Bridge River Project Water Use Plan

Monitoring Program Terms of Reference

BRGMON-11A Lower Bridge River Riparian Vegetation Monitoring

Revision 1
November 30, 2018

BRGMON-11A: Lower Bridge River Riparian Vegetation Monitoring Monitoring Program Terms of Reference Revision 1

1.0 Monitoring Program Rationale

1.1 Introduction

This BRGMON-11A Terms of Reference (TOR) Revision 1 is submitted in compliance with the Bridge River Project Water Use Plan Order (Bridge WUP Order) dated March 30, 2011 (Schedule A, Clause 8a) as follows:

> *a) Monitor influence of the flow regime on the riparian community of lower Bridge River;*

This TOR Revision 1 replaces the vegetation component of BRGMON-11 TOR approved by the Comptroller of Water Rights (CWR) on June 27, 2012. The wildlife monitoring of the original BRGMON-11 TOR is now addressed in the BRGMON-11B TOR, which is submitted in compliance with the Bridge WUP Order Schedule A, Clause 8b as follows:

> *b) Monitor if changes in riparian community and instream flow conditions influence Lower Bridge River corridor wildlife populations.*

1.2 Background

The lack of continuous flow releases from the Terzaghi Dam into the Lower Bridge River has been a long standing concern of the public, First Nations, and regulatory agencies. In 1998, an agreement between BC Hydro and regulatory agencies specified that an instream flow test release and monitoring program be developed and implemented in an attempt to resolve uncertainty about response of the Lower Bridge River aquatic ecosystem to reservoir releases. The agreement specified that an experimental flow release program was to be initiated and continued until a Water Use Plan (WUP) was developed for the Bridge-Seton watershed.

As a result, on July 28, 2000, the Comptroller of Water Rights (CWR), under Section 39 of the *Water Act*, ordered BC Hydro to initiate instream flow releases as of August 1, 2000 with an annual water budget of 3 m^3/s (3 $m^3/s/y$ treatment) plus associated monitoring studies.

Beginning in 2003, BC Hydro embarked on developing Water Use Plans (WUPs) across the province. The WUP Consultative Committee for Bridge River (Bridge CC) recommended that BC Hydro evaluate the relationship between different flow releases at Terzaghi Dam and key physical and biological indicators of productivity. The Bridge River WUP Order, issued on March 30, 2011 under Sections 87 and 88 of the *Water Act* required a flow treatment with an annual water budget to 6 m^3/s (6 $m^3/s/y$ treatment) and a maximum discharge of

15 m^3/s. The Order also required monitoring, plus a long-term flow release recommendation for Terzaghi Dam to be agreed upon by the Comptroller of Water Rights, regulatory agencies, St'át'imc First Nations and stakeholders by May 1, 2015 (Bridge WUP Order, Clause 9).

In terms of vegetation and wildlife, the Bridge CC identified that the test program associated with these flows should explicitly evaluate the impacts of the flow regime on riparian habitat conditions. It was recognized that the temporal dynamics of the riparian plant community occur over a much longer time scales than the aquatic community. It was recommended that the monitoring program document how the flow regime trials affected the riparian community in terms of spatial extent, relative recruitment rate of plant species, the overall productivity of the riparian community and the consequent impact on wildlife populations.

Consequently, riparian and riverine wildlife monitoring was included in the Bridge WUP Order on March 30, 2011 and the BRGMON-11 TOR approved on June 27, 2012, which included a schedule of vegetation monitoring every four years with bird surveys every two years.

May 1, 2015 was the target decision and implementation date for the long-term flow release strategy under Clause 9 of the Bridge WUP Order. However, this target date has been delayed for various reasons. Since 2015, BC Hydro has received CWR approval to delay the target date on numerous occasions to allow more time for further consultation (May 28, 2015; December 18, 2015; December 23, 2016; and February 21, 2018). The target date continues to be deferred while consultation is ongoing.

