Duncan Dam Project Water Use Plan
Monitoring Program Terms of Reference

- DDMMON-11 Duncan Reservoir Burbot Monitoring

3 April 2008
DUNCAN DAM
TERMS OF REFERENCE

1.0 OVERVIEW

This document presents Terms of Reference for monitoring program and physical works for the Duncan Dam Water Use Plan (Table 1). The monitoring programs will determine transfer and recruitment benefits associated with existing transfer procedures and evaluate the effectiveness of an existing fish ladder to allow bull trout upstream access to spawning grounds. The physical works programs will reduce ongoing erosion to a valuable wetland area, install a boat ramp to allow visitors to the campground to launch boats during high usage times of the year and improve nutrient retention in Kootney Lake.

This document provides detailed Terms of Reference for the following programs:

1) DDMMON-1 Lower Duncan River Ramping Rate Monitoring: A 2-year monitoring program to assess the impacts associated with the timing, magnitude and rate of operational changes at Duncan Dam on Lower Duncan River fish species life histories of interest. These assessments will help define future ramping rate protocols for Duncan Dam as dictated by DDMMON#15 – Lower Duncan river Stranding Protocol Development and Finalization (to be submitted in future delivery packages).

2) DDMMON-3 Lower Duncan River Hydraulic Model Development: A multi-year channel survey, hydraulic and habitat modeling study of the Lower Duncan River to assess channel change and operational impacts on fisheries habitats, for consideration in future flow planning processes and to help define ramping rate protocols (as above).

3) DDMMON-4 Lower Duncan River Kokanee Spawning Monitoring: Annual kokanee spawning surveys and mapping in Lower Duncan River, Meadow Creek and Larderou River to assess the relative importance of kokanee spawning in each system and determine the impacts of WUP operations on kokanee spawning in Lower Duncan River specifically.

4) DDMMON-11 Duncan Reservoir Burbot Monitoring: A multi-year monitoring program to document burbot spawning requirements, assess burbot monitoring techniques and monitor burbot populations through recommended means. Results will be assessed to determine linkages to reservoir operations for consideration in future planning processes.

Table 1 Duncan Dam Water Use Plan Physical Works and Monitoring Program Terms of Reference Submission Information

<table>
<thead>
<tr>
<th>Name of Monitoring Program or Physical Works</th>
<th>Order Clause Fulfilled</th>
<th>Submitted with this Package</th>
<th>Previously Submitted To CWR</th>
<th>Submission Date</th>
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11.0 DDMON#11 - Duncan Reservoir Burbot Monitoring

11.1 MONITORING PROGRAM RATIONALE

11.1.1 Background

Duncan Dam was built to provide storage benefits to utilities and developments in the Columbia River watershed downstream of the Kootenay River confluence, and therefore operates within a reservoir rule curve that dictates seasonal reservoir operating targets (see Figure 11-1 below). Burbot were identified by the Duncan Dam Water Use Plan Consultative Committee (DDM WUP CC) as potentially impacted by Duncan Dam operations that typically result in dramatic reservoir fluctuations (increased draw down) during assumed spawning periods. Little is understood on the impact of reservoir operations on burbot life histories, and therefore, there were no specific recommendations derived from the WUP process to protect this resource. This species has long been a valued sport fish in the Duncan River system and remains locally abundant in the reservoir (Colin Spence pers. comm.). Population monitoring and capture of burbot for conservation aquaculture purposes has been conducted annually through limited surveys by Ministry of Environment.

It was hypothesized that the greatest potential impact of reservoir operations on burbot populations may be the dewatering effect of winter drawdown on spawning success and egg survival in sites along the shoreline and in lower sections of tributaries. Burbot typically spawn in late February, either in shallow lake habitats or low velocity stream habitats, and have an egg incubation period of about 1.5 months (see Table 11-1). There have been limited studies on burbot spawning habitat use both in the Duncan Reservoir (Spence and Neufeld 2002, Neufeld 2006) and in general (McPhail 1997; Taylor and McPhail 2000), that indicate the tributary-reservoir interface could be a key location, from late January to late February. It can be expected that spawning and egg incubation in the Duncan system is likely to occur between January and May.

There is also concern that winter drawdown of Duncan Reservoir could affect burbot spawning habitat in tributary streams. In a radio telemetry study of adult burbot in Duncan Reservoir, the extent of spawning migration into the upper Duncan River appeared to be influenced by reservoir water levels and related impacts on back-flooding and stream velocity (Spence and Neufeld 2002). As back-flooding from Duncan Reservoir declined, burbot tended to move downstream into areas with lower water velocities than the locations they had abandoned. Since stream spawning burbot tend to spawn in low velocity stream habitats (McPhail 1997), the burbot may have been moving downstream to more suitable lower velocity spawning sites.

