Bridge-Seton Water Use Plan

Monitoring Program Terms of Reference

- BRGMON-10 Carpenter Reservoir Productivity Model Validation and Refinement

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BRGMON-10
Carpenter Reservoir Productivity Model Validation and Refinement

1 Monitoring Program Rationale

1.1 Background

Two fundamental environmental concerns in the development and selection of the final operating alternative were the effects of the operation of Carpenter Reservoir on aquatic production in the reservoir and the physical quality of the water diverted to Seton Lake. It was hypothesized that there is a lack of suitable food resources in the cold and turbid reservoir to support healthy fish populations.

In response to this concern, a detailed model was developed to predict how different reservoir operations influence physical conditions (i.e., flow velocity, suspended sediment concentration, and light penetration) littoral and pelagic habitat conditions. Light penetration was identified as the key factor for the model because it was believed a critical variable in regulating primary and secondary productivity in glacially turbid lakes and reservoirs. It was also judged unfeasible to develop models that relate the complex hydrodynamics of the reservoir to nutrient and temperature dynamics, because of cost and data availability.

The light based model used predictions of light penetration with empirical correlation between light accumulation and standing crop of benthic or plankton organisms to predict the biomass dynamics of the food sources. Biomass dynamics were translated to production estimates through literature derived production/biomass ratios and used as independent performance measures for comparing alternative Carpenter Reservoir operating scenarios. The model also generated predictions of the seasonal changes in concentration of suspended sediment in water diverted into Seton Lake.

1.2 Management Questions

The Carpenter Lake Reservoir Productivity Model played a central role in the development of the operating strategy for Carpenter Reservoir and directly controlled predictions of pelagic productivity in Seton. The model was effective for performing trade-off analysis; however, three aspects of the model application remain uncertain.

- First, the model was developed and calibrated using sparse physical input data. Driving data for the model (i.e., flows and suspended sediment input from Downton Reservoir tributaries) and the model calibration data (suspended data from the reservoir) were collected inconsistently over a small number of years and limited number of locations in the reservoir. Ideally a large number of locations should be monitored over many years to help fit the model under a full range of variation of inflow conditions.
- Second, benthic and zooplankton sampling is highly variable and a single season of sampling is unlikely to encompass the full range of variation in light and productivity correlation. More data collection is required to increase confidence in the empirical correlation approach, as well as test hypotheses about the relative contribution of nutrients and temperature to aquatic productivity.

- The final uncertainty relates to the differential importance of the littoral and pelagic components of the ecosystem to the fish food base. Clear understanding of the importance of littoral and pelagic food sources is needed as there are differential impacts of operation on pelagic and littoral habitats.

The fundamental assumption of the model was that light penetration was the fundamental driving force in determining productivity in the reservoir and light penetration is affected by reservoir operation through reservoir elevation changes. Suspended sediment concentration, thus light penetration is highly variable in the reservoir and was assumed to be the physical factor which can most likely be influenced by reservoir operation.

This brings forth the following Management Questions:

1) Is light penetration is the primary factor regulating the productivity of littoral habitats in Carpenter Reservoir?
2) Is light penetration is the primary factor regulating the productivity of pelagic habitats in Carpenter Reservoir?
3) Is light penetration in Carpenter Reservoir can be impacted by changes in reservoir operation?
4) Can suspended sediment transport rates into Seton Lake be altered by changes in Carpenter Reservoir operation?

Changes in the operation of Carpenter Reservoir to benefit reservoir productivity would need to be traded-off against impacts to other environmental, social and power values in the system. Thus, changes to reservoir operations to benefit reservoir productivity may be constrained by these other values.

1.3 Detailed Hypotheses about the Impacts of Carpenter Reservoir Operation on Aquatic Productivity and Sediment Transport to Seton Lake

The primary hypotheses that relate to these management questions are:

H_1: Light penetration is the primary factor regulating the productivity of littoral habitats in Carpenter Reservoir

H_2: Light penetration is the primary factor regulating the productivity of pelagic habitats in Carpenter Reservoir

H_3: Light penetration in Carpenter Reservoir can be impacted by changes in reservoir operation

H_4: Suspended sediment transport rates into Seton Lake can be altered by changes in Carpenter Reservoir operation

1.4 Key Water Use Decisions Affected

The refinement and validation of this model will influence the capability, reliability and confidence in predictions about 1) how reservoir operation strategy influences aquatic productivity in Carpenter Reservoir and, 2) what impact the Carpenter Reservoir operation has on aquatic productivity in Seton Lake. Changes to Carpenter Reservoir operations to benefit reservoir productivity would need to be balanced with impacts to other environmental, social, and power values in the Bridge River generating system (e.g., risk of spill in lower Bridge River and Seton River, effects of Carpenter Reservoir riparian habitat).

2 Monitoring Program Proposal

2.1 Objective

The objective of this monitoring program is to collect the information required to validate and refine models of the effects of reservoir operation on the biological productivity of Carpenter Reservoir.

2.2 Approach

The approach adopted for refining and validating the Carpenter Reservoir Productivity model is to undertake further data collection to provide more representative and reliable input data for the driving the physical sub model and to conduct further field monitoring. This sampling will be linked to biological sampling to allow refinement of the physical and biological predictions, as well to permit validation of model components. Results from reservoir productivity monitoring on other BC Hydro reservoirs will also be evaluated to determine if these findings can be applied to improve the Carpenter productivity model.

