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MEMORANDUM

TO: **Big Silver Creek Power Limited Partnership.**

FROM: **Deborah Lacroix, M.Sc., R.P.Bio. and Heidi Regehr, Ph.D., R.P. Bio., Ecofish Research Ltd.**

DATE: **October 25, 2017**

FILE: **1189-12**

RE: **Big Silver Creek Waterpower Project Environmental Assessment Certificate Amendment Application for Schedule B to Seek Approval to Increase the Maximum Diversion Rate**

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1. INTRODUCTION

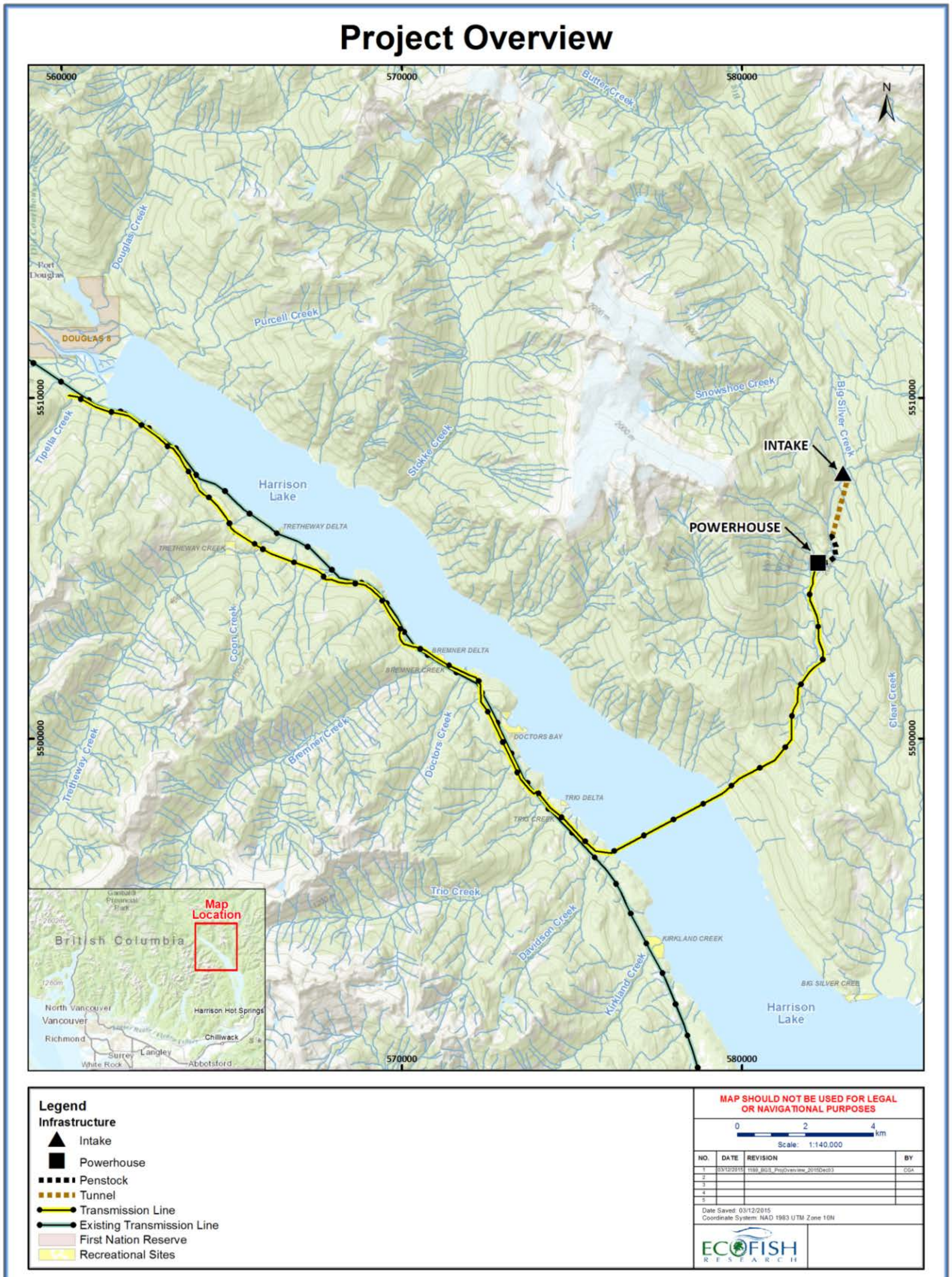
The Big Silver Waterpower Project (the Project) is a 40.6 MW run-of-river hydroelectric project, located 46 km north of Harrison Hot Springs, British Columbia (Map 1), that is operated by the Big Silver Creek Power Limited Partnership (BSCPLP). Water is diverted from Big Silver Creek at an intake located 19 km upstream of Harrison Lake, through a buried penstock to a powerhouse located 15.5 km upstream of the confluence with Harrison Lake. The maximum water diversion rate is restricted to 42.0 m^3/s by the Project's Conditional Water Licence (CWL) (C129606), as well as Condition #7 of Schedule B (Table of Conditions (TOC)) of the Project's Environmental Assessment Certificate (EAC) (#E12-03; EAO 2012).

BSCPLP is requesting an increase in the maximum diversion rate, from the current 42.0 m^3/s to 44.0 m^3/s, to augment the beneficial use of water for hydroelectric power. Given that Condition #7 of the Project's TOC currently limits the rate of diversion of water to 42.0 m^3/s, the requested increase in the maximum diversion rate requires an amendment to the Project's EAC. BSCPLP is concurrently applying for a new Water License from the BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO) water authorizations to permit the increase. Application for an EAC amendment requires that all valued components (VCs) identified during the environmental assessment process that may be affected by the proposed change are assessed to determine if the residual effects predicted in the original Application for an EAC (the EAC Application) will be affected. As part of the Project's EAC Application, an environmental assessment (EA), that assessed Project effects on all environmental and socio-economic VCs, was originally conducted by Ventus *et al.* (2011). An aquatic effects assessment was additionally conducted by Lewis *et al.* (2011a) that provided a detailed analysis of Project effects on the aquatic environment.

The proposed change in maximum diversion rate will affect flows within Big Silver Creek during the Project's operations phase. As such, the potential effects of the proposed change in maximum diversion rate on the VCs of the aquatic environment (fish habitat and its subcomponents) were evaluated in a detailed Aquatic Effects Assessment (hereafter referred to as the AEA), provided in Appendix A. This AEA evaluated all VCs that had been assessed in the original aquatics effects assessment completed in 2011 (Lewis *et al.* 2011a) in light of the proposed change in maximum diversion rate. This AEA, which fully assessed potential effects of the proposed change to hydrology, water quality, and multiple components of fish habitat during all life stages, is a key component of this amendment application. However, because the AEA only addressed VCs related directly to fish habitat and did not consider the other VCs assessed in the original EA (Ventus *et al.* 2011), additional assessment is required for other environmental and all socio-economic VCs. Nevertheless, given that any VCs that may interact with the proposed change are necessarily linked to stream flow and instream habitat, the results of the AEA remain highly relevant to the assessment of other VCs.

In accordance with Section 19(1) of the BC *Environmental Assessment Act* (BCEAA) (2002), BSCPLP, as the Certificate Holder, is requesting an amendment to the EAC (#E12-03) for the Big Silver Waterpower Project to change the maximum allowable diversion rate. Ecofish Research Ltd. (Ecofish) was retained to determine if the original intent to minimize residual adverse effects, on which the Ministers based their decision to grant Project approval, are maintained with the proposed change.

Map 1. Overview of the Big Silver Waterpower Project.



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2. PROPOSED CHANGE

BSCPLP is requesting an increase in the maximum diversion rate, from the current 42.0 m^3/s, which is specified in the Project's EAC and CWL, to 44.0 m^3/s. If the maximum diversion rate is increased, power production would also increase whenever flows exceed the instream flow requirement (IFR) of 1.9 m^3/s and the current diversion maximum (42.0 m^3/s). This would result in the delivery of the contract maximum electricity to the point of interconnection with BC Hydro's transmission system. However, given that diversion of water by the Project is already managed and restricted by the CWL, and that the EAC aims to minimize overlap and potential conflict with provincial permitting, BSCPLP requests that the condition that restricts maximum diversion be entirely removed from the TOC and that the change of the maximum diversion rate, from 42.0 m^3/s to 44.0 m^3/s, be addressed only in the CWL. Nevertheless, given that the request to remove Condition #7 from the TOC is based on the intent to increase the maximum diversion rate, the assessment required to evaluate the consequences of removal of this condition will be based on the proposed increase in the diversion rate.

3. ASSESSMENT METHODS

During the EA process, potential adverse effects were identified and evaluated for selected VCs to assess potential effects from all phases of Project development and mitigation measures were prescribed to avoid or minimize such adverse effects. Many of these identified constraints or conditions intended to mitigate potential effects were incorporated into Schedule B of the EAC (the TOC). Thus, because Schedule B of the EAC reflects the conclusions of the Project's Application for an EAC, and because any changes to these conditions have the potential to modify such conclusions, the potential consequences of the requested amendment on the conclusions of the EA must be evaluated. The assessment presented in this amendment application will ultimately determine whether the proposed change in maximum diversion rate will affect the conclusions of the EAC Application, on which the Ministers based their decision to grant Project approval, and on which Condition #7 of the TOC was based.

The assessment methods for the evaluation of the potential consequences of the proposed change in maximum diversion rate on the conclusions of the EAC Application were to firstly determine whether the VCs selected and assessed during the initial EA would interact with the proposed change. Those VCs anticipated not to interact with the proposed change were discounted. The remaining VCs were then assessed for each potential adverse effect identified in the EA to determine whether conclusions of the EA would be affected if the requested change was made and whether or not additional mitigation would be required. The assessment process therefore involved: 1) identifying environmental and socio-economic VCs with the potential to interact with the proposed change; 2) evaluating potential effects relevant to the proposed change; 3) evaluate the effectiveness of prescribed mitigation measures in mitigating potential Project effects in light of proposed change and recommending additional mitigation if necessary; and 4) evaluate whether conclusions drawn in the Project's EAC Application with respect to the residual effects, characterization of residual effects, and determination of significance, are affected by the proposed change. Consultation that had occurred during development of the amendment application was also documented, as was support from Working Group Members.

4. ASSESSMENT OF PROPOSED CHANGE

All environmental and socio-economic VCs that have the potential to interact with the proposed increase in maximum diversion rate have the potential to be affected by flow changes during Project operations, either directly, or because flow changes cause changes to instream habitat. As such, the only environmental VCs that have the potential to interact with the proposed change are the VCs in the aquatic environment associated with fish habitat, and the terrestrial wildlife VCs that are closely linked to instream habitat (Table 1). No other aspects of the environment, such as riparian habitat, terrestrial habitat, or components of the geophysical or atmospheric environment, have the potential to be affected by the proposed change. For the terrestrial wildlife environmental category, the only VCs that have the potential to interact with the proposed change are Herptiles, given that Pacific Tailed Frogs (*Ascaphus truei*) (also known as Coastal Tailed Frogs) occupy instream habitat and were identified as a focal wildlife species for the Project, and Avifauna, given that American Dippers (*Cinclus mexicanus*) and Harlequin Ducks (*Histrionicus histrionicus*) are riverine birds identified as focal wildlife species that feed on aquatic invertebrates. Similarly, the only socio-economic VC that has the potential to interact with the proposed change is navigable waters, because the navigability of water is dependent on flow (Table 2).

Table 1. Summary of valued environmental components and their potential to interact with the proposed change in maximum diversion rate.

Category	Valued Component	Interaction with Increasing Maximum Diversion Rate
Geophysical Environment	Soil Resources	No
Atmospheric Environment	Air Quality	No
Aquatic Environment	Water Quality	No
	Fish Rearing and overwintering Habitat	Yes
	Fish Spawning and Incubation Habitat	Yes
	Fish Migratory Habitat	Yes
	Riparian Habitat	No
	Macroinvertebrate Habitat	Yes
Terrestrial Wildlife	Herptiles	Yes
	Avifauna	Yes
	Chiropterids	No
	Mammals	No
	Other Sensitive Species	No
Terrestrial Vegetation	Rare Plants	No
	Rare Ecological Communities	No
Timber Resources	Timber Resources	No

Table 2. Summary of valued socio-economic components and their potential to interact with the proposed change in maximum diversion rate.

Category	Valued Components	Interaction with Increasing Maximum Diversion Rate
Valued Economic Market Components	Population Demographics	No
	Housing	No
	Transportation	No
	Services	No
	Local and regional economy	No
	Employment	No
Valued Social Components	Land Use	No
	Navigable waters	Yes
	First Nation Community Interests	No

4.1. Valued Components of the Aquatic Environment

The original aquatic EA (Lewis *et al.* 2011a) assessed the effects of the proposed Project on six subcomponents of the fish habitat VC: water quality, fish rearing and overwintering habitat, fish spawning and incubation habitat, fish migratory habitat, riparian habitat, and macroinvertebrate habitat. An Instream Flow Study (IFS) was also conducted during baseline studies (Lewis *et al.*

2011b) to inform the original aquatic EA. The AEA (Appendix A) assessed the potential effects of the proposed increase in the maximum diversion rate to the same subcomponents of fish habitat identified in the original aquatic EA (Lewis *et al.* 2011a), with the exception of riparian habitat, which will not be affected by the proposed change. This assessment was conducted by evaluating baseline data collected following the guidelines for water flow assessment prepared for the Ministry of Environment (Lewis *et al.* 2004, Hatfield *et al.* 2007) and re-running the instream flow analysis using an IFR of 1.9 m^3/s and a maximum diversion capacity of 44.0 m^3/s. The results of this analysis were compared to the instream flow analysis using the current operational flow scenario (i.e., maximum diversion capacity of 42.0 m^3/s).

Results of the AEA are fully presented in Appendix A. In summary, analyses predicted that the decrease in flow in the diversion reach of 2.0 m^3/s would lead to a 1.2% decrease in the average daily flow, with the greatest changes in flow magnitude expected during freshet period (May through July, with average monthly flows reduced by a maximum of 9% in June). Anticipated changes in water quality and temperature were not expected to have biologically significant adverse effects, given the small magnitude of the proposed flow changes, and based on the results from long-term monitoring programs on other run-of-river waterpower facilities that have similar maximum diversion rates as a percentage of mean annual discharge (MAD). Small incremental losses were predicted for Rainbow Trout parr rearing habitat and Rainbow Trout spawning habitat, but the magnitude of habitat loss was not predicted to result in serious harm to fish based on the small amount of habitat loss relative to that available and observations from other projects (positive effects on fish density and biomass) that also predicted habitat losses. The limited difference between the current and proposed flow scenarios also indicated that the proposed increase in the maximum diversion rate will result in negligible incremental change to fish migratory habitat and ecological considerations (flushing and channel maintenance flows, flood pulses, habitat connectivity, and behavioural cues), and will not alter the residual effects from ramping given the mitigation already in place. The AEA did predict small incremental losses (204 m^2, 0.9%) of habitat suitable for invertebrates that are swift-water specialists during the growing season compared to the current operational flow scenario, although the majority of the loss (76%) will occur in the non-fish-bearing diversion reach. As such, and based on results from operation of similar run-of-river waterpower facilities, this was not expected to result in biologically significant effects to either the invertebrate drift population or the resident fish population in the lower diversion reach.

Overall conclusions of the AEA were that the predicted minor incremental effects to fish habitat that are expected to result from the proposed increase in the maximum diversion rate do not warrant any changes to the residual effects characterizations for the effects of flow diversion on the subcomponents of the fish habitat VC assessed in the original EA (Lewis *et al.* 2011a), given the mitigation measures that have already been implemented to minimize Project effects (Hemmera 2015). Hence, no additional mitigation and/or compensation are required.

4.2. Valued Components of the Terrestrial Environment

Valued components of the terrestrial environment, which include terrestrial wildlife, terrestrial vegetation, and timber resources, were assessed for the Project's EAC Application in Ventus *et al.* (2011). Among the VCs evaluated, only herptiles and avifauna of the terrestrial wildlife category have the potential to be affected by the proposed change in maximum diversion rate (Table 1).

4.2.1. Herptiles: Pacific Tailed Frogs

Pacific Tailed Frogs have the potential to be affected by the proposed change in maximum diversion rate because flow changes may affect key instream habitat characteristics for the species. Preferred habitat is associated with clear and cool step-pool streams, with a low proportion of fine sediments, and a low to moderate disturbance regimes (COSEWIC 2011, Hayes and Quinn 2015).

Pacific Tailed Frogs were selected as a focal wildlife species for assessment in the original EA (Ventus *et al.* 2011; Table 15-24). However, during two years of baseline monitoring (2012 and 2013) the species was not detected in either the upper or the lower diversion of Big Silver Creek (Faulkner *et al.* 2014). These results, along with evaluation of habitat, suggested that the diversion has limited ability to support the species, potentially because Big Silver Creek is a relatively high volume hydrological system with significant channel forming events that may inhibit Pacific Tailed Frog populations.

4.2.1.1. Potential Effects

Potential effects identified for Pacific Tailed Frogs during Project operation in the original EA included habitat alteration and mortality within riparian areas due to maintenance around streams (herbicide use), and effects of flow regulation in the diversion reach (Ventus *et al.* 2011; Table 15-25). Of these, only effects of flow regulation have the potential to interact with the proposed change. Changes in flow have the potential to cause changes in habitat suitability for the species by affecting aspects of the aquatic habitat such as water quality, physical stream characteristics, habitat quality and quantity, and/or temperature. Results from the AEA (Appendix A) were relied on for assessment of the potential for the proposed change in maximum diversion rate to affect key habitat characteristics.

