Columbia River Project Water Use Plan

Physical Works Terms of Reference

CLBWORKS-27 Lower Columbia White Sturgeon Physical Works: Physical works options to address white sturgeon recruitment failure in the lower Columbia River

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Physical Works Terms of Reference

1.0 Introduction

This Terms of Reference (TOR) is for the Lower Columbia White Sturgeon Physical Works: Physical works options to address white surgeon recruitment failure in the lower Columbia River.

During the Columbia River Water Use Plan (WUP) process, the Consultative Committee (CC) agreed that a key focus of fish management in the Columbia River mainstem should be on white sturgeon, *Acipenser transmontanus* (WUP CC 2005). White sturgeon in the Canadian portion of the Columbia River, were listed as endangered under *Canada's Species at Risk Act* (SARA) in 2006. This listing also includes populations of white sturgeon from the Nechako, Kootenay, and Fraser rivers. The listing for the Columbia River population is directed primarily at white sturgeon found between the Canada-US border and Revelstoke Dam. There are estimated to be approximately 1,200 mature white sturgeon in this area with the majority found downstream of Hugh L. Keenleyside Dam (HLK) in the lower Columbia River (Irvine et al. 2007; Wood et al. 2007), and approximately 40 adults estimated upstream of HLK in the middle Columbia River (Fisheries and Oceans Canada 2014).

The major concern to date with respect to white sturgeon in the Columbia River is that the level of natural recruitment is insufficient to maintain self-sustaining populations (UCWSRI 2012). Although existing adult white sturgeon have successfully spawned in multiple river locations (Pend d'Oreille and Columbia River Confluence: Golder 2008a, BC Hydro 2013; Arrow lakes Generating Station: Terraquatic Resource Management 2011; Revelstoke: Golder 2008b), insufficient young are surviving through the early life stages (i.e., egg, larval, and juvenile) to become sexually mature adults. The exact causes of recruitment failure among sturgeon found in the lower Columbia River remain uncertain. However, it is generally agreed that the onset of building the Canadian Columbia Treaty dams in 1968 have had a negative impact in several key areas including, but not limited to, habitat suitability and access, fish movement, and food availability. Additionally, the operation of dams for power and flood control on the Columbia River has substantially altered the range of daily water level fluctuations, turbidity levels, and seasonal flow regimes with reduced flows in the spring and early summer and increased flows in the winter. A logical recovery response would therefore be to alter the hydrograph in the lower Columbia reach to mimic the natural flow regime as much as possible, especially in the spring/summer during white sturgeon spawning and early life stage periods. The WUP CC considered such a mitigative response, but concluded that anything more than opportunistic operational changes faced significant practical and financial impediments (WUP CC 2005). Significant freshet flows were experienced in 2011 and 2012, with 2012 being higher than could be achieved operationally, and responses (detectable recruitment) to these flow years are still being evaluated under Columbia WUP monitoring programs.

The WUP CC asked BC Hydro to explore alternatives to operational changes, and the resulting options focused on limited flow modifications in conjunction with turbidity supplementation (Hildebrand et al. 2003). That recommendation was captured in the WUP as CLBWORKS-28, Lower Columbia River – Planning and Assessment of White Sturgeon Turbidity Experiments.

As an initial response to the uncertainty regarding the cause(s) of recruitment failure, the Upper Columbia White Sturgeon Recovery Initiative (UCWSRI) Technical Working Group (TWG) underwent a recruitment failure hypotheses review between 2006 and 2008 (Gregory and Long 2008). The purpose of the review was to reach consensus on those hypotheses which best explained white sturgeon recruitment declines in the Columbia system, to identify research required to better define the pathways of impact, and to define mitigative measures or management responses with the best likelihood of alleviating the causes of recruitment loss. The process considered impacts including flow regime effects and the benefits of cover provided by the suspended sediment load at spawning sites in the lower Columbia River. The process identified the following hypotheses along with related potential mitigative measures:

a) Changes in flow patterns (magnitude and timing) and reduction in turbidity reduce the survival of early life stages.

    i) Turbidity augmentation
    ii) Flow manipulation – depth and velocity
    iii) Backwater habitat influence manipulation

b) Diminished suitability and availability of habitat (primarily related to substrate conditions) near spawning areas has led to reduced survival of early life stages.