To address these concerns, the WUP CC recommended that a life history and habitat use assessment be undertaken in Duncan Reservoir to gain a better understanding of how the current operating regime might be affecting the burbot population. The objectives of the monitoring program will be to: 1) collect information on general population characteristics (distribution, growth and age structure), focusing on identification of spawning habitat and potential activity within the drawdown zone, and 2) to provide information required to determine the link between effects of reservoir operation and populations.
Completing this study will result in partial fulfillment of requirements ordered by British Columbia’s Comptroller of Water Rights, and will specifically address clause 6(g) of BC Hydro’s Duncan Dam Conditional Water License 27027.

11.1.2 Management Questions

The fundamental management questions to be addressed by the burbot life history and habitat use assessment are:

1. What are some basic biological characteristics of burbot populations in Duncan Reservoir (e.g., distribution, abundance, growth and age structure)?
2. Does winter drawdown of Duncan Reservoir dewater burbot spawning habitat and affect spawning success?
3. Can modifications be made to the operation regime and rule curves of Duncan Reservoir to protect or enhance spawning success of this burbot population?

The monitoring program will assess burbot spawning requirements (habitat use and distribution) through adult radio-telemetry tracking as well as provide an annual assessment of population size and age distribution through juvenile sampling and ageing, respectively. Specifically, the assessment will address uncertainty regarding the extent to which winter drawdown of the reservoir affects burbot spawning success.

11.1.3 Management Hypothesis

The primary aim of this monitoring program is to provide baseline information on the burbot population in Duncan Reservoir to better inform on the relationship between reservoir operations and recruitment. It is designed to specifically test the following hypotheses:

H01: Winter drawdown of Duncan Reservoir dewater burbot spawning habitat and thus reduces egg survival and burbot spawning success.

This hypothesis will be addressed by assessing habitat use of spawning burbot. Habitat preference will be defined for the range of habitat conditions observed, and an overall evaluation of burbot spawning conditions provided by DDM WUP operations will be summarized as part of this study program.

H02: Burbot populations are negatively impacted by Duncan Reservoir operations.

This hypothesis will be addressed by annually assessing juvenile burbot densities along the reservoir shoreline. Recruitment analyses will be correlated to both juvenile stock estimates and spawning conditions for the respective cohort years to determine if operations are influencing population size.

11.1.4 Key Water Use Decision Affected

Implementation of the proposed monitoring program will provide information to support more informed decision making with respect to the need to balance storage in Duncan Reservoir with impacts on fish populations in the reservoir.
Where operational linkages to burbot spawning success are identified, mitigation of impacts to burbot may be incorporated into future water planning processes for Duncan Reservoir.

**Duncan Reservoir Elevation**

*Alternative = Duncan2_Alternative_73_final3 May 2004*

Figure 11-1: Proposed Duncan Reservoir operations for the recommended DDM WUP alternative based on 30 years historic inflow data. Blue, red and green lines are the daily 90th, 50th and 10th percentile elevations respectively. (BC Hydro 2005)

### 11.2 MONITORING PROGRAM PROPOSAL

#### 11.2.1 Objectives and Scope

The primary objectives of this assessment are to obtain baseline data on the biological characteristics of the burbot population in Duncan Reservoir and provide information to evaluate potential effects of reservoir operation on burbot spawning success (there may be additional information on the limnology of the reservoir provided in DDMMON#10 – Duncan Reservoir Fish Habitat Use Studies that can describe the effects of reservoir management on burbot rearing and growth). The monitoring program, which will be conducted annually over the 10-year review period will focus on the reservoir burbot populations (i.e., not fluvial burbot that may be restricted to tributaries).

In addition to standard reporting requirements, consultants for this study will continually inform and seek feedback from the Ministry of Environment and BC Hydro, to ensure the objectives and approach of this study are consistent with the status of burbot stocks in the reservoir, and that the approach is effective in addressing management questions outlined for this study.
Table 11-1: Assumed burbot life history summary utilized in the DDM WUP decision process
(red markings modified from Vonk 2002)

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<th>Mar</th>
<th>Apr</th>
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11.2.2 Approach

There are three key tasks required to address the hypothesis and management questions above:

1. Evaluation of indexing techniques for adult and juvenile burbot: there are significant difficulties in successfully trapping adult burbot for monitoring, as well as unproven techniques for monitoring juveniles. Both techniques will be evaluated and refined in the first four years of study.

