MT06	24-Sep-18	1	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT06	24-Sep-18	2	CO									No
ALE-MT06	24-Sep-18	2	CO									No
ALE-MT06	24-Sep-18	2	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CO									No
ALE-MT06	24-Sep-18	3	CT	125	21.0	1.08					2	No
ALE-MT06	24-Sep-18	4	CO	31							0	No
ALE-MT06	24-Sep-18	4	CO	43	1.0	1.26					0	No
ALE-MT06	24-Sep-18	4	CO	78	5.0	1.05					0	No
ALE-MT06	24-Sep-18	4	CO	86	7.0	1.10					1	No
ALE-MT06	24-Sep-18	4	CO	91	10.0	1.33					1	No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	4	CO									No
ALE-MT06	24-Sep-18	5	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species¹	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	5	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	6	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CO									No
ALE-MT06	24-Sep-18	7	CT	140	30.0	1.09	SC	3	FC	3	2	No
ALE-MT06	24-Sep-18	8	CO	79	6.0	1.22					0	No
ALE-MT06	24-Sep-18	8	CO	86	8.0	1.26					1	No
ALE-MT06	24-Sep-18	8	CO	89	9.0	1.28					1	No
ALE-MT06	24-Sep-18	8	CO	106	9.0	0.76					1	No
ALE-MT06	24-Sep-18	8	CO	107	15.0	1.22	SC	1	FC	1	1	No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	8	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	9	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT06	24-Sep-18	10	CO									No
ALE-MT07	24-Sep-18	1	CO	55	2.0	1.20					0	
ALE-MT07	24-Sep-18	1	CO	59	2.2	1.07					0	
ALE-MT07	24-Sep-18	1	CO	73	5.0	1.29					0	
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	1	CO									
ALE-MT07	24-Sep-18	2	CO	71	1.7	0.47	SC	1	FC	1	0	
ALE-MT07	24-Sep-18	2	CO	84	2.0	0.34	SC	2	FC	2	0	
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	2	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CO									
ALE-MT07	24-Sep-18	3	CT	94	9.0	1.08	SC	4	FC	4	1	
ALE-MT07	24-Sep-18	3	CT	98	11.0	1.17	SC	3	FC	3	1	
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CO									
ALE-MT07	24-Sep-18	4	CT	85	7.0	1.14					1	
ALE-MT07	24-Sep-18	5	CO	93	10.0	1.24	SC	5	FC	5	1	
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT07	24-Sep-18	5	CO									
ALE-MT08	24-Sep-18	1	CO	46							0	No
ALE-MT08	24-Sep-18	1	CO	56			SC	5	FC	5	0	No
ALE-MT08	24-Sep-18	1	CO	79	6.0	1.22	SC	4	FC	5	0	No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No

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Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	1	CO									No
ALE-MT08	24-Sep-18	2	CO	56	2.0	1.14					0	No
ALE-MT08	24-Sep-18	2	CO	57	1.0	0.54					0	No
ALE-MT08	24-Sep-18	2	CO	60	3.0	1.39	SC	1	FC	1	0	No
ALE-MT08	24-Sep-18	2	CO	84	7.0	1.18	SC	2	FC	2	0	No
ALE-MT08	24-Sep-18	2	CO									No
ALE-MT08	24-Sep-18	2	CO									No
ALE-MT08	24-Sep-18	2	CO									No
ALE-MT08	24-Sep-18	2	CO									No
ALE-MT08	24-Sep-18	2	CO									No
ALE-MT08	24-Sep-18	3	CO	45							0	No
ALE-MT08	24-Sep-18	3	CO	78	6.0	1.26					0	No
ALE-MT08	24-Sep-18	3	CO	87	8.0	1.21	SC	3	FC	3	1	No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	3	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	4	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT08	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No

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Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	1	CO									No
ALE-MT09	24-Sep-18	2	CT	100	10.0	1.00	SC	3	FC	3	1	No
ALE-MT09	24-Sep-18	2	CT	104	11.0	0.98	SC	2	FC	2	1	No
ALE-MT09	24-Sep-18	3	CO	50							0	No
ALE-MT09	24-Sep-18	3	CO	66							0	No
ALE-MT09	24-Sep-18	3	CO	80	7.0	1.37					0	No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	3	CO									No
ALE-MT09	24-Sep-18	4	CO	47	1.0	0.96					0	No
ALE-MT09	24-Sep-18	4	CO	50							0	No
ALE-MT09	24-Sep-18	4	CO	50							0	No
ALE-MT09	24-Sep-18	4	CO	50							0	No
ALE-MT09	24-Sep-18	4	CO	52	2.0	1.42					0	No
ALE-MT09	24-Sep-18	4	CO	60	3.0	1.39					0	No
ALE-MT09	24-Sep-18	4	CO	81	7.0	1.32	SC	1	FC	1	0	No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	4	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Table 2. Continued.

Site	Date	Trap #	Species[1]	Measured Length (mm)	Weight (g)	K	Age Sample Type	Age Sample Number	DNA Sample Type	DNA Sample Numer	Age Assigned	Recapture (Y/N)
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No
ALE-MT09	24-Sep-18	5	CO									No

[1] CO = Coho Salmon, CT = Cutthroat Trout, BT = Bull Trout, NFC = No Fish Captured.

Figure 1. Minnow trap #3 at sampling site ALE-MT01 on September 24, 2018.

Figure 2. Minnow trap #3 at sampling site ALE-MT02 on September 24, 2018.

Figure 3. Minnow trap #1 at sampling site ALE-MT03 on September 24, 2018.

Figure 4. Minnow trap #5 at sampling site ALE-MT05 on September 24, 2018.

Figure 5. Minnow trap #7 at sampling site ALE-MT06 on September 24, 2018.

Figure 6. Minnow trap #4 at sampling site ALE-MT07 on September 24, 2018.

Figure 7. Minnow trap #2 at sampling site ALE-MT08 on September 24, 2018.

Figure 8. Minnow trap #3 at sampling site ALE-MT09 on September 24, 2018.

Appendix C. Upper Lillooet Hydro Project Revegetation Assessment Report for the Operational Environmental Monitoring Plan (OEMP) Year 1 - 2018 Monitoring Year (Hedberg 2019)

UPPER LILLOOET HYDRO PROJECT
REVEGETATION ASSESSMENT REPORT FOR THE OPERATIONAL ENVIRONMENTAL MONITORING PLAN (OEMP)
YEAR 1 - 2018 MONITORING YEAR

PREPARED FOR:

UPPER LILLOOET RIVER POWER LIMITED PARTNERSHIP AND BOULDER CREEK LIMITED PARTNERSHIP
1185 WEST GEORGIA STREET, SUITE 900
VANCOUVER, BC V6E 4E6

SUBMITTED BY:

HEDBERG AND ASSOCIATES CONSULTING LTD.
205 - 1121 COMMERCIAL WAY
SQUAMISH, BC V8B 0S5

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Sara B

Sara Barker, MSc

Michael Hedberg RPF #2912

Senior Review

Disclaimer:

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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 2 below).

This report summarizes the results of the revegetation assessment program for the initial monitoring year (Year 1 - 2018).

This report will contain the following sections:

- the scope of the revegetation monitoring program (Section 2);
- a summary of source documents pertaining to restoration works (Section 3);
- the objectives of the restoration program (Section 4);
- the data collection methods and field program details (Section 5);
- the results of the data collection program from the 2018 program (Section 6); and
- the conclusions and recommendations regarding Year 1 (Section 7)

2. Scope of the Revegetation Monitoring Program

The scope of work for the year 1 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. All data collected during a calendar year will be reported on annually in a report due April 30th of the following year (i.e. data collected in 2018, will be reported on by April 2019). This report summarizes the data collected in 2018 (Year 1 of the OEMP program).

Monitoring for the 2018 program 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)
    - Vegetation Restoration Monitoring
    - Invasive Plant Monitoring
- Subcomponent of Section 3.2.1.3 - Wildlife Habitat Restoration, specifically the requirement to ensure the following:

- 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 LTMP);
    - temporary roads or access tracks within WHA 2-399 are deactivated and non-drivable with an ATV.
- 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 LTMP).
- 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. Ecofish Research Ltd (Ecofish). The 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. Approval of the recommended change to the vegetation and invasive species monitoring frequency was still pending at the time of writing this report. It is our recommendation at HAC that the program proceed with Years 3 and 5 of monitoring for both the vegetation and invasive plant monitoring gas previously detailed in Ecofish’s letter (Faulkner *et al.* 2018), in addition to a survival survey in 2019 (Year 2) of trees planted in civil works areas in October 2018 (Appendix F).

3. Revegetation/ Restoration works

Revegetation and restoration works 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. Revegetation Monitoring Program

The 2018 monitoring program was carried out by team leads Codie Johnston RFT, and Sara Barker M. Sc., FIT. Codie Johnston is a BC Certified Accredited Silviculture Surveyor #AA2006008 with 15 years of plant identification experience. Sara Barker also has 15 years of plant identification experience and has gathered vegetation data for environmental assessment projects, terrestrial ecosystem mapping assignments and restoration programs. When availability permitted, Silas Pierre, (a Lil'wat Nation member) was also involved in the data collection program. His role included the identification of berry producing shrubs and percentage cover estimates. The fieldwork for the 2018 monitoring program was carried out in August and September of 2018.

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 will utilize 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 will describe 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 will be utilized to determine if revegetation objectives have been trending towards being met in Year 3 and are being met in Year 5 (the final monitoring year). The details of how success will be measured is described in Section 5.1.1 and 5.2.1 below.

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 and C). 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 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 (also referred to collectively in this report as “perennial woody species”).
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

Within this monitoring year (Year 1 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 this method will be replicated throughout all future monitoring years (Years 3 and 5). Invasive species were identified, recorded and manually removed at each plot.

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 an 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 are 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.

5.1.1.1. Conifer Tree Species (Density Targets)

For the conifer tree component, the recommended density target will be 1000 stems per hectare 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 6 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 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.

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 (subcomponent of Table 14 & 21): 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 (subcomponent of Table 14 & 22) 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 will be 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

In total throughout the project area, revegetation evaluations were carried out at 66 sites covering areas both along rehabilitated transmission line access roads and civil works areas (e.g. spoil piles, borrow pits, facilities construction disturbance footprints etc.). The site locations are shown on the maps in Appendix A and the results of the evaluations are summarized in Table 1 below. All of the data collected at each plot can be found in Appendix B (transmission line site data) and Appendix C (civil works site data). Plot photos and inspection site photos are found in Appendix D. A compiled list of species observed on the project to date is found in Appendix E.

Within the civil works areas, 16 sites had permanent monitoring plots established at a density of 1 plot per hectare. Additional planting was carried out on most civil sites in October 2018 to increase the conifer component (Barker 2019). For all of the civil sites, treeplanting occurred in late 2018, so plots were mostly sampled to determine planting densities as opposed to measuring revegetation success. In future years (Years 3 (2020) and 5 (2023)), the plots that were established this monitoring year (2018, Year 1) and potentially additional sites added in 2020 will be used to evaluate the success of the 2018 planting program. There will also be a survival survey carried out in 2019 to assess the success of the 2018 planting program.

Within the transmission line areas, 18 sites had permanent monitoring plots established on them and 24 sites were inspected.

To summarize, Table 1 shows that all wildlife specific requirements were met in 2018. Moose and deer specific planting programs were implemented within Ungulate Winter Range areas and require no further monitoring. The grizzly bear requirements within WHA 2-399 were not applicable to the particular sites studied as they were located immediately adjacent to road verges and due to safety concerns and in the interest of minimizing wildlife-vehicle collisions, it is not recommended to plant grizzly forage within these sites. The two potential access points within WHA 2-399 have been blocked by large piles of logs and are not accessible by ATV at this time.

All sites in the 2018 monitoring program were on track to meet future success targets and required no further vegetation treatments at this time. No invasive species treatments are required at this time. No major erosion issues were noted and slope shaping and/or any soil decompaction or other soil treatments allowed for successful root penetration of the newly established vegetation.

As shown on Table 1, the total perennial woody species shrub densities ranged between 550 stems per hectare on a sparsely populated site to 41,400 stems per hectare at the site with the highest density. The mean density of all sites is 7,970 stems per hectare. At the transmission line sites, the mean density of all sites was 9906 stems per hectare and at the civil sites was 5909 stems per hectare.

The total percentage ground cover of all layers combined (herb, shrub and tree) in the quadrat surveys ranged between 0 and 34.5% cover. The areas where percentage of covers were between 0-5% were found at sites that were rocky, or shady sites that had patchy and sparse vegetation. It was observed that although some quadrat surveys showed a low percentage cover within the quadrats, overall plots showed positive signs of revegetation growth and regeneration. The mean percentage of cover for all plots surveyed was 11.4% total ground cover. At the transmission line sites, the total average percent cover was 16% and the civil sites results showed an average of 7% total ground cover.

Table 1: Data Summary Table

Site Information and Description							Site Revegetation Requirements			2018 Monitoring Results								
Site Name (also called Stratum)	**Site type**	**Type of survey**	**UWR type**	**WHA Type**	**Project wildlife site**	**GB Class**	**GB Associated Restriction**	**Veg. screen**	**Wildlife Specific planting requirement**	**Meets reveg. wildlife objectives**	**Evidence**	**ATV requirement met**	**Reveg. initiated**	**Major erosion issues noted**	**Invasive treatment required**	**TS/ha woody species**	**Average % cover**	**Further treatments required**
38km Laydown	civil	planted 2018											yes	no	no	3200	0	no
Camp	civil	planted 2018											yes	no	no			no
Operator's Residence	civil	planted 2018											yes	no	no			no
Explosive Magazine	civil	planted 2018											yes	no	no	15,750	26.5	no
Boulder Powerhouse and spoil	civil	plot											yes	no	no	1,600	2.5	no
Boulder Spoil 2	civil	plot											yes	no	no	2,200	13.5	no
Boulder Spoil # 4	civil	planted 2018											yes	no	no			no
Boulder Spoil # 7	civil	planted 2018											yes	no	no			no
Boulder Spoil #6	civil	not cleared	mountain goat		BDR-GB01	Class 1-2	Clearing Restrictions						yes	no	no			no
Upper Spoil # 5	civil	planted 2018											yes	no	no			no
Upper Spoil # 7	civil	planted 2018											yes	no	no			no
Upper Spoil # 6	civil	planted 2018											yes	no	no	1,800	0	no
Upper Spoil # 4	civil	planted 2018			ULL-GB05	Class 1-2	Clearing Restrictions						yes	no	no	1,500	1.5	no
Upper Spoil # 3	civil	planted 2018			ULL-GB05	Class 1-2	Clearing Restrictions						yes	no	no	3,000	4	no
Upper Spoil #8	civil	planted 2018			ULL-GB05	Class 1-2	Clearing Restrictions						yes	no	no	2,600	1	no
Upper Intake Laydown	civil	planted 2018			ULL-GB04	Class 1-2	Clearing Restrictions						yes	no	no	3,100	6.5	no
Keyhole Laydown	civil	planted 2018											yes	no	no	24,000	34.5	no
Diversion Channel Slopes	civil	planted 2018			ULL-GB01	Class 1-2	Clearing Restrictions						yes	no	no	1,333	1.5	no
Upper Lillooet Penstock	civil	plot											yes	no	no	2,450	5	no
Upper Lilloet Powerhouse	civil	plot											yes	no	no	27,800	3.5	no
Upper Spoil # 1	civil	planted 2018			ULL-GB01	Class 1-2	Clearing Restrictions						yes	no	no	1,467	1.5	no
Upper Spoil #2 &Settling Basins	civil	planted 2018			ULL-GB04	Class 1-2	Clearing Restrictions						yes	no	no	550	1	no
41.7km Laydown	civil	planted 2018			ULH-GB01	Class 1-2	Clearing Restrictions	yes					yes	no	no	2,200	3	no
52.1	tx line	inspection	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
53.1/56.1	tx line	plot											yes	no	no	3000	26	no
62.1	tx line	inspection	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
73.1	tx line	plot			ULH-GB14	Class 1-2	Clearing Restrictions	yes					yes	no	no	19,400	10	no
81.1	tx line	inspection			ULH-GB16	Class 1-2	Clearing Restrictions	yes					yes	no	no			no
86.1	tx line	inspection	moose		ULH-GB18	Class 1-2	Clearing Restrictions	yes	50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
87.1	tx line	inspection	moose		ULH-GB18	Class 1-2	Clearing Restrictions	yes	50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
91.1	tx line	inspection	moose					yes	50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
92.1	tx line	inspection	moose					yes	50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
93.1	tx line	inspection	moose					yes	50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
94.1	tx line	inspection	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
100.1	tx line	inspection	black-tailed deer						native species planting requirement	yes	all native species planted		yes	no	no			no
101.1	tx line	inspection	black-tailed deer						native species planting requirement	yes	all native species planted		yes	no	no			no
102.1	tx line	inspection	black-tailed deer					yes	native species planting requirement	yes	all native species planted		yes	no	no			no
105.1	tx line	inspection	black-tailed deer		ULH-GB19	Class 1-2	Clearing Restrictions	yes	native species planting requirement	yes	all native species planted		yes	no	no			no
107.1	tx line	inspection	black-tailed deer					yes	native species planting requirement	yes	all native species planted		yes	no	no			no
108.1	tx line	inspection	black-tailed deer					yes	native species planting requirement	yes	all native species planted		yes	no	no			no
110.1	tx line	inspection	black-tailed deer					yes	native species planting requirement	yes	all native species planted		yes	no	no			no
114.1	tx line	inspection											yes	no	no			no
115.1	tx line	inspection											yes	no	no			no
116.1	tx line	inspection											yes	no	no			no
118.1	tx line	inspection											yes	no	no			no
129.1	tx line	plot	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no	3,600	13.5	no
130.1	tx line	inspection	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no	10,800	13	no
133.1	tx line	plot	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no	200	16	no
139.1	tx line	inspection	moose						50% moose palatable species away from road verges	yes	>50% Alder and cottonwood		yes	no	no			no
140.1	tx line	plot	moose	Grizzly Bear2-399	ULH-GB25	Class 1-2	Clearing Restrictions		50% native fruit bearing shrub	n/a	n/a too close to road	yes	yes	no	no	41,400	26	no
141.1	tx line	inspection	moose	Grizzly Bear2-399	ULH-GB25	Class 1-2	Clearing Restrictions		50% native fruit bearing shrub	n/a	n/a too close to road	yes	yes	no	no			no
161.1	tx line	inspection						yes					yes	no	no			no
163.1	tx line	plot	moose		ULH-GB29	Class 1-2	Clearing Restrictions	yes	50% moose palatable species away from road verges	n/a	n/a too close to road		yes	no	no	20,400	25	no
168.1	tx line	inspection	moose					yes	50% moose palatable species away from road verges	n/a	n/a too close to road		yes	no	no			no
237.1	tx line	plot	black-tailed deer		ULH-GB38	Class 1-2	Clearing Restrictions		native species planting requirement	yes	all native species planted		yes	no	no	12,000	9.5	no
238.1	tx line	plot	black-tailed deer		ULH-GB38	Class 1-2	Clearing Restrictions		native species planting requirement	yes	all native species planted		yes	no	no	6,000	19	no
239.1	tx line	plot			ULH-GB38	Class 1-2	Clearing Restrictions						yes	no	no	2,000	3	no
243.1	tx line	inspection	black-tailed deer		ULH-GB39	Class 1-2	Clearing Restrictions		native species planting requirement	n/a	existing road		yes	no	no			no
245.1	tx line	plot			ULH-GB39	Class 3-5	Clearing Restrictions						yes	no	no	12,800	19.5	no
247.1	tx line	plot			ULH-GB39	Class 3-5	Clearing Restrictions						yes	no	no	8,800	15.5	no
249.1	tx line	plot			ULH-GB39	Class 3-5	Clearing Restrictions						yes	no	no	8,800	15.5	no
250.1	tx line	plot			ULH-GB40	Class 3-5	Clearing Restrictions						yes	no	no	2,400	8	no
255.1	tx line	plot	black-tailed deer						native species planting requirement	yes	all native species planted		yes	no	no	2,000	12	no
260.1	tx line	plot			ULH-GB42	Class 1-2	Clearing Restrictions						yes	no	no	9,400	17.5	no
Ryan Crossing	tx line	plot											yes	no	no	5,400	20	no

7. Conclusions

In general, observations from the 2018 monitoring year showed that revegetation processes have been initiated at all sites. All deer and moose specific wildlife revegetation requirements were met in 2018 and require no further monitoring efforts as this was a planting requirement not a long-term monitoring objective. The grizzly specific wildlife requirements for ATVs were being met, but will continue to be monitored for the length of the program to assess compliance (Year 3 and Year 5).

All sites were on track to meet future success targets; no further vegetation treatments are required at this time. No invasive species treatments are required at this time. No major erosion issues were noted and slope shaping and/or any soil decompaction or other soil treatments allowed for successful root penetration of the newly established vegetation.

Along all sites sampled, pioneering species such as thimbleberry, alder, cottonwood and other early colonizers were present on the landscape. The plants that were present on the majority of sites were vigorous and healthy and no major disease infestations or damaged areas were observed. Very few invasive species were noted and all species that were observed within a plot were hand pulled at the time of survey.

For the majority of the civil sites, planting occurred in late 2018, so plots were mostly sampled to determine planting densities as opposed to measuring revegetation success. In future years (Year 3 and Year 5), the plots that were established this monitoring year as well as any additional plots required will be used to evaluate the success of the 2018 planting program. There will also be a survival survey carried out in 2019 to assess the success of the 2018 planting program.

In conclusion, all of the areas assessed in 2018 are on target to meet project requirements. At this time, no further treatments are suggested at any of the sites visited in 2018. Each site will be closely monitored in future monitoring years (Year 3 and Year 5).

8. References

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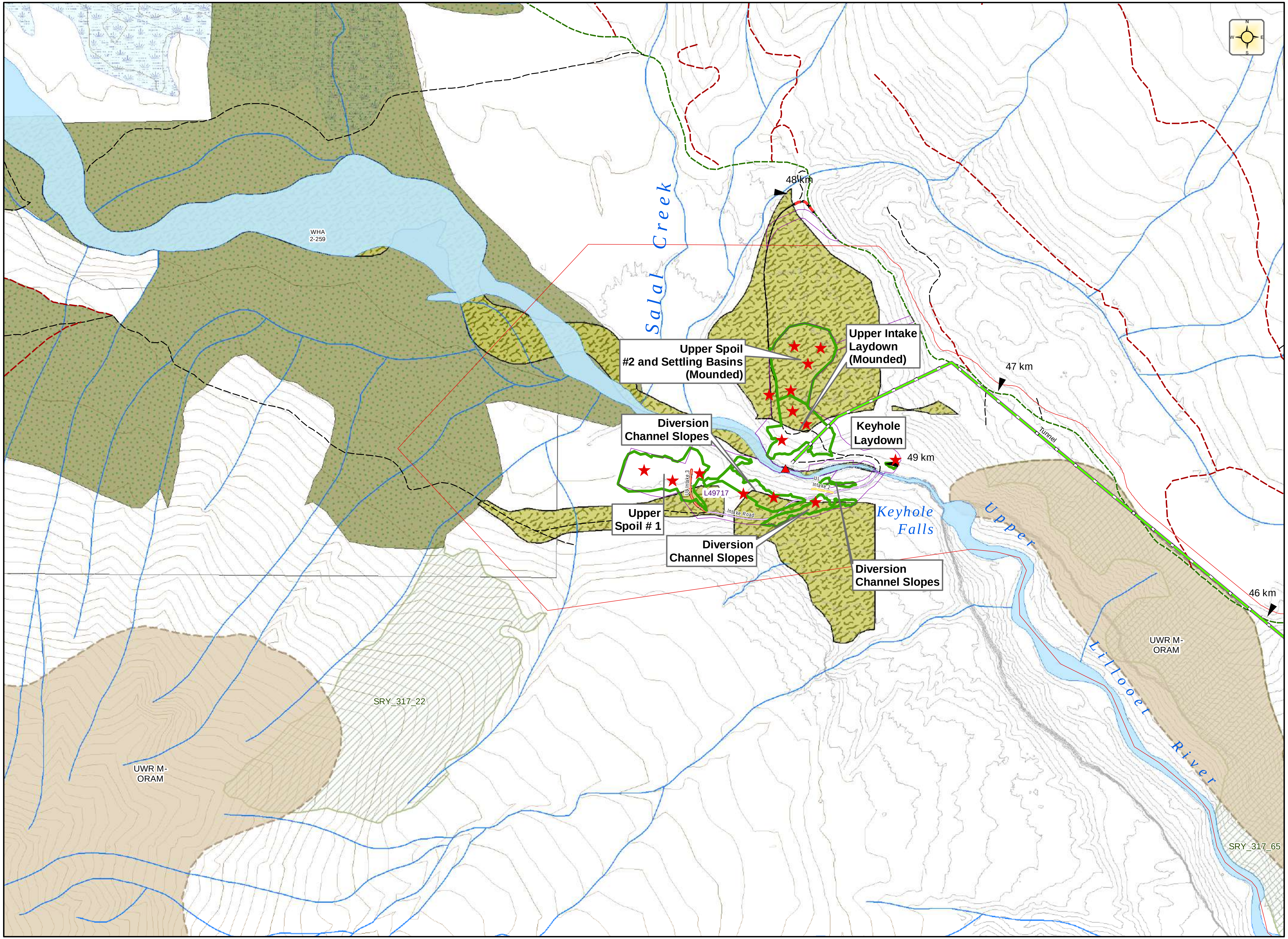
9. Appendices

Appendix A: Maps



INNERGEX

Revegetation Monitoring Year 1 (2018)

- 🟥 🟨 ⬟ Intake, Powerhouse, Tunnel Portal
- 73 Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- ULHP Revegetation Area
- Ⓗ Helipad
- Falling Boundary
- OLTC
- Land Tenure Boundary
- Existing Road
- Road Permit
- Proposed Access
- Forest Service Road
- 34 km 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

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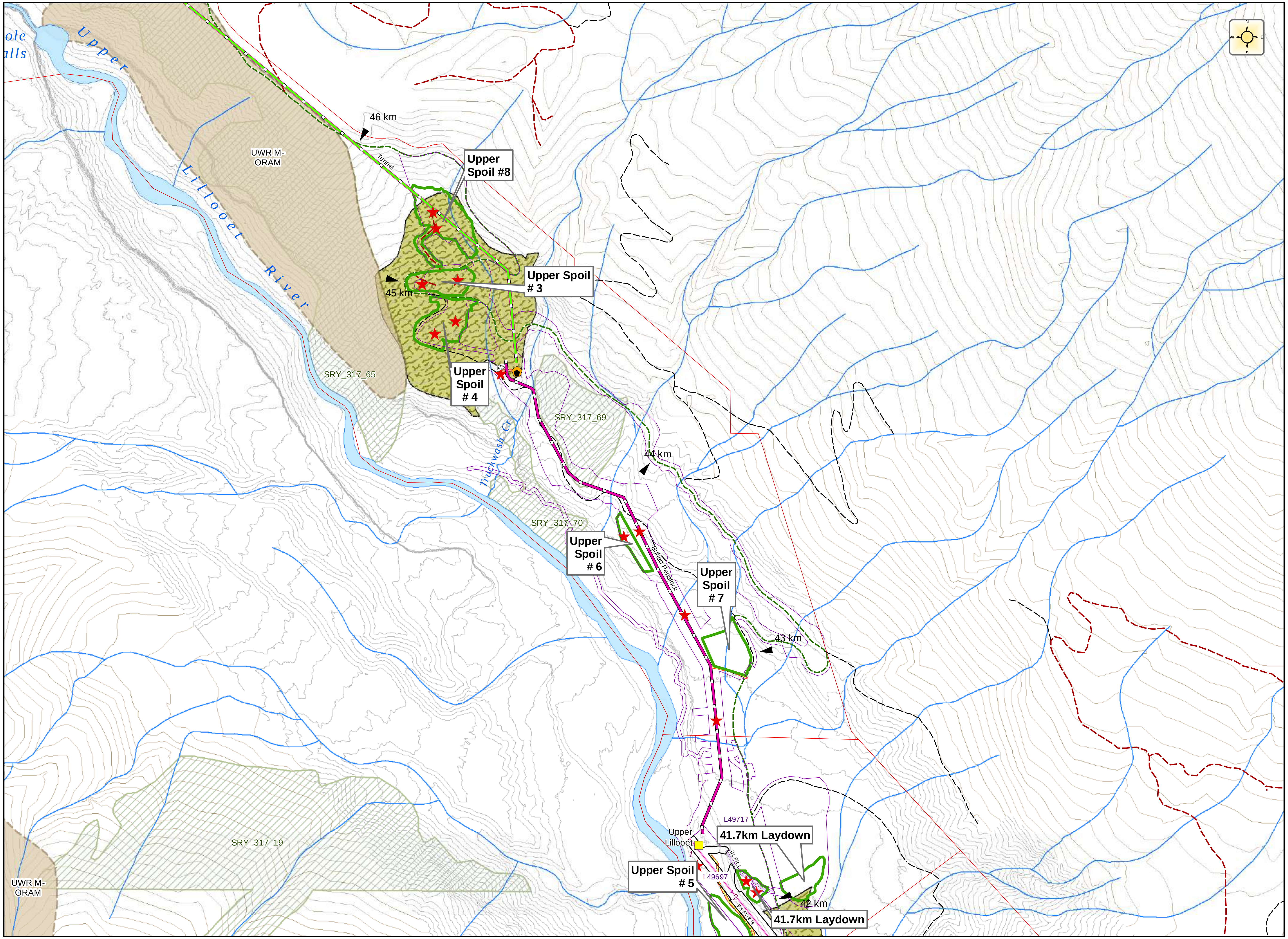

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Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
73 Transmission Line and Poles (R1g Design)
★ Revegetation Plot
▭ ULHP Revegetation Area
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Existing Road
Road Permit
Proposed Access
Forest Service Road
34 km 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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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

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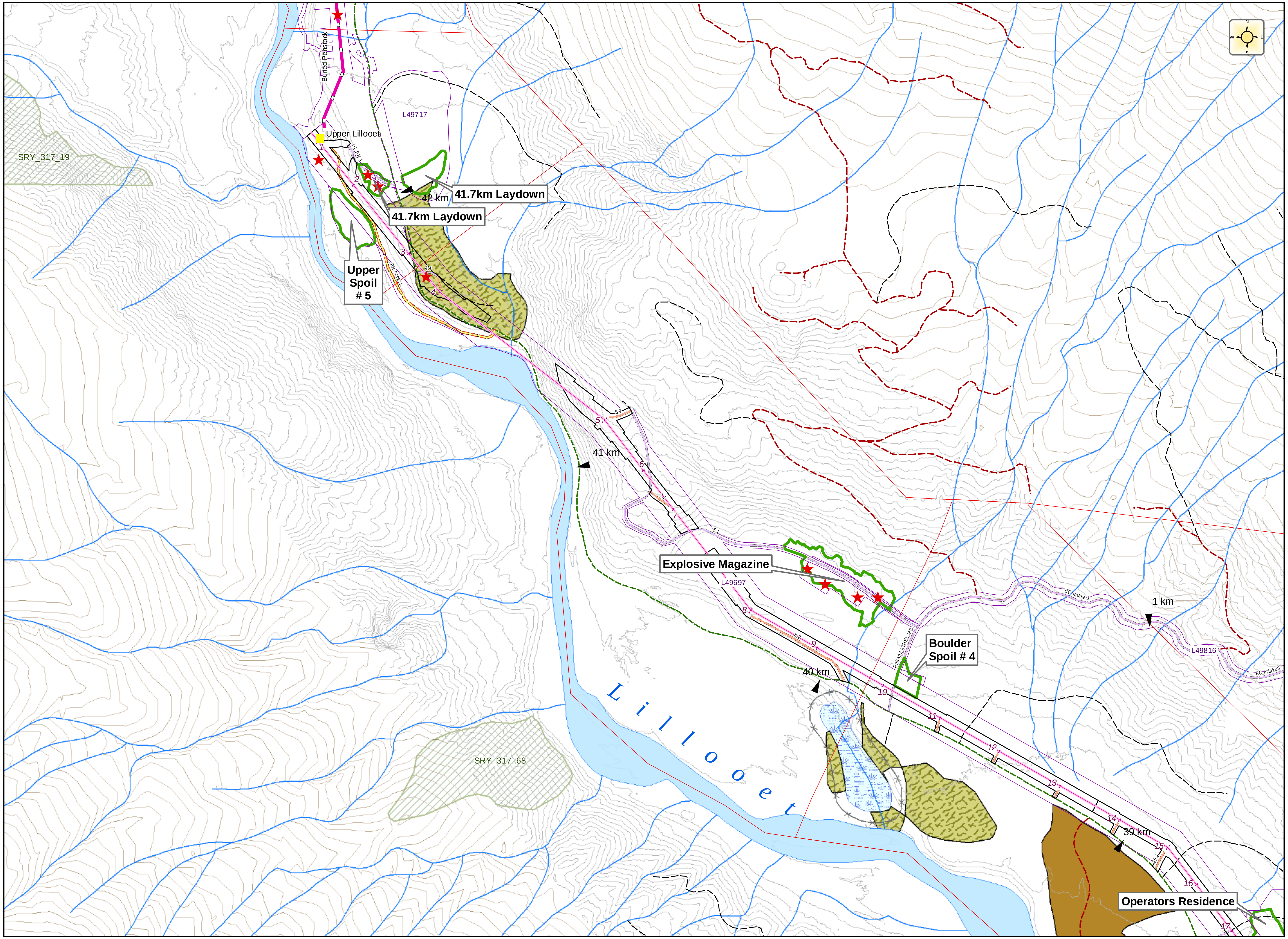

INNERGEX

Revegetation Monitoring Year 1 (2018)

- 🟥 🟨 ⬟ Intake, Powerhouse, Tunnel Portal
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- 🟩 ULHP Revegetation Area
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- Road Permit
- Proposed Access
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- 34 km Paved Road
- Highway
- ► Kilometre Sign

Access Road Type

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- Proposed Tower Road
- Upgrade Existing Road
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- TRIM Intermediate Contour
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- 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

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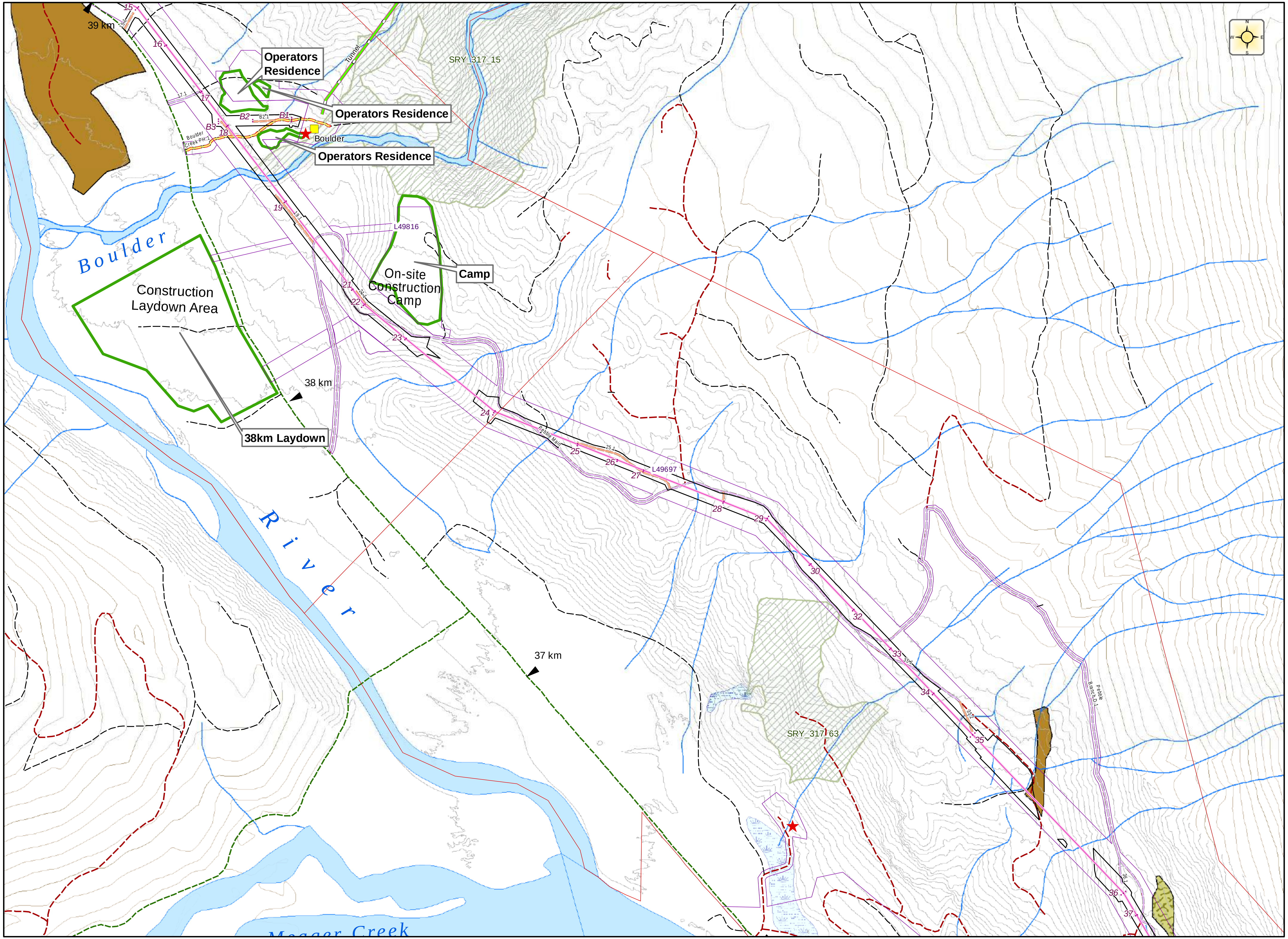

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Revegetation Monitoring Year 1 (2018)

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- Deer Winter Range
- Mtn Goat Winter Range
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- ☐ 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

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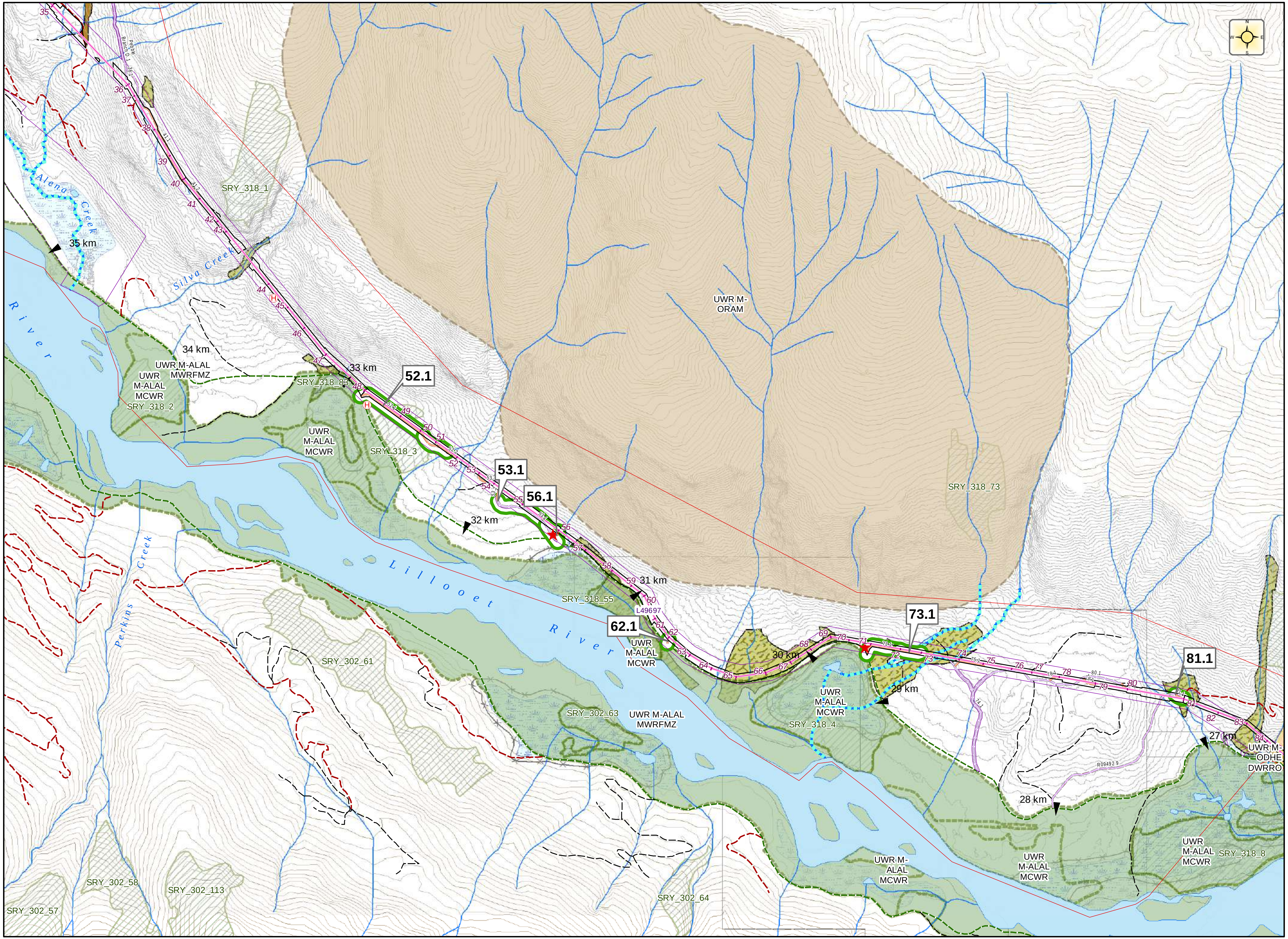

INNERGEX

Revegetation Monitoring Year 1 (2018)

- ▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
- 73 Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- ULHP Revegetation Area
- Ⓗ Helipad
- Falling Boundary
- OLTC
- Land Tenure Boundary
- Existing Road
- Road Permit
- Proposed Access
- Forest Service Road
- 34 km 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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 1 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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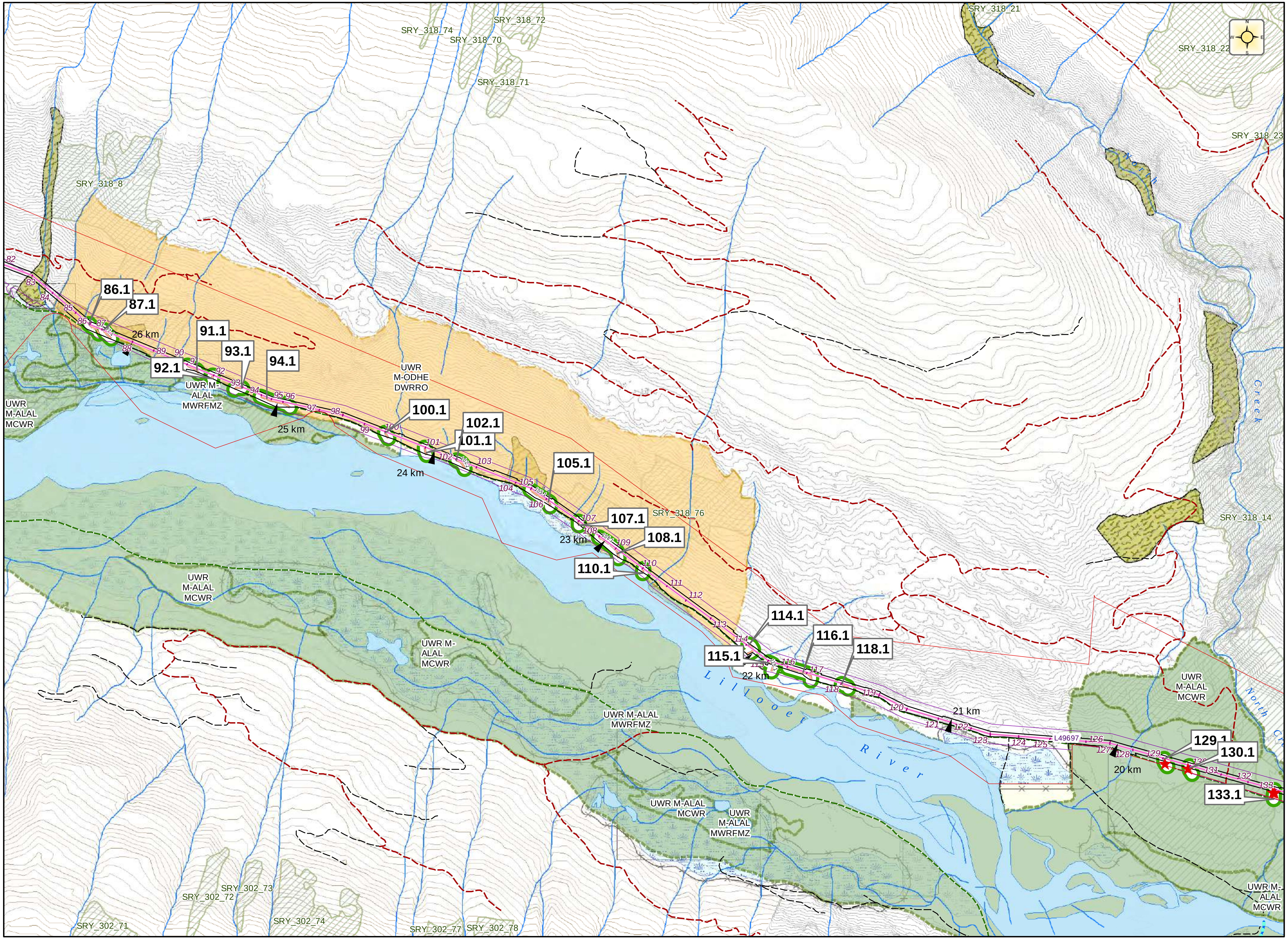