    i) Substrate modification – cleaning
    ii) Substrate modification – addition

c) Changes to fish community have resulted in increased predation on eggs, free embryos, larvae and juvenile sturgeon and significantly reduced survival.

    i) Predation control program – general
    ii) Walleye reduction program

d) Food of the appropriate type and size is not available at the right time and place to promote survival of young sturgeon.

    i) Fertilize transboundary reach
    ii) Seeding of varial zones
    iii) Embayment fertilization

Furthermore, discussions of research needs during the hypothesis review focused on the benefits of studies that would address information gaps through the reconstruction of historic data. This would include stock structure analysis and impact timelines for each hypothesis. Therefore, the need for historic reconstruction is critical to help in guiding mitigative actions.

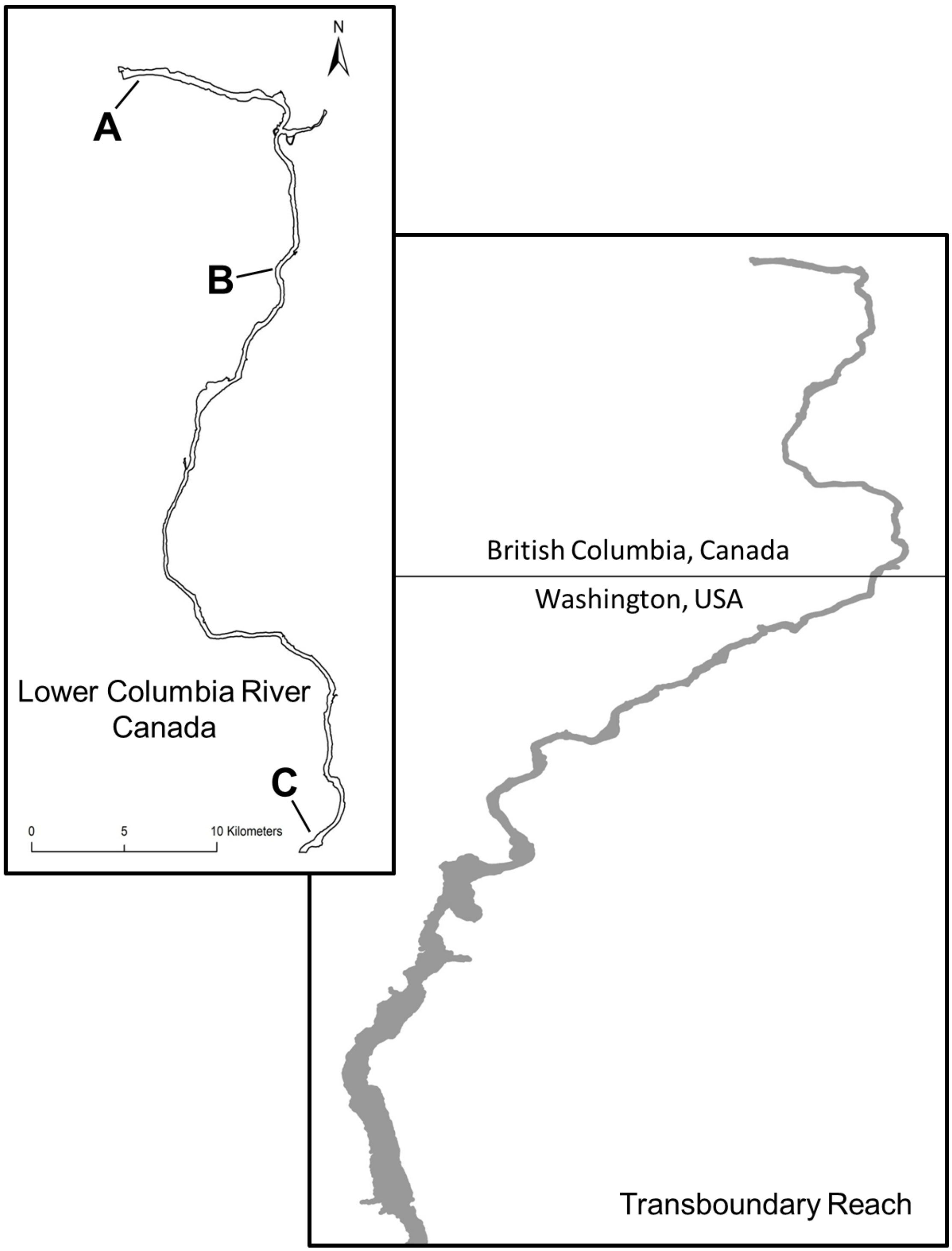
The initial CC report's recommendation was primarily targeted at turbidity augmentation in the lower Columbia River. However, more recent work has identified multiple competing hypotheses (Gregory and Long 2008) resulting in modifying CLBWORKS-28 Lower Columbia River – Planning and Assessment of White Sturgeon Turbidity Experiments to incorporate up-to-date information. This included examining the feasibility of physical works that were developed to test eleven hypotheses that addressed recruitment failure in the lower Columbia River (McAdam 2013; McAdam 2015). Using recruitment hindcasting in combination with a weight-of-evidence evaluation, ten hypotheses (overfishing, connectivity, contaminants, habitat diversity, total gas pressure, turbidity, temperature, flow regulation, nutrients and food supply, and fish species composition) were considered implausible due to poor explanations for recruitment failure. Although alternate mechanisms of recruitment failure may be possible, the geomorphological change (e.g., increased fine substrates at spawning sites) hypothesis was identified by this study as the most plausible explanation for recruitment failure providing direction regarding preferred restoration approaches that could possibly result in a positive effect on recruitment. Accordingly, this TOR is focused on Phase 1 of this project with the objective to determine both the biological and technical feasibility of spawning substrate restoration at white sturgeon spawning locations on the lower Columbia River.

