Bridge-Seton Water Use Plan

Monitoring Program Terms of Reference

- BRGMON-4 Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring Terms of Reference

Addendum 1

March 5, 2015

A1 Addendum to BRGMON-4 Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring Terms of Reference

A1.1 Addendum Rationale

During the Bridge River Water Use Plan (WUP) development process, key information gaps pertaining to Carpenter Reservoir ecosystem were identified. These include:

1) the species composition, relative abundance, distribution and life history requirements of species of fish in the Carpenter Reservoir and its tributaries, and
2) the relationship between operating parameters of the reservoir (i.e., maximum/minimum elevation, filling schedule) and the fish population response.

To resolve these data gaps and uncertainties, the Bridge River Consultative Committee (BRG CC) recommended long term monitoring studies to obtain more comprehensive information on reservoir habitats and fish populations. To that end, a set of management questions related to fisheries management goals and associated hypotheses regarding potential environment responses to the selected WUP operations were also defined.

However, after implementing the study for the first two years, some key deficiencies in the data collection methodologies were identified as described below. Please refer to Table 2 for a summary of the key changes and the rationale for their inclusion.

A1.1.1 Deficiencies in some of the original hypotheses:

Some of the hypotheses in the original Terms of Reference (TOR) cannot be tested using the type of data that can practically be collected under this monitor (e.g., hypotheses related to fish stranding and entrainment impacts). Collecting empirical data to assess impacts of stranding or fish entrainment will not be feasible due to difficulties associated with access to sites around the reservoir. In Bridge River, facilities impacts associated with stranding are addressed through operational procedures (reservoir drawdown rates and fish salvage efforts) and entrainment impacts are addressed through offsetting measures being considered under Bridge-Seton Fish Entrainment Strategy Program.

A1.1.2 Deficiencies in methodological approaches to collecting sufficient sample sizes:

Some data collection approaches (e.g., boat electrofishing, mark-recapture methods) recommended in the original TOR are found to be ineffective in Carpenter Reservoir situation if used alone. Specifically, the recapture rate on marked fish has been low due to poor visibility and lack of adequate information on seasonal fish distribution.

Due to these deficiencies this monitoring study needs to be revised in order to refine the data collection approaches to improve its ability to answer the management questions. The changes made are outlined below.

A1.2 Management Questions

The management questions remain unchanged from the original TOR but some explanatory notes have been added to this Addendum to clarify how the management questions will be answered.

1) What are the basic biological characteristics of fish populations in Carpenter and its tributaries?

   Carpenter Reservoir appears to be dominated by Mountain Whitefish and Bull Trout and to a lesser degree by Rainbow Trout. This management question will be answered using fish population abundance, distribution and biological characteristics data for these key species.

2) Will the selected alternative (N2-2P[1]) operation result in positive, negative or neutral impact on abundance and diversity of fish populations?

   This management question will be answered using weight-of-evidence as exhibited by trends in fish population abundance and trends in their biological characteristics in conjunction with trends in reservoir operation.

3) Which are the key operating parameters that contribute to reduced or improved productivity of fish populations in Carpenter Reservoir and Middle Bridge River?

   This management question will be answered using basic spawning habitat quality and quantity data collected in the reservoir and the tributaries.

4) Is there a relationship between specific characteristics of the instream flow in the Middle Bridge River that contribute to reduced or improved productivity of fish populations in Carpenter Reservoir and the Middle Bridge River?

   This management question will be answered using habitat quality and quantity in the Middle Bridger River as a function of instream flow release at critical life history stages of target species

5) Can refinements be made to the operation of Carpenter Reservoir and management of instream flow releases from Lajoie Generation Station into the Middle Bridge River to improve protection or enhance fish population in both these areas or can existing constraints be relaxed?

   This management question will be answered based on insights gained from results under Management Questions 1-4.

