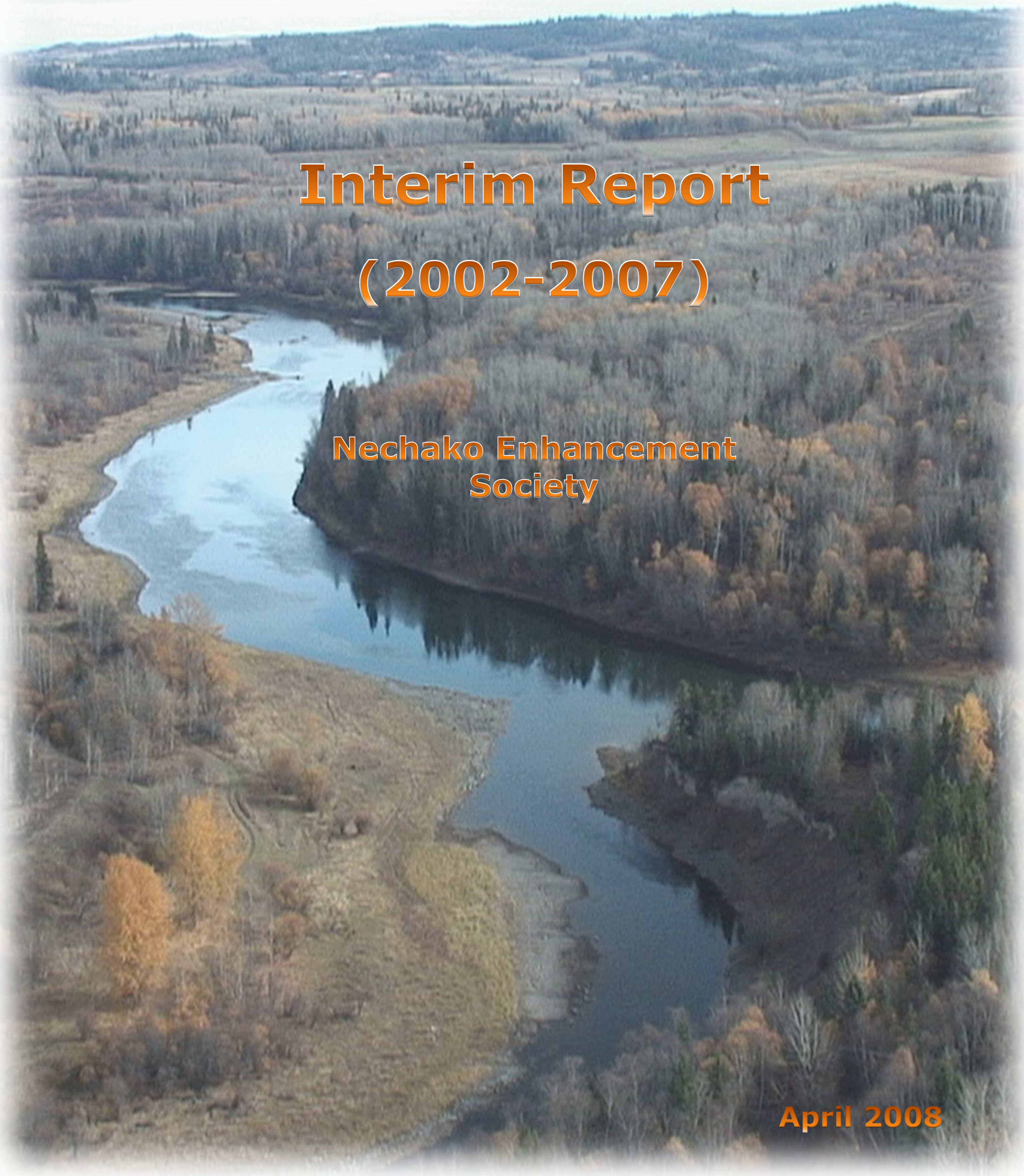
Kenney Dam
Cold Water Release Facility

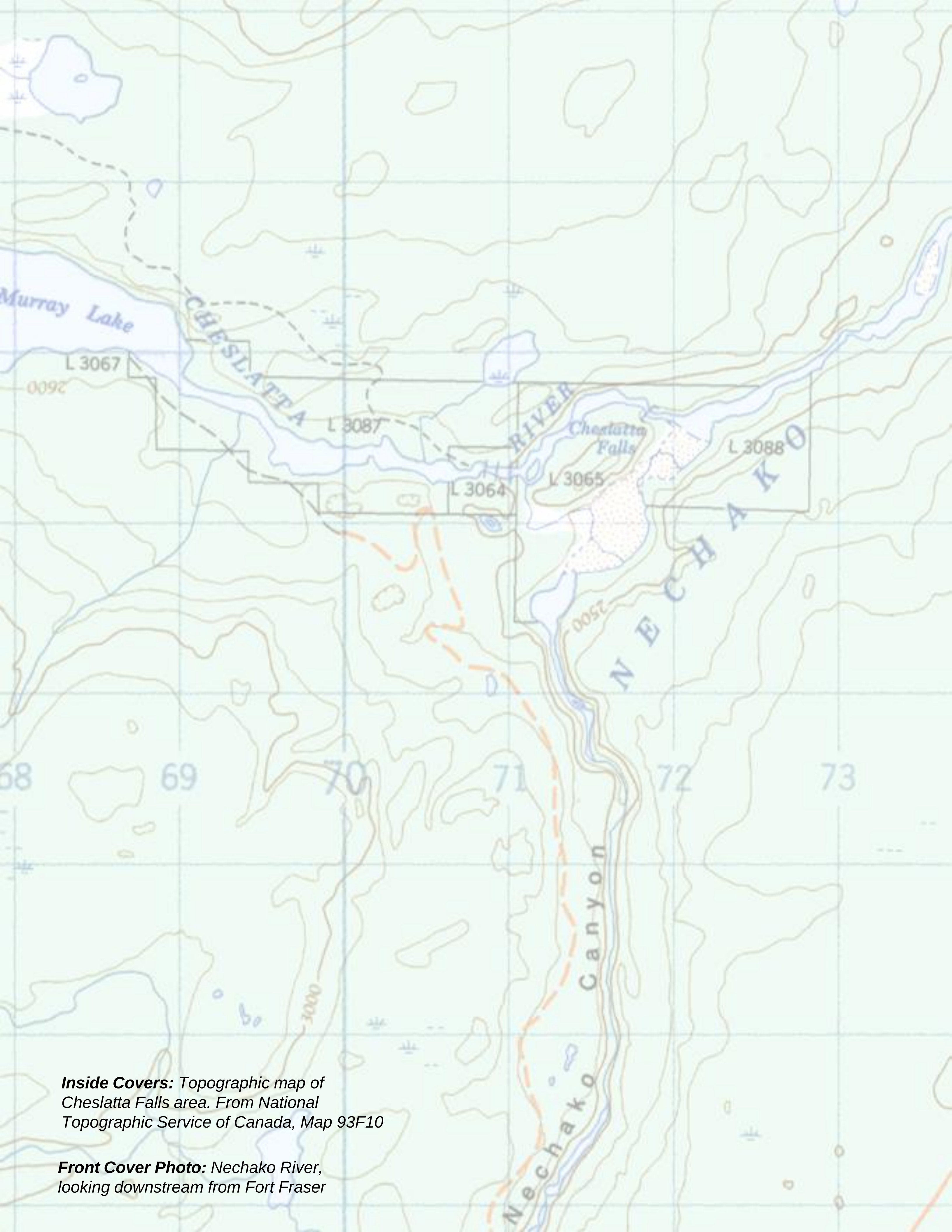


Interim Report

(2002-2007)

Nechako Enhancement Society

April 2008



Inside Covers: *Topographic map of Cheslatta Falls area. From National Topographic Service of Canada, Map 93F10*

Front Cover Photo: *Nechako River, looking downstream from Fort Fraser*

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(2002-2007)

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April 2008

AUTHORSHIP

Prepared by Jacques Whitford AXYS Ltd.

Nechako Enhancement Society, 2008. Kenney Dam Cold Water Release Facility: Interim Report (2002-2007). Prepared for the Nechako Enhancement Society by Jacques Whitford AXYS Ltd.

Except where otherwise noted, cover, back and section photographs provided by: M. Miles and Associates Ltd. 2007.

Nechako Cold Water Release Project: October 18, 2006 Aerial Video Imagery of Cheslatta and Nechako Rivers. Prepared for the Nechako Enhancement Society.

Jacques Whitford AXYS

PREFACE

This report summarizes the work undertaken by the Nechako Watershed Council and the Nechako Enhancement Society since 2002, towards construction of a Cold Water Release Facility at Kenney Dam.

Schedule 4 of the BC/Alcan 1997 Agreement and decisions made in 2001 by the Nechako Environmental Enhancement Fund Management Committee provide a unique opportunity to potentially enhance the downstream Nechako watershed area.

In response to this opportunity and at the request of the Province, the Nechako Watershed Council developed a "Work Plan for the Cold Water Release Facility at Kenney Dam", (March 2002). Subsequently, the Nechako Enhancement Society was formed to implement the Work Plan with funding from the Province and Rio Tinto Alcan.

This Interim Report summarizes, in one document, the 6 years of work costing $1.3M completed to date, addressing technical issues and documenting the remaining information requirements that must be resolved in order to develop the criteria necessary to design, construct commission and operate a CWRF at Kenney Dam.

The next phase in the Work Plan initiates preliminary engineering and environmental assessment related activities that may involve significant expenditures. In addition to supporting these activities, the Interim Report contains key technical information and updated cost estimates that can be used to assess the feasibility of constructing a CWRF and its potential to enhance the downstream Nechako watershed area.

As Directors of the Nechako Enhancement Society, we respectfully submit the Interim Report to the Nechako Watershed Council, partner agencies and stakeholders for consideration prior to embarking on the next phase of this project.

Sincerely,

Don Timlick, Chair
Nechako Enhancement Society

Don Cadden, Director
Nechako Enhancement Society

Justus Benckhuysen, Director
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April 9, 2008

Executive Summary

Planning for a Cold Water Release Facility has been underway since the Nechako Environmental Enhancement Fund (NEEF) Management Committee, in its 2001 final report, determined that a release facility is the best option for enhancing the Nechako watershed.

In 2002, in direct response to a NEEF Management Committee recommendation, the Nechako Watershed Council (NWC) prepared a Work Plan to investigate the feasibility of, and address the planning needs, for the project. The Nechako Enhancement Society (NES) was subsequently formed to implement the Work Plan.

Between 2002 and 2008 the NES and the NWC have implemented the first six years of activities identified in the Work Plan by directing a series of studies and consultation initiatives on the costs, benefits and technical considerations of a CWRF.

Year seven of the Work Plan may involve significant expenditures for preliminary engineering and environmental assessment related activities. Prior to initiating these activities, the NES prepared this Interim Report to summarize, in one document, the work completed to date related to the issues that must be considered in the design, construction and commissioning of a CWRF at Kenney Dam. Any data gaps that exist have also been identified.

In addition to completing additional work on technical issues where data gaps exist, the question of ownership must be resolved in order that a proponent can undertake the necessary steps to complete a CWRF design prepare and submit the necessary environmental assessment report and assume both the risks and responsibilities associated with construction and operation of a CWRF.

The following table provides a brief summary of the current state of knowledge for nine technical issues.

Table: Current State of Knowledge for Technical Issues

Technical Issue	State of Knowledge
Temperature Page 6	Summer temperature criteria for the Nechako River were determined following the 1987 Settlement Agreement between Alcan, the Province of British Columbia and the Government of Canada. The Nechako Fisheries Conservation Plan (NFCP) and Fisheries and Oceans Canada (DFO) independently concluded that current flows management has effectively maintained recommended temperatures upstream of the Stuart River and have also mitigated temperatures between Stuart River and Prince George. DFO also concluded that if a Cold Water Release Facility (CWRF) is constructed, temperatures in the Nechako below the Stuart River confluence may rise above the critical temperature threshold. Additional work is ongoing to clarify temperature and flow criteria for a CWRF.
Flow Page 12	Assuming that both the location for measuring and the Nechako River temperature target itself remain unchanged a CWRF could potentially achieve the temperature objective with less water. As a consequence this could free up water for other purposes, potentially benefiting downstream interests. However, DFO has indicated that if this project goes ahead temperature targets may need to be changed and this will influence how much, if any, freed-up flow is available. Work is ongoing to determine how much freed-up flow could be available.
Reservoir Hydrothermal Page 17	Modelling indicates the reservoir will be able to provide sufficient cold water to address existing temperature targets in the Nechako River in most years. However, in some years, the occurrence of unique wind conditions in July could reduce the available volume of cold water. Under these conditions, there would not be enough cold water to achieve the downstream temperature targets during the Summer Temperature Management Program (STMP). It should be noted that to-date these wind conditions have not been recorded during the STMP period but have been observed in early spring.
Total Gas Pressure Page 21	Water released from a CWRF may acquire an elevated total gas pressure (TGP), which can negatively impact fish. The proposed CWRF has two features to reduce dissolved gas: 1) Flip Bucket Spillway – It has not been confirmed if the flip bucket spillway can deliver water that meets government guidelines. 2) Hollow Cone Valves – Hollow cone valves tested at other facilities were capable of releasing water with acceptable TGP levels.