INNERGEX

Revegetation Monitoring Year 1 (2018)

- 🟥 🟨 ⬟ Intake, Powerhouse, Tunnel Portal
- 73 Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- 🟩 ULHP Revegetation Area
- Ⓗ Helipad
- ☐ Falling Boundary
- ☐ OLTC
- ☐ Land Tenure Boundary
- Existing Road
- Road Permit
- Proposed Access
- Forest Service Road
- 34 km 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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- GB Salmon Feeding Stream (No Construction Aug15 - Dec31)
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- 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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 2 of 10

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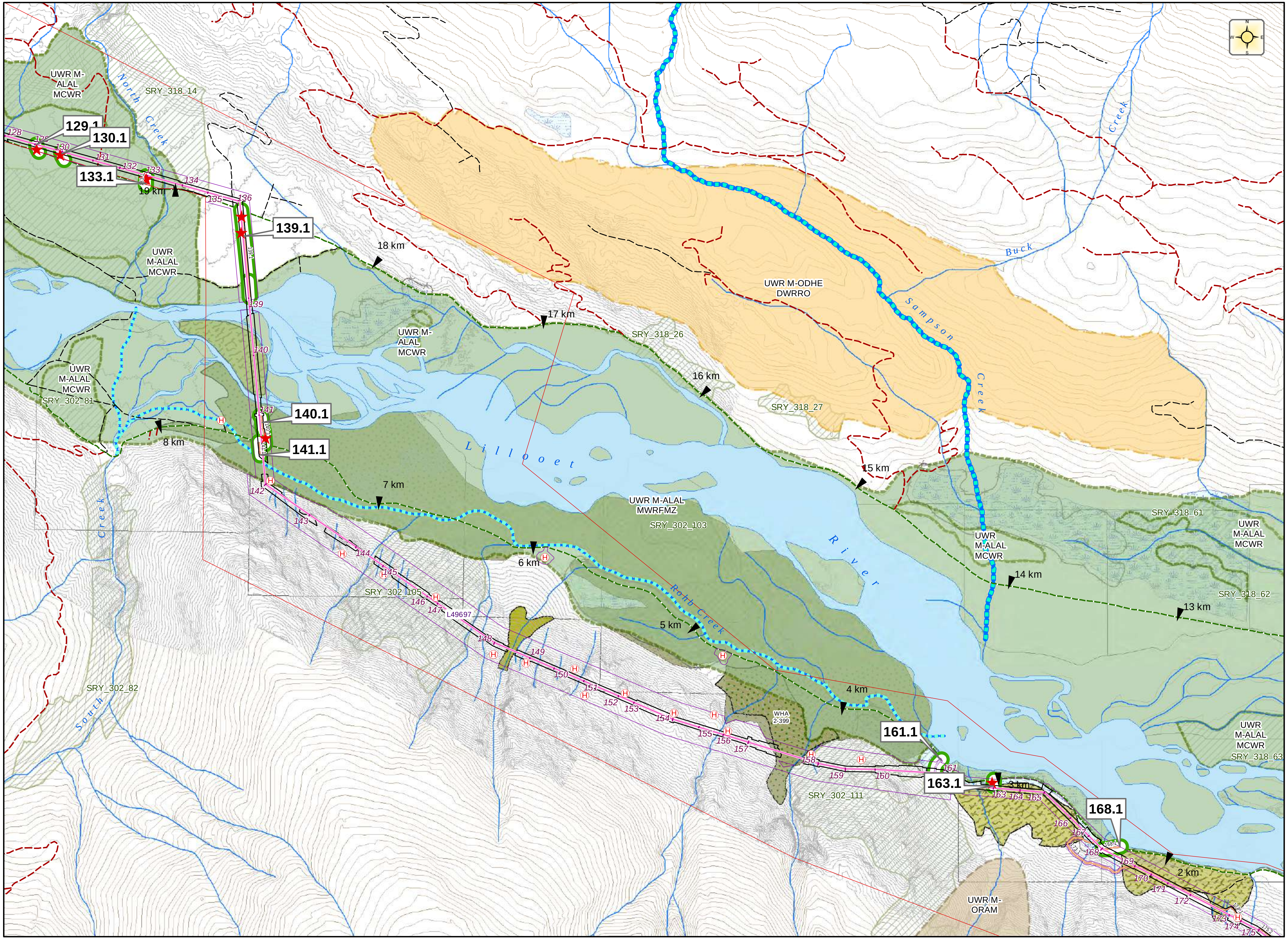
INNERGEX

Revegetation Monitoring Year 1 (2018)



Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Date: Apr,02 2019
Project No. 09-008
Base Map Source: TRIM 20K

Map: 3 of 10

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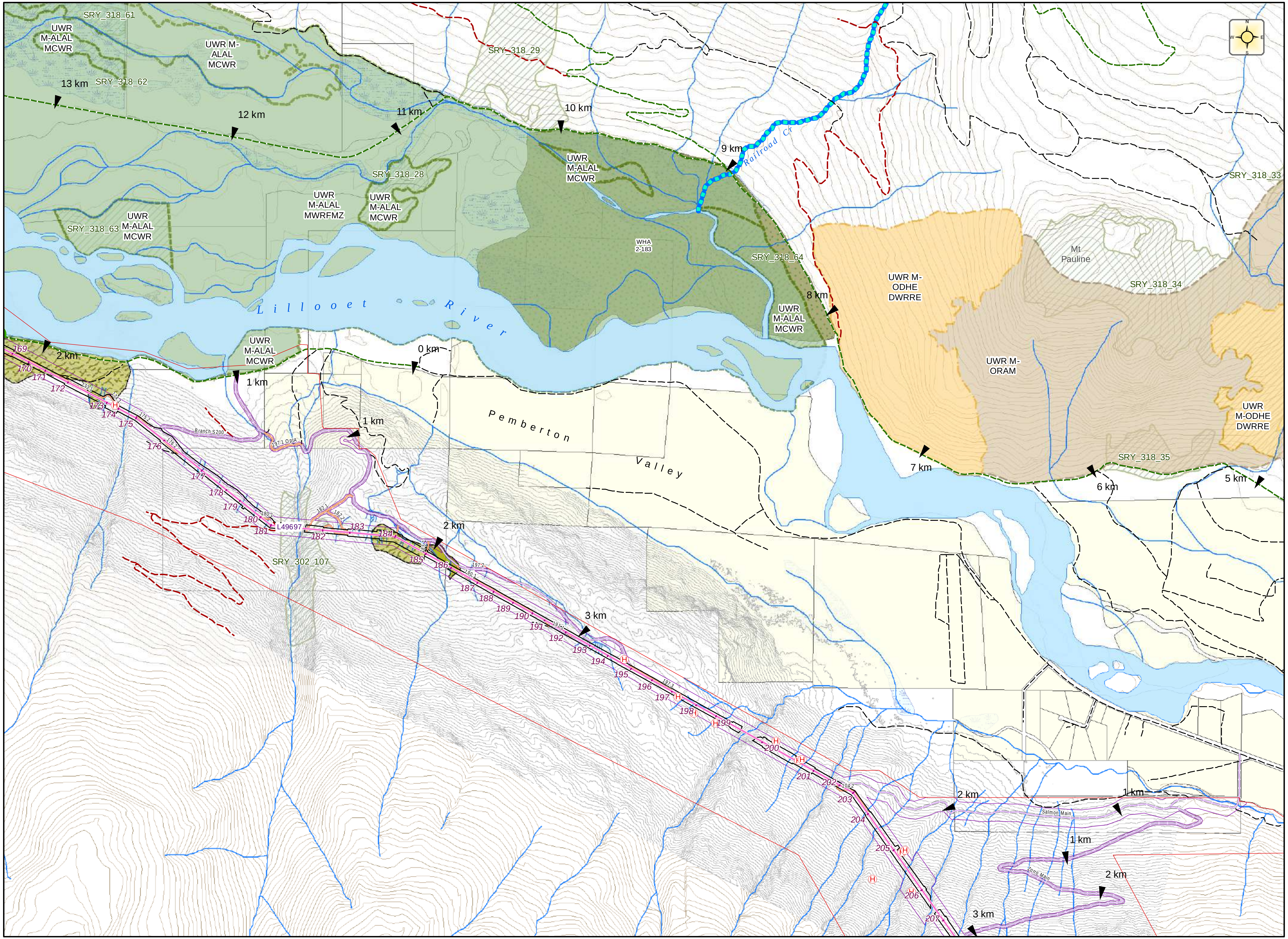

INNERGEX

Revegetation Monitoring Year 1 (2018)

- ▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
- Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- 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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 4 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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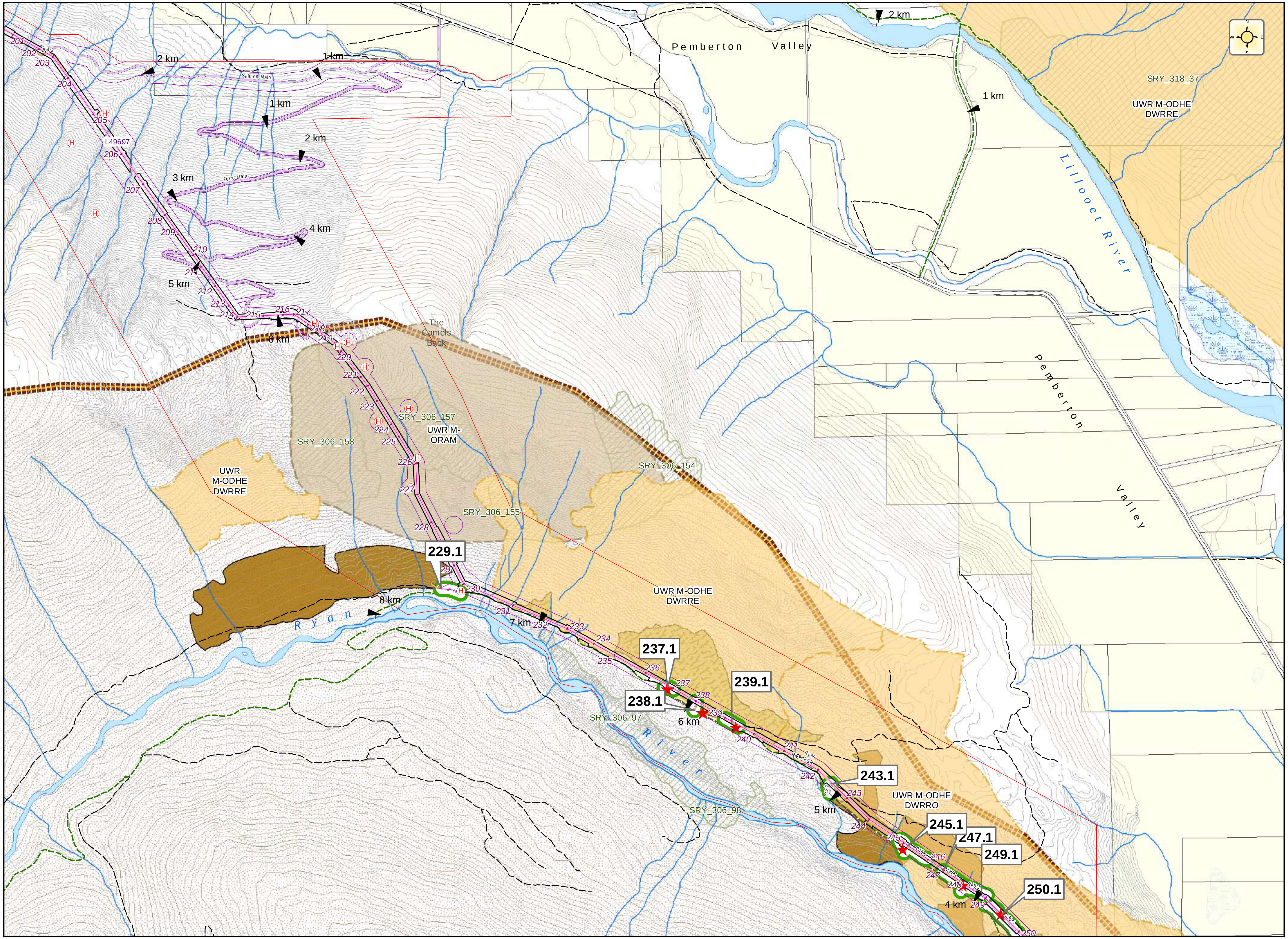

INNERGEX

Revegetation Monitoring Year 1 (2018)

- ▲ 🟨 ⬟ Intake, Powerhouse, Tunnel Portal
- Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- 🟩 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)
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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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 5 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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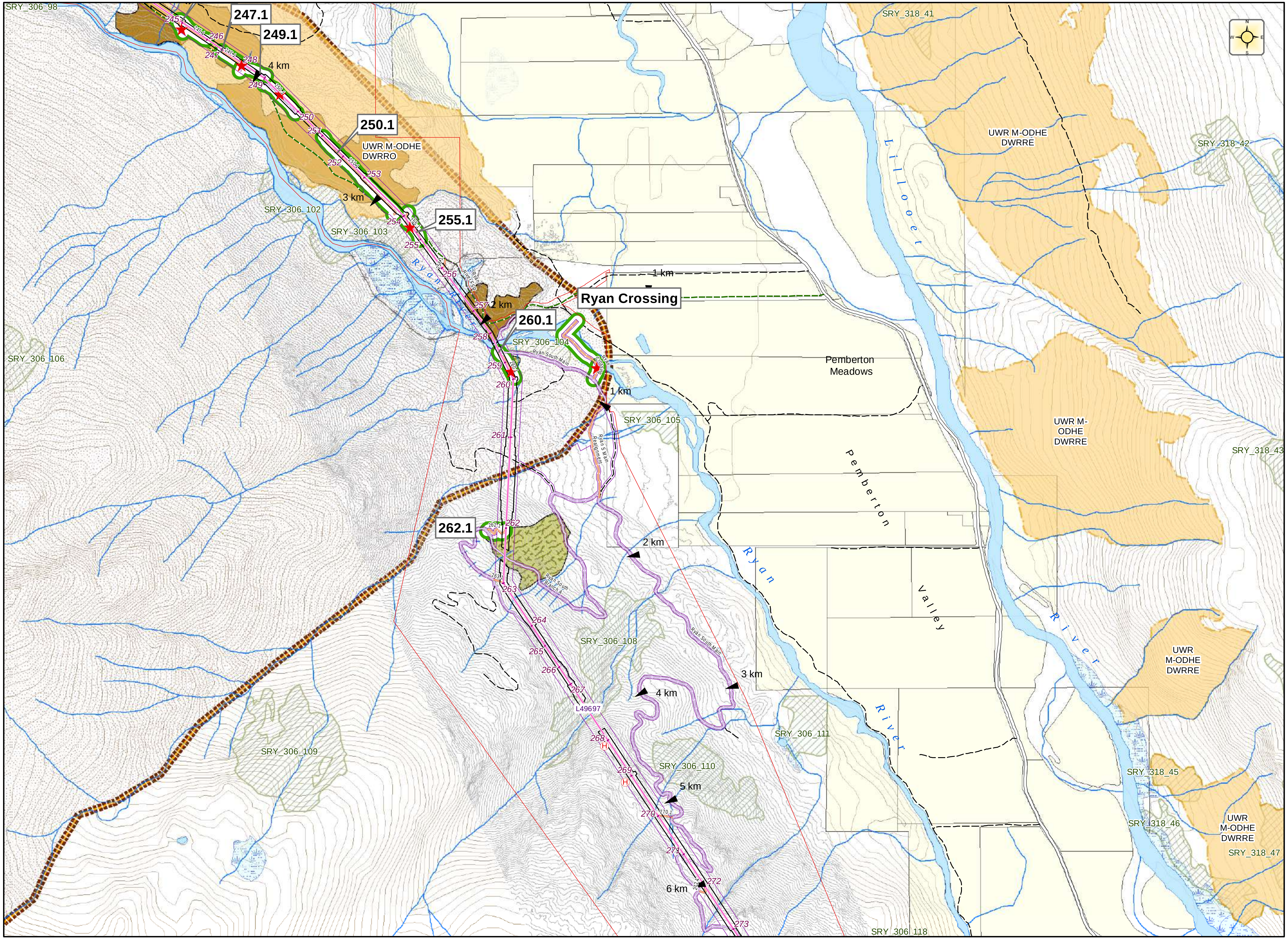

INNERGEX

Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
73 Transmission Line and Poles (R1g Design)
★ Revegetation Plot
ULHP Revegetation Area
Ⓗ Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
34 km 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)
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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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 6 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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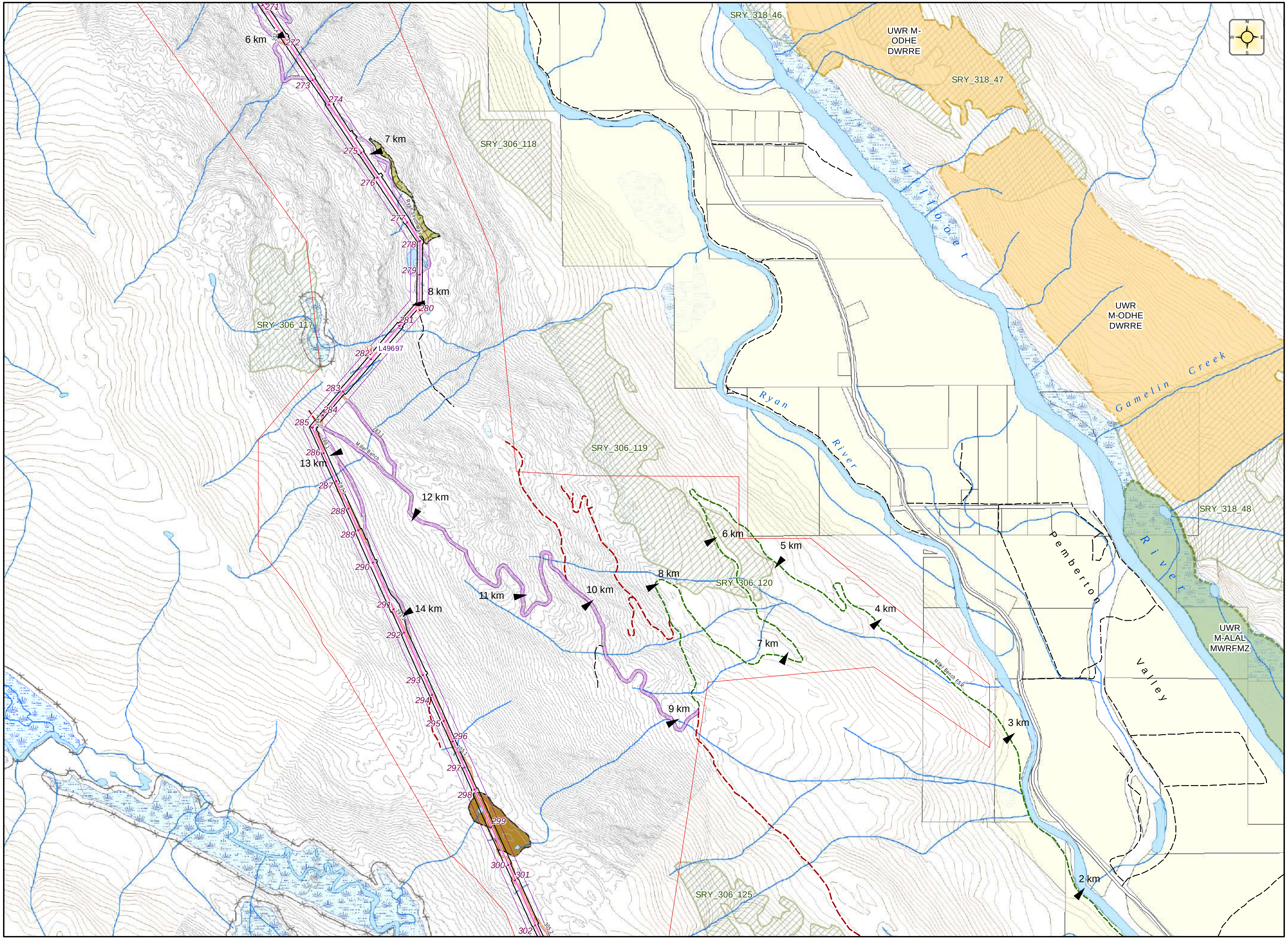

INNERGEX

Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
73 Transmission Line and Poles (R1g Design)
★ Revegetation Plot
▭ ULHP Revegetation Area
Ⓗ Helipad
▭ Falling Boundary
▭ OLTC
▭ Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
34 km 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: Apr,02 2019
Project No. 09-008
Base Map Source: TRIM 20K

Map: 7 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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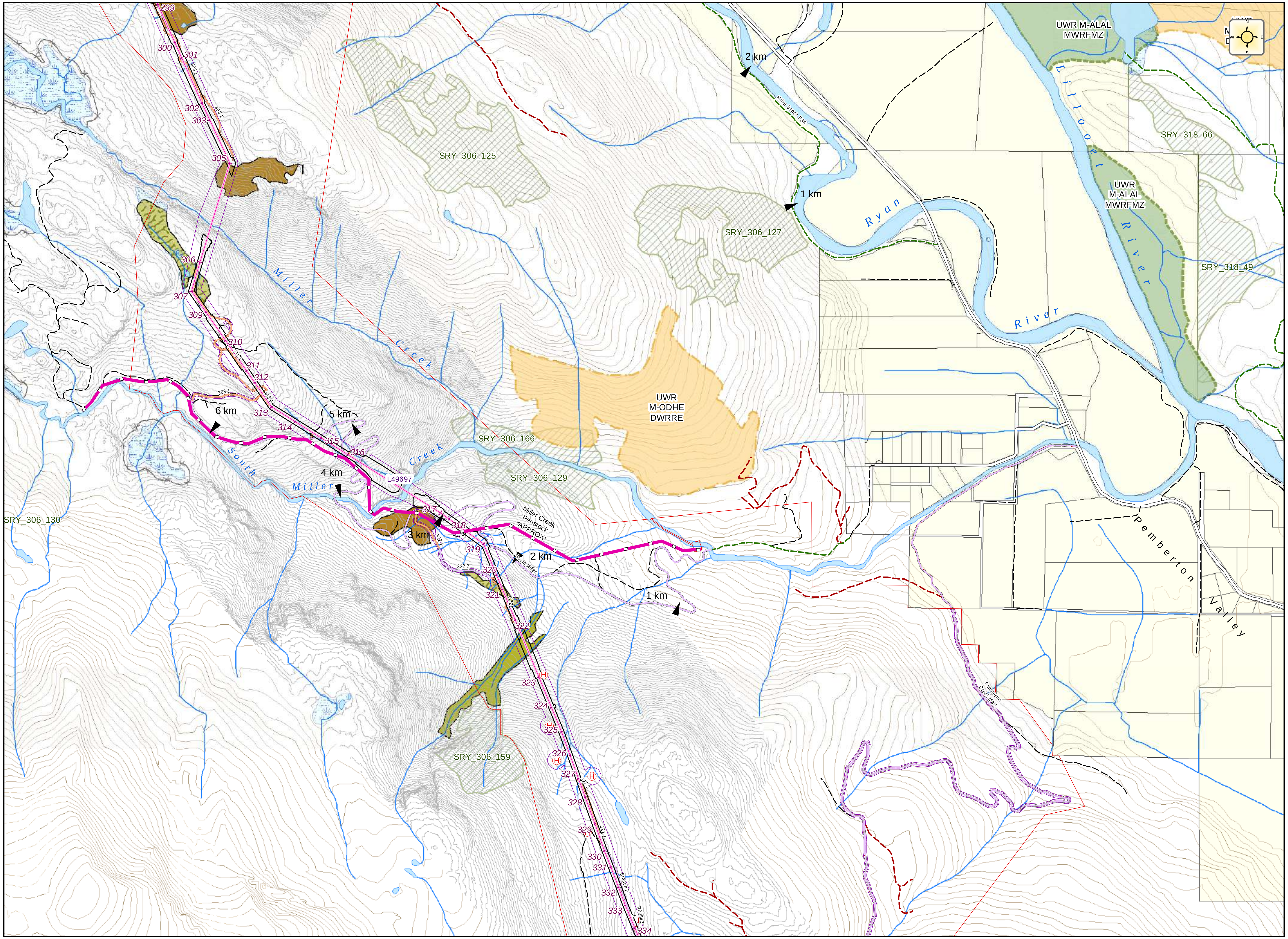

INNERGEX

Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
73 Transmission Line and Poles (R1g Design)
★ Revegetation Plot
ULHP Revegetation Area
Ⓗ Helipad
Falling Boundary
OLTC
Land Tenure Boundary
Existing Road
Road Permit
Proposed Access
Forest Service Road
34 km 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: Apr,02 2019
Project No. 09-008
Base Map Source: TRIM 20K

Map: 8 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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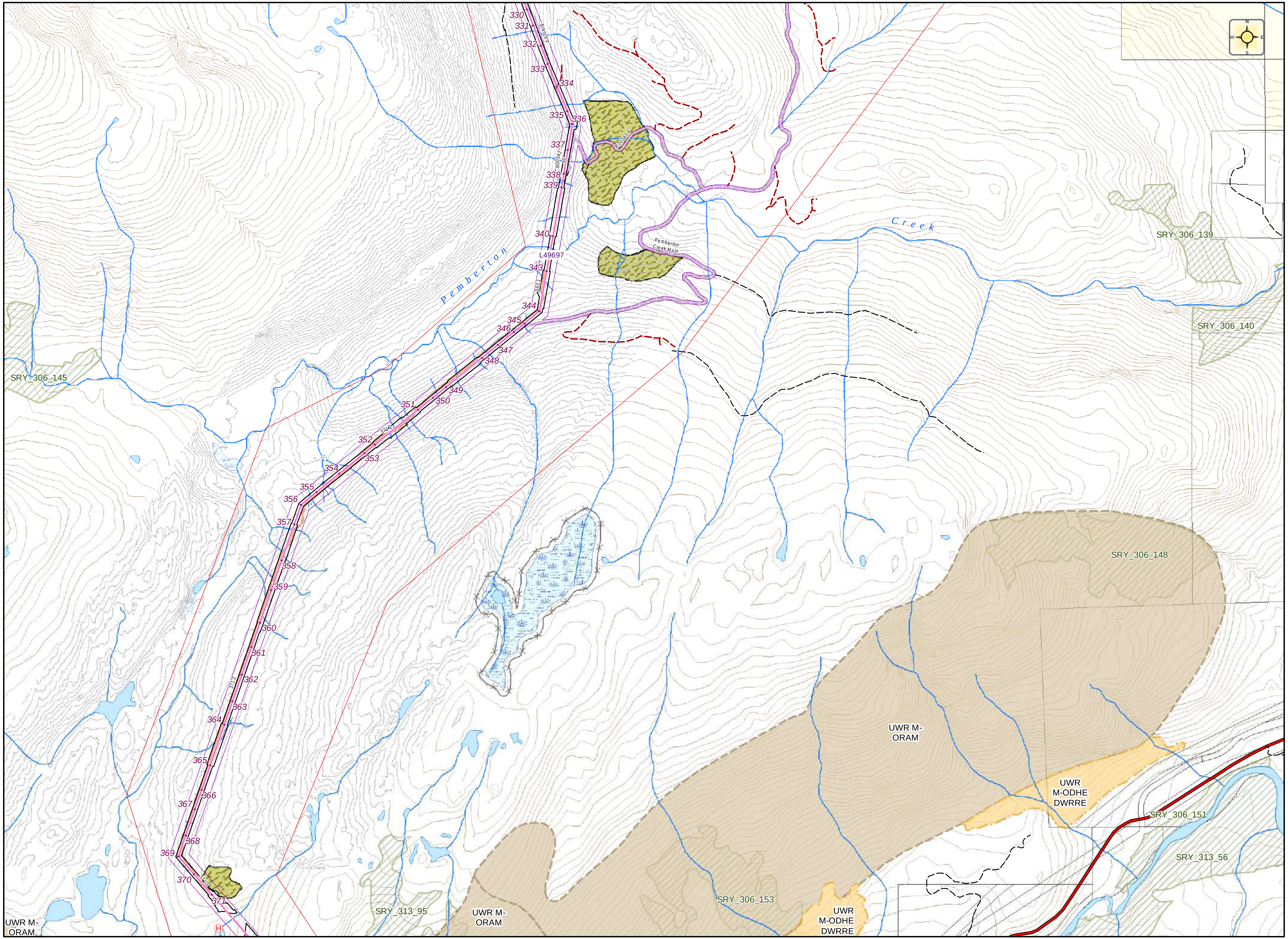

INNERGEX

Revegetation Monitoring Year 1 (2018)

- Intake, Powerhouse, Tunnel Portal
- Transmission Line and Poles (R1g Design)
- Revegetation Plot
- 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

0 100 200 400 600 800 metres

Projection: NAD 1983 UTM Zone 10
Scale: 1:20,000
Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Date: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 9 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
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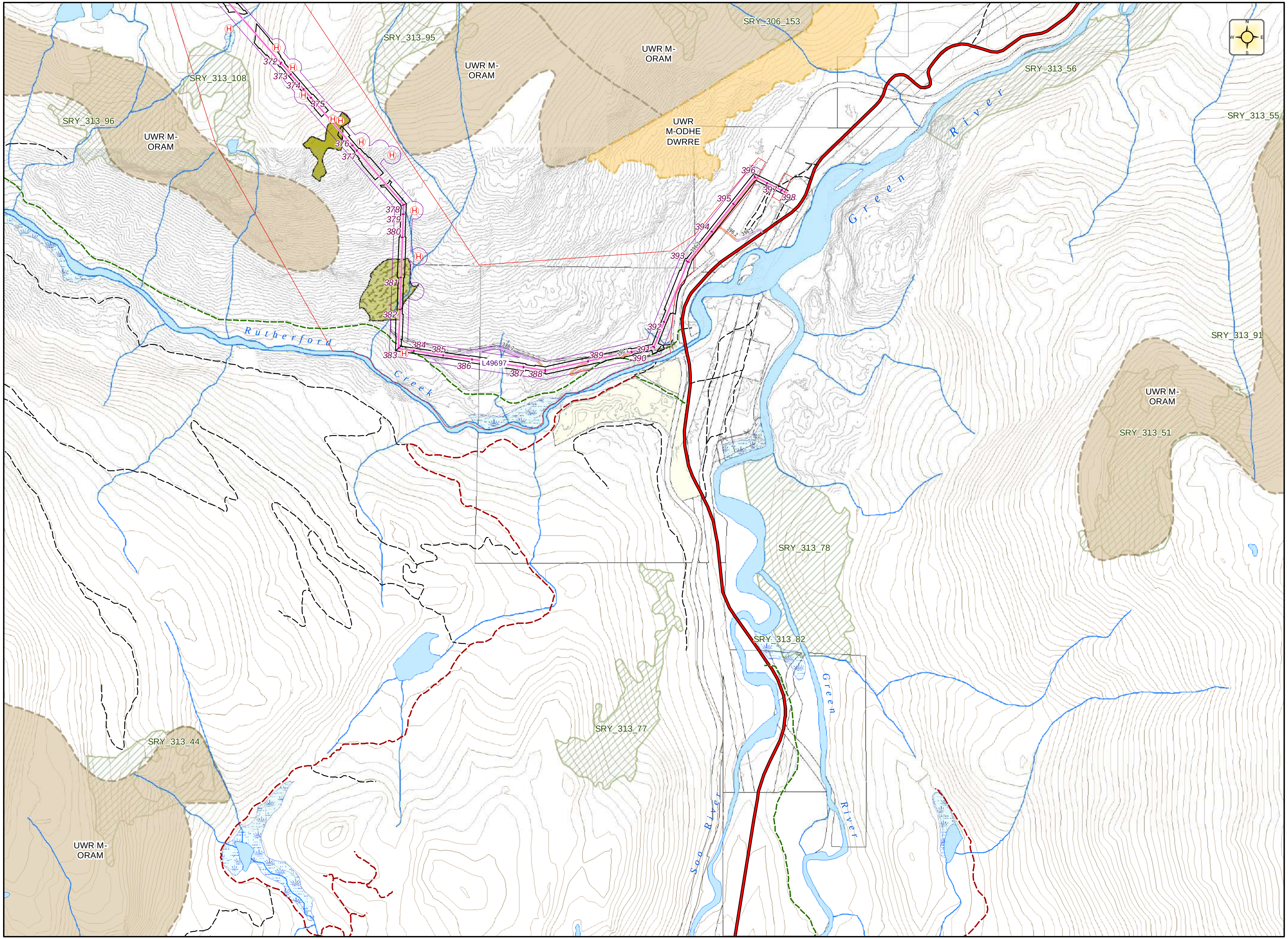

INNERGEX

Revegetation Monitoring Year 1 (2018)

🔺 🟨 ⬟	Intake, Powerhouse, Tunnel Portal
73	Transmission Line and Poles (R1g Design)
★	Revegetation Plot
🟩	ULHP Revegetation Area
Ⓗ	Helipad
☐	Falling Boundary
☐	OLTC
☐	Land Tenure Boundary
- - -	Existing Road
- - -	Road Permit
▬	Proposed Access
- - -	Forest Service Road
34 km	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)
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▨	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: Apr,02 2019 Project No. 09-008
Base Map Source: TRIM 20K

Map: 10 of 10

Map Document: Document Path: D:\Data\09-008\2010\MXD\Reveg\Revegetaton 20K.mxd
Date: 2019-04-02 --5:05:21 PM

Appendix B: Transmission Line Sites Permanent Monitoring Plot Data

Transmission Line Surveys

53.1 /56.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	53.1/ 56.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	13	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Act	1,800	60				
Thimbleberry	800	27				
Red Raspberry	400	13				
Summary:	***3,000***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	25	15	26	15
Herb 2	27	15		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

73.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	73.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	16	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	17,800	92				
Red Raspberry	1,600	8				
Summary:	***19,400***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	7	15	10	18
Herb 2	8	10		
Shrub 2	5	30		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

129.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 129.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 26

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Falsebox	2,000	56				
Plc	1,200	33				
Ceanothus	400	11				
Summary:	***3,600***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	16	15	13.5	20
Herb 2	4	15		
Shrub 2	7	30		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

130.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 130.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 27

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Falsebox	6,600	61				
Plc	3,000	28				
Act	400	4				
Sx	400	4				
Blackberry trailing	200	2				
Fdc	200	2				
Summary:	***10,800***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	4	23	13	17
Herb 2	22	10		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

133.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 133.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 27

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Blackberry trailing	200	100				
Summary:	***200***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	21	15	16	15
Herb 2	11	15		

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

Affix Professional Seal Here

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

140.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 140.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 29

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Dr	26,400	64				
Act	12,000	29				
Thimbleberry	3,000	7				
Summary:	***41,400***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	10	30	26	30
Herb 2	1	15		
Shrub 2	6	35		
Tree 1	30	40		
Tree 2	5	30		

Qualified Forest Professional's Statement

Declaration

Forest Professional	**Date**

Affix Professional Seal Here

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

163.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 163.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 35

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Red Raspberry	6,800	33				
Thimbleberry	6,400	31				
Act	4,800	24				
Red Osier Dogwood	1,600	8				
Fdc	400	2				
Falsebox	200	1				
Swamp gooseberry	200	1				
Summary:	***20,400***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	14	10	25	33
Herb 2	6	20		
Shrub 1	10	60		
Shrub 2	20	40		

Qualified Forest Professional's Statement

Declaration

Forest Professional	**Date**

Affix Professional Seal Here

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

237.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 237.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 49

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	11,000	92				
Rosa spp.	600	5				
Act	200	2				
Mb	200	2				
Summary:	***12,000***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	5	25	9.5	30
Herb 2	4	20		
Shrub 1	10	45		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

238.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	238.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	49	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	3,200	53				
Ceanothus	1,200	20				
Blackberry trailing	800	13				
Brackenfern	800	13				
Summary:	***6,000***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	17	10	19	19
Herb 2	18	15		
Shrub 1	1	35		
Shrub 2	2	15		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

239.1 Road

Project Information \

Project: Longterm Revegetation Mon
Site: 239.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 49

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	1,200	60				
Act	800	40				
Summary:	***2,000***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	3	30	3	33
Herb 2	3	35		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

245.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	245.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	51	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	11,000	86				
Dr	1,000	8				
Blackberry trailing	400	3				
Swamp gooseberry	400	3				
Summary:	***12,800***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	25	50	19.5	48
Herb 2	8	60		
Shrub 2	5	45		
Tree 2	1	36		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

247.1 / 249.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	247.1/ 249.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	51	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	7,600	86				
Ceanothus	1,200	14				
Summary:	***8,800***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	20	20	15.5	28
Herb 2	10	30		
Shrub 1	1	35		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Surveys

250.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	250.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	51/52	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	1,800	75				
Blackberry trailing	200	8				
Dr	200	8				
Swamp gooseberry	200	8				
Summary:	***2,400***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	3	15	8	27
Herb 2	10	20		
Shrub 2	3	45		

Qualified Forest Professional's Statement	
	Affix Professional Seal Here
Declaration	

Forest Professional	**Date**

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

255.1 Road

Project Information

Project:	Longterm Revegetation Mon	**Contractor:**	Hedberg Associates
Site:	255.1 Road	**Surveyor(s):**	Sara Barker
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	53	**Field Finish:**	Oct 16, 2018
		# of Plots:	1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	1,000	50				
Blackberry trailing	600	30				
Dr	200	10				
Red Raspberry	200	10				
Summary:	***2,000***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	20	15	12	22
Herb 2	3	20		
Shrub 1	1	30		
Shrub 2	-			

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

260.1 Road

Project Information

Project: Longterm Revegetation Mon
Site: 260.1 Road
Location: Upper Lillooet Hydro Project
Mapsheet: 54

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	7,800	83				
Red Raspberry	1,000	11				
Act	200	2				
Mb	200	2				
Saskatoon	200	2				
Summary:	***9,400***	***100***	***-***	***-***	***0.00***	***-***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	14	15	17.5	32.5
Herb 2	17	20		
Shrub 1	1	45		
Shrub 2	3	50		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Transmission Line Surveys

INNERGEX

Ryan Crossing

Project Information

Project: Longterm Revegetation Mon
Site: Ryan Crossing Road
Location: Upper Lillooet Hydro Project
Mapsheet: 54

Contractor: Hedberg Associates
Surveyor(s): Sara Barker
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*	*Ocular SPH*	*Ocular %*	*Inv Ht (m)*	*Inv Age*
Thimbleberry	4,200	78				
Blackberry trailing	600	11				
Cw	600	11				
Summary:	***5,400***	***100***	**-**	**-**	***0.00***	**-**

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	10	15	20	25
Shrub 1	10	25		
Shrub 2	20	35		

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

** Note: WSp and FGp are calculated by maximizing the number of preferred stems in each plot up to the prescribed M-value. The FS 659 method uses an uncapped (M+) percentage of preferred stems and applies this to the overall capped (M) densities to yield WSp and FGp values.*

Transmission Line Sites

				Percentage Cover		
Stratum	Timestamp/Date	Spp	TS	Species	% Cover	Height (cm)
53.1/56.1	Sep 18, 2018 13:28	Black Cottonwood	9	Herb 1	25	15
		Red Raspberry	2	Herb 2	27	15
		Thimbleberry	4			
			15			
			15			
73.1	Sep 18, 2018 12:47	Red Raspberry	8	Herb 1	7	15
		Thimbleberry	89	Herb 2	8	10
				Shrub 2	5	30
			97			
			97			
129.1	Sep 18, 2018 11:31	Ceanothus	2	Herb 1	16	15
		Falsebox	10	Herb 2	4	15
		Lodgepole Pine	6	Shrub 2	7	30
			18			
			18			
130.1	Sep 18, 2018 11:00	Black Cottonwood	2	Herb 1	4	23

Transmission Line Sites

				Percentage Cover		
Stratum	Timestamp/Date	Spp	TS	Species	% Cover	Height (cm)
		Trailing Blackberry	1	Herb 2	22	10
		Falsebox	33			
		Douglas Fir	1			
		Lodgepole Pine	15			
		Spruce	2			
			54			
			54			
133.1	Sep 18, 2018 10:28	Trailing Blackberry	1	Herb 1	21	15
				Herb 2	11	15
			1			
			1			
140.1	Oct 3, 2018 11:06	Black Cottonwood	60	Herb 1	10	30
		Red Alder	132	Herb 2	1	15
		Thimbleberry	15	Shrub 2	6	35

Transmission Line Sites

Stratum	Timestamp/Date	Spp	TS	Species	% Cover	Height (cm)
				Percentage Cover		
				Tree 1	30	40
				Tree 2	5	30
			207			
			207			
163.1	Sep 25, 2018 13:57	Black Cottonwood	24	Herb 1	14	10
		Falsebox	1	Herb 2	6	20
		Douglas Fir	2	Shrub 1	10	60
		Red Osier Dogwood	8	Shrub 2	20	40
		Red Raspberry	34			
		Swamp Gooseberry	1			
		Thimbleberry	32			
			102			
			102			
237.1	Sep 25, 2018 11:14	Black Cottonwood	1	Herb 1	5	25
		Bigleaf Maple	1	Herb 2	4	20
		Rose Spp	3	Shrub 1	10	45
		Thimbleberry	55			
			60			
			60			

Transmission Line Sites

				Percentage Cover		
Stratum	Timestamp/Date	Spp	TS	Species	% Cover	Height (cm)
238.1	Sep 25, 2018 10:50	Trailing Blackberry	4	Herb 1	17	10
		Bracken Fern	4	Herb 2	18	15
		Ceanothus	6	Shrub 1	1	35
		Thimbleberry	16	Shrub 2	2	15
			30			
			30			
239.1	Sep 25, 2018 10:23	Black Cottonwood	4	Herb 1	3	30
		Thimbleberry	6	Herb 2	3	35
			10			
			10			
245.1	Sep 12, 2018 13:44	Trailing Blackberry	2	Herb 1	25	50
		Red Alder	5	Herb 2	8	60
		Swamp Gooseberry	2	Shrub 2	5	45
		Thimbleberry	55	Tree 2	1	36
			64			
			64			

Transmission Line Sites

Stratum	Timestamp/Date	Spp	TS	Percentage Cover Species	% Cover	Height (cm)
247.1/ 249.1	Sep 12, 2018 13:19	Ceanothus	6	Herb 1	20	20
		Thimbleberry	38	Herb 2	10	30
				Shrub 1	1	35
			44			
			44			
250.1	Sep 12, 2018 12:59	Trailing Blackberry	1	Herb 1	3	15
		Red Alder	1	Herb 2	10	20
		Swamp Gooseberry	1	Shrub 2	3	45
		Thimbleberry	9			
			12			
			12			
255.1	Sep 12, 2018 11:35	Trailing Blackberry	3	Herb 1	20	15
		Red Alder	1	Herb 2	3	20
		Red Raspberry	1	Shrub 1	1	30
		Thimbleberry	5			
			10			
			10			

Transmission Line Sites

				Percentage Cover		
Stratum	Timestamp/Date	Spp	TS	Species	% Cover	Height (cm)
260.1	Sep 12, 2018 09:43	Black Cottonwood	1	Herb 1	14	15
		Bigleaf Maple	1	Herb 2	17	20
		Red Raspberry	5	Shrub 1	1	45
		Saskatoon	1	Shrub 2	3	50
		Thimbleberry	39			
			47			
			47			
Ryan Crossing	Sep 12, 2018 10:55	Trailing Blackberry	3	Herb 1	10	15
		Western Red Cedar	3	Shrub 1	10	25
		Thimbleberry	21	Shrub 2	20	35
			27			
			27			
			816			

Card: Roads Stratum: 260.1/Plot: 21/Comments Sep 12, 2018 09.58.11 AM.jpg

Card: Roads Stratum: 260.1/Plot: 21/Comments Sep 12, 2018 10.03.55 AM.jpg

Card: Roads Stratum: 260.1/Plot: 21/Comments Sep 12, 2018 10.35.22 AM.jpg

Card: Roads Stratum: Ryan Crossing/Plot: 22/Comments Sep 12, 2018 10.55.04 AM.jpg

Card: Roads Stratum: Ryan Crossing/Plot: 22/Comments Sep 12, 2018 11.09.56 AM.jpg

