NECHAKO WATERSHED COUNCIL REPORT: ASSESSMENT OF POTENTIAL FLOW REGIMES FOR THE NECHAKO WATERSHED

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Disclaimer:

This internal discussion paper was commissioned to assist the Nechako Watershed Council with the process of developing consensus recommendations on flow regimes for the Nechako Watershed downstream of the Kenney Dam, assuming that a Cold Water Release Facility is constructed at Kenney Dam.

Any views or opinions expressed in this draft are those of the author and do not necessarily reflect those of the members of the Nechako Watershed Council (NWC) or the Nechako Enhancement Society (NES), until the final draft has been signed off by all NWC.

Date: January 24, 2005

Executive Summary

This report summarizes the Nechako Watershed Council's (NWC) work, analyses, and consensus-based recommendations completed to date related to proposed flow regimes for the Nechako Watershed downstream of Kenney Dam if funds are contributed to the Nechako Environmental Enhancement Fund (NEEF) and the decision of the NEEF Management Committee to use the funds for the constructions of a cold-water release facility (CWRF) at Kenney Dam is implemented.

This report is a "working" or "living" document, recognizing that the NWC is still in the midst of a consensus-based decision-making process to develop recommendations on a preferred flow regime. This document is intended to support that work by summarizing and presenting key information that has been generated and collected to date to support the NWC's efforts to develop and evaluate possible flow regimes. This report will serve as a building block for the NWC's further work on designing optimal flow regimes for the Nechako Watershed downstream of the Kenney Dam if funds are contributed to the Nechako Environmental Enhancement Fund and the decision of the NEEF Management Committee to use the funds for the constructions of a cold-water release facility (CWRF) at Kenney Dam is implemented.

The Nechako Watershed

The Nechako River system is a valuable and important drainage in north-central British Columbia due to its ecological attributes, and because of the benefits the system provides to human population as a source of food, commerce and recreation. The system supports white sturgeon, ocean and Fraser River commercial fisheries, in-river First Nations' subsistence fisheries, and recreational fisheries. The Nechako River also provides water for agricultural purposes, generates power, hosts various outdoor recreationalists (canoeists, river boats, etc.) and has played an important role in the history and development of this part of the province.

The impoundment of water into the Nechako Reservoir and the resultant spillway releases have altered the hydrology of the Nechako River system since 1952 (when Alcan's Kenney Dam was completed). Water from the Nechako Reservoir is released downstream in two ways:

- water released to the Nechako River (both for fisheries conservation/protection and to spill excess reservoir inflows) exits on the eastern end of the reservoir, through the Skins Lake Spillway, passing through the Cheslatta River, Cheslatta Lake, and Murray Lake and entering the Nechako River at Cheslatta Falls,
- water released for power generation exits westward through the Tahtsa system into an underground tunnel to the Kemano powerhouse then into the Kemano River which meets up with the Pacific Ocean downstream.

There is currently no water release facility at Kenney Dam. As a result, the only flow in the Nechako Canyon (the nine-kilometer reach of the Nechako River between Kenney Dam and Cheslatta Falls) is from local natural inflow.

Benefit of a Proposed Cold Water Release Facility

Current priorities for the management of water releases from the Nechako Reservoir include: 1) dam safety, 2) flood management, 3) fisheries conservation and protection, and 4) power generation at Kemano. The proposed cold water release facility (CWRF) would provide benefits by:

- Creating the ability to release water from the Kenney Dam (instead of only from the Skins Lake Spillway).
- reducing the volume of water releases required to achieve the cooling of summer water temperatures for fisheries downstream, thereby "freeing up" flows.

The availability of these "freed up flows", combined with the ability to release flows from Kenney Dam, would provide the opportunity to consider both:

- Addressing ***new*** interests and initiatives, such as ecological restoration of the Murray-Cheslatta System and the Nechako Canyon, power generation at Kenney Dam; and
- Enhancing conditions for other ***existing*** interests, including agricultural water use, water quality, water-based transportation (float planes), improved flexibility of reservoir operations and recreation, among others.

The extent of the benefits derived for these interests will depend on the design of post-CWRF flow regime. The NWC is committed to developing an optimal post-CWRF flow regime that maximizes and balances the potential social, environmental and economic benefits of the operation of the proposed CWRF at Kenney Dam.

Summary of NWC Work on Issues & Studies

To date, the NWC has:

- Identified and become informed about 24 key issues and interests throughout the watershed and along the river, focusing on flow related issues
- Translated some of these interests into specific flow targets (i.e., flow volumes required to meet these interests throughout the year)
- Reviewed numerous studies and reports in the process of completing the tasks above.