Technical Issue	State of Knowledge
Fish Entrainment Page 27	Fish, particularly juveniles, can become entrained and pass through water release facilities. The risk of fish entrainment at a CWRF is low to moderate, depending on time of year. There are no government guidelines by which to assess the acceptability of these risks.
Sediment Page 30	Large volumes of sediment have been deposited in the Nechako Canyon and within the Cheslatta Fan since the construction of the Kenney Dam. Discharge from a CWRF will mobilize some of the sediment deposited in the Nechako Canyon and the Cheslatta Fan. Likely erosion and deposition zones have been identified in and downstream of the Nechako Canyon but the short and long – term impacts to fish populations, including sturgeon and salmon, are unknown at this time. Additional modelling work has been initiated.
Cheslatta River and Lake System Rehabilitation Page 36	Significantly lower flows and a more natural flow regime in the Cheslatta River and Lake are prerequisites for the rehabilitation of fisheries productivity in Murray and Cheslatta Lakes. They are also important for the rehabilitation of river and stream habitat within the system. An optimal flow regime for the Cheslatta River and Lake system has not been identified to-date.
Benefits Page 41	Many of the issues that benefit from the construction of a CWRF are flow dependent. They will be affected by Nechako River temperature criteria and how much freed-up flow is available, neither of which are not known at this time. Rehabilitation of the Cheslatta River and Lake system and generation of hydroelectricity at Kenney Dam are the two primary benefits of a CWRF that are not directly dependent on flow and temperature criteria. Twenty-two additional flow-related interests (such as canoeing, flood control, and fish) identified by the NWC depend on the amount of freed-up flow available; which, if any, of these interests could not be met cannot be determined at this time.
Design and Cost Page 44	The costs for constructing a CWRF are estimated in 2008 to be in the order of $184M to $197M. Costs of constructing a 20MW hydroelectric generating station are estimated at $46M to $55M and the costs of constructing a transmission line are estimated to be $10M. Owner's costs, environmental assessment and other project costs such as the cost of commissioning flows and construction of a Cheslatta Fan channel are not included in the above noted costs. All CWRF cost estimates to-date are based on conceptual level engineering developed in 2001. Further engineering is required to establish that the concept is technically feasible and that the facility will perform as required by the design criteria before an accurate cost estimate can be completed.

Table of Contents

List of Tables

List of Figures

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Photo: Nechako Canyon and Scour Hole Lake

1 INTRODUCTION

The Nechako Environmental Enhancement Fund (NEEF) was established as part of the BC/Alcan 1997 Agreement between the Government of British Columbia and the Aluminum Company of Canada (Alcan). This Agreement addressed outstanding legal matters arising from the rejection of the Kemano Completion Project by the Government of British Columbia.

Schedule 4 of the 1997 Agreement established the NEEF Management Committee with a mandate to "...review, assess and report on options that may be available for the downstream enhancement of the Nechako watershed area." The NEEF Management Committee released its final report in June 2001. The report includes two decisions and five sets of recommendations. One decision called for the construction of a Cold Water Release Facility (CWRF) on the Nechako River at the Kenney Dam (Figure 1–1).

The Committee believed that a CWRF would allow for a more natural flow regime in the Nechako River and create conditions that would support rehabilitation of the Cheslatta River and Lake system.

The Nechako Watershed Council (NWC) was formed in 1998 to provide a forum for the diverse interests in the Nechako watershed and the communities that depend on the watershed. In 2001, the NWC was asked by government to prepare a Work Plan for studies that would identify the activities and costs required for construction of a CWRF. This was prepared cooperatively by the NWC, the Province of British Columbia, Alcan, and the Fraser Basin Council and submitted to The Honourable Rick Thorpe, Minister of Competition, Science and Enterprise in February 2002.

The Work Plan identified 14 activities, divided into three phases: Planning, Pre-Engineering and Environmental Review, and Implementation, to be implemented over a period of up to 11 years. In 2002, Year 1 of the Work Plan, the Nechako Enhancement Society (NES) was formed to serve as the body responsible for implementation of the Work Plan. To-date, six years into Work Plan implementation, a total of $1.3M has been spent on Planning and Pre-Engineering activities. Much of the effort during this six year period has focused on the collection, assessment, and analysis of additional data required to develop a range of design and operating criteria necessary to plan, assess the feasibility of and build the proposed facility.

Year Seven of the Work Plan may involve significant expenditures for preliminary engineering and environmental assessment related activities. Prior to initiating these activities, the NES and the NWC prepared this Interim Report to summarize in one document the work completed to date, the gaps identified and progress made to date in addressing the issues that must be considered in relation to the design, construction and commissioning of a CWRF at Kenney Dam.

Figure 1–1: Map of Nechako River Watershed

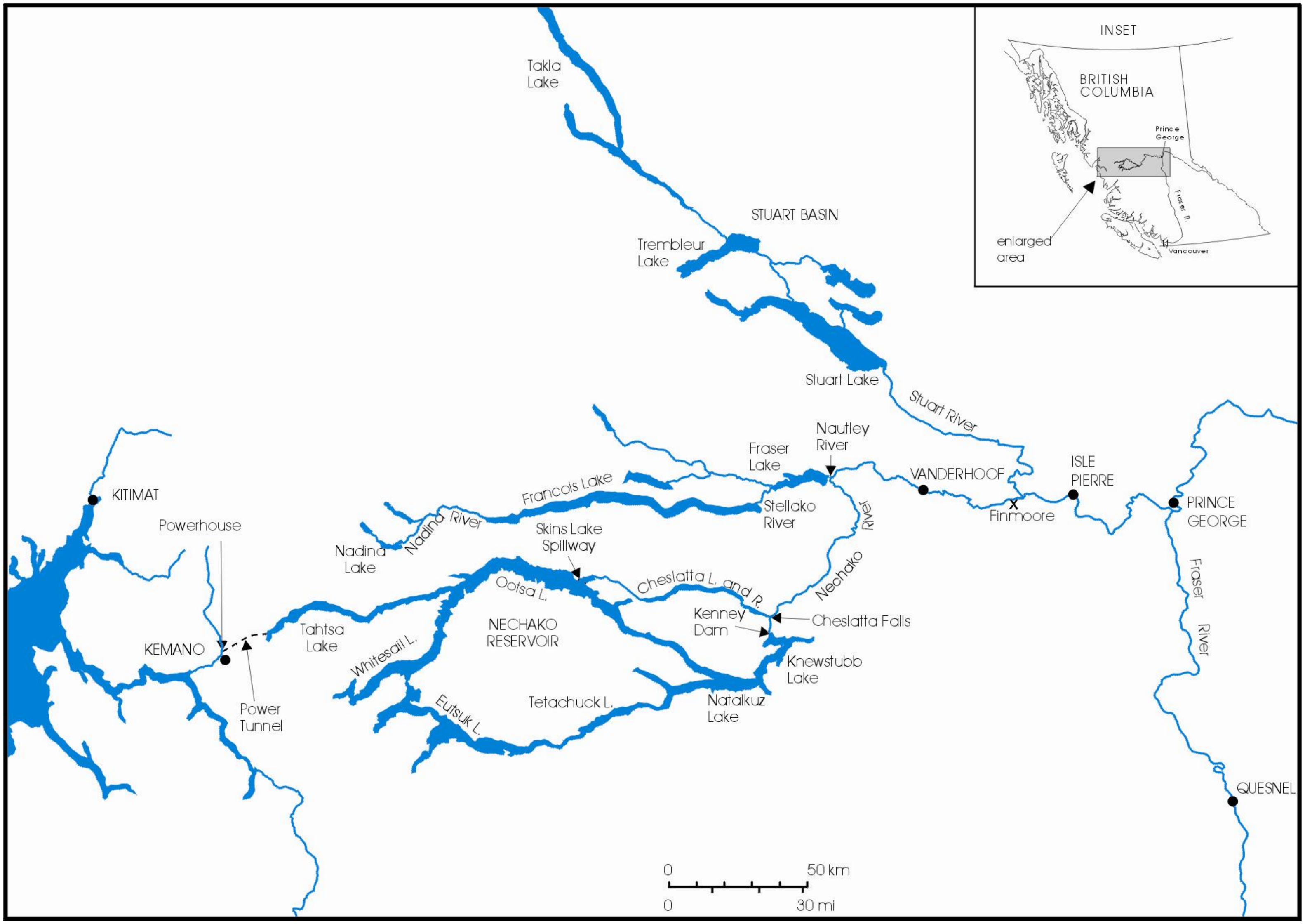

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Photo: Kenney Dam
Photo provided by Alcan.

2 ISSUES

This Interim Report provides a summary of the technical studies undertaken by the NES and NWC over the past six years and focuses attention on the nine factors identified in the Work Plan that posed design and operating criteria uncertainty for a CWRF. This report summarizes what is known about the design aspects and operating criteria that the regulatory agencies can currently take a position on, and identifies what additional information is still required. Specifically, this report discusses the following nine issues surrounding the design and construction of a CWRF: temperature, flow, reservoir hydrothermal characteristics, total gas pressure (TGP), fish entrainment, Cheslatta Fan and Nechako Canyon sediment, Cheslatta Lake and River rehabilitation, benefits, and design and costs.

Photo: Stuart River, just upstream of the confluence with the Nechako River

2.1 TEMPERATURE

Water temperatures in the Nechako River are fundamentally important to fish and have been the focus of considerable scientific, fisheries, and water management attention. The 1987 Settlement Agreement between Alcan, the Federal Government, and the Province of BC sets out the legal requirements for temperatures in the Nechako River. Temperature management is the primary reason for building a Cold Water Release Facility, rather than a water release facility at Kenney Dam.

The Nechako Fisheries Conservation Program (NFCP) – established as part of the 1987 Settlement Agreement, outlined temperature requirements[1] for the Nechako River (monitored upstream of the Stuart River confluence near Finmore; see Figure 1–1). The NFCP recommended that the average daily water temperature should not exceed 21.7°C more than once in 200 years, and should not exceed 20°C more

[1] NFCP Technical Committee. 2003.

than 3.88 days per year. In addition, the temperature should change at a rate of no more than 1°C per hour[2] in order to prevent temperature shock problems for fish.

Currently, the NFCP manages river temperatures by regulating Nechako Reservoir outflows at the Skins Lake Spillway. This work schedules daily water releases during July and August using weather forecasts and computer models to predict downstream water temperatures. The releases are referred to as Summer Temperature Management Program (STMP) flows. In 2005 the NFCP completed a review[3] of technical data collected from the Nechako River since the inception of the STMP and concluded that the intent and spirit of the Conservation Goals set out in the 1987 Settlement Agreement have been met. The report confirmed that STMP flows have effectively maintained recommended temperatures upstream of the Stuart confluence since its inception and that Chinook returns have generally been within the target range, the production of juvenile Chinook is related the number of spawners the previous year, and the amount of rearing habitat is sufficient for the number of spawners in the target range.

It has been suggested that it should be possible to meet downstream temperature objectives following construction of the CWRF by releasing smaller volumes of colder reservoir water thus freeing up flows that could be used to achieve other purposes, assuming that temperature criteria remain unchanged. A combination of water volume and temperature should provide the same cooling effect as the current STMP flows. Activities identified in the Work Plan and undertaken by the NES have attempted to determine the validity of this assumption.

2.1.1 Information Status

The NES held a workshop in April 2004 with agency representatives from Fisheries and Oceans Canada (DFO) and the BC Ministries of Water, Land, and Air Protection and Sustainable Resource Management. Workshop participants discussed a report[4] examining the question of appropriate

[2] Government of British Columbia. 2006.
[3] NFCP. 2005.
[4] Triton. 2004.

release water temperatures. The study concluded that water temperature targets could be achieved with either 10°C or 12°C releases.

Following the workshop, DFO undertook a further examination of the STMP's effectiveness for controlling temperatures for fish in the Nechako River and assessed the potential effectiveness of a CWRF. DFO's examination[5] re-confirmed the NFCP's earlier conclusion that STMP flows have effectively maintained recommended temperatures upstream of the Stuart confluence since its inception (see Figure 1–1). DFO found that the river temperature would be higher in most years without STMP flows. DFO also examined the downstream consequences of possible future release scenarios and determined that the temperature of the Nechako River is strongly related to release water temperature and flow volume.

DFO examined a cooling power relationship as a mechanism to equate the influence of water temperature management schemes to migration habitat quality and sockeye fitness further downstream. The study examined the potential effect of current water temperatures on fish, upstream and downstream of the Stuart confluence. STMP flows appear to have improved temperatures in both areas. DFO found that pre-spawning mortality of sockeye increases with increasing water temperature, while migration and spawning success are possibly related to river conditions such as cool temperatures. The impact of the STMP flows on sockeye survival has not yet been studied.

However, DFO indicated that a reduction in the volume of the summer cooling flows after construction of a CWRF may increase Nechako River temperatures between the Stuart River confluence and Prince George, where warm Stuart River waters increase the Nechako River's temperature. Typically, Stuart River temperatures are measurably greater than the Nechako River by August 1. These warm waters mix with the Nechako waters at the Stuart River confluence. Currently, because of the STMP the Nechako River discharge is much higher than the Stuart, so the warming effect of Stuart River waters on the Nechako River is not significant. If a CWRF is

[5] Macdonald et al. 2007.

constructed and Nechako River releases are smaller and therefore flows are lower, the Stuart River water may raise downstream temperatures of the Nechako below the Stuart River confluence above the critical 20°C threshold[6].

In an effort to assess the potential impact of climate change on temperature management, DFO modelled the impacts of air and release water temperature on Nechako temperatures[7]. They found that a 1.25°C increase in average air temperature during the STMP period would cause the Nechako River temperature to exceed the targeted maximum temperatures more often, especially when flows are low and release water temperatures are high. Exceeding these maximum water temperatures is detrimental to fish populations.