2.3 Methods

There are three general tasks proposed for the Carpenter Reservoir Productivity Model Validation and Refinement program. Each task is described below.

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) logistical coordination, 4) technical oversight in field and analysis components; and 5) liaison with regulators and St'at'imc.

2.3.2 Task 2 Field Surveys

Limnological Surveys

Carpenter Reservoir will be sampled four times per year during the period May-October at sample locations for physical, chemical, and biological variables. Surveys will be conducted at six to eight fixed stations down the longitudinal axis of the reservoir. At each station, profiles will be conducted to document suspended sediment concentration and composition, temperature, conductivity and light penetration.

Continuously recording thermographs will be placed in key tributaries, and a thermistor chain will be anchored in the reservoir. Measurements of turbidity from Lajoie Generating Station tailrace, Middle Bridge River, Hurley River, Gun Creek, Tyaughton Creek, and several smaller tributaries will be collected to document seasonal changes in suspended sediment input during these surveys. Physical data collection will also occur at the Bridge River 1 Generating Station to estimate seasonal variation of diversion water quality. This sampling approach will serve to provide detailed documentation of temporal and spatial changes in the physical conditions in the reservoir that are key elements of the model.

Chemical and biological variables will be collected at two stations to help link the influence of habitat conditions on chemical and biological differences. Chemical variables include: total suspended solids, turbidity, alkalinity, pH, silicate, total dissolved solids, nitrogen (nitrate, ammonia, particulate), phosphorus (total, particulate, and soluble reactive), and carbon (dissolved inorganic, particulate).

Biological variables include: bacterioplankton numbers, phytoplankton biomass (chlorophyll) and species composition, photosynthetic rates, and zooplankton biomass and species composition. Methods and sampling locations for field studies will closely follow those conducted during 2000 and 2001 to further extend the database. The consultant is encouraged to review the document mentioned here to ensure consistency of data collection approaches.

Collection of physical and chemical information should be coordinated with other programs that are collecting similar data from similar locations (e.g., BRGMON-6 Seton Lake productivity and BRGMON-12 Metals and Contaminants).

Littoral Sampling

Littoral sampling proposed for the monitoring program will be designed to build upon sampling efforts conducted in the year 2000 employing the rapid assessment methodology. This method allows for the collection and rapid processing of data. Stratified sampling in relation to the progression of the reservoir is used to investigate the relationship between habitat variables (light penetration, cover, vegetation, etc.) and standing crop biomass of benthic organisms. Data collection in 2000 was incomplete to fully understand and quantify the relationship between light penetration, flow velocity, cover, and vegetation. The field studies will be conducted over two years to collect empirical data to quantify these relationships. The consultant is encouraged to review the document mentioned here to ensure consistency of data collection approaches.

Model Validation

There will be three primary model validation tasks:

1) Review results from reservoir productivity monitoring on other BC Hydro reservoirs to determine if and how these findings can be applied to improve the Carpenter productivity model.

2) Use the updated and more comprehensive model input data (suspended sediment, flow) from tributaries, more extensive data from within Carpenter Reservoir, and associated output sediment concentration from the Bridge River 1 Generating Station tailrace to refine model structure/parameters. This will provide calibrated estimates of seasonal changes in suspended sediment concentration in the reaches of the reservoir, as well as sediment load that is discharged into Seton Lake.

3) Assemble and analyze additional field data to:

   a) use the additional field data to test predictions of the model, and

   b) use the additional field data to re-evaluate functional relationships between light and other habitat variables to observed benthic or pelagic standing crop biomass. This analysis will be implemented to test the quality of the “old” model and to use the new data to refine either the structure and/or parameter estimates.

2.3.3 Task 3 Reporting

A data report that summarizes data collection methods will be prepared in Years 1 and 2. Upon completion of the three-year study program a detailed technical report will be prepared.

2.4 Interpretation of Monitoring Program Results

The Carpenter Reservoir Productivity Model helped to make trade-off decisions in the Bridge-Seton Water Use Plan. A fundamental uncertainty in the trade-off analysis was the accuracy and precision of the predictions of how Carpenter Reservoir operations can impact conditions that affect biological productivity. The results from this study will allow a significant reduction in uncertainty in addressing fundamental trade-offs and improve the quality of decisions in the Bridge-Seton Water Use Plan review. In addition, this study will reduce uncertainty about the quality of water that is introduced into Seton Lake from the diversion.

2.5 Schedule

Field sampling is scheduled to occur during Years 1 to 3. Review of reservoir productivity models will occur in Year 1. Model validation will occur during Year 3 once all of the field data have been collected.

2.6 Budget

The total estimated cost of the Carpenter Reservoir Productivity Model Validation and Refinement is $971,990.

3 References

Bridge River WUP Consultative Committee Report (WUP CC), 2003. Compass Resource Management and BC Hydro. A report produced for BC hydro Water Use Planning group. (Executive Summary available on website: http://www.bchydro.com/content/dam/hydro/medialib/internet/documents/environment/pdf/wup_bridge_river_executive_summary_pdf.pdf)

Bridge River Power Development Water Use Plan, March 17, 2011: Revised for Acceptance for the Comptroller of Water Rights. (http://www.bchydro.com/content/dam/hydro/medialib/internet/documents/planning_regulatory/wup/lower_mainland/2011q2/bridge_river_wup_rev.pdf)