Card: Roads Stratum: 255.1/Plot: 23/Plot Name Sep 12, 2018 11.51.29 AM.jpg

Card: Roads Stratum: 255.1/Plot: 23/Comments Sep 12, 2018 12.00.37 PM.jpg

Card: Roads Stratum: 247.1/Plot: 25/Comments Sep 12, 2018 01.23.19 PM.jpg

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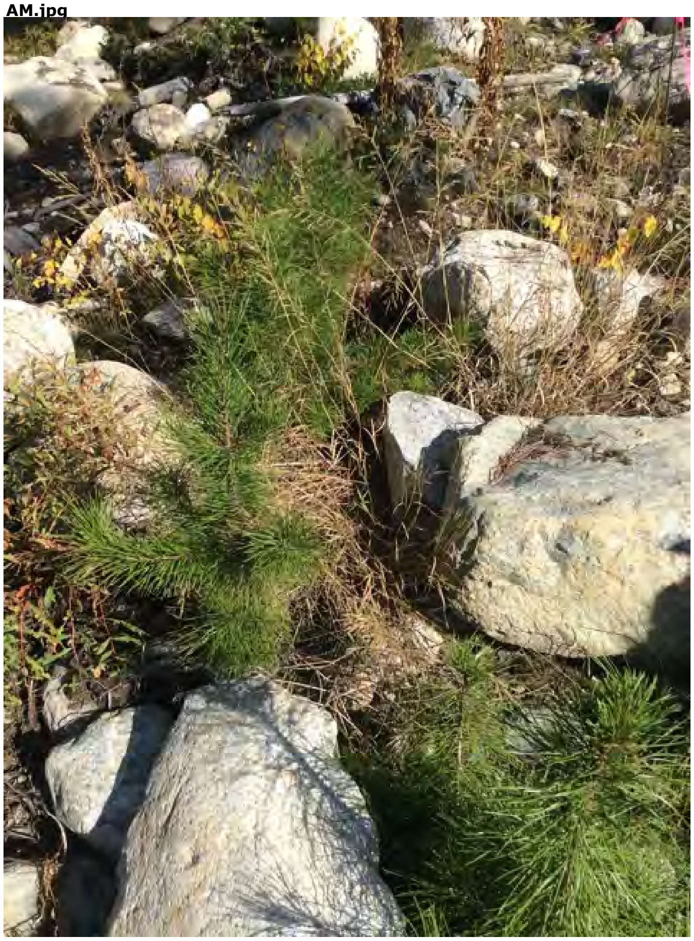
Card: Roads Stratum: 250.1/Plot: 24/Comments Sep 12, 2018 01.00.12 PM.jpg

Card: Roads Stratum: 130.1/Plot: 28/Comments Sep 18, 2018 11.04.43 AM.jpg



Card: Roads Stratum: 130.1/Plot: 28/Comments Sep 18, 2018 11.05.09 AM.jpg

Card: Roads Stratum: 133.1/Plot: Plot 27/Comments Sep 18, 2018 10.34.16 AM.jpg

Card: Roads Stratum: 133.1/Plot: Plot 27/Comments Sep 18, 2018 10.38.09 AM.jpg

Card: Roads Stratum: 73.1/Plot: 30/Comments Sep 18, 2018 12.50.06 PM.jpg

Card: Roads Stratum: 73.1/Plot: 30/Comments Sep 18, 2018 12.50.24 PM.jpg

Card: Roads Stratum: 129.1/Plot: 29/Comments Sep 18, 2018 11.34.17 AM.jpg

Card: Roads Stratum: 129.1/Plot: 29/Comments Sep 18, 2018 11.34.47 AM.jpg

Card: Roads Stratum: 239.1/Plot: 32/Comments Sep 25, 2018 10.27.19 AM.jpg

Card: Roads Stratum: 239.1/Plot: 32/Comments Sep 25, 2018 10.27.43 AM.jpg

Card: Roads Stratum: 245.1/Plot: 26/Comments Sep 12, 2018 01.52.39 PM.jpg

Card: Roads Stratum: 237.1/Plot: 34/Comments Sep 25, 2018 11.16.06 AM.jpg

Card: Roads Stratum: 237.1/Plot: 34/Comments Sep 25, 2018 11.25.07 AM.jpg

Card: Roads Stratum: 238.1/Plot: Plot 33/Latitude Sep 25, 2018 10.53.46 AM.jpg

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Card: Roads Stratum: 140.1/Plot: Plot 35/Comments Oct 03, 2018 11.08.39 AM.jpg

Card: Roads Stratum: 140.1/Plot: Plot 35/Comments Oct 03, 2018 11.08.57 AM.jpg

Card: Roads Stratum: 163.1/Plot: 35/Comments Sep 25, 2018 02.02.25 PM.jpg

Card: Roads Stratum: 163.1/Plot: 35/Comments Sep 25, 2018 02.02.44 PM.jpg

Card: Roads Stratum: 4.1/Plot: Plot 36/Comments Oct 03, 2018 01.35.28 PM.jpg

Card: Roads Stratum: 4.1/Plot: Plot 36/Comments Oct 03, 2018 01.42.59 PM.jpg

Card: Roads Stratum: 56.1/Plot: 31/Comments Sep 18, 2018 01.29.59 PM.jpg

Appendix C: Civil Works Sites Permanent Monitoring Plot Data

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
36 Km Borrow Pit

INNERGEX

Project Information

Project:	Longterm Revegetatio	**Contractor:**	Hedberg Associates
Site:	36 Km Borrow Pit	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	36km Brw	**Field Finish:**	Oct 16, 2018
Net Area:	0.5 Ha	**# of Plots:**	1

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	1,800	56
Douglas Fir	800	25
Red Alder	400	13
Vaccinium	200	6
Summary:	***3,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*
No vegetation in quadrant plots		

Qualified Forest Professional's Statement		
		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
	22-Oct-18	

Civil Works
41.7 Km Laydown

Project Information

Project: Longterm Revegetatio
Site: 41.7 Km Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1
Net Area: 1.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 2

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	800	36
Red Raspberry	600	27
Thimbleberry	500	23
Oregon Grape	300	14
Summary:	***2,200***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	4	7	3	7
Herb 2	1	6		
Shrub 1	1	8		

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**
	22-Oct-18

Affix Professional Seal Here

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Boulder Powerhouse and Spoil

INNERGEX

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Boulder Powerhouse and Spoil	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	BO-1	**Field Finish:**	Oct 16, 2018
Net Area:	1.4 Ha	**# of Plots:**	1

Inventory Information

Species	***TS (SPH)***	***TS %***
Western Red Cedar	400	25
Red Raspberry	400	25
Thimbleberry	400	25
Western Hemlock	200	13
Red Osier Dogwood	200	13
Summary:	***1,600***	***100***

Veg / Brush	***% Cover***	***Avg Ht. (cm)***	***Average % Cover***	***Average Ht. (cm)***
Herb 1	3	10	2.5	18
Herb 2	1	10		
Tree 1	1	35		

Qualified Forest Professional's Statement		
		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
	22-Oct-18	

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Civil Works
Boulder Spoil # 2

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Boulder Spoil #2	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	BO-2a	**Field Finish:**	Oct 16, 2018
Net Area:	1.25 Ha	**# of Plots:**	2

Inventory Information

Species	***TS (SPH)***	***TS %***
Thimbleberry	1,400	64
Falsebox	700	32
Rose	100	5
Summary:	***2,200***	***100***

Veg / Brush	***% Cover***	***Avg Ht. (cm)***	***Average % Cover***	***Average Ht. (cm)***
Herb 1	17	11	13.5	15
Herb 2	9	15		
Shrub 2	1	18		

Qualified Forest Professional's Statement		*Affix Professional Seal Here*
Declaration		
Forest Professional	**Date**	
	22-Oct-18	

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Civil Works
Diversion Channel Slopes

Project Information

Project: Longterm Revegetation Monitoring
Site: Diversion Channel Slopes
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 3

Inventory Information

Species	*TS (SPH)*	*TS %*
Amabalis Fir	267	20
Sitka Alder	267	20
Vaccinium	200	15
Black Cottonwood	133	10
Red Elderberry	133	10
Salal	133	10
Highbrush Cranberry	67	5
Salmonberry	67	5
Thimbleberry	67	5
Summary:	***1,333***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average% Cover*	*Average Ht. (cm)*
Herb 1	1	13	1.5	18
Herb 2	1	11		
Shrub 2	1	30		

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Explosive Magazine

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: Explosive Magazine
Location: Upper Lillooet Hydro Project
Mapsheet: 3
Net Area: 2.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 4

Inventory Information

Species	***TS (SPH)***	***TS %***
Salix	8,650	55
Red Raspberry	3,900	25
Thimbleberry	2,250	14
Douglas Fir	400	3
Black Cottonwood	250	2
Red Alder	100	1
Ceanothus	50	0
Western Red Cedar	50	0
Bigleaf Maple	50	0
Lodgepole Pine	50	0
Summary:	***15,750***	***100***

Veg / Brush	***% Cover***	***Avg Ht. (cm)***	***Average% Cover***	***Average Ht. (cm)***
Herb 1	10	22	26.5	113
Herb 2	9	46		
Shrub 1	22	195		
Shrub 2	12	190		

Qualified Forest Professional's Statement

Declaration

Forest Professional	**Date**
	22-Oct-18

Affix Professional Seal Here

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Keyhole Laydown

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: Keyhole Laydown
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 0.1 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	14,800	62
Vaccinium	7,200	30
Highbrush Cranberry	800	3
Red Elderberry	600	3
Salix	400	2
Amabalis Fir	200	1
Summary:	***24,000***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	60	20	34.5	35
Herb 2	4	45		
Shrub 1	2	35		
Shrub 2	3	40		

Qualified Forest Professional's Statement

Declaration

Forest Professional	**Date**
	22-Oct-18

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Intake and Laydown

INNERGEX

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Intake and Laydown	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-5	**Field Finish:**	Oct 16, 2018
Net Area:	2.4 Ha	**# of Plots:**	4

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	1,700	55
Amabalis Fir	300	10
Salix	300	10
Sitka Alder	200	6
Western Red Cedar	150	5
Douglas Fir	100	3
Rose	100	3
Western Hemlock	50	2
Kinnicinick	50	2
Oregon Grape	50	2
Red Elderberry	50	2
Thimbleberry	50	2
Summary:	***3,100***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Total % Cover*	*Average Ht. (cm)*
Herb 1	7	10	6.5	8
Herb 2	5	10		
Shrub 2	1	5		

Qualified Forest Professional's Statement

Declaration

Forest Professional	**Date**
	22-Oct-18

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Lillooet Penstock

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: Upper Lillooet Penstock
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1, UL-2, UL-3
Net Area: 4.6 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 4

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	900	37
Salix	550	22
Black Cottonwood	450	18
Douglas Fiur	250	10
Thimbleberry	250	10
Red Osier Dogwood	50	2
Summary:	***2,450***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	9	7	5	5
Herb 2	1	3		

Qualified Forest Professional's Statement		
		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
	22-Oct-18	

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Lillooet Powerhouse

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: Upper Lillooet Powerhouse
Location: Upper Lillooet Hydro Project
Mapsheet: UL-1
Net Area: 0.5 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 1

Inventory Information

Species	*TS (SPH)*	*TS %*
Western Hemlock	14,600	53
Black Cottonwood	6,800	24
Red Raspberry	2,800	10
Western Red Cedar	1,600	6
Salix	1,000	4
Douglas Fir	400	1
Red Osier Dogwood	400	1
Red Alder	200	1
Summary:	***27,800***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Total % Cover*	*Average Ht. (cm)*
Herb 1	1	6	3.5	61
Shrub 1	1	3		
Shrub 2	4	130		
Tree 2	1	6		

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Spoil # 1

INNERGEX

Project Information

Project: Longterm Revegetation Monitoring
Site: Upper Spoil # 1
Location: Upper Lillooet Hydro Project
Mapsheet: UL-5
Net Area: 2.4 Ha

Contractor: Hedberg Associates
Surveyor(s): C. Johnston
Field Start: Sep 5, 2018
Field Finish: Oct 16, 2018
# of Plots: 3

Inventory Information

Species	*TS (SPH)*	*TS %*
Sitka Alder	800	55
Black Cottonwood	533	36
Salal	67	5
Thimbleberry	67	5
Summary:	***1,467***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	1	5	1.5	12
Herb 2	1	10		
Shrub 2	1	20		

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**
	22-Oct-18

Affix Professional Seal Here

Civil Works

Upper Spoil # 2 & Settling Basin

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Spoil # 2 & Settling Basin	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-5	**Field Finish:**	Oct 16, 2018
Net Area:	2.8 Ha	**# of Plots:**	4

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	250	45
Sitka Alder	100	18
Black Cottonwood	50	9
Hardhack Spirea	50	9
Salal	50	9
Thimbleberry	50	9
Summary:	***550***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	1	10	1	13
Shrub 1	1	15		

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

INNERGEX

Civil Works
Upper Spoil # 3

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Spoil # 3	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-4	**Field Finish:**	Oct 16, 2018
Net Area:	1.1 Ha	**# of Plots:**	2

Inventory Information

Species	*TS (SPH)*	*TS %*
Black Cottonwood	1,300	43
Red Raspberry	1,300	43
Thimbleberry	300	10
Salix	100	3
Summary:	***3,000***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	3	8	4	18
Herb 2	1	15		
Shrub 1	3	25		
Tree 2	1	25		

Qualified Forest Professional's Statement		Affix Professional Seal Here
Declaration		
Forest Professional	**Date**	
	22-Oct-18	

Civil Works
Upper Spoil # 4

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Spoil # 4	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-4	**Field Finish:**	Oct 16, 2018
Net Area:	1.6 Ha	**# of Plots:**	2

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	800	53
Black Cottonwood	300	20
Thimbleberry	300	20
Red Osier Dogwood	100	7
Summary:	***1,500***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Total % Cover*	*Average Ht. (cm)*
Herb 1	2	10	1.5	10
Herb 2	1	10		

Qualified Forest Professional's Statement		
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Forest Professional	**Date**	
	22-Oct-18	

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Spoil # 6

INNERGEX

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Spoil # 6	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-3	**Field Finish:**	Oct 16, 2018
Net Area:	1.0 Ha	**# of Plots:**	1

Inventory Information

Species	***TS (SPH)***	***TS %***
Douglas Fir	1,200	67
Black Cottonwood	400	22
Sitka Alder	200	11
Summary:	***1,800***	***100***

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

No vegetation in the quadrant plots.

Qualified Forest Professional's Statement	
Declaration	
Forest Professional	**Date**
	22-Oct-18

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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

Civil Works
Upper Spoil # 8

INNERGEX

Project Information

Project:	Longterm Revegetation Monitoring	**Contractor:**	Hedberg Associates
Site:	Upper Spoil # 8	**Surveyor(s):**	C. Johnston
Location:	Upper Lillooet Hydro Project	**Field Start:**	Sep 5, 2018
Mapsheet:	UL-4	**Field Finish:**	Oct 16, 2018
Net Area:	2.2 Ha	**# of Plots:**	2

Inventory Information

Species	*TS (SPH)*	*TS %*
Red Raspberry	1,600	62
Falsebox	400	15
Black Cottonwood	200	8
Salix	200	8
Douglas Fir	100	4
Red Osier Dogwood	100	4
Vaccinium		
Summary:	***2,600***	***100***

Veg / Brush	*% Cover*	*Avg Ht. (cm)*	*Average % Cover*	*Average Ht. (cm)*
Herb 1	1	1	1	3
Shrub 2	1	4		

Qualified Forest Professional's Statement		Affix Professional Seal Here
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Forest Professional	**Date**	
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Project: Longterm Revegetation Monitoring 2018

							Percentage Cover		
Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
36 Km Borrow Pit	S	Oct 16, 2018 11:55	5607380	472682	Act	9		0	0
					Red Alder	2			
					Douglas Fir	4			
					Vaccinium	1			
						16			
						16			
41.7 Km Laydown	M	Sep 26, 2018 14:03	5611544	468614	Oregon Grape	1	Herb 1	7	8
					Red Raspberry	5	Herb 2	1	6
					Thimbleberry	1			
						7			
	N	Sep 26, 2018 14:13	5611576	468586	Black Cottonwood	8	Herb 1	1	5
					Oregon Grape	2	Herb 2	1	5
					Red Raspberry	1	Shrub 1	1	8
					Thimbleberry	4			
						15			
						22			
Boulder Powerhouse and Spoil	Q	Oct 15, 2018 12:05	5609329	471312	Western Red Cedar	2	Herb 1	3	10
					Western Hemlock	1	Herb 2	1	10
					Red Osier Dogwood	1	Tree 1	1	35
					Red Raspberry	2			
					Thimbleberry	2			
						8			
						8			
Boulder Spoil # 2	K	Sep 26, 2018 12:51	5610839	472717	Rose	1	Herb 1	4	10
					Thimbleberry	2	Herb 2	6	10
						3			
	L	Sep 26, 2018 13:07	5610904	472802	Falsebox	7	Herb 1	30	11
					Thimbleberry	12	Herb 2	13	20
							Shrub 2	2	18
						19			
						22			

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
Diversion Channel Slopes	008	Sep 6, 2018 14:46	5614006	466025	Thimbleberry	1	Herb 1	1	15
							Herb 2	2	10
						1			
	009	Sep 6, 2018 14:59	5613996	466110	Salal	1	Shrub 2	2	30
					Sitka Alder	1			
					Vaccinium	1			
						3			
	013	Sep 7, 2018 11:58	5613982	466228	Black Cottonwood	2	Herb 1	1	10
					Amabalis Fir	4	Herb 2	2	12
					Highbrush Cranberry	1			
					Red Elderberry	2			
					Salal	1			
					Salmonberry	1			
					Sitka Alder	3			
					Vaccinium	2			
						16			
						20			
Explosive Magazine	001	Sep 5, 2018 11:00	5610467	469823	Douglas Fir	1	Herb 2	1	60
					Red Raspberry	25	Shrub 1	90	195
					Salix	146	Shrub 2	50	190
						172			
	002	Sep 5, 2018 11:25	5610423	469873	Black Cottonwood	5	Herb 1	1	25
					Red Alder	2	Herb 2	28	20
					Douglas Fir	6			
					Lodgepole Pine	1			
					Red Raspberry	7			
					Salix	6			
					Thimbleberry	17			
						44			
	003	Sep 5, 2018 11:44	5610387	469964	Red Raspberry	46	Herb 1	11	20
					Salix	17	Herb 2	1	5
					Thimbleberry	1			
						64			
	004	Sep 5, 2018 12:01	5610386	470022	Ceanothus	1	Herb 1	29	20
					Western Red Cedar	1	Herb 2	8	100
					Douglas Fir	1			
					Bigleaf Maple	1			
					Salix	4			
					Thimbleberry	27			
						35			
						315			
Keyhole Laydown	007	Sep 6, 2018 13:49	5614102	466453	Amabalis Fir	1	Herb 1	60	20

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
					Highbrush Cranberry	4	Herb 2	4	45
					Red Elderberry	3	Shrub 1	2	35
					Red Raspberry	74	Shrub 2	3	40
					Salix	2			
					Vaccinium	36			
						120			
						120			
Upper Intake and Laydown	014	Sep 7, 2018 14:41	5614284	466097	Black Cottonwood	32		0	0
					Amabalis Fir	6			
					Salix	6			
					Sitka Alder	3			
						47			
	A	Sep 18, 2018 08:55	5614239	466163	Black Cottonwood	2	Shrub 2	2	5
					Western Red Cedar	2			
					Kinnicinick	1			
					Rose	2			
						7			
	B	Sep 18, 2018 09:10	5614202	466202	Western Red Cedar	1	Herb 1	15	10
					Sitka Alder	1	Herb 2	10	10
					Thimbleberry	1			
						3			
	C	Sep 18, 2018 09:22	5614158	466133	Douglas Fir	2		0	0
					Western Hemlock	1			
					Oregon Grape	1			
					Red Elderberry	1			
						5			
						62			
Upper Lillooet Penstock	H	Sep 18, 2018 13:12	5613003	467895	Black Cottonwood	5	Herb 1	15	6
					Red Raspberry	5	Herb 2	2	3
					Salix	6			
					Thimbleberry	1			
						17			
	I	Sep 18, 2018 14:09	5612560	468286	Black Cottonwood	3	Herb 1	4	8
					Douglas Fir	3	Herb 2	1	3
					Red Osier Dogwood	1			
					Red Raspberry	12			
					Thimbleberry	4			
						23			
	O	Sep 26, 2018 14:46	5612326	468413	Black Cottonwood	1		0	0
					Douglas Fir	1			
					Red Raspberry	1			
						3			

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
	P	Sep 26, 2018 14:58	5612028	468501	Douglas Fir	1		0	0
					Salix	5			
						6			
						49			
Upper Lillooet Powerhouse	R	Oct 15, 2018 12:25	5611619	468448	Black Cottonwood	34	Herb 1	1	6
					Western Red Cedar	8	Shrub 1	1	3
					Red Alder	1	Shrub 2	4	130
					Douglas Fir	2	Tree 2	1	6
					Western Hemlock	73			
					Red Osier Dogwood	2			
					Red Raspberry	14			
					Salix	5			
						139			
						139			
Upper Spoil # 1	010	Sep 7, 2018 09:41	5614043	465826	Thimbleberry	1	Herb 1	1	5
							Shrub 2	2	20
						1			
	011	Sep 7, 2018 09:54	5614073	465745	Salal	1		0	0
						1			
	012	Sep 7, 2018 10:14	5614064	465902	Black Cottonwood	8	Herb 2	1	10
					Sitka Alder	12			
						20			
						22			
Upper Spoil # 2 & Settling Basin	015	Sep 7, 2018 15:00	5614297	466159	Black Cottonwood	1	Herb 1	1	10
					Hardhack Spirea	1	Shrub 1	1	15
					Red Raspberry	5			
					Sitka Alder	1			
						8			
	016	Sep 7, 2018 15:16	5614372	466207	Thimbleberry	1		0	0
						1			
	017	Sep 7, 2018 15:26	5614417	466242	Sitka Alder	1		0	0
						1			
	018	Sep 7, 2018 15:35	5614421	466169	Salal	1		0	0
						1			
						11			
Upper Spoil # 3	D	Sep 18, 2018 10:52	5613268	467774	Black Cottonwood	9	Herb 1	2	6
					Red Raspberry	10	Herb 2	2	15
					Thimbleberry	3	Shrub 1	6	25
							Tree 2	2	25
						22			
	E	Sep 18, 2018 11:06	5613256	467673	Black Cottonwood	4	Herb 1	4	12

Stratum	Plot No.	Timestamp/Date	UTM N	UTM E	Spp	TS	Species	% Cover	Height (cm)
					Red Raspberry	3	Herb 1	1	5
					Salix	1			
						8			
						30			
Upper Spoil # 4	F	Sep 18, 2018 11:57	5613152	467767	Black Cottonwood	3			
					Red Osier Dogwood	1			
					Red Raspberry	7			
					Thimbleberry	3			
						14			
	G	Sep 18, 2018 12:18	5613117	467709	Red Raspberry	1	Herb 1	2	10
							Herb 2	1	10
						1			
						15			
Upper Spoil # 6	J	Sep 18, 2018 14:21	5612547	468241	Black Cottonwood	2			
					Douglas Fir	6			
					Sitka Alder	1			
						9			
						9			
Upper Spoil # 8	005	Sep 5, 2018 14:00	5613414	467713	Falsebox	3	Herb 1	1	1
					Red Osier Dogwood	1	Shrub 2	1	4
					Red Raspberry	16			
					Salix	2			
						22			
	006	Sep 5, 2018 14:11	5613459	467704	Black Cottonwood	2		0	0
					Falsebox	1			
					Douglas Fir	1			
						4			
						26			
						886			

Card: Civil Works Stratum: 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: 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: 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: 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: Diversion Channel Slopes/Plot: 008/Comments
Overview photo looks towards plot center from the North side of the plot. S

Card: Civil Works Stratum: Diversion Channel Slopes/Plot: 009/Comments
Overview photo looks at plot from the North side. Sep 06, 2018 03.00.48 P

Card: Civil Works Stratum: Diversion Channel Slopes/Plot: 013/Comments
Overview photo looks South towards plot center. Sep 07, 2018 12.01.34 P

Card: Civil Works Stratum: Explosive Magazine/Plot: 001/Comments
Overview photo looks North towards plot center. Sep 05, 2018 11.22.20 A

Card: Civil Works Stratum: Explosive Magazine/Plot: 002/Comments
Overview photo looks North towards plot center. Sep 05, 2018 12.20.55 PM

Card: Civil Works Stratum: Explosive Magazine/Plot: 003/Comments
Overview photo looks North toward plot center. Sep 05, 2018 11.47.35 AM.

Card: Civil Works Stratum: Explosive Magazine/Plot: 004/Comments Sep
05, 2018 12.02.37 PM.jpg

Card: Civil Works Stratum: Keyhole Laydown / Plot: 00 / Comments Overview photo looks towards plot center from North side of plot. Sep 06, 2018 02.1

Card: Civil Works Stratum: Keyhole Laydown / Plot: 00 / Comments Rest of site is not plantable. Sep 06, 2018 02.14.40 PM.jpg

Card: Civil Works Stratum: Upper Intake and Laydown/Plot: 014/Comments Overview photo looks South towards plot center. Sep 07, 2

Card: Civil Works Stratum: Upper Intake and Laydown/Plot: A/Comments Overview photo looks South towards plot center. Sep 18, 2018 09.00.54 A

Card: Civil Works Stratum: Upper Intake and Laydown/Plot: B/Comments Overview photo looks South towards plot center. Sep 18, 2018 09.12.42 A

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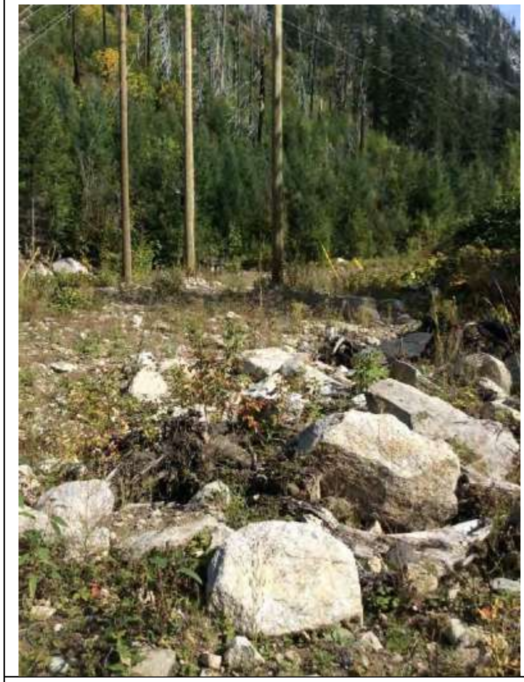
Appendix D: Inspection Site Photos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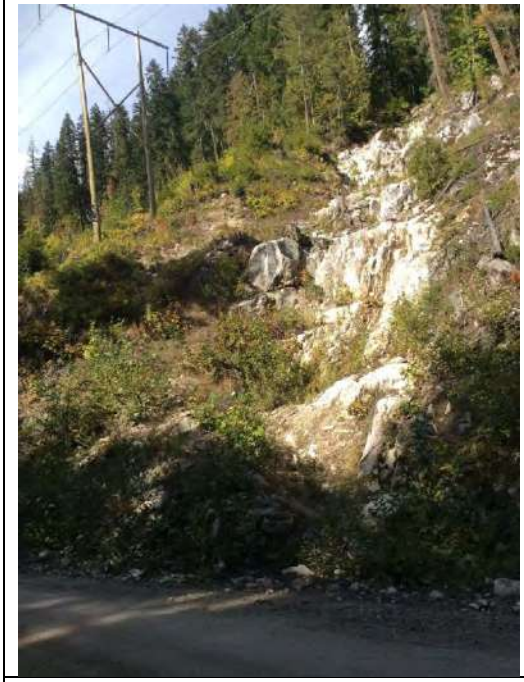	
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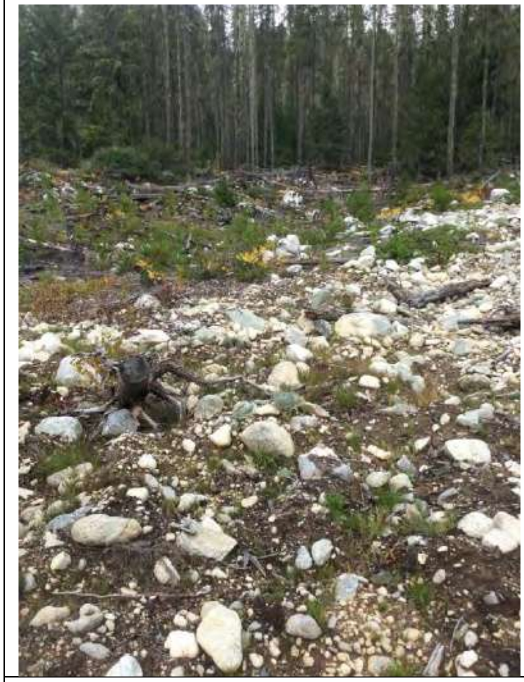	
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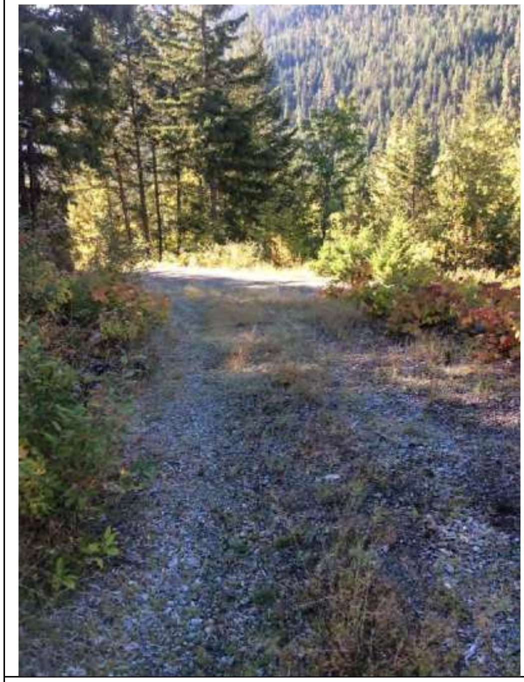	
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Appendix E:

Field note description	Common name	Latin name
Act	Black Cottonwood	Populus trichocarpa
Ba	amablis fir or balsam	Abies amabilis
Blackberry trailing	Pacific trailing blackberry	Rubus ursinus
Ceanothus	snowbrush/ redstem ceanothus	Ceanothus spp.
Cw	western redcedar	Thuja plicata
Dr	red alder	Alnus rubra
Falsebox	falsebox	Paxistima myrsinites
Fdc	Douglas fir	Pseudotsuga menziesii
Hardhack Spirea	Spirea or Douglas Spirea	Spiraea douglasii
Highbrush Cranberry	highbush cranberry	Viburnum edule
Hw	western hemlock	Tsuga mertensiana
Kinnicinick	bearberry/ kinnickinick	Arctostaphylos uva-ursi
Mb	bigleaf maple	Acer macrophyllum
Oregon Grape	tall oregon grape	Mahonia aquifolium
Plc	lodgepole pine	Pinus contorta
Red Elderberry	red elderberry	Sambucus racemosa
Red Osier Dogwood	red osier dogwood	Cornus stolonifera
Red Raspberry	red raspberry	Rubus idaeus
Rose	Rose	Rosa spp.
Salal	salal	Gaultheria shallon
Salix	willow	Salix spp.
Salmonberry	salmonberry	Rubus spectabilis
Saskatoon	saskatoon	Amelanchier alnifolia
Sitka Alder	sitka alder	Alnus viridis
Swamp gooseberry	black/swamp gooseberry	Ribes lacustre
Sx	Spruce hybrid	Picea cross
Thimbleberry	thimbleberry	Rubus parviflorus
Vaccinium	black huckleberry	Vaccinium membranaceum

Appendix F: Reforestation summary of October 2018 tree planting for civil works sites at the Upper Lillooet Hydroelectric Project

HEDBERG and ASSOCIATES
CONSULTING LTD.

205 - 1121 Commercial Way
PO Box 1609
Squamish, BC
Canada V8B 0S5

Tel: 604.815.4555
Fax: 604.815.4551
www.hedbergassociates.com

Memorandum

Attn: Tanya Katamay-Smith
From: Sara Barker
Date: March 26, 2019
RE: Reforestation summary of October 2018 tree planting for civil works sites at the Upper Lillooet Hydroelectric Project

---

The following memorandum has been prepared to summarize the reforestation works that occurred at the Upper Lillooet Hydro Project (ULHP) in the fall of 2018. Hedberg and Associates Consulting Ltd. (HAC) has been retained by, the Upper Lillooet River Power Limited Partnership and Boulder Creek Power Limited Partnership (collectively, the Partnerships) to coordinate and supervise the reforestation works. The reforestation works were carried out at 19 civil works sites along the ULHP as shown in Table 1 below.

Table 1: ULHP Reforestation Sites

Zone	Elevation (m)	Latitude	Civil Works Site Name	Area (Ha)	Total Trees	SPH
1	450	50.30 - 50-40	38km Laydown	13.0	23,400	1,800
	550		Camp	6.5	10,400	1,600
	450		Operators residence	1.4	2,240	1,600
2	500		Explosive Magazine	2.5	1,500	600
	500		Boulder Spoil #4	0.4	720	1,800
	800		Boulder Spoil #7	0.6	360	600
3	500		Upper Spoil #5	1.1	1,980	1,800
	500		41.7km Laydown	1.1	1,760	1,600
4	650		Upper Spoil #6	1.0	1,800	1,800
	650		Upper Spoil #7	1.3	2,250	1,800
5	700		Upper Spoil #3	1.1	1,540	1,400
	700		Upper Spoil #4	1.6	2,240	1,400
	700		Upper Spoil #8	2.2	3,520	1,600
6	700		Upper Spoil #1	2.4	3,840	1,600
	700		Upper Spoil #2 & Settling Basins	2.8	4,480	1,600
	700		Upper Intake & Laydown (Contoured)	1.6	1,920	1,200
	700		Upper Intake & Laydown (Mounded)	0.8	1,280	1,600
	700		Keyhole Laydown	0.1	180	1,800
	700		Diversion Channel Slopes	2.5	4,000	1,600
Total				44.0	69,410	

The reforestation prescriptions for each civil works site were prepared by Wes Staven of HAC and are detailed in the “Final Revegetation Assessment for the Upper Lillooet Hydro Project” report by Barker and Staven (2017). The prescriptions reflected the biogeoclimatic zone and site series association within which the sites were located. Planting densities ranged depending on the difficulty rating and expected survival rates for each site, with high densities prescribed on sites that were expected to have a higher planting difficulty and lower survival, in an attempt to achieve an adequately reforested area without the need for a follow-up fill plant (Barker and Staven 2017). Planting densities that were prescribed were somewhat higher than is typical for a Forest Licensee planting activity, but this was recommended due to the lack of an overstory seed source (due to the wildfire) that would normally provide for additional natural ingress (Barker and Staven 2017). The final tree and fertilizer allocations are shown in the attached spreadsheet.

The seedlings used for this project were sown in 2017 and were grown by Woodmere Nursery, in Telkwa, BC. In total, there were 69, 410 trees planted. The seedlings were planted from October 9-16th, 2018. The treeplanting labour for this project was completed by Rainforest Field Services Ltd. The field supervisor who oversaw the treeplanting labourers was Robin Belevance of Rainforest Field Services Ltd. Codie Johnston of HAC carried out the field verification of the planting prescriptions and the Quality Control of the treeplanting program. The Quality Control results showed that the projected was completed with quality. The weather conditions during planting were warm, sunny and dry.

If you have any further questions pertaining to the 2018 civil works sites planting program, please contact Sara Barker at (604) 815-4555 x 230.

Yours sincerely,

Sara

Sara Barker
Hedberg and Associates Consulting Ltd.

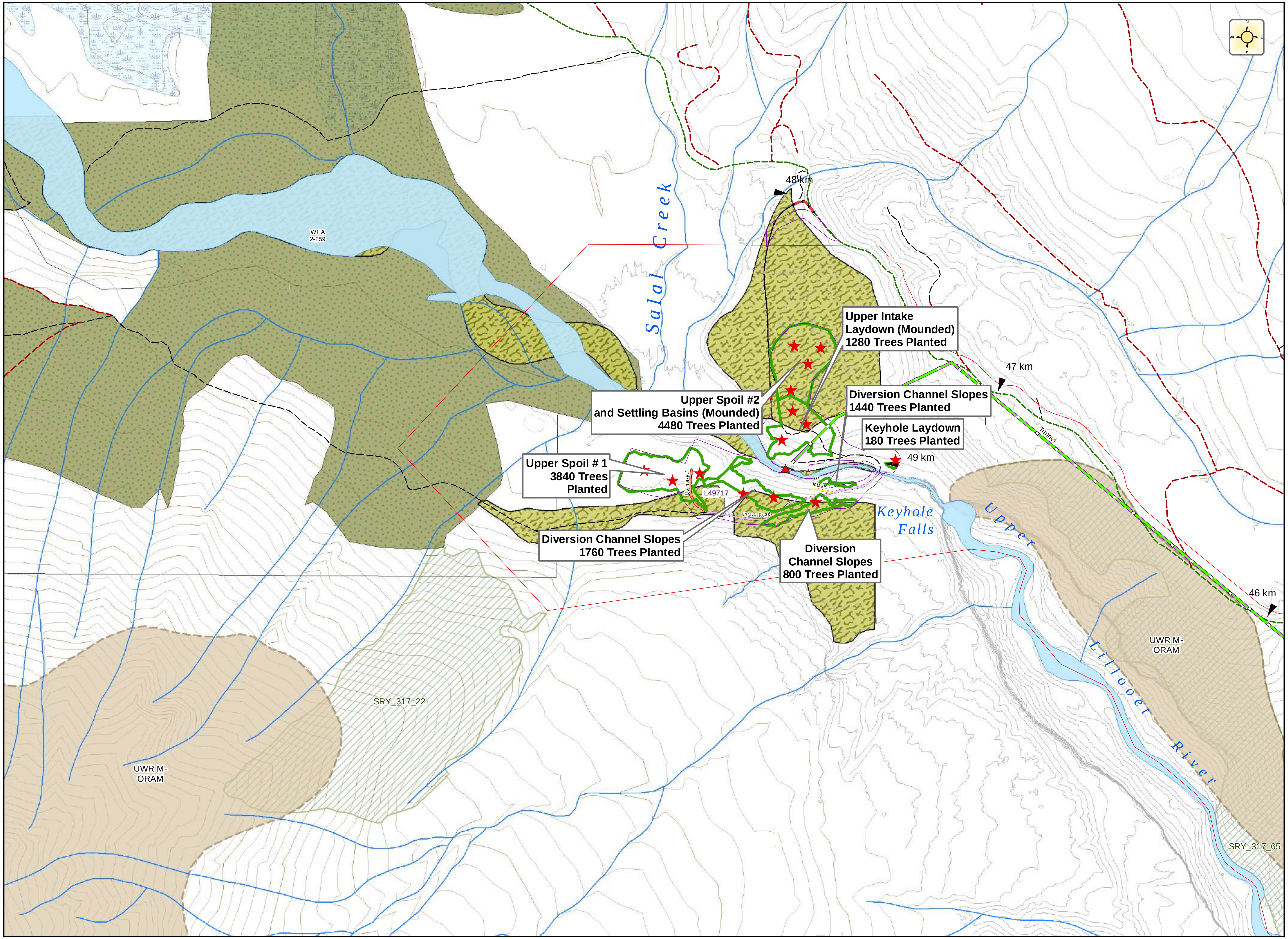
References:

Barker, S. and Staven, W. 2017. Final Revegetation Assessment for the Upper Lillooet Hydro Project. Consultant’s report prepared for Upper Lillooet River Power LP and Boulder Creek Power LP. Vancouver, BC.