The results of the DFO study on cold shock[8] were discussed at a second NES workshop[9] in May 2006. Cold shock is a stress response in fish to a rapid decrease in water temperature and can be lethal if the rate of temperature decrease is too rapid. The consequences of cold shock depend on the magnitude of the temperature change, the acclimation history of the fish, and the individual physiology and behaviour of the fish. DFO recommended gradual changes in water temperature and volume, dependent on existing river conditions and mixing between a CWRF discharge and ambient water. A CWRF structure must be capable of meeting these control criteria. The release temperatures at a CWRF could be managed using an adaptive, initially conservative approach and monitored in situ to characterize optimal flow rates and discharge temperatures. DFO also recommended developing a small scale experimental laboratory to test operational strategies prior to activating a CWRF; work on this topic has been initiated by DFO.

The May 2006 workshop participants supported the recommendations made by the two reports and raised two additional considerations for Nechako River fish. The first was concern that colder water in the Nechako Canyon may depress rainbow trout populations, which may be displaced by bull trout. The second consideration is that sturgeon will likely

[6] Macdonald et al. 2007.
[7] Macdonald et al. 2007.
[8] Cooke. 2006.
[9] NES. 2006.

benefit from cooler temperatures, as current temperatures are above optimal.

An ongoing review of all previous temperature and flow related studies is currently underway. The intent of the review is to utilize this previous work to extract pertinent technical criteria and constraints and to develop a set of potentially achievable flow and temperature scenarios before then identifying those that are technically feasible. In their Progress Report the investigators note that the primary determining factor that will influence the amount of water that can be reallocated from the STMP period to other times of the year is the release temperature from a CWRF during the summer months.[10] They note that the temperature of water released from a CWRF will have an effect on the volume that needs to be released, the volume of freed-up flows available for use at other times, productivity, fish growth and recreational activities. They conclude their Progress Report with a preliminary recommendation that a release temperature that results in a mixed water temperature of 12°C at Cheslatta Falls is appropriate.

2.1.2 Information Gaps

The 2006 NES workshop participants identified additional research that may benefit operational planning of a CWRF. They focused on specific temperature criteria in three areas: temperature and flow relationships, sturgeon, and upper Nechako River temperatures. The participants suggested further research on temperature and flow criteria and on the relationship between temperature and sturgeon recruitment failure.

The Progress Report[11] outlines areas requiring further research on the impacts of temperature (such as macrophyte response, fish behavioural changes, and bird habitat and foraging issues) and recommends that water chemistry, algae, invertebrates, and juvenile salmonid size and abundance be monitored after construction of a CWRF.

[10] Triton. 2008.
[11] Triton, 2008

Temperature and flow modeling currently underway in collaboration with DFO will develop a clearer understanding of technically achievable flow and temperature scenarios. The flow and temperature criteria from the 1987 Settlement Agreement (currently being met by the STMP flows) form a baseline for this modeling. Currently, temperature criteria in the Nechako River only apply upstream of the Stuart confluence as established by the 1987 Settlement Agreement. DFO has suggested that when considering operational planning, temperature and flow criteria for a CWRF it is appropriate to include consideration of the section of the river between the Stuart confluence and Prince George.[12] Further clarification on this issue is currently being pursued. Once clarified, the amount of water potentially available for other downstream benefits can then be determined.

[12] Macdonald and Morrison. 2008.

Photo: Cheslatta Falls

2.2 FLOW

A central issue in the Nechako River is establishment of a flow regime that will balance competing demands in the watershed. The NWC identified eight key objectives that will shape the development of the future flow regime[13]:

- restoration of the Cheslatta watershed
- maintenance of flows to the Cheslatta River
- year round flows from the Kenney Dam
- reduction of high summer flows
- protection of fish resources
- maintenance of flood mitigation capability
- compliance with legal agreements (e.g., between Alcan and the Federal and Provincial governments)
- sustainability of social, economic, and environmental interests

[13] NWC. 2000.

Water flow is the tool used to manage summer temperatures in the Nechako watershed for sensitive fish species, such as Chinook and the migrating sockeye salmon. Water temperature targets at Finmore are currently met using flows released from the Nechako Reservoir through the Skins Lake Spillway and down the Cheslatta River and Lake system before entering the Nechako River (16 m^3/s averaged over the course of a year and involving instantaneous discharges of up to 453 m^3/s). The volume and timing of these flows are managed by the Nechako Fisheries Conservation Program (NFCP). A CWRF could achieve this same objective by drawing water both from the surface and from deep in the reservoir and releasing the flow directly to the Nechako River at a predetermined temperature and volume. If both the location for measuring and the Nechako River temperature target itself remain unchanged, models[14] estimate that cooling flows can be reduced from an annual average of 16 m^3/s to 3m^3/s, creating 13 m^3/s of "freed-up" flows (Figure 2–1).

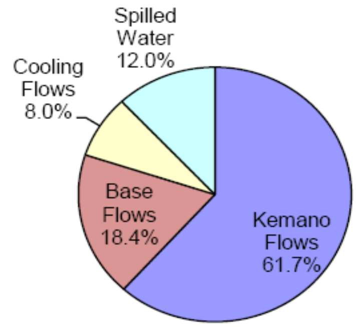
As indicated in the previous discussion on temperature, recent work by DFO[15] indicates that there may be a requirement to redefine temperature criteria for the Nechako River below the Stuart confluence. If the STMP temperature criteria are altered, the volume of water required for cooling is likely to be much greater thus potentially reducing the amount of freed up flows available.[16]

[14] see Boudreau. 2005b.
[15] Macdonald and Morrison. 2008.
[16] Triton. 2008.

Figure 2–1: Current and potential allocation of Nechako Reservoir inflows.[17]

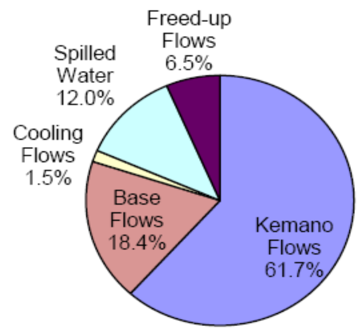
Present Average Distribution

Reservoir Inflow	195.0
Cheslatta Inflow	5.0
Kemano Flows	123.3
Base Flows	36.8
Cooling Flows	16.0
Spilled Water	23.9
Total Outflow	200.0



Post-CWRF Average Distribution

Reservoir Inflow	195.0
Cheslatta Inflow	5.0
Kemano Flows	123.3
Base Flows	36.8
Cooling Flows	3.0
Spilled Water	23.9
Freed-up Flows	13.0
Total Outflow	200.0



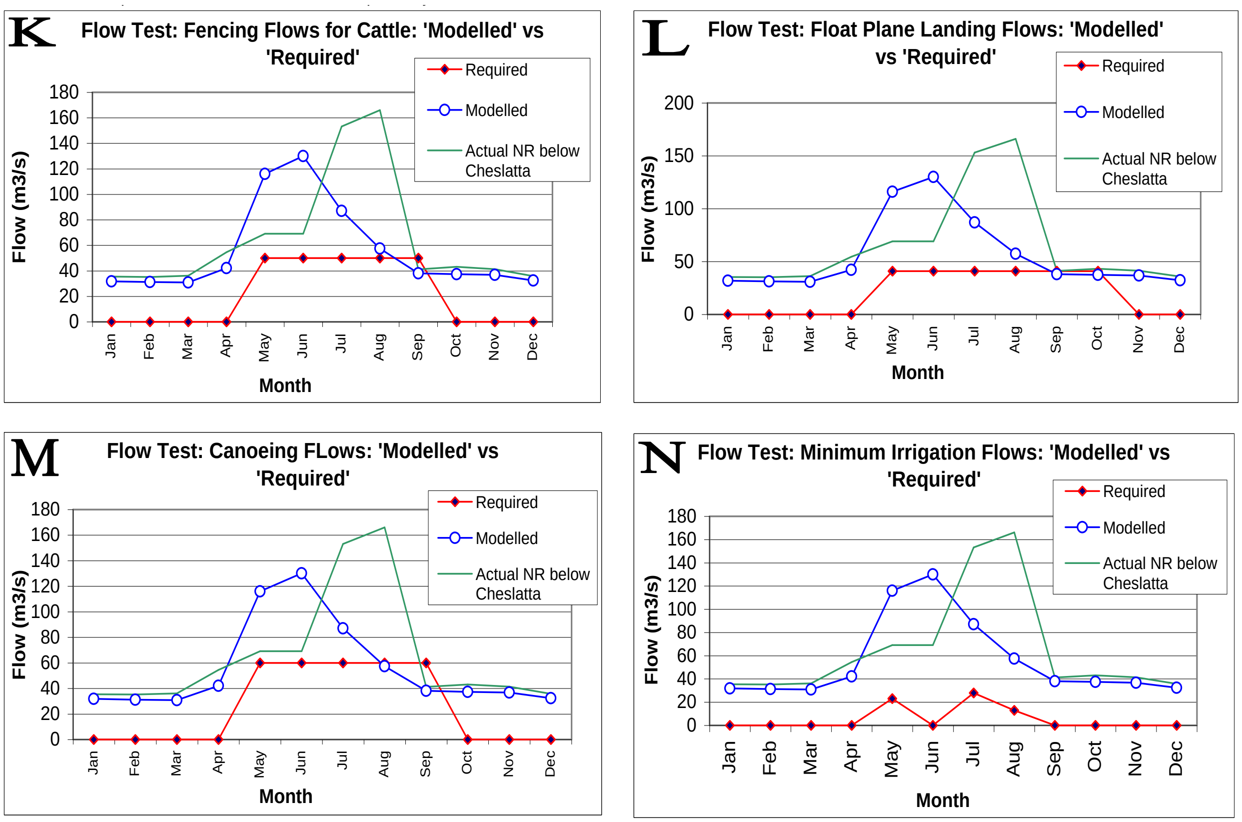
2.2.1 Information Status

The NWC identified 24 flow-related topics and issues some of which had a wide variety of flow targets, and some of which were difficult to quantify. This highlighted the need for additional, more complex flow modeling. Subsequent modeling activities focused on the allocation of the any potential freed up flows and the impact of annual fluctuations in reservoir inflow.

The Nechako Downstream Allocation Model (N-DAM) assessed a set of flow regimes with variable freed up flow allocations (allocation between the Nechako River and the Nechako Reservoir). It was concluded that most of the 24 issues' flow requirements, and a natural hydrograph shape, can be met under a wide variety of freed up flow allocation scenarios. However, some issues' requirements cannot be met throughout the entire year under any of the modeled scenarios (e.g., float plane flow requirements not met in October). The Nechako Reservoir Operations Model (NROM) expanded on the N-DAM by accounting for annual variation in reservoir inflows and estimating the probability that there would be sufficient water in the reservoir to provide the minimum outflow for each of the N-DAM scenarios. The NROM used historical reservoir inflow data to determine how much flow would have been available in any given year. These results were then used to determine the probability that freed up flows can be released to the Nechako River, assuming that future weather and inflow patterns are similar to those in the past.

Figure 2–2: Examples of N-DAM simulation results and comparisons with identified flow requirements

Red lines indicate water needs identified by the 24 interest groups. Green lines indicate current Nechako River flows. Blue lines indicate modeled Nechako River flows for the flow scenario allocating all freed-up flows to the Nechako River.[18]



[17] Based on Boudreau. 2005b. Figure 4-2.
[18] Bouillon. 2003.

The NROM also examined differences between fixed and variable flow sharing formulas. It confirmed that fixed scenarios will not be able to meet all of the water requirements in all years. The variable flow allocation scenario will also be unable to meet all of the water requirements in all years.

The Progress Report on the ongoing review of previous temperature and flow related studies points out that there are three over-riding factors that define the period of influence for changes in flow. They are that water for redistribution to other times of the year would primarily be taken from the quantity of water currently released during the STMP period, that with a CWRF in place there will still be a need to achieve downstream water temperature targets during the July 20th to August 20th period and that the NFCP conservation goal and release of minimum discharges from the Nechako Reservoir to the Nechako River (based on the 1987 Settlement Agreement) need to be respected.[19] The authors go on to state that within these constraints, the primary determining factor that will influence the amount of water that can be reallocated from the STMP period to other times of the year is the release temperature from a CWRF during the summer months.

2.2.2 Information Gaps

Several unresolved issues and data gaps that affect the development of an optimal flow regime were highlighted in a 2005 summary report.[20] Clear definitions of the 24 NWC issues and their associated objectives are needed and flow sharing principles to guide the development of Skins Lake Spillway and CWRF flow regimes are required. Completion of the principles and clarification of their purpose would further the task of determining an optimal flow regime. Furthermore, a simulation of pre-impoundment flows in the Nechako River is necessary, as it will allow determination of natural pre-impoundment flow regimes and assist with identification of "natural" Nechako River flows.

The Progress Report indicates several additional areas that require further review and consideration and identifies a number of areas where future monitoring may be required.[21]

[19] Triton. 2008.
[20] Boudreau. 2005b.
[21] Triton, 2008

Photo: Nechako Reservoir with Kenney Dan in the background

2.3 RESERVOIR HYDROTHERMAL

A criterion in the design and planning of a CWRF is the ability of the Nechako Reservoir to provide enough water at the required temperature to meet the 1987 Settlement Agreement criteria.

The summer temperature of reservoir water tends to be stratified into layers, with warmer water near the surface and cooler layers at greater depths. To achieve Nechako River summer temperature targets, a CWRF is designed to mix warmer water from the surface with colder water from deep within the reservoir. To do this, a CWRF must have access to sufficient amounts of cold water (10°C or cooler) from the Nechako reservoir during the July 20 to August 20 STMP period.