The AEA assessed whether the proposed change to maximum diversion rate is anticipated to affect water quality. However, anticipated changes in water quality were not expected to have biologically significant adverse effects. Thus, the proposed change in maximum diversion rate will not alter the original conclusions of the EA, that Project operation would have low magnitude, non-significant, residual effects on water quality (Lewis *et al.* 2011a). This conclusion was based on the baseline water quality conditions in Big Silver Creek relative to typical natural conditions in BC, and the change in water quality that would be needed to exceed water quality guidelines for the protection of aquatic life.

Stream characteristics, such as mesohabitat characteristics, substrate, and embeddedness, which are a key habitat characteristic for Pacific Tailed Frogs, may be affected by flow changes. However, assessment of hydrology in the AEA indicated that the proposed increase in the maximum diversion rate is predicted to cause relatively small flow changes in the diversion reach, equivalent to a 1.2% decrease in the average daily flow, with the largest effects expected to occur during the freshet when flows are naturally high (Appendix A). The proposed increase in the maximum diversion rate will have an effect on flows in the diversion reach only when natural flow exceeds the current diversion maximum. The IFR will not change; hence, any flow equal or less than 45.9 m^3/s or during natural low flow periods will not be affected.

The AEA also specifically assessed the potential effect of the increase in maximum flow diversion of ecological considerations such as flushing flows, channel maintenance flows, flood pulses, and habitat connectivity, all of which have the potential to alter habitat suitability for Pacific Tailed Frogs by changing physical stream characteristics. Flushing flows remove fine particles from the stream bed and are therefore important in preventing increased sedimentation which may infill interstitial spaces. Low embeddedness is a key habitat feature for Pacific Tailed Frogs owing to their use of interstitial spaces to provide protection from predators and bedload movements (COSEWIC 2011, Hayes and Quinn 2015, ECCC 2016). The AEA predicted that the proposed flow scenario would result in a negligible (<1%) reduction in the frequency of flows >100% MAD (which may be used as an indicator of sufficient flushing flows) relative to the current flow scenario. Similarly, a negligible decrease in the frequency of channel maintenance flows is anticipated that will not adversely affect channel maintenance processes. The frequency of channel maintenance flows may affect habitat suitability for Pacific Tailed Frogs by affecting physical stream characteristics and system stability. However, the slight predicted decrease in frequency may improve rather than reduce habitat suitability given that significant channel forming events of Big Silver Creek may inhibit Pacific Tailed Frog populations (Faulkner *et al.* 2014). Potential changes in flood pulses associated with the proposed change in maximum diversion rate were also considered negligible in the AEA and of little relevance to the diversion reach given the morphology of the channel and the nature of the riparian zone. Potential impacts to habitat connectivity, which may affect population connectivity of Pacific Tailed Frogs, were also assessed in the AEA, and it was concluded that habitat connectivity would not be affected given the lack of secondary channels in the diversion reach and the maintenance of the IFR.

Pacific Tailed Frogs have a narrow temperature tolerance range and stream temperature is an important component of habitat suitability that may also be affected by flow changes. Eggs and larvae are thought capable of normal development in temperatures ranging between approximately 5°C to 18°C, and water temperature is known to impact distribution, abundance, and maturation time for Pacific Tailed Frog eggs and larvae (Brown 1975, Hayes and Quinn 2015). The AEA predicted that reduced flows in the diversion reach will result in increased water temperatures during summer (the active, and breeding, period for Pacific Tailed Frogs) and reduced water temperatures during winter (the inactive period for Pacific Tailed Frogs). However, predicted changes relative to the current flow scenario were minor. During August, when stream temperatures are highest, a 2% increase in temperature in the diversion is anticipated. This is equivalent to changing a maximum hourly temperature of 13.2°C (the maximum recorded in August in 2011) (Faulkner *et al*. 2014), to 13.5°C. Further, the daily average flow is predicted to change an average of only 1 day per year. During winter, when Pacific Tailed Frog tadpoles become inactive and are thought to burrow into gravel and cobble substrates (Hayes and Quinn 2015), the lowest temperatures in the diversion (recorded in January) are anticipated to be reduced by 4% relative to the current flow scenario, and change between scenarios is predicted on an average of only 3 days per year. These differences in temperatures between flow scenarios were considered not significant in the AEA, given the natural range of inter-annual variability, and the evaluation of the original EA remained unchanged. They are also unlikely to affect Pacific Tailed Frogs, and given that water temperatures in Big Silver Creek were evaluated to be sub-optimally cold for the species during the active season (Faulkner *et al*. 2014), minor increases in summer stream temperatures are more likely to be beneficial.

The reduction of flows within the diversion reach also has the potential to reduce habitat availability (quantity) for Pacific Tailed Frogs due to decreased wetted widths. However, results of the AEA indicated that habitat losses for fish that would result from the proposed increase in maximum diversion rate, relative to the current diversion rate evaluated in the original EA, were minor in absolute terms and were not predicted to result in serious harm to fish.

4.2.1.2. Mitigation Measures

Mitigation measures prescribed in the original EA to address potential flow-related Project effects on Pacific Tailed Frogs were general prescriptions for flow regulation. The EA specified that flow within diversion reach will be maintained as defined by operating parameters set by provincial government, and that strategies will be in place to maintain fish habitat (Ventus *et al.* 2011). The maintenance of adequate flow for fish was therefore considered to also provide adequate protection for Pacific Tailed Frogs.

The AEA concluded that no additional mitigation and/or compensation was required given the proposed change in maximum diversion rate. Thus, given the mitigation (flow regulation) already in place, no additional mitigation is required to address the proposed change in maximum diversion rate for Pacific Tailed Frogs.

4.2.1.3. Evaluation of Changes to Residual Effects Characterization

In the original EA, residual effects were not anticipated for Project operations given the mitigation measures that would be implemented to manage flow in the diversion (Ventus *et al.* 2011; Table 15-25). Further, baseline monitoring for the species suggested that the diversion reach has limited ability to support the species (Faulkner *et al.* 2014). Thus, based on the minor or negligible predicted effects of the proposed increase in maximum diversion rate by the AEA on hydrology, water quality, physical stream characteristics, water temperature, and habitat quantity, along with the lack of documented occupancy by the species in the diversion reach during baseline studies, the proposed change in maximum diversion rate does not change the conclusion of the original EA of no residual effects for the Herptile VC (Pacific Tailed Frogs).

4.2.2. Avifauna: American Dipper and Harlequin Duck

American Dipper and Harlequin Duck have the potential to be affected by the proposed change in maximum water diversion because these two avian riverine species have been observed on Big Silver Creek (Appendix K of Ventus *et al.* 2011) and feed on instream macroinvertebrates (Feck and Hall 2004, Bond *et al.* 2007). Thus, flow changes may affect the foraging habitat for these two species by directly or indirectly affecting their food supply. Both species were selected as a focal wildlife species for assessment in the original EA (Ventus *et al.* 2011; Table 15-24).

4.2.2.1. Potential Effects

No adverse potential effects were identified during Project operations for American Dipper and Harlequin Duck (Ventus *et al.* 2011). In contrast, only potential positive effects were identified for operations owing to potential increases in foraging potential that may result from flow regulation. Potential impacts to the instream habitat quantity, or macroinvertebrate populations, which was assessed in the AEA and could potentially affect availability of foraging habitat, was not considered in the original EA.

Potential effects of the proposed increase in maximum diversion rate relative to the current flow scenario to hydrology, water quality and temperature, ecological considerations (such as flushing flows), and habitat quantity, which are also relevant to the evaluation of potential effects on American Dipper and Harlequin Duck, were assessed in the AEA (Appendix A) and are discussed in relation to potential effects on Pacific Tailed Frogs above (Section 4.2.1.1). All of these potential effects, which may indirectly affect the two avian riverine species by affecting their food supply, were evaluated to be not biologically significant.

In addition, the AEA also directly assessed the extent to which the proposed change in maximum diversion rate is predicted to impact the macroinvertebrate population. The AEA estimated that the proposed increase in maximum diversion rate, relative to the current flow scenario, would cause an incremental loss of 204 m^2 (0.9%) of habitat suitable for invertebrates that are swift-water specialists during the growing season. However, these predicted losses for swift-water specialists do not reflect potential changes for the entire macroinvertebrate community, and habitat losses for swift-water specialists are expected to be offset to a degree by an increase in habitat suitable for slow water specialists. The AEA concluded that the predicted marginal incremental losses in invertebrate habitat was not expected to result in biologically significant effects to the invertebrate drift population and does not warrant a change to the residual effects characterization for the effects of flow diversion on macroinvertebrate habitat in the original EA.

4.2.2.2. Mitigation Measures

No mitigation measures were prescribed for Project operations for either American Dipper or Harlequin Duck, given that adverse potential effects were not identified. The AEA, which evaluated impacts of the proposed change in maximum diversion rate to the aquatic environment (including the macroinvertebrate population), concluded that no additional mitigation and/or compensation were required. Thus, no additional mitigation is required to address the proposed change in maximum diversion rate for American Dipper and Harlequin Duck.

4.2.2.3. Evaluation of Changes to Residual Effects

No adverse effects were identified during Project operations for American Dipper and Harlequin Duck in the original EA; thus, there were also no residual effects identified (Ventus *et al.* 2011; Tables 15-33 and 15-34). Based on the minor predicted effects of the proposed increase in maximum diversion rate on hydrology, water quality and temperature, ecological considerations, habitat quantity, and macroinvertebrate habitat, the proposed change in maximum diversion rate does not change the conclusion of the original EA of no residual effects for the Avifauna VC (American Dipper and Harlequin Duck).

4.3. Valued Socio-economic Components

4.3.1. Navigable Waters

Changes in flow can affect the navigability of watercourses, and for Big Silver Creek, flow changes have the potential to affect recreational users (whitewater kayakers). Thus, the proposed change in maximum diversion rate has the potential affect the navigability of the Big Silver Creek diversion. Navigable waters was selected as a VC for assessment in the original EA (Ventus *et al.* 2011). During the EA (Ventus *et al.* 2011), the characteristics of the Big Silver Creek diversion reach was deemed suitable for expert kayakers. The Project received approval (Transport Canada 2013) under the *Navigable Waters Protection Act* (1985). Since the issuance of the permit, Big Silver Creek was declassified as a navigable water under the *Navigation Protection Act* (1985).

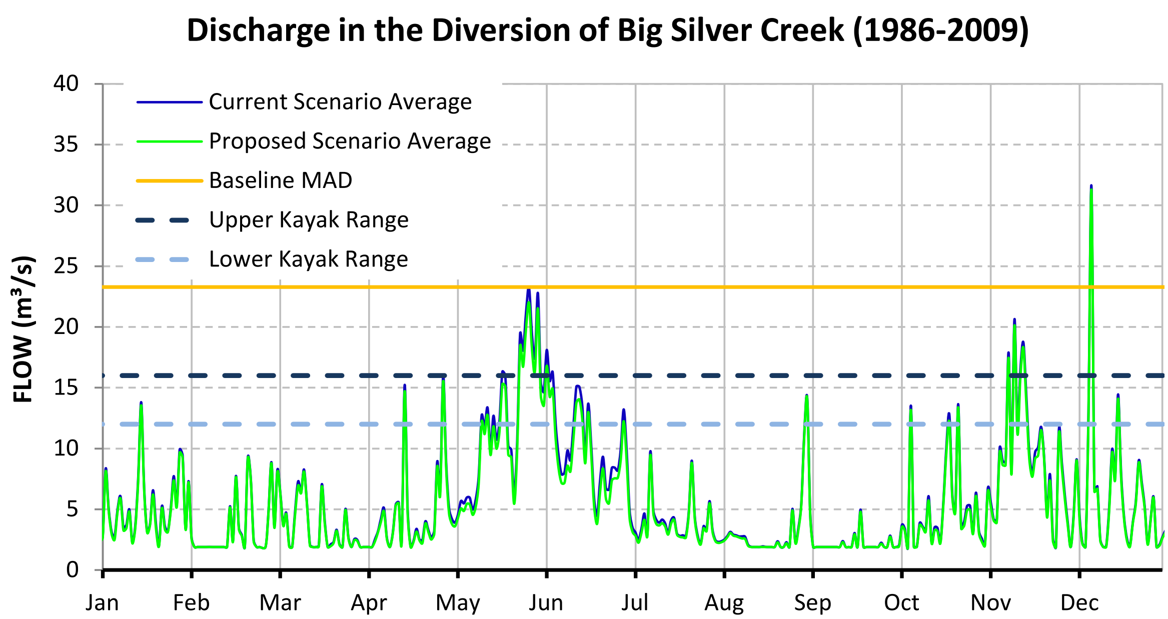
4.3.1.1. Potential Effects

Potential effects to navigable waters were identified for Project operations in the original EA. Two potential adverse effects were identified: flow diversion and interactions between kayakers and the headpond. Of these, only flow diversion has the potential to interact with the proposed change. Specifically, one navigable run on Big Silver Creek, the Middle Run, which is located predominantly within the diversion reach, is affected by Project-related flow changes (Typlan 2011). However, potential positive effects of flow diversion during Project operation were identified, given that flow reduction creates new opportunities for kayaking of the diversion reach when natural flows are too high. Typlan's (2017) assessment of pre and post project flows concluded that the reduction in flows would create 15 days of flows in excess of 16 m^3/s to accommodate paddlers that require higher flows and 39 days of flow at the lower kayaking range of 12 m^3/s that would be available to paddlers with the reduction of excessive natural flows. The reduction of flow was predicted to provide additional suitable flow days in November and December and during the early summery months coinciding with the freshet period.

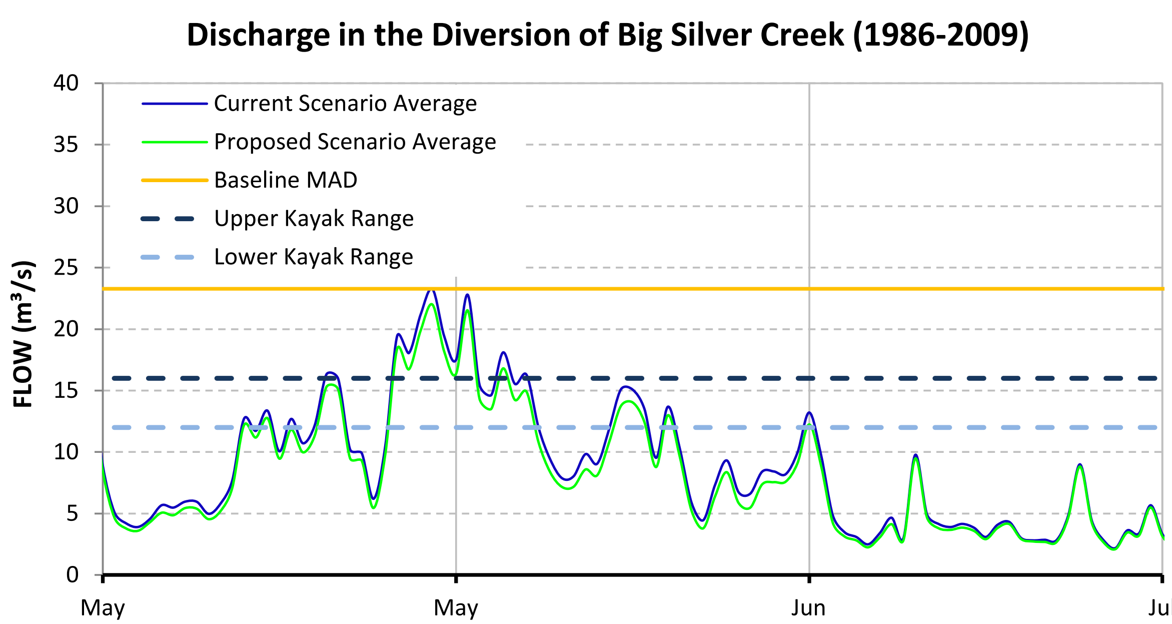
The proposed increase in the maximum diversion rate has the potential to affect the evaluation of the potential effects on the navigable waters VC because additional flow will be diverted from Big Silver Creek, when available. Typlan's (2017) pre and post project flow assessment was repeated with the current approved scenario (42.0 m^3/s) and the proposed scenario (44 .0 m^3/s) (Figure 1). Increasing the maximum diversion rate by 2 m^3/s will continue to create kayaking flows within the upper and lower kayaking flow ranges during the same time period. However, the number of days created would be reduced by 2 days at both the lower and higher kayaking flow ranges.

Figure 1. Current and proposed scenario discharge in the Big Silver Creek diversion reach over the entire year (a) and from May through July (b) with regards to lower (12 m^3/s) and upper (16 m^3/s) kayaking ranges (Typlan 2011).

a)



b)



4.3.1.2. Mitigation Measures

Mitigation measures were prescribed in the original EA to address potential effects of flow alterations to recreational users. Mitigation addressing flow changes included making real time flow data available to prospective recreational users by providing this information online, and designing and establishing directional signage for whitewater runs. In addition, Project approval under the *Navigable Waters Protection Act* included conditions to release flows for recreational navigation (15 m^3/s minimum) downstream of the intake on a set number of days each year, and that these opportunities will be made publicly available on the company website at least one month prior to the release dates (Transport Canada 2013).

Mitigation measures prescribed in the EA and required as part of Project approval under the *Navigable Waters Protection Act* have been implemented. Flows are posted in real time on the company website (http://www.innergex.com/kayak/en/big-silver-creek) along with paddling dates and the navigational flows that will be occurring in the diversion reach on those dates. During the first year of operations (2017), four kayaking dates (July 23, July 30, August 20, August 27) were posted online. However, no kayakers were observed nor signed up during the first year of Project operations (Kennedy, pers. comm. 2017), in spite of the implementation of these mitigation measures. Thus, given the mitigation already in place, no additional mitigation is required to address the proposed change in maximum diversion rate for the Navigable Waters VC.