A1.3 Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Fish Populations

The primary hypotheses (and sub-hypotheses) associated with the management questions have been updated as follows:

H1: *The Carpenter Reservoir fish community is dominated by Mountain Whitefish and Bull Trout.*

- H_{1A}: *There is no measureable trend (negative or positive) in abundance or relative abundance of Bull trout in Carpenter Reservoir after the implementation of WUP operations*
- H_{1B}: *There is no measureable trend (negative or positive) in biological characteristics (e.g., growth, size distribution, condition, and survival) of fish (bull trout and mountain whitefish) in Carpenter Reservoir after the implementation of WUP operation.*

[1] N2-2P represents the current WUP operations selected

H2: *Implementation of the selected alternative following the WUP process had a negative impact on Bull Trout abundance or index of abundance compared with pre-WUP modelled abundance.*

H3: *Implementation of the selected alternative following the WUP process had a negative impact on the area of preferred habitat for adult Mountain Whitefish*.

H4: *There is no relationship between abundance or relative abundance of Bull Trout and reservoir productivity as predicted by the Carpenter Lake Reservoir Productivity Model (MON10)*

H5: *Rainbow trout spawning in the drawdown zone is negatively impacted by inundation in the late spring and summer in Carpenter Reservoir.*

H6: *Operation of Carpenter Reservoir at low elevations reduces adult Mountain Whitefish productivity through the dewatering of preferred habitat areas.*

H7: *Operation of Lajoie Generating Station restricts the amount of available effective spawning habitat for Mountain Whitefish in Middle Bridge River through egg dewatering.*

H8: *Operation of Lajoie Generating Station restricts the amount of available effective spawning habitat for Kokanee in Middle Bridge River through egg dewatering.*

H9*: Current management of Carpenter Reservoir and Lajoie Generating Station can be refined to improve productivity of fish populations in both areas.*

The range of operations across the years of monitoring provides the operational contrast required to evaluate these hypotheses. The hypotheses will be tested using inferences based on a weight-of-evidence, rather than direct tests at specific sites.

A2 Monitoring Program Proposal

A2.1 Objectives and Scope

The primary objectives of the Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring are:

1) To collect comprehensive information on the life history, biological characteristics, distribution, abundance and composition of the fish community in Carpenter Reservoir and Middle Bridge River, and;
2) To analyze trends in relative abundance of target fish populations in the reservoir and assess the effects of reservoir operation on fish populations to: a) document impacts of the N2-2P alternative on existing reservoir fish populations, and, b) allow better future decisions regarding preferred operation of Carpenter Reservoir.

The scope of the program is limited to key fish populations in Carpenter Reservoir and its fish bearing tributaries. Key species identified are mountain whitefish, bull trout, rainbow trout and kokanee.

A2.2 Approach

The general approach to this monitoring program will be to collect a comprehensive long term data set on fish populations and habitat conditions, in Carpenter Reservoir and Middle Bridge River, to resolve current gaps in data and scientific understanding through the collection of coincidental information on habitat conditions and fish population. Using this information, it is possible to identify changes in population structure, and changes over time can be used to develop and test hypotheses about the relationship between habitat conditions and population response. This will be accomplished by:

a) Collecting time series information on the abundance and biological characteristics of resident fish populations and reservoir habitat conditions;

b) Assessing correlation of abundance of younger ages (recruitment) of fish with reservoir operating parameters. For this step, it is important to understand the relative contribution of those younger ages that recruit from habitats that are not affected by operations (e.g., Tyaughton Creek, Gun Creek) and those habitats that are affected by operations (e.g., middle Bridge River, reservoir drawdown zone);

c) Conducting spawner surveys in the Middle Bridge River and other key reservoir tributaries to assess impacts of reservoir operations and instream flow fluctuations on spawning habitat quality and quantity;

d) Implementing a “stock synthesis” approach to estimating potential recruitment anomalies associated with operating impacts, which combines age composition and relative trend data collected during monitoring to better define recruitment changes; and

e) Examination of trends in growth or distributional changes with operations. The advantage of this approach is that it provides an explicit method for linking habitat conditions created by operating parameters of the reservoir to response of fish populations.