2.3.1 Information Status

Three studies[22] prepared in the early 1990s examined the ability a CWRF to deliver sufficient cooling flows. Their

[22] Triton. 1991.; Triton. 1992.; Triton. 1995.

objective was to model the depth of the 10°C water in the Nechako Reservoir under a variety of release scenarios and environmental conditions. Under extreme water requirements, defined as a one in 200 year return period of hot, dry conditions, the studies concluded that Kenney Dam Release Facility could provide water at 10°C for 31 days of the 32 day cooling period.

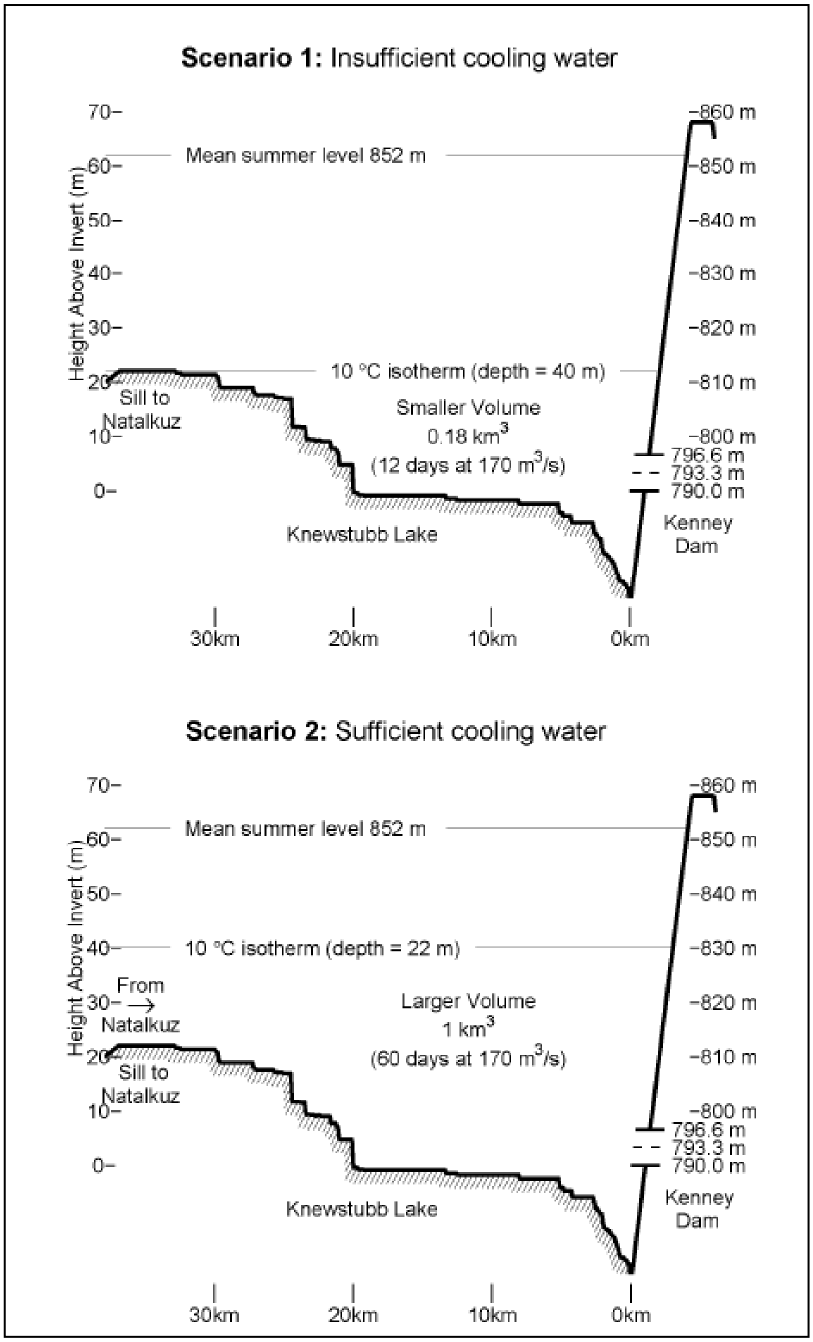
In 2004, Dr. Lawrence and Dr. Pieters from the UBC Departments of Civil Engineering and Earth and Ocean Sciences were contracted to confirm that the modeling undertaken in the early 1990s was sufficient to determine if the now proposed CWRF structure could provide enough water to meet existing regulatory criteria. They concluded that further analysis of existing data and the collection of additional data were both necessary. They also identified additional sources of uncertainty, including the potential impact of winds on the ability of the reservoir to supply cold water, the problem of applying meteorological data from Prince George to the Nechako Reservoir, and the potential effects of climate change.

New measurements of reservoir characteristics and local climate were taken. These investigations[23] concluded that had a CWRF been in place during the years for which data were collected (1990, 1994, 2005-2007) the Reservoir would have been able to provide sufficient cooling water to meet the current Nechako River temperature requirements. These investigations also concluded that water withdrawals alone would not push the 10°C isotherm below 60 m before August 20. However, a substantial storm in early July, with 10 m/s winds lasting two days, would cause mixing that could push the isotherm below the level of a 40 m deep sill that exists between Knewstubb and Natalkuz Lakes (Figure 2–3). This would effectively cut off cold water transfer between the lakes, and the volume of cold water in Knewstubb Lake may not be sufficient to satisfy the maximum cooling water requirement. Wind storms of this magnitude have been recorded in spring, but to date, have not been observed in July.

[23] Lawrence et al. 2007.

Figure 2–3: Profile of the Nechako Reservoir, showing the shallow sill between Natalkuz and Knewstubb Lakes, the deep water intake level of the proposed CWRF, and the Kenney Dam

The volume of 10°C water available at different 10°C isotherm depths is illustrated.[24]



[24] Lawrence et al. 2007. Figure 8.1

2.3.2 Information Gaps

The primary data gap concerning reservoir hydrothermal conditions is the return period of meteorological conditions that would cause the 10°C isotherm to drop below the 40 m sill, rendering the Reservoir unable to provide sufficient amount of cold water. The likelihood of such conditions is the subject of continuing investigations. Other unanswered questions include the impacts of different rates of water release; the effects of internal waves on the transfer of cold water between Natalkuz and Knewstubb lakes; the methodology for interpreting hydrothermal data; and the potential impact of climate change on reservoir water temperatures. Finally, details of the timing and volume of water releases should be determined prior to further modeling efforts[25] being undertaken.

[25] Lawrence and Pieters. 2005.

Photo: Cheslatta Falls

2.4 TOTAL GAS PRESSURE

Elevated total gas pressure (TGP) occurs downstream of many hydroelectric facilities and waterfalls. It is a cause of concern because it can be harmful to fish. Elevated TGP occurs when water and air are forced together under pressure in deep plunge pools below spillways. The increased levels of dissolved gases can cause a number of harmful conditions in fish, which impair swimming ability, increase susceptibility to infection and predation, and can cause death. These are collectively referred to as gas bubble trauma.[26]

DFO has stated that measures to control TGP must be considered and incorporated into the design of a CWRF at Kenney Dam. They have identified three compliance locations where TGP criteria are to be applied:

- Nechako River immediately downstream of Kenney Dam
- Nechako River immediately downstream of Cheslatta Falls

[26] Fidler. 2003.

- Cheslatta River immediately downstream of Skins Lake Spillway

2.4.1 Information Status

The ability to control TGP downstream of in-stream structures such as a CWRF is a *Fisheries Act* requirement. Studies and research completed on this aspect include:

- A review of TGP criteria
- Monitoring and modeling of TGP levels in Nechako River
- Completion of a stakeholder workshop
- A performance review of flip bucket deflectors (ramp that sprays the water) for controlling TGP

TGP Criteria Review

In 2003, DFO reviewed and updated its TGP guidelines to recognize that water bodies have diverse physical and biological characteristics and that fish species have different susceptibilities to high levels of TGP. The new guidelines provide for site specific TGP thresholds in special circumstances.[27]

DFO has indicated that a CWRF must ensure that TGP levels in the Nechako River downstream of Kenney Dam meet Guideline A (≤110%) and TGP levels downstream of Skins Lake Spillway and Cheslatta Falls must meet Guideline C (no increase over background levels).

TGP Modeling Study

In 2004, Triton Environmental Consultants Limited and Aspen Applied Sciences Ltd. were retained to assess the ability of the proposed CWRF design to meet federal and provincial TGP guidelines. The study consisted of the following eight tasks:[28]

- Review of the existing TGP criteria.
- Re-examination of past work on TGP issues at CWRF.

[27] Fidler. 2003.
[28] Triton and Aspen. 2005.

- Implementation of a TGP monitoring program at five locations in the project area between May and October, 2004.
- Review of scientific literature on the effectiveness of flip bucket deflectors on controlling TGP levels downstream of existing facilities.
- Modeling of TGP levels at two locations. The Model for the Nechako River below Cheslatta Falls used estimated TGP levels at Kenney Dam. The model for the Cheslatta River was based on expected future discharge conditions.
- Review of previous studies of Kenney Dam to establish the effectiveness of hollow cone valves (structures that disperse water to reduce its energy) in controlling TGP levels.
- Identification of fish species found in the Nechako River that have not been examined for their susceptibility to high TGP levels and their compatibility with federal and provincial guidelines.
- Recommendation for additional studies to estimate TGP resulting from a CWRF, as well as the ability of the proposed CWRF design to meet regulations.

TGP was monitored at five locations in the vicinity of Kenney Dam: below the Skins Lake spillway, at the outlet of Murray Lake, in the Nechako River below Cheslatta Falls, in the Cheslatta River upstream of Cheslatta Lake, and in Knewstubb Lake within the Nechako Reservoir.

Reliable data was collected for the months of June and October.[29] TGP levels recorded below the Skins Lake Spillway and Cheslatta Falls both exceeded the recommended threshold of 110%. TGP levels in the Nechako Reservoir above the Kenney Dam were within limits set out in the federal and provincial guidelines.[30] These data only provide a general indication of the baseline TGP levels and do not provide insight into TGP levels during peak releases or seasonal variation. The literature review found that all available models for predicting

[29] Triton and Aspen. 2005.
[30] Triton and Aspen. 2005.

TGP require measurements of TGP at a completed facility in order to provide accurate results. Given that a CWRF is in the concept phase, use of these models was not pursued.[31]

Triton and Aspen employed a model to evaluate the effect of a CWRF on TGP at Cheslatta Falls. This model used data from BC Hydro's Seven Mile Dam on the Pend d'Oreille River to estimate levels of TGP below the CWRF once it is completed. Modeling was conducted across a range of flow conditions (14.2 m^3/s to 509 m^3/s) to demonstrate the dissipation rates of TGP between Kenney Dam and Cheslatta Falls under a variety of meteorological conditions. The outcome of the analysis predicted that, in some scenarios, TGP at Cheslatta falls should be no higher than currently observed levels for the modeled flow regime.[32]

In their final report the investigators observed that additional TGP monitoring will not significantly add to the knowledge of conditions on the Nechako River and that data from Seven Mile Dam should be analyzed further to determine if it can be used for the design of a CWRF.[33] If new models are developed by others to estimate TGP associated with hydro-electric projects, it was also recommended that their use should be considered if they could better estimate the effects of flip bucket deflectors on TGP.

TGP Workshop

On July 13, 2005 the NES conducted a Total Gas Pressure Workshop, which was attended by DFO, BC Ministry of Environment, NES, Alcan, and experts and consultants with relevant knowledge. The workshop focused on the technical aspects of TGP and aimed to establish TGP criteria that will apply to the design and construction of a CWRF, and identify data gaps for approval.[34] The results of the workshop are summarized in Table 2–1.[35]

[31] Triton and Aspen. 2005.
[32] Triton and Aspen. 2005.
[33] Triton and Aspen. 2005.
[34] NES. 2005b.
[35] NES. 2005b.

Table 2–1: Results of the NES TGP Workshop, July 13, 2005

Topic	Workshop Outcomes
Applicable Water Quality Guidelines	Guideline A below the Kenney Dam Spillway
	Guideline C below Cheslatta Falls
	Guideline C below Skins Lake Spillway
Modeling	Triton's modeling demonstrates that TGP levels should meet the 110% TGP criterion below Cheslatta Falls
	Future modeling scenarios should address: a.) Lower flows in Murray-Cheslatta system b.) Dissipation of TGP in the Nechako River downstream of Cheslatta Falls
TGP Data Requirements	Pre and post CWRF TGP data needed at Cheslatta Falls to show Guideline C is met
	Pre- and post-CWRF TGP data needed at Skins Lake Spillway to show Guideline C is met
	TGP data from Skins Lake Spillway and Cheslatta Falls to be used to validate the modeled TGP/flow relationship
	Post CWRF TGP monitoring downstream of Kenney Dam to demonstrate that Guideline A is achieved
Next Steps	Ensure a CWRF design achieves the 110% TGP criteria at Kenney Dam before proposing a monitoring method for field programs
	Confirm water release through a hollow cone valve can meet the 110% TGP criteria
	Confirm TGP monitoring methods with DFO and MoE before starting data collection at Cheslatta Falls, Skins Lake Spillway, and Kenney Dam

Effectiveness of a Flip Bucket (Flip Lip) Deflector in Controlling TGP

Flip bucket deflectors at other hydroelectric facilities – in particular the Seven Mile Dam – can maintain and lower TGP levels. However, there are important differences between the Seven Mile Dam and the proposed CWRF. These differences and our limited understanding of the mechanisms which cause increases and decreases of TGP at these facilities, and the absence of a good prototype match for the proposed CWRF facility limit the usefulness of these results.[36] The deficiency of historical data creates the need for further modeling before the effectiveness of the flip bucket design proposed at a CWRF can be fully evaluated.