In 2016, Dam Safety issued a directive to reduce storage capacity of Downton Reservoir by ~50% in order to manage seismic risk. In the same year, BC Hydro advanced critical infrastructure upgrades at the Bridge Generating Station which affected the volume of water that could be diverted through the generating station from Carpenter Reservoir to Seton Lake. As a result, releases higher than the annual average 6 m^3/s would need to be discharged from Terzaghi Dam down Lower Bridge River in some years, until the critical upgrades are complete.

Since 2016, BC Hydro has also received a number of variances from the CWR to vary the Terzaghi Dam discharges from those specified in the WUP Order, and to implement a modified flow regime at Terzaghi Dam . These variances permitted BC Hydro to exceed the annual average 6 m^3/s hydrograph and the 15 m^3/s maximum discharge during the annual high flow period (~March to August). Outside of the high flow period, Terzaghi Dam has been operated according to the seasonal hydrograph limits. On February 21, 2018, the CWR confirmed that BC Hydro can continue to operate under the February 2017 variance order while consultation is underway and until a new decision is made by the CWR. The 2017 variance permitted modified discharges in accordance with a set of guiding principles jointly developed with DFO, MFLNRORD and the St'at'imc First Nations.

From 2016 to 2018 the hydrograph peak and duration during the high flow period were shaped by inflow volumes, with Terzaghi Dam discharges reaching 97 m^3/s in 2016, 127 m^3/s in 2017, and 100 m^3/s in 2018.

As part of BC Hydro's variance requests, BC Hydro noted that BRGMON-11 riparian vegetation monitoring outlined in the BRGMON-11 2012 TOR would continue largely unchanged for the remainder of the WUP monitoring period. Without any significant changes to the TOR, the enhanced effect size potential increases the potential for BRGMON-11 (now split into BRGMON-11A and -11B) to identify flow-related effects. In this regard, continued WUP monitoring is advantageous to addressing the original Management Questions in the BRGMON-11 program.

The changes in this TOR Revision 1 are intended to improve the ability of the TOR to meet the requirements of the WUP Order, including informing a long-term flow recommendation.

1.3 Revision Rationale and Summary of Key Changes

The rationale for changes to the TOR are summarized below.

Separate the goals and tasks related to the independent riparian vegetation and wildlife monitoring components.

The TOR has been separated into BRGMON-11A for vegetation monitoring and BRGMON-11B for wildlife monitoring.

- By having two separate revised TOR's (BRGMON-11A and BRGMON-11B there is clarity with respect to which Management Questions must be addressed for each BRGMON-11 component.

- The separated TORs are more consistent with the way the studies are implemented – with two separate contactors. The two revised TOR's provide clarity with respect to which project tasks must be addressed by the each contractor.

Improve clarity, particularly through revision of Management Question and hypothesis.

- The original TOR had a single general Management Question related to vegetation, the wording of this question has been modified to include community persistence.

- Definitions of cottonwood establishment and recruitment have been added as additional relevant ecological measures, and to provide clarity to the program.

- Similarly, some of the management hypotheses have been refined to better define the response variables to be tested.

Update monitoring tasks based on monitoring results and the revised management question.

- Additional monitoring to provide quantitative data on variables that may affect riparian community persistence.

- New methods have been added for cottonwood seed timing, seedling establishment and recruitment.

Focus on a long-term flow recommendation and ensure comparability across all flow regimes implemented in the Lower Bridge River.

- Only minor wording changes have been made to the original TOR to ensure it is applicable to all available instream flow regimes. This will insure the TOR provides information to support the long-term flow recommendation as required by Section 9 of the Bridge WUP Order.

These changes do not change the scope or intent of the monitoring program, and all improve the TOR's relevance to the ordered monitoring program. A detailed summary of the revision changes to this WUP TOR revision is provided in Appendix A.

1.4 Modified Operations Monitoring not included in this Revision

While operating under the CWR approved variances, BC Hydro has added additional monitoring years to the original WUP schedule (Years 5 and 6, 2017 and 2018) for BRGMON-11A. These additional monitoring years are not included in this TOR Revision 1 budget. These additional years have been added to monitor the short-term effect of the modified flow regime on riparian vegetation.