2. Life history and habitat use assessment: over the four years of evaluation of indexing techniques, burbot life history and habitat use will be assessed. Spawning locations and impacts of reservoir operations will be assessed.

3. Abundance and distribution monitoring: where effective adult and juvenile indexing techniques are defined in years 1-4, indexing will continue in years 5-10 to track burbot abundance and distribution.

Where the indexing techniques proposed here do not meet study objectives, alternative study options will be reviewed in consideration of both study needs and budget.

Once completed, monitoring data and available regional information will be integrated to develop both a status report and summary of operating recommendations for future management of the burbot population in Duncan Reservoir.

11.2.3 Methods

11.2.3.1 Project Coordination

Project co-ordination will involve the general administration and technical oversight of the assessment study. This will include but not be limited to 1) budget management, 2) study team selection, 3) logistics co-ordination, 4) technical oversight in field and analysis components, and 5) facilitation of data transfer among relevant projects. Logistics and technical oversight for this project may include study design recommendations and regulatory liaising to ensure study modifications are appropriate.

A safety plan must be developed and submitted to the BC Hydro contact, for all aspects of the study involving field work, in accordance with BC Hydro procedures and guidelines. Specific safety training may be required.

It is the responsibility of the consultant team for this program, in coordination with the contract authority, to continually plan and report study activities to the Ministry of Environment to ensure methods and their possible impacts on burbot populations in the reservoir are supportive and consistent with regional management objectives. This will include reviewing the methods and results on an
annual basis to ensure the program’s management questions are being addressed adequately and providing recommendations towards correcting any issues with the program, or cancelling the program altogether. The following considerations will be addressed each year:

- Is the annual sampling program providing a reasonable assessment of burbot population dynamics in Duncan Reservoir?
- Is the sampling methodology appropriate for both the unbiased monitoring of adult behaviour and the preservation of burbot sampled? And
- Is there agreement on likely impact pathways that describe reservoir impacts on burbot spawning success that can replace the need for further study?

11.2.3.2 Evaluation of Burbot Indexing Techniques (Years 1-4)

Two indexing techniques will be evaluated during respective field sampling periods annually for the first four years of the Duncan Dam Water Use Plan (DDM WUP) review period: adult burbot capture and tracking, and shorebased juvenile burbot electrofishing (or viable alternatives as recommended by the study consultant and approved by the study coordinator).

**Adult Burbot Capture and Tracking**

Each year for the first 4 years of study, during the fall period, adult burbot will be caught using “cod traps”, setting traps in historic trapping locations summarized in Neufeld (2006). Trap sets and deployment will follow the description by Spence (2000) and decompression methods will follow those refined in Spence and Neufeld (2002). Decompression trauma is a significant issue with burbot monitoring, and where not significantly avoided, will result in cessation of this task. Sampling effort for the purpose of tagging adults may be focused in areas of suspected high burbot abundance (i.e., hotspots) as suggested by local knowledge or past studies (these sites would be in addition to those being sampled for population monitoring). Where trapping and decompression techniques are considered both safe and representative, Ministry of Environment approval may be sought to expand the trapping program to replicate monitoring studies (i.e. catch per unit effort) conducted in the past (see Neufeld 2006). Otherwise, trap effort will be limited to collect the minimum required to track adults during spawning.

Once healthy burbot specimens are caught, each will be measured for total length and weight, and tagged with conventional external tags (e.g., T-bar anchor tags). Prior to tagging, the consultant will consult local specialists (e.g. from Ministry of Environment) to determine what tag type is most appropriate (Floy tags were used in Neufeld 2006).

Specimens that succumb to trap-related trauma will have their otoliths extracted for ageing. Sexual maturity will be assessed in sacrificed burbot.

Radio telemetry tags will be applied to the captured burbot, using surgical methods consistent with previous burbot studies (e.g., Spence and Neufeld 2002; Arndt and Baxter 2006). Sexual maturity will be assessed for radio tagged burbot (tags will be applied to fully mature specimens only). Budget has been set aside for 30 transmitters which should ensure that a portion of the tagged samples will be spawning and will not succumb to sampling mortality or tag loss.
Radio telemetry tracking by boat\(^1\) will be undertaken during the typical burbot spawning and egg incubation period of each study year (February through April). Tracking surveys will be conducted about five times during the expected burbot spawning period. The locations of tracked burbot will be marked on a map and documented using a GPS receiver. The final survey should identify potential spawning locations as demonstrated by adults holding near tributary confluences or upwelling shoreline regions.