[36] BC Hydro. 2006.
RL&L. 1998a.
WSDE. 2002.

2.4.2 Information Gaps

Information gaps for TGP preclude the prediction of site specific TGP levels at the three points of compliance that may be required for regulatory approval of a CWRF. Modeling has not been completed which can evaluate the ability of a CWRF to meet regulatory requirements. As well, there is an absence of data on existing TGP levels under various flow regimes at the compliance points. There are two key considerations in addressing this information gap:

- selection of a TGP model
- location where data must be collected to use for the modeling

While the recommendation for additional TGP data collection and modeling conflicts with the 2005 recommendation from Triton and Aspen, their report was completed before DFO identified the requirement to demonstrate TGP compliance for a CWRF. Model selection and data collection at a representative site should be completed with input from DFO to ensure that the results will be accepted.

To address the existing (baseline) TGP data gap, it will be necessary to collect additional TGP information at the three compliance points before construction of a CWRF. This monitoring program must include collection of data from the full range of flow conditions. Once this data has been collected and a CWRF design selected, better predictions of the expected TGP levels from a CWRF spillway design can be completed.

Photo: Rainbow Trout. Photo provided by Triton Environmental Consultants Ltd.

2.5 FISH ENTRAINMENT

Entrainment, the accidental downstream transport of fish through the water conveyance infrastructure of a dam is an issue of concern associated with the operation of a CWRF.[37] Entrainment at a CWRF would occur when fish are drawn into a dam's deep water and surface water intake structures by water velocities too strong to swim against. Injury or mortality may result depending on the type of equipment the fish pass through. The flows at a CWRF will pass through one or more of the hollow cone valves, power generating turbines, and/or spillway – all of which have caused fish injury and mortality at other facilities. As the destruction of fish by means other than fishing is prohibited under Section 32 of the *Fisheries Act*, the entrainment of fish at a CWRF needed to be evaluated.

[37] NWC. 2002.

2.5.1 Information Status

An assessment of the risk for fish entrainment at a CWRF was conducted in 2005.[38] This study looked at the relative abundance, size, weight, and temporal distribution of resident species in Knewstubb Arm to determine what fish species and life stages were at risk. The assessment also considered risks to reservoir populations resulting from entrainment and identified regulatory agency concerns.

Sixteen fish species have been recorded in the Nechako Reservoir. Field surveys were undertaken in November 2003 as well as February, May, August and September 2004 to establish seasonal use and distribution. Based on the results of the field studies a qualitative examination was conducted on the risk of entrainment for four important recreational fish species in the Nechako Reservoir: burbot, Kokanee, mountain whitefish, and rainbow trout. The risk of entrainment was based on fish size and distance from the dam's intake structures. The larger and stronger the fish, the more likely it will be able to escape the higher water velocities near the dam.

The risk of entrainment of the four important recreational fish species was determined to be:

Burbot: Eggs and larvae – low; juveniles – low; adults – moderate in winter and low in summer.

Kokanee: Eggs and larvae – low; juveniles – low; adults – moderate in winter and low in summer.

Mountain Whitefish: Eggs and larvae – low; juveniles – low; adults – moderate. **Rainbow Trout:** Eggs and larvae – low; juveniles – low; adults – moderate. The study reviewed development applications for the Forest Kerr Hydro Project, the Waneta Generation Station upgrade and the Brilliant Dam Expansion Project to gain an understanding of regulatory agency concerns about fish entrainment at facilities similar to a CWRF. In the Forest Kerr situation, DFO indicated that entrainment mitigation measures (e.g., screening) were not cost effective, and proponents were required to estimate the magnitude of fish entrainment

[38] Triton. 2005b.

impacts. BC Hydro personnel indicated that DFO was primarily concerned with entrainment at facilities where there were migrating fish, or where entrainment may endanger a fish population. The study concluded with a recommendation that these concerns will need to be rationalized in the context of both the *Policy for the Management of Fish Habitat* and the *Fisheries Act.*

2.5.2 Information Gaps

Very little information is available to estimate the effects of entrainment at the proposed CWRF on resident fish populations in Nechako Reservoir. Flow modeling based on the final intake designs, intake velocities, and known burst speeds of individual fish (for all life history stages) would provide a basis for determining potential entrainment zones surrounding the intakes. Such a model, in conjunction with fish population and distribution data for Knewstubb Arm, would facilitate prediction of the risks entrainment poses to the species in the reservoir. Further discussion with Provincial representatives about fish entrainment criteria and concerns is also necessary in order to determine assessment criteria.

The potential impact of a CWRF on the distribution of fish within Knewstubb arm is also unclear – more fish may approach Kenney Dam when currents pull their prey toward the dam instead of away.[39]

[39] Triton. 2005b.

Photo: Cheslatta Fan, Scour Hole Lake in the background

2.6 SEDIMENT

Since the construction of the Kenny Dam and diversion of releases through the Cheslatta River and Lake system sediment has accumulated in two areas of the Nechako River. This has been the subject of at least two studies.[40] An estimated 28,000 m^3 of clay, silt, sand and organic material has accumulated in the Canyon and an estimated 0.9 million m^3 of sediment has been deposited in the Cheslatta Fan area.[41] Rewatering the Nechako Canyon and Cheslatta Fan following the construction of a CWRF would restore fish habitat, however it would also mobilize sediments, potentially impacting downstream Chinook salmon spawning beds[42] and Nechako River white sturgeon habitat. The NWC[43] identified the need to further assess the impacts of re-watering on suspended sediments in downstream areas. British Columbia guidelines stipulate that suspended sediments should not exceed 5-25 mg/L above background levels, depending on the duration of the input and the background sediment levels. As well, streambed substrate

[40] TECL, Dec. 1991
[41] TECL, Dec. 1991
[42] NEEFMC. 2001.
[43] NWC. 2002.

composition at potential salmon spawning sites should not include more than 10% fine sediment.

Three studies commissioned by the NEEF Management Committee and the NES, have examined options for passing flows through the Cheslatta Fan and their associated downstream impacts.

2.6.1 Information Status

The NEEF Management Committee commissioned a report in 2000[44] to evaluate options for passing flows through the Cheslatta Fan, with the goal of minimizing impact on fisheries in a cost effective way. The report evaluated various options using 16 criteria related to fisheries, economics, aesthetics, and long-term viability. It concluded that the best option was a meandering pilot channel (Figure 2–4), which would be excavated through the fan and allowed to develop naturally with increasing flows.

The NES commissioned a second study in 2003[45] to re-evaluate the meandering pilot channel and river-cut channel options using the same criteria, also to evaluate the impacts of returning flows to the Nechako Canyon. This second report re-evaluated the cost and potential impact of the meandering pilot channel and did not recommend it, in part because the cost estimate climbed to $1.4M. The report also raised the concern that at high discharge rates (experienced during peak flows) the Nechako River could shift from the meandering pilot channel to the existing channel unless an armoured dyke is constructed. If the river shifted, sediment from both the meandering pilot channel and the existing channel would be mobilized, instead of sediment from a single location, reducing water quality. The report recommended that the NES proceed instead with further evaluation of the reactivated natural channel option, which allows the river to re-define the existing channel. The report further recommended mitigating the impact of sediment through successively increasing commissioning flows and riparian planting to reduce erosion, and concluded that additional channel engineering elements

[44] Hayco. 2000.
[45] EDI. 2003.

that would help reduce erosion (a pilot side channel, berms, armouring) could be included without substantial cost.

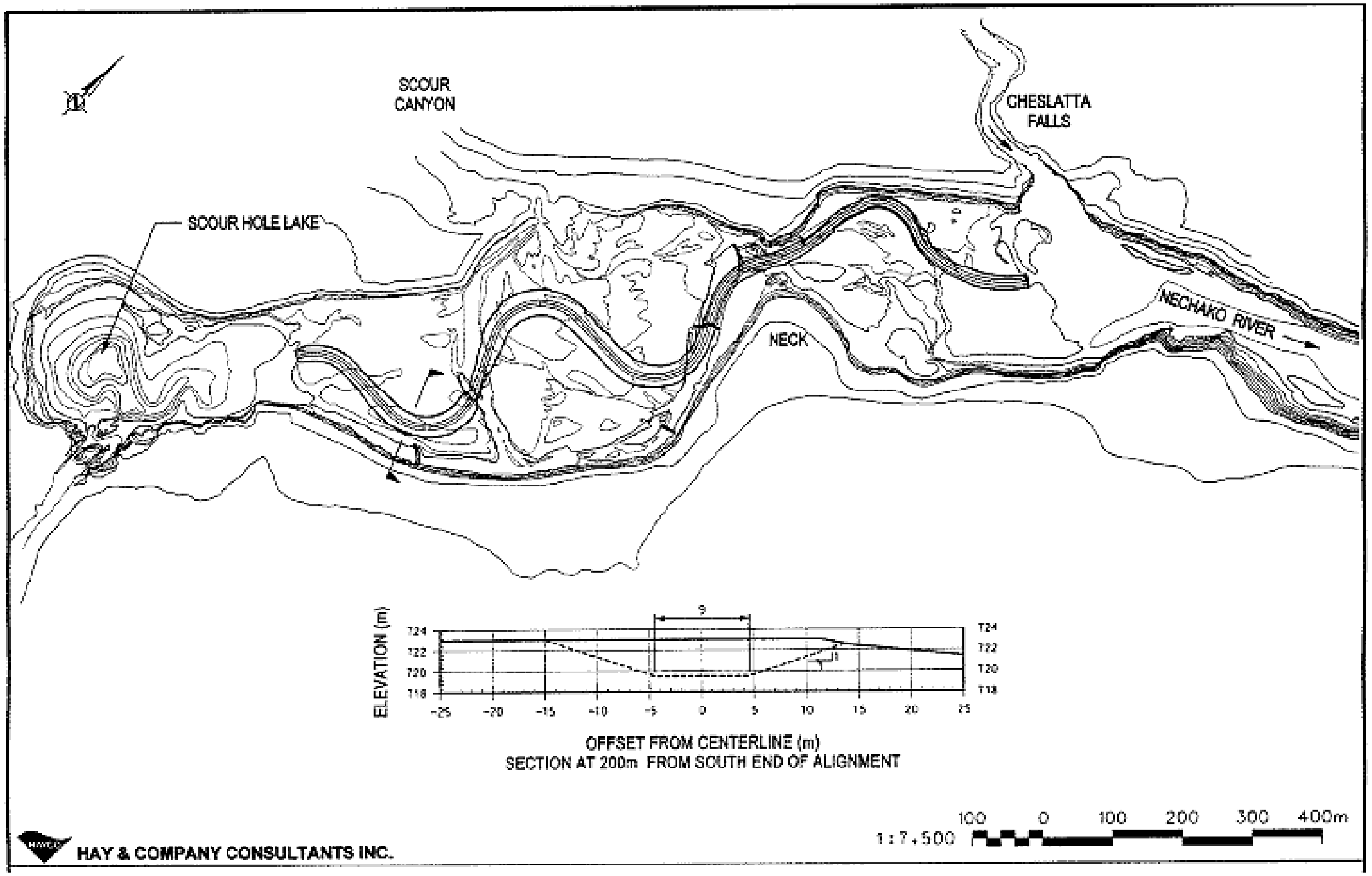
The 2003 study also examined the impacts of re-watering the Nechako Canyon. Re-watering would primarily impact fish, wildlife and vegetation inhabiting the Canyon; the volume of sediment could be mitigated by managing flows, excavating certain areas, and protecting other areas from erosion using berms.

The increased flows may displace rainbow trout from the Canyon and present a migration barrier to other fish. The wildlife that have begun to use the canyon since it was dewatered, including otter, moose, beaver and waterfowl, may also be displaced. Vegetation in the Canyon may be washed downstream, but is not expected to negatively affect the ecosystem or cause debris jams.

The 2003 study was reviewed at an NES workshop on October 5, 2005.[46] The workshop participants determined that more information was necessary regarding the composition and volume of material on the Fan, and how that material would be moved by CWRF flows. Further information was also required regarding the locations of likely deposition zones downstream in relation to sensitive areas.

[46] NES. 2005a.

Figure 2–4: Meandering Pilot Channel option for passing flows through the Cheslatta Fan[47]



[47] Hayco. 2000. Figure 6.11.

The NES commissioned further work[48] in order to address these issues. In the first year of study investigators assembled existing physical data, assessed historical changes in channel processes over time and developed hydraulic and sediment models to predict future possible changes. In the second year of investigation, the models were run and predictions concerning future changes were made. It was predicted that considerable erosion will occur after the inception of a CWRF, that the channel will incise up to 4 m deep between Scour Hole Lake and the Neck, and that a large amount of sediment will be removed at the Neck, eroding a 10 m hole. Downstream of the Neck and for the next 5 km sediment will be deposited, up to 2 m deep in places, with minor deposition for another 15 km.

The study identified areas where pre-excavation, armouring, and floodplain engineering (e.g., re-vegetation) will be most beneficial to reduce the amount of mobilized sediment; pre-excavation could reduce downstream sediment deposition by 60–90%. The study also made recommendations for locations that will be eroded, suggesting measures such as excavation prior to channel commissioning to reduce downstream deposition.

2.6.2 Information Gaps

On October 5, 2005 the NES held a workshop[49] on passing flows through the Nechako Canyon and Cheslatta Fan. Workshop participants (DFO, NES, NFCP, the Province of BC, and consultants) reviewed the previous work and developed a list of information gaps. Some of those information gaps have not been addressed.[50] There remains a need to develop a water balance with proposed flow volumes, to determine the historical and current volumes of sediment carried in the Nechako River and identify the quality of the fish habitat in modelled depositional areas. There is also a need to consider the impacts of various commissioning scenarios on the reservoir habitat, the cost of

[48] NHC. 2007 &2008.
[49] NES 2005a.
[50] NHC. 2008

commissioning flows and to develop a preliminary layout for the meandering pilot channel.