The NWC has not yet determined how to address flow objectives, particularly if all interests cannot be accommodated.

Summary of NWC Work on Modeling Flow Scenarios

To date, the NWC has developed three different flow modeling tools: the initial NWC Flow Model, the Nechako Downstream Allocation Model (N-DAM), and the Nechako Reservoir Operation Model. The models have become progressively more sophisticated in their ability to incorporate the real life complexities of the Nechako Watershed flow management.

Each of these modeling tools have helped the NWC develop a better understanding of possible downstream flow allocation options, the impact of those flow allocation options on NWC interests, and the impact of the variability of reservoir inflows on the ability to meet desired downstream flow targets. Based on the results of modeling simulations completed to date, the NWC concluded that all freed up flow sharing scenarios (whether they are based on fixed or variable flow sharing formula) provide positive benefits to NWC stakeholders over the current flow regime.

The NWC has not yet decided whether to focus the design of an optimal post-CWRF flow regime on a fixed sharing or variable sharing formula. Whichever it chooses, further work will still be required to refine specific flow regime, simulate the projected consequences of that flow regime for all affected interests, and communicate an understanding of the rationale for recommending the preferred flow regime to the public at large.

Assessing the Benefits & Impacts of CWRF & Possible Flow Regimes

While the NWC agrees (and also believes that there is broad stakeholder agreement) that constructing a Cold Water Release Facility (CWRF) at Kenney Dam is the best option for meeting the region's needs and objectives, a full assessment of its expected benefits and impacts has not yet been made by the parties engaged in its implementation. Part of the reason for this is that an optimal flow regime has not yet been developed and recommended by the NWC. Here is a summary of the NWC's progress on benefits assessment to date.

- The NWC commissioned a review of different evaluation methods and assessment frameworks available.
- Based on these recommendations, the Nechako Enhancement Society (NES) commissioned a report detailing a proposed Multiple Accounts Analysis (MAA) framework to identify and evaluate the benefits from the proposed Cold Water Release Facility.
- The NWC has chosen the Multiple Accounts Analysis framework as its preferred method for evaluating the potential benefits of constructing a CWRF.
- In order to compare the benefits of a variety of post-CWRF flow regimes (vs. the benefits of the CWRF project as a whole), the NWC has explored the use of some evaluation tests conducted during the Nechako Downstream Allocation Model (N-DAM) simulations.

Further work is required by the NWC to clarify which combination of assessment frameworks/models and assessment indicators it will use to assist with the development and selection of an optimal post-CWRF flow regime.

Developing a Preferred Post-CWRF Flow Regime: Areas of Agreement, Unresolved Issues & Information Gaps

The NWC is working towards reaching consensus on the reallocation of flows that would be freed up if a CWRF were constructed at Kenney Dam, including developing recommendations in two key areas. A summary of the NWC's progress in each area is outlined below:

- ***Distribution of releases from Skins Lake Spillway and from a CWRF at Kenney Dam***. As a starting point, the NWC began by developing a set of draft flow regime principles. These are still under discussion, and the NWC continues to build consensus on the final content and wording of these principles. Two other emerging areas of agreement are: 1) the NWC's general comfort with – and confidence in – the approach and methodologies of the Nechako Downstream Allocation Model (N-DAM) and the Nechako Reservoir Operations Model, and 2) the desire to try to achieve the monthly flow targets established to address the NWC's issues (modified by more recent learning about the impact of annual variability of reservoir inflows) when designing an optimal post-CWRF flow regime. To date, the NWC has not yet tested support for specific post-CWRF flow regimes. The NWC has, however, identified a number of remaining unresolved issues and data gaps to be addressed to aid in the development of feasible flow regimes. Many of these are being addressed by studies that are currently being coordinated and managed by the Nechako Enhancement Society.
- ***Mechanisms under which those releases could be implemented and managed***. To date, the NWC has focused primarily on developing an optimal post-CWRF flow regime, and less on the mechanisms for implementing and managing those flows. Since little

discussion of this topic has occurred, no specific areas of agreement have yet emerged.

Possible next steps for moving forward with consensus-building in these two areas include: 1) reaching agreement on the draft Flow Principles, 2) addressing unresolved issues and filling data gaps, 3) developing a small range of flow scenarios proposing how water gets allocated downstream under average, below average and above average reservoir inflow conditions, and 4) testing agreement on that range of flow scenarios with the full NWC membership.

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1 Introduction

This report summarizes the Nechako Watershed Council's (NWC) work, analyses, and discussions completed to date related to proposed future flow regimes for the Nechako Watershed downstream of Kenney Dam if funds are contributed to the Nechako Environmental Enhancement Fund and the decision of the NEEF Management Committee to use the funds for the constructions of a cold-water release facility (CWRF) at Kenney Dam is implemented.