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

INNERGEX

Revegetation Monitoring Year 1 (2018)



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HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

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Project No. 09-008
Base Map Source: TRIM 20K

Map: 1 of 4

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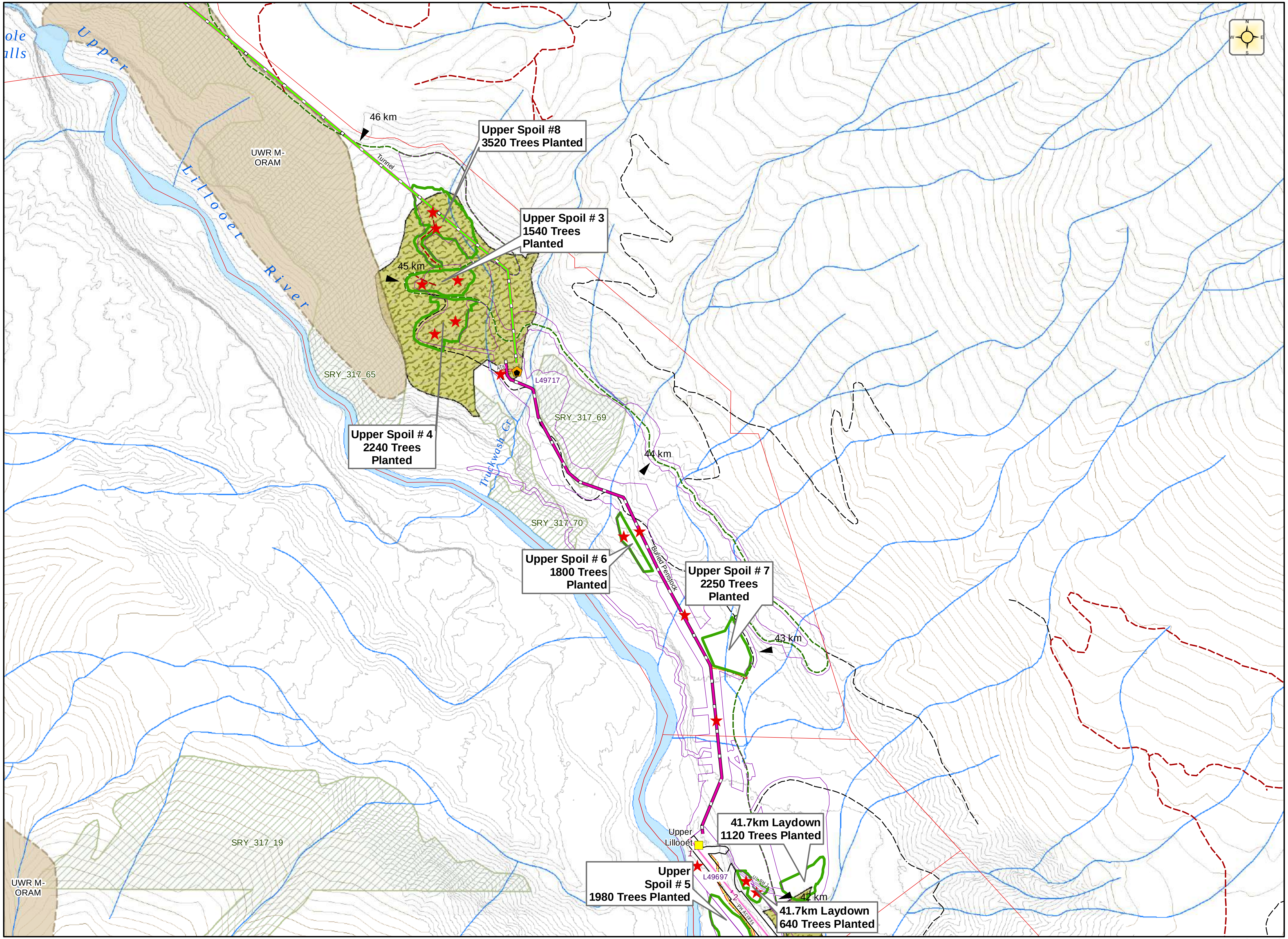

INNERGEX

Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟	Intake, Powerhouse, Tunnel Portal
73	Transmission Line and Poles (R1g Design)
★	Revegetation Plot
🟩	ULHP Revegetation Area
Ⓗ	Helipad
☐	Falling Boundary
☐	OLTC
☐	Land Tenure Boundary
- - -	Existing Road
- - -	Road Permit
- - -	Proposed Access
- - -	Forest Service Road
34 km	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

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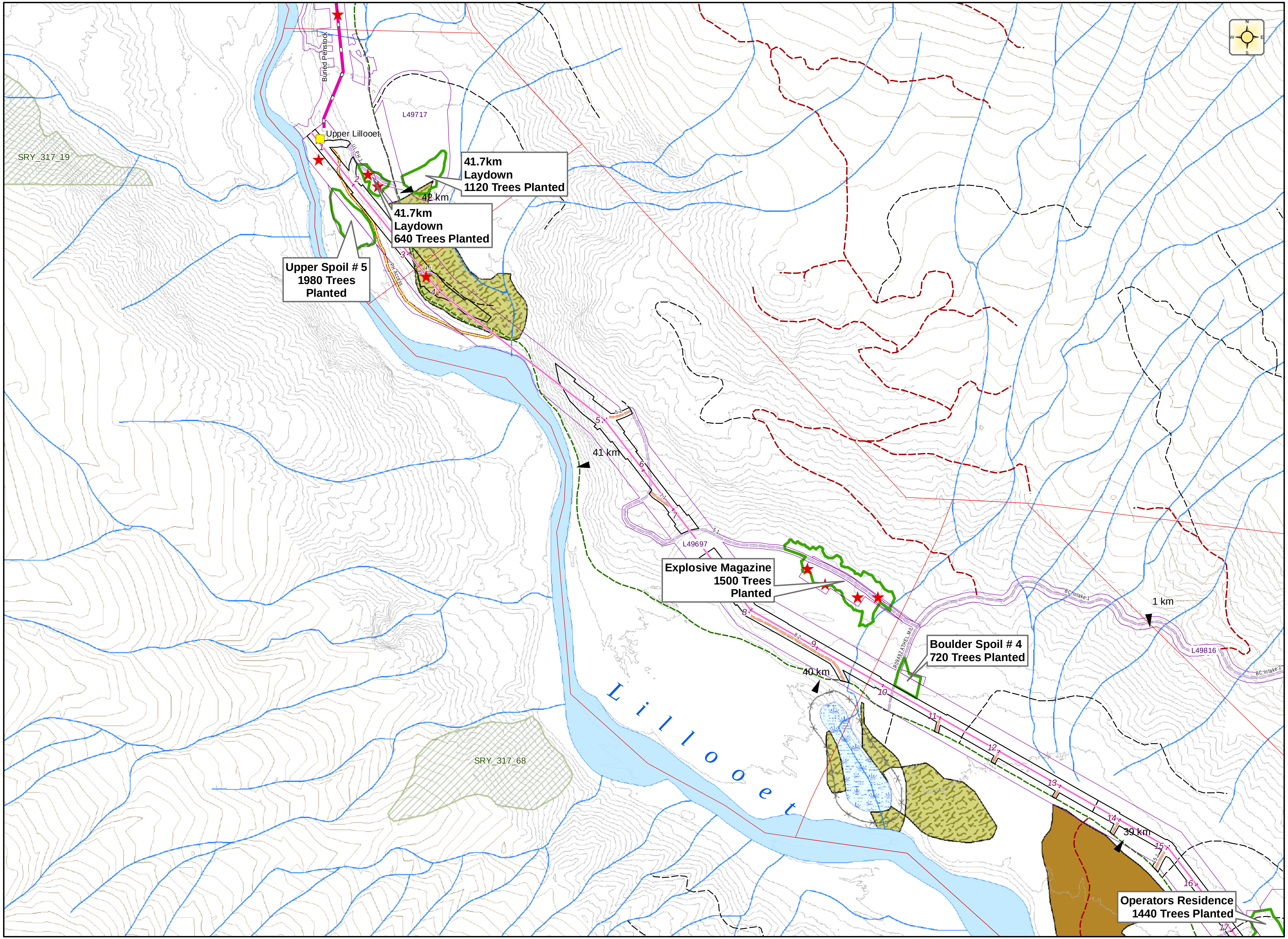

INNERGEX

Revegetation Monitoring Year 1 (2018)

- ▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
- 73 Transmission Line and Poles (R1g Design)
- ★ Revegetation Plot
- ▭ ULHP Revegetation Area
- Ⓗ Helipad
- ▭ Falling Boundary
- ▭ OLTC
- ▭ Land Tenure Boundary
- Existing Road
- Road Permit
- Proposed Access
- Forest Service Road
- 34 km Paved Road
- Highway
- ► Kilometre Sign

Access Road Type
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- Proposed Tower Road
- Upgrade Existing Road
- LiDAR (10m)
- TRIM Index Contour
- TRIM Intermediate Contour
- River, Stream
- ▭ Lake, River
- ▨ Wetland

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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
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NATURAL RESOURCE MANAGEMENT

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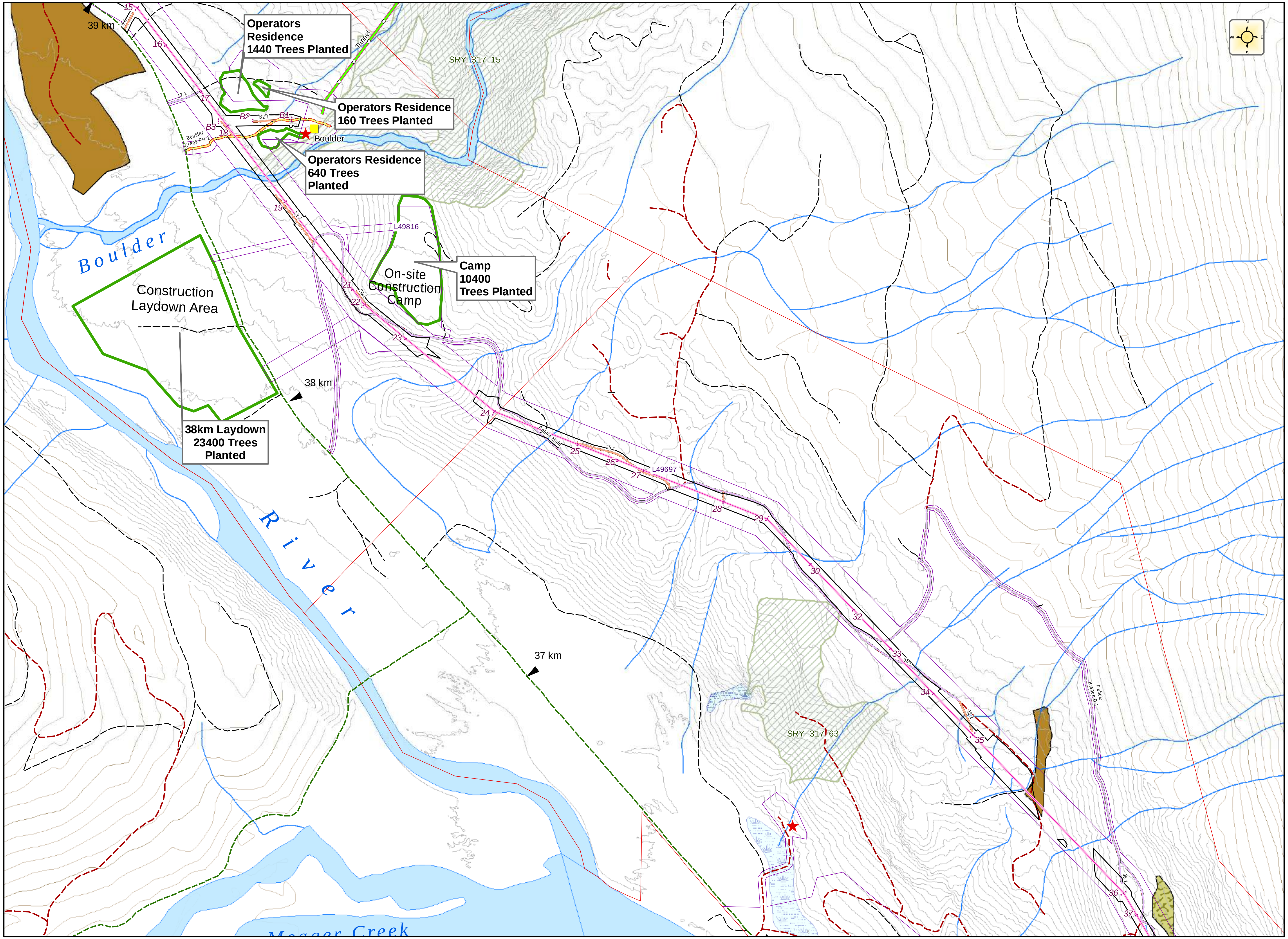

INNERGEX

Revegetation Monitoring Year 1 (2018)

▲ ■ ⬟ Intake, Powerhouse, Tunnel Portal
73 Transmission Line and Poles (R1g Design)
★ Revegetation Plot
▭ ULHP Revegetation Area
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▭ OLTC
▭ Land Tenure Boundary
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- - - Road Permit
Proposed Access
- - - Forest Service Road
34 km Paved Road
Highway
► Kilometre Sign

Access Road Type
Proposed Facility Road
Proposed Tower Road
Upgrade Existing Road
LiDAR (10m)
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Wetland

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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
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Contour Interval: 10 m LiDAR; 20m TRIM

HEDBERG ASSOCIATES
NATURAL RESOURCE MANAGEMENT

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Appendix D. Upper Lillooet Hydro Project Footprint Impact Verification

Upper Lillooet Hydro Project

Footprint Impact Verification

Prepared for:

Upper Lillooet River Power Limited Partnership
Boulder Creek Power Limited Partnership
900–1185 West Georgia Street
Vancouver, BC, V6E 4E6

May 31, 2018

Prepared by:

Ecofish Research Ltd.

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

For inquiries contact: Technical Lead documentcontrol@ecofishresearch.com 250-334-3042

Citation:

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Certification: *Certified – stamped version on file*

Senior Reviewer:

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089
Wildlife Biologist/Project Manager

Andrew Harwood, Ph.D., R.P. Bio. No. 1652
Senior Fisheries Scientist/Project Manager

Technical Lead:

Deborah Lacroix, M.Sc., R.P. Bio. No. 2089
Wildlife Biologist/Project Manager

Disclaimer:

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EXECUTIVE SUMMARY

The Project's *Fisheries Act* Authorization (FAA) (09-HPAC-PA2-00303; DFO 2014) requires that the Upper Lillooet Hydro Project (the Project) provide compensation for unavoidable fish habitat losses as a result of construction of the Project. The FAA and the Project's Operational Environmental Monitoring Plan also require a post-construction footprint impact verification report to be prepared, providing details on the quantity and quality of fish habitat losses in comparison to amounts authorized under the FAA and previously estimated for the Project's Aquatic Environmental Assessment. The revised FAA for the Project (DFO 2014) authorizes the permanent loss of 1,935 m^2 of aquatic habitat for the construction of the Upper Lillooet River Hydroelectric Facility (HEF) intake. No FAA was required for the Boulder Creek HEF.

The post-construction footprint was calculated by digitizing the overlap of permanent infrastructure and associated clearing areas, provided as georeferenced engineering drawings, with aquatic and riparian habitats in the Project area.

The total verified permanent aquatic footprint for the Upper Lillooet River HEF and the Boulder Creek HEF (1,188 m^2) is less than pre-construction estimates (2,788 m^2), the amount authorized under the FAA (1,935 m^2), and the amount created through the Alena Creek Fish Habitat Enhancement Project (FHEP) (3,194 m^2). The permanent aquatic footprint of the Upper Lillooet River HEF was verified to be 569 m^2 and was associated with construction of the intake, and excavation and riprap armouring at the tailrace. The verified permanent loss is 1,566 m^2 less than that predicted prior to construction and 1,366 m^2 less than authorized under the FAA. The permanent aquatic footprint of the Boulder Creek HEF was verified to be 619 m^2 and was associated with construction of the powerhouse and tailrace. This verified loss is 34 m^2 less than that predicted prior to construction of the Boulder Creek HEF.

The total verified permanent riparian footprint for both HEFs (29,827 m^2) is also less than the pre-construction estimate (35,607 m^2). Although the verified permanent riparian footprint is more than the amount of riparian habitat created by the Alena Creek FHEP (4,060 m^2), the revised FAA for the Project (DFO 2014) did not require offsetting for riparian habitat impacts. A total of 25,591 m^2 of riparian habitat was permanently lost due to the construction of the Upper Lillooet River HEF, which is 3,494 m^2 less than the 29,085 m^2 estimated prior to construction. For the Boulder Creek HEF, a total of 4,236 m^2 of riparian habitat was permanently lost due to construction, which is less than the 6,522 m^2 estimated prior to construction.

We conclude that the Alena Creek FHEP was sufficient in offsetting the authorized habitat losses for the Project. We also consider the footprint impact verification requirements of the OEMP (Harwood *et al.* 2018) and FAA to be complete.

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LIST OF MAPS

1. INTRODUCTION

Ecofish Research Ltd. (Ecofish) was retained by the Upper Lillooet River and Boulder Creek Power Limited Partnerships (collectively, the Partnerships) to prepare a footprint impact verification report for the Upper Lillooet Hydro Project (ULHP) (the Project), which is comprised of two hydroelectric facilities (HEFs). The largest of the two facilities, the Upper Lillooet River HEF, is located on the mainstem of the Upper Lillooet River (Watershed Code (WC): 119) while the other facility, the Boulder Creek HEF, is located on Boulder Creek (WC: 119-848100) (Map 1). Footprint impact verification consists of confirming the quantity and quality of aquatic and riparian habitat impacted by constructing Project infrastructure and ancillary components.

2. BACKGROUND AND OBJECTIVE

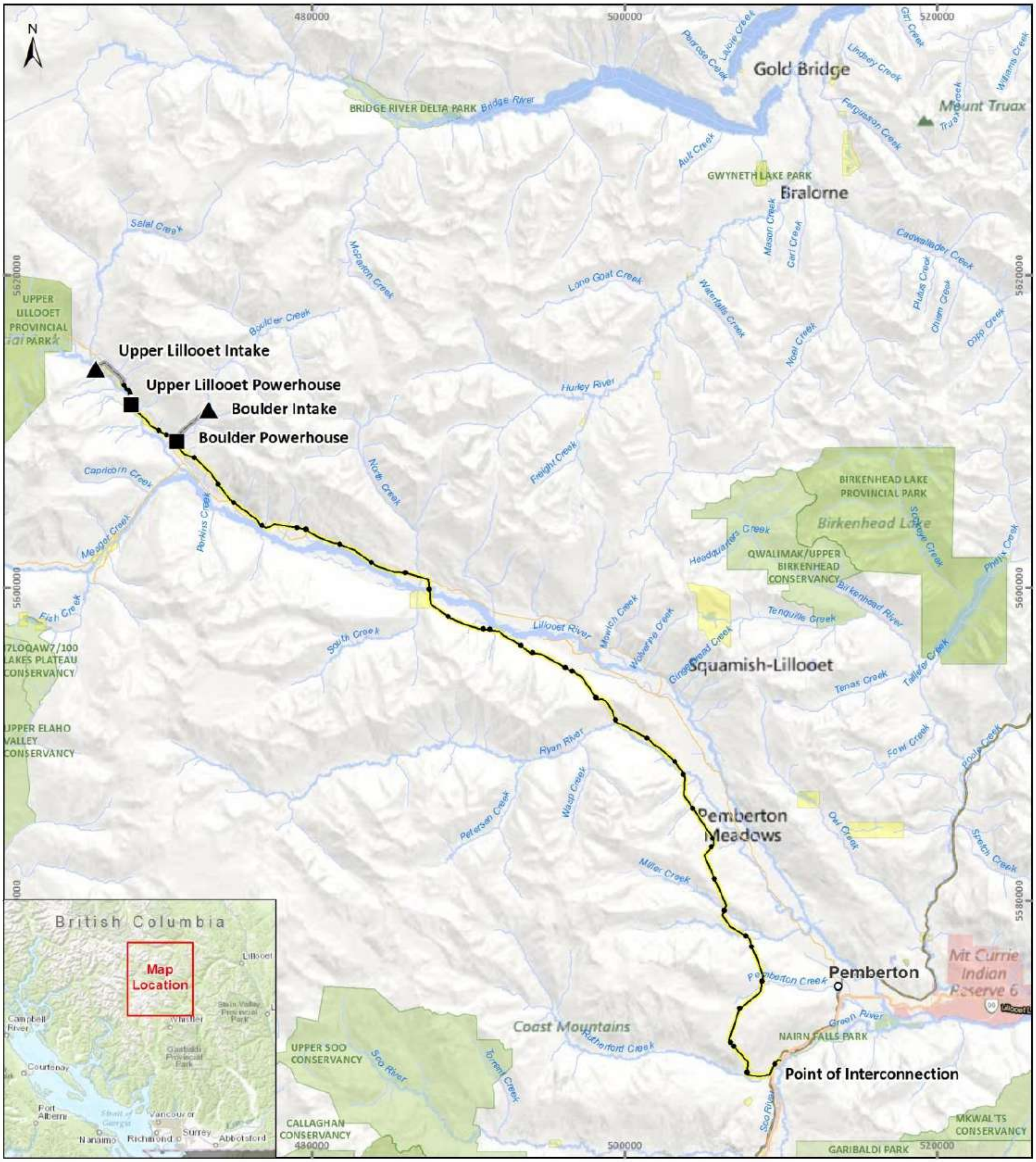
2.1. Requirements Regarding Footprint Impact Verification

The Project received an Environmental Assessment Certificate (EAC) under the BC *Environmental Assessment Act* on January 8, 2013 (#E12-01; EAO 2013) and a *Fisheries Act* Authorization (FAA) on September 26, 2013 (09-HPAC-PA2-00303; DFO 2013) which was amended on June 17, 2014 as part of the Transitional Review process (DFO 2014). Condition #9 of the Project's EAC (EAO 2013), and the Project's FAA (DFO 2013, 2014), require compensation for unavoidable fish habitat losses as a result of Project construction (i.e., HEF footprints). The Project's EAC requires that a Habitat Compensation Plan (HCP) be approved by Fisheries and Oceans Canada (DFO) (Condition #9; EAO 2013) and an Operational Environmental Monitoring Plan (OEMP) be prepared (Condition #3; EAO 2013). The Alena Creek Fish Habitat Enhancement Project (FHEP) was designed and constructed to fulfill the requirements for an HCP. The Project's OEMP requires the actual footprint impact to be measured post-construction using as-built drawings prepared by a qualified land surveyor, engineer, or other professional with experience in this work (Harwood *et al* 2018). The FAA also requires the Proponent to provide a footprint impact verification report following Project construction. The revised FAA (DFO 2014) authorizes the permanent loss of 1,935 m^2 of aquatic fish habitat resulting from the construction of the Upper Lillooet River HEF intake. No FAA was required for the Boulder Creek HEF.

2.2. Previous Footprint Calculations

The Project footprint was first predicted in the Aquatic Effects Assessment (AEA) (Lewis *et al.* 2012). Footprint predictions were later revised in Buchanan *et al.* (2013a,b) and Lacroix *et al.* (2013) to account for location, access and design changes to the Project. Buchanan *et al.* (2013a,b) classified riparian habitat losses by riparian habitat quality (i.e., climax, high, medium, and low) based on fish-bearing status and forest stand age, and distance from the water's edge, (i.e., 0-15 m, 15-30 m, and 30-50 m from the water's edge), to reflect the relative importance of riparian value (FEMAT 1993, Naiman *et al.* 2000).

Project Overview



Legend

○ Cities

ULHP Infrastructure

▲ Intake

■ Powerhouse

--- Penstock

═ Tunnel

●—● Transmission Line

— Road

🟥 First Nation Reserve

🟨 Recreational Site

🟩 Parks and Protected Areas

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 2 4 6 8 10 12 14 km

Scale: 1:350,000

NO.	DATE	REVISION	BY
1	14/04/2016	1095_ULP_ProjOverview_2014Jun26_CA	CGA
2			
3			
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Date Saved: 14/04/2016
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 1

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2.3. Objective

The objective of the footprint impact verification report is to compare the as-built footprint of the Project to fish habitat losses predicted from the preliminary design drawings and to those authorized in the FAA, and to make recommendations with regards to the potential modifications to the HCP to address residual effects, if the footprint impact verification shows that the permanent footprint was greater than the predicted amount of habitat loss used to determine habitat offset requirements required under the HCP. The quantity of habitat altered by the Project will be determined from the as-built drawings, with the quality of habitat affected determined based on the location and the pre-construction assessment of habitat quality. This report does not include the footprint of the transmission line; compliance monitoring prescribed under the OEMP will evaluate any potential footprint impacts associated with the transmission line following habitat restoration (Harwood *et al.* 2018).

The amended FAA for the Project (DFO 2014) does not include temporary aquatic or permanent riparian footprints; however, we have calculated these Project footprints and compared them with the pre-construction estimates to ensure that there has been no change in the assessment of effects (Lewis *et al.* 2012) or impacts that may alter DFO's conclusion that no FAA was required for these habitat losses.

3. METHODS

The post-construction footprint was calculated by digitizing the overlap of permanent infrastructure and associated clearing areas with aquatic and riparian habitats in the Project area.

The sources of the spatial data used to calculate the aquatic and riparian footprint are listed in Table 1. Engineered as-built drawings of Project infrastructure were completed by qualified professionals.

Table 1. Spatial data used in the footprint impact verification.

Spatial Data Component	Spatial Data Source	Date Received
Boulder Creek Intake Infrastructure	C3D-16643-BDR-IN-X-010.dwg	17-Jan-2018
Boulder Creek Powerhouse Infrastructure	C3D-16643-BDR-IN-X-010.dwg	17-Jan-2018
Boulder Creek Roads	Long_Term_Tenure_Addition.shp	29-Jan-2018
Upper Lillooet River Intake Infrastructure	C3D_ULR-IN-X-010a011.dwg	17-Jan-2018
	ULR-IN-X-010_r8 Intake General Layout AB [OR]	17-Jan-2018
Upper Lillooet River Powerhouse Infrastructure	C3D_ULR-PH-X-021A025.dwg	17-Jan-2018
	ULR-PH-X-021_r1-Tailrace Plan and View AB.pdf	17-Jan-2018
	C3D15-ULR-PH-X-010.dwg	30-Jan-2018
Upper Lillooet River Penstock	ULR-PS-final fill.shp	11-Jan-2018
Upper Lillooet River Roads	Long_Term_Tenure_Addition.shp	29-Jan-2018
	The permanent clearing boundary of the new road across Truckwash Creek was digitized from Google Earth	-
Helipads	Created 10 x 10m footprint areas around centroids from Heli_Clearing.shp	29-Jan-2018
Boulder Creek mainstem	Boulder Powerhouse - B07_194301.dwg	21-Jun-2011
	Boulder Intake - BC_Fig1.0(DRAFT).dwg	4-Oct-2013
	Boulder Intake - B03_194300.dwg	21-Jun-2011
Lillooet River Mainstem	ULL Intake and Powerhouse - FWA_RIVERS.shp	1-Mar-2013
Boulder Creek and Lillooet River tributaries	ULHP_Streams_2018_01_18.shp	19-Jan-2018

3.1. Aquatic Footprint

Permanent aquatic habitat loss is associated with the permanent removal or covering of aquatic habitat that will last for the life of the Project. Permanently impacted aquatic areas (e.g., the physical footprint of the tailrace) include both permanently and seasonally wetted aquatic habitat that are of varying quality and serve in one or more life history phases (rearing, overwintering, spawning, etc.) of an aquatic organism.

Several assumptions were used in the calculation of the permanent aquatic footprint. Table 2 compares design-related assumptions used in this report to those used in the pre-construction footprint impact predictions (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b), and Table 3 compares the methodological assumptions.

Table 2. Comparison of design-related assumptions used in the calculation of aquatic footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification.

Infrastructure	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	Verification
Headpond	Aquatic habitat losses associated with the headpond are not considered in the aquatic habitat balance but were addressed separately in the sections of the AEA addressing fish rearing and overwintering habitat, and fish spawning and incubation	No change. Moreover, not applicable for the Boulder Creek HEF FIV as this reach of Boulder Creek is non-fish-bearing.
Intake	It was assumed that at the Boulder Creek HEF intake the portion of stream located between the overflow weir and IFR pipe may become dewatered at times when flows are only released through the IFR pipe. This area was included in the Project footprint with impacts to be confirmed post-construction.	Water will be released at the Coanda through window boxes in the Coanda and by the ultrasonic flow meter, thus no portion of the stream will become dewatered, even at low flows.
Penstock	There was no permanent aquatic loss associated with any penstock tributary crossings as all penstock crossings were buried and the stream channels were rebuilt following the natural grade with native materials; thus, any aquatic habitat disruption is temporary.	No change. Further, additional sections of the water conveyance systems were built as tunnels, rather than buried penstocks as previously designed.
Powerhouse	It was assumed that there will be no temporary aquatic construction footprint associated with building the powerhouse, excluding the tailrace.	No change.
Tailrace	Excavating the connection point between the tailrace channel and the mainstem is assumed to contribute to the permanent loss of 2 m of stream bank along the width of the tailrace.	No change.
Roads	It was assumed that there will be no temporary aquatic construction footprint associated with upgrading and/or replacing existing, or pre-existing, bridges on the forestry roads. There was no permanent aquatic loss attributed to any road crossings over non-fish-bearing streams as it was assumed that well-designed culverts were installed. For fish-bearing streams, it was assumed that culverts were designed to permit free passage of fish such that there will not be a permanent aquatic loss of productive capacity; thus, any habitat disruption is temporary. It was also assumed that all culvert installation followed best management practices (BMPs): "Develop with Care 2014" (MOE 2014) and "Culverts and Fish Passage" (MOTI 2013).	No change. Further, field verified roads were defined by Long_Term_Tenure_Addition.shp .

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

Table 2. Comparison of design-related assumptions used in the calculation of aquatic footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification (continued).

Infrastructure	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	Verification
Riprap	Instream grouted riprap is assumed not to provide any fish habitat. Riprap is grouted as a key mitigation measure to prevent fish stranding. Grouted riprap is constructed by pouring grout or concrete on to the surface of the rocks, thereby securing the rocks against damage caused by high instream velocities. Some of the rock surface protrudes from the grouting; however, no space is left between rocks to provide fish habitat attributes such as cover or food (MELP 2000). Consequently, grouted riprap design accounts for 100% permanent aquatic habitat loss. Instream non-grouted riprap was assumed to account for 50% permanent aquatic habitat loss (i.e., a reduction of 50% in habitat quantity and quality). Consequently, 50% of the aquatic area of non-grouted riprap would remain as fish habitat during Project operation. The potential effects of instream riprap have not been well studied (Schmetterling *et al.* 2001). For the purposes of this assessment, we assumed that the placement of non-grouted riprap will constitute a partial aquatic habitat loss. This is because only a proportion of the area will remain as functional fish habitat.	No change.

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

Table 3. **Comparison of methods-related assumptions used in the calculation of aquatic footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification.**

Considerations	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	Verification
Channel Presence	If a site was visited as part of a field-assessment, and found to have no stream, the site was classified as "no visible channel" – NVC (MOF 1998), and was not included in the footprint calculations.	No change. In addition, non-classified drainages (NCD) were not included in the footprint calculations.
Fish presence	The fish-bearing status of tributaries was determined based on information collected from project-specific field programs, previous studies, and government databases. If no information was available, then the following stream gradient criteria were used to determine fish presence (MOF 1998): • If a stream has no downstream slope gradients >20% and flows directly into a stream, ocean or a lake known to support fish, then the stream is considered fish-bearing. • Otherwise, the stream is considered non-fish-bearing. • Gradient was calculated from Canadian Digital Elevation Data (CDED) downloaded from GeoBase. The data provided a grid cell size of 20 m. • Stream data used the 1:20,000 Freshwater Atlas Stream Network downloaded from DataBC.	No change. Further, field verified streams were defined by ULHP_Streams_2018_01_18.shp
Tributary widths	When possible, the average stream width calculated during the field riparian assessments or during other Project field work was used. Otherwise, the average channel width was estimated based on stream order. First order streams were estimated to be 2 m, second order streams to be 5 m, and third order streams to be 10 m.	No change. Further, field verified streams were defined by ULHP_Streams_2018_01_18.shp
Lillooet River and Boulder Creek Mainstems	Lillooet River Mainstem from ULL Intake and PWH - FWA_RIVERS.shp Boulder Creek Mainstem from Boulder PWH - B07_194301.dwg	No change; however, the river profile in the ULR HEF intake and powerhouse drawings was also considered in the footprint calculations.

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[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

3.2. Riparian Footprint

Permanent riparian habitat loss is associated with the permanent removal of riparian vegetation associated with Project infrastructure such as the intake, powerhouse, tailrace and switchyard and associated permanent clearing areas, due to the required construction within riparian areas.

Riparian habitat is defined as the areas within the riparian management zone (RMZ), following Section 52 of the Forest Planning and Practices Regulation, under the *Forest and Range Practices Act* (2002). In addition, riparian habitat loss was calculated by distance from the water's edge using the following categories 0 to 15 m, 15 to 30 m, and 30 to 50 m of the water's edge. This categorization was added because the relative importance of riparian value changes with the distance from the channel. For example, riparian functions such as bank stability and reduction of sediment entrainment can be achieved within half a tree length, or within 0 to 15 m of the stream (FEMAT 1993, Naiman *et al.* 2000).

Riparian habitat value was rated following the criteria described below:

1. **Low riparian habitat value**: site within the RMZ of a non-fish-bearing stream which has been previously impacted. The forest is less than 40 years old.
2. **Medium riparian habitat value**: site within the RMZ of a non-fish-bearing stream where the forest is greater than 40 years old; alternately, a site within the RMZ of a fish-bearing stream where the forest is less than 40 years old.
3. **High riparian habitat value**: site within the RMZ of a fish-bearing stream where the forest is greater than 40 years but less than 80 years old.
4. **Climax riparian habitat value**: site within the RMZ of a fish-bearing stream which has received minimal impact. The forest is typically mature or old growth, greater than 80 years old (Koning 1999).

Several assumptions were used in the calculation of permanent riparian footprint. Table 4 compares design-related assumptions used in the FIV to those used in the pre-construction footprint impact predictions (Lewis *et al.* 2012, Buchanan *et al.* 2013a,b), and Table 5 compares the methodological assumptions.

Table 4. **Comparison of design-related assumptions used in the calculation of riparian footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification.**

Infrastructure	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	Verification
Headpond	Flooding the headpond was considered to result in permanent riparian habitat loss.	Flooding the headpond was not considered to result in permanent riparian habitat loss, as vegetated areas bordering the newly flooded headpond will provide riparian functions. Moreover, the Boulder Creek HEF headpond is mostly constrained by geographic features and thus does not extend much into vegetated areas.
Penstock	The permanent penstock RoW for the Upper Lillooet River HEF was assumed to be 7.5 m, and the temporary width is 21.25 m on either side. The permanent penstock RoW for the Boulder Creek HEF and North Creek HEF was assumed to be 6 m, and the temporary width is 22 m on either side.	The permanent penstock RoW for the Upper Lillooet River HEF was defined by ULR-PS-final fill.shp. Temporary riparian habitat loss was not included in the FIV. The Boulder Creek HEF water conveyance system consisted solely of a tunnel and the North Creek HEF was not constructed.
	Two options for the Boulder Creek HEF penstock were being explored in 2012. The first option combines a tunnel with a section of buried high-pressure steel penstock, while the second option is purely a tunnel. The subsurface tunnel was assumed not to have any impacts to riparian vegetation.	A tunnel was constructed to convey diverted water from the Boulder Creek HEF intake to the powerhouse. Hence, riparian vegetation was not impacted for this infrastructure.
Powerhouse, Tailrace and Switchyard	Temporary and permanent clearing boundaries were provided in preliminary design drawings.	Permanent clearing boundaries were provided in the spatial data sources. Temporary riparian habitat loss was not included in the FIV.

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

Table 4. Comparison of design-related assumptions used in the calculation of riparian footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification (continued).

Infrastructure	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	**Verification**
Access Roads	The permanent access road RoW width was assumed to be 12 m (Staven, pers. comm. 2011) and the temporary RoW width was 4 m on either side.	Permanent access road RoWs were provided in Long_Term_Tenure_Addition.shp, with the exception of the new section of the re-aligned Upper Lillooet FSR crossing Truckwash Creek. The permanent clearing boundary, for this section of the new Upper Lillooet FSR was digitized from Google Earth imagery. Temporary riparian habitat loss was not included in the FIV.
	Temporary upgrades to existing roads in riparian areas are rehabilitated (Staven and Hedberg 2011 – Appendix C) which includes: pulling back the road prism, re-contouring the slope, replacing the overburden, and revegetation (including trees) (Staven and Hedberg 2011). No new clearing areas are anticipated from upgrades to existing roads (Staven, pers. comm. 2011). Therefore, due to the rehabilitation of permanently de-graded sites, temporary upgrades to existing roads in riparian areas have been credited with a long-term habitat gain of 12 m for the rehabilitation of the existing road.	Field verified roads were defined by Long_Term_Tenure_Addition.shp. It was assumed that no previously existing roads were rehabilitated.
	Riparian impacts have not been considered for new bridges and bridge upgrades. This is because new bridges will require new roads and upgraded bridges will occur on existing roads. Either way, riparian impacts are accounted for through road clearing areas and there are no riparian impacts from spans over wetted areas of the stream.	No change.

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

Table 4. Comparison of design-related assumptions used in the calculation of riparian footprint impacts prior to construction (Lewis *et al.* 2012, Lacroix *et al.* 2013, Buchanan *et al.* 2013a,b) and for post-construction verification (continued).

Infrastructure	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	**Verification**
Helicopter staging areas.	Helicopter staging areas are not considered in the footprint analysis as they will not occur in riparian areas (Staven and Hedberg 2011).	Helicopter staging areas were assessed to determine whether they encroached into riparian areas. Helicopter staging areas consisted of 10 x 10 m heli pads centered on point locations provided in Heli_Clearing.shp. Based on these assumptions, none of the helicopter staging areas are located in riparian areas. Hence, no change.

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b)

Table 5. Comparison of methods-related assumptions used in the calculation of riparian footprint impacts prior to construction (Lewis *et al.* 2012, Buchanan *et al.* 2013a,b) and for post-construction verification.

Considerations	Comparison of Assumptions	
	Lewis *et al.* (2012)[1]	Verification
Riparian Management Zone (RMZ)	RMZ widths varied with location and fish-bearing status: • The fish-bearing reach of Boulder Creek was afforded a 50 m RMZ; • The non-fish-bearing reach of Boulder Creek was afforded a 20 m RMZ; • The Lillooet River was afforded a 50 m RMZ above Meager Creek.	No change.
	Riparian RMZ areas for tributaries are defined as follows: • 50 m for a stream that is a 3rd order stream or greater; • 30 m if the stream is smaller than a 3rd order stream and the stream is considered fish-bearing; and • 20 m for a stream that is considered non-fish-bearing.	No change.
Riparian habitat value	Riparian habitat values were assigned based on fish presence and riparian stand age as well as distance from the stream edge.	No change.
Pre-existing infrastructure	Existing FSRs, including pre-existing bridges, were removed from riparian footprint areas. It was assumed that the existing FSR RoW is 6 m, based on the average stabilized road width tabled in the BC Ministry of Forests "Forest road engineering guidebook" (MOF 2002).	Existing FSRs, including pre-existing bridges were removed from riparian footprint areas. It was assumed that the existing FSR RoW is 12 m, based on the RoW of new Project access roads.
Level of precision	Riparian footprint areas were created by overlaying multiple layers of spatial data, each with its own limitations on accuracy. Some areas that resulted from these calculations were less than 1 m^2 and were excluded from the footprint because they represent a level of precision that is not reflective of the input data (the spatial equivalent of too many significant figures).	All polygons were included in the footprint analysis and total areas rounded to the nearest meter during summary calculations, thus polygons < 0.5 m^2 were excluded.

[1] The same assumptions were also used in Lacroix *et al.* (2013) and Buchanan *et al.* (2013a,b).

4. RESULTS

4.1. Aquatic Footprint

4.1.1. Upper Lillooet River HEF

Pre-construction estimates and verified aquatic habitat loss for the Upper Lillooet River HEF are summarized in Table 6. The Upper Lillooet River HEF's permanent aquatic footprint was verified to be 569 m^2 (Table 6) and was associated with construction of the intake and excavation and riprap armouring at the tailrace. The total verified permanent loss is 1,566 m^2 less than that predicted prior to construction (Buchanan *et al.* 2013a) and 1,366 m^2 less than authorized under the FAA (DFO 2014). The verified permanent loss of fish-bearing habitat at the intake was 469 m^2 which is 1,466 m^2 less than the pre-construction estimate. The verified permanent loss at the powerhouse and tailrace is 100 m^2 less than the pre-construction estimate. The reduction in aquatic habitat loss in comparison to the pre-construction estimate is due to intake and tailrace design changes. Figure 1, Figure 2 and Figure 3 illustrate the footprint of the Upper Lillooet River HEF during the construction period.

Table 6. Verified aquatic habitat loss by infrastructure type in comparison to the most recent pre-construction estimates for the Upper Lillooet River HEF.

Fish Bearing Status	Infrastructure	Area of Aquatic Habitat Loss (m^2)					
		Verified			Pre-construction Estimate[1]		
		Permanent	Temporary	Total	Permanent	Temporary	Total
Fish Bearing	Intake	469	-	**469**	1,935	100	**2,035**
	Penstock	-	155	**155**	-	526	**526**
	Powerhouse/Tailrace	100	-	**100**	200	-	**200**
Fish Bearing Total		*569*	*155*	***724***	*2,135*	*626*	***2,761***
Non-Fish Bearing	Penstock	-	345	**345**	-	916	**916**
	Roads	-	-	**-**	-	318	**318**
Non-Fish Bearing Total		-	*345*	***345***	-	*1,234*	***1,234***
Total		**569**	**500**	**1,069**	**2,135**	**1,860**	**3,995**

[1] Buchanan *et al.* 2013a.

Figure 1. Upper Lillooet River HEF intake during the spring/summer of 2017, following revegetation planting.

Figure 2. Upper Lillooet River HEF intake during construction, on September 22, 2016.

Figure 3. Upper Lillooet River HEF tailrace during the fall of 2016.

4.1.2. Boulder Creek HEF

Pre-construction estimates and verified aquatic habitat loss for the Boulder Creek HEF are summarized in Table 7. The permanent aquatic footprint in the fish-bearing section of Boulder Creek was verified to be 39 m^2 and was associated with construction of the powerhouse and tailrace. The verified loss is 85 m^2 less than that predicted prior to construction (Buchanan *et al.* 2013b). The verified permanent loss of non-fish bearing habitat of 580 m^2 was associated with the Boulder Creek HEF intake and was 51 m^2 more than the pre-construction estimate; nevertheless, the total permanent aquatic habitat loss associated with the Boulder Creek HEF was 34 m^2 less than predicted prior to construction (Buchanan *et al.* 2013b). The overall reduction in the aquatic footprint is due to tailrace design changes. Figure 4, Figure 5, Figure 6 and Figure 7 illustrate the footprint of the Boulder Creek HEF during the construction period.

Table 7. Verified aquatic habitat loss by infrastructure type in comparison to the most recent pre-construction estimates for the Boulder Creek HEF.

Fish Bearing Status	**Infrastructure**	**Aquatic Habitat Loss (m^2)**					
		Verified			**Pre-construction estimate[1]**		
		Permanent	**Temporary**	**Total**	**Permanent**	**Temporary**	**Total**
Fish Bearing	Powerhouse/Tailrace	39	-	**39**	124	-	**124**
Non-fish Bearing	Intake	580	-	**580**	529	406	**935**
Total		619	-	**619**	**653**	**406**	**1,059**

Buchanan *et al.* 2013b.

Figure 4. Boulder Creek HEF intake and diversion tunnel under construction, on September 7, 2016.

Figure 5. Boulder Creek HEF intake and access road, under construction on September 7, 2016.

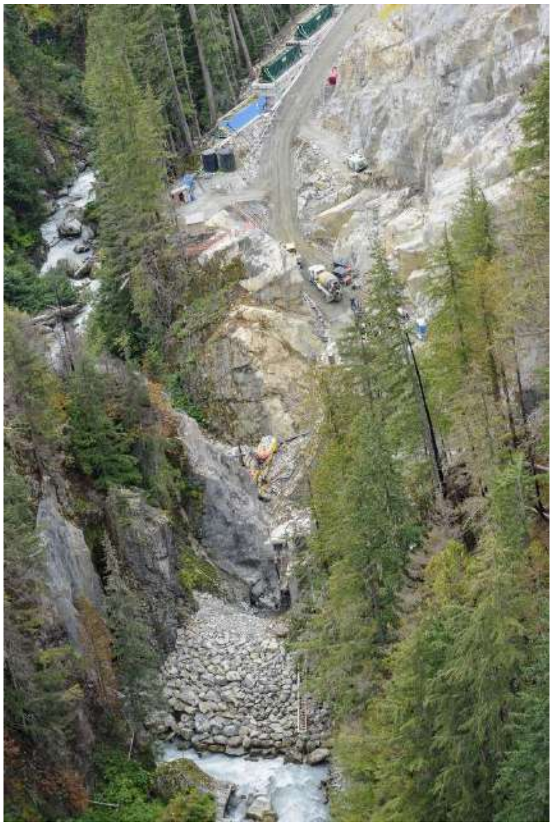

Figure 6. Boulder Creek powerhouse footprint during construction, on March 14, 2016.

Figure 7. Boulder Creek HEF tailrace in the fall of 2016, after completion.

4.2. Riparian Footprint

4.2.1. Upper Lillooet River HEF

Through the issuance of an amended FAA (DFO 2014), DFO confirmed that an authorization under the *Fisheries Act* was not required for the anticipated temporary or permanent riparian habitat loss associated with construction of the Project. Nevertheless, we have calculated the permanent riparian footprints and compared them with the pre-construction estimates to ensure that there has been no change in the assessment of effects (Lewis *et al.* 2012) or impacts that may alter DFO's conclusion that no FAA was required for riparian habitat loss.

A total of 25,591 m^2 of riparian habitat adjacent to the Upper Lillooet River was permanently lost due to construction of the Upper Lillooet River HEF (Table 8). The verified permanent riparian habitat loss was calculated to be 3,494 m^2 (12%) less than the 29,085 m^2 estimated prior to construction (Buchanan *et al* 2013a). The lower amount of verified permanent riparian habitat loss (compared to the pre-construction estimate) was a result of Project design changes that resulted in greater avoidance of impacts, primarily at the intake. A detailed breakdown of the permanent riparian habitat impacts based on riparian habitat value and distance from the water's edge (Section 3.2) is described below.

The largest proportion of verified riparian habitat loss (53%) occurred in climax value habitat for the construction of intake, penstock, powerhouse/tailrace and access roads. However, the amount of climax riparian habitat lost was 37% less than predicted during pre-construction estimates (Table 8). The verified medium value riparian habitat loss comprised 18% of the total riparian habitat loss as a result of the construction of intake, penstock and access roads. This amount was approximately 4% more than the pre-construction estimate (Table 8). The verified low value riparian habitat loss comprised 29% of the total riparian habitat loss as a result of the construction of penstock and access roads. This amount was approximately 145% more than the pre-construction estimate (Table 8). The increased loss of low value riparian habitat is associated with additional roads and road improvements required to support the construction of the Project, particularly the realignment of the Lillooet River FSR in the vicinity of Truckwash Creek (Table 8).

The largest proportions of the riparian habitat impacted (74%) were approximately equally distributed within 0 to 15 m (37%) and 30 to 50 m (37%) from the water's edge. The riparian habitat within 0 to 15 m from the water's edge is where the effect of riparian habitat on aquatic habitat is considered greatest (FEMAT 1993, Naiman *et al.* 2000). Over a quarter (17%) of the riparian habitat impacted is within 15 to 30 m of the water's edge (6,831 m^2) (Table 8), respectively. The verified footprint within 0 to 15 m from the water's edge (the most important riparian class) was approximately 9% less than the pre-construction estimate (Buchanan *et al.* 2013a).

Table 8. Verified riparian habitat loss in comparison to the pre-construction estimate, by riparian habitat value, infrastructure type and distance from the water's edge, for the Upper Lillooet River HEF.

Riparian Habitat Value	Fish Bearing	Infrastructure	Permanent Riparian Habitat Loss with the RMZ (m^2) by Distance from the Water's Edge							
			Verified				Pre-construction Estimate[1]			
			0-15 m	15-30 m	30-50 m	Total	0-15 m	15-30 m	30-50 m	Total
Climax	Yes	Intake	1,176	2,125	1,290	**4,591**	9,010	4,495	726	**14,231**
		Penstock	465	462	555	**1,482**	241	237	256	**734**
		Powerhouse/Tailrac	339	1,328	3,156	**4,823**	1,493	1,607	2,384	**5,484**
		Roads	686	512	1,559	**2,757**		71	1,165	**1,236**
Climax Total			*2,666*	*4,427*	*6,560*	***13,653***	*10,744*	*6,410*	*4,531*	***21,685***
Medium	Yes	Intake	1		-	**1**	-	-	-	**-**
		Penstock	-	53	1,361	**1,414**	-	-	78	**78**
		Roads	-	60	1,487	**1,547**	-	-	-	**-**
	No	Penstock	378	107	-	**485**	303	666	1,678	**2,647**
		Roads	893	186	-	**1,079**	695	358	593	**1,646**
Medium Total			*1,272*	*406*	*2,848*	***4,526***	*998*	*1,024*	*2,349*	***4,371***
Low	No	Penstock	846	212	-	**1,058**	458	410	612	**1,480**
		Roads	4,568	1,786	-	**6,354**	1,094	350	105	**1,549**
Low Total			*5,414*	1,998	-	***7,412***	*1,552*	*760*	*717*	***3,029***
Total			**9,352**	**6,831**	**9,408**	**25,591**	**13,294**	**8,194**	**7,597**	**29,085**

[1] Buchanan *et al.* 2013a.

4.2.2. Boulder Creek HEF

A total of 4,236 m^2 of riparian habitat was permanently lost due to the construction of the Boulder Creek HEF (Table 9). This verified permanent riparian habitat loss was calculated to be 2,286 m^2 (35%) less than the 6,522 m^2 estimated prior to construction (Buchanan *et al* 2013b). The change in penstock design to a tunnel is the primary cause of the decreased footprint in comparison to pre-construction estimates. The lower amount of verified permanent riparian habitat loss (compared to the pre-construction estimate) was a result of Project design changes that resulted in greater avoidance of impacts, primarily at the intake. A detailed breakdown of the permanent riparian habitat impacts based on riparian habitat value and distance from the water's edge (Section 3.2) is presented below.