Regarding the Nechako Canyon several issues remain unclear: the water flow that will initiate sediment movement; the rate that will clear the bulk of the fine sediments; and the maximum concentration of sediment at the mouth of the Canyon. Estimates of the total volume of sediment in the Canyon may need to be updated if plans to pre-excavate portions of the Canyon are implemented.

Prior to finalizing excavation plans, the specific location of the pilot channel should be determined and deep test pits dug to identify sediment size in the proposed channel bed. Pre-excavation in the predicted erosion zones would reduce the amount of mobilized sediment, and subsequently the amount of sediment deposited downstream.

Further discussions with agencies will be required to discuss alternative suspended sediment criteria for the Cheslatta Fan, as the concentrations of suspended sediments may exceed water quality regulations for short periods of time. Determining who will accept the risk, both short and long term, of sediment discharge should it exceed the established criteria is yet to be established.

Photo: Cheslatta River during flood

2.7 CHESLATTA RIVER AND LAKE REHABILITATION

The NEEF Management Committee concluded that rehabilitation of the Cheslatta River and Lake system (Figure 2–5) is one of the most important benefits of the proposed CWRF, based on community consultation and a commissioned report.[51] The NEEF Management Committee recommended that a more natural flow regime should be implemented in the Cheslatta River and Lake system by transferring Nechako River base, cooling and flood (up to 1 in 200 year) flows to the CWRF. The NEEF Management Committee also recommended an adaptive management approach to fine-tune an optimal flow regime. Finally, the NEEF Management Committee recommended that the primary objective of the adaptive management program be fisheries rehabilitation.

The issues involved with rehabilitation of the Cheslatta River and Lake system have been examined in a number of reports, with particular focus on documenting the history of the system and the

[51] NHC. 2000.

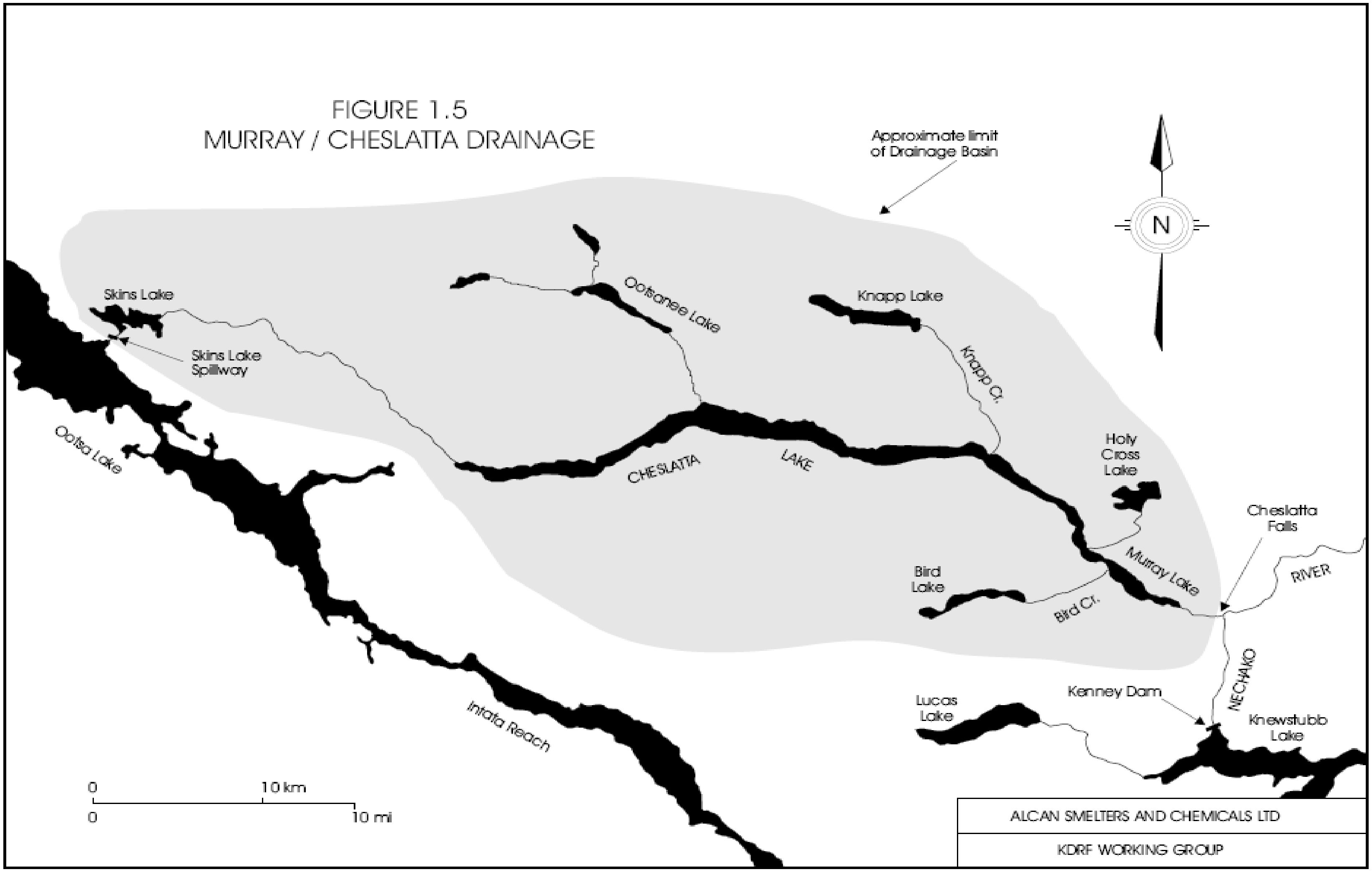
decreased productivity of Murray and Cheslatta Lakes since diversion of flows from Skins Lake Spillway through the system, and on proposing rehabilitation strategies. Important questions remain (such as the optimal flow regime).

2.7.1 Information Status

In 1992 the Cheslatta Carrier Nation developed a discussion paper[52] outlining their goals and objectives relative to the Cheslatta River and Lake. The discussion paper outlined a long-term, broad based plan, the Cheslatta Redevelopment Project, which had the goal of providing for the long term economic and psychological needs of the Cheslatta Carrier Nation and the local community, as well as to highlight environmental considerations and the sustainability of the project. The Cheslatta Redevelopment Project was devised to take advantage of the recreational opportunities of the Cheslatta River and Lake system, and aid the rehabilitation of the Cheslatta River and Lake through support for a Ministry of Environment "Fish Management Plan". The discussion paper identified rehabilitation of the Cheslatta River and Lake system as critical for local economic development due to the direct economic benefits of tourism and to the skills that band members and local residents would develop by participating in rehabilitation efforts.[53] The Cheslatta Redevelopment Project included planning for capital projects.

[52] Cheslatta Band. 1992.

Figure 2–5: Cheslatta River Watershed[54]



[54] Figure provided by Triton Environmental Consultants Ltd.

Prior to completing their 2001 report, the NEEF Management Committee commissioned a study[55] to enhance their understanding of the Cheslatta River and Lake system. The study's primary objective was to outline clear rehabilitation strategies for tributaries to the Cheslatta River and Lake; for Cheslatta River and Falls, and for riparian areas throughout the Cheslatta River and Lake system. The study also made recommendations on flow management and lake levels within the system. The study emphasized, and the NEEF Management Committee agreed, that fishery rehabilitation should be the main priority in the Cheslatta River and Lake system, while other objectives such as tourism and recreation should be secondary.

In 2005 the NES commissioned a report[56] to summarize the state of knowledge in the Cheslatta River and Lake system, identify areas of agreement between multiple stakeholders, and assess the need for additional work. The focus of the previous work centred around the need to implement a rehabilitation plan for sport fisheries on Murray and Cheslatta Lakes. Two actions deemed critical to rehabilitation were the reduction of erosive flows and stabilization of lake levels. A naturalized flow regime will contribute to fish rehabilitation and can be implemented only if Nechako base and cooling flows were routed through the Kenney Dam.

On March 9, 2005 the NES facilitated a workshop on Cheslatta River and Lake rehabilitation. The workshop was attended by representatives from the Province of BC, the federal government, Alcan, the NES, the NWC, and technical experts. At the workshop the participants reviewed previous work and brainstormed approaches to rehabilitation.

The NES commissioned two studies[57] to examine the effects of flows on productivity in the lakes. The first study's[58] objectives were to determine the critical

[55] NHC. 2000.
[56] Golder. 2005.
[57] Stockner and Slaney. 2006.; Bos et al. 2008.
[58] Stockner and Slaney. 2006.

nutrient levels and flows required to increase primary productivity, and in turn fish stocks. The study concluded that inherent natural production can be increased more quickly with a flow rate of 5-10 m^3/s. Nutrient levels can also be improved in the short term through fertilization. Higher flows, such as 15-20 m^3/s, will decrease carbon retention in both lakes and slow the increase in productivity. In-stream works, such as strategic placement of gravel, were recommended to augment the positive impacts of the reduced flow regime. The second study[59] sought to quantitatively document the productivity of Cheslatta Lake before and after the change in flow regime using lake sediment cores. Core samples were collected and analysis showed that the altered flow regime had a dramatic impact on the physical and biological environment of the lake. It also provided a measure of historical productivity which could be used to develop rehabilitation targets.

In 2007 the NES issued a contract for investigators[60] to conduct conceptual planning in advance of the development of detailed rehabilitation prescriptions. This study was scheduled to take place in the summer of 2007, but was delayed as a consequence of the high water levels. This study is currently scheduled to take place in the summer of 2008.

2.7.2 Information Gaps

Although plans have been developed to complete a field assessment of rehabilitation opportunities (originally planned for the summer of 2007) these have temporarily been placed on hold. Plans to engage in stakeholder and First Nations consultations to arrive at a consensus on a flow regime are being developed and will be implemented in 2008.

[59] Bos et al. 2008.
[60] Slaney et al. 2007.

Photo: Nechako River

2.8 BENEFITS

The specific benefits that could be realized have been identified but are currently unquantified as they are dependent upon the amount of freed-up flows, the resolution and definition of the Skins Lake Spillway flow regime and the design and operation of a CWRF at Kenney Dam.

2.8.1 Information Status

The NEEF Management Committee Report identified five objectives for the downstream enhancement of the Nechako watershed. These were: to produce a natural flow regime by reducing the current high-volume summer flows; to have the ability to redistribute flows to enhance the downstream environment and the needs of the downstream users; to create conditions that would allow the rehabilitation of the Cheslatta River and Lake system; to continue to protect fish in the Nechako River; and to maintain or improve flood control.

Between 1998 and 2000 the NWC identified and investigated 24 topics and issues related to a CWRF. An important underlying assumption throughout these investigations was that some level of freed-up flows would be available to address some or all of these topics and issues.

The NWC commissioned a report in 2002[61] to summarize benefits assessment methodologies and guide the selection of an evaluation framework for a CWRF.[62] The report recommended adoption of the multiple attribute analysis framework, which has the advantage of incorporating cost-benefit analysis as one of the categories of interests impacted by the project, and ensures that all relevant social, economic, environmental and distribution issues are explicitly addressed. The NES then commissioned a report detailing a proposed Multiple Accounts Analysis framework,[63] and has since adopted the Multiple Accounts Analysis method as its preferred framework for evaluating the benefits of a CWRF.[64]

In 2005 the NWC commissioned an internal discussion paper[65] to assist with the process of developing consensus recommendations on flow regimes. The report summarized the NWC work, analysis, and consensus-based recommendations developed to date, and was intended to be a 'living' document, recognizing that the NWC is still in the midst of a consensus-based decision-making process to develop a post-CWRF flow regime.

Realization and quantification of the potential benefits arising from a CWRF are ultimately dependent on the criteria established by regulatory agencies that a CWRF must meet and the eventual flow regimes at both a CWRF and the Skins Lake Spillway. In 2007 the NES initiated a study to review existing reports and information and to identify criteria and constraints to develop a range of temperature and flow scenarios that incorporate all pertinent criteria. Once this study is completed a set of potentially achievable temperature and flow scenarios for both commissioning and

[61] Holman. 2002
[62] Holman. 2002.
[63] RCAL. 2003.
[64] Boudreau. 2005b.
[65] Boudreau. 2005b.

operation of the proposed CWRF will be produced. Technically, achievable temperature and flow scenarios will also be identified from those potentially achievable scenarios.

As the degree to which the topics and issues will benefit from a CWRF is flow-dependent, the volume and allocation of the freed-up flows will affect the level of benefit for many of the 24 topics and issues identified by the NWC. The temperature criteria for the Nechako River will affect the amount of freed-up flows available for customized distribution.[66] The temperature criteria may change in the near future,[67] with the possible result that little or no water will be freed-up.[68]

2.8.2 Information Gaps

Not until the amount of freed-up flows, the definition of the Skins Lake Spillway flow regime and design, and operational details of a CWRF are known, can specific benefits be further quantified.

[66] Triton. 2008.
[67] Macdonald and Morrison. 2008.
[68] Triton. 2008.

Photo: Kenney Dam

2.9 DESIGN AND COST

The NES and NWC are at the end of their sixth year of work and nearing the completion of the planning and investigative activities of the Work Plan. Before initiating pre-engineering and environmental review related activities, both of which are estimated to cost significantly more than the work done to date, the NES undertook to update and document previous estimates detailing the costs for construction of the CWRF and associated infrastructure.