This report is a "working" or "living" document, recognizing that the NWC is still in the midst of a consensus-based decision-making process to develop recommendations on a preferred downstream flow regime. This document is intended to support that work by summarizing and presenting key relevant information that has been generated and collected to date, including:

- hydrological and other technical information (Chapters 2)
- identified issues and interests (Chapter 3)
- possible flow options and the results of the modeling that has been conducted to simulate these options (Chapter 4)
- assessment frameworks and indicators developed to evaluate possible flow options (Chapter 5)
- current areas of agreement, areas of disagreement, unresolved issues and remaining data gaps (Chapter 6).

This report will serve as a building block for the NWC's further work on an optimal post-CWRF flow regime.

The remainder of this chapter provides a brief overview of the relationship between the key organizations and programs involved in the effort to design post-CWRF flow regimes for the Nechako River downstream of Kenney Dam. The final portion of this chapter also briefly outlines: 1) the rationale for constructing a Cold Water Release Facility (CWRF) at Kenney Dam, 2) the NWC's CWRF work plan, and 3) how this report fits into that work plan.

1.1 Key Players & Programs in the Nechako Watershed

In 1996, the former Fraser Basin Management Board (now the Fraser Basin Council) initiated a collaborative process which led to the creation of the Nechako Watershed Council. Formed in June 1998, the Nechako Watershed Council's (NWC) purpose is to "enhance the long-term health and viability of the Nechako Watershed with consideration for all interests, and to provide a forum to address water management and related issues in the Watershed and to work toward cooperative resolution of these issues"[1]. The NWC consists of 25 groups, including Alcan, communities, businesses, First Nations, non-governmental organizations and government representatives[2]. All decisions by the Council are made by consensus. In the 1997 legal agreement between Alcan and the British Columbia government, the Nechako Environmental Enhancement Fund Management Committee (NEEFMC) commits to consulting

[1] Nechako Watershed Council (NWC). 1998. *Nechako Watershed Council Terms of Reference*. Available on the NWC website at: http://nechakowatershedcouncil.com/termsof.htm

[2] For a list of the NWC's current membership, visit their website at: http://nechakowatershedcouncil.com/Participants.htm

with the Nechako Watershed Council on the options available for downstream enhancement of the Nechako watershed area, including the uses and priorities of the NEEF[3].

A second umbrella organization of public interest and First Nations organizations, the Nechako River Alliance (NRA), was also formed in 1998 by groups and individuals who chose not to participate in the NWC.

The NWC is currently working to reach a consensus on the reallocation and management of flows that would be "freed up" by the construction and operation of a proposed cold water release facility (CWRF) at Kenney Dam, including: 1) flow releases from Skins Lake Spillway, 2) flow releases from the proposed CWRF, and 3) the mechanisms under which those releases are implemented and managed.

Aside from the NWC, there are also a number of other multi-agency and/or multi-stakeholder organizations and programs that play a key role in influencing decisions about water management in the Nechako Watershed. Here is a brief overview of their respective mandates and their involvement in designing post-CWRF flow regimes.

- **Nechako Fisheries Conservation Program (NFCP)** – In 1987, the provincial and federal governments and Alcan signed a Settlement Agreement[4] designed to ensure that Nechako River Chinook and sockeye populations are conserved. The NFCP was created under that agreement and assigned responsibility for managing the delivery of Nechako Reservoir fisheries flows to the Nechako River, and to carry out a program of temperature control and Chinook research and monitoring. Its membership includes representatives of Alcan, the federal department of Fisheries and Oceans Canada (DFO), and the BC Ministry of Water, Land and Air Protection (MWLAP)[5].
- **Nechako Environmental Enhancement Fund (NEEF) and Management Committee (NEEFMC)** - The Nechako Environmental Enhancement Fund (NEEF) was set up as a result of a 1997 Agreement between Alcan and the British Columbia government. This agreement addressed outstanding legal matters arising from rejection of the Kemano Completion Project by the Government of British Columbia. In the agreement, Alcan commits to providing up to $50 million CDN in matching funds for activities and projects aimed at enhancing the watershed with a credit of up to $10 million for studies and reports that can be used to design and construct the CWRF.[6] The agreement established the NEEF Management Committee (NEEFMC) with a mandate to review, assess and report on options that may be available for the downstream enhancement of the Nechako watershed area. The NEEFMC consists of representatives of the BC provincial government, Alcan, and the federal government (or an independent party in the event that the federal government chooses not to participate).
- **Nechako Enhancement Society (NES)** - The Nechako Enhancement Society was established in 2002 to administer, support and fund the planning of a cold water release facility at Kenney Dam.[7] This involves coordinating and overseeing the implementation the NWC's *"Proposed Work Plan for the Cold Water Release Facility at Kenney Dam"*. The membership of the Nechako Enhancement Society includes

[3] Province of British Columbia & Alcan Aluminum Ltd.; *BC/Alcan 1997 Agreement*; August 5, 1997. See Sections 11 and 14.