The verified habitat loss in climax and medium value riparian habitat each comprised 40% of the total verified riparian habitat loss, due to the construction of intake, powerhouse/tailrace and access roads. The amounts of climax and medium value riparian habitat loss were 55% and 39% less than the pre-construction estimates, respectively (Table 9). The verified loss of low value riparian habitat was 855 m^2 in total, in contrast with the pre-construction estimate of 1 m^2 (Table 9). Similar to the Upper Lillooet River HEF, the increased loss of low value riparian habitat is associated with additional roads and road improvements required to support construction of the Project, in particular the new section of road that was constructed to link the previously existing road to the Boulder Creek HEF intake.

The largest proportion of the verified riparian habitat loss (40%) was within 0 to 15 m of the water's edge, which is where the effect of riparian habitat on aquatic habitat is considered greatest (FEMAT 1993, Naiman *et al.* 2000). Nevertheless, the verified loss of riparian habitat within 0 to 15 m from the water's edge was approximately 22% less than predicted during the pre-construction estimate (Buchanan *et al.* 2013b). Approximately 30% (1,257 m^2) and 28% (1,200 m^2) of the riparian habitat loss was within 15 to 30 m and 30 to 50 m of the water's edge, respectively (Table 9).

Table 9. Verified riparian habitat loss in comparison to the pre-construction estimate, by riparian habitat value, infrastructure type and distance from the water's edge, for the Boulder Creek HEF.

Riparian Habitat Value	Fish Bearing	Infrastructure	Permanent Riparian Habitat Loss with the RMZ (m^2) by Distance from the Water's Edge							
			Verified				Pre-construction estimate[1]			
			0-15 m	15-30 m	30-50 m	Total	0-15 m	15-30 m	30-50 m	Total
Climax	Yes	Penstock	-	-	-	**-**	-	197	787	**984**
		Powerhouse/Tailrace	336	709	655	**1,700**	842	747	419	**2,008**
		Roads	-	-	-	**-**	-	121	644	**765**
Climax Total			*336*	*709*	*655*	***1,700***	*842*	*1,065*	*1,850*	***3,757***
Medium	Yes	Powerhouse/Tailrace	-	41	545	**586**	-	31	686	**717**
		Roads	-	-	-	**-**	-	-	96	**96**
	No	Intake	638	76	-	**714**	1,093	234	-	**1,327**
		Roads	176	205	-	**381**	19	86	-	**105**
		Laydown Area	-	-	-	**-**	338	181	-	**519**
Medium Total			*814*	*322*	*545*	***1,681***	*1,450*	*532*	*782*	***2,764***
Low	No	Roads	629	226	-	**855**	-	-	-	**-**
		Laydown Area	-	-	-	**-**	-	1	-	**1**
Low Total			*629*	*226*	*-*	***855***	*-*	*1*	*-*	***1***
Total			**1,779**	**1,257**	**1,200**	**4,236**	**2,292**	**1,598**	**2,632**	**6,522**

[1] Buchanan *et al.* 2013b.

4.3. Habitat Compensation vs. Footprint Impact

Under the HCP, a total of 3,194 m^2 of aquatic habitat was created (e.g., Figure 8) and/or enhanced (e.g., Figure 9) as part of the Alena Creek FHEP to offset Project footprint habitat losses (West *et al.* 2017). The total aquatic habitat created and/or enhanced represents 165% of that required by the FAA (i.e., 1,935 m^2 to compensate for aquatic habitat loss at the Upper Lillooet River HEF intake) (DFO 2014), and 681% greater than the actual permanent footprint loss at the intake (469 m^2, Table 6). Additionally, the FHEP included a variety of ancillary habitat benefits that were not quantified (West *et al.* 2017). These ancillary habitat benefits are:

- More reliable upstream passage to approximately 1,300 m^2 of spawning area upstream of the enhanced Reach 3 of Alena Creek;
- Construction of Reach 3, which preserved good quality rearing habitat provided by a beaver pond and woody debris jam, while ensuring passage around these features; and
- Installation of gravel augmentation piles within the upstream extent of both enhanced reaches (Reaches 1 and 3) to replenish gravel that may be transported out of the created and enhanced areas and allow for downstream expansion of the riffle pool sequence to unenhanced areas of Alena Creek.

Finally, although the revised FAA (DFO 2014) did not require any offsetting for the Project's permanent and verified riparian footprint (29,827 m^2), the Alena Creek FHEP also restored 4,060 m^2 of riparian habitat within areas affected by the Meager Creek slide, by clearing gaps within areas of dense red alder colonization and replanting with coniferous trees (Harwood *et al.* 2016).

Figure 8. Aerial photo taken from the UAV showing the constructed channel for the Alena Creek FHEP on the left, and the retained beaver dam and pond on the right.

Figure 9. Sample screenshot from downstream (Reach 1) orthomosaic image showing riffle-pool sequence and habitat features for the Alena Creek FHEP.

5. CONCLUSIONS

The total verified permanent aquatic footprints for the Upper Lillooet River HEF (569 m^2) and the Boulder Creek HEF (619 m^2) are less than pre-construction estimates (2,135 and 653 m^2, respectively), the amount authorized under the FAA (1,935 m^2), and the amount created in the Alena Creek FHEP (3,194 m^2).

The total verified permanent riparian footprint for both HEFs (29,827 m^2) is also 16% less than the pre-construction estimate (35,607 m^2). Permanent loss of the riparian habitat within 0-15 m from the water's edge for the Project, where the potential effects of riparian vegetation on the aquatic habitat is considered the greatest, was approximately 21% less than the pre-construction estimate. Most of this reduced impact occurred in the Upper Lillooet River HEF (30% less than the pre-construction estimate) where many of the affected riparian areas were revegetated and not left treated/managed as permanent footprint. Permanent riparian habitat impacts on fish-bearing habitat for both facilities (i.e., 18,901 m^2) were approximately 28% less than the pre-construction estimates (i.e., 26,333 m^2). The revised FAA for the project (DFO 2014) did not require any offsetting for riparian habitat impacts; however, the Alena Creek FHEP restored 4,060 m^2 of riparian habitat within areas affected by the Meager Creek slide. Therefore, when considering the riparian habitat created by the Alena Creek FHEP, the overall permanent habitat loss for the entire project is 28% less than pre-construction estimates.

We conclude that the Alena Creek FHEP is sufficient in offsetting the authorized habitat losses for the Project. Therefore, the HCP does not need to be modified to address any additional verified footprint impacts resulting from the construction of the permanent infrastructure and ancillary components associated with the Project. As total aquatic and riparian footprints were less than predicted, we conclude that there has been no change in the original assessment of effects (Lewis *et al.* 2012). We also consider the footprint impact verification component of the OEMP (Harwood *et al.* 2018) and the FAA to be complete.

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Appendix E. Representative Water Quality, Water Temperature and Air Temperature Site Photographs, 2018

LIST OF FIGURES

1. UPPER LILLOOET RIVER

Figure 1. Looking upstream at ULL-USWQ02 on March 28, 2018.

Figure 2. Looking downstream at ULL-USWQ02 on March 28, 2018.

Figure 3. Looking upstream at ULL-USWQ03 on November 1, 2018.

Figure 4. Looking downstream at ULL-USWQ03 on November 1, 2018.

Figure 5. Looking upstream at ULL-USAT on March 28, 2018

Figure 6. Looking upstream at ULL-DVWQ01 on November 1, 2018.

Figure 7. Looking downstream at ULL-DVWQ01 on November 1, 2018.

Figure 8. Looking upstream at ULL-TAILWQ on November 1, 2018.

Figure 9. Looking downstream at ULL-TAILWQ on November 1, 2018.

Figure 10. Looking from RR to RL at ULL-TAILWQ on November 1, 2018.

Figure 11. Looking upstream at ULL-DSWQ on March 28, 2018.

Figure 12. Looking downstream at ULL-DSWQ on March 28, 2018.

Figure 13. Looking at ULL-DSAT on March 28, 2018.

2. BOULDER CREEK

Figure 14. Looking upstream at BDR-USWQ2 on September 24, 2018.

Figure 15. Looking downstream at BDR-USWQ2 on September 24, 2018.

Figure 16. Looking upstream at NTH-USWQ1 on September 24, 2018.

Figure 17. Looking downstream at NTH-USWQ1 on September 24, 2018.

Figure 18. Looking upstream at BDR-DVWQ on March 16, 2018.

Figure 19. Looking downstream at BDR-DVWQ on March 16, 2018.

Figure 20. Looking at BDR-DVAT location on March 16, 2018.

Figure 21. Looking upstream at BDR-TAILWQ on March 16, 2018.

Figure 22. Looking downstream at BDR-TAILWQ on March 16, 2018.

Figure 23. Looking upstream at BDR-DSWQ on March 16, 2018.

Figure 24. Looking downstream at BDR-DSWQ on March 16, 2018.

Appendix F. Water Quality Laboratory Reports

ECOFISH RESEARCH LTD
ATTN: Tera Kasubuchi
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5

Date Received: 29-MAR-18
Report Date: 06-APR-18 17:56 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L2073845

Project P.O. #: 1095-58.40.01
Job Reference: 1095-58.40.01
C of C Numbers: OL-2894
Legal Site Desc:

Shane Stack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L2073845-1	L2073845-2	L2073845-3	L2073845-4	L2073845-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	28-MAR-18	28-MAR-18	28-MAR-18	28-MAR-18	28-MAR-18
	Sampled Time	16:50	15:10	15:10	15:10	11:30
	Client ID	ULL-DSWQ-A	ULL-DVWQ01-A	ULL-DVWQ01-B	ULL-DVWQ01-C	ULL-USWQ02-A
WATER						
Physical Tests	Conductivity (uS/cm)	153	154	155	154	166
	pH (pH)	7.88	7.86	7.87	7.87	7.92
	Total Suspended Solids (mg/L)	5.0	3.7	3.5	3.5	7.5
	Total Dissolved Solids (mg/L)	107	107	111	107	112
	Turbidity (NTU)	2.29	1.52	1.65	1.68	3.19
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	43.5	44.2	43.9	44.5	44.2

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2073845-6	L2073845-7			
	Description	Water	Water			
	Sampled Date	28-MAR-18				
	Sampled Time	16:50				
	Client ID	ULL-FIELD BLANK	ULL-TRIP BLANK			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	<2.0	<2.0			
	pH (pH)	5.45	5.46			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	<10	<10			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	<1.0	<1.0			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.			
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.			
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510
Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.			
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value
This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode It is recommended that this analysis be conducted in the field.			
TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.			
TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D
This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.			
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity
This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

OL-2894

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L2073845 Report Date: 06-APR-18

Client: ECOFISH RESEARCH LTD
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5
Contact: Tera Kasubuchi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-TITR-VA	**Water**							
Batch R4004395								
WG2742451-3 CRM		**VA-ALK-TITR-CONTROL**						
Alkalinity, Total (as CaCO3)			102.1		%		85-115	03-APR-18
WG2742451-5 DUP		**L2073845-1**						
Alkalinity, Total (as CaCO3)		43.5	42.8		mg/L	1.6	20	03-APR-18
WG2742451-1 MB								
Alkalinity, Total (as CaCO3)			<1.0		mg/L		1	03-APR-18
EC-PCT-VA	**Water**							
Batch R4004395								
WG2742451-4 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			101.5		%		90-110	03-APR-18
WG2742451-5 DUP		**L2073845-1**						
Conductivity		153	152		uS/cm	0.5	10	03-APR-18
WG2742451-1 MB								
Conductivity			<2.0		uS/cm		2	03-APR-18
PH-PCT-VA	**Water**							
Batch R4004395								
WG2742451-2 CRM		**VA-PH7-BUF**						
pH			7.01		pH		6.9-7.1	03-APR-18
WG2742451-5 DUP		**L2073845-1**						
pH		7.88	7.87	J	pH	0.01	0.3	03-APR-18
TDS-VA	**Water**							
Batch R4004622								
WG2744218-2 LCS								
Total Dissolved Solids			100.3		%		85-115	03-APR-18
WG2744218-1 MB								
Total Dissolved Solids			<10		mg/L		10	03-APR-18
TSS-LOW-VA	**Water**							
Batch R4005398								
WG2744324-2 LCS								
Total Suspended Solids			99.7		%		85-115	04-APR-18
WG2744324-1 MB								
Total Suspended Solids			<1.0		mg/L		1	04-APR-18
TURBIDITY-VA	**Water**							
Batch R4000758								
WG2742757-11 CRM		**VA-FORM-40**						
Turbidity			101.3		%		85-115	31-MAR-18
WG2742757-2 CRM		**VA-FORM-40**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
TURBIDITY-VA	**Water**							
Batch R4000758								
WG2742757-2 CRM		**VA-FORM-40**						
Turbidity			101.8		%		85-115	31-MAR-18
WG2742757-5 CRM		**VA-FORM-40**						
Turbidity			101.3		%		85-115	31-MAR-18
WG2742757-8 CRM		**VA-FORM-40**						
Turbidity			101.5		%		85-115	31-MAR-18
WG2742757-1 MB								
Turbidity			<0.10		NTU		0.1	31-MAR-18
WG2742757-10 MB								
Turbidity			<0.10		NTU		0.1	31-MAR-18
WG2742757-4 MB								
Turbidity			<0.10		NTU		0.1	31-MAR-18
WG2742757-7 MB								
Turbidity			<0.10		NTU		0.1	31-MAR-18

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
pH by Meter (Automated)							
	1	28-MAR-18 16:50	03-APR-18 08:30	0.25	136	hours	EHTR-FM
	2	28-MAR-18 15:10	03-APR-18 08:30	0.25	137	hours	EHTR-FM
	3	28-MAR-18 15:10	03-APR-18 08:30	0.25	137	hours	EHTR-FM
	4	28-MAR-18 15:10	03-APR-18 08:30	0.25	137	hours	EHTR-FM
	5	28-MAR-18 11:30	03-APR-18 08:30	0.25	141	hours	EHTR-FM
	6	28-MAR-18 16:50	03-APR-18 08:30	0.25	136	hours	EHTR-FM
	7	Not provided	04-APR-18 10:45	0.25	146	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2073845 were received on 29-MAR-18 08:56.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

L2073845-COFC

COC #: OL-2894

ALS Environmental

Chain of Custody / Analytical Request

Canada Toll Free : 1 800 668 9878
www.alsglobal.com

Page 1 of 1

Report To

Company: Ecofish Research Ltd.
Contact: Tera Kasubuchi
Address: Suite F, 450 - 8th Street
Courtenay, BC
Canada, V9N 1N5
Phone: 250-334-3042
Fax: 250-897-1742

Invoice To ☑ Email ☐ Mail

Company: Ecofish Research Ltd.
Contact: Accounts Payable
Address: Suite F, 450 - 8th Street
Courtenay, BC
Canada, V9N 1N5
Email: accountspayable@ecofishresearch.com
Phone: 250-334-3042

Lab Work Order # (lab use only)

Reporting

Distribution: ☐ Fax ☐ Mail ☑ Email
☐ Criteria on Report (select from Guidelines below)
Report Type: ☐ Excel ☑ Digital
Report Format: CROSSTAB_ALSQC
Report Email(s): tjensma@ecofishresearch.com
ayeomansroutledge@ecofishresearch.com
tkasubuchi@ecofishresearch.com
EDD Format: ECF100
EDD Email(s): bbennett@ecofishresearch.com
kganshorn@ecofishresearch.com
tkasubuchi@ecofishresearch.com

Project Info

Job #: 1095-58.40.01
PO/AFE: 1095-58.40.01
LSD:
Quote #:
ALS Contact: Shane Stack
Sampler: ~~Arin Yeomans-Routledge~~ Leah Hull

Service Requested

- ● Regular (Standard Turnaround Times - Business Days) - R
- ○ Priority (3 Days) - surcharge will apply - P
- ○ Priority (2 Days) - surcharge will apply - P2
- ○ Emergency (1-2 day) – surcharge will apply - E
- ○ Same Day or Weekend Emergency - surcharge will apply - E2
- ○ Specify date required - X

Analysis Requests

Please indicate below Filtered, Preserved or both(F, P, F/P)

Sample #	Sample Identification (This will appear on the report)	Longitude	Latitude	Date	Time	Sample Type	Number of Containers	Turbidity	pH	Solids - Filterable (TDS)	Solids - Non-filterable (TSS)	Specific Conductivity	Alkalinity
	ULL-DSWQ-A			28-Mar-2018	16:50	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-~~DWWQ-A~~ DWWQ01-A			↓	15:10	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-~~DWWQ-B~~ DWWQ01-B			↓	↓	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-~~DWWQ-C~~ DWWQ01-C			↓	↓	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-~~USWQ-A~~ USWQ02-A			↓	11:30	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-FIELD BLANK			↓	16:50	Water	~~2~~ 1	R	R	R	R	R	R
	ULL-TRIP BLANK					Water	~~2~~ 1	R	R	R	R	R	R

Special Instructions/Comments

Only recieved 1 bottle per sample not 2 in cooler

The questions below must be answered for water samples (check Yes or No)

Are any sample taken from a regulated DW system? ☐ Yes ☒ No
If yes, please use an authorized drinking water COC
Is the water sampled intended to be potable for human consumption? ☐ Yes ☒ No

Guidelines

SAMPLE CONDITION (lab use only)

☐ Frozen ☐ Cold ☐ Ambient ☐ Cooling Initiated

SHIPMENT RELEASE (client use)

Released by:	Date:	Time:
Mike Marquardson	29-March 2018	7:00 am

SHIPMENT RECEPTION (lab use only)

Received by:	Date:	Time:	Temperature:
JC	MAR 2 9 2018	856am	3 °C

SHIPMENT VERIFICATION (lab use only)

Verified by:	Date:	Time:	Observations:
			☐ Yes If Yes add SIF

ECOFISH RESEARCH LTD
ATTN: Tera Kasubuchi
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5

Date Received: 02-NOV-18
Report Date: 09-NOV-18 16:26 (MT)
Version: FINAL

Client Phone: 250-334-3042

Certificate of Analysis

Lab Work Order #: L2191486

Project P.O. #: 1095-58.40
Job Reference: UPPER LILLUOET
C of C Numbers: 17-721122
Legal Site Desc:

Shane Stack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2191486-1	L2191486-2	L2191486-3	L2191486-4	L2191486-5
	Description					
	Sampled Date	01-NOV-18	01-NOV-18	01-NOV-18	01-NOV-18	01-NOV-18
	Sampled Time	10:42	12:58	14:50	14:50	14:50
	Client ID	ULL-USWQ03	ULL-DVWQ01	ULL-DSWQ-A	ULL-DSWQ-B	ULL-DSWQ-C
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	106	111	103	102	102
	pH (pH)	7.57	7.68	7.63	7.60	7.59
	Total Suspended Solids (mg/L)	8.3	7.2	7.2	7.8	7.6
	Total Dissolved Solids (mg/L)	82	85	78	80	83
	Turbidity (NTU)	9.39	5.14	7.50	6.33	6.88
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	27.0	30.0	27.9	27.2	26.7

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L2191486-6	L2191486-7			
	Sample ID	L2191486-6	L2191486-7			
	Description					
	Sampled Date	01-NOV-18				
	Sampled Time	15:16				
	Client ID	ULL-PAG-FB	ULL-TRAVEL			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	<2.0	<2.0			
	pH (pH)	5.47	5.40			
	Total Suspended Solids (mg/L)	<1.0	<1.0			
	Total Dissolved Solids (mg/L)	<10	<10			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	<1.0	<1.0			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

ALS Test Code	Matrix	Test Description	Method Reference**
EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

ALS Test Code	Matrix	Test Description	Method Reference**
TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

ALS Test Code	Matrix	Test Description	Method Reference**
TSS-LOW-VA	Water	Total Suspended Solids by Grav. (1 mg/L)	APHA 2540D

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total suspended solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.
Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.

ALS Test Code	Matrix	Test Description	Method Reference**
TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

17-721122

GLOSSARY OF REPORT TERMS
Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: ECOFISH RESEARCH LTD
Suite 906 - 595 Howe Street
Vancouver BC V6C 2T5
Contact: Tera Kasubuchi

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ALK-TITR-VA	**Water**							
Batch R4322972								
WG2922605-3 CRM		**VA-ALK-TITR-CONTROL**						
Alkalinity, Total (as CaCO3)			97.3		%		85-115	06-NOV-18
WG2922605-1 MB								
Alkalinity, Total (as CaCO3)			<1.0		mg/L		1	06-NOV-18
EC-PCT-VA	**Water**							
Batch R4322972								
WG2922605-4 CRM		**VA-EC-PCT-CONTROL**						
Conductivity			95.0		%		90-110	06-NOV-18
WG2922605-1 MB								
Conductivity			<2.0		uS/cm		2	06-NOV-18
PH-PCT-VA	**Water**							
Batch R4322972								
WG2922605-2 CRM		**VA-PH7-BUF**						
pH			7.01		pH		6.9-7.1	06-NOV-18
TDS-VA	**Water**							
Batch R4322716								
WG2923527-2 LCS								
Total Dissolved Solids			102.5		%		85-115	05-NOV-18
WG2923527-1 MB								
Total Dissolved Solids			<10		mg/L		10	05-NOV-18
TSS-LOW-VA	**Water**							
Batch R4320847								
WG2923479-2 LCS								
Total Suspended Solids			94.9		%		85-115	05-NOV-18
WG2923479-1 MB								
Total Suspended Solids			<1.0		mg/L		1	05-NOV-18
TURBIDITY-VA	**Water**							
Batch R4319627								
WG2923344-2 CRM		**VA-FORM-40**						
Turbidity			105.0		%		85-115	05-NOV-18
WG2923344-3 DUP		**L2191486-1**						
Turbidity		9.39	9.69		NTU	3.1	15	05-NOV-18
WG2923344-1 MB								
Turbidity			<0.10		NTU		0.1	05-NOV-18

Quality Control Report

Workorder: L2191486 Report Date: 09-NOV-18

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
Turbidity by Meter							
	1	01-NOV-18 10:42	05-NOV-18 14:00	3	4	days	EHT
	2	01-NOV-18 12:58	05-NOV-18 14:00	3	4	days	EHT
	3	01-NOV-18 14:50	05-NOV-18 14:00	3	4	days	EHT
	4	01-NOV-18 14:50	05-NOV-18 14:00	3	4	days	EHT
	5	01-NOV-18 14:50	05-NOV-18 14:00	3	4	days	EHT
	6	01-NOV-18 15:16	05-NOV-18 14:00	3	4	days	EHT
pH by Meter (Automated)							
	1	01-NOV-18 10:42	06-NOV-18 23:26	0.25	133	hours	EHTR-FM
	2	01-NOV-18 12:58	06-NOV-18 23:26	0.25	131	hours	EHTR-FM
	3	01-NOV-18 14:50	06-NOV-18 23:26	0.25	129	hours	EHTR-FM
	4	01-NOV-18 14:50	06-NOV-18 23:26	0.25	129	hours	EHTR-FM
	5	01-NOV-18 14:50	06-NOV-18 23:26	0.25	129	hours	EHTR-FM
	6	01-NOV-18 15:16	06-NOV-18 23:26	0.25	128	hours	EHTR-FM
	7	Not provided	06-NOV-18 23:26	0.25	108	hours	EHTR-FM

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L2191486 were received on 02-NOV-18 11:40.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2191486-COFC

COC Number: 17 - 721122

Page - of

Report To	Contact and company name below will appear on the final report	
Company:	Ecolish Research	
Contact:		
Phone:		
Company address below will appear on the final report		
Street:		
City/Province:		
Postal Code:		
Invoice To	Same as Report To	☐ YES ☐ NO
	Copy of Invoice with Report	☐ YES ☐ NO
Company:		
Contact:		

Report Form

Select Report Format: ☐ PDF ☐ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☐ YES ☐ NO

☐ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

Email 3

Invoice Distribution

Select Invoice Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax

Email 2

...low - Contact your AM to confirm all E&P TATs (surcharges may apply)

Regular [R] ☐ Standard TAT if received by 3 pm - business days - no surcharges apply

PRIORITY (Business Days)
- **4 day [P4-20%]** ☐
- **3 day [P3-25%]** ☐
- **2 day [P2-50%]** ☐

EMERGENCY
- **1 Business day [E-100%]** ☐
- **Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)]** ☐

Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm

For tests that can not be performed according to the service level selected, you will be contacted.

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

SAMPLES ON HOLD

Sample is hazardous (please provide further details)

NUMBER OF CONTAINERS

Project Information

ALS Account # / Quote #:

Job #: Upper Lillooet

PO / AFE: 1095 - 58.40

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center:

PO#

Major/Minor Code:

Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (lab use only):

ALS Contact:

Sampler:

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type
	UU-USWQ03	Nov 1, 2018	10:42	
	UU-DUWQ01	↓	12:58	
	UU-DSWQA		14:50	
	UU-DSWQB			
	UU-DSWQE	↓	↓	
	UU-PAG Field Blank	↓	15:10	

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?
☐ YES ☒ NO

Are samples for human consumption/ use?
☐ YES [✓ NO]

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐		SIF Observations	Yes ☐	No ☐
Ice Packs ☑	Ice Cubes ☐	Custody seal intact	Yes ☐	No ☐
Cooling Initiated ☑				

INITIAL COOLER TEMPERATURES °C	FINAL COOLER TEMPERATURES °C
	1

SHIPMENT RELEASE (client use)			**INITIAL SHIPMENT RECEPTION (lab use only)**			**FINAL SHIPMENT RECEPTION (lab use only)**		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by: HA	Date: 2/11	Time: 11:40am

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

JULY 2017 FRONT

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

White Paper Co. 604 951-3900

Appendix G. Water Quality Guidelines, Typical Parameter Values and Data Tables

LIST OF TABLES

1. BC WATER QUALITY GUIDELINES

Table 1. pH typical freshwater values and BC WQG (MOE 2018) for the protection of freshwater aquatic life.

Freshwater	pH (pH units)	Typical Ranges and BC Water Quality Guideline for the Protection of Aquatic Life	Reference
Typical Range	4 to 10	Natural fresh waters have a pH range from 4 to 10, lakes tend to have a pH ≥ 7.0 and coastal streams commonly have pH values of 5.5 to 6.5.	RISC 1998
BC WQG	<6.5	No statistically significant decrease in pH from background. No restriction on the increase in pH except in boggy areas that have a unique fauna or flora. Site-specific ambient water quality objectives to restrict the pH increase in areas with a unique fauna and flora are recommended.	MOE 2018
	6.5-9.0	Unrestricted change permitted within this pH range. This component of the freshwater WQGs should be used cautiously if the pH changes causes the carbon dioxide concentrations to exceed a 10 µmol/L minimum or a 1360 µmol/L short-term.	

Table 2. Total suspended solids and turbidity guidelines for the protection of aquatic life in British Columbia.

Period	British Columbia[1] Suspended Sediment and Turbidity Guidelines for the Protection of Aquatic Life	
	Total Suspended Sediments (mg/L)	Turbidity (NTU)
Clear Flow Period (< 25 mg/L or < 8 NTU)	"Induced suspended sediment concentrations should not exceed background levels by more than 25 mg/L during any 24-hour period (hourly sampling preferred). For sediment inputs that last between 24 hours and 30 days (daily sampling preferred), the average suspended sediment concentration should not exceed background by more than 5 mg/L."	"Induced turbidity should not exceed background levels by more than 8 NTU during any 24-hour period (hourly sampling preferred). For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU."
Turbid Flow Period (≥ 25 mg/L or ≤ 8 NTU)	"Induced suspended sediment concentrations should not exceed background levels by more than 10 mg/L at any time when background levels are between 25 and 100 mg/L. When background exceeds 100 mg/L, suspended sediments should not be increased by more than 10% of the measured background level at any one time."	"Induced turbidity should not exceed background levels by more than 5 NTU at any time when background turbidity is between 8 and 50 NTU. When background exceeds 50 NTU, turbidity should not be increased by more than 10% of the measured background level at any one time."

[1] reproduced from Singleton (2001)

Table 3. Dissolved oxygen guidelines for the protection of aquatic life in British Columbia.

BC Guidelines for the Protection of Aquatic Life[1]			
	Life Stages Other Than Buried Embryo/Alevin	**Buried Embryo/Alevin[2]**	**Buried Embryo/Alevin[2]**
Dissolved Oxygen Concentration	Water column mg/L O_2	Water column mg/L O_2	Interstitial Water mg/L O_2
Instantaneous minimum[3]	5	9	6
30-day mean[4]	8	11	8

[1] MOE (1997a) and MOE (1997b)

[2] For the buried embryo / alevin life stages these are in-stream concentrations from spawning to the point of yolk sac absorption or 30 days post-hatch for fish; the water column concentrations recommended to achieve interstitial dissolved oxygen values when the latter are unavailable. Interstitial oxygen measurements would supersede water column measurements in comparing to criteria.

[3] The instantaneous minimum level is to be maintained at all times.

[4] The mean is based on at least five approximately evenly spaced samples. If a diurnal cycle exists in the water body, measurements should be taken when oxygen levels are lowest (usually early morning).

Table 4. Total gas pressure BC WQG for the protection of aquatic life (MOE 2018).

Water Depth	Water Use	Maximum Allowable ΔP (Excess Gas Pressure) for the Protection of Aquatic Life in BC[1]
> 1 m	Freshwater	76 mm Hg regardless of pO_2 levels
< 1 m	Shallow Water/Hatchery Environments	24 mm Hg is the most conservative form (assuming water column depth = 0 m)[2]
All depths	Background Levels Higher than BC WQG	No increase in ΔP or %TGP

[1] Adapted from Fidler and Miller (1994) and BC WQG Summary Report (MOE 2018).

[2] Derived from equation: $\Delta P_{\text{initiation of swim bladder overinflation}} = 73.89 * \text{water depth (m)} + 0.15 * pO_2$, where $pO_2 = 157$ mm Hg (i.e., sea level, normoxic condition) (Fidler and Miller 1994).

2. BASELINE (2010-2012) AND OPERATIONAL (2018) WATER QUALITY MONITORING RESULTS.

Table 5. Summary of general water quality parameters measured *in-situ* from 2010 to 2012 (baseline) and 2018 (Year 1).

Year	Date	Site	pH				Specific Conductivity (µS/cm)				Water Temperature (°C)				Air Temperature (°C)			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2010	26-Apr	ULL-USWQ	7.06	-	-	-	101.7	101.0	103.0	1.2	2.1	2.1	2.1	0.0	6.2	6.2	6.3	0.0
		ULL-DVWQ	7.09	-	-	-	97.0	96.0	98.0	1.0	2.9	2.9	2.9	0.0	8.4	8.4	8.5	0.1
	12-Sep	ULL-USWQ	6.66	6.66	6.66	0.00	101.0	99.0	103.0	2.0	5.3	5.2	5.3	0.1	6.3	6.3	6.3	0.0
		ULL-DVWQ	6.95	6.94	6.95	0.01	53.7	52.0	55.0	1.5	4.9	4.9	4.9	0.0	8.3	8.3	8.3	0.0
	12-Nov	ULL-USWQ	7.96	7.96	7.96	0.00	116.7	116.0	117.0	0.6	3.0	3.0	3.0	0.0	4.4	4.4	4.4	0.0
		ULL-DVWQ	8.28	8.28	8.28	0.00	102.3	102.0	103.0	0.6	2.5	2.5	2.5	0.0	-	-	-	-
2011	25-Feb	ULL-USWQ1	6.07	6.05	6.09	0.02	150.7	149.0	153.0	2.1	0.1	0.1	0.1	0.0	-2.0	-2.0	-2.0	0.0
		ULL-DVWQ	6.94	6.93	6.96	0.02	165.3	164.0	166.0	1.2	0.3	0.3	0.3	0.0	-2.1	-2.1	-2.1	0.0
	1-Oct	ULL-USWQ1	5.82	5.77	5.86	0.05	43.7	43.0	44.0	0.6	5.7	5.7	5.7	0.0	10.9	10.9	10.9	0.0
		ULL-DVWQ	7.11	-	-	-	48.7	48.0	50.0	1.2	6.2	6.2	6.2	0.0	10.7	10.7	10.7	0.0
	19-Nov	ULL-USWQ1	5.38	-	-	-	117.3	117.0	118.0	0.6	0.0	0.0	0.0	0.0	-17.0	-17.0	-17.0	0.0
		ULL-DVWQ	-	-	-	-	104.7	104.0	105.0	0.6	0.0	0.0	0.0	0.0	-11.0	-11.0	-11.0	0.0
2012	27-Feb	ULL-USWQ1	6.41	6.38	6.43	0.03	132.0	129.0	136.0	3.6	0.0	0.0	0.0	0.0	-18.3	-19.0	-18.0	0.6
		ULL-DVWQ	7.56	7.56	7.57	0.01	148.0	148.0	148.0	0.0	0.4	0.4	0.4	0.0	-1.0	-1.0	-1.0	0.0
	27-Apr	ULL-USWQ	-	-	-	-	98.3	98.0	99.0	0.6	3.8	3.8	3.8	0.0	8.0	8.0	8.0	0.0
		ULL-DVWQ	-	-	-	-	83.0	83.0	83.0	0.0	3.1	3.1	3.1	0.0	7.5	7.5	7.5	0.0
2018	28-Mar	ULL-USWQ02	7.98	7.95	8.00	0.03	170.4	170.2	170.5	0.2	2.9	2.8	2.9	0.1	-	-	-	-
	29-Mar	ULL-DVWQ01	-	-	-	-	-	-	-	-	3.3	3.3	3.4	0.1	2.9	2.9	2.9	0.0
		ULL-TAILWQ	-	-	-	-	160.0	-	-	-	5.9	5.9	5.9	0.0	2.9	2.9	2.9	0.0
		ULL-DSWQ	-	-	-	-	160.0	160.0	160.0	0.0	4.6	4.6	4.6	0.0	3.5	3.5	3.5	0.0
	01-Nov	ULL-USWQ03	6.68	6.56	6.76	0.10	115.5	115.4	115.6	0.1	3.9	3.9	3.9	0.0	4.0	4.0	4.0	0.0
		ULL-DVWQ01	7.39	7.34	7.43	0.05	119.4	119.3	119.5	0.1	5.2	5.2	5.2	0.0	5.0	5.0	5.0	0.0
		ULL-TAILWQ	7.27	7.24	7.29	0.03	109.3	109.0	109.4	0.2	4.1	4.1	4.1	0.0	-	-	-	-
		ULL-DSWQ	7.35	7.35	7.36	0.01	111.3	111.3	111.4	0.1	4.5	4.5	4.6	0.1	6.0	6.0	6.0	0.0

[1] Average of three replicate measurements (n=3), unless otherwise indicated. A single entry indicates n=1. A "-" indicates data were not available due to equipment malfunction or failure due to cold temperatures. pH and specific conductivity were also measured in the laboratory.

Table 6. Summary of general water quality parameters measured ALS Environmental from 2010 to 2012 (baseline) and 2018 (Year 1).

Year	Date	Site	pH pH units				Specific Conductivity (µS/cm)				Total Suspended Solids (mg/L)				Turbidity (NTU)				Total Alkalinity (as $CaCO_3$) (mg/L)			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2010	26-Apr	ULL-USWQ	7.73	7.71	7.74	0.02	-	-	-	-	6.2	5.7	6.4	0.4	7.41	7.30	7.55	0.13	-	-	-	-
		ULL-DVWQ	7.76	7.75	7.77	0.01	-	-	-	-	10.2	8.4	12.4	2.0	6.40	6.30	6.48	0.09	-	-	-	-
	12-Sep	ULL-USWQ	7.50	7.48	7.51	0.02	57.9	56.9	59.1	1.1	48.4	43.3	57.3	7.7	33.30	31.20	35.00	1.93	15.1	14.9	15.3	0.2
		ULL-DVWQ	7.51	7.50	7.52	0.01	52.5	52.5	52.6	0.1	40.0	37.3	42.0	2.4	32.40	31.50	33.70	1.15	14.1	14.1	14.1	0.0
	12-Nov	ULL-USWQ	7.33	7.23	7.40	0.09	-	-	-	-	<3.1	<3.0	3.1	0.1	2.48	2.43	2.54	0.06	-	-	-	-
		ULL-DVWQ	7.54	7.52	7.55	0.02	-	-	-	-	3.5	3.1	4.4	0.8	2.26	2.14	2.37	0.12	-	-	-	-
2011	25-Feb	ULL-USWQ1	7.64	7.63	7.66	0.02	151.7	151.0	152.0	0.6	8.0	3.8	14.8	6.0	1.68	1.59	1.84	0.14	36.1	34.4	38.7	2.3
		ULL-DVWQ	7.87	7.85	7.89	0.02	164.7	163.0	166.0	1.5	7.5	6.8	7.8	0.6	1.94	1.72	2.09	0.19	44.9	44.7	45.0	0.2
	1-Oct	ULL-USWQ1	7.57	7.57	7.57	0.00	55.4	55.4	55.5	0.1	41.1	38.0	46.7	4.8	50.30	49.10	51.70	1.31	14.3	14.0	14.7	0.4
		ULL-DVWQ	7.62	7.62	7.63	0.01	63.2	63.1	63.3	0.1	57.8	53.3	66.0	7.1	69.47	69.20	69.60	0.23	16.0	15.8	16.3	0.3
	19-Nov	ULL-USWQ1	7.81	7.75	7.84	0.05	-	-	-	-	12.0	11.3	13.3	1.15	4.18	3.94	4.45	0.26	-	-	-	-
		ULL-DVWQ	7.93	7.91	7.96	0.03	134.0	-	-	-	16.2	11.3	19.3	4.29	5.84	5.64	6.03	0.20	34.7	-	-	-
2012	27-Feb	ULL-USWQ1	7.85	7.85	7.86	0.01	-	-	-	-	<3.0	<3.0	<3.0	0.00	1.88	1.78	1.98	0.10	-	-	-	-
		ULL-DVWQ	7.99	7.98	7.99	0.01	160.0	-	-	-	4.2	3.3	4.7	0.81	2.80	2.44	3.07	0.32	44.8	-	-	-
	27-Apr	ULL-USWQ	7.87	7.71	8.06	0.18	-	-	-	-	25.6	24.7	26.7	1.03	11.47	11.40	11.60	0.12	-	-	-	-
		ULL-DVWQ	7.62	7.57	7.67	0.05	84.9	-	-	-	40.9	40.0	42.0	1.01	14.00	13.90	14.10	0.10	23.1	-	-	-
2018	28-Mar	ULL-USWQ02	7.92	-	-	-	166.0	-	-	-	7.5	-	-	-	3.19	-	-	-	44.2	-	-	-
		ULL-DVWQ01	7.87	7.86	7.87	0.01	154.3	154.0	155.0	0.58	3.6	3.5	3.7	0.12	1.62	1.52	1.68	0.09	44.2	43.9	44.5	0.3
		ULL-DSWQ	7.88	-	-	-	153.0	-	-	-	5.0	-	-	-	2.29	-	-	-	43.5	-	-	-
	01-Nov	ULL-USWQ03	7.57	-	-	-	106.0	-	-	-	8.3	-	-	-	9.39	-	-	-	27.0	-	-	-
		ULL-DVWQ01	7.68	-	-	-	111.0	-	-	-	7.2	-	-	-	5.14	-	-	-	30.0	-	-	-
		ULL-DSWQ	7.61	7.59	7.63	0.02	102.3	102.0	103.0	0.58	7.5	7.2	7.8	0.31	6.90	6.33	7.50	0.59	27.3	26.7	27.9	0.6

[1] Average of three replicates (n=3) on each date unless otherwise indicated. A single value listed under Avg. indicates n=1. Parameters that have a concentration below the detection limit are assumed to have a concentration equal to the detection limit for calculation purposes. A "-" indicates data were not available or not required to meet QA/QC objectives.

Table 7. Summary of dissolved gas water quality parameters measured *in-situ* from 2010 to 2012 (baseline) and 2018 (Year 1).

Year	Date	Site	Dissolved Oxygen (mg/L)				Dissolved Oxygen (% saturation)				TGP (mm Hg)				Barometric Pressure (mm Hg)				TGP (%)				Δ P (mm Hg)			
			Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD	Avg[1]	Min	Max	SD
2010	26-Apr	ULL-USWQ	13.79	13.77	13.82	0.03	99.9	99.7	100.1	0.2	700	700	700	0	699	699	699	0	100	100	100	0	1	1	1	0
		ULL-DVWQ	14.08	14.06	14.10	0.02	104.4	104.3	104.6	0.2	731	730	731	1	715	714	715	1	102	102	102	0	16	15	17	1
	12-Sep	ULL-USWQ	12.55	12.53	12.57	0.02	99.1	98.7	99.3	0.3	700	700	700	0	706	706	706	0	99	99	99	0	-6	-6	-6	0
		ULL-DVWQ	13.90	13.90	13.91	0.01	108.5	108.4	108.6	0.1	722	721	723	1	722	722	722	0	100	100	100	0	0	-1	1	1
	12-Nov	ULL-USWQ	13.56	13.55	13.57	0.01	100.9	100.9	100.9	0.0	712	712	712	0	719	719	719	0	99	99	99	0	-7	-7	-7	0
		ULL-DVWQ	14.62	14.61	14.62	0.01	107.1	107.0	107.1	0.1	734	733	734	1	734	734	734	0	100	100	100	0	0	-1	0	1
2011	25-Feb	ULL-USWQ1	14.21	14.19	14.25	0.03	97.4	97.1	97.7	0.3	711	711	711	0	705	704	705	1	101	101	101	0	6	6	7	1
		ULL-DVWQ	13.92	13.91	13.93	0.01	96.1	96.0	96.3	0.2	734	734	734	0	723	722	723	1	102	102	102	0	11	11	12	1
	1-Oct	ULL-USWQ1	11.60	11.58	11.61	0.02	92.4	92.3	92.4	0.1	700	700	700	0	693	692	693	1	101	101	101	0	7	7	8	1
		ULL-DVWQ	11.86	11.86	11.86	0.00	95.9	95.9	96.0	0.1	733	732	734	1	711	710	712	1	103	103	103	0	22	22	23	1
	19-Nov	ULL-USWQ1	12.42	12.40	12.45	0.03	85.1	85.0	85.2	0.1	704	704	704	0	702	702	702	0	100	100	100	0	2	2	2	0
		ULL-DVWQ	12.78	12.75	12.80	0.03	87.6	87.4	87.8	0.2	733	733	733	0	716	716	716	0	102	102	102	0	17	17	17	0
2012	27-Feb	ULL-USWQ1	13.41	13.37	13.46	0.05	91.8	91.4	92.2	0.4	709	709	709	0	710	710	710	0	100	100	100	0	-1	-1	-1	0
		ULL-DVWQ	11.26	11.25	11.27	0.01	77.9	77.8	77.9	0.1	733	733	733	0	724	724	724	0	101	101	101	0	9	9	9	0
	27-Apr	ULL-USWQ	13.40	13.38	13.41	0.02	101.8	101.7	101.8	0.1	722	722	722	0	705	705	706	1	102	102	102	0	17	16	17	1
		ULL-DVWQ	14.16	14.16	14.16	0.00	105.6	105.6	105.7	0.1	741	741	741	0	723	722	723	1	103	102	103	1	18	18	19	1
2018	28-Mar	ULL-USWQ02	-	-	-	-	-	-	-	-	701	700	701	1	103	102	103	1	718	716	719	2	17	16	18	1
	29-Mar	ULL-DVWQ01	-	-	-	-	-	-	-	-	715	715	715	0	103	103	103	0	733	733	733	0	18	18	18	0
		ULL-TAILWQ	-	-	-	-	-	-	-	-	716	715	717	1	102	102	102	0	731	731	731	0	15	14	16	1
		ULL-DSWQ	-	-	-	-	-	-	-	-	717	717	718	1	102	102	102	0	733	733	733	0	16	15	16	1
	01-Nov	ULL-USWQ03	11.57	11.56	11.58	0.01	88.1	87.9	88.3	0.2	704	704	705	1	101	101	102	1	713	711	714	2	9	7	10	2
		ULL-DVWQ01	11.45	11.41	11.49	0.04	90.2	89.7	90.6	0.5	718	717	720	2	103	102	103	1	737	737	737	0	19	17	20	2
		ULL-TAILWQ	11.50	11.43	11.62	0.11	88.0	87.3	89.0	0.9	718	718	719	1	102	102	102	0	733	731	735	2	15	13	17	2
		ULL-DSWQ	11.50	11.40	11.62	0.11	89.0	88.3	90.1	0.9	719	719	720	1	101	100	101	1	725	723	726	2	5	3	7	2

[1] Average of three replicate measurements (n=3), unless otherwise indicated. A single entry indicates n=1. A "-" indicates data were not available due to equipment malfunction or failure due to cold temperatures. pH and specific conductivity were also measured in the laboratory.

Grey shading indicates that readings are suspect due to cold air temperatures resulting in meter issues.

3. QUALITY ASSURANCE AND QUALITY CONTROL – 2018 (YEAR 1)

Table 8. Hold time exceedance table 2018.