These additional years of monitoring are complementary to the BRGMON-11A WUP monitoring and the results of both programs will be integrated into a single comprehensive annual report (during monitoring years) to help inform future flow regime decisions. Reporting costs will be appropriately pro-rated to WUP and modified operations according to the scope of each of the programs.

1.5 Management Questions

Management Questions 1 and 2 in the original BRGMON-11 TOR (2012) were intended to improve understanding of changes in Lower Bridge River riparian vegetation community under the flow treatments. Management Question 2 addressed wildlife population response to riparian community change; this question is addressed in the new BRGMON-11B TOR Revision 1.

This BRGMON-11A TOR Revision 1 incorporates new information and updates the management question and hypothesis to assure that the most relevant ecological measures are being considered.

The Management Question 1 is slightly revised from 2012

1) **Revised Question:** What is the influence of the instream flow regime on the persistence of the riparian vegetation community of the Lower Bridge River?[1]

[1] Wording modified slightly from original TOR. Original MQ-1: What is the influence of instream flow regime on the spatial extent, species diversity, and relative productivity of the riparian community of the Lower Bridge River?

The intent of this monitoring program is to document how the riparian community is affected by flow releases and how the changes in flow regime impact the riparian community in terms of community persistence (spatial extent, diversity, richness, cover, relative recruitment rate of plant species, their relative productivity using biomass as a metric and black cottonwood establishment and recruitment success).

Black cottonwood response and growth is the main species of focus (keystone species), as this is the dominant riparian vegetation along the Lower Bridge River, a key vegetation species for wildlife habitat. Without black cottonwoods, the function of the riparian community would be drastically changed (Hall et al. 2009).

1.6 Detailed Hypotheses about the Impacts of Instream Flow on Riparian Vegetation in Lower Bridge River

The explicit hypotheses to be tested from the results of the monitoring program relate both to the entire community as well as focusing on differential success of annual and perennial species. Management hypotheses are intended to guide the selection of response variables; however, the hypotheses presented here are not an exhaustive list and other response variables could be examined. Alternative hypotheses were not developed because explanatory variables may change with further implementation and development of monitoring. These hypotheses include:

H_o: (null hypothesis) There is no relationship between the magnitude of instream flow release and riparian vegetation along the Lower Bridge River.

H_1: The species composition of the riparian vegetation community in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam

H_2: The relative productivity (biomass) of the riparian vegetation in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam.

H_3: The abundance of invasive or exotic plant species in the Lower Bridge River corridor is related to the instream flow release from Terzaghi Dam.

H_4: The relative rate of recruitment of perennial plant species and especially woody plants (i.e. black cottonwood) in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam.

H_5: The rate of growth of perennial plant species in the Lower Bridge River corridor is directly related to the instream flow release from Terzaghi Dam.

The definition and methods to be used for black cottonwood seedling establishment, survival and recruitment is as follows:

- **"Establishment"** represents the germination or colonization of a seedling.

- **"Recruitment"** represents the successful establishment and survival of a seedling through the vulnerable first three growing seasons; the subsequent saplings are more likely to contribute to the floodplain forest population (Rood et al. 2007). Methods to determine recruitment include tracking their survival through three growing seasons. Recruitment is the result of two sequential but somewhat independent processes of establishment (or colonization) and survival:

- ***Recruitment = Establishment (colonization) + Survival***

For example: seedlings established in 2016 (that survived to the October 2018 field sampling) would be considered successful recruits. Therefore, the 2016 seedlings will shift to be part of the vegetation monitoring design, utilizing cover by species to assess growth and cover expansion during the subsequent year of riparian vegetation monitoring.

Higher flows may limit colonization of marginal areas because inundation thresholds will be exceeded, and it is expected that lower flow levels will increase the spatial extent of riparian vegetation. However, it is also believed that very low flows may limit riparian vegetation because of insufficient groundwater or hyporheic flow to support vegetation development or sustain high levels of productivity over the entire floodplain of the river.