4.3.1.3. Evaluation of Changes to Residual Effects Characterization

In the original EA, positive residual effects were anticipated for Project operations given the prescribed mitigation measures and that flow reduction creates new opportunities for kayaking of the diversion reach during early summer (and that accessibility is increased) (Ventus *et al.* 2011; Table 17-4). The proposed change in maximum diversion rate does not change the conclusion of the original EA for the Navigable Waters VC as additional kayaking days at appropriate flows continue to be created. This conclusion is further supported with the fact that mitigation is currently implemented to encourage the use and enhance safety of Big Silver Creek diversion reach to paddlers, even though there appears to be a lack of use in the first year of operations (Kennedy, pers. comm. 2017). Moreover, Big Silver Creek was declassified as navigable under the *Navigation Protection Act* Schedule[1].

5. CONSULTATION

Consultation with working group members is an important component of the pre-application phase of the amendment application process, and the BC Environmental Assessment Office (EAO) strongly encourages Certificate Holders to work with government agencies and Indigenous groups

[1] http://laws-lois.justice.gc.ca/eng/acts/N-22/page-8.html#h-27

to resolve any potential issues of concern prior to submitting their application (EAO 2016). As such, BSCPLP has conducted consultation with government agencies and Indigenous groups. The Sts'ailes Nation and the Douglas First Nation (Xa'xtsa Nation) were consulted regarding BSCPLP's intent to amend the current maximum diversion rate, and a letter of support was received from both Nations (Appendix B). BSCPLP's desire to submit an application to increase the maximum diversion rate was discussed with Scott Babakaiff of the BC Ministry of Forests, Lands & Natural Resource Operations (MFLNRO) and a request to conduct testing with the proposed 44.0 m^3/s maximum diversion rate was submitted. This request was approved by MFLNRO and a temporary water license was received (Use Approval as per Section 10 of the *Water Sustainability Act* (2014) to temporarily divert water in excess of CWL (#C129606) maximum of 42.0 m^3/s (Babakaiff, pers. comm. 2017).

6. SUMMARY AND CONCLUSIONS

BSCPLP, as the certificate holder, is seeking an increase in the maximum diversion rate for the Big Silver Waterpower Project from the current 42.0 m^3/s to 44.0 m^3/s. This increase in maximum diversion rate would allow the delivery of the contract maximum electricity to the point of interconnection with BC Hydro's transmission system while maintaining the IFR of 1.9 m^3/s. Because the maximum diversion rate is currently restricted by both the Project's EAC (Condition #7 of the TOC) and CWL, BSCPLP requests an amendment to Schedule B of the EAC to remove the condition that restricts maximum diversion. If the maximum diversion rate is managed solely by the Project's CWL, this would minimize overlap and the potential for future conflict between the EAC and CWL. Nevertheless, the assessment for this EAC amendment was based on the proposed increase in maximum diversion rate. The assessment for the amendment application, which is presented in this document, was conducted by identifying VCs with the potential to interact with the proposed change, and evaluating potential effects relevant to the proposed change, mitigation measures, and the consequences of the proposed change to the conclusions of the original EA on which the Ministers based their decision to grant Project approval.

The proposed change in maximum diversion rate is relevant only to the Project's operations phase and has the potential to affect only VCs that interact with flow in the Big Silver Creek diversion. Potential effects of the proposed change in maximum diversion rate on the VCs of the aquatic environment (fish habitat and its subcomponents) were assessed in a separate report (the AEA, presented in Appendix A). Other environmental and socio-economic VCs identified in the original EA (Ventus *et al.* 2011) that were not evaluated in the AEA are evaluated in this document. VCs of the terrestrial environment that have the potential to interact with the proposed change include Herptiles (Pacific Tailed Frogs) and Avifauna (American Dipper and Harlequin Duck). Navigable waters was identified as the single socio-economic VC that interacts with the proposed change.

The AEA (Appendix A) assessed the potential effects of the proposed increase in the maximum diversion rate to the same subcomponents of fish habitat identified in the original aquatic EA (Lewis *et al.* 2011a), with the exception of riparian habitat, which does not interact with the proposed change. The AEA predicted a 1.2% decrease in the average daily flow in the diversion. This incremental change was predicted to result in minor effects on water quality and water temperature, small incremental losses for Rainbow Trout parr rearing habitat and Rainbow Trout spawning habitat, negligible effects on migratory habitat and stream ecological processes (flushing and channel maintenance flows, flood pulses, habitat connectivity, and behavioural cues), and no effects on ramping given the mitigation already in place. In summary, the AEA concluded that the predicted minor incremental effects to fish habitat do not warrant any changes to the residual effects characterizations relative to those from the original EA (Lewis *et al.* 2011a) or the addition of mitigation.

Assessment of the potential effects of the proposed increase in maximum diversion rate on Pacific Tailed Frogs relative to those predicted in the original EA (flow regulation in the diversion reach; Ventus *et al.* 2011) considered impacts to key aquatic habitat characteristics for the species. As noted above, the AEA evaluated effects of the proposed change in maximum diversion rate to several physical, biological and ecological parameters associated with riverine aquatic habitats. Results of the AEA supported conclusions that the proposed increase in maximum diversion rate will have minor or negligible effects on key Pacific Tailed Frog habitat characteristics. Further, the diversion reach was documented to have limited ability to support the species during baseline conditions (Faulkner *et al.* 2014). As such, the proposed change in maximum diversion rate does not change the conclusion of the original EA for the Herptile VC. Hence, no residual effects are identified and no additional mitigation is required.

No adverse potential effects were identified for Project operations for American Dipper and Harlequin Duck in the original EA (Ventus *et al.* 2011). Assessment of the potential effects of the proposed increase in maximum diversion rate relative to those predicted in the original EA considered impacts to the aquatic foraging habitat of the two avian riverine species as presented in the AEA. Potential effects to hydrology, water quality and temperature, ecological considerations (such as flushing flows), and habitat quantity may affect the invertebrate food supply of American Dipper and Harlequin Duck; however, as assessed for Pacific Tailed Frogs, any changes resulting from the proposed increase in maximum diversion rate relative to the current diversion rate were evaluated to be not biologically significant. Further, although the AEA estimated that the proposed increase in maximum diversion rate would cause the incremental loss of some habitat suitable for invertebrates, this was not expected to result in biologically significant effects to the invertebrate drift population. As such, the proposed change in maximum diversion rate does not change the conclusion of the original EA for the Avifauna VC (American Dipper and Harlequin Duck). Hence, no residual effects are identified and no additional mitigation is required.

Potential effects to navigable waters were identified for Project operations in the original EA because Big Silver Creek was considered navigable under the *Navigable Waters Protection Act* (2009) and expert kayakers could make use of the diversion reach at some natural flows. However, the original EA determined that flow reduction due to water diversion creates new opportunities for kayaking of the diversion reach during early summer and winter when natural flows are too high. In addition, mitigation was prescribed and has been implemented to enhance kayaking opportunities. These included making flow data available in real time online, establishing signage to increase safety, and providing release flows for recreational navigation downstream of the intake on a set number of days each year. No kayakers were documented or signed-up pre-selected kayaking flow days during the first year of Project operations. Given the lack of negative potential effects, the proposed change in maximum diversion rate does not change the conclusion of the original EA for the Navigable Waters VC. Moreover, Big Silver Creek was declassified as navigable under the *Navigable Waters Protection Act* (2017).

In conclusion, for all environmental and socio-economic VCs that have the potential to interact with the proposed change in maximum diversion rate, residual effects remain unchanged from the original EA and no additional mitigation is required.

Yours truly,

Ecofish Research Ltd.

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Appendix A. Aquatic Effects Assessment to Support a Request to Increase the Maximum Diversion Rate.

Big Silver Creek Waterpower Project

Aquatic Effects Assessment to Support a Request to Increase the Maximum Diversion Rate

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EXECUTIVE SUMMARY

The Big Silver Waterpower Project (the Project) is a 40.6 MW run-of-river project located ~46 km north of the community of Harrison Hot Springs (Map 1), which is operated by the Big Silver Creek Power Limited Partnership (BSCPLP). Currently the Project is diverting a maximum flow of 42.0 m^3/s, with the minimum instream flow requirements (IFR) of 1.9 m^3/s released year round as per clause e) of the Conditional Water Licence (CWL) C129606. BSCPLP is requesting an increase in the maximum diversion rate from 42.0 m^3/s to 44.0 m^3/s to augment the beneficial use of water for hydroelectric power generation under the CWL. To support the application for a CWL to allow for this increase in the maximum diversion rate, this report assesses the potential effects on the Valued Environmental Component (VEC) of fish habitat, and its subcomponents that were assessed in the original EA.

The Project consists of a Coanda intake with a headpond elevation of 245.4 masl located approximately 19 km upstream of Harrison Lake, with a buried penstock that conveys water to a powerhouse located on Big Silver Creek approximately 15.5 km upstream of the confluence with Harrison Lake. The aquatic Effects Assessment (EA) completed in 2011 (Lewis *et al.* 2011a) was based on baseline conditions presented in Lewis *et al.* (2011b). On August 17, 2012, the Project received an Environmental Assessment Certificate (EAC #E12-03) under the BC *Environmental Assessment Act* (Province of BC 2002). The project received its *Fisheries Act* Authorization (08-HPAC-PA2-00159) on April 17, 2014 (DFO 2014), which was subsequently revised on January 5, 2016 (DFO 2016).

The original aquatic EA assessed the effects of the proposed Project on six subcomponents of the VEC, fish habitat: water quality, fish rearing and overwintering habitat, fish spawning and incubation habitat, fish migratory habitat, riparian habitat, and macroinvertebrate habitat (Lewis *et al.* 2011a). With the exception of riparian habitat, which will not be affected by the proposed change in the maximum diversion rate, we assess the potential effects of the proposed increase in the maximum diversion rate to the same subcomponents of fish habitat. This was done by evaluating baseline data collected following the guidelines for water flow assessment prepared for the Ministry of Environment (Lewis *et al.* 2004, Hatfield *et al.* 2007) and re-running the instream flow analysis using an IFR of 1.9 m^3/s and a maximum diversion capacity of 44.0 m^3/s.

The proposed increase in the maximum diversion rate will have an effect on flows in the diversion reach only when natural flow exceeds the IFR and the current diversion maximum (42.0 m^3/s). Flow in the diversion reach will be decreased by a maximum of 2.0 m^3/s. Across the year, a 1.2% decrease in the average daily flow is expected. The largest changes in flow magnitude are expected to occur during the freshet period of May through July, with average monthly flows being reduced by a maximum of 9% in June. Changes in water quality and temperature due to the proposed increase in the maximum diversion rate are not expected to have biologically significant adverse effects, given the magnitude of the proposed flow changes and the results from long-term monitoring programs on other run-of-river streams (Jesus *et al.* 2004, Wu *et al.* 2009, Summit 2015) that have similar maximum diversion rates as a percentage of mean annual discharge (MAD) to Big Silver Creek. This is supported by baseline water quality data relative to water quality guidelines, and baseline water temperatures relative to the optimal temperatures for Rainbow Trout.

The proposed increase in maximum diversion rate is predicted to result in small incremental losses to rearing habitat for Rainbow Trout parr in the CSFP (2 m^2, 0.1%), and over the growing season (39 m^2, 1.0%), compared to habitat available under the current operational flow scenario. This magnitude of rearing habitat loss is not predicted to result in serious harm to fish based on the habitat losses predicted for Rainbow Trout on the Kwalsa projects (-1% to -57%) and the positive effects on fish density and biomass observed on those projects (Faulkner *et al.* 2015). The proposed increase in the maximum diversion rate is also predicted to result in a loss of 0.2 m^2 (-2.3%) of Rainbow Trout spawning habitat compared to baseline conditions. Again, this magnitude of spawning habitat loss is not predicted to result in serious harm to fish given the small amount of habitat loss (0.2 m^2) and the number of Rainbow Trout spawning pairs that can be supported by the remaining spawning habitat in the 480 m long lower diversion reach.

The increase in diverted flow throughout the year will result in an increase in the magnitude of stage changes in the lower diversion and downstream reaches during ramping events, which may impact rearing fish. However, given the minor difference (~5 minutes) in the time required for a compliant shut-down from full capacity under the current and proposed maximum diversion rates, and the small difference in maximum stage change (-1.4 cm, -2%) at downstream SSMSs under a worst-case non-compliant shut-down, the proposed increase in the maximum diversion rate is not expected to alter the residual effects from ramping given the mitigation measures already in place.

The limited difference between the current and proposed flow scenarios also leads us to conclude that the proposed increase in the maximum diversion rate will result in negligible incremental change to fish migratory habitat and ecological considerations such as flushing and channel maintenance flows, flood pulses, habitat connectivity and behavioural cues.

Finally, the proposed increase in the maximum diversion rate is predicted to result in small incremental losses of 204 m^2 (0.9%) of habitat suitable for invertebrates that are swift water specialists during the growing season compared to the current operational flow scenario. However, this habitat loss is for swift water specialists only and the majority of the loss (156 m^2, 76%) is in the non-fish-bearing diversion reach. The minor incremental increase in invertebrate habitat loss is therefore not expected to result in biologically significant effects to the invertebrate drift population, or the resident fish population in the lower diversion reach. This conclusion is supported by the lack of adverse effects to fish populations from the operation of similar run-of-river facilities at the Kwalsa-Stave projects (Faulkner *et al.* 2015) that have similar maximum diversion rates as a percentage of MAD to Big Silver Creek.

Based on the predicted minor incremental effects to fish habitat, and the mitigation measures that have already been implemented to minimize Project effects, the proposed increase in the maximum diversion rate does not warrant any changes to the residual effects characterizations for the effects of flow diversion on the subcomponents of the fish habitat VEC assessed in the original EA (Lewis *et al*. 2011a). We conclude that the proposed increase in the maximum diversion rate is predicted to have no biologically significant adverse residual effects on the fish habitat VEC. Consequently, no additional mitigation and/or compensation is required.

Any uncertainty as to whether the proposed increase in the maximum diversion rate may result in serious harm to fish must also consider the offsetting that has already been implemented to compensate for habitat losses predicted in the original EA. To compensate for Rainbow Trout rearing and Dolly Varden spawning habitat losses associated with flow diversion, along with footprint impacts to instream and riparian habitat, fish habitat creation and enhancement was undertaken in Jimmy Charlie Slough near the Harrison River (Hemmera 2015a, b). The Fish Habitat Enhancement Project (FHEP) created 1,125 m^2 and enhanced 10,502 m^2 of aquatic habitat, and created 6,430 m^2 of riparian habitat (Regehr *et al.* 2017). This represented an excess of 6,387 m^2 of aquatic habitat compared to the compensation requirements of the revised FAA (DFO 2016, Regehr *et al*. 2017). Consequently, although the proposed increase in the maximum diversion rate is expected to result in an incremental loss of 39 m^2 of Rainbow Trout rearing habitat compared to the current flow scenario, and 0.2 m^2 of Rainbow Trout spawning habitat compared to baseline conditions, the offsetting implemented at the Jimmy Charlie FHEP ensures that there will be no residual effect on productivity and serious harm to fish even if the incremental habitat effects are larger than predicted.

The data currently being collected on water temperature, ramping effects, and fish density and biomass for the Big Silver Creek long-term monitoring program (LTMP; Harwood *et al*. 2016), currently in Year 1 of 5, will allow these predictions to be tested should the proposed increase to the maximum diversion rate be approved and implemented. No additional monitoring other than that prescribed in the LTMP is warranted given the minor incremental effects predicted.

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1. INTRODUCTION

1.1. Background

The Big Silver Waterpower Project (the Project) is a 40.6 MW run-of-river project located southeast of Mount Breckenridge and ~46 km north of the community of Harrison Hot Springs (Map 1), which is operated by the Big Silver Creek Power Limited Partnership (BSCPLP). BSCPLP is requesting an increase in the maximum diversion rate from the current 42.0 m^3/s to 44.0 m^3/s to augment the beneficial use of water for hydroelectric power generation under the Conditional Water Licence (CWL). Ecofish Research Ltd. (Ecofish) was retained by BSCPLP to assess the aquatic effects of this proposed increase in the maximum diversion rate. This report describes the objectives, scope and results of the assessment conducted to support the application for a CWL to allow for this increase in the maximum diversion rate for the Project.

Big Silver Creek (watershed code (WC) 110-599000) is a southward flowing stream that drains into the northeast end of Harrison Lake. Big Silver Creek has a mean annual flow of 23.3 m^3/s at the Project's intake, with a median daily flow of 13.9 m^3/s, a minimum daily flow of 0.77 m^3/s, and a maximum daily flow of 425 m^3/s (Lewis *et al.* 2011a, b). Fish are present downstream of the tailrace and in the lower 0.5 km of the diversion reach. Fish species distribution is limited by the presence of migration barriers. A migration barrier to anadromous fish species exists approximately 9.5 km downstream of the tailrace and 6 km upstream of Harrison Lake. The upstream limit of resident fish is 480 m upstream of the tailrace (Faulkner *et al.* 2014) (Map 2).

The Project consists of a Coanda intake with a headpond elevation of 245.4 masl located approximately 19 km upstream of Harrison Lake, with a buried penstock that conveys water to a powerhouse located on Big Silver Creek approximately 15.5 km upstream of the confluence with Harrison Lake. Currently the Project is diverting a maximum flow of 42.0 m^3/s, with the minimum instream flow requirements (IFR) of 1.9 m^3/s released year round as per clause e) of the CWL C129606.