Year	Date	Site	Hold Time Exceedances			
			Parameter	Recommended Hold Time	Actual Hold Time	Qualifier
2018	1-Nov	ULL-USWQ03	Turbidity	3 days	4 days	EHT
		ULL-DVWQ01		3 days	4 days	EHT
		ULL-DSWQ		3 days	4 days	EHT

Hold time exceedances apply to all replicates for each site unless otherwise indicated. The hold time for pH is 15 min. and is therefore exceeded for all samples on all dates.

ALS Legend & Qualifier Definitions

EHT: Exceeded ALS recommended hold time prior to analysis.

Table 9. Triplicate precision QA/QC exceedances.

Date	Site	Parameter	Relative Standard Deviation (%)
1-Nov-2018	ULL-DSWQ	ΔP	39

QA/QC objective: relative standard deviation (RSD) <18 %.

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

UPPER LILLOOET HYDRO PROJECT

STANDARD OPERATING PROCEDURE

Harlequin Duck Spot Check Protocol

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1. INTRODUCTION

Harlequin Duck spot checks are a requirement of the Upper Lillooet Hydro Project (the Project) Operational Environmental Monitoring Plan. Spot checks are intended to record the presence or absence of Harlequin Ducks and any evidence of successful breeding in the Project area. Spot checks are scans that are conducted from specific vantage points and at specific times during the Harlequin Duck breeding season. It is important to record some information every time a spot check is conducted, even if no Harlequin Ducks are observed. Timing, locations, and methods of spot checks should be consistent so that annual results are comparable.

2. SPOT CHECK METHODS

Specific methods should be followed for each spot check to keep data comparable. The methods to be followed are:

- Always conduct spot checks from the same vantage point for each Location ID (Table 1).
- Conduct a thorough scan of the visible area from the vantage point using binoculars and/or a spotting scope. Note that female Harlequin Ducks and juveniles are much less conspicuous than males and extra effort is required to spot them. Pay close attention to riparian areas where ducks may be partly concealed in overhanging riparian vegetation and scan exposed instream rocks where birds may haul out. Due to their brownish colour, females that are hauled out on rocks may blend in and can be difficult to see. Foraging birds may be diving in which case they will be underwater part of the time thus several scans of the water are required.

2.1. Locations

Spot checks will be conducted at the intake and powerhouse to focus on the locations where Harlequin Ducks were observed during baseline studies. Harlequin Ducks were also observed approximately 600 m upstream of the powerhouse, incidentally during baseline data collection for other monitoring components; however, this area is not visible from an easily accessible vantage point so observations in this area will continue to be collected incidentally when Ecofish crews download the logger and conduct potential fish stranding searches in this area. Spot checks should always take place from the same vantage points, and any deviation in methodology must be recorded. Each location has a label (ID) that should be entered into the “Location” field of the datasheet (Table 2). Each Location ID is associated with UTM coordinates. Spot check locations were flagged in May 2018 and are described below.

- Harlequin Ducks will be monitored from one of two vantage points at the intake to capture potential activity in the headpond as well as slightly upstream and downstream (ULL-HADU01a, ULL-HADU01b; Table 1, Figure 2). The vantage point at ULL-HADU01a is accessible early in the season when snow prohibits safe access to potential vantage points closer to the river. The vantage point at ULL-HADU01b is only accessible when snow does not prevent safe access. When monitoring from ULL-HADU01b it is recommended that the surveyor walk out onto the intake for the best view.

- Harlequin Ducks will be monitored from a vantage point at the powerhouse to capture potential activity near the tailrace as well as slightly upstream and downstream (NST-HADU02; Table 1, Figure 3).

Table 1. Harlequin Duck monitoring points at the intake.

Infrastructure	Location ID	UTM Coordinates (Zone 10U)		Description
		Easting	Northing	
Intake	ULL-HADU01a	466156	5614170	Above the road at the intake. To be used when snow prevents access to ULL-HADU01b.
	ULL-HADU01b	466105	5614110	Adjacent to the intake fence. To be used when accessible. To get the best view, walk out onto the intake from here when safe.
Powerhouse	ULL-HADU02	468416	5611634	On the boulders immediately downstream of the powerhouse.

Figure 1. View of ULL-HADU01a on April 30, 2018.

Figure 2. View of ULL-HADU01b on May 31, 2018.

Figure 3. View of ULL-HADU02 on May 3, 2018.

2.2. Timing

There are two time periods that are most valuable for conducting spot checks. These are:

1) the pre-incubation period (month of May), when Harlequin Duck pairs are on the river but before the female begins to incubate. Once incubation begins the male leaves and the female becomes secretive; and
2) the brood-rearing period (late July to late August) after ducklings hatch, adult males have departed, and the female is rearing her brood. At this time family groups, as well as females that have not bred successfully, can be seen on the river.

Spot checks will be scheduled to occur during these two time periods. Each time a spot check is conducted, the date and time will be recorded on the datasheet (Table 2).

2.2.1. Pre-incubation (May)

- Three spot checks will be conducted at each location during May; spot checks should be at least five days apart.

2.2.2. Brood-rearing (August 1 – August 30)

- Three spot checks will be conducted at each location from August 1 through to August 30; spot checks should be at least five days apart, with two of the spot checks occurring between August 1 and August 15.

2.3. What to Record

All required information listed below must be recorded on the Harlequin Duck spot check survey datasheet (Table 2) every time a spot check is conducted, regardless of what is seen. Please review the **Harlequin Duck Fact Sheet** for important information on identification and species biology.

Information that must be recorded includes:

- Date of the spot check.
- Time of the spot check.
- Initials of the person(s) conducting the spot check.
- Location of the spot check (specify the Location ID).
- The total number of Harlequin Ducks seen, including “0” if none were seen (enter in “Total Number” field in the datasheet). The numbers of each sex/age category should be entered into the appropriate fields of the datasheet. Including the total numbers of:
  - adult males;
  - adult female-like birds (note that juveniles are hard to distinguish from adult females and are therefore included in this group);
  - ducklings (smaller than adults early in the brood-rearing period); and
  - individuals of unknown sex (cannot be identified as adult males or adult female-like birds, and are not ducklings that can be distinguished by size).

- Record comments in the "Comments" column of the datasheet for every spot check:
    - if no Harlequin Ducks are seen, state this in words;
    - pair(s) (male and female close together) or family group (for example: a female with three female-like birds that may be juveniles based on their proximity and synchronous behaviour);
    - other species (e.g., American Dippers, mergansers, Barrow's Goldeneye); and
    - visibility limitations (e.g., due to poor weather, or if the water level in the river is unusually high or low.
- Take photos of all Harlequin Ducks and other wildlife observaed and record photo numbers in the appropriate field of the data sheet.

2.4. Equipment Required

Equipment required for spot check includes:

- Clipboard with datasheets and Harlequin Duck Fact Sheet.
- Binoculars and/or spotting scope.
- Digital Camera.

Table 2. Harlequin Duck spot check datasheet.

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

Date	Time	Location[1]	Total Number[2]	Number of Adult Males	Number of female-like[3]	Number of Ducklings	Number of Unknown Sex	Comments (describe behaviour and other observations of interest such as weather conditions and other species observed)[4]	Photo Number	Observer Initials

[1] Location ID as described in Spot Check Protocols. If location is different, note at UTM or mark on a map.

[2] Indicate zero if no Harlequin Ducks are seen.

[3] Includes adult females and large juveniles that look like adult females.

[4] Describe behaviour (e.g., feeding, preening, hauled out on rocks, flying upstream or downstream) and wether birds are behaving as a group (e.g., "feeding together; appear to be a pair"); note any other observations of interest such as other riverine species (e.g., American Dippers); any limitations on survey methods (e.g., poor visibility due to poor weather) or unusual conditions (e.g., water levels very high). Include some comments for every spot check.

3. HARLEQUIN DUCK FACT SHEET

3.1. Physical Description

Male

- Dark from a distance, white streaks and colourful patches can be seen closer up;
- Slate blue plumage and belly, chestnut sides and streaks of white on the head and body; and
- Crown has a black stripe with a larger white patch in front of the eye and a small white ear patch.

Female

- Plain brownish-grey with lighter underside;
- The face in front of the eye is light in colour and has distinctive white ear patch; and
- Roughly half the size of a Mallard duck.

Immature

- After hatching, ducklings can be distinguished by their small size relative to the adult female;
- When larger but while still on the breeding stream, juveniles of both sexes resemble the adult female; and
- Young males begin to look like adults in fall, but they do not gain full adult plumage until the next summer.

3.2. Life History

- Arrive on breeding streams shortly after spring break-up;
- Females lay 3-10 eggs that hatch after approximately one month;

- Males leave the breeding stream once the female begins to incubate;
- Females and their young return to the coast together in late September; and
- Individuals often return to the same breeding site year after year.

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

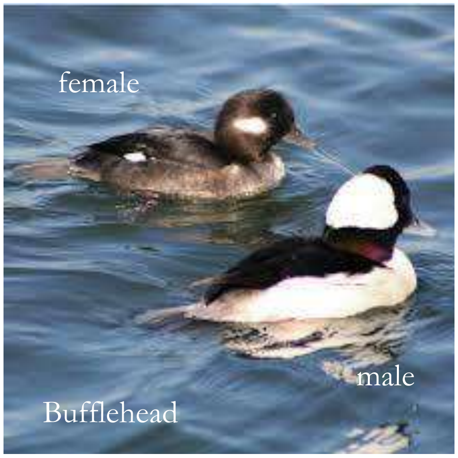
- Can be distinguished from Harlequin Ducks by their black and with bodies, and dark green heads with a single white spot near the bill.

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 I. Riparian Revegetation Permanent Monitoring Site Photographs, 2018

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Figure 2. View north through ULL-PRM01 plot centre from 3 m south of plot centre on September 7, 2018.

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Figure 7. View north through ULL-PRM06 plot centre from 3 m south of plot centre on September 6, 2018.

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Figure 9. View north through ULL-PRM08 plot centre from 3 m south of plot centre on September 6, 2018.

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2. ULL-PRM01

Figure 3. Representative site photo taken at 154° from ULL-PRM01 on September 7, 2018.

Figure 4. Representative site photo taken 270° from ULL-PRM01 plot centre on September 7, 2018.

3. ULL-PRM02

Figure 5. **Representative site photo taken at 64° from ULL-PRM02 on September 7, 2018.**

Figure 6. **Looking upstream at the dam from ULL-PRM02 on September 7, 2018.**

4. ULL-PRM03

Figure 7. Representative site photo taken at 144° from ULL-PRM03 on September 6, 2018.

Figure 8. Representative site photo taken 270° from ULL-PRM03 plot centre on September 6, 2018.

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Figure 9. Representative site photo taken at 164° from ULL-PRM04 on September 7, 2018.

Figure 10. Representative site photo taken 90° from ULL-PRM04 plot centre on September 7, 2018.

6. ULL-PRM05

Figure 11. Representative site photo taken at 312° from ULL-PRM05 on September 7, 2018.

Figure 12. Representative site photo taken 180° from ULL-PRM05 plot centre on September 7, 2018.

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Figure 13. Representative site photo taken at 104° from ULL-PRM06 on September 6, 2018.

Figure 14. Representative site photo taken 90° from ULL-PRM06 plot centre on September 6, 2018.

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Figure 15. Representative site photo taken at 270° from ULL-PRM07 on September 6, 2018.

Figure 16. Representative site photo taken 90° from ULL-PRM07 plot centre on September 6, 2018.

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Figure 17. Representative site photo taken at 222° from ULL-PRM08 on September 6, 2018.

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Figure 20. Representative site photo taken from edge of stream at ULL-PRM09 on September 6, 2018.

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Figure 21. Representative site photo taken at 86° from ULL-PRM10 on September 6, 2018.

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Figure 23. Representative site photo taken at 88° from ULL-PRM11 on September 6, 2018.

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Appendix K. Habitat Summaries and Representative Photographs of Closed-Site Electrofishing Sites

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Table 1. **Summary of habitat, cover, and substrate at closed-site electrofishing sites in the diversion and upstream reaches of the Upper Lillooet River in 2018.**

Reach	Site	Habitat	Cover[1]		Substrate (%)[2]						Gradient (%)
			Dom.	Sub. Dom.	BR	BO	CO	LG	SG	F	
Diversion	ULL-DVEF02b	Riffle	BO	CO	0	25	30	10	10	25	2.0
	ULL-DVEF04	Run	BO	CO	0	35	20	5	5	35	1.0
	ULL-DVEF05	Run	BO	CO	0	25	20	5	5	45	1.5
	ULL-DVEF06	Riffle	BO	CO	0	30	5	15	20	30	3.0
	ULL-DVEF07b	Riffle	BO	CO	0	7	8	20	25	40	2.0
Upstream	ULL-USEF01	Riffle	BO	CO	0	20	35	5	5	35	1.0
	ULL-USEF02b	Riffle	CO	BO	0	2	60	15	3	20	1.0
	ULL-USEF03	Riffle	CO	n/a	0	0	55	9	1	35	1.0
	ULL-USEF06	Riffle	CO	BO	0	5	50	5	5	35	1.0
	ULL-USEF07	Glide	CO	BO	0	35	55	5	3	2	1.0
	ULL-USEF10	Riffle	CO	BO	0	25	50	5	5	15	2.0
	ULL-USEF11	Riffle	CO	BO	0	25	45	0	0	30	1.0
	ULL-USEF12	Riffle	LWD	BO	0	25	30	15	10	20	1.0
	ULL-USEF13	Riffle	CO	BO	0	5	35	5	5	50	1.0
	ULL-USEF14	Riffle	CO	BO	0	10	60	5	5	20	2.5

[1] Cover Codes: Dom. = Dominant, Sub-Dom. = sub-dominant, BO = boulder, CO = cobble, LWD = Large woody debris.

[2] F = fine (<2 mm), SG = small gravel (2 - 16 mm), LG = large gravel (16 - 64 mm), CO = cobble (64 - 256 mm), BO = boulder (256-4,000 mm), and BR = bedrock (>4,000 mm).

Figure 1. Looking upstream at ULL-DVEF02b on March 24, 2018.

Figure 2. Looking downstream at ULL-DVEF02b on March 24, 2018.

Figure 3. Looking upstream at ULL-DVEF04 on March 24, 2018.

Figure 4. Looking downstream at ULL-DVEF04 on March 24, 2018.

Figure 5. Looking upstream at ULL-DVEF05 on March 24, 2018.

Figure 6. Looking downstream at ULL-DVEF05 on March 24, 2018.

Figure 7. Looking upstream at ULL-DVEF06 on March 24, 2018.

Figure 8. Looking downstream at ULL-DVEF06 on March 24, 2018.

Figure 9. Looking upstream at ULL-DVEF07b on March 24, 2018.

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Figure 11. Looking upstream at ULL-USEF01 on March 26, 2018.

Figure 12. Looking downstream at ULL-USEF01 on March 26, 2018.

Figure 13. **Looking upstream at ULL-USEF02b on March 26, 2018.**

Figure 14. **Looking downstream at ULL-USEF02b on March 26, 2018.**

Figure 15. Looking upstream at ULL-USEF03 on March 26, 2018.

Figure 16. Looking downstream at ULL-USEF03 on March 26, 2018.

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Figure 18. Looking downstream at ULL-USEF06 on March 25, 2018.

Figure 19. Looking upstream at ULL-USEF07 on March 25, 2018.

Figure 20. Looking downstream at ULL-USEF07 on March 25, 2018.

Figure 21. Looking upstream at ULL-USEF10 on March 26, 2018.

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Figure 23. Looking upstream at ULL-USEF11 on March 27, 2018.

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Appendix L. Closed-Site Electrofishing Fish Aging Figures and Individual Fish Data

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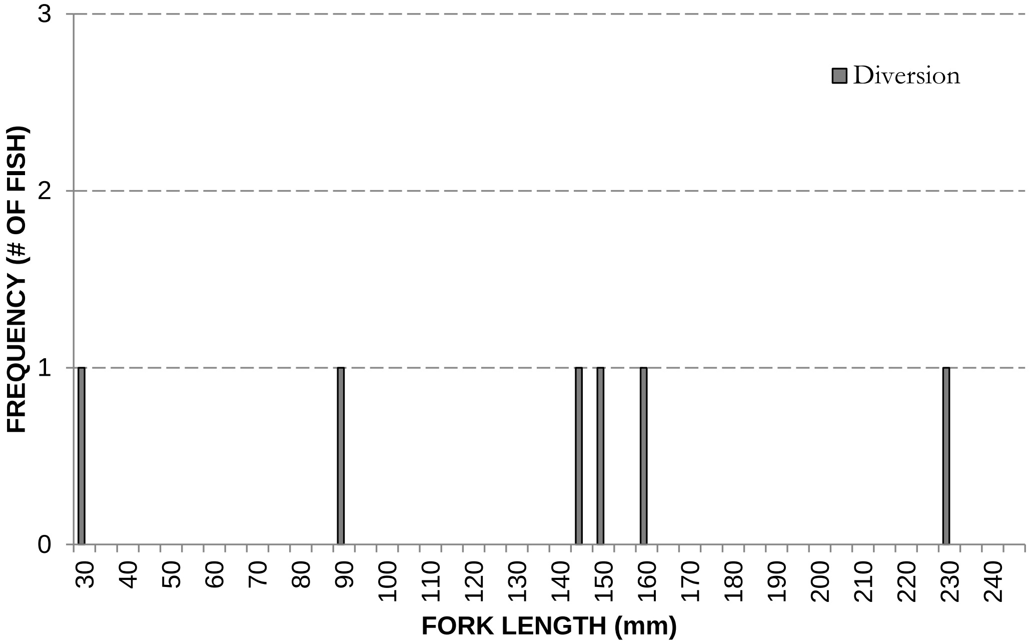

Figure 2. **Length-weight regression of Bull Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.**

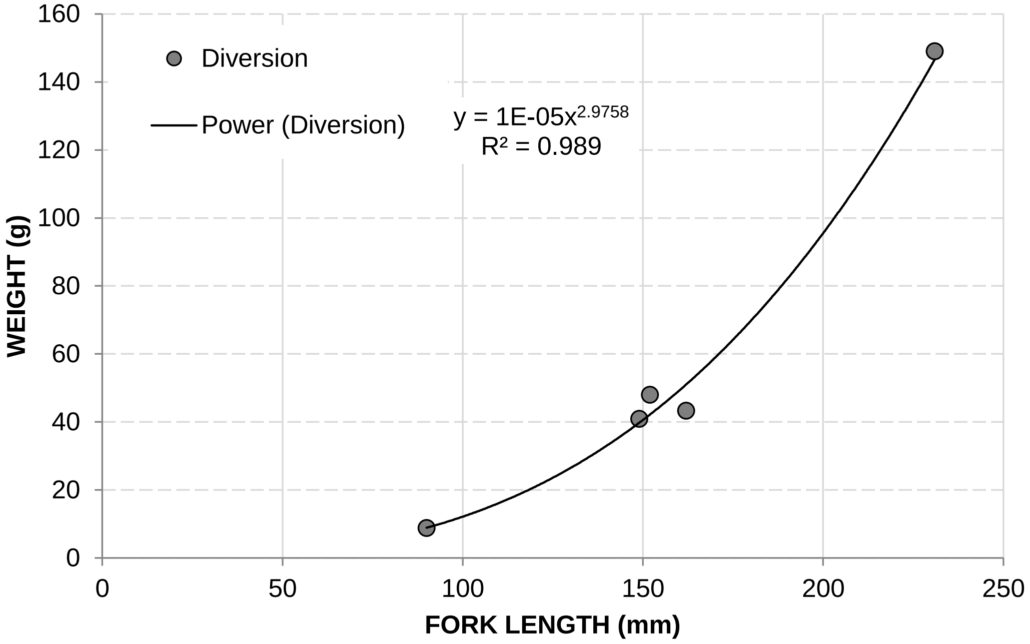

Figure 3. Length-frequency of Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.

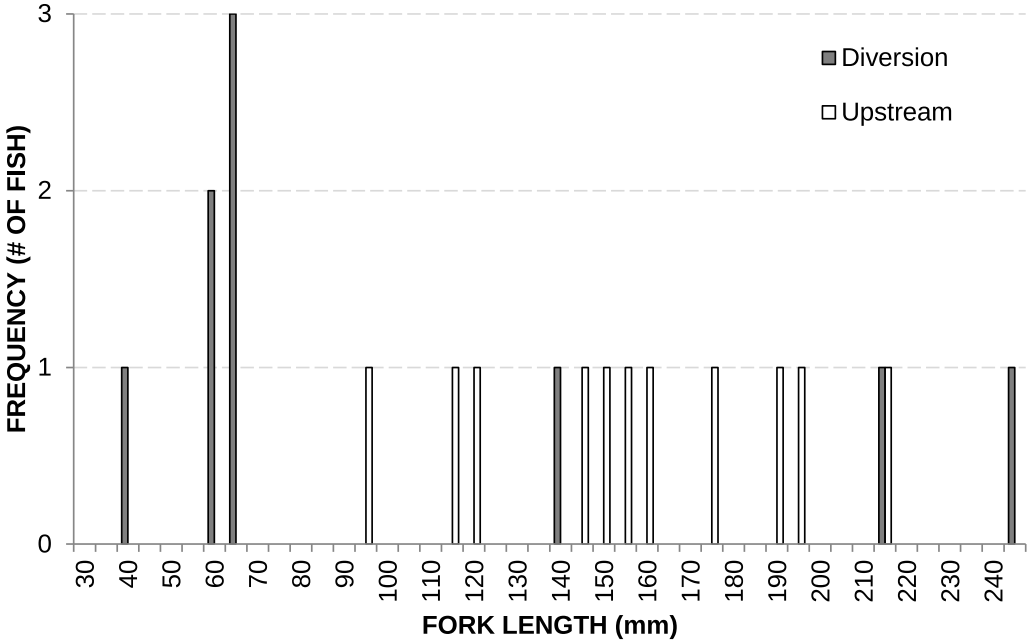

Figure 4. Length-weight regression of Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.

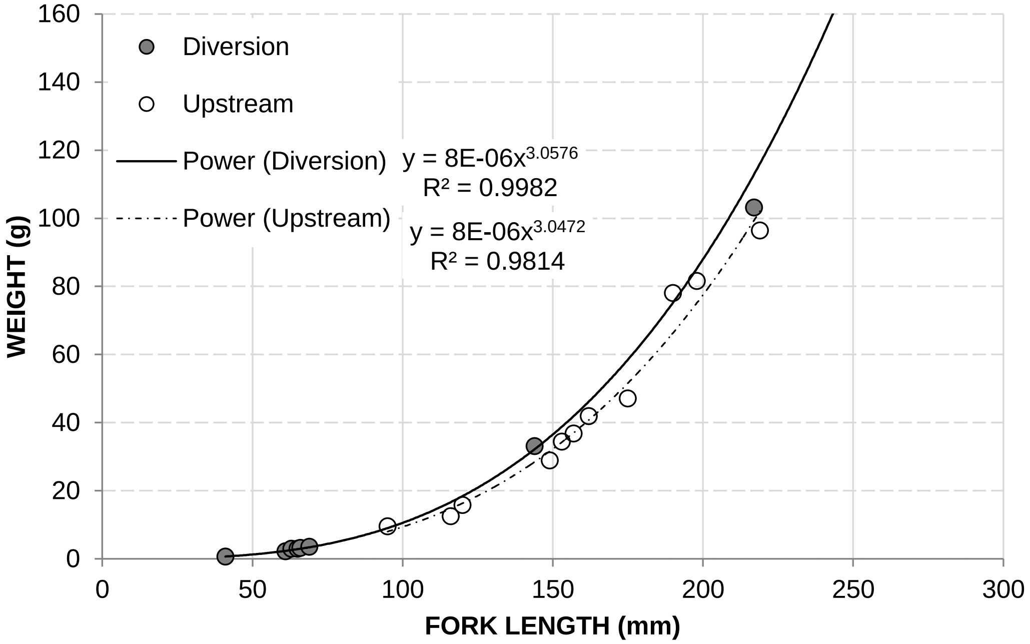

Figure 5. **Length at age relationship for Cutthroat Trout captured during closed-site electrofishing in the Upper Lillooet River in 2018.**

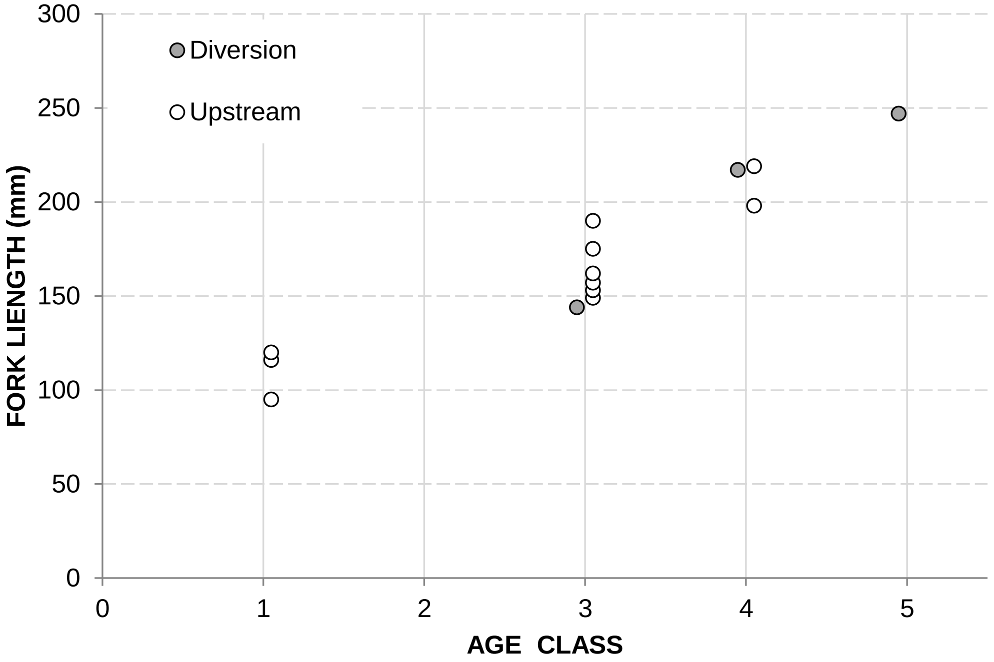

Figure 6. **Length-frequency of Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2018.**

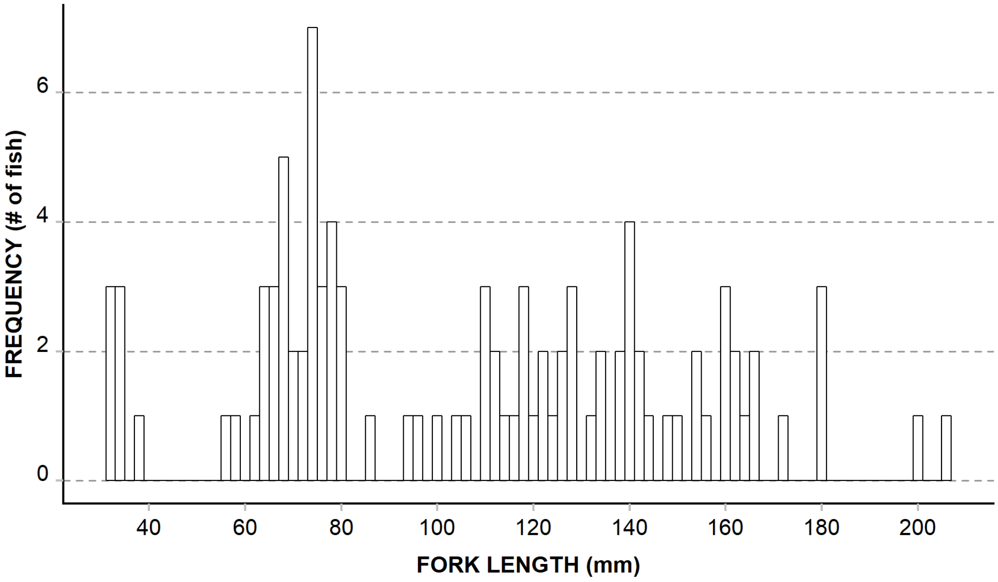

Figure 7. Length-weight regression for Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2018.

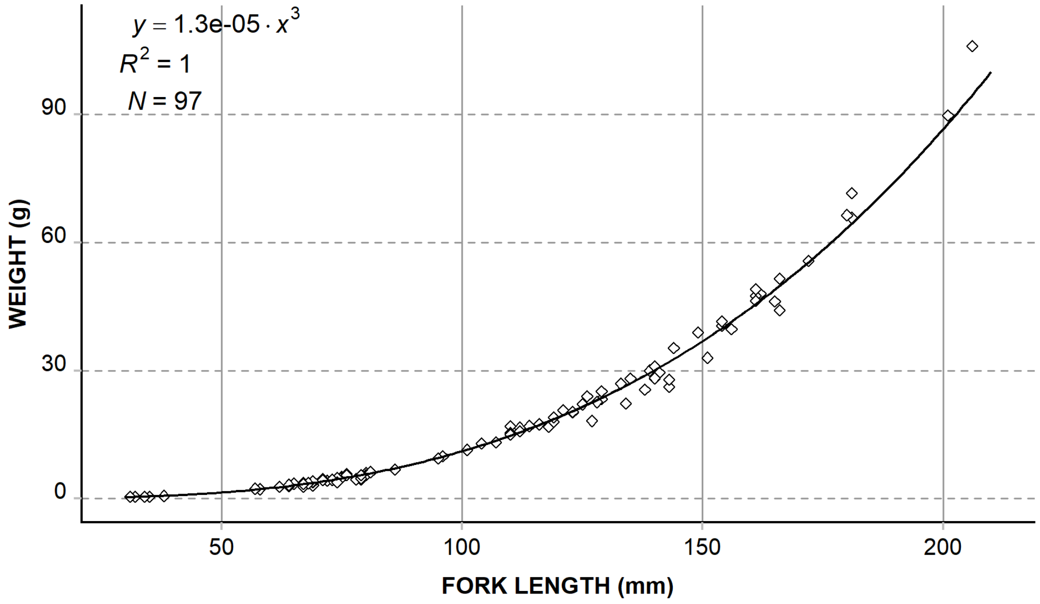

Figure 8. Length at age relationship for Cutthroat Trout captured during closed-site electrofishing in 87.0 km Tributary in 2018.

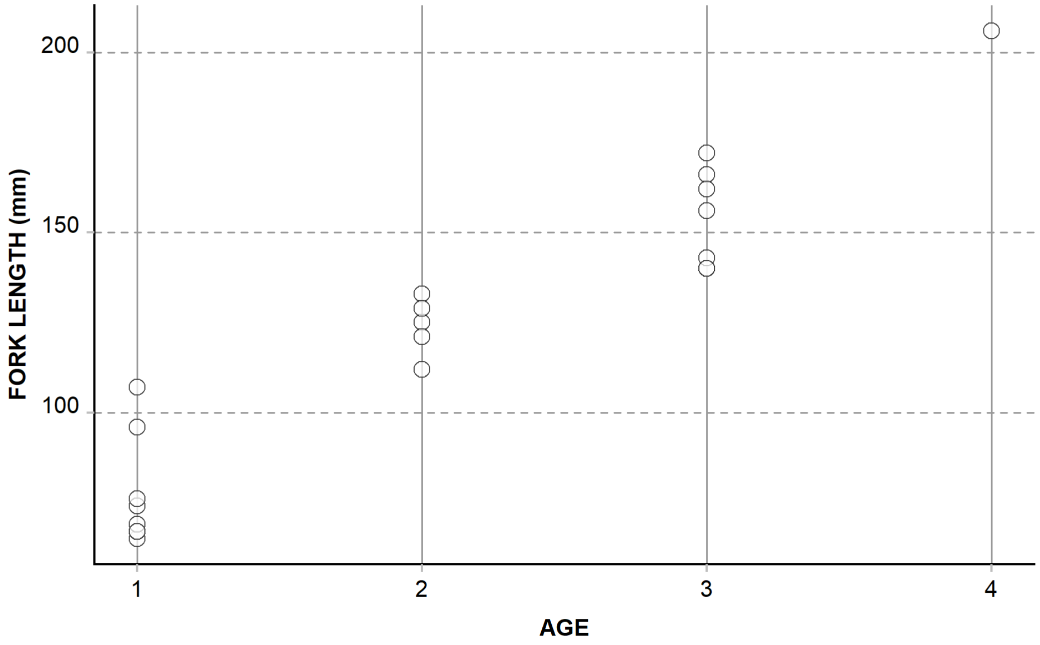

Table 1. Summary of all fish captured during closed-site electrofishing in the Upper Lillooet River in 2018.

Reach	Site	Date	Method[1]	Pass #	Species[2]	Measured Length (mm)	Weight (g)	Condition Factor	Aging Structure & Sample	Measured Age	DNA Sample Number	Mean Fat %	PIT Tag #
Diversion	ULL-DVEF02b	24-Mar-18	EF	1	BT	90	8.8	1.207133	FR-2		2		Tag: 989001006647225
Diversion	ULL-DVEF02b	24-Mar-18	EF	1	BT	149	40.9	1.236416	FR-5		5		Tag: 989001006647183
Diversion	ULL-DVEF02b	24-Mar-18	EF	1	CT	63	2.9	1.159782	SC-1	0	1		
Diversion	ULL-DVEF02b	24-Mar-18	EF	1	CT	65	2.9	1.055985	SC-4	0	4		
Diversion	ULL-DVEF02b	24-Mar-18	EF	1	CT	69	3.5	1.06542	SC-3	0	3		
Diversion	ULL-DVEF02b	24-Mar-18	EF	2	NFO								
Diversion	ULL-DVEF04	24-Mar-18	EF	1	BT	152	48	1.366817	FR-1		1		Tag: 989001006335405
Diversion	ULL-DVEF04	24-Mar-18	EF	1	BT	231	149	1.208789	FR-2		2		Tag: 989001006335425
Diversion	ULL-DVEF04	24-Mar-18	EF	1	CT	41	0.6	0.870562					
Diversion	ULL-DVEF04	24-Mar-18	EF	1	CT	61	2.2	0.969244	SC-3	0	3		
Diversion	ULL-DVEF04	24-Mar-18	EF	2	NFO								
Diversion	ULL-DVEF05	24-Mar-18	EF	1	BT	30							
Diversion	ULL-DVEF05	24-Mar-18	EF	1	BT	162	43.3	1.018457	FR-1		1		Tag: 989001006335428
Diversion	ULL-DVEF05	24-Mar-18	EF	1	CT	144	33.1	1.108512	SC-2	3	2		Tag: 989001006335406
Diversion	ULL-DVEF05	24-Mar-18	EF	2	NFO								
Diversion	ULL-DVEF06	24-Mar-18	EF	1	CT	66	3.2	1.113059	SC-1	0	1		
Diversion	ULL-DVEF06	24-Mar-18	EF	1	CT	217	103.1	1.008973	SC-3	4	3	2.3	Tag: 989001006647170
Diversion	ULL-DVEF06	24-Mar-18	EF	1	CT	247	170.2	1.129454	SC-2	5	2	1.8	Tag: 989001006647239
Diversion	ULL-DVEF06	24-Mar-18	EF	2	NFO								
Diversion	ULL-DVEF07b	24-Mar-18	EF	1	NFO								
Diversion	ULL-DVEF07b	24-Mar-18	EF	2	NFO								
Upstream	ULL-USEF01	26-Mar-18	EF	1	NFO								
Upstream	ULL-USEF01	26-Mar-18	EF	2	NFO								
Upstream	ULL-USEF02b	26-Mar-18	EF	1	NFO								
Upstream	ULL-USEF02b	26-Mar-18	EF	2	NFO								
Upstream	ULL-USEF03	26-Mar-18	EF	1	NFO								
Upstream	ULL-USEF03	26-Mar-18	EF	2	NFO								
Upstream	ULL-USEF06	25-Mar-18	EF	1	CT	153	34.4	0.960471	SC-1	3	1		Tag: 989001006335355
Upstream	ULL-USEF06	25-Mar-18	EF	2	NFO								
Upstream	ULL-USEF07	25-Mar-18	EF	1	CT	95	9.5	1.108033	SC-5	1	5		Tag: 989001006647178
Upstream	ULL-USEF07	25-Mar-18	EF	1	CT	157	36.8	0.950931	SC-2	3	2		Tag: 989001006647254
Upstream	ULL-USEF07	25-Mar-18	EF	1	CT	190	78	1.137192	SC-3	3	3		Tag: 989001006647210
Upstream	ULL-USEF07	25-Mar-18	EF	1	CT	198	81.6	1.051222	SC-4	4	4		Tag: 989001006647224
Upstream	ULL-USEF07	25-Mar-18	EF	2	CT	116	12.5	0.800822	SC-1	1	1		Tag: 989001006647264
Upstream	ULL-USEF07	25-Mar-18	EF	3	NFO								
Upstream	ULL-USEF10	26-Mar-18	EF	1	CT	162	41.9	0.985528	SC-1	3	1		Tag: 989001006647207
Upstream	ULL-USEF10	26-Mar-18	EF	2	NFO								
Upstream	ULL-USEF11	27-Mar-18	EF	1	CT	219	96.4	0.917793	SC-1	4	1		Tag: 989001006335247
Upstream	ULL-USEF11	27-Mar-18	EF	2	NFO								
Upstream	ULL-USEF12	27-Mar-18	EF	1	CT	120	15.8	0.914352	SC-2	1	2		Tag: 989001006335423
Upstream	ULL-USEF12	27-Mar-18	EF	1	CT	175	47.1	0.878834	SC-1	3	1		Tag: 989001006335415
Upstream	ULL-USEF12	27-Mar-18	EF	2	NFO								

[1] EF = Electrofishing.

[2] BT = Bull Trout, CT = Cutthroat Trout.

[3] FR = Rin ray, SC = scale.

Table 2. Summary of all fish captured during closed-site electrofishing in 87.0 km Tributary in 2018.

Capture Method[1]	Site	Date	Pass/ Trap #	Species[2]	Measured Length (mm)	Weight (g)	K	Scale Sample #	DNA Sample #	Assigned Age	Pit Tag #	Recapture (Yes/No)
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	67	3.7	1.09	15	15	1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	68	3.6	1.02			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	69	3.8	1.03	11	11	1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	69	4.0	1.08	14	14	1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	71	4.3	1.07			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	71	4.6	1.14			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	72	4.2	1.00			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	73	4.4	1.01			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	74	3.8	0.84			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	76	5.6	1.14	5	5	1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	79	5.5	1.00			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	95	9.4	0.99			1	Tag: 989001006647023	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	96	9.9	1.01	12	12	1	Tag: 989001006647019	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	104	12.9	1.04	8	8	1	Tag: 989001006647051	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	110	15.0	1.02			2	Tag: 989001006646784	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	114	17.0	1.04			2	Tag: 989001006646843	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	118	16.8	0.93			2	Tag: 989001006646807	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	119	18.0	0.97			2	Tag: 989001006647033	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	121	20.7	1.06	9	9	2	Tag: 989001006646799	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	123	20.3	0.99	2	2	2	Tag: 989001006646833	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	127	18.2	0.81	3	3	2	Tag: 989001006647021	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	129	25.1	1.06			2	Tag: 9890010076646989	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	138	25.5	0.88	7	7	3	Tag: 989001006646773	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	140	28.1	0.93	1	1	3	Tag: 989001006646830	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	140	28.2	0.94			3	Tag: 989001006646804	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	140	31.0	1.03	13	13	3	Tag: 989001006646793	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	143	26.2	0.82	6	6	3	Tag: 989001006646996	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	151	33.0	0.88	10	10	3	Tag: 989001006646771	no
EF	ULL-HPTB87.0EF01	16-Oct-18	1	CT	166	44.1	0.89	4	4	3	Tag: 989001066468929	no
EF	ULL-HPTB87.0EF01	16-Oct-18	2	CT	67	3.4	1.00			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	2	CT	76	5.5	1.12			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	2	CT	119	19.0	1.02			2	Tag: 989001006646688	no
EF	ULL-HPTB87.0EF01	16-Oct-18	2	CT	128	22.6	0.98			2	Tag: 989001006646776	no
EF	ULL-HPTB87.0EF01	16-Oct-18	2	CT	143	27.9	0.87			3	Tag: 989001006647044	no
EF	ULL-HPTB87.0EF01	16-Oct-18	3	CT	31	0.4	1.16			0		no
EF	ULL-HPTB87.0EF01	16-Oct-18	3	CT	34	0.4	0.88			0		no
EF	ULL-HPTB87.0EF01	16-Oct-18	3	CT	64	3.2	1.08			1		no
EF	ULL-HPTB87.0EF01	16-Oct-18	3	CT	101	11.4	1.00			1	Tag: 989001006646670	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	31	0.4	1.16			0		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	32	0.4	1.06	4	4	0		no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	34	0.4	0.88			0		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	35	0.4	0.81			0		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	38	0.6	0.95			0		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	67	2.8	0.83	10	10	1		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	74	4.8	1.06	11	11	1		
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	112	15.8	1.02	2	2	2	Tag: 989001006646819	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	126	24.0	1.09	8	8	2	Tag: 989001006646668	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	129	23.3	0.99	9	9	2	Tag: 989001006646848	

[1] EF = Electrofishing

[2] CT = Cutthroat Trout

Table 2. Continued.

Capture Method[1]	Site	Date	Pass/ Trap #	Species[2]	Measured Length (mm)	Weight (g)	K	Scale Sample #	DNA Sample #	Assigned Age	Pit Tag #	Recapture (Yes/No)
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	133	26.9	1.04	7	7	2	Tag: 989001006646795	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	134	22.3	0.84	1	1	2	Tag: 989001006646770	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	135	28.1	1.04	3	3	2	Tag: 989001006646819	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	144	35.3	1.08	6	6	3	Tag: 989001006647046	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	154	41.5	1.04	5	5	3	Tag: 989001006646980	no
EF	ULL-HPTB87.0EF02	17-Oct-18	1	CT	156	39.7	0.96	12	12	3	Tag: 989001006646842	
EF	ULL-HPTB87.0EF02	17-Oct-18	2	CT	79	4.7	0.85	14	14	1	Tag: 989001006646845	
EF	ULL-HPTB87.0EF02	17-Oct-18	2	CT	107	13.2	0.97	13	13	1	Tag: 989001006647027	
EF	ULL-HPTB87.0EF02	17-Oct-18	2	CT	116	17.4	1.01			2	Tag: 989001006646798	
EF	ULL-HPTB87.0EF02	17-Oct-18	3	CT	76	5.7	1.16	15	15	1	Tag: 989001006647050	
EF	ULL-HPTB87.0EF02	17-Oct-18	3	CT	139	30.0	1.02			3	Tag: 989001006647024	
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	57	2.3	1.10			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	58	2.2	1.00			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	62	2.8	1.04			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	64	2.9	0.98			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	65	3.5	1.13	11	11	1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	74	4.4	0.97	10	10	1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	74	4.5	0.99			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	74							no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	75	4.9	1.04			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	75	5.1	1.08			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	78	4.5	0.85			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	79	4.5	0.82	6	6	1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	80	5.5	0.96			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	80	6.0	1.05			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	86	6.8	0.96			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	110	16.9	1.15	8	8	2	Tag: 989001006646808	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	112	16.6	1.07	9	9	2	Tag: 989001006646853	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	125	22.1	1.03	12	12	2	Tag: 989001006646853	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	141	29.5	0.96			3	Tag: 989001006647036	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	154	40.5	1.02			3	Tag: 989001006647040	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	161	47.5	1.04			3	Tag: 989001006647781	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	161	49.1	1.08			3	Tag: 989001006647029	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	162	47.5	1.02	7	7	3	Tag: 989001006646827	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	162	48.0	1.04			3	Tag: 989001006646775	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	166	51.5	1.03	4	4	3	Tag: 989001006646862	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	172	55.7	1.01	5	5	3	Tag: 989001006647054	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	180	66.4	1.05	3	3	3	Tag: 989001006646814	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	181	65.8	1.02	2	2	3	Tag: 989001006646817	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	181	71.6	1.11			3	Tag: 989001006646815	no
EF	ULL-HPTB87.0EF03	17-Oct-18	1	CT	206	106.0	1.12	1	1	4	Tag: 989001006646841	no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	69	3.1	0.84			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	69	3.8	1.03			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	81	6.2	1.04			1		no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	110	15.4	1.05			2	Tag: 989001006647039	no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	123	20.2	0.99			2	Tag: 989001006647042	no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	149	38.9	1.08			3	Tag: 989001006646820	no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	161	46.3	1.02			3	Tag: 989001006647045	no
EF	ULL-HPTB87.0EF03	17-Oct-18	2	CT	201	89.8	1.02			3	Tag: 989001006646794	no
EF	ULL-HPTB87.0EF03	17-Oct-18	3	CT	165	46.2	0.94			3	Tag: 989001006646854	no

[1] EF = Electrofishing

[2] CT = Cutthroat Trout

Appendix M. Habitat Summaries and Representative Photographs of Snorkel Mark Re-sight Sites

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Table 1. Summary of Site Conditions at mark re-sight sites in Boulder Creek, 2018.