A2.3 Methods

General Fish Population Index Surveys

General fish population index surveys are proposed to provide information on seasonal and inter-annual variation in the relative abundance, distribution and growth rate of all species in the reservoir fish community. All fish captured will be sampled, but bull trout, rainbow trout and mountain whitefish will be key species for intensive sampling. Additional target species for monitoring may be selected based on their ecological and social value, and the ability to consistently sample them.

Index surveys will involve:

a) Gillnetting in littoral and pelagic areas as well as at creek mouths to determine presence/absence and/or catch rates for different Carpenter Reservoir species. Bull trout and mountain whitefish are expected to be the dominant species, but the pelagic areas of the reservoir have not been sufficiently sampled in the two pilot years. This gillnetting piece to establish relative abundances would be exploratory gillnetting (likely one season) to determine what species (if any) utilize the pelagic environment at the lower end of the reservoir;

b) Mountain whitefish gillnetting in different whitefish habitat types during two separate indexing periods (high pool and low pool) to evaluate operational

impacts on preferred mountain whitefish habitats. The gillnet data may not necessarily provide a quantitative index of abundance; instead, it will provide valuable information on relative habitat use and behaviour of mountain whitefish in different areas of the system; and

c) Implementing a combination of angling, gillnetting and boat electrofishing on target species to collect data for a mark recapture study for the period of the remaining 8 years. This involves one or two intensive periods of mark/capture events per year to increase the probability of recapture using a large sample size. An open mark recapture model could be run using two capture periods, one in the spring and one in the fall prior to bull trout spawning. Attempts should be made to combine bull trout capture with whitefish gill netting periods if specific mesh sizes and length of sets could be aligned.

All fish collection efforts will be accompanied by detailed sampling of the biological characteristics of the fish populations and standardized habitat descriptions. All fish captured in the field program should be measured for weight/length, evaluated for sex and sexual maturity [as possible], and appropriate aging structures should be collected. Bull trout stomach content will be collected from sub-samples for two to three years to assess primary food source for top predators in Carpenter Reservoir. Bull trout are expected to occupy both pelagic and littoral habitats, and stomach analysis could determine if there are two different bull trout feeding types (e.g., the dominant food source for littoral bull trout is whitefish, while the dominant food source for pelagic bull trout is kokanee), or if bull trout diets are similar regardless of capture location.

Analyses of the biological information will include examination of weight-length relationships, length frequency, age structure, and patterns of growth of fish populations in each of the geographic zones of the study area. Habitat data collected at each index site should include factors that are considered significant to fish sampling. These include but are not limited to: temperature, light intensity (ambient/in situ), depth, water flow velocity, bank type, meso-habitat type, proximity to cover, and any other factors deemed to be important to sampling gear efficiency or fish habitat use.

Rainbow Trout and Bull Trout Tagging

a) PIT tagging of rainbow trout to assess use of drawdown area by rainbow trout. Rainbow trout are currently found in low numbers in the reservoir and are susceptible to impacts caused by reservoir operations. Data collection will involve angling in creek mouths prior to rainbow trout spawning period. In the first year, two PIT aerials will be installed in key tributaries that are particularly affected by the drawdown, and an additional two aerials will be installed in a couple of tributaries that are much larger and suspected to provide spawning habitat that is unaffected by drawdown (e.g., Tyaughton Creek, Gun Creek, etc.). If tributaries affected by the drawdown are found to be utilized for spawning, in subsequent years multiple arrays will be installed bounding the drawdown zone to determine if they spawn in areas that will be inundated.

b) Acoustic tagging: information on spatial distribution will be obtained using acoustic tracking of Bull Trout in Carpenter Reservoir to obtain a representative distribution of Bull Trout population during mark recapture periods. Reservoir gill netting and acoustic tagging (n=30 initial year, more additional tags each year or every second year) will be implemented. Determination on sample size will be determined by contractor based on insights from studies in the last two years.