The aquatic Effects Assessment (EA) completed in 2011 (Lewis *et al.* 2011a) was based on baseline conditions presented in Lewis *et al.* (2011b). The Big Silver Creek Waterpower Project was included with the Tretheway Creek and Shovel Creek waterpower projects for the Application for an Environmental Assessment Certificate (the Application) and was collectively referred to as the TSB Project. On August 17, 2012, the Project received an Environmental Assessment Certificate (EAC #E12-03) under the BC *Environmental Assessment Act* (2002). The project received its *Fisheries Act* Authorization (08-HPAC-PA2-00159) on April 17, 2014 (DFO 2014), which was subsequently revised on January 5, 2016 (DFO 2016).

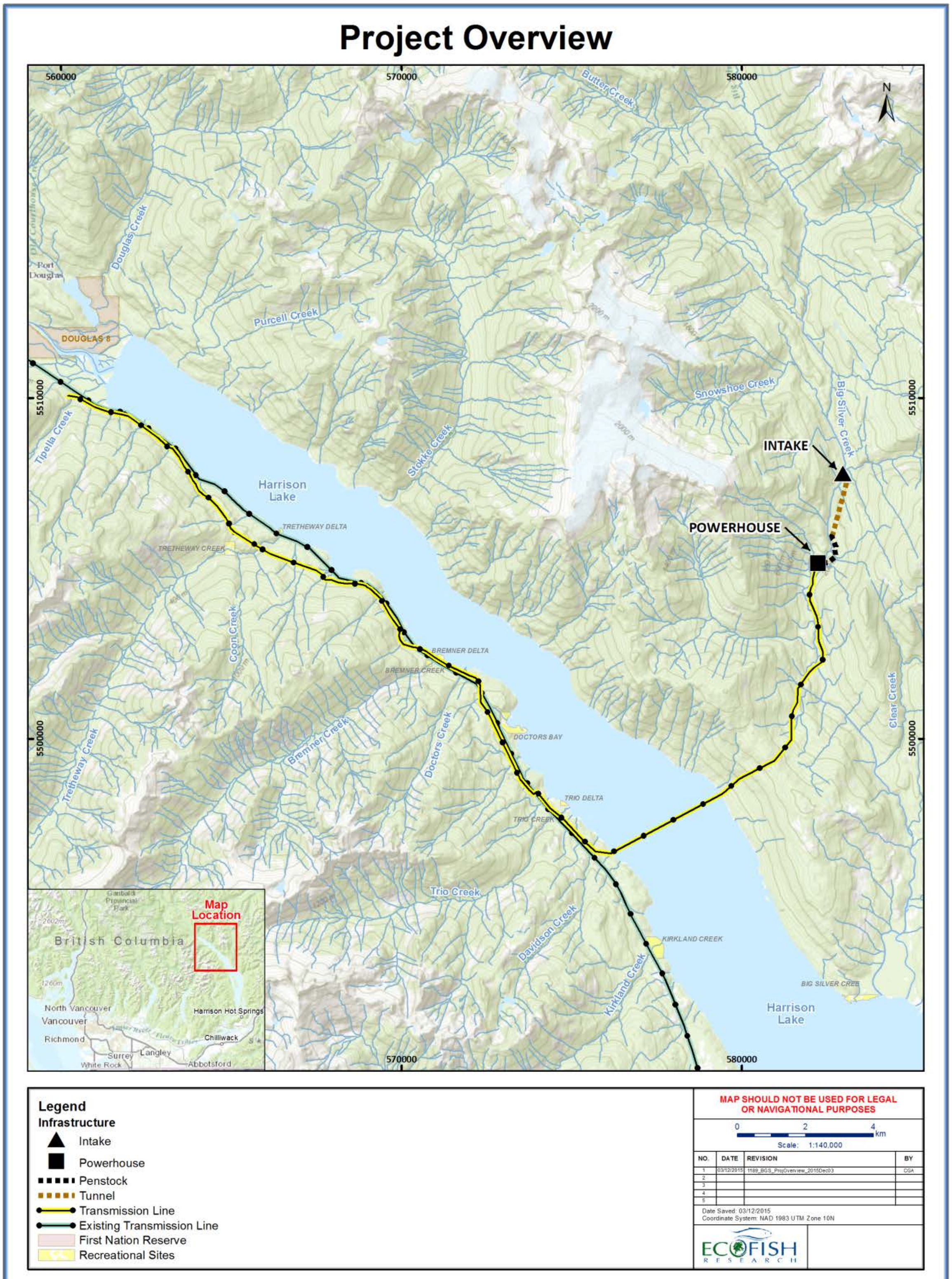
The proposed increase in the maximum diversion rate will require an amendment to Condition 7 of the Project's EAC, which limits the rate of diversion of water to 42 m^3/s. This report will support this EAC amendment, but does not represent an application for an EAC amendment as it only addresses the Valued Environmental Component (VEC) of fish habitat and not the other VECs assessed in the original EA. The application for an EAC amendment will be provided to the EAO under a separate cover.

1.2. Objectives

The objectives of this aquatic effects assessment were to:

1. Synthesize available physical (water quality and temperature) and biological data (both existing field data and other relevant data) on Big Silver Creek from regulatory agency sources and baseline data reports. These data include the raw data used in the original EA conducted by Ecofish (Lewis *et al* 2011a).
2. Describe physical (hydrology, water quality and temperature) and biological (fish habitat, invertebrate drift habitat) conditions near the Project that may be affected by the increase in the maximum diversion rate (i.e., diversion and downstream reaches of the Project).
3. Describe fish species present, distribution and abundance, and life history timing (periodicity) in the diversion and downstream reaches of the Project.
4. Define habitat flow relationships for important species and life history phases (e.g., Rainbow Trout and invertebrate drift) in Big Silver Creek using existing data.
5. Integrate hydrological data with Rainbow Trout and invertebrate habitat flow relationships to calculate the quantity of habitat in a daily time series, and interpret the biological significance of any changes between the current maximum diversion and the proposed maximum diversion as per Hatfield *et al.* (2007).
6. Provide expert opinion on the effects of the proposed increase in the maximum diversion rate on flushing flows, flood pulse, connectivity, source of fish behavioural cues, and passage and spawning flows.
7. Provide a determination of residual effects and identify any mitigation or offsetting necessary.
8. Provide a determination as to whether any additional monitoring is warranted.

Map 1. **General location map for the Big Silver Creek Waterpower Project, showing Project infrastructure in relation to Harrison Lake.**



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1.3. Geographic Scope

In the assessment of run-of-river hydroelectric projects, the environmental effects are typically evaluated in three locations: 1) an upstream reach above the intake, 2) the diversion reach between the intake and the powerhouse, and 3) the downstream reach below the powerhouse (Lewis *et al.* 2004). The present aquatic effects assessment focuses on the impacts to the diversion and downstream reaches only, because the proposed operational change will not affect the upstream reach.

Big Silver Creek has two distinct sections of the diversion reach: the upper diversion reach, which is non fish-bearing, and the lower diversion reach that contains resident fish (Map 2). Effects in both of these reaches will be evaluated.

The proposed change in the maximum diverted flow may also affect the rate of flow change downstream of the powerhouse during flow ramping events, and may therefore affect both resident and anadromous fish species.

2. METHODS

2.1. Baseline Conditions

2.1.1. Hydrology and Instream Flow Study

Real-time hydrological data for Big Silver Creek have been collected since October 2003. For the purpose of the EA, Knight Piésold (Cathcart, J., pers. comm. 2011) developed a synthetic hydrology time series for the Big Silver Creek intake based on the relationship between real-time data and flows at the Stave and Nahatlatch Rivers to extend the period of record from 1986 to 2009 (Lewis *et al.* 2011b).

The Instream Flow Study (IFS) for the Project was conducted during the baseline studies (Lewis *et al.* 2011b) to inform the EA (Lewis *et al* 2011a). The IFS was completed following the methods outlined in the BC Instream Flow Methodology (Appendix A in Lewis *et al.* 2004), with depth and velocity data collected following procedures set forth in the "Manual of British Columbia Hydrometric Standards" (RISC 2009). Microhabitat characteristics along nine transects in the diversion reach were measured at three or four different flows. An additional two transects were located in the downstream reach and were sampled at three different flows. The habitat-flow relationships specific to Big Silver Creek were analyzed and a model was developed to assist in selecting an appropriate flow regime. Habitat areas (weighted usable area (WUA) in m^2) were calculated to demonstrate the quantity of habitat available under dry, normal, and wet year scenarios. These WUAs were calculated using the average relationship between habitat and flow over all diversion transects.

2.1.2. Water Quality and Temperature

During baseline studies, water chemistry parameters were measured either *in situ* or through laboratory analysis. Water temperature was recorded through the installation and periodic downloading of duplicate temperature loggers. Two water quality sites were established to collect baseline data: one located upstream of the intake and the second located in the lower section of the diversion reach. Water quality sampling dates were spread quarterly over the year to capture any seasonal changes in baseline conditions. For each parameter in each quarter, averages, minima, maxima, and standard deviations at each site were calculated from all replicate samples collected in the quarter (Lewis *et al.* 2011b).

2.1.3. Fish Habitat and Fish Community

Biological conditions and fish distribution in Big Silver Creek diversion reach were confirmed through a comprehensive literature search that included the BC Fish Information Summary System (BC FISS) and baseline fish and fish habitat surveys summarized in Lewis *et al.* (2011b) and Faulkner *et al.* (2014). Baseline fish surveys consisted of closed-site electrofishing and minnow trapping / index snorkelling in the lower diversion reach and the downstream reach (within ~1 km of the powerhouse location) in 2006 and 2012. These surveys for juvenile fish were supplemented with nine snorkel surveys between October 2006 and May 2009 to evaluate the abundance and distribution of adult salmonids in the lower diversion and downstream reaches.

2.1.4. Invertebrate Drift

Baseline invertebrate drift sampling on Big Silver Creek occurred at two sites (upstream, diversion) on October 11, 2006 and at three sites (upstream, diversion, downstream) on August 12, 2008 and September 18, 2008. Sampling sites were generally located in the downstream half of riffles; further details of sampling methodology are presented in Faulkner *et al.* (2014). Detailed taxonomic analyses were conducted and density, biomass, Simpson's family level diversity, richness, and the Canadian Ecological Flow Index (CEFI) were analyzed as per Lewis *et al.* (2013).

2.2. <u>Effects Assessment</u>

The original aquatic EA assessed the effects of the proposed Project on six subcomponents of the VEC, fish habitat: water quality, fish rearing and overwintering habitat, fish spawning and incubation habitat, fish migratory habitat, riparian habitat, and macroinvertebrate habitat (Lewis *et al.* 2011a). With the exception of riparian habitat, which will not be affected by the proposed change in the maximum diversion rate, we assess the potential effects of the proposed increase in the maximum diversion rate to the same subcomponents of fish habitat. Similarly, we assess the residual adverse environmental effects (i.e., those that cannot be completely avoided through avoidance or mitigation measures) using the same criteria as employed in the original EA:

- **Magnitude**: This refers to the magnitude or severity of the effect. Low magnitude effects may have no impact, while high magnitude effects may have an impact.
- **Geographic Extent**: This refers to the extent of change over the geographic area of the proposed project. The geographic extent of effects can be local or regional. Local effects may have a lower impact than regional effects.
- **Duration** and **Frequency**: This refers to the length of time the effect lasts and how often the effect occurs. The duration of an effect can be short-term or long-term.

The frequency of an effect can be frequent or infrequent. Short term and/or infrequent effects may have a lower impact than long-term and/or frequent effects.

- **Reversibility**: This refers to the degree to which the effect is reversible. Effects can be reversible or permanent. Reversible effects may have lower impact than irreversible or permanent effects.
- **Context**: This refers to the ability of the environment to accept change. For example, the effects of a project may have an impact if they occur in areas that are ecologically sensitive, with little resilience to imposed stresses.
- **Likelihood** and **Probability**: CEAA requires an assessment of likelihood for any residual adverse environmental effect predicted to be significant, while BCEAA requires an assessment of probability that an adverse effect will occur in circumstances where it is not certain that the effect will materialize, i.e., probability is a criterion that is used to inform significance under BCEAA.

The definitions used for the above criteria in the original Project EA are provided in Table 1. For the purposes of this assessment, we evaluate how the proposed increase in maximum diversion rate will alter the residual effect characterizations made in the original EA. If the proposed change to the maximum diversion rate is expected to result in a meaningful or measureable change to a subcomponent of fish habitat from that predicted in the original EA, the predicted residual effects are characterized using the definitions provided in Table 1.

The proposed change to the maximum diversion rate was evaluated by analysing baseline data following the guidelines for water flow assessment prepared for the Ministry of Environment (Lewis *et al.* 2004, Hatfield *et al.* 2007). The instream flow analysis from Lewis *et al.* (2011b) was updated using an IFR of 1.90 m^3/s and a maximum diversion capacity of 44.0 m^3/s. Physical habitat was calculated as a function of daily flow for each day using the baseline, current scenario and proposed scenario flows. Habitat flow curves for Big Silver Creek (Lewis *et al.* 2011b) were used to estimate effects on Rainbow Trout, Dolly Varden/Bull Trout, and invertebrate habitat in Big Silver Creek.

In the original EA, residual effects to fish habitat were assessed in the context of the potential for the harmful alteration, disruption or destruction (HADD) of fish habitat, following the Policy for the Management of Fish Habitat (DFO 1986). This approach required proponents to avoid potential HADDs through relocation or redesign, or by employing technically and economically feasible mitigation measures, as described in the HADD decision framework (DFO 1998). If environmental effects could not all be reasonably avoided or mitigated, DFO could authorize a HADD under Section 35(2) of the *Fisheries Act* with unmitigable effects to fish habitat fully compensated for at a replacement ratio of at least 1:1.

In 2012, a number of changes were made to the *Fisheries Act*, which came into effect in 2013. The most important change to the *Fisheries Act* in 2012 was a shift of focus to protecting the productivity of fish that are part of a commercial, recreational or Aboriginal (CRA) fishery, or those species that support CRA fisheries, and the replacement of several old *Fisheries Act* prohibitions with a single new prohibition under section 35(1) against carrying any work or activity that may cause serious harm to fish that are a part of a CRA fisheries or those fish species that support them (Simms 2017). CRA fisheries are interpreted to be those fish that fall within the scope of applicable federal or provincial fisheries regulations, as well as those that can be fished by Aboriginal organizations or their members for food, social or ceremonial purposes or for purposes set out in a land claims agreement. In light of the changes to the *Fisheries Act* since the original EA was written, this assessment follows the approach mandated by the new *Fisheries Act* and assesses any residual adverse effects on fish habitat in the context of their potential to result in serious harm to fish. Serious harm is defined as:

- **death of fish**;
- **permanent alteration to fish habitat** of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes; and
- **destruction of fish habitat** of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.

A significant adverse residual effect on CRA fisheries is considered an effect that causes a reduction in the productive capacity of fish habitat or an effect that causes mortality or injury to fish in an uncompensated manner that can cause a long term reduction of population numbers or adversely affect the productivity and sustainability of fish populations.

Table 1. Criteria definitions for characterization of residual environmental effects.

Criteria	Rating	Criteria Definition
Magnitude	Low	Disturbance predicted to be slightly above background conditions, but well within established or accepted protective standards and normal fluctuations, or to cause no detectable change in ecological parameters.
	Moderate	Disturbance predicted to be considerably above background conditions but within scientific effects thresholds, or to cause a detectable change in ecological parameters within the range of natural variability.
	High	Disturbance predicted to be considerably above background conditions and to cause a detectable change in ecological parameters outside of the range of natural variability.
Geographic Extent	Site-specific	Effects occur within or in close proximity to a specific site within the Project boundary.
	Local	Effects occur mainly within or in close proximity to the Project boundary.
	Regional	Effects extending outside of the Project boundary to the regional area.
Duration	Short-term	Effects occur only during Project development or for a period of 1 to 3 years.
	Long-term	Effects persist for the entire length of the operational phase of the Project.
	Permanent	Effects persist indefinitely.
Frequency	Once	Effects only occur once.
	Infrequent	Effects occur intermittently and sporadically.
	Frequent	Effects occur on a frequent basis.
	Continuous	Effects occur continually.
Reversibility	Reversible	Effects are reversible.
	Irreversible	Effects are not reversible.
Context	Undisturbed	Area relatively pristine or not adversely affected by human activity. High ability to respond to effects.
	Disturbed	Area showing evidence of existing negative effects. Ability to respond to effects is compromised.
Probability	Low	Previous research, knowledge, or experience indicates there is a small likelihood/probability that the environmental component has experienced the same impact from activities of similar types of projects.
	Moderate	Previous research, knowledge, or experience indicates the environmental component *may have* experienced the same impact from activities of similar types of projects.
	High	Previous research, knowledge, or experience indicates the environmental component *has* experienced the same impact from activities of similar types of projects.
	Unknown	There is insufficient research, knowledge, or experience to indicate whether the environmental component has experienced the same impact from activities of similar types of projects.

2.3. Long-Term Monitoring

Faulkner *et al.* (2014) designed and implemented a long term monitoring plan (LTMP) for the present Project consistent with the requirements for small hydroelectric projects in British Columbia, based on provincial guidelines (Hatfield *et al.* 2007) and the DFO Long-term Monitoring Protocols (Lewis *et al.* 2013). The Big Silver LTMP is currently in its first full year and the Year 1 annual report will be delivered to regulatory agencies by March 31, 2018.