1.7 Key Water Use Decision Affected

The key water use planning decision affected by BRGMON-11A will be establishment of a long term instream flow regime for the Lower Bridge River that considers the overall aquatic and riparian objectives for the area. The objective of the recommended program was to evaluate impacts of the flow trials on the riparian community and to use these data to help make predictions about the long term response of the plant community to instream flow releases. Ultimately this information will contribute to the decision about the long term flow regime for the Lower Bridge River.

2.0 Monitoring Program Proposal

2.1 Objective

The objective of the BRGMON-11A monitoring is to quantify the response of key physical and biological indicators in the Lower Bridge River to different instream flow regimes to determine which variables explain any changes in the riparian community. Monitoring will continue for the remainder of the monitor period and results will be used to inform the long-term flow release regime for the Lower Bridge River.

2.2 Approach

Additional monitoring implemented under this BRGMON-11A TOR Revision 1 will provide quantitative data on variables that may affect riparian community persistence. Analysis will integrate all monitoring results to inform what factors affect riparian community persistence. Analysis will follow the standardized protocols for ecological sampling and data collection. This general approach will ensure the continuity of data across all instream flow regimes.

The proposed monitoring program will have four components:

1) Aerial photograph analysis at three separate intervals within the 10-year study to estimate the change in riparian communities that have resulted from the changing instream flow regimes.

2) Repeated vegetation transect surveys at fixed locations will be completed at three separate intervals within the 10-year study. Large vegetation plots will be surveyed four times within the study.

3) Black cottonwood seed timing and seedling establishment and recruitment.

4) Dendrochronological surveys will be completed at three separate intervals within the 10-year study to gather data needed to estimate changes in productivity of a key perennial species under each flow treatment level and across years.

The sampling design will be treated as a repeated measures design for sampling changes in riparian community associated with change to the instream flow regime. A baseline survey was conducted in 2000 which provided random site selection and baseline information for the “no flow release treatment” from Terzaghi Dam. Further studies in 2007 examined cottonwood growth and recruitment post flow release.

2.3 Methods

The proposed monitoring program has the following primary tasks:

2.3.1 Task 1 Project Coordination

Project coordination involves the general administrative and technical oversight of the program. This will include but not be limited to: 1) budget management; 2) staff selection; 3) logistic coordination; 4) technical oversight in field and analysis components; and 5) liaison with regulatory and First Nations groups.

2.3.2 Task 2 Riparian Vegetation, Data Collection and Analysis

Aerial Photography

To assess the overall impacts of the instream flow regime on riparian vegetation aerial photography will be used during Years 1, 4, and 9 of the study. Low level spatial geo-referenced colour air photos will be used to develop GIS based maps

of the riparian vegetation and to compute changes in the spatial extent and location of vegetation occurring after 10 years. This task will be completed concurrently with the proposed aerial photography for the Carpenter and Downton Reservoir vegetation monitoring programs to reduce additional costs for duplicate flights.

Transect Surveys and Large Vegetation Plots

Transect surveys are proposed to 1) ground truth assessments of general changes in species composition occurring over the entire spatial area of the Lower Bridge River riparian area; 2) provide detailed geo-referenced topographic data of the transect; and 3) provide a detailed assessment of the changes in species composition and relative productivity and persistence of riparian habitats resulting from the implementation of the flow treatment. During the 2009 study, analyses were carried out on cottonwood trees along the Lower Bridge and Yalakom Rivers to allow for comparison between free flowing and controlled river systems.

Previous monitoring methods completed in Year 1 (2013), Year 4 (2016), and Year 5 (2017, modified operations year) will be repeated. These included: 1) permanent benchmarking of transects to allow repeated vegetation surveys through time; 2) supplemental sampling at the transects to quantify relative riparian productivity (biomass sampling); 3) monitoring of newly established 10 m X 40 m permanent large vegetation plots; 4) permanent photo point monitoring sites; 5) repeating all vegetation surveys (including the biomass sampling) after approximately 10 years; 6) based on the data collected, undertake a quantitative assessment of the changes in riparian community health, and growth in relation to flow regime.

In Year 6 2018 (modified operations year), vegetation plots have been established in the Yalakom River and act as a non-regulated river vegetation composition, successional, and potentially cottonwood recruitment comparison. Plots will be sampled again in 2021, Year 9.