Reach	Sampling Event	Site	Date	Estimated Visibility (m)	Water Temp. (°C)	Air Temp. (°C)	Daily Average Flow (m^3/s)[1]
Diversion	Mark	BDR-DVSN01	15-Mar-18	6.0	2.0	0.5	0.70
		BDR-DVSN02	15-Mar-18	4.5	2.0	0.5	0.70
		BDR-DVSN03	15-Mar-18	4.5	2.0	0.3	0.70
		BDR-DVSN04	15-Mar-18	6.0	2.0	0.5	0.70
		BDR-DVSN05	15-Mar-18	4.5	2.0	0.0	0.70
	Re-sight	BDR-DVSN01	16-Mar-18	6.0	2.0	1.5	0.73
		BDR-DVSN02	16-Mar-18	4.5	2.5	1.5	0.73
		BDR-DVSN03	16-Mar-18	6.0	2.3	0.8	0.73
		BDR-DVSN04	16-Mar-18	6.0	2.0	0.5	0.73
		BDR-DVSN05	16-Mar-18	6.0	2.0	0.8	0.73
Downstream	Mark	BDR-DSSN01B	13-Mar-18	4.5	2.0	2.0	0.92
		BDR-DSSN02B	13-Mar-18	6.0	2.0	2.0	0.92
		BDR-DSSN03	13-Mar-18	4.0	2.0	1.5	0.92
		BDR-DSSN04	13-Mar-18	6.0	2.0	2.0	0.92
		BDR-DSSN05	13-Mar-18	4.5	2.0	1.5	0.92
	Re-sight	BDR-DSSN01B	14-Mar-18	5.0	2.3	1.0	0.93
		BDR-DSSN02B	14-Mar-18	n/a	2.0	1.0	0.93
		BDR-DSSN03	14-Mar-18	5.0	2.0	1.0	0.93
		BDR-DSSN04	14-Mar-18	6.0	2.0	1.0	0.93
		BDR-DSSN05	14-Mar-18	5.0	2.0	1.0	0.93

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

Table 2. Summary of habitat data at mark re-sight sites in Boulder Creek, 2018

Reach	Site	Habitat	Complete Site			Surveyed Area		Max. Depth (m)	Cover[1]		Substrate (%)[2]							Gradient (%)
			Length (m)	Width (m)	Area (m^2)	% of Total	Area (m^2)		Dom.	Sub-dom.	BR	BO	LC	SC	LG	SG	F	
Diversion	BDR-DVSN01	Cascade	98	13.3	784	57	446	0.8	BO	CO	0	35	15	20	15	10	5	8.0
	BDR-DVSN02	Cascade	101	10.0	606	70	424	1.2	BO	DP	10	25	15	20	10	10	10	6.0
	BDR-DVSN03	Cascade	108	16.0	936	65	605	1.0	BO	CO	5	25	20	20	10	10	10	4.0
	BDR-DVSN04	Cascade	91	12.0	1,001	58	582	1.1	BO	DP	10	25	10	15	10	20	10	6.0
	BDR-DVSN05	Cascade	107	13.3	856	70	599	1.3	BO	DP	5	25	15	15	15	15	10	5.0
Downstream	BDR-DSSN01B	Riffle	104	10.3	1,074	90	964	0.8	CO	BO	0	25	35	20	10	8	3	3.0
	BDR-DSSN02B	Riffle	103	11.3	1,167	85	989	0.8	BO	CO	0	40	25	15	5	5	10	4.0
	BDR-DSSN03	Cascade	111	10.0	1,073	79	852	1.4	BO	CO	0	45	20	10	10	10	5	5.0
	BDR-DSSN04	Cascade	108	11.0	1,188	70	832	1.8	BO	CO	5	35	20	15	10	10	5	6.0
	BDR-DSSN05	Cascade	99	9.7	957	79	760	1.7	BO	CO	0	40	25	10	15	5	5	6.0

[1] Cover codes: Dom. = dominant, Sub-Dom. = sub-dominant, BO = boulder, CO = cobble, DP = deep pool

[2] F = fine (<2 mm), SG = small gravel (2 - 16 mm), LG = large gravel (16 - 64 mm), SC = small cobble (64 - 128 mm), LC = large cobble (128 - 256 mm), BO = boulder (256-4,000 mm), and BR = bedrock (>4,000 mm)

Figure 1. Looking upstream at BDR-DSSN01B on March 16, 2018.

Figure 2. Looking downstream at BDR-DSSN01B on March 16, 2018.

Figure 3. Looking upstream at BDR-DSSN02B on March 16, 2018.

Figure 4. Looking downstream at BDR-DSSN02B on March 16, 2018.

Figure 5. Looking upstream at BDR-DSSN03 on March 16, 2018.

Figure 6. Looking downstream at BDR-DSSN03 on March 16, 2018.

Figure 7. Looking upstream at BDR-DSSN04 on March 16, 2018.

Figure 8. Looking downstream at BDR-DSSN04 on March 16, 2018.

Figure 9. Looking upstream at BDR-DSSN05 on March 16, 2018.

Figure 10. Looking downstream at BDR-DSSN05 on March 16, 2018.

Figure 11. Looking upstream at BDR-DVSN01 on March 16, 2018.

Figure 12. Looking downstream at BDR-DVSN01 on March 16, 2018.

Figure 13. Looking upstream at BDR-DVSN02 on March 16, 2018.

Figure 14. Looking downstream at BDR-DVSN02 on March 16, 2018.

Figure 15. Looking upstream at BDR-DVSN03 on March 16, 2018.

Figure 16. Looking downstream at BDR-DVSN03 on March 16, 2018.

Figure 17. Looking upstream at BDR-DVSN04 on March 16, 2018.

Figure 18. Looking downstream at BDR-DVSN04 on March 16, 2018.

Figure 19. Looking upstream at BDR-DVSN05 on March 16, 2018.

Figure 20. Looking downstream at BDR-DVSN05 on March 16, 2018.

Appendix N. Snorkel Mark Re-sight Fish Aging Figures and Individual Fish Data

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Figure 1. Length-frequency of Bull Trout captured during mark re-sight snorkelling in Boulder Creek in 2018.

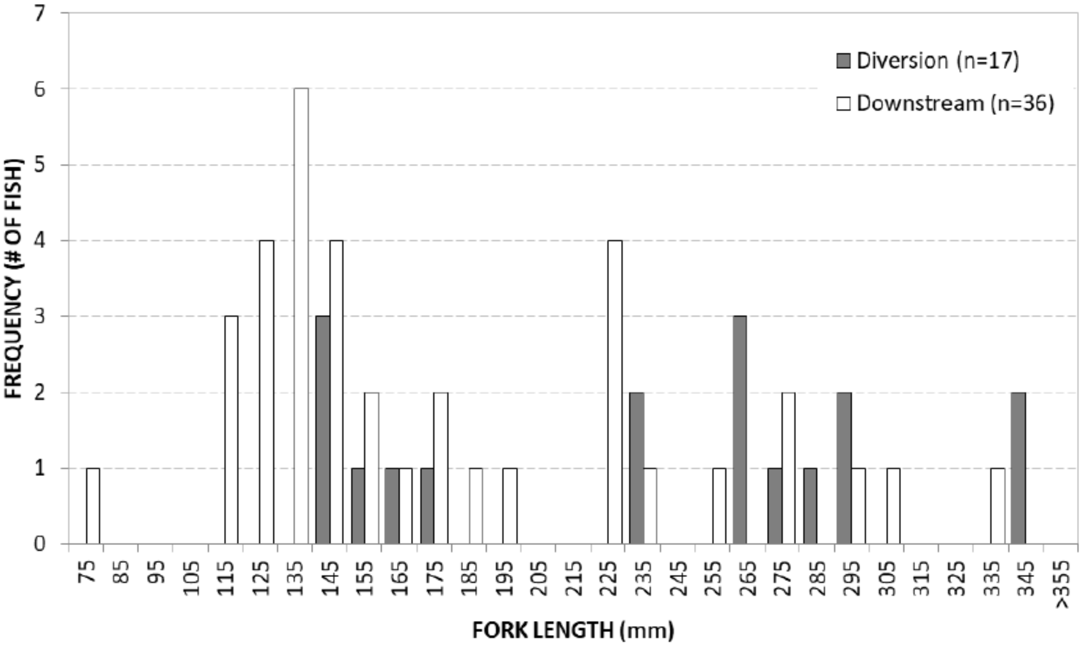

Figure 2. Length-weight regression for Bull Trout captured during mark re-sight snorkelling in Boulder Creek in 2018.

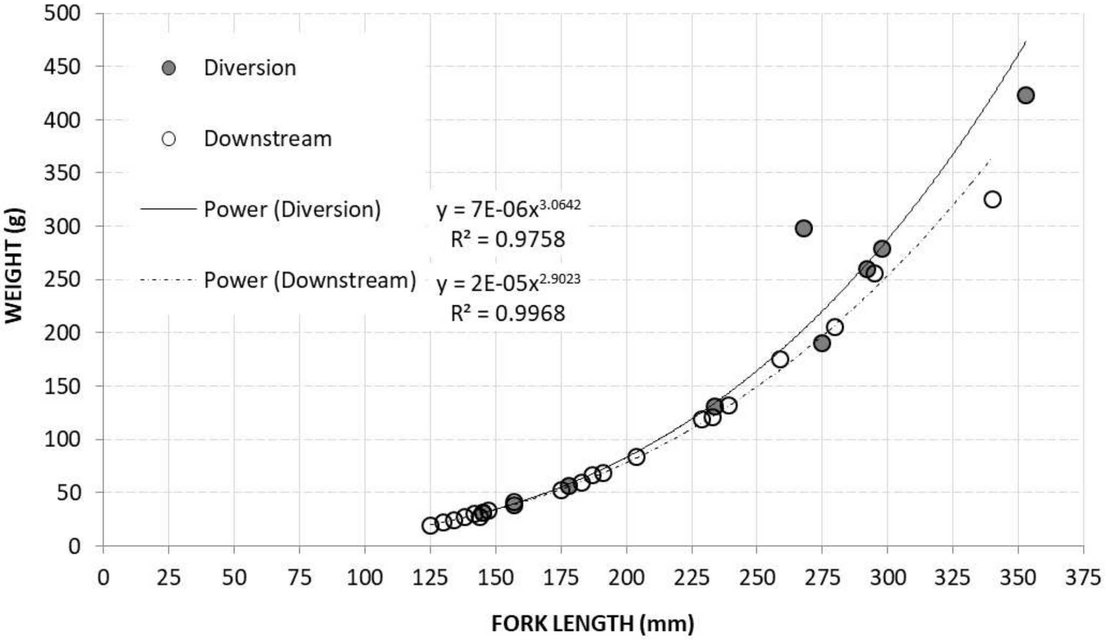

Figure 3. Length-frequency of Cutthroat Trout captured during mark re-sight snorkelling in Boulder Creek in 2018.

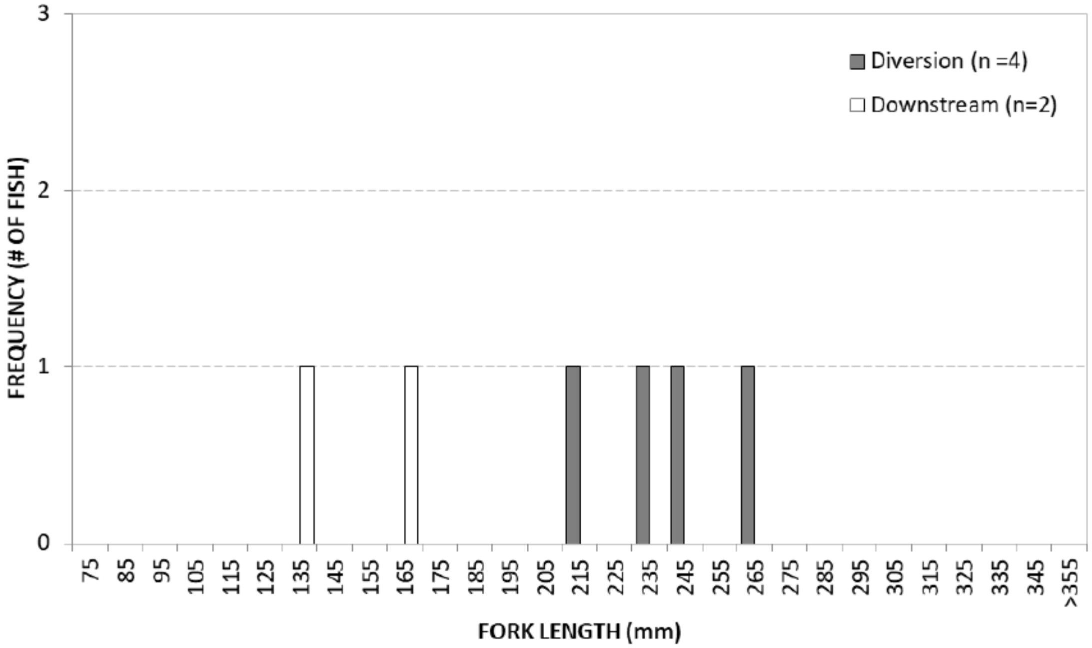

Figure 4. Length-weight regression for Cutthroat Trout captured during mark re-sight snorkelling in Boulder Creek in 2018.

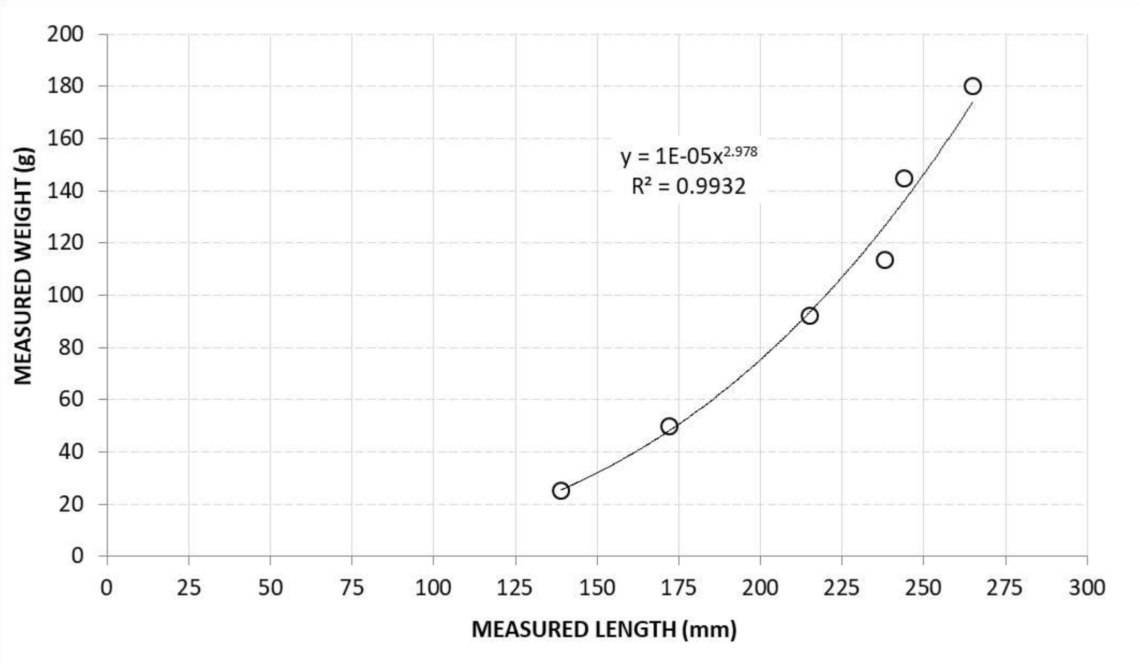

Table 1. Summary of all fish captured during mark-resight sampling in Boulder Creek, 2018.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample	Tag Colour	Recapture	PIT Tag #
BDR-DSSN01B	14-Mar-18	Downstream	SN	CT	130	139	25.2	0.94	SC8		No	989001006335302
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	140						No	
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	145	145	31.3	1.03	FR2		No	989001006335287
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	145	142	30.6	1.07	FR1		No	989001006335321
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	150	157	41.1	1.06	FR7		No	989001006696595
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	155	144	26.9	0.90	FR3		No	989001006335297
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	160						No	
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	180	175	52.1	0.97	FR4	SP PU	Yes	989001006335299
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	135	125	18.7	0.96	FR5		No	989001006335300
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	210	204	84	0.99	FR6	PI	Yes	989001006696570
BDR-DSSN01B	14-Mar-18	Downstream	SN	BT	260						No	
BDR-DSSN01B	13-Mar-18	Downstream	SN	BT	130	142				SP GR	No	
BDR-DSSN01B	13-Mar-18	Downstream	SN	BT	140	147				SP GR	No	
BDR-DSSN01B	13-Mar-18	Downstream	SN	BT	150						No	
BDR-DSSN01B	13-Mar-18	Downstream	SN	BT	160	174				SP PU	No	
BDR-DSSN01B	13-Mar-18	Downstream	SN	BT	200	204				PI	No	
BDR-DSSN02B	14-Mar-18	Downstream	SN	CT	180	172	50	0.98	SC1		No	989001006335245
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	160						No	
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	170						No	
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	190	183	59	0.96	FR2		No	989001006335251
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	290	295	256	1.00	FR5	OR	Yes	989001006335276
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	240	233	120.9	0.96	FR4	YE	Yes	989001006335281
BDR-DSSN02B	14-Mar-18	Downstream	SN	BT	240	229	118.3	0.99	FR3		No	989001006335250
BDR-DSSN02B	13-Mar-18	Downstream	SN	CT	180						No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	130	124				SP BL	No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	140						No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	200	230				YE	No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	250	230				YE	No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	270	230				YE	No	
BDR-DSSN02B	13-Mar-18	Downstream	SN	BT	320	295				OR	No	
BDR-DSSN03	14-Mar-18	Downstream	SN	NFO							No	
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	130						No	
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	140					SP GR	Yes	
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	140	134	24	1.00	FR3	SP GR	Yes	989001006335326

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample	Tag Colour	Recapture	PIT Tag #
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	160						No	
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	190	191	68.8	0.99	FR2	SP PU	Yes	989001006696573
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	250	280	205.5	0.94	FR4	RE	Yes	989001006696612
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	205	187	66.5	1.02	FR1	SP PU	Yes	989001006335306
BDR-DSSN03	14-Mar-18	Downstream	SN	BT	320						No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	80						No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	105	119				SP GR	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	180	149				SP GR	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	185	189				SP PU	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	135	134				SP GR	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	135	139				SP GR	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	210	184				SP PU	No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	65	75					No	
BDR-DSSN03	13-Mar-18	Downstream	SN	BT	225	283				RE	No	
BDR-DSSN04	14-Mar-18	Downstream	SN	NFO							No	
BDR-DSSN04	14-Mar-18	Downstream	SN	BT	150	147	33	1.04	FR2		No	989001006335280
BDR-DSSN04	14-Mar-18	Downstream	SN	BT	245	239	132	0.97	FR1	YE	Yes	989001006335232
BDR-DSSN04	13-Mar-18	Downstream	SN	CT	130						No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	120	134				SPBL	No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	170						No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	170	160				SPSI	No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	175						No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	230	240				YE	No	
BDR-DSSN04	13-Mar-18	Downstream	SN	BT	135	124				SPBL	No	
BDR-DSSN05	14-Mar-18	Downstream	SN	BT	115	138	27.1	1.03	FR2		No	989001006335327
BDR-DSSN05	14-Mar-18	Downstream	SN	BT	150	130	22.3	1.02	FR1		No	989001006335292
BDR-DSSN05	14-Mar-18	Downstream	SN	BT	300					RE	Yes	
BDR-DSSN05	14-Mar-18	Downstream	SN	BT	300	340	325	0.83	FR1		No	989001006335309
BDR-DSSN05	14-Mar-18	Downstream	SN	BT	280	259	175	1.01	FR3		No	989001006335252
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	130						No	
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	140						No	
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	220						No	
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	135	140				SP GR	No	
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	280	280				RE	No	
BDR-DSSN05	13-Mar-18	Downstream	SN	BT	330	305				RE	No	
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	140						No	

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Table 1. Continued.

Site	Date	Location	Method[1]	Species[2]	Estimated Length (mm)	Length (mm)	Weight (g)	Condition Factor (K)	Aging Structure & Sample	Tag Colour	Recapture	PIT Tag #
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	140	145	30.9	1.01	FR2		No	989001006335266
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	170	157	38	0.98	FR1		No	989001006335269
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	170	178	56.6	1.00	FR4		No	989001006335322
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	180					s. sparkle	Yes	
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	300	292	260	1.04	FR3	orange	Yes	989001006335241
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	280						No	
BDR-DVSN01	16-Mar-18	Diversion	SN	BT	350					orange	Yes	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	145	165				SP SI	No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	160	150				SP SI	No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	180						No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	210	240				YE	No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	310	350				orange	No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	270	290				OR	No	
BDR-DVSN01	15-Mar-18	Diversion	SN	BT	285	300				OR	No	
BDR-DVSN02	16-Mar-18	Diversion	SN	NFO							No	
BDR-DVSN02	16-Mar-18	Diversion	SN	CT	275	244	144.8	1.00	SC2	pink	Yes	9890001006335290
BDR-DVSN02	16-Mar-18	Diversion	SN	CT	260	215	92	0.93	SC4	pink	Yes	9890001006335319
BDR-DVSN02	16-Mar-18	Diversion	SN	BT	240	234	130.9	1.02	FR1	pink	Yes	9890001006335259
BDR-DVSN02	16-Mar-18	Diversion	SN	BT	310	298	279	1.05	FR3		No	9890001006696631
BDR-DVSN02	15-Mar-18	Diversion	SN	CT	200	245				PI	No	
BDR-DVSN02	15-Mar-18	Diversion	SN	CT	230	223				PI	No	
BDR-DVSN02	15-Mar-18	Diversion	SN	BT	140	148				SP GR	No	
BDR-DVSN02	15-Mar-18	Diversion	SN	BT	240	240				PI	No	
BDR-DVSN02	15-Mar-18	Diversion	SN	BT	305						No	
BDR-DVSN03	16-Mar-18	Diversion	SN	NFO							No	
BDR-DVSN03	16-Mar-18	Diversion	SN	CT	180	238	113.6	0.84	SC3		No	989001006646577
BDR-DVSN03	16-Mar-18	Diversion	SN	BT	300	275	190.5	0.92	FR4	orange	Yes	989001006335307
BDR-DVSN03	16-Mar-18	Diversion	SN	BT	330	353	423	0.96	FR1		No	989001006335277
BDR-DVSN03	16-Mar-18	Diversion	SN	BT	290	268	298	1.55	FR2		No	989001006696626
BDR-DVSN03	15-Mar-18	Diversion	SN	BT	350						No	
BDR-DVSN03	15-Mar-18	Diversion	SN	BT	275	274				OR	No	
BDR-DVSN03	15-Mar-18	Diversion	SN	BT	305	282				OR	No	
BDR-DVSN03	15-Mar-18	Diversion	SN	BT	265	272				OR	No	
BDR-DVSN04	16-Mar-18	Diversion	SN	CT	280	265	180	0.97	SC1		No	989001006335257
BDR-DVSN04	15-Mar-18	Diversion	SN	CT	290						No	
BDR-DVSN05	16-Mar-18	Diversion	SN	NFO							No	
BDR-DVSN05	15-Mar-18	Diversion	SN	NFO							No	

[1] SN = snorkelling

[2] BT = Bull Trout, CT = Cutthroat Trout and NFO = No Fish Observed.

[3] FR = Fin Ray and SC = Scale Sample.

Appendix O. Habitat Summaries and Representative Photographs of Angling Sites

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Table 1. Summary of channel habitat data from angling sites in Boulder Creek and Lillooet River in fall, 2018.

Site	Date	Water Temp. (◦C)	Habitat Type	Site Length (m)	Avg. Channel Width (m)	Avg. Wetted Width (m)	Avg. Bankfull Width (m)	Average Gradient (%)	Avg. Residual Pool Depth (m)
BDR-DVAG01	18-Sep-14	5.0	Cascade/Pool	30	17	9	2	3.0	0.8
BDR-DVAG05	18-Sep-14	5.0	Cascade	14	33	9	2	0.0	0.3
BDR-DVAG06	18-Sep-27	8.5	Cascade/Pool	20	17	10	2	1.0	0.0
BDR-TRAG01	18-Sep-14	5.0	Run	52	8	8	2	1.0	0.5
BDR-DSAG01	18-Sep-14	5.0	Cascade	32	35	32	1	4.0	0.3
BDR-DSAG02	18-Sep-14	5.0	Cascade	2	20	18	2	6.0	0.3
BDR-DSAG06	18-Sep-14	5.0	Cascade	21	16	13	2	6.0	0.8
BDR-DSAG07	18-Sep-14	5.0	Riffle	55	20	41	2	2.0	0.5
ULL-DVAG15	18-Sep-13	5.0	Cascade	46	44	18	2	3.5	0.8
ULL-DVAG16	18-Sep-13	5.0	Step/Pool	45	26	16	4	0.5	2.0
ULL-TRAG01	18-Sep-13	5.0	Step/Pool	18	42	40	3	1.0	1.0
ULL-DSAG08	18-Sep-13	5.0	Riffle/Pool	124	38	30	2	1.5	1.0
ULL-DSAG09	18-Sep-13	5.0	Riffle/Pool	30	35	29	3	2.0	0.8
ULL-DSAG10	18-Sep-13	5.0	Riffle/Pool	3	34	25	4	3.0	1.5

Table 2. Summary of habitat characteristics from angling sites in Boulder Creek and Lillooet River in fall, 2018.

Stream	Project Area	Site	Date	Total Cover	Crown Closure (%)	Left Bank Texture	Right Bank Texture	Bed Material[1]		D95 (cm)[2]	D (cm)[3]
								Dom.	Subdom.		
Boulder Creek	Diversion	BDR-DVAG01	18-Sep-14	A - Abundant (>20%)	1-20%	Bedrock	Boulders	BO	G	150	220
		BDR-DVAG05	18-Sep-14	n/c	1-20%	Bedrock	Boulders	BO	CO	120	200
		BDR-DVAG06	18-Sep-27	n/c	1-20%	Bedrock	Cobbles/Boulders	BO	CO	120	150
	Tailrace	BDR-TRAG01	18-Sep-14	M - Moderate (5-20%)	0%	Anthropogenic	Anthropogenic	R	BO	120	150
	Downstream	BDR-DSAG01	18-Sep-14	A - Abundant (>20%)	1-20%	Boulders	Boulders	BO	G	80	150
		BDR-DSAG02	18-Sep-14	A - Abundant (>20%)	1-20%	Boulders	Boulders	BO	CO	n/c	n/c
		BDR-DSAG06	18-Sep-14	A - Abundant (>20%)	1-20%	Gravels	Boulders	BO	CO	150	200
		BDR-DSAG07	18-Sep-14	M - Moderate (5-20%)	0%	Gravels	Gravels	CO	BO	n/c	n/c
Lillooet River	Diversion	ULL-DVAG15	18-Sep-13	A - Abundant (>20%)	0%	Gravels	Gravels	CO	BO	150	220
		ULL-DVAG16	18-Sep-13	A - Abundant (>20%)	0%	Cobbles	Cobbles	CO	BO	150	220
	Tailrace	ULL-TRAG01	18-Sep-13	M - Moderate (5-20%)	0%	Boulders	Boulders	BO	R	120	200
	Downstream	ULL-DSAG08	18-Sep-13	M - Moderate (5-20%)	0%	Cobbles/Boulders	Cobbles	F	BO	80	200
		ULL-DSAG09	18-Sep-13	n/c	1-20%	Boulders	Gravels	BO	CO	80	150
		ULL-DSAG10	18-Sep-13	M - Moderate (5-20%)	0%	Boulders	Boulders	BO	CO	150	250

n/c = Data not collected

[1] R = Bedrock (>4000 mm), BO = Boulders (256-4000 mm), CO = Cobbles (64-256 mm) , G = Gravels (2-64 mm), F = Fines (<2 mm)

[2] D95 = Represents the diameter of the bed material that is larger than 95% of the total substrate.

[3] D = Represents the largest, moveable (by flowing water), sediment particle on the channel bed.

Figure 1. Looking from river right to river left at BDR-DVAG01 on September 14, 2018.

Figure 2. Looking from river right to river left at BDR-DVAG04 on September 27, 2018.

Figure 3. Looking from river left to river right at BDR-DVAG05 on September 27, 2018.

Figure 4. Looking from river right to river left at BDR-DVAG06 on October 10, 2018.

Figure 5. Looking downstream from river right at BDR-TRAG01 on October 10, 2018.

Figure 6. Looking from river right upstream at BDR-DSAG01 on October 10, 2018.

Figure 7. Looking downstream from river left at BDR-DSAG02 on September 27, 2018.

Figure 8. Looking from river right to river left at BDR-DSAG06 on September 14, 2018.

Figure 9. Looking upstream at BDR-DSAG07 on September 14, 2018.

Figure 10. Looking upstream at ULL-DVAG15 on September 13, 2018.

Figure 11. Looking from river left to river right at ULL-DVAG16 on October 9, 2018.

Figure 12. Looking from river right to river left at ULL-TRAG01 on October 9, 2018.

Figure 13. Looking from river left to river right at ULL-DSAG08 on September 13, 2018.

Figure 14. Looking upstream from river left at ULL-DSAG09 on September 13, 2018.

Figure 15. Looking from river left to river right at ULL-DSAG10 on September 13, 2018.

Appendix P. Angling and Open-Site Electrofishing Sampling Summaries and Individual Fish Data

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Table 1. Summary of effort and captures at all angling sites in Boulder Creek and Upper Lillooet River in 2018.

Stream	Date	Project Area	Site	Effort (rod hrs)	Captured Fish[1]		CPUE (fish/hr)[1]	
					BT	CT	BT	CT
Boulder Creek	14-Sep-18	Diversion	BDR-DVAG01	1.6	2	0	1.3	0.0
			BDR-DVAG04	1.0	1	0	1.0	0.0
			BDR-DVAG05	1.1	0	0	0.0	0.0
		Tailrace	BDR-TRAG01	1.7	4	0	2.4	0.0
		Downstream	BDR-DSAG01	1.0	1	0	1.0	0.0
			BDR-DSAG02	0.9	2	0	2.3	0.0
			BDR-DSAG06	1.5	2	0	1.4	0.0
			BDR-DSAG07	1.1	2	0	1.8	0.0
	September 14 Total:			**9.8**	**14**	**0**	**1.4**	**0.0**
	27-Sep-18	Diversion	BDR-DVAG01	1.0	0	0	0.0	0.0
			BDR-DVAG04	1.0	0	0	0.0	0.0
			BDR-DVAG05	1.0	1	0	1.0	0.0
			BDR-DVAG06	1.3	0	0	0.0	0.0
		Tailrace	BDR-TRAG01	1.0	1	0	1.0	0.0
		Downstream	BDR-DSAG01	1.0	2	0	2.0	0.0
			BDR-DSAG02	1.5	3	0	2.1	0.0
			BDR-DSAG06	1.2	1	0	0.8	0.0
			BDR-DSAG07	1.2	1	0	0.9	0.0
	September 27 Total:			**10.2**	**9**	**0**	**0.9**	**0.0**
	10-Oct-18	Diversion	BDR-DVAG01	1.6	0	0	0.0	0.0
			BDR-DVAG04	1.2	0	0	0.0	0.0
			BDR-DVAG05	1.2	0	0	0.0	0.0
			BDR-DVAG06	1.5	0	0	0.0	0.0
		Tailrace	BDR-TRAG01	1.3	1	0	0.8	0.0
		Downstream	BDR-DSAG01	1.1	0	0	0.0	0.0
			BDR-DSAG02	1.6	0	0	0.0	0.0
			BDR-DSAG06	1.2	1	0	0.8	0.0
			BDR-DSAG07	1.2	1	0	0.8	0.0
	October 18 Total:			**11.7**	**3**	**0**	**0.3**	**0.0**
Upper Lillooet River	13-Sep-18	Diversion	ULL-DVAG16	1.1	1	0	0.9	0.0
		Tailrace	ULL-TRAG01	1.1	1	0	0.9	0.0
		Downstream	ULL-DSAG09	2.4	1	0	0.4	0.0
			ULL-DSAG10	1.1	1	0	0.9	0.0
	September 13 Total:			**5.7**	**4**	**0**	**0.7**	**0.0**
	28-Sep-18	Diversion	ULL-DVAG15	1.2	1	0	0.8	0.0
			ULL-DVAG16	1.5	2	1	1.4	0.7
		Tailrace	ULL-TRAG01	1.1	2	0	1.8	0.0
		Downstream	ULL-DSAG08	1.1	3	0	2.8	0.0
			ULL-DSAG09	1.2	0	0	0.0	0.0
			ULL-DSAG10	1.1	1	0	0.9	0.0
	September 28 Total:			**7.2**	**9**	**1**	**1.3**	**0.1**
	09-Oct-18	Diversion	ULL-DVAG16	1.0	2	0	2.0	0.0
		Tailrace	ULL-TRAG01	1.2	1	0	0.9	0.0
		Downstream	ULL-DSAG08	1.2	0	0	0.0	0.0
			ULL-DSAG09	1.2	2	0	1.7	0.0
			ULL-DSAG10	1.2	2	0	1.7	0.0
	10-Oct-18	Diversion	ULL-DVAG15	1.2	0	0	0.0	0.0
	October 9-10 Total:			**6.9**	**7**	**0**	**1.0**	**0.0**

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

Table 2. Summary of all fish captured during angling in Boulder Creek and Upper Lillooet River in 2018.

Waterbody	Reach	Site	Date	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
Upper Lillooet River	Diversion	ULL-DVAG15	43371	BT	242	157	1.11	FR	1	1	Tag: 989001006696300
Upper Lillooet River	Diversion	ULL-DVAG15	43383	NFC							
Upper Lillooet River	Diversion	ULL-DVAG16	43356	BT	269	198	1.02	FR	3	3	
Upper Lillooet River	Diversion	ULL-DVAG16	43371	BT	220	120	1.13	FR	1	1	Tag: 989001006696320
Upper Lillooet River	Diversion	ULL-DVAG16	43371	BT	400	630	0.98	FR	2	2	Tag: 989001006696348
Upper Lillooet River	Diversion	ULL-DVAG16	43371	CT	260	201	1.14	FR	3	3	Tag: 989001006696297
Upper Lillooet River	Diversion	ULL-DVAG16	43382	BT	194	76	1.04	FR	1	1	Tag: 989001006647034
Upper Lillooet River	Diversion	ULL-DVAG16	43382	BT	268	204	1.06	FR	2	2	Tag: 989001006647062
Upper Lillooet River	Tailrace	ULL-TRAG01	43356	BT	241	142	1.01	FR	2	2	
Upper Lillooet River	Tailrace	ULL-TRAG01	43371	BT	240	152	1.10				
Upper Lillooet River	Tailrace	ULL-TRAG01	43371	BT	283	228	1.01	FC	1	1	Tag: 989001006696292
Upper Lillooet River	Tailrace	ULL-TRAG01	43382	BT	184	86.1	1.38	FR	1	1	Tag: 989001006640768
Upper Lillooet River	Downstream	ULL-DSAG08	43371	BT	200	83	1.04	FR	3	3	Tag: 989001006696307
Upper Lillooet River	Downstream	ULL-DSAG08	43371	BT	270	185	0.94	FR	1	1	Tag: 989001006696290
Upper Lillooet River	Downstream	ULL-DSAG08	43371	BT	285	220	0.95	FR	2	2	Tag: 989001006696341
Upper Lillooet River	Downstream	ULL-DSAG08	43382	NFC							
Upper Lillooet River	Downstream	ULL-DSAG09	43356	BT	220	114	1.07	FR	4	4	
Upper Lillooet River	Downstream	ULL-DSAG09	43371	NFC							
Upper Lillooet River	Downstream	ULL-DSAG09	43382	BT	178	58	1.03	FR	1	1	Tag: 989001006646732
Upper Lillooet River	Downstream	ULL-DSAG09	43382	BT	201	88	1.08	FR	2	2	Tag: 989001006647014
Upper Lillooet River	Downstream	ULL-DSAG10	43356	BT	252	164	1.02	FR	1	1	
Upper Lillooet River	Downstream	ULL-DSAG10	43371	BT	220	101	0.95	FR	1	1	
Upper Lillooet River	Downstream	ULL-DSAG10	43382	BT	260	182	1.04	FR	1	1	Tag: 989001006646785
Upper Lillooet River	Downstream	ULL-DSAG10	43382	BT	268	205	1.06	FR	2	2	Tag: 989001006646766
Boulder Creek	Diversion	BDR-DVAG01	43357	BT	215	106	1.07	FR	13	13	
Boulder Creek	Diversion	BDR-DVAG01	43357	BT	290	260	1.07	FR	12	12	
Boulder Creek	Diversion	BDR-DVAG01	43370	NFC							
Boulder Creek	Diversion	BDR-DVAG01	43383	NFC							
Boulder Creek	Diversion	BDR-DVAG04	43357	BT	230	134	1.10	FR	14	14	
Boulder Creek	Diversion	BDR-DVAG04	43370	NFC							
Boulder Creek	Diversion	BDR-DVAG04	43383	NFC							
Boulder Creek	Diversion	BDR-DVAG05	43357	NFC							
Boulder Creek	Diversion	BDR-DVAG05	43370	BT	195	87	1.17	FR	1	1	Tag: 989001006696845
Boulder Creek	Diversion	BDR-DVAG05	43383	NFC							
Boulder Creek	Diversion	BDR-DVAG06	43370	NFC							
Boulder Creek	Diversion	BDR-DVAG06	43383	NFC							
Boulder Creek	Tailrace	BDR-TRAG01	43357	BT	206	96	1.10	FR	9	9	
Boulder Creek	Tailrace	BDR-TRAG01	43357	BT	266	204	1.08	FR	8	8	
Boulder Creek	Tailrace	BDR-TRAG01	43357	BT	295	308	1.20	FR	6	6	
Boulder Creek	Tailrace	BDR-TRAG01	43357	BT	312	308	1.01	FR	7	7	
Boulder Creek	Tailrace	BDR-TRAG01	43370	BT	210			FR	1	1	Tag: 989001006335243
Boulder Creek	Tailrace	BDR-TRAG01	43383	BT	268	193	1.00	FR	1	1	Tag: 989001006647049
Boulder Creek	Downstream	BDR-DSAG01	43357	BT	365	515	1.06	FR	1	1	
Boulder Creek	Downstream	BDR-DSAG01	43370	BT	270	200	1.02	FR	2	2	Tag: 989001006696343
Boulder Creek	Downstream	BDR-DSAG01	43370	BT	450	1055	1.16	FR	1	1	Tag: 989001006335260
Boulder Creek	Downstream	BDR-DSAG01	43383	NFC							
Boulder Creek	Downstream	BDR-DSAG02	43357	BT	261	180	1.01	FR	3	3	
Boulder Creek	Downstream	BDR-DSAG02	43357	BT	285	221	0.95	FR	2	2	
Boulder Creek	Downstream	BDR-DSAG02	43370	BT	270	218	1.11				Tag: 989001006696315
Boulder Creek	Downstream	BDR-DSAG02	43370	BT	360	465	1.00	FR	2	2	Tag: 989001006335395
Boulder Creek	Downstream	BDR-DSAG02	43370	BT	400	656	1.03	FR	1	1	Tag: 989001006696325
Boulder Creek	Downstream	BDR-DSAG02	43383	NFC							
Boulder Creek	Downstream	BDR-DSAG06	43357	BT	202	95	1.15	FR	10		
Boulder Creek	Downstream	BDR-DSAG06	43357	BT	298	249	0.94	FR	11	11	
Boulder Creek	Downstream	BDR-DSAG06	43370	BT	290	243	1.00				Tag: 989001006696285
Boulder Creek	Downstream	BDR-DSAG06	43383	BT	258	170	0.99	FR	1	1	Tag: 989001006646774
Boulder Creek	Downstream	BDR-DSAG07	43357	BT	247	152	1.01	FR	4	4	
Boulder Creek	Downstream	BDR-DSAG07	43357	BT	275	206	0.99	FR	5	5	
Boulder Creek	Downstream	BDR-DSAG07	43370	BT	270	188	0.96	FR	1	1	Tag: 989001006696302
Boulder Creek	Downstream	BDR-DSAG07	43383	BT	196	83	1.10	FR	1	1	

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[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.

Table 3. Summary of all fish captured during open-site electrofishing surveys in Upper Lillooet River diversion reach tributaries in 2018.

Site	Date	Species[1]	Measured Length (mm)	Weight (g)	Condition Factor (K)	Age Structure	Age Sample #	DNA Sample #	PIT Tag #
ULL-DVTB83.2km	43391	CT	61	2.5	1.101414				
ULL-DVTB83.2km	43391	CT	72	4.3	1.152049	SC	6	6	
ULL-DVTB83.2km	43391	CT	73	4.5	1.156762	SC	2	2	
ULL-DVTB83.2km	43391	CT	80	5.9	1.152344	SC	10	10	Tag: 989001006646806
ULL-DVTB83.2km	43391	CT	84	6.9	1.164156	SC	9	9	Tag: 989001006646994
ULL-DVTB83.2km	43391	CT	86	7.5	1.179141				Tag: 989001006646840
ULL-DVTB83.2km	43391	CT	92	8.2	1.053053				Tag: 989001006646846
ULL-DVTB83.2km	43391	CT	95	8.3	0.968071				Tag: 989001006647061
ULL-DVTB83.2km	43391	CT	95	9.2	1.073043				Tag: 989001006646809
ULL-DVTB83.2km	43391	CT	95	9.4	1.09637				Tag: 989001006646835
ULL-DVTB83.2km	43391	CT	111	13.8	1.009044				Tag: 989001006646818
ULL-DVTB83.2km	43391	CT	112	15.8	1.124613				Tag: 989001006647058
ULL-DVTB83.2km	43391	CT	115	15.8	1.038876				Tag: 989001006647057
ULL-DVTB83.2km	43391	CT	115	16.1	1.058601				Tag: 989001006646864
ULL-DVTB83.2km	43391	CT	116	14.7	0.941767				Tag: 989001006647031
ULL-DVTB83.2km	43391	CT	116	17.1	1.095525	SC	3	3	Tag: 989001006646987
ULL-DVTB83.2km	43391	CT	122	19.5	1.073878	SC	5	5	Tag: 989001006647055
ULL-DVTB83.2km	43391	CT	123	17	0.913553	SC	7	7	Tag: 989001006647016
ULL-DVTB83.2km	43391	CT	128	20.2	0.963211	SC	8	8	Tag: 989001006646838
ULL-DVTB83.2km	43391	CT	152	33.7	0.95962	SC	4	4	Tag: 989001006646811
ULL-DVTB83.2km	43391	CT	163	43.3	0.999828	SC	1	1	Tag: 989001006646979
ULL-DVTB83.2km	43391	TR	39	0.4	0.67432				
ULL-DVTB83.6km	43391	NFC							
ULL-DVTB83.7km	43391	BT	64	3	1.144409				
ULL-DVTB83.7km	43391	BT	66	3.5	1.217408				
ULL-DVTB83.7km	43391	BT	66	3.6	1.252191				
ULL-DVTB83.7km	43391	BT	69	4	1.217623				
ULL-DVTB83.7km	43391	BT	70	4	1.166181				
ULL-DVTB83.7km	43391	BT	71	4	1.117596				
ULL-DVTB83.7km	43391	BT	73	4.6	1.182468				
ULL-DVTB83.7km	43391	CT	96	7.5	0.847711	SC	2	2	Tag: 989001006647022
ULL-DVTB83.7km	43391	CT	101	11.7	1.13559	SC	3	3	Tag: 989001006646813
ULL-DVTB83.7km	43391	CT	103	14.3	1.308653	SC	1	1	Tag: 989001006646822
ULL-DVTB83.7km	43391	CT	143	27.9	0.954105	SC	4	4	Tag: 989001006646772
ULL-DVTB83.7km	43391	TR	49	1.2	1.019983				

[1] BT = Bull Trout, CT = Cutthroat Trout, NFC = No fish caught.

Appendix Q. Harlequin Duck riparian habitat at transmission line crossings: compliance monitoring results and photographs

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1. ULH-HADUCM01

Figure 1. Harlequin Duck riparian habitat on the north side of the Lillooet River at the transmission line crossing at ULH-HADUCM01, assessed on September 21, 2018.

Table 1. Harlequin Duck habitat restoration compliance monitoring summary on the north side of the Lillooet River at the transmission line crossing ULH-HADUCM01, assessed on September 21, 2018.

General comment:	Good natural regeneration, plenty of coarse woody debris.
Clearing restricted to topping trees:	yes
Tree heights (m):	10, 4, 3
Average tree height (m):	6
Shrub heights (m):	1, 2, 1.5
Average shrub height (m):	2
Coarse woody debris present:	yes

2. ULH-HADUCM02

Figure 2. Harlequin Duck riparian habitat on the south side of the Lillooet River at the transmission line crossing at ULH-HADUCM02, assessed on September 21, 2018.

Table 2. Harlequin Duck habitat restoration compliance monitoring summary on the south side of the Lillooet River at the transmission line crossing ULH-HADUCM02, assessed on September 21, 2018.