The LTMP consists of three types of monitoring: compliance, effectiveness and response monitoring. Compliance monitoring is conducted to ensure that conditions outlined in CWL and the DFO Authorization are adhered to (e.g., instream flow requirements). Effectiveness monitoring is conducted to verify that mitigation and compensation measures implemented for the Project are effective at achieving the goals they were designed for. 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.

The components included in the LTMP that are relevant to the proposed increase in the maximum diversion rate and the current assessment are:

1) **Water Flow**
    a) **Instream Flow** (objective: To ensure compliance with instream flow requirements);
    b) **Ramping Rates** (objective: To test the effectiveness of standard ramping rates and, based on test results, determine long-term ramping rates that minimize the risk of stranding fish.)
2) **Water Temperature** (objective: to monitor water temperature in the upstream, diversion and downstream reaches to determine whether Project operation is having any biologically significant effects on temperature);
3) **Stream Channel Morphology** (objective: to monitor potential project effects on channel stability and sediment conditions during operations and evaluate how any changes affect the availability and suitability of fish habitat);
4) **Fish Community** (objective: to monitor fish community health during operations and identify any changes in abundance, density, condition, distribution, or timing of migration);
5) **Water Quality** (objective: to test whether water quality changes during operations to the extent that the productive capacity of fish habitat may be adversely affected); and
6) **Invertebrate Abundance** (objective: to test whether changes occur in the density, biomass or community composition of the invertebrate drift population to the extent that productive capacity of fish habitat in the diversion and/or downstream sections may be reduced).

3. BASELINE CONDITIONS

The following subsections summarize baseline data collected for the Project; further details of these studies are provided in Lewis *et al.* (2011b) and Faulkner *et al.* (2014).

3.1. Hydrology

Hydrological analysis conducted during baseline studies showed that at the intake location Big Silver Creek has a mean annual discharge (MAD) of 23.3 m^3/s, with a median daily flow of 13.9 m^3/s, a minimum daily flow of 0.77 m^3/s, and a maximum daily flow of 425.1 m^3/s. The median monthly flow ranges from 25.5 m^3/s (110% MAD) to 44.5 m^3/s (191% MAD) from May through July, the high flow months. Following freshet, inflows drop continuously through August, with a median flow of 11.1 m^3/s (51% MAD). During September, the lowest flow month, flows average 9.97 m^3/s (43% MAD) with a median value of 7.8 m^3/s (33% MAD). From October to March, median flows remain relatively low, between 7.1 m^3/s (31% MAD) and 14.6 m^3/s (63% MAD); intermittent flood events occur throughout these months. The flows exhibit increasing stability between February and March, reflective of decreasing precipitation and a lower probability of rain on snow events. Additional data collection and analysis of hydrological data post-EA submission yielded a MAD of 22.6 m^3/s at the intake site (KPL 2013). The difference between MAD values is believed to be largely due to the use of a longer period of hydrological records and the use of a refined modelling approach for the data analysis. To facilitate comparison with the results of the original EA, we have based our comparisons on the MAD value of 23.3 m^3/s.

The IFS calculated habitat area for resident fish species and invertebrates in the proposed diversion reach of the project under various flows (Lewis *et al.* 2011b). The maximum habitat area was found at 11.3 m^3/s for Rainbow Trout fry, 60 m^3/s for Rainbow Trout parr, 0.5 m^3/s for Dolly Varden/Bull Trout juveniles, and 10.0 m^3/s for invertebrates. Maximum spawning habitat was provided at 9.0 m^3/s for Rainbow Trout and 6.0 m^3/s for Dolly Varden/Bull Trout. The majority of Rainbow Trout rearing habitat was provided at much lower flows: the flow that provides 90% of the habitat was calculated as 0.5 m^3/s for Rainbow Trout fry and 25.3 m^3/s for Rainbow Trout parr. Ninety percent of spawning habitat is present at flows of 7.9 m^3/s for Rainbow Trout and 5.5 m^3/s for Dolly Varden/Bull Trout.

3.2. Water Quality and Temperature

The following provides a summary of water chemistry results taken in situ or from laboratory samples over the course of baseline sampling in Big Silver Creek:

- Specific conductivity (conductivity normalized to 25°C) ranged from 15.0 µS/cm to 26.6 µS/cm.
- pH measurements ranged from 6.18 to 7.88.
- Alkalinity ranged from 5.2 mg/L (as $CaCO_3$) to 9.1 mg/L (as $CaCO_3$).
- All total suspended solids results registered less than the MDL of 3.0 mg/L (or 1.0 mg/L used in 2013). Turbidity was also very low, but detectable in all samples ranging from 0.15 NTU to 1.33 NTU.

- Dissolved oxygen concentrations measured in situ ranged from 11.30 mg/L to 14.80 mg/L and the % saturation ranged from 91.2% to 122.5%.
- Total gas pressure (TGP; ΔP) measurements ranged from -3 mm Hg to 47 mm Hg.
- With the exception of nitrate, low-level nitrogen nutrients were less than or near their respective detection limit. Ammonia concentrations ranged from <5.0 μg/L to 9.5 μg/L and were most often <5.0 μg/L. Nitrite concentrations ranged from <1.0 μg/L to 1.4 μg/L and were most often <1.0 μg/L. Nitrate was consistently detected in all samples at concentrations ranging from 51.1 μg/L to 142.0 μg/L.
- Both orthophosphate and total phosphate were less than or near their respective detection limits. Orthophosphate concentrations were consistently less than the MDL of 1.0 μg/L. Total phosphate concentrations ranged from <2.0 μg/L to 4.6 μg/L in individual replicates and were most often less than the detection limit of 2.0 μg/L.

Over the baseline period of record (October 2006 to August 2012), water temperatures showed an annual cycle typical of coastal streams in southern British Columbia. The observed temperatures also showed diurnal fluctuations that reached up to 5.4°C during the summer months. The spatial variability of water temperature in the Big Silver Creek diversion reach indicated that, on average, water temperature in the diversion reach is 0.2°C to 0.4°C warmer than the upstream reach.

The lowest monthly-mean temperatures ranged between 0.6°C and 1.8°C. For four of the six years of record, the lowest mean-monthly temperatures occurred in January. For the other two years of record, the lowest mean-monthly temperatures occurred in December or February. The minimum hourly temperature recorded was 0°C. This temperature occurred frequently during wintertime but the number of winter months with a minimum temperature of 0°C differed between the winters covered by the record (0 to 5 months).

The highest monthly-mean temperatures at the monitoring stations ranged between 10.1°C and 14.2°C and occurred in August, except in 2011 when the highest monthly-mean temperatures occurred in September. In 2009, maximum hourly temperatures reached 19.7°C, whereas in 2011, maximum temperatures did not exceed 14.0°C. These differences in temperature show the relatively high inter-annual variability in the stream temperatures.

The water temperature records show that Big Silver Creek has relatively cold temperatures. For the years of the record with complete data, daily-mean temperatures below 1°C occurred 8 to 41 times per year. In contrast to occurrences of extremely cold daily-mean temperatures, days with extremely warm mean temperatures >18°C did not occur in the upstream or diversion reach during the period of record. The maximum daily-mean temperature was 16.2°C and occurred in the diversion reach on August 02, 2009.

An important indicator of the health of aquatic life is the degree days in the growing season. The growing season was taken to begin when the weekly-average water temperature exceeded and remained above 5°C and to end when the weekly-average temperature dropped below 4°C (as per Coleman and Fausch 2007). The growing season was determined for years of the record with complete data. For Big Silver Creek, the length of the growing season ranged between 170 and 206 days in 2007 to 2011. In the diversion reach, the shortest growing season occurred in 2011 and had the least degree days (1,337 degree days), whereas the longest growing season occurred in 2010 with a length of 206 days and 1,757 degree days.

3.3. Fish Habitat

An abridged 1:20,000 Reconnaissance Level Fish and Fish Habitat Inventory (RLFFHI) was conducted on the Big Silver Watershed by Whelen (1999). This was supplemented by a Level 1 fish habitat assessment procedure (FHAP) survey, as per Johnston and Slaney (1996), to collect quantitative information on fish habitat at a finer scale than the RLFFHI.

The available fish habitat in Big Silver Creek is delineated by the presence of two separate barriers that limit fish movement and distribution. The first is located 7 km upstream of Harrison Lake and acts as a barrier to anadromous fish (Whelen 1999, Wilson *et al.* 1999). The second barrier (the upper barrier) is located 16 km upstream of Harrison Lake and acts as the upper limit of fish presence in the watershed (Map 2).

The FHAP Level 1 survey was completed in four reaches: (1) upstream of the intake (1,584 m) (non-fish-bearing); (2) the upper diversion reach (2,602 m) (non-fish-bearing); (3) the lower diversion reach (480 m) (resident fish section); and (4) downstream of the tailrace (278 m) (resident fish section).

The surveyed area was dominated by fast-flowing water. Riffle habitat was the most dominant fast-flowing mesohabitat type, representing 31% of the total habitat area. In comparison, glide habitat was the most dominant slow-flowing mesohabitat type, representing 19% of the total habitat.

In general, the surveyed area was frequently confined. However, the upstream reach was only occasionally confined, with a relatively low gradient and regular meander pattern. The upper diversion reach increased in gradient and confinement, and included a deeply entrenched, sinuous canyon section. The lower diversion was frequently confined, while the downstream reach was only occasionally confined.

Overall, streambed composition consisted primarily of boulder and cobble, although dominant substrate type varied with reach. Boulder was the dominant substrate type in 47% of mesohabitat units, while 43% of habitat units had cobble as the sub-dominant substrate. The dominant form of cover available to fish was boulder cover, representing 23.6% of the total habitat area. Deep pools were the sub-dominant form of cover, comprising 19.1% of total habitat area, with only a small percentage of overhanging vegetation (1.0%) available as cover.

Riparian characteristics were similar throughout the surveyed area, with the riparian zone of all reaches being dominated by young, second growth mixed forest. Two mesohabitat units were classified as occurring within mature forest, while only 10 of the 98 riparian observations (or 10%)

were classified as coniferous rather than mixed forest. Crown closure was low throughout, varying from 0 to 20%, as a result of bankfull widths averaging over 25 m.

A total of 38.9 m^2 of functional and 69.6 m^2 of non-functional spawning gravel was recorded in the lower diversion reach. This represented only 0.4% of the reach's total wetted area (9,982 m^2) at the time of the survey. Thus, the units were classified as containing a low amount of spawning gravel suitable for resident fish.

Overall, rearing habitat for juveniles in the diversion reach was classified as fair. Rearing value in the lower diversion reach was good for larger age class fish, based on relatively deep water, large substrate, and moderate habitat complexity. Instream cover attributed to boulders and water depth provided good protection for fish.

The gradient was lower in the downstream reach than in the diversion reach, providing good access for fish throughout. Instream cover was minimal in the downstream reach, and was mostly attributed to relatively small boulders. In contrast to the lower diversion reach, rearing value in the downstream reach was classified as good for fry, as younger age class fish would be able to use the small interstitial spaces as cover. However, due to the lack of cover and deep pools, rearing value for larger age class fish was classified as fair.

3.4. Fish Community

According to provincial fish databases, the anadromous fish section of Big Silver Creek, below the km 7 barrier, supports populations of Steelhead and the five species of Pacific salmon, and either resident or adfluvial populations of coastal Cutthroat Trout, Dolly Varden/Bull Trout, Longnose Dace, Mountain Whitefish, Northern Pikeminnow, Rainbow Trout, chub and sculpins (MOE 2010b). During sampling in the anadromous section by Ecofish only resident Rainbow Trout (23 total), adult Coho Salmon (41 total), six Steelhead, two Cutthroat Trout (either anadromous or adfluvial), a single Pink Salmon, and two adult Mountain Whitefish were directly observed.

The resident fish section of Big Silver Creek extends from the falls at km 7 to the falls at km 16, and supports a population of resident Rainbow Trout. During baseline snorkel swims, two adult Dolly Varden/Bull Trout were recorded upstream of the powerhouse location on November 1, 2007. These individuals were observed by a junior technician and could not be confirmed by the senior crew member. The fact that no additional observations were made, and that no fry and parr have been captured during two years of electrofishing surveys in the lower diversion and downstream reaches, indicates that species identification of these fish was either erroneous or that Dolly Varden/Bull Trout occur at very low densities in Big Silver Creek. This species was conservatively included in the original EA (Lewis *et al.* 2011a) but the assessment of effects presented herein focuses on effects to Rainbow Trout. To facilitate comparison to the original EA potential habitat effects to Dolly Varden/Bull Trout, if they are present in very low abundance, are presented in footnotes.

In both baseline sampling years, Rainbow Trout density in the downstream reach was at least double that in the lower diversion reach. In the downstream reach, average Rainbow Trout density (FPUobs) for all age classes ranged from 14.7 fish/100 m^2 (S.D. = 14.7) in 2006 to 22.3 fish/100 m^2 (S.D. = 12.6) in 2012. In the lower diversion reach, the average Rainbow Trout density for all age classes ranged from 6.1 fish/100 m^2 (S.D. = 4.7) in 2006 to 6.8 fish/100 m^2 (S.D. = 8.0) in 2012.

3.5. <u>Invertebrate Drift</u>

Invertebrate drift density was highly variable within all sites in the 2008 and 2012 sampling periods, with the coefficient of variation ranging from 15.99% to 84.61%. There were no apparent seasonal trends in invertebrate drift density, but densities were generally lower in 2008 compared to 2012. The lowest mean density observed was at the diversion site on Big Silver Creek on August 28, 2012 (0.69 individuals/m^3, S.D. = 0.18 individuals/m^3). Similar to density, the invertebrate drift biomass was also highly variable. Considering all data, the coefficient of variation ranged from 14.19% to 77.11%. As with density, there were no apparent seasonal trends in invertebrate drift biomass, but biomass was generally lower in 2008 compared to 2012. The highest mean biomass observed was at the diversion site on Big Silver Creek on September 18, 2008 (3.93 mg dry weight/m^3, S.D. = 3.03 mg dry weight/m^3). The lowest mean biomass observed was at the downstream site on Big Silver Creek on October 11, 2012 (0.10 mg dry weight/ m^3, S.D. = 0.032 mg dry weight/m^3).

Compared to density and biomass, the Simpson's diversity index (1-λ, family level data) showed relatively low variability with the coefficient of variation ranging from 1.53% to 22.72%. There appears to be a seasonal trend in diversity such that it is typically higher in August compared to September (2008) or October (2012), although this was not consistently the case at all sites. Over the course of monitoring, the highest mean diversity was 0.85 at the downstream site on August 12, 2008 and on August 28, 2012 (S.D. = 0.016 and 0.024, respectively); a diversity of 0.85 (S.D. = 0.013) was also observed at the diversion site on Big Silver Creek on August 12, 2008. Compared to density and biomass, richness (# of families) also showed relatively low variability with the coefficient of variation ranging from 7.3% to 23.7%. Compared to all other parameters, the Canadian Ecological Flow Index (CEFI) showed the lowest variability (the coefficient of variation ranged from 0.49% to 2.71%). Within a sample date, the CEFI index was generally lowest at the downstream site.

Due to high natural variability in the baseline data, the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) recently approved the decision to exclude invertebrate drift monitoring from the Big Silver LTMP (Rosenboom, pers. comm., 2017).

4. EFFECTS ASSESSMENT

4.1. <u>Hydrology</u>

The proposed increase in the maximum diversion rate will only affect flow magnitude in the diversion reach of Big Silver Creek. Based on the available hydrological data, the proposed increase in the maximum diversion rate is predicted to cause relatively small flow changes in the diversion reach of Big Silver Creek (Figure 1, Table 2). Under the current scenario, the average daily flow is 5.70 m^3/s (24.5% MAD) while under the proposed scenario the average daily flow is 5.42 m^3/s (23.3% MAD). Based on the available data, a 1.2% decrease in the average daily flow is expected as a result of the proposed increase in the maximum diversion rate. Although the proposed increase in the maximum diversion rate will have a year-round effect on flows in the diversion reach when natural flow exceeds the IFR and the current diversion maximum (42.0 m^3/s), the largest effects are expected to occur during the freshet period of May through July (Table 3). Average monthly flows are expected to be reduced by a maximum of 9% in June. Figure 1a shows the annual current and proposed flows in the diversion reach, with Figure 1b showing the expected changes in flow during the May through July period.

Figure 2 shows the difference between the current and proposed scenarios in a typical year, a dry year, and a wet year. The proposed increase in the maximum diversion rate is expected to decrease the frequency of flows above 100% and 200% MAD by 0.5% and 0.1% respectively (Table 2). The frequency of a 1-in-2 year flood, determined to be 202 m^3/s (NHC (2011), will decrease by only 0.01%.

Table 2. Summary of average daily flows in Big Silver Creek diversion reach under the current and proposed IFR scenarios.

Metric	Baseline	Current Scenario	Proposed Scenario	Difference[1]
Average Daily Flow (m^3/s)	23.3	5.70	5.42	-0.28
Average Daily Flow (%MAD)	100%	24.5%	23.3%	-1.2%
Flows Above 100% MAD (%)	33.6%	5.4%	4.9%	-0.5%
Flows Above 200% MAD (%)	12.8%	2.2%	2.1%	-0.1%
Flows Above 202 m^3/s (%)[2]	0.25%	0.08%	0.07%	-0.01%

[1]Difference between proposed and current scenario.