2.9.1 Information Status

The NEEF Management Committee Report focused much of its attention on the design of a water release facility and on river management issues that would result from the construction of a release facility. The NEEF Management Committee examined eight options for a release facility ranging in cost from $94M to $243M that would be capable of securing the outcomes they considered essential. Three of these essential outcomes include: the ability to create a more natural year-round flow by redistributing the current high summer flows required to maintain cool water temperatures for migrating sockeye; the reduction of flows in the Cheslatta River and Lake system in order to facilitate the environmental rehabilitation of that system; and the management of flood flows.

The NEEF Management Committee eventually selected a CWRF as the best option. In 2001, Klohn-Crippen[69] was asked to provide a conceptual layout and cost estimate to construct a CWRF at Kenney Dam. The cost was determined to be $96M expressed in 2001 dollars.

The cost estimate was updated in 2005[70] and again in 2006[71] to account for increased construction costs and to estimate the cost of a hydroelectric facility. The conceptual layout has not changed substantially since the original pre-feasibility design in 2001, except for the addition of more detailed preliminary engineering for a hydroelectric facility. In 2005 the cost for the CWRF was determined to be $109M and in 2006 the cost was determined to be $117M, expressed in 2006 dollars (Table 2–2).

In 2008 the cost estimate was again updated.[72] The 2008 estimate indicated that a CWRF would now cost $139M, expressed in 2008 dollars.

Previous cost estimates prepared by Klohn Crippen Berger Ltd. did not include escalation costs as the timing of expenditures was not known at the time. Previous estimates also did not include an amount for interest during construction. Assuming that preliminary engineering would commence in July of 2008, environmental review and permitting would be completed by December of 2010, detailed engineering would be completed by June 2012 and that construction would be completed by August 2014 these additional

[69] KCL. 2001.
[70] Klohn Crippen, 2005
[71] KCBL. 2006.
[72] WHS. 2008.

costs were estimated in 2008.[73] As shown in Table 2–2, utilizing both intermediate and high assumed rates for escalation and interest the estimated costs to completion were $184M for the intermediate scenario and $197M for the high scenario. It should be noted that these cost estimates do not include owners costs, costs associated with the environmental assessment, construction of a 20 MW hydroelectric generating facility, transmission line, and other project costs such as the costs of commissioning flow water and construction of the Cheslatta Fan channel.

[73] WHS, 2008

Table 2–2: Estimated and Escalated Capital Costs[74]

Description	Estimated Costs 2001 ($1,000)	Estimated Costs 2005 ($1,000)	Estimated Costs Jan 2006 ($1,000)	Estimated Costs Escalated to Jan 2008 ($1,000)	Estimated Costs Escalated to Completion "Intermediate" ($1,000)	Estimated Costs Escalated to Completion "High" ($1,000)
Contractor's Direct and Indirect Costs	70,797	80,895	87,595	100,741	126,472	136,223
Contingency for Civil Works (20%)	11,000	12,000	12,000	14,052	17,598	18,959
Contingency for Marine Works (50%)	6,000	7,000	7,500	9,101	11,530	12,411
Sub-total Estimated Construction Cost	**87,797**	**99,895**	**107,095**	**123,894**	**155,600**	**167,593**
Interest During Construction (IDC)					11,047	11,905
Investigations and Preliminary Engineering	1,250	1,400	1,500	2,250	2,581	2,581
Detailed Engineering (4.5% Jan 2008)	3,600	4,000	4,300	5,575	6,308	6,308
Construction Services (5.5% Jan 2008)	3,300	3,750	4,000	6,814	8,272	8,272
Total Estimated Project Cost	**95,957**	**109,045**	**116,895**	**138,533**	**183,808**	**196,659**

In 2008 a technical memorandum prepared as part of the cost estimate explained why it is considered to be premature to undertake a detailed cost estimate at this time and outlined the steps, information, and expertise required to provide such a detailed estimate when it is undertaken.[75]

With respect to why it is premature to undertake a more detailed estimate at this time, it was noted that the 2006 estimate was based solely on conceptual level engineering developed in 2001. Investigations and further engineering are required to establish that the concept is technically feasible and that the facility will

[74] WHS, 2008.
[75] WHS, 2008

perform as required by the design criteria before an accurate cost estimate can be completed. In addition, it was pointed out there is also an issue concerning constructability and construction methodology particularly with regard to the deep-water pipelines.

There was also a practical reason pointed out for not undertaking a detailed estimate at this time. Previous estimates were prepared using proprietary software which has since been replaced by a more up-to-date methodology and software standard. To convert data from previous cost estimates and to utilize this new standard it was estimated that an investment of $100,000 would be required.[76]

The 2006 cost estimate provided a 'ballpark' cost estimate for the addition of a small hydroelectric generating station at a CWRF and an associated transmission line. Costs for a single unit facility with an installed capacity of 20 MW was estimated at $20-24 million, and the costs for constructing a 69 kV transmission line, approximately 70 km in length, was estimated to be $15 million. In the 2008 study it was not considered possible to reliably estimate what the price of raw materials (copper, nickel and stainless steel) and hence the cost of a turbine-generator unit and associated equipment will be six or seven years from now. Nevertheless, for the purposes of providing some indication of potential costs a "ballpark" estimate of potential cost ranging from $46M – $55M was provided.[77]

BC Transmission Corporation estimate the costs, expressed in 2008 dollars, of building a transmission line from a CWRF to the highway at Fraser Lake to be in the order of $10M.[78]

2.9.2 Information Gaps

Since the 2006 cost estimate was completed, industry has adopted a new standard for completing estimates.

[76] WHS, 2008
[77] WHS, 2008
[78] Don Timlick, Rio Tinto Alcan. 2008 Pers. Comm..

A more detailed cost estimate cannot be compiled until the next stage of engineering has been completed and a qualified team has been identified to complete the estimate.[79] Feasibility engineering is necessary to refine a CWRF design, particularly the underwater components. A contracting approach and construction schedule should be outlined during the next stage of engineering. The estimate should be compiled by a team of experienced engineers, including an experienced user of the new industry-standard cost estimation software, and an experienced marine contractor.

Operating cost estimates can be further refined, as current estimates lack an empirical example from a water release facility as complex as that proposed for the Kenney Dam. Operators of existing facilities may help refine current estimates based on operating and maintenance costs of their own facilities.

Before an estimate of total costs can be completed owner's costs including administration costs, long-term financing costs and any costs associated with a federal and provincial environmental review and permitting including associated environmental studies will need to be identified. Typically, costs for environmental studies and review for major projects commonly range from 1% to 3% of the overall capital costs.[80]

[79] WHS. 2008.
[80] Ward Prystay, Jacques Whitford AXYS. 2008. Pers.Comm.

Photo: Cheslatta Lake

3 SUMMARY AND CONCLUSIONS

Planning for a CWRF has been underway since the Nechako Environmental Enhancement Fund Management Committee in its 2001 final report decided that a release facility is the best option for enhancing the Nechako watershed.

Between 2002 and 2008 the NES and the NWC have implemented activities identified in the NWC Work Plan by directing a series of studies and consultation initiatives on the costs, benefits and technical considerations of a CWRF. These efforts have closely followed the NWC's Work Plan in both schedule and focus on the nine priority issues of: (i) Nechako River water temperature; (ii) Nechako River flows; (iii) Hydrothermal characteristics and behavior of the Nechako Reservoir; (iv) Total gas pressure downstream of a CWRF; (v) Fish entrainment into a CWRF; (vi) Sediment; (vii) Cheslatta River and Lake system rehabilitation; (viii) Benefits; and (ix) Design and costs of a CWRF.

To-date, six years into the Work Plan implementation, $1.3M has been spent on Planning and Pre-Engineering activities. The NES adopted a consultative and science based approach to completing the work plan. Experts were retained to undertake the technical studies and input was sought from DFO, the Cheslatta First Nation, and residents along the south side of Cheslatta Lake and River. This consultative approach allowed significant progress to be made towards the assessment of the feasibility of constructing a CWRF. The following table provides a brief summary of the current state of knowledge for the technical issues and any outstanding information requirements.

Despite having taken six years and spending in excess of $1M, considerable further work is indicated. Although much, if not all, of this further work will likely need to be completed if a CWRF is to be built, it is reasonable to consider how much of this work needs to be undertaken prior to committing significant additional funds for preliminary engineering and environmental assessment activities.

It is anticipated that a section 35(2) *Fisheries Act* authorization will be required for construction and operation of the facility. This will trigger an environmental assessment under the *Canadian Environmental Assessment Act* (CEAA). Before the environmental assessment can even begin, there are two key items that will need to be resolved.

Before preparing a Project Description for an environmental assessment, work aimed at resolving and defining both the Skins Lake Spillway flow regime, and the design and temperature and flow operating criteria of a CWRF need to be significantly advanced, if not completed. This information will allow both the scope of project and scope of assessment required at the commencement of any environmental assessment to be completed.

The NEEF Management Committee recommended that Alcan and the Province of BC create a joint venture agreement for a public-private consortium which would design, build, and own a CWRF. This question of ownership must be resolved in order that a proponent can undertake the necessary steps to complete a CWRF design, prepare and submit the necessary environmental assessment report, and assume both the risks and responsibilities associated with construction and operation of a CWRF.

Depending upon what a CWRF design and operating criteria entail, the scope of the environmental assessment will determine the likely costs, timelines for additional studies and work, and the likelihood of success of an environmental assessment.

Table 3–1: Summary of State of Knowledge and Recommended Further Work

Issue	State of Knowledge	Recommended Further Work
Temperature (NWC Work Plan Activity 6)	Summer temperature criteria for the Nechako River were determined following the 1987 Settlement Agreement between Alcan, the Province of British Columbia and the federal government. In 2005 the NFCP completed a review of data collected since the inception of STMP flows and concluded that the intent and spirit of the Conservation goals have been met and that recommended temperatures have been effectively maintained. An independent examination of the STMP's effectiveness for controlling temperature conducted by DFO while confirming that STMP flows had effectively maintained recommended temperatures, also examined downstream consequences of possible future release scenarios. They concluded that if a CWRF is constructed and Nechako River releases are smaller and therefore flows are lower, the Stuart River water may raise downstream temperatures of the Nechako below the Stuart River confluence above the critical temperature threshold. DFO recommended that a CWRF structure must be capable of allowing gradual changes in water temperature and volume in order to mitigate the effects of cold shock on fish and that a CWRF could be managed using an adaptive, initially conservative approach. Additional temperature and flow modelling and a review of all previous temperature and flow related studies are currently underway by DFO and the NES. Preliminary results from these ongoing investigations suggest that a 12 ^{O} C release temperature is recommended. Once completed, the results of additional modelling will further clarify both temperature and flow criteria for a CWRF. Once clarified, the amount of freed-up flows potentially available for other downstream benefits can then be determined.	▪ Completion of further temperature and flow modelling to clarify both temperature and flow criteria for a CWRF.
Flow (NWC Work Plan Activity 2)	Water flow is the tool currently used to manage summer temperature in the Nechako River. Water temperature targets are currently met using flows released through the Skins Lake Spillway and down the Cheslatta River and Lake system. The volume and timing of these flows are managed by the NFCP. Assuming that both the location for measuring and the Nechako River temperature target itself remain unchanged a CWRF could potentially achieve the same objective by releasing a lower volume of colder water. The lower volume of water required for summer cooling flows may free up water for other purposes, potentially benefitting downstream interests. There are three overriding factors that define the period of influence for change in flow. Water for redistribution to other times of the year would primarily be taken from the quantity of water currently released from the STMP period. With a CWRF in place there will still be a need to achieve downstream water temperature targets during the July 20th to August 20th period and that the NFCP conservation goal and release of minimum discharges from the Nechako River will need to be respected.	▪ Complete the definition of the flow and temperature of water to be released to achieve in river salmon temperature criteria. Doing so will clarify the amount of water available for reallocation and facilitate the completion of a definition of flow related topics and issues that might be resolved with a CWRF in operation. ▪ A number of related areas requiring further work have been identified as follows: ▪ Assess previous recommendations[81] concerning next steps for developing a post-CWRF flow regime. ▪ Complete final wording of the NWC flow regime principles. ▪ Clearly define the 24 flow issues and their associated objectives.
Reservoir Hydrothermal (NWC Work Plan Activity 6)	The lake bottom topography, temperature gradient, and weather of Knewstubb Lake have been studied to determine if it is possible to achieve temperature criteria using water released from a CWRF. The reservoir will be able to provide sufficient cold water to address the target temperatures in the Nechako River in most years. However, modeling indicates that the occurrence of unique wind conditions in July could change the temperature profile of the reservoir and reduce the available volume of cold water. Under these conditions, there would not be enough cold water to achieve the downstream temperature targets for the entire STMP period. To-date, these wind conditions have not ben recorded during the STMP period but have been observed in early spring.	▪ Consider benefits and costs of undertaking long term hydrothermal modelling and conductivity-temperature-depth surveys in the Nechako Reservoir to better define the risks of not having sufficient cold water. ▪ Assess the impacts on the ability of a CWRF to supply sufficient cold water of: ▪ Water release rates ▪ Internal waves ▪ Assess the methodology for interpreting hydrothermal data. ▪ Examine the potential impact of climate change on reservoir water temperatures.
Total Gas Pressure (NWC Work Plan Activity 6)	Water released from a CWRF may acquire an elevated total gas pressure (TGP), which can negatively impact fish. The proposed CWRF has two features to reduce dissolved gas: a flip bucket spillway (a release chute with an inverted terminus) and hollow-cone valves (cone-shaped structures which spread the water). It has not been confirmed if the flip bucket spillway can deliver water that meets government guidelines. Hollow cone valves tested at other facilities were capable of releasing water with acceptable TGP levels.	▪ Complete modeling to evaluate the ability of a CWRF to meet regulatory requirements. ▪ Collect additional data at the three compliance points to satisfy DFO modelling requirements.