Reservoir Tributaries and Middle Bridge River Spawner Surveys

Tributary spawner surveys are proposed to document the abundance and distribution of fish spawning in the tributaries of Carpenter Reservoir and spawning intensity within and outside of the reservoir drawdown zone. The surveys will focus on rainbow trout, mountain whitefish and kokanee as these species are most likely to be impacted by backwatering impacts in the reservoir and flow instream flow release fluctuations in the middle Bridge River.

It is proposed that weekly surveys be conducted through the rainbow trout spawning period (June-early August) and kokanee and mountain whitefish spawning period (September-early October). Visual surveys will be used where water clarity allows and standard fisheries sampling techniques such as angling/beach seining will be applied where turbid conditions are encountered (Gun Creek, Tyaughton Creek, Middle Bridge River) to produce estimates of spawning abundance and spatial distribution of spawning sites. A stratified sampling design may be required to sub-sample these large watersheds.

Habitat Monitoring

To investigate the impacts of reservoir operations on fish populations, supplemental habitat information will be collected during the fish sampling surveys. These include but may not be limited to:

1) installation and maintenance of thermographs in key reservoir tributaries;
2) systematic monitoring of suspended sediment concentration from key tributaries; and
3) seasonal limnological surveys to document temperature/oxygen profiles and light penetration/water clarity

These data may be obtained from BRGMON-10. The contractor is expected to coordinate with BRGMON-10 to ensure required data are being collected and establish data sharing protocol with the contractor.

Pre-WUP and WUP Reservoir Fish Productivity Modelling

Evaluating operational impacts on reservoir fish population is very challenging without having pre-WUP baseline data. However, some level of investigation could be accomplished using modelling techniques based on empirical relationship observed between productivity and reservoir operations (reservoir drawdown and filling regime) from data collected in this monitor and BRGMON-10 and then use the relationship to extrapolate/model in the context of pre-WUP reservoir levels/operating conditions. For this modelling exercise, reservoir productivity data will be obtained from BRGMON-10. Pre-WUP reservoir operations data will be obtained from BC Hydro.

The modelling task involves:

a) Modelling the empirical relationship between reservoir productivity (BRGMON-10) and Bull Trout abundance or index of abundance using reservoir productivity and fish data. This portion is fairly closely tied with the results of BRGMON-10. As mentioned earlier fish indexing results may not provide a good quality quantitative index that could be examined for trends over time or correlate with operations. The outcome could be more qualitative information about what type of habitat bull trout prefer and potentially describe bull trout behaviour to some extent. Qualitative information could then be compared with preferred bull

trout habitat with productivity as predicted by BRGMON-10 and examine how these productive/preferred areas change over time or at high vs. low pool.

b) Modelling the empirical relationship between reservoir productivity (BRGMON-10) and area of preferred habitat for adult Mountain Whitefish using reservoir productivity and fish data. This portion is fairly closely tied with the results of BRGMON-10. The fish indexing results may not provide a good quantitative whitefish index that could be used to examine for trends over time or correlate with operations. The outcome would be more qualitative information about what type of habitat whitefish prefer and potentially describe whitefish behaviour to some extent. Qualitative information could then be compared with preferred whitefish habitat with productivity as predicted by BRGMON-10 and examine how these productive/preferred areas change over time or at high vs. low pool.

c) Modelling pre-WUP response of productivity and bull trout index or abundance to changes in pre-WUP reservoir conditions using empirical relationship established from bullet ‘a’.

d) Modelling pre-WUP response of productivity and mountain whitefish preferred habitat areas to changes in pre-WUP reservoir conditions using empirical relationship established from bullet ‘b’.

e) Modelling change in Mountain Whitefish spawning habitat during incubation period in the Middle Bridge River using aerial photography (i.e., what proportion of Mountain Whitefish habitat becomes dewatered?). The study begins with mapping and ground truthing aerial photos, and in later years use transects of egg screens to obtain a relative egg density estimate in both dewatered and flowing areas to determine relative egg loss.

f) Modelling change in Kokanee spawning habitat during incubation period in the Middle Bridge River using aerial photography (i.e., what proportion of mountain whitefish habitat becomes dewatered?). The study begins with mapping and ground truthing methods, and in later years use transects of egg screens to obtain a relative egg density estimate in both dewatered and flowing areas to determine relative egg loss.

g) Modelling potential alterative reservoir management operations and their effect on population metrics to inform future refinement on facility operations.