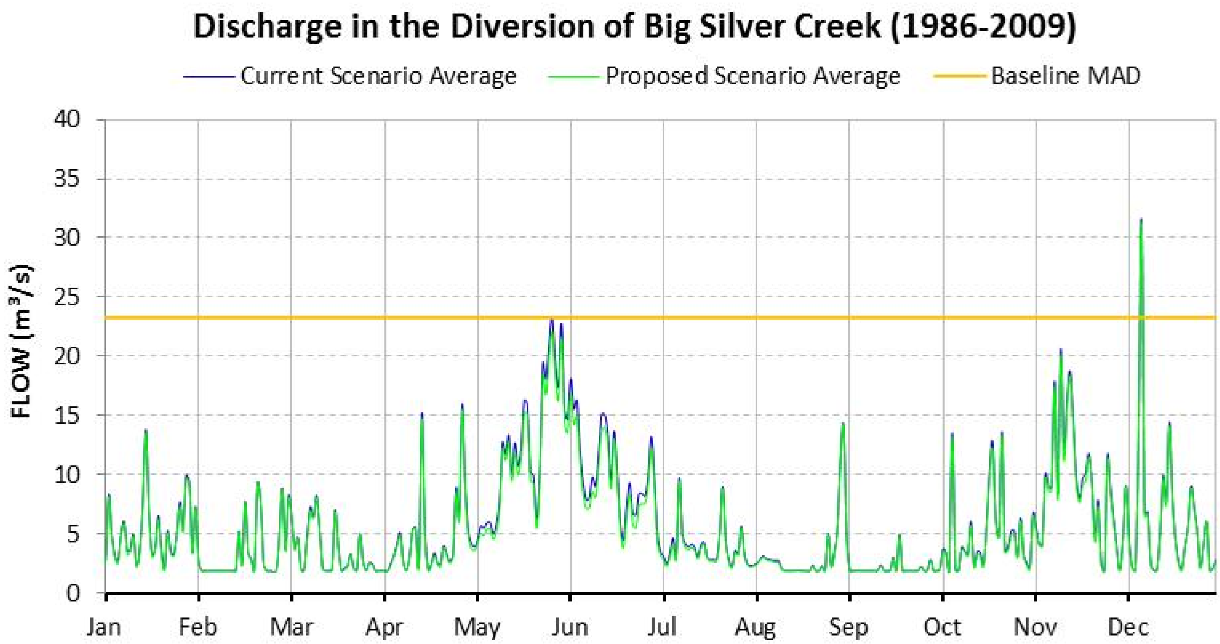
[2]A flow of 202 m^3/s represents the 1-in-2 year flood as determined by NHC (2011).

Table 3. Summary of average monthly flows in Big Silver Creek diversion reach under the current and proposed IFR scenarios.

Month	Average Discharge (m^3/s)			Difference between Current and Proposed Scenario	
	Baseline	Current Scenario	Proposed Scenario	m^3/s	%
Jan	18.0	4.76	4.57	-0.19	-4%
Feb	12.1	3.64	3.59	-0.05	-1%
Mar	14.5	4.00	3.90	-0.10	-3%
Apr	24.6	4.41	4.23	-0.18	-4%
May	44.1	11.4	10.6	-0.75	-7%
Jun	47.4	10.8	9.81	-0.98	-9%
Jul	28.8	3.96	3.74	-0.23	-6%
Aug	15.8	3.26	3.18	-0.07	-2%
Sep	10.0	2.11	2.08	-0.02	-1%
Oct	18.2	5.03	4.81	-0.22	-4%
Nov	27.5	9.02	8.68	-0.35	-4%
Dec	18.1	5.89	5.73	-0.16	-3%
Annual	**23.3**	**5.70**	**5.42**	**-0.28**	**-5%**

Figure 1. Current and proposed scenario discharge in the Big Silver Creek diversion reach over the entire year (a) and from May through July (b).

a)



b)

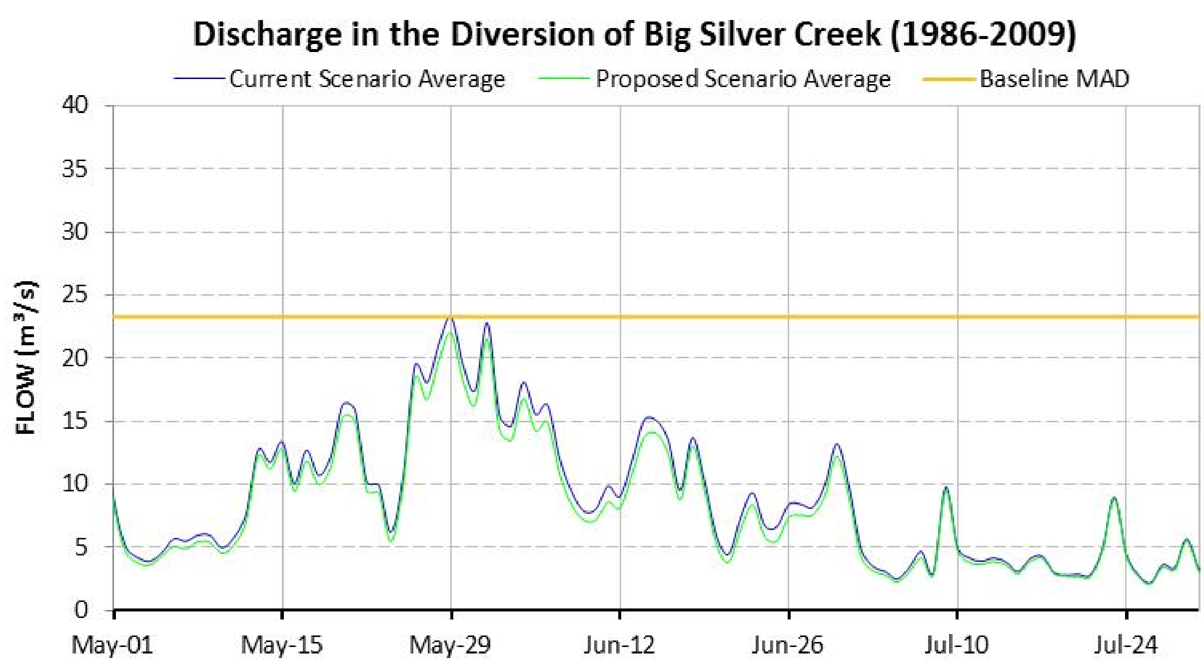
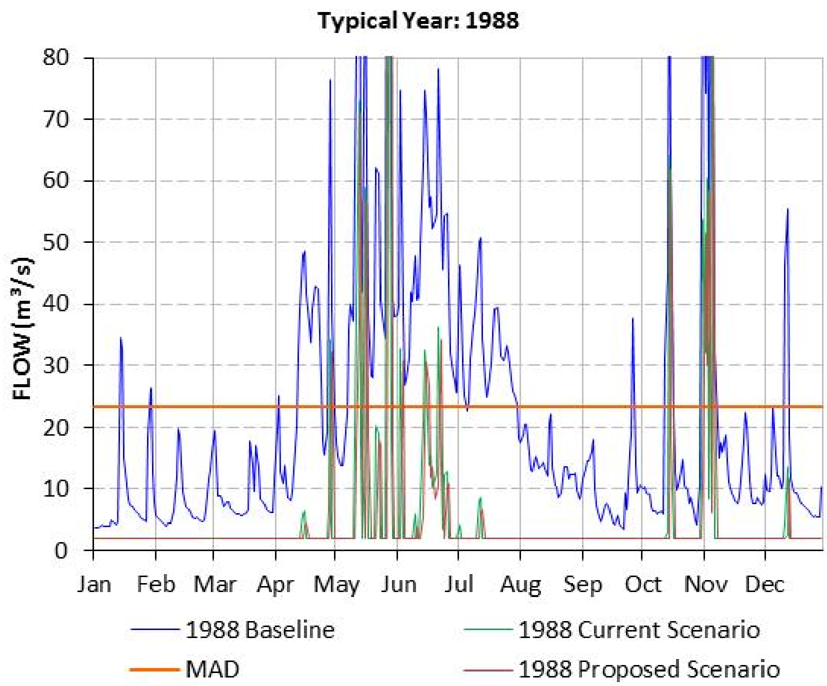
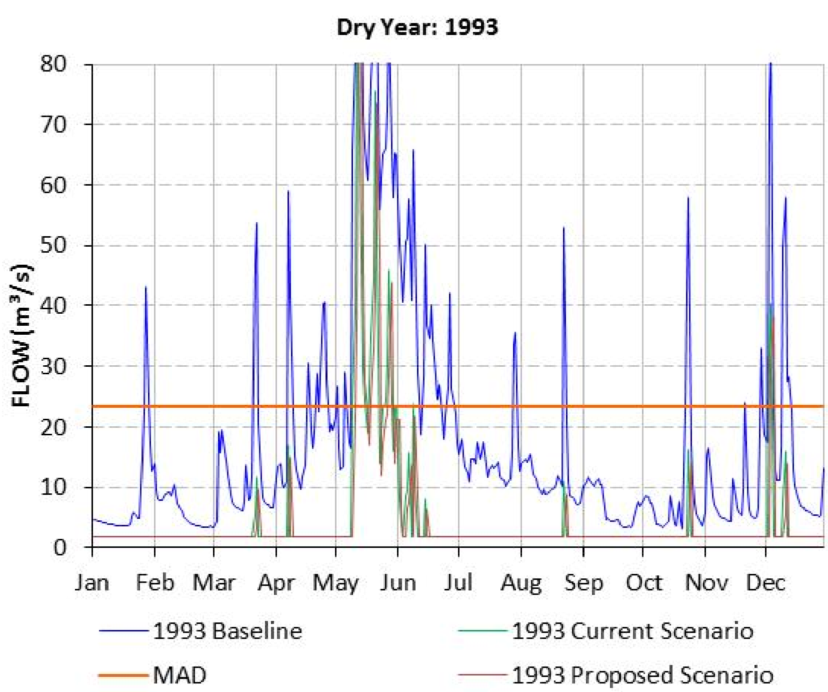


Figure 2. Current and proposed scenario discharge in the Big Silver Creek diversion reach during a typical (a), dry (b) and wet (c) year.

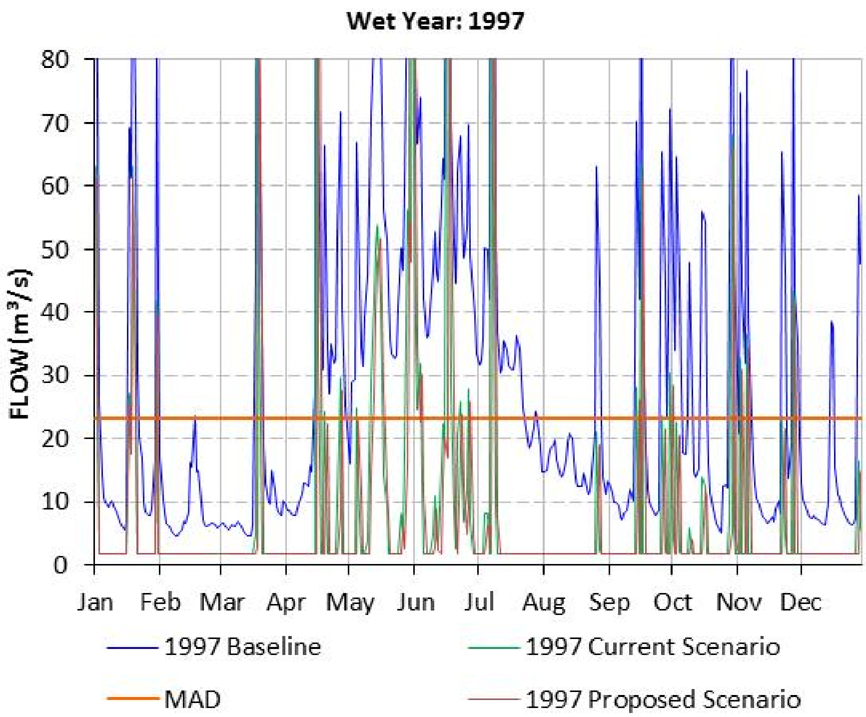
a)



b)



c)



4.2. Water Quality and Temperature

The reduction of flow through the diversion reach and concomitant increase of flow through the Project's powerhouse as a result of the proposed increase in the maximum diversion rate may affect surface water quality in the diversion and downstream reaches. Water quality parameters that could potentially be affected are total suspended solids and turbidity, dissolved oxygen, and TGP. Water temperature may be also affected by the proposed increase in the maximum diversion rate, but the effects on temperature are assessed from a fish habitat perspective under fish rearing and overwintering habitat (Section 4.3), and spawning and incubation habitat (Section 4.4), as in the original EA.

The original EA predicted that Project operation would have low magnitude residual effects on water quality, which would not be significant (Lewis *et al.* 2011a). Based on the EA conclusions, and the water quality monitoring results from other run-of-river projects that failed to identify any biologically significant effects on water quality (Jesus *et al.* 2004, Wu *et al.* 2009, Summit 2015), the long-term monitoring of most water quality parameters on Big Silver Creek was not recommended in the Project's LTMP (Harwood *et al.* 2016). The proposed increase in the maximum diversion rate does not alter this recommendation based on the baseline water quality conditions in Big Silver Creek relative to typical natural conditions in British Columbia, and the change in water quality that would be required to exceed water quality guidelines for the protection of aquatic life. This magnitude of effect is not predicted to occur from the proposed increase to the maximum diversion rate given the results of other long-term monitoring programs that have monitored the effects of much larger flow changes than those predicted in Table 3 (i.e., maximum change in average monthly discharge of 9% compared to changes >50% when reducing flows from natural to an IFR).

The only water quality parameter that the LTMP recommended monitoring was TGP, for which monitoring was recommended for a period of one year given the use of Francis turbines on the Project. Francis turbines contain the water column wholly under pressurized conditions, which increases the opportunity for entrainment of gases. The results of this one year of monitoring are still outstanding; however, given the magnitude of change expected to average daily flows under the proposed increase in the maximum diversion rate (-0.28 m^3/s, -1.2% of MAD), and the maximum additional flow that will be passing through the powerhouse (2 m^3/s), measureable changes to TGP are not expected. Furthermore, any potential increase in TGP from the greater amount of flow being passed through the turbines may be offset by the decreased amount of flow passing over the 6 m high falls, located 480 m upstream of the powerhouse, during high flow events that are likely to naturally increase TGP. This is supported by baseline TGP data (Lewis *et al.* 2011b) that show the highest TGP values in spring and fall when flows are highest. The proposed increase to the maximum diversion rate does not therefore warrant a change to the residual effects characterization for the effects on water quality in the original EA (Lewis *et al.* 2011a).

4.3. Fish Rearing and Overwintering Habitat

The original EA assessed the potential effects on rearing and overwintering habitat during operations by evaluating the effects of the IFR, ramping rates, changes in water temperature, and headpond creation. Changes to rearing and overwintering habitat from the creation of the headpond are not expected to differ under the proposed increase in the maximum diversion rate and are thus not assessed herein; however, the other three pathways of effect are evaluated here.

The proposed increase to the maximum diversion rate will reduce flows in the fish-bearing lower diversion reach and may therefore affect rearing and overwintering habitat quantity and quality. The magnitude of these changes was assessed by re-running the instream flow analysis used for the EA with the proposed new diversion scenario. Table 4 presents habitat calculations for Rainbow Trout in the lower diversion reach under the existing and proposed flow scenarios. Effects to Rainbow Trout fry are expected to be neutral, with either no change or increases in habitat of <1%. There is a predicted loss of rearing habitat for Rainbow Trout parr from the proposed increase of the maximum diversion rate, with an incremental 2 m^2 loss (-0.1%) in the critical stream flow period (CSFP) and 39 m^2 loss (-1.0%) across the growing season compared to the current flow scenario (these losses represent -0.04% and -0.65% losses compared to baseline habitat in the CSFP and growing season, respectively). This magnitude of rearing habitat loss is not predicted to result in serious harm to fish based on the habitat losses predicted for Rainbow Trout on the Kwalsa projects (-1% to -57%) and the positive effects on fish density and biomass observed on those projects (Faulkner *et al.* 2015).

With respect to overwintering habitat, we consider it unlikely that the proposed increase to the maximum diversion rate will affect the quantity and quality of the existing overwintering habitat in the lower diversion reach to the extent that the productivity of fish habitat will be affected. Results of baseline fish habitat surveys show that the lower diversion reach habitat is dominated by riffle (47%) and cascade (30%), with pools comprising only 7% of the total habitat area (Lewis *et al*. 2011b). Pools in the lower diversion reach had an average depth of 2.4 m (SD = 0.71) when surveyed under winter low flow conditions in January 2008 (Lewis *et al*. 2011b). The IFR will maintain flows over the winter and daily flows in January are only predicted to change on average 3 days per year (median = 3 days, range = 0 to 9 days) under the proposed increase in the maximum diversion rate, and by a maximum of 2 m^3/s. The proposed increase in the maximum diversion rate is therefore not expected to have a measurable effect on overwintering pool depth compared with the current flow scenario. Furthermore, competitive interactions between salmonids are reduced in winter compared to the low flow period of the summer growing season such that aggregations of fish within pools are common (Cunjak and Power 1986).

Based on the predicted effects to rearing and overwintering habitat, and the monitoring results from the Kwalsa projects, the proposed increase in the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of flow diversion on rearing and overwintering habitat in the original EA (Lewis *et al*. 2011a).

Table 4. Estimated rearing habitat effects of the current and proposed flow scenarios for Rainbow Trout in the lower diversion reach of Big Silver Creek[1].