Black cottonwood seed timing and seedling establishment and recruitment

The local timing of the Lower Bridge River (LBR) black cottonwood seed development and dispersal timing will be observed and local timing established over Years 4, 5, 6 and 9 in the spring. Select sites will be monitored along the LBR Reaches 3 and 4 for the timing of cottonwood seed development and seed rain release. In the fall, cottonwood seedling establishment and recruitment will be surveyed via vegetation plots and targeted reaches in Reaches 3 and 4. Density, age, survival, and elevation of seedlings relative to annual peak flow will be recorded and mapped. Recruitment will be tracked and analyzed according to the definition established in this BRGMON-11A TOR Revision 1.

Dendrochronology

Previous black cottonwood research on the LBR will be used as background information and provide a basis for continuing the studies for the next 10 years. Dendrochronology will be used to evaluate the effects of the naturalized yet

reduced flow regime on relative productivity (measured as growth rate). Standard tree coring techniques are applied to measure growth increment of the trees based on annuli (i.e., tree ring) width. It is proposed that upon completion of the flow trials, approximately 120 cores or disks will be taken in Reach 2, 3 and 4 of Lower Bridge River as well as along the Yalakom River as a control). These growth increments will be measured in the laboratory and then analyzed in relation to the flow regime as the previous study did (Hall et al. 2009).

2.3.3 Task 3 Reporting

This project will require reporting following each year of field work plus a detailed final synthesis report prior to the review of the WUP:

- An annual technical report will be prepared in the year following field work that summarizes the key qualitative observations and empirical results from the BRGMON-11A monitoring as they relate to the persistence of the riparian community of the Lower Bridge River. Annual quantitative results from each monitoring component will be drawn upon as required to carry out detailed statistical analyses and determine how physical conditions and productivity indicators vary with the magnitude and duration of discharges. Additional data collected under the modified operations program will supplement analysis and reporting, and additional hypothesis testing for modified operations. Analysis results will be used address the Management Question of BRGMON-11A.

- At the end of the planned BRGMON-11A monitoring program, a single Final report summarizing all BRGMON-11A results including results from any added years during modified flow regime will be prepared.

Reports will follow the standard format for WUP monitoring projects (templates to be provided by BC Hydro). All reports will be provided to BC Hydro as Microsoft Word and Adobe Acrobat (*.pdf) format.

2.4 Interpretation of Monitoring Program Results

The data collected in the proposed monitoring program, and conclusions drawn from analyses in the final report will ultimately be used to assess the degree to which management objectives and technical expectations were met by the implementation of various operational regimes.

The program will provide several quantitative measures to compare performance of the flow regulation regimes. Determining the importance and confidence level associated with the different factors associated with the instream flow regime will ultimately allow for the design of a long-term flow release strategy for the Lower Bridge River.

2.5 Schedule

The schedule for the annual activities is phased to accommodate the requirements of the program, the program has been extended by one year to

reflect a delay in the original TOR planning (Year 1 has been moved to 2013, Year 10 has been moved to 2022).

The BRGMON-11A Riparian Vegetation Monitoring work will be primarily conducted over five years (Table 1).

- In Years 1, 4, and 9 specific activities are proposed to meet the goals of the program in relation to instream flow regime changes.

- In Years 5 and 6, work not previously scheduled for WUP were added to measure short term impacts of modified operations instream flow regime changes (grey columns in Table 1).

- In the final year of the program immediately prior to the review of the Water Use Plan, aerial photography and baseline vegetation surveys will repeated to allow a final assessment of observed changes in the riparian area in the Lower Bridge River corridor.

The schedule for the proposed program is provided below in Table 1.

Table 1: Schedule (Years 2017 and 2018 are Modified Operations Years)

		Year									
		1	2	3	4	5	6	7	8	9	10
Module	**Task**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Module 1 Vegetation Monitoring	1-1. Project Coordination	x			x	x	x			x	x
	1-2. Data Collection										
	1-2a. Aerial Photography/Analysis	x			x					x	
	1-2b. Transect Surveys	x			x					x	
	1-2c. Large Vegetation Plots				x	x	x			x	
	1-2d. Broad Scale Photo Points				x	x	x			x	
	1-2e. Cottonwood seedling and seed release surveys				x	x	x			x	
	1-2f. Dendrochronology	x			x					x	
	1-3. Reporting										
	1-3a. Annual Report	x			x	x	x			x	
	1-3b. Final Report										x

2.6 Budget

Total revised program cost:$639,686.