[81] Boudreau, K. 2005. Consultant's recommendations about next steps for developing preferred post-CWRF flow regime. Memo to the Nechako Enhancement Society and Nechako Watershed Council from Kristann Boudreau (4Thought Solutions Inc.).

Issue	State of Knowledge	Recommended Further Work
Fish Entrainment (NWC Work Plan Activity 6)	Fish, particularly juveniles, can become entrained and pass through water release facilities. The risk of fish entrainment at a CWRF is low to moderate, depending on time of year. At this time Fisheries and Oceans Canada and Ministry of Environment have not established acceptable entrainment criteria for hydroelectric facilities.	▪ Conduct flow modeling using final intake designs, intake velocities, and fishes' known burst speeds to estimate the effects of entrainment.
Sediment (NWC Work Plan Activity 6)	Large volumes of sediment have been deposited in the Nechako Canyon and within the Cheslatta Fan since the construction of the Kenney Dam. The infusion of water from a CWRF will mobilize the sediment and transport it downstream. Of the options considered for passing flows through the Fan, the Meandering Pilot Channel (an excavated but unlined channel) was determined to be the most cost effective method to reduce the impact of downstream sedimentation. Likely erosion and deposition zones have been identified in and downstream of the Nechako Canyon. Modeling of sediment mobilization from the Nechako Canyon and Cheslatta Fan to downstream areas of the Nechako River has been initiated.	▪ Investigate the water flow that will initiate sediment movement and clear the bulk of the fine sediments, and the maximum concentration of sediment at the mouth of the canyon. ▪ Determine with engineers whether pre-excavation of the Canyon will be necessary; if so, more detailed estimates of the total volume of sediment in the canyon. ▪ Evaluate the impact of roads on erosion in the canyon. ▪ Finalize pilot channel location and dig deep test pits to aid pre-excavation planning. ▪ Discuss Cheslatta Fan sediment criteria and sediment mitigation plans with agency representatives. ▪ Determine the historical and current volumes of sediment carried in the Nechako River. ▪ Identify the quality of, and likely impact, to fish habitat in depositional areas. ▪ Consider the impacts of various commissioning scenarios on the reservoir habitat. ▪ Determine the cost of establishing the pilot channel. ▪ Consider the cost of commissioning flows.
Cheslatta River and Lake System Rehabilitation (NWC Work Plan Activity 6)	A CWRF at Kenney Dam is essential for rehabilitation of the Cheslatta River and Lake system, as Nechako River base and cooling flows can be routed through a CWRF instead of through the Skins Lake Spillway. Lower flows and a more natural flow regime in the Cheslatta River and Lake are prerequisites for the restoration of productivity in Murray and Cheslatta Lakes. They are also important for the rehabilitation of river and stream habitat within the system. An optimal flow regime for the Cheslatta River and Lake system has not yet been identified yet.	▪ Clarify goals for optimal flow regime, particularly regarding recreational interests. ▪ Determine an optimal pattern of flows for the Murray-Cheslatta system (based on the Stellako River or another local system). ▪ Carry out an economic assessment based on updated environmental information and an assumed average annual flow.
Benefits (NWC Work Plan Activity 5)	The issues that benefit from the construction of a CWRF are flow dependent and will be affected by Nechako River temperature criteria. Rehabilitation of the Cheslatta River and Lake system and generation of hydroelectricity at Kenney Dam are the two primary benefits of a CWRF. Twenty-two additional flow-related interests (such as canoeing, flood control, and fish) and flow levels necessary to achieve the goals of each interest have been identified by the NWC.	▪ Upon development of temperature and flow criteria and an optimal flow regime, conduct an assessment of expected benefits and impacts resulting from any freed-up flows.
Design and Cost (NWC Work Plan Activity 8)	Assuming that preliminary engineering would commence in July 2008, environmental review and permitting completed by December 2010, detailed engineering completed by 2012 and that construction would be completed by August 2014 the costs for constructing a CWRF are estimated in 2008 to be in the order of $184M to $197M. Costs of constructing a 20MW hydroelectric generating station are "ball parked" at $46M to $55M and the costs of constructing a Transmission line are estimated to be $10M. Owners costs, environmental assessment and other project costs such as the cost of commissioning flows and construction of a Cheslatta Fan channel are not included in the above noted costs. All CWRF cost estimates to-date are based on conceptual level engineering developed in 2001. Investigation and further engineering are required to establish that the concept is technically feasible and that the facility will perform as required by the design criteria before an accurate cost estimate can be completed. Issues concerning constructability and construction methodology particularly with regard to the deep water pipelines have also been identified.	▪ Feasibility engineering is necessary to refine a CWRF design. ▪ A contract approach and construction schedule should be outlined and a detailed cost estimate completed by a team of experienced engineers and estimators.

Photo: Cheslatta River

4 NWC WORK PLAN

The NWC Work Plan tracking record (Figure 4–1) provides a summary of the key activities completed, undertaken and planned thus far. Activities completed as of April 2008 are marked in red, while those currently underway are marked in orange, and those planned but not initiated are in green.

Figure 4–1: NWC Work Plan Tracking Record

	STATUS	ACTIVITY
Year One 2002 $100K - Province $100K - Alcan	Completed	Establish Implementation Process - NES
	Completed	Fund NWC for related discussions
	Completed	Information & Communication Program
	Completed	Compile Background Information
	Completed	Assess Public Intestest re: "Flows"
	Completed	Cheslatta Fan Study
	Completed	Nechako Canyon Debris Study
Year Two 2003 $100K - Province $100K - Alcan	Completed	Fund NWC for related discussions
	Completed	Fish Entrainment at CWRF
	Completed	Release Water Temperature Studies
	Completed	Total Gas Pressure Study
Year Three 2004 $100K - Province $100K - Alcan	Completed	Fund NWC for related discussions
	Completed	Summary Report on Flow Discussion
	Completed	Reservoir Hydrothermal preliminary study
	Completed	Sedimentation Requirements - follow up to EDI study (TOR)
	Completed	Contract a Technical Advisor
Year Four 2005 $100K - Province $100K - Alcan	Completed	Fund NWC for related discussions
	Completed	Contract a Technical Advisor
	Completed	Murray Cheslatta System Literature Review
	Completed	Reservoir Hydrothermal Study - Year 1
	Completed	Total Gas Pressure Technical Workshop
	Completed	Cheslatta Fan Sedimentation Technical Workshop
	Completed	Benefits Assessment
	Completed	Murray Cheslatta Habitat Assessment Report
Year Five 2006 $120K - Province $120K - Alcan	Completed	Fund NWC for related discussions
	Completed	Contract with Technical Advisor
	Completed	Murray-Cheslatta Rehabilitation Technical Workshop
	Completed	Temperature Workshop with DFO
	Completed	Reservoir Hydrothermal Study - Year 2
	Completed	Cheslatta Fan Sediment Studies
	Completed	Summary Report of Technical Workshops
Year Six 2007 $120K - Province $120K - Alcan	Completed	Second Temperature Workshop with DFO
	Completed	Fund NWC for related discussions
	Completed	Contract with Technical Advisor
	Underway	Cheslatta Fan Sediment Study
	Completed	Viability of Pilot Channel
	Completed	Cheslatta Lake Core Sampling
	on hold	Assessment of Rehabilitation Options for Murray-Cheslatta System
	on hold	Meet with Cheslatta First Nation re Murray-Cheslatta Rehabilitation Options
	on hold	Murray-Cheslatta Rehabilitation Options Workshop
	Underway	Additional Temperature/Flows work with DFO
	on hold	Total Gas Pressure validation
	Completed	Costing CWRF
	Completed	Interim Evaluation of CWRF Option
	on hold	Multiple Accounts Analysis for basin
	Underway	Temperature/Flow scenarios and risk assessment for Nechako R.
Year Seven 2008 $100K - Province $100K-Alcan	Planned	Cheslatta Fan - Preliminary Engineering
	Planned	Murray Cheslatta Stakeholder Engagement
	Planned	Rehabilitation Opportunities - Murray Cheslatta
	Planned	First Nation Engagement/Workshop - Murray Cheslatta
	Planned	Temperature/Flows - Nechako River
	Planned	TGP Validation
	Planned	Technical Manager (Reports, Meetings,Workshops,EA Strategy)
FUTURE YEARS (NOTE: Budget estimates in this section are in 2001$)	Planned	CWRF - Preliminary Engineering ($1.25M & 15 mo.)
	Planned	Environmental Review & Permitting ($1.64M & 12 - 15 mo.)
	Planned	Cheslatta Fan - Detailed Engineering & Construction ($780K & 12 mo)
	Planned	CWRF - Detailed Engineering & Tendering ($3.6M & 21 mo)
	Planned	CWRF - Facility Construction ($92.1M & 29 mo)
	Planned	CWRF - Commissioning ($500K & 3 mo.)
	Planned	Adaptive Management of Operations & Monitoring ($1.75M/yr)

NWC WORKPLAN PHASES

LEGEND
- Red: Activities Completed
- Yellow: Activities Underway
- Green: Activities Planned

PHASE 1 - Planning - (Year One 2002 to Murray Cheslatta System Literature Review, 2005)

PHASE 2 - Pre-Engineering & Environmental Review - (Year Two 2003 to Environmental Review & Permitting)

PHASE 3 - Implementation - (Cheslatta Fan - Detailed Engineering & Construction to Adaptive Management of Operations & Monitoring)

Total Budget to end Yr. 6:
$640K - Province
$640K - Alcan

Photo: Skins Lake Spillway
Photo provided by Alcan.

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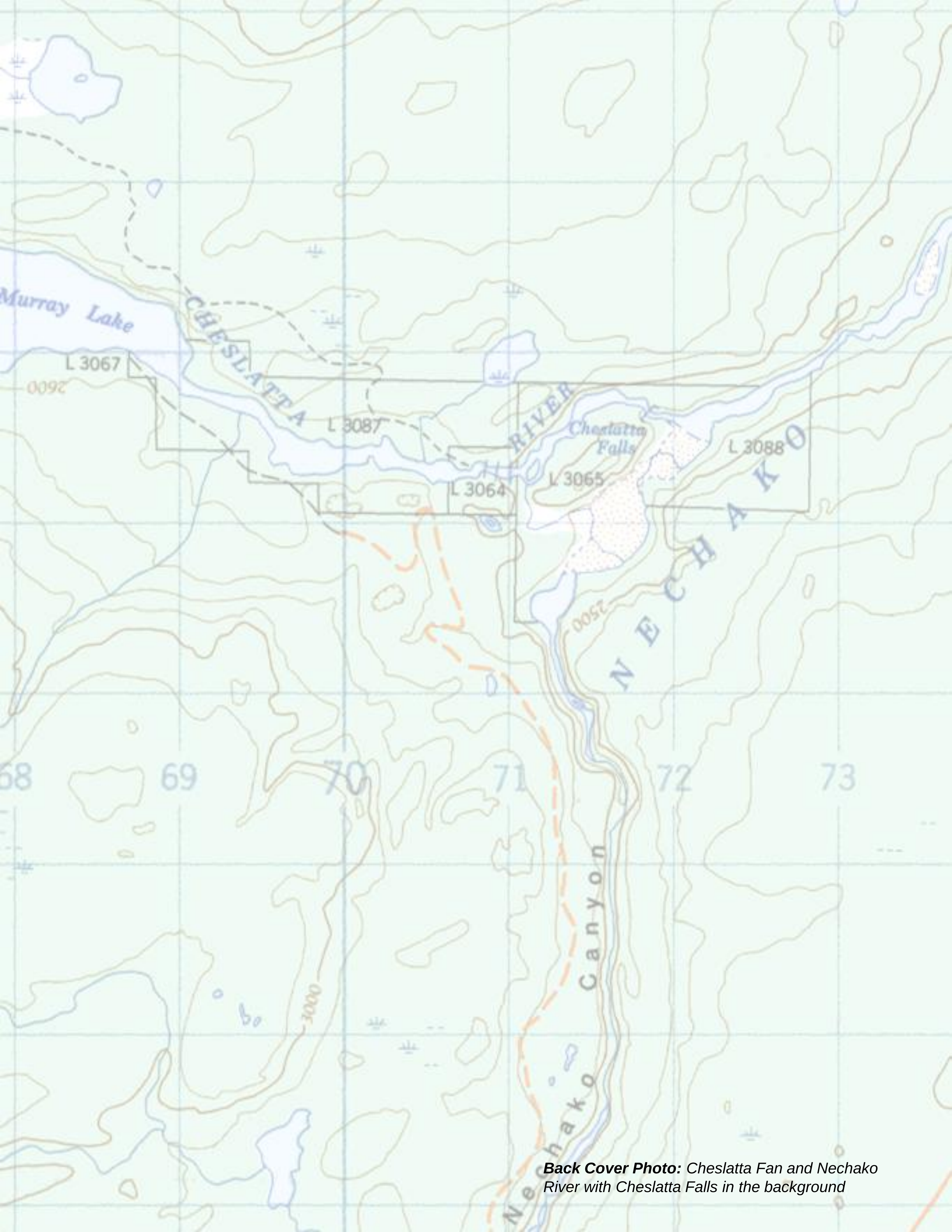

Back Cover Photo: *Cheslatta Fan and Nechako River with Cheslatta Falls in the background*