General comment:	Young cottonwood and alders and good natural regeneration. Coarse woody debris deposits are natural. No trees were cleared within 30 m of the high-water mark.
Clearing restricted to topping trees:	topping was not necessary
Tree heights (m):	8, 3, 3
Average tree height (m):	5
Shrub heights (m):	3, 4, 3
Average shrub height (m):	3
Coarse woody debris present:	yes

3. ULH-HADUCM03

Figure 3. Harlequin Duck riparian habitat on the north side of the Ryan River at the transmission line crossing at ULH-HADU03, assessed on June 19, 2018.

Table 3. Harlequin Duck habitat restoration compliance monitoring summary on the north side of the Ryan River at the transmission line crossing ULH-HADUCM03, assessed on June 19, 2018.

General comment:	The area is limited by the bridge abutment and road crossing. Coarse woody debris could not be placed safely unless anchored, which may create a potential hazard/log catchement at high flow.
Clearing restricted to topping trees:	yes
Tree heights (m):	3, 5, 8
Average tree height (m):	5
Shrub heights (m):	0.5, 1, 1
Average shrub height (m):	1
Coarse woody debris present:	no – not feasible

4. ULH-HADUCM04

Figure 4. **Harlequin Duck riparian habitat on the south side of the Ryan River at the transmission line crossing at ULH-HADU04, assessed on June 19, 2018.**

Table 4. **Harlequin Duck habitat restoration compliance monitoring summary on the south side of the Ryan River at the transmission line crossing ULH-HADUCM04, assessed on June 19, 2018.**

General comment:	Dense shrubs and small trees at water's edge, coarse woody debris left in place.
Clearing restricted to topping trees:	yes
Tree heights (m):	2, 4, 5
Average tree height (m):	4
Shrub heights (m):	1, 1, 1
Average shrub height (m):	1
Coarse woody debris present:	yes

Appendix R. Incidental Wildlife Observations

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Table 1. Incidental wildlife sightings: Mammals.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
American Black Bear	*Ursus americanus*	15-Nov-2018	10:54:00	473411	5605961	Alena Creek	Sign		1	LI	U	Adult
		15-Nov-2018	12:17:00	473030	5606656	Alena Creek	Sign		1	LI	U	Adult
		15-Nov-2018	12:20:00	473035	5606650	Alena Creek	Sign		1	LI	U	Adult
		15-Nov-2018	12:17:00	473030	5606650	Alena Creek	Sign		1	LI	U	Adult
		5-Dec-2018	10:50:00	473191	5606562	Alena Creek	Sign		1	LI	U	Adult
		5-Dec-2018	10:05:00	473359	5606107	Alena Creek	Sign		1	LI	U	Adult
		23-May-2018	10:28:00	487456	5599913	Lillooet River transmission line crossing - south side	Sign	tracks	1		U	Unknown
		27-Jun-2018	13:31:29	470992	5609150	Lillooet River FSR km ~38.7 at bridge over Boulder Creek	Sighting	disturbed, crossed road	1	TF	U	Adult
		27-Jun-2018	13:00:28	485528	5600991	Lillooet River FSR - km 20.5	Sighting	ran across road	1	FL	U	Adult
		27-Jun-2018	16:40:14	485493	5601008	Lillooet River FSR - km 20.5	Sighting	likely same bear observed earlier, under transmission line	1	LI	U	Adult
Grizzly Bear	*Ursus arctos*	15-Sep-2018		468062	5613114	Lillooet River FSR - km 44.2, at the commercial honey bee hive near Truckwash Creek	Sighting	date approximate	1	FD	U	Unknown
		9-Apr-2018	09:21:00	468056	5613117	Truckwash Creek bridge	Sign	tracks	1	TF	U	Unknown
Bear		30-Apr-2018	13:21:00	472351	5610740	Boulder Creek HEF Intake Access Road	Sign	scat	1	EX	U	Unknown
Bobcat	*Lynx rufus*	15-Nov-2018	13:05:00	472708	5607000	Alena Creek	Sign		1	LI	U	Unknown
Cougar	*Puma concolor*	7-Mar-2018		467202	5613854	Lillooet River FSR - km 45	Sign	tracks on the FSR	1	LI	U	Unknown
	Puma concolor	30-Apr-2018	15:40:00	487503	5600122	Lillooet River transmission line crossing	Sign	carcass located an old road to the left of the power lines, looks like a dump site for a hunter	3		U	Unknown
Ermine	*Mustela erminea*	10-Sep-2018	18:00:00	473321	5611348	Boulder Creek HEF Intake Access Road - km 6	Sighting		1	HU	U	Unknown
Grey Wolf	*Canis lupus*	23-Apr-2018	08:50:00	472932	5606254	Lillooet River, near confluence with Meager Creek	Sign	tracks	1	TF	U	Unknown
mammal		7-Mar-2018		468089	5612711	old Lillooet River FSR near Truckwash Creek Rd, river left	Sign	large gait	1	LI	U	Unknown

Table 1. Continued.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Moose	*Alces americanus*	21-Oct-2018	07:30:00	491385	5598591	Lillooet River FSR - km 14	Sighting	crossing the road	1	TF	U	Unknown
		22-Nov-2018	08:15:00	472029	5607692	Lillooet River FSR - km 37	Sighting	female with calf (listed separately)	1	TF	F	Adult
		22-Nov-2018	08:15:00	472029	5607692	Lillooet River FSR - km 37	Sighting	calf with female (listed separately)	1	TF	U	Juvenile
		15-Nov-2018	13:05:00	472711	5607009	Alena Creek	Sign		1	LI	U	Unknown
		5-Dec-2018	11:31:00	472829	5606953	Alena Creek	Sign		1	LI	U	Unknown
		30-Apr-2018	11:19:00	472667	5610870	Boulder Creek HEF Intake Access Road	Sign	tracks	1	TF	U	Unknown
		30-Apr-2018	11:21:00	472716	5610899	Boulder Creek HEF Intake Access Road	Sign	scat	1	EX	U	Unknown
		23-May-2018	00:10:28	487456	5599913	Lillooet River transmission line crossing - south side	Sign	scat	1		U	Unknown
		9-Apr-2018	06:15:00	492804	5598184	Lillooet River FSR - km 12-13	Sighting		3	FL	F	Adult
		9-Apr-2018	06:15:00	492804	5598184	Lillooet River FSR - km 12-13	Sighting		3	FL	U	Juvenile
Mountain Goat	*Oreamnos* [redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		Sensitive location and timing information has been removed to protect this species.										
		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Mule Deer	*Odocoileus hemionus*	30-Apr-2018	15:40:00	487503	5600122	Lillooet River transmission line crossing	Sign	carcass located an old road to the left of the power lines, looks like a dump site for a hunter	6		U	Unknown
Wolverine	*Gulo gulo*	14-Mar-2018	13:30:00	471776	5609304	Boulder Creek HEF Diversion	Sign	tracks on river right bank in snow	1	TF	U	Unknown
		7-Mar-2018		466422	5614087	Keyhole Falls Bridge	Sign	possible wolverine track	1	LI	U	Unknown

Table 2. Incidental observations: Bear attractants associated with wildlife sightings.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Commercial Honey Bee Hive		15-Sep-2018		470067	5610045	First spur road on the left going up the Boulder Creek HEF Intake Access Road	Sighting	hive 4 - in this location for the season	1			
		15-Sep-2018		468771	5612257	Lillooet River FSR - hairpin turn near Truckwash Creek	Sighting	hive 2- in this location for the season.	1			
		15-Sep-2018		468060	5613106	Lillooet River FSR - km 44.2 near Truckwash Creek	Sighting	hive 1 - in this location for the season	1			
		15-Sep-2018		470072	5610331	Lillooet River FSR near Boulder Creek	Sighting	hive 3 - in this location for the season	1			

Table 3. Incidental wildlife sightings: Avian.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	**Scientific Name**			**Easting**	**Northing**							
American Wigeon	*Anas americana*	20-Apr-2018	11:00:00	466071	5614133	Upper Lillooet River HEF headpond	Sighting		10	FD	F	Adult
		20-Apr-2018	11:00:00	466071	5614133	Upper Lillooet River HEF headpond	Sighting		10	FD	M	Adult
Bald Eagle	*Haliaeetus leucocephalus*	15-Dec-2018	16:30:00	472686	5606940	Lillooet River FSR - km 36	Sighting	sitting in a tree	2	LI	U	Unknown
		22-Nov-2018	11:30:00	469343	5610404	Lillooet River FSR - km 41	Sighting		1	LI	U	Unknown
		15-Nov-2018	10:54:00	473409	5605965	Alena Creek	Sighting	perched in trees	7	LI	U	Unknown
		5-Dec-2018	10:54:00	473116	5606588	Alena Creek	Sighting		4	LI	U	Adult
		5-Nov-2018	14:38:00	466317	5614102	Upper Lillooet River HEF headpond	Sighting		1	TF	U	Unknown
Barrow's Goldeneye	*Bucephala islandica*	20-Apr-2018	11:00:00	466016	5614182	Upper Lillooet River HEF headpond	Sighting		6	FD	F	Adult
		20-Apr-2018	11:00:00	466016	5614182	Upper Lillooet River HEF headpond	Sighting		6	FD	M	Adult
bird carcass		30-Apr-2018	15:40:00	487503	5600122	Lillooet River transmission line crossing	Sign	pile of feathers off an old road to the left of the power lines, looks like a dump site for a hunter	1		U	Unknown
Bufflehead	*Bucephala albeola*	20-Apr-2018	11:00:00	466041	5614169	Upper Lillooet River HEF headpond	Sighting		1	FD	F	Adult
		20-Apr-2018	11:00:00	466041	5614169	Upper Lillooet River HEF headpond	Sighting		2	FD	M	Adult
Common Merganser	*Mergus merganser*	20-Apr-2018	11:00:00	466076	5614125	Upper Lillooet River HEF headpond	Sighting		1	FD	F	Adult
Duck		31-Aug-2018		465995	5614200	Upper Lillooet River HEF headpond	Sighting	dabblers, likely Green-winged Teal	6	LI	F	Unknown
Harlequin Duck	*Histrionicus histrionicus*	20-Apr-2018	11:00:00	466023	5614192	Upper Lillooet River HEF headpond	Sighting		1	FD	M	Adult
		20-Apr-2018	11:00:00	466023	5614192	Upper Lillooet River HEF Intake	Sighting		1	FD	F	Adult
		16-Sep-2018		466035	5614167	Upper Lillooet River HEF headpond	Sighting	Bufflehead or Harlequin Duck	2	LI	F	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. Continued.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Mallard	*Anas platyrhynchos*	20-Apr-2018	11:00:00	466030	5614176	Upper Lillooet River HEF headpond	Sighting		20	FD	F	Adult
		20-Apr-2018	11:00:00	466030	5614176	Upper Lillooet River HEF headpond	Sighting		20	FD	M	Adult
Ring-necked Duck	*Aythya collaris*	20-Apr-2018	11:00:00	466054	5614151	Upper Lillooet River HEF headpond	Sighting		10	FD	F	Adult
		20-Apr-2018	11:00:00	466054	5614151	Upper Lillooet River HEF headpond	Sighting		10	FD	M	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. Incidental wildlife sightings: Amphibians.

Species		Date	Time	UTM Coordinates (Zone 10U)		Location	Sighting Or Sign	Comments	Number	Activity[1]	Sex	Age
Common Name	Scientific Name			Easting	Northing							
Coastal Tailed Frog	*Ascaphus truei*	31-Aug-2018	11:50:00	468398	5612364	ULL-ASTR04IM	Sighting	observed during habitat survey	1	LI	U	Age Class 3
		31-Aug-2018	13:10:00	468457	5612553	ULL-ASTR04US	Sighting		1	LI	U	Metamorph
		31-Aug-2018	13:10:00	468453	5612458	ULL-ASTR04US, near the upstream culvert	Sighting		3	LI	U	Age Class 2 or 3
Northern Pacific Treefrog	*Pseudacris regilla*	17-May-2018	18:39:47	473014	5606332	Puddle in Meager Creek landslide area	Sighting	tadpoles	200	RR	U	Tadpole
Western Toad	*Anaxyrus boreas*	10-Sep-2018	18:00:00	471117	5609493	Boulder Creek HEF Intake Access Road - km 2	Sighting	crossing the road	1	TF	U	Unknown
		28-Jun-2018	16:30:00	472926	5606246	Lillooet River, near confluence with Meager Creek	Sighting	on gravel bar	1	ST	U	Adult
		17-May-2018	18:37:34	473015	5606330	Puddle in Meager Creek landslide area	Sighting	tadpoles	500	RR	U	Tadpole
		5-Jul-2018	17:02:32	472631	5606691	Lillooet River, near confluence with Meager Creek	Sighting		1	BA	UNK	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

Appendix S. Coastal Tailed Frog Streams at Transmission Line Crossings: Compliance Monitoring Results and Photographs

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1. ULH-ASTRCM01

Figure 1. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM01, assessed on August 31, 2018.

Table 1. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM01, assessed on August 31, 2018.

General comment:	No clearing required. The stream was dry at the time of the assessment
Clearing restricted to topping trees:	n/a
Effective sediment and erosion control:	yes
Cut wood left in place:	n/a

2. ULH-ASTRCM02

Figure 2. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM02, assessed on August 31, 2018.

Table 2. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM02, assessed on August 31, 2018.

General comment:	Trees are burnt but still topped with cut wood left in place.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

3. ULH-ASTRCM03

Figure 3. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM03, assessed on September 21, 2018.

Table 3. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM03, assessed on September 21, 2018.

General comment:	River left of the stream appears to be an old clear cut. Cut wood placed over the creek.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

4. ULH-ASTRCM04

Figure 4. **Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM04, assessed on September 24, 2018.**

Table 4. **Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM04, assessed on September 24, 2018.**

General comment:	Some topped trees visible, wood left in place, no erosion issues observed. Small patch of fallen trees on river right appear to be windfall.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

5. ULH-ASTRCM05

Figure 5. **Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM05, assessed on September 24, 2018.**

Table 5. **Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM05, assessed on September 24, 2018.**

General comment:	Topped trees visible, wood left in place, no erosion issues observed near transmission line. Small slide observed upstream of transmission line is unrelated to the transmission line.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

6. ULH-ASTRCM06

Figure 6. **Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM06, assessed on June 19, 2018.**

Table 6. **Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM06, assessed on June19, 2018.**

General comment:	Very little flow when assessed. It appears that a high flow deposited material upstream of the culvert but the culvert is still passable.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

7. ULH-ASTRCM07

Figure 7. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM07.

Not assessed – No photo available

Table 7. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM07.

General comment:	Assessment not required as this transmission line crossing is over a non-classified drainage. Coastal Tailed Frogs were only detected further downslope where the drainage is more defined (salvages at ULL-TBTFSA09 to ULL-TBTFSA13).
Clearing restricted to topping trees:	n/a
Effective sediment and erosion control:	n/a
Cut wood left in place:	n/a

8. ULH-ASTRCM08

Figure 8. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM08, assessed on September 24, 2018.

Table 8. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM08, assessed on September 24, 2018.

General comment:	The transmission line is high enough here that no topping or clearing was necessary.
Clearing restricted to topping trees:	n/a
Effective sediment and erosion control:	yes
Cut wood left in place:	n/a

9. ULH-ASTRCM09

Figure 9. Coastal Tailed Frog stream crossed by the transmission line at ULH-ASTRCM09, assessed on September 24, 2018.

Table 9. Coastal Tailed Frog habitat restoration compliance monitoring summary at Transmission Line Crossing ULH-ASTRCM09, assessed on September 24, 2018.

General comment:	Topped trees visible, wood left in place, no erosion issues observed.
Clearing restricted to topping trees:	yes
Effective sediment and erosion control:	yes
Cut wood left in place:	yes

Appendix T. Grizzly Bear, Moose and Mule Deer Habitat Along the Transmission Line: Vegetated Screen Compliance Monitoring Results and Photographs

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1. ULH-MAMCM01

Figure 1. **Vegetated screen along the transmission line at ULH-MAMCM01, assessed on June 14, 2018.**

Table 1. **Vegetated screen monitoring summary at ULH-MAMCM01.**

General comment:	Site is partially burnt and will likely regenerate naturally but should be reassessed at a later date. Planting is not recommended at this time.
Species:	Grizzly Bear
Screen widths (m):	10, 5, 5
Average screen width (m):	7
Screen heights (m):	3, 6, 3
Average screen height (m):	4
% Screen coverages:	10, 20, 10
Average % screen coverage:	13
Percent stems preferred forage:	n/a, not within WHA 2-399

2. ULH-MAMCM02

Figure 2. **Vegetated screen along the transmission line at ULH-MAMCM02 (at the top of the hill in the photo), assessed on June 14, 2018.**

Table 2. **Vegetated screen monitoring summary at ULH-MAMCM02.**

General comment:	The area is burnt and will likely regenerate naturally but should be reassessed at a later date. Planting is not recommended at this time.
Species:	Grizzly Bear
Average screen width (m):	n/a
Average screen height (m):	n/a
Average % coverage:	n/a
Percent stems preferred forage:	n/a, not within WHA 2-399

3. ULH-MAMCM03

Figure 3. **Vegetated screen along the transmission line at ULH-MAMCM03, assessed on June 14, 2018.**

Table 3. **Vegetated screen monitoring summary at ULH-MAMCM03.**

General comment:	Mature vegetation was retained and site was not disturbed by construction.
Species:	Moose
Screen widths (m):	40, 20, 20
Average screen width (m):	27
Screen heights (m):	15, 8, 10
Average screen height (m):	11
% Screen coverages:	100, 100, 100
Average % screen coverage:	100

4. ULH-MAMCM04

Figure 4. Vegetated screen along the transmission line at ULH-MAMCM04A (river left of the creek), assessed on June 14, 2018.

Table 4. Vegetated screen monitoring summary at ULH-MAMCM04.

General comment:	Screen was maintained on river left of the creek. The screen is expected to grow to a height of 5 m within two or three years.
Species:	Grizzly Bear
Screen widths (m):	20, 10, 12
Average screen width (m):	14
Screen heights (m):	4, 3, 5
Average screen height (m):	4
% Screen coverages:	100, 100, 100
Average % screen coverage:	100
Percent stems preferred forage:	n/a, not within WHA 2-399

Figure 5. Vegetated screen along the transmission line at ULH-MAMCM04B (river right of the creek), assessed on on June 14, 2018.

Table 5. Vegetated screen monitoring summary at ULH-MAMCM04B.

General comment:	There is no screen on river right of the creek, but there is abundant immature revegetation that is expected to grow to a height of 5 m within five years.
Species:	Grizzly Bear
Average screen width (m):	n/a
Average screen height (m):	n/a
Average % coverage:	n/a
Percent stems preferred forage:	n/a, not within WHA 2-399

5. ULH-MAMCM05

Figure 6. Vegetated screen along the transmission line at ULH-MAMCM05, assessed on on June 14, 2018.

Table 6. Vegetated screen monitoring summary at ULH-MAMCM05.

General comment:	Good shrub cover.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	20, 15, 15
Average screen width (m):	17
Screen heights (m):	5, 5, 5
Average screen height (m):	5
% Screen coverages:	80, 100, 100
Average % screen coverage:	93
Percent stems preferred forage:	Grizzly Bear – n/a, not within WHA 2-399

6. ULH-MAMCM06

Figure 7. **Vegetated screen along the transmission line at ULH-MAMCM06, assessed on on June 14, 2018.**

Table 7. **Vegetated screen monitoring summary at ULH-MAMCM06.**

General comment:	Good dense shrub cover. Screen is expected to grow taller than 5 m within 2 or 3 years.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	20, 15, 15
Average screen width (m):	17
Screen heights (m):	3, 2, 2
Average screen height (m):	2
% Screen coverages:	20, 50, 20
Average % screen coverage:	30
Percent stems preferred forage:	Grizzly Bear – n/a, not within WHA 2-399

7. ULH-MAMCM07

Figure 8. Vegetated screen along the transmission line at ULH-MAMCM07, assessed on on June 14, 2018.

Table 8. Vegetated screen monitoring summary at ULH-MAMCM07.

General comment:	Vegetation is regenerating naturally and expected to grow taller than 5 m, except within the 70 m wide scree slope where planting would not be feasible due to the substrate.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	2, 5, 2
Average screen width (m):	3
Screen heights (m):	3, 2, 1
Average screen height (m):	2
% Screen coverages:	20, 10, 0
Average % screen coverage:	10
Percent stems preferred forage:	Grizzly Bear – n/a, not within WHA 2-399

8. ULH-MAMCM08

Figure 9. **Vegetated screen along the transmission line at ULH-MAMCM08, assessed on on June 14, 2018.**

Table 9. **Vegetated screen monitoring summary at ULH-MAMCM08.**

General comment:	A diversity of dense vegetation is regenerating naturally and expected to grow taller than 5 m.
Species:	Mule Deer
Screen widths (m):	15, 20, 15
Average screen width (m):	17
Screen heights (m):	2, 5, 3
Average screen height (m):	3
% Screen coverages:	40, 80, 20
Average % screen coverage:	47

9. ULH-MAMCM09

Figure 10. Vegetated screen along the transmission line at ULH-MAMCM09, assessed on on June 14, 2018.

Table 10. Vegetated screen monitoring summary at ULH-MAMCM09.

General comment:	Some vegetation will likely grow taller than 5 m over time but limited regeneration in some areas. Planting may be recommended in the future.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	1, 3, 2
Average screen width (m):	2
Screen heights (m):	1, 1, 1.5
Average screen height (m):	1
% Screen coverages:	5, 2, 5
Average % screen coverage:	4
Percent stems preferred forage:	Grizzly Bear – n/a, not within WHA 2-399

10. ULH-MAMCM10

Figure 11. Vegetated screen along the transmission line at ULH-MAMCM10, assessed on on June 14, 2018.

Table 11. Vegetated screen monitoring summary at ULH-MAMCM10.

General comment:	Vegetation is expected to fill in and grow taller than 5 m.
Species:	Mule Deer
Screen widths (m):	8. 10, 10
Average screen width (m):	9
Screen heights (m):	1, 1, 1
Average screen height (m):	1
% Screen coverages:	10, 10, 10
Average % screen coverage:	10

11. ULH-MAMCM11

Figure 12. **Vegetated screen along the transmission line at ULH-MAMCM11, assessed on on June 14, 2018.**

Table 12. **Vegetated screen monitoring summary at ULH-MAMCM11.**

General comment:	Maintained screen includes some approximately 20 m tall conifers. Remaining vegetation is expected to grow taller than 5 m.
Species:	Mule Deer
Screen widths (m):	5, 10, 5
Average screen width (m):	7
Screen heights (m):	2, 1, 2
Average screen height (m):	2
% Screen coverages:	50, 30, 40
Average % screen coverage:	40

12. ULH-MAMCM12

Figure 13. **Vegetated screen along the transmission line at ULH-MAMCM12, assessed on on June 14, 2018.**

Table 13. **Vegetated screen monitoring summary at ULH-MAMCM12.**

General comment:	Vegetation is expected to fill in and grow taller than 5 m.
Species:	Moose
Screen widths (m):	10, 5, 5
Average screen width (m):	7
Screen heights (m):	2, 1, 2
Average screen height (m):	2
% Screen coverages:	10, 10, 10
Average % screen coverage:	10

13. ULH-MAMCM13

Figure 14. Vegetated screen along the transmission line at ULH-MAMCM13, assessed on on June 14, 2018.

Table 14. Vegetated screen monitoring summary at ULH-MAMCM13.

General comment:	Young and mature pine were retained.
Species:	Moose
Screen widths (m):	25, 25, 25
Average screen width (m):	25
Screen heights (m):	18, 20, 20
Average screen height (m):	19
% Screen coverages:	30, 30, 30
Average % screen coverage:	30

14. ULH-MAMCM14

Figure 15. Vegetated screen along the transmission line at ULH-MAMCM14, assessed on on June 6, 2018.

Table 15. Vegetated screen monitoring summary at ULH-MAMCM14.

General comment:	Within WHA 2-399 the road was deactivated with the addition of coarse woody debris, and a vegetation screen was maintained. The screen consisted of maintained vegetation and no planting was observed. Vegetation is on a trajectory to grow taller than 5 m.
Species:	Grizzly Bear and Moose
Road deactivated:	Yes
Screen widths (m):	5, 10, 12
Average screen width (m):	9
Screen heights (m)	3, 2, 2.5
Average screen height (m):	3
% Screen coverages	100, 100, 100
Average % screen coverage:	100
Percent stems preferred forage:	Grizzly Bear – 67%

15. ULH-MAMCM15

Figure 16. **Vegetated screen along the transmission line at ULH-MAMCM15, assessed on on June 6, 2018.**

Table 16. **Vegetated screen monitoring summary at ULH-MAMCM15.**

General comment:	Vegetation is expected to fill in and continue to grow taller.
Species:	Moose
Screen widths (m):	8, 15, 10
Average screen width (m):	11
Screen heights (m):	8, 3, 3
Average screen height (m):	5
% Screen coverages:	100, 100, 100
Average % screen coverage:	100

16. ULH-MAMCM16

Figure 17. **Vegetated screen along the transmission line at ULH-MAMCM16, assessed on on June 6, 2018.**

Table 17. **Vegetated screen monitoring summary at ULH-MAMCM16.**

General comment:	Road deactivated and screen maintained within WHA 2-399. The South Creek debris flow that flowed into this area did not affect the maintained screen. The screen consisted of maintained vegetation and no planting was observed.
Species:	Grizzly Bear and Moose
Road deactivated:	Yes
Screen widths (m):	8, 10, 10
Average screen width (m):	9
Screen heights (m):	8, 2, 5
Average screen height (m):	5
% Screen coverages:	100, 30, 40
Average % screen coverage:	57
Percent stems preferred forage:	Grizzly Bear – 71%

17. ULH-MAMCM17

Figure 18. Vegetated screen along the transmission line at ULH-MAMCM17, assessed on on June 6, 2018.

Table 18. Vegetated screen monitoring summary at ULH-MAMCM17.

General comment:	There is a small gap in the screen at the transmission line pole but the gap is difficult to see through from the road. There is no screen on river right of the creek approximately 90 m along the road, but this is a result of Squamish Mills activity and isn't attributable to the Project.
Species:	Grizzly Bear
Screen widths (m):	8, 5, 10
Average screen width (m):	8
Screen heights (m):	3, 2, 3
Average screen height (m):	3
% Screen coverages:	80, 80, 100
Average % screen coverage:	87
Percent stems preferred forage:	n/a, not within WHA 2-399

18. ULH-MAMCM18

Figure 19. Vegetated screen along the transmission line at ULH-MAMCM18, assessed on on June 6, 2018.

Table 19. Vegetated screen monitoring summary at ULH-MAMCM18.

General comment:	Easy road access and no screen maintained; however, natural regeneration is expected to grow taller and fill in.
Species:	Grizzly Bear
Screen widths (m):	20, 20, 20
Average screen width (m):	20
Screen heights (m):	1,2,2
Average screen height (m):	2
% Screen coverages:	0, 40, 50
Average % screen coverage:	30
Percent stems preferred forage:	n/a, not within WHA 2-399

19. ULH-MAMCM19

Figure 20. Vegetated screen along the transmission line at ULH-MAMCM19, assessed on on June 6, 2018.

Table 20. Vegetated screen monitoring summary at ULH-MAMCM19.

General comment:	Tower access road deactivated. Short maintained screen is expected to grow taller and fill in.
Species:	Grizzly Bear
Road deactivated:	Yes
Screen widths (m):	10, 10, 10
Average screen width (m):	10
Screen heights (m):	5, 3, 1
Average screen height (m):	3
% Screen coverages:	0, 30, 30
Average % screen coverage:	20
Percent stems preferred forage:	n/a, not within WHA 2-399

20. ULH-MAMCM20

Figure 21. Vegetated screen along the transmission line at ULH-MAMCM20, assessed on on June 19, 2018.

Table 21. Vegetated screen monitoring summary at ULH-MAMCM20.

General comment:	Screen on this steep slope is expected to grow taller than 5 m and fill in.
Species:	Mule Deer
Screen widths (m):	15, 15, 12
Average screen width (m):	14
Screen heights (m):	5, 2, 5
Average screen height (m):	4
% Screen coverages:	25, 50, 50
Average % screen coverage:	42

21. ULH-MAMCM21

Figure 22. Vegetated screen along the transmission line at ULH-MAMCM21, assessed on on June 19, 2018.

Table 22. Vegetated screen monitoring summary at ULH-MAMCM21.

General comment:	Screen on this steep slope is expected to grow taller than 5 m and fill in. The transmission line is over the road in places here.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	5, 5, 2
Average screen width (m):	4
Screen heights (m):	5, 4, 3
Average screen height (m):	4
% Screen coverages:	50, 50, 60
Average % screen coverage:	53
Percent stems preferred forage:	Grizzly Bear - n/a, not within WHA 2-399

22. ULH-MAMCM22

Figure 23. **Vegetated screen along the transmission line at ULH-MAMCM22, assessed on on June 19, 2018.**

Table 23. **Vegetated screen monitoring summary at ULH-MAMCM22.**

General comment:	Screen on this steep slope is expected to grow taller than 5 m and fill in. The transmission line is over the road in places here.
Species:	Grizzly Bear
Screen widths (m):	10, 8, 2
Average screen width (m):	7
Screen heights (m):	5, 2, 2
Average screen height (m):	3
% Screen coverages:	50, 50, 60
Average % screen coverage:	53
Percent stems preferred forage:	n/a, not within WHA 2-399

23. ULH-MAMCM23

Figure 24. Vegetated screen along the transmission line at ULH-MAMCM23, assessed on on June 19, 2018.

Table 24. Vegetated screen monitoring summary at ULH-MAMCM23.

General comment:	Minimal screen at this site. Wood chips are restricting regeneration, but the vegetation is expected to fill in and grow taller than 5 m over time.
Species:	Grizzly Bear
Screen widths (m):	3, 10, 10
Average screen width (m):	8
Screen heights (m):	0.5, 2, 1
Average screen height (m):	1
% Screen coverages:	0, 0, 0
Average % screen coverage:	0
Percent stems preferred forage:	n/a, not within WHA 2-399

24. ULH-MAMCM24

Figure 25. Vegetated screen along the transmission line at ULH-MAMCM24, assessed on on June 19, 2018.

Table 25. Vegetated screen monitoring summary at ULH-MAMCM24.

General comment:	The short vegetation along the road is expected to fill in and grow taller than 5 m, but the overall height will be limited by the transmission line above.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	n/a
Average screen width (m):	
Screen heights (m):	0.5, 0.5, 1
Average screen height (m):	1
% Screen coverages:	0, 0, 0
Average % screen coverage:	0
Percent stems preferred forage:	Grizzly Bear - n/a, not within WHA 2-399

25. ULH-MAMCM25

Figure 26. Vegetated screen along the transmission line at ULH-MAMCM25, assessed on on June 19, 2018.

Table 26. Vegetated screen monitoring summary at ULH-MAMCM25.

General comment:	The vegetated screen is expected to fill in and grow taller than 5 m.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	5, 10, 10
Average screen width (m):	8
Screen heights (m):	5, 3, 5
Average screen height (m):	4
% Screen coverages:	50, 80, 70
Average % screen coverage:	67
Percent stems preferred forage:	Grizzly Bear - n/a, not within WHA 2-399

26. ULH-MAMCM26

Figure 27. Vegetated screen along the transmission line at ULH-MAMCM26, assessed on on June 19, 2018.

Table 27. Vegetated screen monitoring summary at ULH-MAMCM26.

General comment:	The vegetated screen is expected to fill in and grow taller than 5 m.
Species:	Grizzly Bear and Mule Deer
Screen widths (m):	40, 40, 40
Average screen width (m):	40
Screen heights (m):	1, 2, 3
Average screen height (m):	2
% Screen coverages:	50, 50, 50
Average % screen coverage:	50
Percent stems preferred forage:	Grizzly Bear - n/a, not within WHA 2-399

27. ULH-MAMCM27

Figure 28. Vegetated screen along the transmission line at ULH-MAMCM27, assessed on on June 21, 2018.

Table 28. Vegetated screen monitoring summary at ULH-MAMCM27.

General comment:	Road deactivated and vegetated screen growing well. The screen is expected to grow taller than 5 m.
Species:	Grizzly Bear
Screen widths (m):	20, 50, 50
Average screen width (m):	40
Screen heights (m):	2, 3, 2
Average screen height (m):	2
% Screen coverages:	90, 81, 80
Average % screen coverage:	84
Percent stems preferred forage:	n/a, not within WHA 2-399

28. ULH-MAMCM28

Figure 29. Vegetated screen along the transmission line at ULH-MAMCM28, assessed on on June 21, 2018.

Table 29. Vegetated screen monitoring summary at ULH-MAMCM28.

General comment:	Short vegetated screen is expected to fill in and become taller than 5 m.
Species:	Grizzly Bear
Screen widths (m):	30, 50, 40
Average screen width (m):	40
Screen heights (m):	0.3, 1, 1.5
Average screen height (m):	1
% Screen coverages:	0, 0, 10
Average % screen coverage:	3
Percent stems preferred forage:	n/a, not within WHA 2-399

Appendix U. Wildlife Sign Observed During Systematic Winter Ground-based Surveys within the Truckwash Creek Mountain Goat Migration Corridor and near the Boulder Creek HEF Intake

LIST OF TABLES

Table 1. **Wildlife sign observed during systematic winter ground-based surveys within the Truckwash Creek Mountain Goat migration corridor.**

Date	Species		Transect	UTM Coordinates (Zone 10U)	
	Common Name	Scientific Name		Easting	Northing
14-Jan-2018	American Marten	*Martes americana*	ULL-SNTR01	467753	5613205
				467798	5612923
				467824	5613319
				467926	5612995
			ULL-SNTR02	467942	5613229
			ULL-SNTR03	467805	5613121
				467820	5613076
				467853	5613018
	Douglas Squirrel	*Tamiasciurus douglasii*	ULL-SNTR01	467691	5612987
				467898	5612921
			ULL-SNTR02	467931	5619226
	Fisher	*Pekania pennanti*	ULL-SNTR01	467900	5613295
	mammal	unknown species	ULL-SNTR01	467681	5613087
				467900	5613295
			ULL-SNTR03	467853	5613018
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR01	467691	5612987
				467798	5612923
				467844	5612902
				467898	5612921
				467900	5613295
			ULL-SNTR02	467930	5613190
			ULL-SNTR03	467833	5613301
	Wolverine	*Gulo gulo*	ULL-SNTR01	467692	5612989
15-Feb-2018	American Marten	*Martes americana*	ULL-SNTR01	467658	5613093
				467830	5613023
				467862	5612912
				467923	5613277
	mammal	unknown species	ULL-SNTR01	467629	5613276
				467830	5613023
			ULL-SNTR05	467950	5613232
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR01	467658	5613093
				467685	5613221
				467809	5613307
				467812	5613040
				467847	5612910
				467897	5612962
			ULL-SNTR04	467853	5613062
			ULL-SNTR05	467971	5613307

Table 1. Continued.

Date	Species		Transect	UTM Coordinates (Zone 10U)	
	Common Name	Scientific Name		Easting	Northing
7-Mar-2018	American Marten	*Martes americana*	ULL-SNTR01	467654	5613070
				467824	5613037
				467896	5612962
			ULL-SNTR04	467865	5613293
			ULL-SNTR05	467934	5613225
				467953	5613333
	Coyote	*Canis latrans*	ULL-SNTR01	467824	5613037
	Douglas Squirrel	*Tamiasciurus douglasii*	ULL-SNTR05	467934	5613225
	mammal	unknown species	ULL-SNTR01	467748	5613276
			ULL-SNTR05	467949	5613291
				467966	5613357
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR01	467654	5613070
				467799	5612936
			ULL-SNTR04	467878	5613238
9-Apr-2018	American Black Bear	*Ursus americanus*	ULL-SNTR05	467947	5613296
	Grizzly Bear	*Ursus arctos*	ULL-SNTR01	467686	5613063
	mammal	unknown species	ULL-SNTR01	467826	5613041
			ULL-SNTR04	467888	5613297
			ULL-SNTR05	467926	5613193
				467962	5613246
				468029	5613089
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR04	467846	5613127
				467847	5613098
				467849	5613148
[redacted]	American Marten	*Martes americana*	ULL-SNTR01	467807	5612937
	Bear	unknown species	ULL-SNTR01	467761	5613202
	Bobcat	*Lynx rufus*	ULL-SNTR04	467873	5613242
	Coyote	*Canis latrans*	ULL-SNTR05	467921	5613195
	Grey Wolf	*Canis lupus*	ULL-SNTR05	467938	5613251
	Grizzly Bear	*Ursus arctos*	ULL-SNTR05	467927	5613176
	mammal	unknown species	ULL-SNTR01	467936	5612968
	Mountain Goat	*Oreamnos americanus*	[redacted]	[redacted]	[redacted]
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR04	467849	5613142

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

Table 1. Continued.

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

Date	Species		Transect	UTM Coordinates (Zone 10U)	
	Common Name	**Scientific Name**		**Easting**	**Northing**
[redacted]	Moose	*Alces americanus*	ULL-SNTR04	467851	5613184
				467888	5613304
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Mule Deer	*Odocoileus hemionus*	ULL-SNTR01	467659	5613086
				467802	5612960
				467825	5612924
				467827	5613042
				467882	5612966
				467905	5613219
				467908	5612957
			ULL-SNTR04	467836	5613071
				467847	5613065
				467851	5613184
			ULL-SNTR05	467905	5613219
				467951	5613249
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR04	467870	5613293
	ungulate	unknown species	ULL-SNTR04	467847	5613065
			ULL-SNTR05	467971	5613347
	Yellow-pine Chipmunk	*Neotamias amoenus*	ULL-SNTR04	467847	5613065
4-Dec-2018	Bobcat	*Lynx rufus*	ULL-SNTR04	467874	5613288
	Moose	*Alces americanus*	ULL-SNTR01	467912	5612958
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR01	467820	5613041
				467847	5612915
			ULL-SNTR04	467847	5613161
				467868	5613214
				467874	5613288
	unidentified		ULL-SNTR05	468001	5612957
30-Jan-2019	American Marten	*Martes americana*	ULL-SNTR01	467825	5613039
				467883	5612918
	Bobcat	*Lynx rufus*	ULL-SNTR05	467931	5613203
	mammal	unknown species	ULL-SNTR04	467903	5613265
	Snowshoe Hare	*Lepus americanus*	ULL-SNTR01	467759	5612963
				467832	5613027
			ULL-SNTR04	467902	5613266
			ULL-SNTR05	467931	5613203
				467948	5613290

Table 2. Wildlife sign observed during systematic winter ground-based surveys near the Boulder Creek HEF intake.

Date	Species		Transect	UTM Coordinates (Zone 10U)	
	Common Name	Scientific Name		Easting	Northing
6-Feb-2018	American Marten	*Martes americana*	BDR-SNTR03	473199	5611430
	Bobcat	*Lynx rufus*	BDR-SNTR03	473009	5611095
				473145	5611230
				473191	5611373
	mammal		BDR-SNTR01	472865	5610993
			BDR-SNTR02	473277	5611408
			BDR-SNTR03	473191	5611373
				473198	5611412
	Snowshoe Hare	*Lepus americanus*	BDR-SNTR02	473247	5611442
				473300	5611355
22-Feb-2018	American Marten	*Martes americana*	BDR-SNTR01	472874	5610981
			BDR-SNTR02	473209	5611465
			BDR-SNTR03	472706	5610977
				472844	5611095
				472929	5611155
	Douglas Squirrel	*Tamiasciurus douglasii*	BDR-SNTR03	473195	5611443
	mammal		BDR-SNTR01	472094	5610993
				473015	5611056
				473075	5611077
				473086	5611082
				473140	5611137
				473308	5611247
			BDR-SNTR03	472706	5610977
				473018	5611239
				473078	5611297
	Snowshoe Hare	*Lepus americanus*	BDR-SNTR02	473285	5611410
			BDR-SNTR03	472844	5611095
				473151	5611340
6-Mar-2018	American Marten	*Martes american*	BDR-SNTR01	473002	5611058
				473228	5611184
			BDR-SNTR03	472844	5611099
				473029	5611248
	Douglas Squirrel	*Tamiasciurus douglasii*	BDR-SNTR01	473002	5611058
			BDR-SNTR02	473274	5611398
			BDR-SNTR03	472844	5611099
	mammal		BDR-SNTR03	472851	5611117
	owl (unknown species)		BDR-SNTR02	473308	5611342
31-Mar-2018	no species detected		BDR-SNTR01	-	-
			BDR-SNTR02	-	-
			BDR-SNTR03	-	-

Table 2. Continued.

Date	Species		Transect	UTM Coordinates (Zone 10U)	
	Common Name	Scientific Name		Easting	Northing
12-Apr-2018	American Marten	*Martes americana*	BDR-SNTR02	473201	5611473
				473213	5611472
				473297	5611397
			BDR-SNTR03	472751	5611017
				472918	5611156
				473120	5611324
	Coyote	*Canis latrans*	BDR-SNTR01	473363	5611406
[redacted]	mammal		BDR-SNTR01	473080	5611086
	Moose	*Alces americanus*	BDR-SNTR01	472962	5611025
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Snowshoe Hare	*Lepus americanu*	BDR-SNTR02	473301	5611346
			BDR-SNTR03	473178	5611393
	Sooty Grouse	*Dendragapus fuliginosus*	BDR-SNTR03	472986	5611227
	ungulate (unknown species)		BDR-SNTR03	472861	5611117
8-May-2018	mammal		BDR-SNTR02	473284	5611414
	Snowshoe Hare	*Lepus americanus*	BDR-SNTR02	473302	5611372
			BDR-SNTR03	473182	5611452
30-Nov-2018	Snowshoe Hare	*Lepus americanus*	BDR-SNTR02	473294	5611291
			BDR-SNTR03	472714	5610996
				472787	5611056
				473192	5611462
	unknown species		BDR-SNTR02	473319	5611202
			BDR-SNTR03	472720	5610970
				472839	5611096

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

Appendix V. Summary of Wildlife Photographed by Remote Infrared Cameras within the Truckwash Creek Mountain Goat Migration Corridor and near the Boulder Creek HEF Intake

LIST OF TABLES

Table 1. **Wildlife photographed by remote infrared camers within the Truckwash Creek Mountain Goat migration corridor.**

Species		Camera	Number of Dates Photographed January 26, 2017 to January 30, 2019
Common Name	Scientific Name		
American Black Bear	*Ursus americanus*	ULL-CAM14	7
		ULL-CAM15	41
		ULL-CAM16	24
American Marten	*Martes americana*	ULL-CAM14	3
		ULL-CAM15	15
		ULL-CAM16	1
American Robin	*Turdus migratorius*	ULL-CAM16	1
Bear (unknown species)		ULL-CAM02	1
bird (unknown species)	*bird*	ULL-CAM02	1
		ULL-CAM16	1
Bobcat	*Lynx rufus*	ULL-CAM14	1
		ULL-CAM15	1
Cougar	*Puma concolor*	ULL-CAM15	3
Dark-eyed Junco	*Junco hyemalis*	ULL-CAM15	2
Douglas Squirrel	*Tamiasciurus douglasii*	ULL-CAM15	19
		ULL-CAM16	1
Elk	*Cervus canadensis*	ULL-CAM14	1
Grizzly Bear	*Ursus arctos*	ULL-CAM15	2
Moose	*Alces americanus*	ULL-CAM02	1
		ULL-CAM08	1
		ULL-CAM15	25
Mountain Goat Sensitive location and timing information has been removed to protect this species.	*Oreamnos americanus*	[redacted]	[redacted]
		[redacted]	[redacted]
		[redacted]	[redacted]
Mule Deer	*Odocoileus hemionus*	ULL-CAM02	1
		ULL-CAM02	7
		ULL-CAM08	15
		ULL-CAM14	31
		ULL-CAM15	104
		ULL-CAM16	32
mustelid (unknown species)		ULL-CAM15	1
rodent (unknown species)		ULL-CAM02	4
		ULL-CAM15	1
Snowshoe Hare	*Lepus americanus*	ULL-CAM08	1
		ULL-CAM14	6
		ULL-CAM15	6
Steller's Jay	*Cyanocitta stelleri*	ULL-CAM15	2
unidentified animal	*unidentified*	ULL-CAM02	1
		ULL-CAM14	1
		ULL-CAM15	7
		ULL-CAM16	2
Varied Thrush	*Ixoreus naevius*	ULL-CAM15	1

Table 2. Wildlife photographed by remote infrared cameras near the Boulder Creek HEF intake.

Species		Camera	Number of Dates Photographed December 21, 2017 to January 17, 2019
Common Name	**Scientific Name**		
American Black Bear	*Ursus americanus*	BDR-CAM01	9
		BDR-CAM02	7
		BDR-CAM03	3
American Marten	*Martes americana*	BDR-CAM01	1
Bobcat	*Lynx rufus*	BDR-CAM02	1
Ermine	*Mustela erminea*	BDR-CAM08	1
Grizzly Bear	*Ursus arctos*	BDR-CAM02	2
Moose	*Alces americanus*	BDR-CAM01	2
		BDR-CAM02	2
		BDR-CAM03	2
Mule Deer	*Odocoileus hemionus*	BDR-CAM01	26
		BDR-CAM02	26
		BDR-CAM03	20
Douglas Squirrel or Red Squirrel	*Tamiasciurus sp.*	BDR-CAM01	1
Wolverine	*Gulo gulo*	BDR-CAM02	1