This TOR is submitted in response to the *Water Act* Order issued by the Comptroller of Water Rights (CWR) on January 26, 2007, Schedule F, Clause 2(a) and Conditional Studies List Clause 10(a). The Order requires TOR for the "physical works options to address credible hypotheses for sturgeon recruitment failure in the lower Columbia River".

1.1 Location

The lower Columbia River is located in the West Kootenay Region of British Columbia and extends 57 km from HLK to the Canada-USA Border (**Error! Reference source not found.**). The three white sturgeon spawning areas of interest include Keenleyside (river kilometer (rkm) 0.1), Kinnaird (rkm 13.4 to 18.4) and Waneta (rkm 56.0). Each spawning area is described below in Section 2.2.

Figure 1: Location map of the identified white sturgeon spawning areas in the lower Columbia River, Canada. Spawning areas include Keenleyside (rkm 0.1; A), Kinnaird (rkm 13.4 to rkm 18.4; B), and Waneta (rkm 56.0; C).



1.2 Background

The level of natural recruitment of white sturgeon residing in the transboundary reach of the Columbia River is insufficient to maintain a self-sustaining population (UCWSRI 2012). The UCWSRI began recovery efforts in 2000 with the goal to build a healthy future for white sturgeon in the lower Columbia River in British Columbia, Canada and Washington, USA (UCWSRI 2012). Information on spawning activity and duration has been complied at 3 locations in the lower Columbia River.

1.2.1 Spawning Habitats and Use

White sturgeon spawning in the lower Columbia River typically occurs in the late spring/early summer when water temperatures exceed 14.0°C and freshet flows are on a descending pattern (Hildebrand et al. 1999; BC Hydro 2013). The Waneta spawning area (rkm 56.0) in the lower Columbia River is located at the Pend d'Oreille River confluence immediately upstream of the Canada/US border (Figure 1). This location is thought of as the primary white sturgeon spawning area within the Canadian portion of the lower Columbia River with monitoring of spawning activity occurring annually since 1993 (R. L. & L. 1994; Hildebrand et al. 1999; Irvine et al. 2007; Golder 2009). Jay et al. (2014) estimated 89 (31, 70; 95% CI) individuals to have spawned at the Waneta spawning area in 2011. Spawning at the Waneta site occurs from mid-June through early-August. Two secondary spawning areas, Keenleyside and Kinnaird, are located in upstream sections of the lower Columbia River. Spawning at the Keenleyside area has been previously documented immediately downstream of HLK (rkm 0.1) with geographical boundaries described by Terraquatic Resource Management (2011; Figure 1). The Kinnaird spawning area extends for 5 rkm downstream of Highway 3 Bridge (rkm 13.4 to rkm 18.4). The exact location(s) of egg deposition remains unknown, however spawn monitoring surveys and movement studies indicate white sturgeon spawning activity occurs annually (BC Hydro 2013, 2015; Figure 1). Jay et al. (2014) estimated 29 (9, 34) and 28 (19, 58) adult white sturgeon spawned at the Keenleyside and Kinnaird spawning areas in 2011, respectively. Spawning at these two upstream areas is later than at the Waneta area and occurs generally from mid-July to mid-August.