Species - Stage	Limiting Factor	Period	Baseline Habitat (m^2)	Current Scenario Habitat (m^2)	Proposed Scenario Habitat (m^2)	Current Scenario Difference (m^2)	Proposed Scenario Difference (m^2)	Difference in Scenarios (m^2)	Difference in Scenarios (%)
Rainbow Trout Fry	CSFP[1]	1-Sep to 30-Sep	1,923	1,965	1,966	42	43	0	0.0%
	Growing Season	1-May to 15-Nov	1,518	1,901	1,907	383	389	6	0.3%
	Fry Emergence	16-Jun to 15-July	1,196	1,915	1,922	719	726	7	0.4%
Rainbow Trout Parr	CSFP[1]	1-Sep to 30-Sep	5,343	3,547	3,545	-1,795	-1,798	-2	-0.1%
	Growing Season	1-May to 15-Nov	5,925	3,960	3,922	-1,964	-2,003	-39	-1.0%

Cells highlighted in pink indicate predicted habitat loss

[1]CSFP - Critical Stream Flow Period is the month of lowest flow during the growing season.

The increase in diverted flow throughout the year will result in an increase in the magnitude of stage changes in the lower diversion and downstream reaches during ramping events. Big Silver Creek operates under approved ramping rates that limit the rate of stage change (-2.5 cm/hr during the fry

[1] Dolly Varden/Bull Trout habitat effects were evaluated in the original EA; however, these species are no longer considered present in the Big Silver Creek resident reach (Section 3.4). Even if they are present, predicted effects on rearing habitat are expected to be neutral, with slight increases in habitat predicted compared to the current flow scenario (1 m^2 or 0.0% for juveniles in the CSFP, 8 m^2 or 0.5% over the growing season, and 8 m^2 or 0.6% during fry emergence (16-Apr to 15-May)).

present period (June 15 to October 31 in the diversion reach; February 1 to October 31 in the downstream reach) and -5.0 cm/hr when juveniles are present). These ramping rates are monitored continuously in real-time and any non-compliance issues are subject to searches to document ramping effects to fish. Based on approved ramping rates at high flows, there is only a small difference (~5 minutes) in the time required for a compliant shut-down from full capacity under the current and proposed maximum diversion rates. In the case of an instantaneous non-compliant shut-down from full capacity, the maximum predicted stage change under the current scenario at one of the downstream SSMSs is -67.0 cm, compared to -68.4 cm under the proposed increase in the maximum diversion rate. This illustrates that the difference in stage change between the current and proposed scenario is minor (-1.4 cm, -2%) even under a worst-case scenario. Given the magnitude of the increase in maximum diversion rate (2 m^3/s), and the mitigation measures in place to minimize the effects of ramping, we judge that the proposed increase in the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of flow ramping on rearing and overwintering habitat in the original EA (Lewis *et al*. 2011a).

Reduced flows in the lower diversion reach also have the potential to affect rearing and overwintering habitat by increasing water temperatures in the summer and reducing water temperatures and increasing the risk of frazil ice formation during winter. Frazil ice build-up has the potential to reduce habitat quantity and cause mortality of overwintering fish. Despite the potential for such effects, long-term monitoring of the effects of similar run-of-river projects at the six Kwalsa-Stave projects located in close proximity to Big Silver Creek has shown that temperature effects, although measureable, were <1°C and did not result in adverse biological effects (Summit 2015, EDI 2015, Faulkner *et al*. 2015). The Kwalsa-Stave projects have similar maximum diversion rates as a percentage of MAD (160% MAD to 202% MAD) as Big Silver's current (180% MAD) and proposed (189% MAD) maximum diversion rate. Furthermore, the maximum flow change in the diversion reach is 2 m^3/s, which is a much smaller decrease in flows than those monitored at the Kwalsa-Stave projects when flows were decreased from natural flows to an IFR.

The change in average discharge in the month with the highest baseline temperatures (August) is 2% (Table 3), suggesting that the maximum change in water temperature in August that may result from the proposed increase in the maximum diversion rate is 2%. The maximum hourly temperature in the Big Silver Creek diversion reach in August during baseline years ranged from 13.2°C (2011) to 18.0°C (2009) (Faulkner *et al*. 2014). Based on these baseline temperatures, a 2% increase in temperature would result in hourly temperatures ranging from 13.5°C to 18.4°C. Maximum temperature increases of this magnitude are likely to improve rearing conditions for Rainbow Trout in the diversion reach given that the optimal rearing temperature for Rainbow Trout is from 16.0 to 18.0°C (Oliver and Fidler 2001). Based on the synthetic flow record, the number of days on which daily average flow is predicted to change in August between the current and proposed scenarios is an average of 1 day a year (median = 0, range = 0 to 14). Together these analyses suggest that changes in water temperature in August will be infrequent under the proposed increase in the maximum diversion rate, but positive in nature when they do occur.

The change in average discharge in the month with the lowest baseline temperatures (January) is 4% (Table 3), suggesting that the maximum change in water temperature in January that may result from the proposed increase in the maximum diversion rate is 4%. The minimum hourly temperature in the Big Silver Creek diversion reach in January during baseline years ranged from 0.0°C (2009) to 1.0°C (2010) (Faulkner *et al.* 2014). Based on these baseline temperatures, a maximum 4% decrease in temperature would increase the frequency with which hourly temperatures were <1.0°C. However, based on the synthetic flow record, the number of days on which daily average flow is predicted to change in January between the current and proposed scenarios is an average of 3 days a year (median = 3, range = 0 to 9). For comparison, the number of days that water temperature in the diversion reach was <1.0°C during baseline conditions ranged from 8 days (2010) to 33 days (2009) (Faulkner *et al.* 2014). A modest increase in the number of days that water temperature is <1.0°C is not predicted to be significant given this natural range of inter-annual variability.

Based on the above analysis of potential effects on water temperature, and the results of long-term monitoring at similar run-of-river projects, the proposed increase in the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of temperature change on rearing and overwintering habitat in the original EA (Lewis *et al.* 2011a).

The data currently being collected on water temperature, ramping effects, and fish density and biomass for the Big Silver Creek LTMP (Harwood *et al.* 2016) will allow these predictions to be tested should the increase to the maximum diversion rate be approved and implemented.

4.4. Fish Spawning and Incubation Habitat

The original EA assessed the potential effects on spawning and incubation habitat during operations by evaluating the effects of the IFR, ramping rates, changes in water temperature, and headpond creation. Changes to spawning and incubation habitat from the creation of the headpond are not expected to differ under the proposed increase in the maximum diversion rate and are thus not assessed herein. Similarly, any effects from ramping are expected to be similar to effects described above for rearing and overwintering habitat. Consequently, the remainder of this section addresses potential effects to spawning and incubation habitat from changes to water temperature and the availability of suitable spawning habitat.

The maximum change in average monthly discharge predicted under the proposed increase in the maximum diversion rate occurs in June, which falls within the Rainbow Trout spawning and incubation period. The change in average discharge (based on an average of changes to daily flow) is predicted to be 9% (Table 3), suggesting that the maximum change in water temperature in June that may result from the proposed increase in the maximum diversion rate is 9%. The maximum hourly temperature in the Big Silver Creek diversion reach in June during baseline years ranged from 9.0°C (2011, 2012) to 12.3°C (2009) (Faulkner *et al.* 2014). Based on these baseline temperatures, a 9% increase in temperature would result in hourly temperatures ranging from 9.8°C to 13.4°C in June. The optimal temperature for Rainbow Trout spawning is from 10.0 to 15.5°C and the optimal temperature for incubation is 10.0 to 12.0°C (Oliver and Fidler 2001). Maximum temperature increases of the magnitude predicted are likely to improve spawning and incubation conditions for Rainbow Trout in the diversion reach given that 89% of the mean weekly temperatures during baseline were below the lower bound of the optimum temperature range by >1°C within the incubation period (April 16 to July 31), and 100% were below the lower bound of the optimum temperature range by >1°C for the spawning period (April 16 to June 30) (Faulkner *et al.* 2014).

The proposed increase to the maximum diversion rate will reduce flows in the fish-bearing lower diversion reach and may therefore affect rearing and overwintering habitat quantity and quality. The magnitude of these changes was assessed by re-running the instream flow analysis used for the EA with the proposed new diversion scenario. Table 5 presents habitat calculations for Rainbow Trout in the lower diversion reach under the existing and proposed flow scenarios. The instream flow analysis predicts a loss of 0.8 m^2 of spawning habitat for Rainbow Trout compared to the current flow scenario, and a 0.2 m^2 (-2.3%) loss of spawning habitat compared to baseline conditions. This magnitude of spawning habitat loss is not predicted to result in serious harm to fish given the small loss in absolute terms (0.2 m^2) and because the 9.5 m^2 of spawning habitat predicted under the flow scenario would be sufficient for 95 spawning pairs in the 480 m long lower diversion reach (assuming a minimum spawning patch size of 0.1 m^2 as per Johnston and Slaney 1996).

The data currently being collected on water temperature and fish density and biomass for the Big Silver Creek LTMP (Harwood *et al.* 2016) will allow these predictions to be tested should the increase to the maximum diversion rate be approved and implemented.

Based on the predicted effects to spawning and incubation habitat, the proposed increase to the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of flow diversion on spawning and incubation habitat in the original EA (Lewis *et al.* 2011a).

Table 5. Estimated spawning habitat effects of the current and proposed flow scenarios for Rainbow Trout in the lower diversion reach of Big Silver Creek[2].

Species - Stage	Period	Baseline Habitat (m^2)	Current Scenario Habitat (m^2)	Proposed Scenario Habitat (m^2)	Current Scenario Difference (m^2)	Proposed Scenario Difference (m^2)	Difference in Scenarios (m^2)	Difference in Scenarios (%)[1]
Rainbow Trout Spawning	16-Apr to 30-Jun	9.8	10.3	9.5	0.6	-0.2	-0.8	-7.5%

Cells highlighted in pink indicate predicted habitat loss

[1]Note that there is a -7.5% difference in Rainbow Trout spawning habitat between scenarios, but a -2.3% difference between the proposed scenario and baseline conditions

[2] Dolly Varden/Bull Trout habitat effects were evaluated in the original EA; however, these species are no longer considered present in the Big Silver Creek resident reach (Section 3.4). Even if they are present, predicted effects on spawning habitat are expected to be negligible, with a 0.1 m^2 loss (-1.6%) of spawning habitat predicted compared to the current flow scenario.

4.5. Fish Migratory Habitat

Flow diversion may affect migratory conditions in the diversion reach by a) reducing flows such that migration is more difficult due to shallow depths, b) introducing attractant flows from the tailrace that may delay upstream migration into the diversion reach, and/or c) altering migration cues that often coincide with high flow events. The release of the IFR, which will not change under the proposed maximum diversion rate increase, has been shown to mitigate the potential adverse effect of impeding fish migration due to shallow water depths by the commissioning phase hydraulic connectivity study (Girard *et al.* 2016). The connectivity study demonstrated that the IFR was sufficient to allow fish migration throughout the lower diversion reach.

With respect to tailrace attractant flows, we judge that the maximum 2 m^3/s increase in the amount of flow exiting the tailrace (from 42.0 m^3/s to 44.0 m^3/s) as opposed to flowing through the diversion reach will have a negligible effect on the ability of resident fish to migrate into the lower diversion reach during the spring (Rainbow Trout) and fall (Dolly Varden/Bull Trout) spawning seasons. This is particularly the case because spawning occurs at times when flow in the diversion reach will be higher than the IFR due to spill (Figure 1). Similarly, we consider that the migratory cues provided by high flow events will be maintained under the proposed increase in the maximum diversion rate because although flows will be lower during high flow events, the increase in the maximum diversion rate has little effect on the frequency of spills over the intake (Figure 2) within the spawning migration and spawning periods (March through June).

Based on the above, the proposed increase to the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of flow diversion on migratory habitat in the original EA (Lewis *et al.* 2011a).

4.6. Macroinvertebrate Habitat

The original EA assessed the potential effects on macroinvertebrate habitat during operations by evaluating the effects of the IFR and headpond creation. However, changes to macroinvertebrate habitat from the creation of the headpond are not expected to differ under the proposed increase in the maximum diversion rate, thus only the effects from the withdrawal of additional flow from the diversion reach are evaluated here.

The proposed increase to the maximum diversion rate will reduce flows throughout the diversion reach and may therefore affect macroinvertebrate habitat quantity and quality. The magnitude of these changes was assessed by re-running the instream flow analysis used for the EA with the proposed new diversion scenario. Table 6 presents habitat calculations for macroinvertebrate habitat in the upper and lower diversion reach under the existing and proposed flow scenarios. There is an estimated incremental loss of 204 m^2 (0.9%) of habitat suitable for invertebrates that are swift water specialists during the growing season compared to the current flow scenario. These predicted losses are only for macroinvertebrates that are swift-water specialists, and do not reflect potential changes for the entire macroinvertebrate community. Habitat losses for swift-water specialists are expected to be offset to a degree by an increase in habitat suitable for slow water specialists. Moreover, the majority of the incremental habitat loss for invertebrates compared to the current flow scenario occurs in the non-fish-bearing upper diversion reach. Of the 204 m^2 of predicted habitat loss, 48 m^2 (24%) are in the fish-bearing lower diversion reach and 156 m^2 (76%) are in the upper diversion reach.

The minor incremental increases in invertebrate habitat loss, along with the location of the majority of the habitat losses in the non-fish-bearing upper diversion reach, are such that biologically significant effects to the invertebrate drift population, or the resident fish population in the lower diversion reach, are not expected from the proposed increase in the maximum diversion rate. This conclusion is supported by the lack of adverse effects to fish populations from the operation of similar run-of-river facilities at the Kwalsa-Stave projects (Faulkner *et al.* 2015), which have similar maximum diversion rates as a percentage of MAD (160% MAD to 202% MAD) as Big Silver's current (180% MAD) and proposed (189% MAD) maximum diversion rate. The data currently being collected on fish density and biomass for the Big Silver Creek LTMP (Harwood *et al.* 2016) will allow this prediction to be tested should the increase to the maximum diversion rate be approved and implemented. Due to high natural variability in the baseline data, MFLNRO recently approved the decision to exclude invertebrate drift monitoring from the Big Silver LTMP (Rosenboom, pers. comm., 2017).

Based on the predicted marginal incremental losses in invertebrate habitat, the proposed increase to the maximum diversion rate does not warrant a change to the residual effects characterization for the effects of flow diversion on macroinvertebrate habitat in the original EA (Lewis *et al.* 2011a).

Table 6. Estimated macroinvertebrate habitat effects of the current and proposed flow scenarios during the growing season throughout the Big Silver Creek diversion reach.

Species - Stage	Limiting Factor	Period	Reach	Baseline Habitat (m^2)	Current Scenario Habitat (m^2)	Proposed Scenario Habitat (m^2)	Current Scenario Difference (m^2)	Proposed Scenario Difference (m^2)	Difference in Scenarios (m^2)	Difference in Scenarios (%)
Invertebrates	Growing Season	1-May to 15-Nov	Lower Diversion	5,563	3,130	3,081	-2,433	-2,482	-48	-1.5%
			Upper Diversion	25,650	18,924	18,768	-6,726	-6,882	-156	-0.8%
Total				**31,213**	**22,053**	**21,849**	**-9,160**	**-9,364**	**-204**	**-0.9%**

Cells highlighted in pink indicate predicted habitat loss

4.7. Ecological Considerations

The Assessment Methods (Lewis *et al.* 2004) recommend that the following ecological considerations be evaluated in the analysis of the effects of water withdrawal: flushing flows, channel maintenance flows, flood pulses, habitat connectivity, and behavioural cues. Each of the potential impacts identified in the Assessment Methods have been examined and addressed to the extent judged necessary, given the conditions in the diversion reach and the proposed increase to the maximum diversion rate.

Flushing and channel maintenance flows are required to ensure that the physical structure of the channel is not altered in a way that reduces the quality or quantity of fish habitat. Flushing flows are moderately high flows, relative to MAD, that remove fine particles from the stream bed. Flushing flows are substantially lower than channel forming flows and do not maintain channel slope or cross sectional area. Flushing flows are important in streams with sediment loads that support fish spawning. The fish-bearing section of the Big Silver Creek diversion reach is limited to the lower 0.5 km. However, increased sedimentation may also infill interstitial spaces and affect the quality of invertebrate habitat throughout the diversion. Flows above MAD may be used as an indicator of sufficient flushing flows; however, even lower flows may provide adequate flushing. Under the current flow scenario, flows above 100% MAD are experienced 5.4% of the time, which will decrease by 0.5% to 4.9% of the time under the proposed increase to the maximum diversion rate (Table 2). This <1% reduction in the frequency of flows >100% MAD is not expected to adversely affect the flushing of fine sediment that may have accumulated on or between the substrate within the diversion reach.

Channel maintenance flows are substantially higher than MAD and are channel-forming flows with sufficient power to modify stream channel shape. Channel-forming flows in channels at or near dynamic equilibrium are approximately equal to the bankfull discharge (Leopold *et al.* 1964). To evaluate the effects of the proposed increase in the maximum diversion rate on channel maintenance flows, we compared the frequency of flows >200% MAD under the current and proposed flow scenarios, along with the frequency of a 1-in-2 year flood (determined by NHC (2011) to be 202 m^3/s). Under the current flow scenario, flows above 200% are experienced 2.2% of the time, which will be reduced to 2.1% of the time under the proposed flow scenario. The frequency of flows above 202 m^3/s is only reduced by 0.01% (Table 2). As with flushing flows, these negligible decreases in the frequency of high flows are not expected to adversely affect channel maintenance processes.