The successful Contractor is expected to provide details on specifics of modelling approaches in their study proposal.

A2.4 Data Analysis and Reporting

A detailed technical report of the findings of the program will be prepared for distribution annually. Data assembly and data analysis will be initiated upon completion of the field season and a draft report will be prepared. Upon completion of the proposed program a synthesis report will be prepared for use in the next review of the BRG Water Use Plan. A summary of the time-sequence of changes to reservoir operations will be prepared to compare changes to operations from the operating regime, and the operations experienced by each fish cohort.

A2.5 Interpretation of Monitoring Program Results

The proposed monitoring program will provide valuable information for three specific categories of uncertainty.

1) Quantitative documentation of the basic biological characteristics of the fish populations through collection of comprehensive data set to establish abundance, diversity, distribution, growth rates, habitat use, and life history of fish populations in the Carpenter and Middle Bridge River. These data will be compared against a suitable benchmark for reservoirs/and lakes in B.C. to provide insight on the potential for improvement.
2) Review of the trends in relative abundance of the general fish community. The data collected will allow quantitative inferences in the trends in abundance of the key fish species in the reservoir in relation to the general operation of the reservoir and help determine if the implemented alternative (N2-2P), in general, has had a positive, neutral, or negative impact on the abundance and diversity of reservoir fish populations. Auxiliary data on other external factors (habitat conditions) will be collected to support inferences about the relationship between operational changes and observed trends.
3) Quantitative evaluation of correlations between trends in relative fish abundance and reservoir productivity using reservoir productivity data from BRGMON-10.
4) Examination of the influence of reservoir operating parameters on key species in the community. Analyses will be conducted on a life stage and species specific basis to determine if there is correlation between operating parameters of the reservoir (i.e., minimum elevation, maximum elevation, annual drawdown) and the abundance or growth. The strength of inferences will depend of the amount of “contrast” in operations and number of large drawdown events. Qualitative inferences can then be drawn on the relative importance of the previously identified performance measures for reservoir fish in limiting population abundance and community diversity. The importance of these effects will be interpreted in light of the observed trends in abundance. Each step in the analyses above builds upon the previous step to develop increasing resolution on the effects of reservoir operations on fish communities.

A2.6 Budget

Total Revised Program Cost: $1,745,622.

The increase in total budget was due to: 1) methodological changes requiring implementation of additional data collection methods (gillnetting, telemetry) in order to address observed deficiencies in the original study approaches and; 2) changes in labour rate and equipment costs that were identified in the first two years of implementation

Table 2: BRGMON-4 Carpenter Reservoir and Middle Bridge River Fish Habitat and Population Monitoring Program: Key changes and rationale for their inclusion

Section	Change	Rationale
1.3 Detailed Hypotheses	Updated hypotheses 1-2 Added hypotheses 3-9	Some of the original hypotheses cannot be tested using the type of data that can practically be collected under this monitor (e.g., hypotheses related to fish stranding and entrainment impacts). Collecting empirical data to assess impacts of stranding or fish entrainment will not be feasible due to difficulties associated with access to sites around the reservoir. In Bridge River, facilities impacts associated with stranding are addressed through operational procedures (reservoir drawdown rates and fish salvage efforts) and entrainment impacts are addressed through offsetting measures being considered under Bridge-Seton Fish Entrainment Strategy Program.
2.3 Methods	Modifications include: • key species identified, • additions to methodology used (gillnetting, acoustic tagging), • addition of the pelagic zone • removal of beach seine requirement • addition of key tributaries • addition of modelling pre-WUP and WUP reservoir fish productivity	Some data collection methodologies (e.g., boat electrofishing, mark-recapture methods) recommended in the original TOR were found to be ineffective in Carpenter Reservoir situation if used alone. Specifically, the recapture rate on marked fish has been low due to poor visibility and lack of adequate information on seasonal fish distribution.