Two boat reconnaissance surveys will be conducted to examine potential burbot spawning sites identified during the tracking surveys. The first survey will occur during the suspected burbot spawning period (i.e., February to March), with the purpose of verifying the location and local habitat use of burbot spawners. Locations will be georeferenced and elevation of spawning areas estimated for assessment of potential reservoir management impacts. Once located, the habitat characteristics of burbot spawning sites will be documented, including water temperature (temperature loggers will be installed in duplicate at up to 3 main spawning sites), dissolved oxygen concentration, water velocity, water depth and substrate size composition. If timing is not conducive to direct observations or burbot are not staging at time of survey, another survey will be performed later to meet the objective of documenting actual spawning locations and habitat characteristics.

The second boat reconnaissance survey will be conducted towards the end of the suspected burbot egg incubation period (i.e., early March to mid April), and will have the purpose of assessing changes in habitat characteristics at suspected burbot spawning locations after reservoir water levels have dropped. Important changes in habitat characteristics may include desiccation, freezing, changes in water velocity, and changes in sediment size composition. Habitat characteristics will be recorded again, with temperature loggers downloaded and replaced for the following year’s study.

Reporting for this task is outlined below.

**Shorebased Juvenile Burbot Monitoring**

Juvenile burbot sampling is a potential method for monitoring recruitment success in the Duncan Reservoir. Although unsuccessfully attempted in the Duncan Reservoir in previous opportunistic field studies (Neufeld pers. comm.), this methodology was successfully applied in Windermere and Columbia Lakes (Taylor 2002). Juvenile sampling is less harmful to the specimen and is potentially more representative than adult sampling, and is therefore being considered here.

It is proposed that 20 index shoreline sites be selected randomly/systematically throughout the length of the reservoir in advance of study. Site reconnaissance may be necessary to ensure representation prior to sampling. Boat access is budgeted for this study, but some sites may be accessible by vehicle. Sampling is anticipated to take place mid-summer, but consideration should be made such that:

(a) sampling conditions be repeated annually – temperature, reservoir elevation, locations and sampling effort must remain consistent

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\(^1\) Aerial surveys have been used in the past, particularly when issues of ice cover limit tracking by boat. This alternative means for tracking will be considered within the cost limitations for this study.
(b) reservoir elevations are stable over the sampling period – all 20 sites must be sampled in a relatively short period to maintain between site consistency

(c) reservoir elevations are conducive to juvenile capture – large changes in reservoir elevation (typically rising over the summer, see Figure 11-1) prior to habitat sampling may interfere with rearing behaviour of juveniles, and therefore result in non-representative population estimates. Therefore, the mid-July to mid September period is recommended, and furthermore, later in that period is preferred to ensure burbot are acclimated to the reservoir condition.

The sampling methodology outlined in Taylor (2002) is to be applied here – sites will be open, with measured length and distance from shore (consistent for each site year to year), and will be passed twice with the electrofisher. Caught fish will be aged (“young of year” or juvenile) and measured for length and held until the site sampling is complete. Depletion removal assumptions will be applied when calculating the total fish estimate at each site, before converting to fish/shoreline length. The geometric mean of all site estimates by burbot age (age 0 and >age 0) will represent burbot densities for annual comparison.

Physical habitat characteristics will be recorded for each site, each year: dominant and sub-dominant substrate composition, percent cover (vegetation and bank/substrate), average shore slope and temperatures during sampling.

In the first year of sampling, budget has been allocated for two periods of sampling: mid June and mid August. Because juvenile burbot prefer specific habitat types, it is probable that specific reservoir elevations are optimal for sampling. Between these two sampling period, a preferred sampling elevation may be identified for future repetition.

Reporting for this task is outlined below.

11.2.3.3 Burbot Indexing (Years 5-10)

Depending on the methodology recommended in the year 4 study report – either adult trapping or juvenile sampling – the sampling approach refined in years 1-4 will be applied annually to provide population indicators (either catch per unit effort for adults, or fish/100m shoreline for juveniles). Budget has been set aside assuming adult burbot trapping will be selected, as this is likely the most costly alternative.

Reporting for this task is outlined below.

11.2.3.4 Data Analysis and Reporting

Data Analysis

Data analysis will include the following parameters:

- Telemetry data, including time and location data for every tracking event for each tracked fish will be summarized in tabular and graphics format. Summary tracking statistics for individual fish, including date tagged, average rate of movement, total distance moved and last date of relocation will be included;

- Data from spawning habitat surveys (e.g. chemical and physical mean habitat characteristics) will be described for each actual/potential burbot spawning location;
• Length and age frequency distributions, length-weight relationships, and size at age data (i.e., growth pattern), presented graphically for trap-sampled and shoreline sampled burbot; and

• Juvenile burbot catch rates will be calculated as number of burbot caught per 100m of shoreline as a geometric mean of catch rates for each site, with confidence limits. Catch rates will be provided for all age classes observed.