Flood pulses are high flows that inundate over bank areas, providing access for fish to floodplain areas and fertilizing floodplains with dissolved nutrients. However, the residual effect that a decrease in the frequency of flood pulses will have on riparian habitat is limited by the morphology of the channel and the nature of the riparian zone. The upper diversion reach is frequently confined and includes a long, deeply entrenched, sinuous canyon, with the lower diversion reach also a single thread channel that is frequently confined (Lewis *et al.* 2011b). The entire diversion reach therefore does not support broad floodplains characteristic of low gradient streams. Consequently there is limited opportunity for riparian inundation and the riparian habitat is dominated by second growth mixed forest, rather than early seral deciduous vegetation characteristic of seasonally inundated riparian areas. There are no significant areas along the diversion reach that would require maintenance via flood pulse inundation, and thus changes to the frequency of flood pulses are not predicted to have meaningful effects on riparian community structure. Moreover, as noted above, there is negligible change in the frequency of flood events compared to the current flow scenario.

Habitat connectivity addresses the role flow plays in linking habitats in the aquatic and riparian ecosystems (Lewis *et al.* 2004). Off channel habitats such as relic back channels may only be accessible during higher flow periods. However, given the confined nature of the Big Silver Creek diversion reach, no secondary channels were identified during the baseline FHAP survey (Lewis *et al.* 2011b). Consequently, the reduction in flow through the diversion reach from the proposed increase in the maximum diversion rate will not affect lateral connectivity to side channels. With respect to longitudinal connectivity, the commissioning phase hydraulic connectivity study confirmed that maintenance of the IFR of 1.9 m^3/s was sufficient to allow fish migration through the lower diversion reach and invertebrate drift throughout the entire diversion reach (Girard *et al.* 2016). Since release of the IFR will not be altered under the proposed increase in the maximum diversion rate, habitat connectivity will not be affected.

Changes to flow timing, magnitude and temperature also have the potential to affect fish as they act as important behavioural cues that often stimulate movement to spawning, rearing or overwintering habitat. The proposed increase to the maximum diversion rate is not expected to adversely affect behavioural cues in the Big Silver Creek diversion reach. This is because high flow events, and the natural timing of these, will be maintained under the proposed increase in the maximum diversion rate through spills over the intake (Figure 2), and the frequency with which flows of a specific magnitude occur (e.g., >100% MAD, >200% MAD) will be reduced by <1% (Table 2). Finally, water temperature changes caused by similar run-of-river projects in close proximity to Big Silver Creek, although measureable, were reported as <1°C and did not result in adverse biological effects to resident fish populations (Summit 2015, Faulkner *et al.* 2015). This is also expected to be the case on Big Silver Creek based on baseline water temperatures compared to optimal water temperatures for Rainbow Trout (Section 4.3 and 4.4).

In summary, the channel morphology of the Big Silver Creek diversion reach and the limited difference between the current and proposed flow scenarios, leads us to conclude that the proposed increase in the maximum diversion rate will result in negligible incremental change to ecological processes compared to the current flow scenario.

5. SUMMARY OF RESIDUAL EFFECTS

Based on the data presently available, and our experience with similar projects in the region, the residual effects from the proposed operational increase in the maximum diversion rate will not be significant. This assessment of significance has high confidence based on the professional judgement of senior qualified personnel, the scientific literature, and empirical monitoring results on the aquatic effects of hydroelectric projects in BC, Alaska, and the Pacific Northwest. This assessment relies on modelling results of the instream flow study conducted for the Project, and the results of recent long-term monitoring programs conducted at run-of-river hydro projects of similar size and configuration in the BC lower mainland. The proposed increase in the maximum diversion rate is predicted to have no biologically significant adverse residual effects on water quality and temperature, fish rearing and overwintering habitat, fish spawning and incubation habitat, fish migratory habitat, or macroinvertebrate habitat based on the magnitude of the predicted changes and the mitigation measures that have already been implemented. Residual effects of the Project continue to be monitored under the LTMP, such that the predictions presented herein can be tested should the increase to the maximum diversion rate be approved and implemented.

Any uncertainty as to whether the proposed increase in the maximum diversion rate may result in serious harm to fish must also consider the offsetting that has already been implemented to compensate for habitat losses predicted in the original EA. To compensate for Rainbow Trout rearing and Dolly Varden spawning habitat losses associated with flow diversion, along with footprint impacts to instream and riparian habitat, fish habitat creation and enhancement was undertaken in Jimmy Charlie Slough near the Harrison River (Hemmera 2015a, b). The Fish Habitat Enhancement Project (FHEP) created 1,125 m^2 and enhanced 10,502 m^2 of aquatic habitat, and created 6,430 m^2 of riparian habitat (Regehr *et al.* 2017). This represented an excess of 6,387 m^2 of aquatic habitat compared to the compensation requirements of the revised FAA (DFO 2016, Regehr *et al.* 2017). Consequently, although the proposed increase to the maximum diversion rate is expected to result in an incremental loss of 39 m^2 of Rainbow Trout rearing habitat compared to the current flow scenario, and 0.2 m^2 of Rainbow Trout spawning habitat compared to baseline conditions, the offsetting implemented at the Jimmy Charlie FHEP ensures that there will be no residual effect on productivity and serious harm to fish even if the habitat effects are larger than predicted.

Changes in water quality due to the proposed increase in the maximum diversion rate are not expected to have residual adverse effects, given the magnitude of the proposed flow changes. This determination is consistent with results from long-term monitoring programs of water quality on other run-of-river streams, which have not identified any biologically significant effects of water quality from project operation even when flow changes have been much greater than those predicted to occur as a result of the proposed increase in the maximum diversion rate (Summit 2015, Jesus *et al.* 2004, Wu *et al.* 2009). With respect to water temperature, small increases in temperature are anticipated in the diversion reach in the summer, and small decreases in the downstream reach, as observed on other run-of-river projects (e.g., Summit 2015). Water temperature is also expected to decrease slightly in the diversion reach in winter. However, based on the magnitude of the proposed flow change and the magnitude of temperature changes observed on other run-of-river projects when flows are decreased from natural levels to an IFR, these changes are not predicted to result in biologically significant adverse effects. This is supported by a comparison of baseline water temperatures with optimal water temperatures for Rainbow Trout, and the magnitude and frequency of water temperature changes expected under the proposed increase in the maximum diversion rate.

The proposed increase in the maximum diversion rate is predicted to result in small incremental losses to rearing habitat for Rainbow Trout parr in the CSFP (2 m^2, 0.1%) and over the growing season (39 m^2, 1.0%) compared to the current flow scenario. However, this magnitude of rearing habitat loss is not predicted to result in serious harm to fish based on the habitat losses predicted for Rainbow Trout on the Kwalsa projects (-1% to -57%) and the positive effects on fish density and biomass observed on those projects (Faulkner *et al*. 2015). Based on the average depth of pools within the fish-bearing lower diversion reach under baseline conditions, and maintenance of the IFR over the winter months, the proposed increase in the maximum diversion rate is not expected to have biologically significant effects on the quantity and quality of overwintering habitat in the lower diversion reach.

The increase in diverted flow throughout the year will result in an increase in the magnitude of stage changes in the lower diversion and downstream reaches during ramping events, which may impact rearing fish. However, given the minor difference (~5 minutes) in the time required for a compliant shut-down from full capacity under the current and proposed maximum diversion rates, and the small difference in maximum stage change (-1.4 cm, -2%) at downstream SSMSs under a worst-case non-compliant shut-down, the proposed increase in the maximum diversion rate is not expected to alter the residual effects from ramping given the mitigation measures already in place.

As with rearing habitat in the growing season, the proposed increase in the maximum diversion rate is predicted to result in minor incremental losses in spawning habitat in the lower diversion reach. The instream flow analysis predicts a loss of 0.2 m^2 (-2.3%) of Rainbow Trout spawning habitat compared to baseline conditions. This magnitude of spawning habitat loss is not predicted to result in serious harm to fish given the small loss in absolute terms (0.2 m^2) and the number of Rainbow Trout spawning pairs that can be supported by the remaining spawning habitat in the short lower diversion reach.

The proposed increase in the maximum diversion rate is not expected to have residual adverse effects on fish migratory habitat given the magnitude of the proposed flow changes. The release of the IFR, which will not change under the proposed maximum diversion rate increase, has been shown to mitigate the potential adverse effect of impeding fish migration due to shallow water depths by the commissioning phase hydraulic connectivity study (Girard *et al*. 2016). Also, the maximum 2 m^3/s increase in the amount of flow exiting the tailrace (from 42.0 m^3/s to 44.0 m^3/s) as opposed to flowing through the diversion reach will have a negligible effect on the ability of resident fish to migrate into the lower diversion reach during the Rainbow Trout spawning season.

The proposed increase in the maximum diversion rate is predicted to result in an incremental loss of 204 m^2 (0.9%) of habitat suitable for invertebrates that are swift water specialists during the growing season compared to the current flow scenario. However, this habitat loss is for swift water specialists only and the majority of the loss (76%) is in the non-fish-bearing diversion reach. The minor incremental increase in invertebrate habitat loss is therefore not expected to result in biologically significant effects to the invertebrate drift population, or the resident fish population in the lower diversion reach. This conclusion is supported by the lack of adverse effects to fish populations from the operation of similar run-of-river facilities at the Kwalsa-Stave projects (Faulkner *et al*. 2015).

Finally, the channel morphology of the Big Silver Creek diversion reach and the limited difference between the current and proposed flow scenarios, leads us to conclude that the proposed increase in the maximum diversion rate will result in negligible incremental change to flushing and channel maintenance flows, flood pulses, habitat connectivity and behavioural cues compared to the current flow scenario.

Based on the predicted minor incremental effects to fish habitat, and the mitigation and habitat compensation measures that have already been implemented to minimize or offset Project effects, the proposed increase to the maximum diversion rate does not warrant any changes to the residual effects characterizations for the effects of flow diversion on the subcomponents of the fish habitat VEC assessed in the original EA (Lewis *et al*. 2011a). Consequently, we conclude that additional mitigation and/or compensation is not required. The data currently being collected on water temperature, ramping effects, and fish density and biomass for the Big Silver Creek LTMP (Harwood *et al*. 2016) will allow these predictions to be tested should the increase to the maximum diversion rate be approved and implemented. No additional monitoring other than that prescribed in the LTMP is warranted given the minor incremental effects predicted.

6. CLOSURE

This report assessed the potential environmental effects of a proposed increase to the maximum diversion rate for the Big Silver Waterpower Project from 42.0 m^3/s to 44.0 m^3/s. The assessment focused on potential effects to the fish habitat VEC evaluated in the Project's original EA (Lewis *et al*. 2011a). We conclude that the proposed increase in the maximum diversion rate is predicted to have no biologically significant residual effects on water quality and temperature, fish rearing and overwintering habitat, fish spawning and incubation habitat, fish migratory habitat, or macroinvertebrate habitat based on the magnitude of the predicted changes and the mitigation and compensation measures that have already been implemented. Consequently, no additional mitigation and/or compensation is required, and monitoring of the Project's effects on the environment should proceed as prescribed in the Project's LTMP (Harwood *et al*. 2016) if the increase in the maximum diversion rate is approved and implemented.

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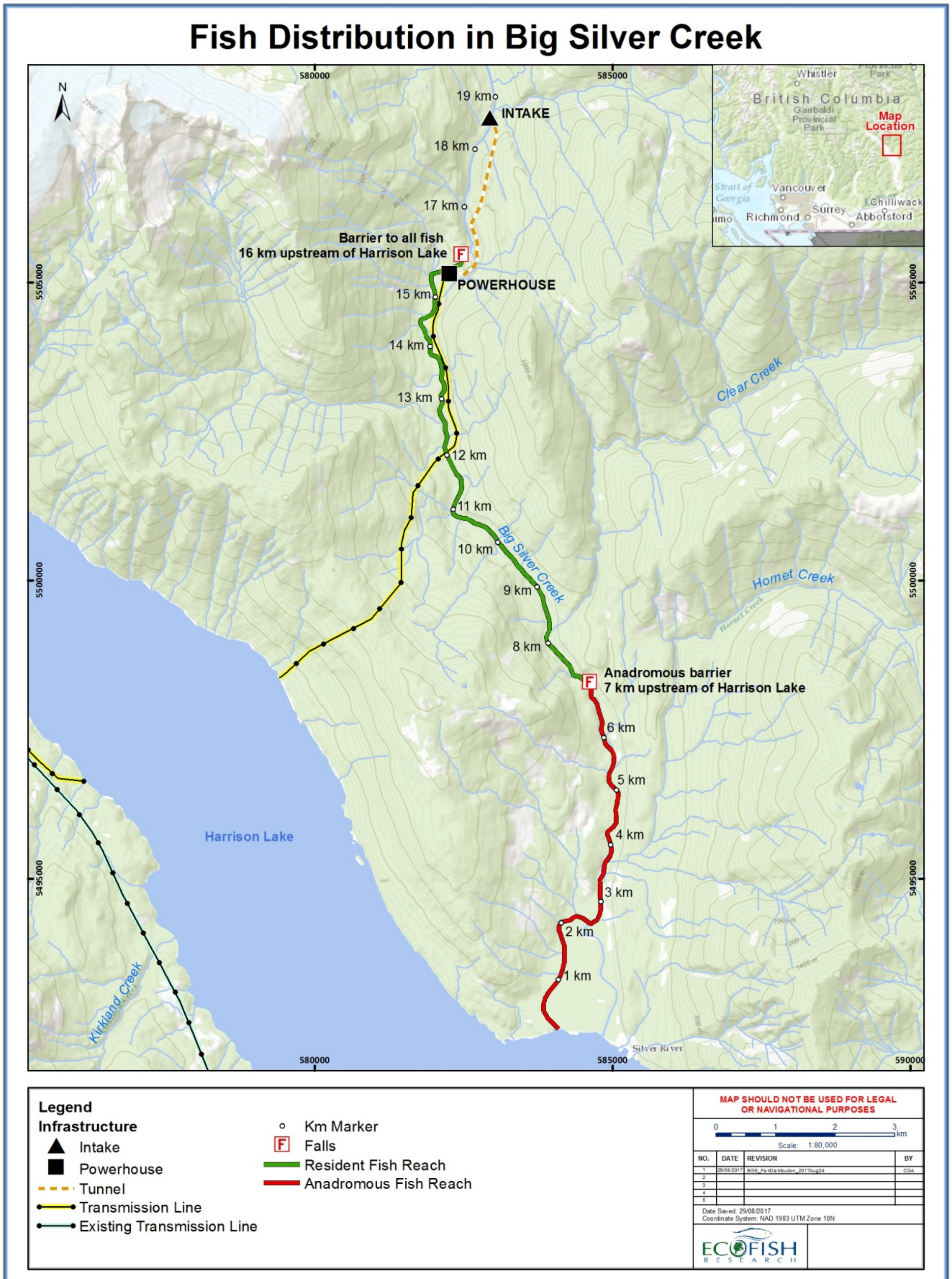
PROJECT MAPS

Map 2. Fish distribution and barrier locations in Big Silver Creek.



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Appendix B. Letter of support for the EAC amendment to increase maximum diversion rate of the Big Silver Creel Waterpower Project from Sts'ailes First Nations.

Xaxtsa
Douglas First Nation
321 IR Road #10
Mount Currie, B.C., V0N 2K0
Tel. (604) 894-0020 Fax. (604) 894-0019

October 25, 2017

Front Counter BC
10428 153 Street #200
Surrey, BC
V3R 1E1

BC Environmental Assessment Office
836 Yates Street
Victoria, BC
V8W 1L8

Re: Big Silver Creek Hydroelectric Project – Conditional Water Licence Application / EAC Amendment

To Whom It May Concern,

Xa'xtsa - Douglas First Nation has been informed by Innergex Renewable Energy Inc., on behalf of Big Silver Creek Power Limited Partnership (BSCPLP), of BSCPLP's desire to apply for a new Conditional Water Licence (CWL) to replace the current CWL #129606 for the Big Silver Creek Hydro Project (the Project).

We understand that BSCPLP is requesting the new CWL to permit an increase in the maximum allowable temporary diversion of water from Big Silver Creek from the current amount of 42 m^3/s to the new amount of 44 m^3/s. We understand that no new infrastructure will be installed and the new Conditional Water Licence will have no effect on the generation capacity of the existing Big Silver Creek Hydroelectric Project. We support the issuance of a new Conditional Water Licence for the Project.

As well, we understand that the BC Environmental Assessment Certificate (EAC) E12-03 (clause 7) must be modified to reflect the new maximum water diversion value (44 m^3/s). We support the proposed amendment of the Project's EAC.

Sincerely,

Chief Don Harris
Xa'xtsa – Douglas First Nation

4690 Salish Way | Agassiz, BC V0M 1A1
t 604 796 2116 | w stsailes.com

Sts'ailes

September 22, 2017

Front Counter BC
10428 153 Street #200
Surrey, BC
V3R 1E1

BC Environmental Assessment Office
836 Yates Street
Victoria, BC
V8W 1L8

Re: Big Silver Creek Hydroelectric Project – Conditional Water Licence Application / EAC Amendment

Two Whom It May Concern,

Sts'ailes has been informed by Innergex Renewable Energy Inc., on behalf of Big Silver Creek Power Limited Partnership (BSCPLP), of BSCPLP's desire to apply for a new Conditional Water Licence (CWL) to replace the current CWL #129606 for the Big Silver Creek Hydro Project (the Project).

We understand that BSCPLP is requesting the new CWL to permit an increase in the maximum allowable temporary diversion of water from Big Silver Creek from the current amount of 42 m^3/s to the new amount of 44 m^3/s. We understand that no new infrastructure will be installed and the new Conditional Water Licence will have no effect on the generation capacity of the existing Big Silver Creek Hydroelectric Project. We support the issuance of a new Conditional Water Licence for the Project.

As well, we understand that the BC Environmental Assessment Certificate (EAC) E12-03 (clause 7) must be modified to reflect the new maximum water diversion value (44 m^3/s). We support the proposed amendment of the Project's EAC.

Sincerely,

Chief Ralph Leon