3.0 References

Hall, Alexis A., Rood, Stewart B. and Higgins, Paul S. 2009. Resizing a River: A Downscaled, Seasonal Flow Regime Promotes Riparian Restoration. Restoration Ecology – Journal of the Society for Ecological Restoration International.

Appendix A: Key changes to the BRGMON-11A TOR and rationale

Section	Changes	Rationale
All Sections	• Removed all references to wildlife and bird monitoring	• Wildlife monitoring will be conducted under BRGMON-11B
	• Generalize references to 'flow regime' instead of few instances where specific flows used (e.g., remove references to 6 m^3/s/year)	• Ensure the TOR meets the Order and inform a long term flow recommendation as required by Section 9
1.1 Introduction	• Included references to the WUP Order.	• To ensure appropriate Order references are provided.
1.2 Background	• Updated the background section summarizing the pre-WUP and WUP flow treatments. • Added background on the modified flow regime.	• Added new relevant history and background since the original TOR from 2012.
1.3 Revision Rationale and Summary of Key Changes 1.4 Modified Operations	• Summarizes the changes in the Revision and the rationale • Clarifies scope not included in this TOR related to only modified operations.	• Provides continuity from previous TOR.
1.5 Management Questions	• Wording was slightly altered to the original Management Question 1 • Management Question 2 was removed	• Management Question 1 was revised to improve clarity and incorporate additional relevant ecological measures. • Management Question was not related to vegetation
1.6 Management Hypothesis	• Refined the management hypotheses to specify additional response variables to be tested.	• The management hypotheses were added to address additional relevant ecological measures. • Hypothesis addressing wildlife were removed.
1.7 Key Water Use Decisions Affected	• Minor wording changes.	• Minor changes reflecting wildlife scope removed from this TOR
2.1 Objective and Scope	• Minor wording	• Minor changes reflecting wildlife scope removed from this TOR • The focus of the program continues to be to define a long term flow release regime for the Lower Bridge River
2.2 Approach	• Updated to provide a better overview of the monitoring approach and tasks.	• Cottonwood seed timing and seedling establishment and recruitment was not previously included in this section.

Section	Changes	Rationale
2.3 Methods	• In Task 2*: Riparian Vegetation, Data Collection and Analysis:* added large vegetation plots, cottonwood seed timing and seedling establishment and recruitment surveys, and Yalakom vegetation plot surveys	• Inclusion of additional ecological measures in this revised program
	• In Task 3: *Analysis and Reporting,* replaced the requirement for a 2015 synthesis report with a 2022 synthesis report. • Added a requirement for the annual reports to include monitoring results from both WUP and modified operation monitoring to carry out detailed data analyses.	• Reflects clarity of requirements at the end of the TOR period • Annual reporting will need to take into account modified operations to fully describe/interpret/analyze any observed changes in riparian community.
2.4 Interpretation of Monitoring Program Results	• Interpretation of the results was updated to reflect the removal of short and long-term indicators	• Requirements for data interpretation have changed as a result of the modified flow regime.
2.5 Schedule	• No changes to the seasonal timing of WUP monitoring components, • Showing additional years for modified operations monitoring(Years 5 and 6) – which are not included WUP budget	• Adjustment of monitoring schedule to shift the 10-Year program one year further (Year 10 from 2021 to 2022). • Removed items related to Wildlife monitoring now included in BRGMON-11B
2.6 Budget	• Updated as required to incorporate the removal and addition of monitoring components. • Excludes modified flow regime monitoring (Years 5 and 6). • Reporting budget has been included as a pro-rated proportion of WUP reporting	• Removed items related to Wildlife monitoring now included in BRGMON-11B
3.0 References	• Updated as required.	