Research completed through the White Sturgeon Recovery Plan identified spawning habitat as a limiting factor of natural recruitment requiring implementation of habitat restoration actions developed from an understanding of relations between white sturgeon survival and habitat as defined by river flow, local hydraulics, river bed substrates, water temperature, and water quality (UCWSRI 2012). Therefore, sustainability of a naturally reproducing population will partially depend on the success of efforts to restore habitat conditions suitable for spawning and rearing.

1.2.2 Spawning Substrate Restoration

Restoration efforts typically require consideration of three spatial scales, namely the whole river (e.g., mitigation), the spawning reach (e.g., hydraulic suitability) and actual spawning sites (e.g., water depth and substrate conditions). Recent evidence (McAdam et al. 2005; Paragamian et al. 2009; McAdam 2015) supports the need for evaluating substrate remediation at spawning sites to address ongoing recruitment failures of white sturgeon. Strong negative effects of degraded substrates on development and survival occur at the egg (Kock et al. 2006, Forsythe et al. 2013) and yolk-sac larvae (Gadomski and Parsley 2005b, Gessner et al. 2009, McAdam 2011, Boucher et al. 2014) stages. Linkage between recruitment failure and altered substrate conditions at spawning sites demonstrates the critical importance of benthic substrates to the proper functioning of spawning habitat (McAdam et al. 2005, Paragamian et al. 2009, Hastings et al. 2013).

Monitoring of restored habitat in the middle Columbia River demonstrated that white sturgeon yolk-sac larvae released over substrates with increased interstitial space showed a greater tendency to hide, remained in the substrate regardless of the flow conditions, and dispersed downstream volitionally (Crossman and Hildebrand 2014). Though successful in improving conditions, the modified spawning habitat deteriorated rapidly within two years (J. Crossman, BC Hydro, unpublished data). The highly variable flow regime in the study area resulted in the downstream displacement of restored substrate, demonstrating the importance of thorough evaluation of site specific hydraulics on substrate retention and maintenance prior to construction as well as post-project monitoring.

Detailed modelling (McDougall et al. 2013; Hildebrand et al. 2014) and direct measurement (e.g., using ADCP; Johnson et al. 2006) have both been used as tools to understanding hydraulic responses. Three-dimensional hydrodynamic flow patterns and sediment flow dynamics have been modeled for the Waneta spawning area (ASL 2016) and for the white sturgeon spawning area downstream of Revelstoke Dam in the middle Columbia River (CLBMON-20 and CLBMON-54; Hildebrand et al. 2014) to examine sediment transport and changes to physical conditions (depths and water velocities) caused by hydroelectric dam operations. These types of modeling exercises are useful tools that can be used to both describe spawning habitat conditions and evaluate tradeoffs between different restoration options.

2.0 Approach

2.1 General

The objective of this project is to determine the feasibility of spawning substrate restoration at white sturgeon spawning locations on the lower Columbia River. Restoration will be evaluated based on both biological and technical feasibility as well as social, regulatory, and financial trade-offs. The project will be completed in three phases: Phase 1 Identification – develop restoration options and evaluate the feasibility of each option; Phase 2 Definition – development of preliminary designs associated with recommended options emerging from Phase 1; Phase 3 Implementation – completion of the design selection in Phase 2.

This TOR only includes Phase 1, as there is potential the project may not proceed beyond Phase 1. This Phase includes the development of habitat restoration options for the three identified white sturgeon spawning areas. Feasibility and tradeoffs of restoration options will be evaluated through facilitated workshops directed by BC Hydro and attended by the Consultant and relevant experts. Candidate options will be ranked for each area and determined if suitable for advancement to the next phase. CWR approval will be sought before proceeding to each of Phase 2 Definition and Phase 3 Implementation as project scope and associated costs will be better understood. The three phases for this project are described further below.