• Data from juvenile habitat surveys will be described for each site and summarized as arithmetic means for the reservoir.

**Reporting**

Reporting will be provided as follows:

• Year 1: technical reports will be prepared summarizing the results of the respective field tasks: burbot trapping and tracking surveys will be evaluated and recommendations provided for improving burbot survival during catch/tagging, and the burbot electrofishing summary will outline what sample timing is best as dictated by the most reliable catch estimates. These reports will summarize catch methodology, sampling sites and habitat characteristics, catch rates and tagging information (including biological characteristics of trap-caught burbot - e.g., size, age, and maturity).

• Years 2 and 3: annual technical reports will include the same information as in year 1, comparing annual results with historical and regional values, and providing clear recommendations for study improvement.

• Year 4: this report will again summarize the results of both field studies. The report will finalize the spawning behaviour and physical impacts observed during the adult burbot tracking studies, providing clear summaries of spawning habitat preferences, spawning timing and locations, and operations impact assessments by reservoir level. The report will also dictate the preferred method for population monitoring for years 5-10, considering the success of both field methods proposed. The study plan will include the recommended budget (subject to the funding prescribed here) and methodology. Where no practical monitoring tool is recommended, the report must identify tools for future management consideration that would best deal with the management questions herein.

• Years 5-9: as above, annual reports will be prepared summarizing the population monitoring results collected per the methodology recommended in the year 4 report.

• In year 10, a final report will be prepared summarizing the efforts for this monitoring program which will include:
  (a) an executive summary;
  (b) a description of the methods employed;
  (c) a data summary;
  (d) a comparison of results between years;
(e) a detailed summary of the findings as they relate to the ecological hypothesis and the key management questions.

Reports will follow the standard format that is being developed for WUP monitoring programs. All reports will be provided in hard copy and as Microsoft Word and Adobe Acrobat (*.pdf) format, and all maps and figures will be provided either as embedded objects in the Word file or as separate files.

11.2.4 Interpretation of Monitoring Program Results

The monitoring program will provide valuable information to address two specific categories of uncertainty related to the operational impacts of Duncan Reservoir on the burbot population:

1. This program will provide a baseline dataset on the biological characteristics of the burbot population in Duncan Reservoir. This baseline dataset will allow for better assessment of the current status and productivity of the Duncan Reservoir burbot population (i.e., growth rate, condition, and age structure), factors affecting burbot productivity, and the response of the burbot population to potential future changes in reservoir operations.

2. Identifying burbot spawning times and locations will enable an assessment whether reservoir operations have the potential to affect burbot spawning success and, thereby, population productivity. If there is convincing evidence for such an effect, mitigation measures will be discussed (e.g., operation changes or physical works). If the findings are inconclusive, future research needs will be outlined.

As discussed in S11.2.3.1, this study will be reviewed annually to ensure it is appropriate, consistent with local management objectives, and effective at addressing the management questions posed herein. These reviews are to result in either continuation as stated, revisions to the methods, or cancellation of the program.

11.2.5 Schedule

The study will be conducted over the 10-year review period, and will be initiated in Year 1 of implementation of the DDM WUP. Note that conditions on and around Duncan Reservoir can be dangerous and unpredictable and the sampling program may be altered, interrupted, or curtailed in any given year. As discussed above local regulatory concerns and issues with sampling methodologies can result in program changes or cancellation.

A schedule of study implementation is suggested as follows:

- June 2008 – Contract start, safety plan, materials ordered and coordinated;
- Late June to September 2008-2011 – Juvenile burbot sampling
- January/February 2009-2012 – Trapping and tracking adult burbot
- May 2009-2012– Draft Reports prepared, review with MOE RE: study approach in 2012
- July 2009-2012 – Final reporting
- Studies to continue annually per recommendations in 2012 to 2018
11.2.6 Budget

The CC originally approved a budget of $800K (plus inflation) for burbot life history, habitat use assessments, and annual monitoring. The monitoring program as proposed in these terms of reference is estimated to cost $834K. Assuming a start date of 2008, program costs will be inflated to $958K. Revisions recommended by Ministry of Environment to the approach approved by the CC resulted in the cost increases shown below. However, there may be cost savings if study recommendations in Year 4 result in either a reduced study effort or focus on juvenile burbot monitoring, as it is assumed that adult burbot capture will continue annually in Years 5-10.

The table below summarizes the proposed budget. Note that administration is charged to the total budget, and contingency is charged to the field resources only. The total budgets applied to these values are summarized in the “Units” columns.

11.3 REFERENCES