2.1.1 Phase 1: Identification

This phase includes characterizing existing habitat conditions for the three identified spawning areas for white sturgeon in the lower Columbia River; Keenleyside, Kinnaird, and Waneta. These data will be used to develop options to restore suitability for each spawning area and assess the feasibility of the options. The latter component will involve two workshops to identify and rank candidate options for each area, determine if candidate options are suitable for advancement to the next phase (i.e., social, regulatory, and financial considerations) and evaluate preliminary environmental risks. Following First Nations and stakeholders' engagement, recommended options will be taken to Phase 2 Definition. If restoration is determined to be infeasible or unsuitable, the project will not proceed to Phase 2. If restoration is feasible, BC Hydro will seek CWR approval at the end of Phase 1 prior to proceeding to Phase 2.

2.1.2 Phase 2: Definition

This phase will be addressed in a subsequent TOR and will involve developing preliminary designs and cost estimates associated with the recommended options emerging from Phase 1. At present, this phase will be completed in-house by BC Hydro. This phase will also include the design of monitoring programs, the collection of required pre-construction baseline data, and regulatory and environmental risk assessments. This design and monitoring development will be followed by regulatory approvals and First Nations and stakeholder reviews as appropriate. BC Hydro will seek CWR approval at the end of this phase, prior to proceeding to Phase 3

2.1.3 Phase 3: Implementation

This phase will be addressed in a subsequent TOR and will involve the completion of the design selected in Phase 2 including detailed drawings, refined cost estimates, construction schedule and permitting as required; construction of the selected design; and completion reporting including ongoing maintenance, post-construction monitoring, and effectiveness monitoring as required.

3.0 Scope

The TOR has been broken into several tasks, as follows.

3.1 Task 1 – Data Collection and Analyses

There are three identified spawning areas in the lower Columbia River. This task will involve the evaluation of current spawning habitat conditions including water velocities, depths, substrate composition, and other important physical variables. This will be completed for all three of the identified white sturgeon spawning areas, Keenleyside, Kinnaird, and Waneta (Figure 1). These data should be collected as part of a study design that allows for description of existing conditions, including suitability for white sturgeon (Task 2), and evaluation of restoration options if deemed necessary (Task 3). A “kickoff” meeting was held March 9, 2018 with relevant experts to discuss the study design and methodology.

The general boundaries for the Keenleyside spawning area extend from HLK and Arrow Lakes Generating Station to approximately 1.25 km downstream (adjacent to Rialto Creek) as described in Terraquatic Resource Management (2011). The exact location that spawning occurs in the Kinnaird area is presently unknown and as such, the area of interest encompasses a larger section of river (approximately 5 km) downstream from Highway 3 bridge (rkm 13.4 to rkm 18.4; Figure 1). Evaluation of this area should be conducted at a level sufficient to identify potential spawning areas based on the preferred white sturgeon spawning criteria as described in the Upper Columbia White Sturgeon Recovery Plan (UCWSRI 2012). The Waneta spawning area extends approximately 1 km from downstream of Waneta dam to the Canada/USA border (UCWSRI 2012).

The anticipated timeline for the Task 1 objectives will be as follows:

- Data Collection and Analyses: April 2018 to March 2019
- Reporting: April 2019

3.2 Task 2: Development of Restoration Options

This task will involve preparation for and participation in a facilitated workshop to review results from Task 1 describing existing spawning habitat conditions. The outcome of the workshop will be the development of potential substrate restoration options for evaluation during Task 3. These options will be developed based on both biological requirements of the species and results from physical data collection. Social, regulatory, and financial trade-offs will also be considered. This workshop will occur in the spring of 2019 and BC Hydro will coordinate the facilitation of the workshop as well as the list of attendees including relevant experts in white sturgeon biology.

The anticipated timeline for the Task 2 objectives:

- Facilitated Workshop to assess study results and discuss restoration options: May 2019

3.3 Task 3: Evaluation of restoration options

This task will involve evaluating the options selected during the workshop completed for Task 2. The evaluation should rank the feasibility of the various restoration options developed from a physical perspective based on considerations of erosion, deposition, and longevity. It is expected that aspects related to biological feasibility and social, regulatory and financial trade-offs will be discussed during the workshops. Any additional data that may be required to complete this evaluation during Task 3 should be identified if not discussed during the workshop in Task 2. However, it is expected that the project be developed so data collected during Task 1 can satisfy requirements for subsequent phases. This is expected to occur in June to October 2019.

The key deliverables of this task will include:

- An update of the preliminary report (Task 1) that includes revisions as a result of the 1st workshop outcome (Task 2).

The anticipated timeline for the Task 3 objectives:

- Additional data collection if required: June - October 2019

3.4 Task 4: Selection of Restoration Options

This task will involve preparation for and participation in a second workshop to examine the results of the evaluation of restoration options conducted in Task 3. This workshop will occur in the winter of 2020 and BC Hydro will coordinate the meeting including facilitation and the list of attendees. If after the conclusion of the second facilitated workshop there still remains significant uncertainty in the feasibility of the proposed restoration option(s), a detailed summary of what would be required to improve confidence should be made in the final report. This information can be used to evaluate next steps in the project, one of which could be to conclude that the restoration proposed is not feasible or suitable.

If a restoration option(s) is selected as feasible, the workshop participants should consider pre- and post-project effectiveness monitoring. Requirements or considerations for both environmental and archaeological assessments will be discussed during the second workshop with the formal assessments conducted during Phase 2 Definition. This would be done for each spawning area if applicable and the information would be available for inclusion in Phase 2 if the project proceeds to that phase.

The anticipated timeline for the Task 4 objectives:

- A second facilitated workshop to discuss restoration options: February 2020

3.5 Task 5: Final Feasibility Report from all Tasks

A report providing the results of the feasible restoration option(s) and recommendation will be developed based on a review of the technical feasibility study, and from agency, stakeholder, First Nations, and public input. This assessment will:

i) Provide background information (including raw data) summarizing all the information compiled as part of this study;

ii) Identify restoration options selected as feasible for Phase 2 and describe the recommendation rationale and a description of the trade-offs made between all options considered as part of this project, if applicable;

iii) Describe, as required, any potential environmental concerns/risks for each recommended site;

iv) Propose a schedule with key tasks and a preliminary estimate of costs for implementing the recommended sites; and

v) Describe any coordination required with other programs under the White Sturgeon Management plan (e.g., spawn monitoring work under CLBMON-28), where required.

The anticipated timeline for the Task 5 objectives:

- Final Report summarizing results from all Tasks: May 2020

4.0 Schedule and Deliverables

This work is scheduled to occur from April 2018 through to May 2020. The schedule for delivering on tasks is outlined in Table 1. The schedule is a general guideline.

Table 1: Breakdown of tasks and deliverables to be provided in 2018-2020 in support of CLBWORKS-27.

Year	Task	Period of Work	Description of Work	Deliverables
2018	2. Study Design Development Meeting	March (completed)	Discuss and develop study design.	Finalize study design
2018 - 2019	2. Data Collection and Analyses	April – March	Field data collection as required to describe existing conditions and evaluate restoration options at the three spawning areas, Keenleyside, Kinnaird, and Waneta.	Progress reports
2019	2. Preliminary Report	April	Report describing all work and results to date.	Preliminary Report
2019	3. Workshop: Development of Restoration Options	Late May	Review and discussion of Preliminary Report and development of potential substrate restoration options.	Develop restoration options
2019	4. Evaluation of restoration options and additional data collection	June - October	Assess and rank feasibility of developed options. Field data collection as required.	Progress reports
2019	4. Secondary Report	December	Updated Preliminary Report including summary of evaluation of restoration options.	Secondary Report
2020	5. Workshop: Selection of Restoration Option(s)	February	Review and discuss evaluation of restoration options and select the most feasible option(s) or conclude restoration is not feasible or suitable.	Select restoration option(s) or terminate study.
2020	6. Final Report	May	Final report providing the results of the project discussing feasible restoration option(s) and recommendations for Phase 2, if applicable.	Final Report

5.0 Budget

Total Program Cost: $448,505.

6.0 References

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