[4] Province of British Columbia, Government of Canada and Alcan Aluminum Ltd.; 1987 Settlement Agreement.

[5] Formerly the BC Ministry of Environment, Lands and Parks (MELP).

[6] Province of British Columbia and Alcan Aluminum Ltd.. 1997. *BC/Alcan 1997 Agreement.* August 5, 1997. Section 15.

[7] Nechako Enhancement Society. 2002. Constitution (Form 3).

equal representation from the provincial government of British Columbia and Alcan. The Nechako Watershed Council acts as an advisory body to the NES.

- **Nechako River White Sturgeon Recovery Initiative** – White sturgeon have been in decline in British Columbia for a number of years, especially those in the Nechako, Kootenay, and Columbia River systems. In the early 1990's, their populations were considered "vulnerable" and as a protective measure, in 1994, all recreational harvest of sturgeon was halted in BC. By 1998, white sturgeon were considered in danger of possible extinction if the reasons for the population decline are not addressed. In 2000, the provincial government initiated a recovery planning process (the Nechako River White Sturgeon Recovery Initiative) designed to ensure technical soundness and meaningful participation of the public. Participation in the planning process involves a co-operative effort among provincial and federal government agencies, First Nations, industry and other stakeholders[8].

1.2 Proposed Cold Water Release Facility (CWRF) at Kenney Dam

The name given to the CWRF reflects its ability to release relatively cold water during the summer, thereby providing the capability to control downstream water temperatures. The capacity to draw water from two levels in the reservoir, either separately or simultaneously, would enable the facility to release water downstream at different temperatures, depending on the season and the specific objectives. Such a facility would be expected to provide a number of social, environmental and economic benefits.

The concept of constructing a cold water release facility at Kenney Dam is not a new one: the idea has been contemplated for decades and was explored in detail during the design of the proposal for the Kemano Completion Project (which did not proceed). While neither the NWC nor the Nechako Environmental Enhancement Fund Management Committee (NEEFMC) were the originators of the idea, both came to the conclusion that it offered a possible solution to a number of the issues identified by stakeholders in the Nechako Watershed.

Between 1999 and 2001, the Nechako Environmental Enhancement Fund Management Committee (NEEFMC) engaged a broad range of interests in a consultative process by opening up a dialogue to identify, explore and evaluate a range of options for the downstream enhancement of the Nechako Watershed area[9]. Members of the NWC participated in this process. The result of this consultation was a strong indication that downstream enhancement can occur with the establishment of a more natural flow regime which would provide a broad range of opportunities to address various interests downstream of the Kenney Dam. A water release facility at Kenney Dam was believed to be able to facilitate a more natural flow regime and thus was identified as the preferred option for downstream enhancement of the Nechako River watershed area because it also had potential to address the broadest range of interests. Evaluation of various types of water release facilities led the NEEFMC to conclude that a cold water release facility (CWRF) would yield the greatest benefits.

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[8] For more information, see the website for the BC Ministry of Water, Land and Air Protection at: http://wlapwww.gov.bc.ca/nor/fish/sturgeon/

[9] Praxis Pacific. 1999. NEEF Multi-Interest Involvement Process: October 1999 Workshop Report. Prepared for: Nechako Environmental Enhancement Fund Management Committee. Prepared by: Praxis Pacific, Vancouver, BC. December 7, 1999.

Praxis Pacific. 2000. April 2000 Public Meeting Report. Prepared for: Nechako Environmental Enhancement Fund Management Committee. Prepared by: Praxis Pacific, Vancouver, BC. May 23, 2000.

In addition to a water release facility, other options for downstream enhancement were suggested. For example: 1) in-stream works to improve fish habitat and spawning beds, 2) creation of a long-term fund to support conservation and stewardship activities, 3) improved cattle fencing, 4) a fish hatchery, and 5) vegetation work to improve habitat for birds. It was suggested that *these options could be carried out in addition to – but not instead of -* the construction of a water release facility, and that a water release facility would make these options possible or more effective. *No single option was suggested as an alternative to a water release facility.*

Based on these findings and the related technical analyses commissioned in support of their work, the NEEFMC developed a series of decisions and recommendations[10] regarding: 1) the construction of a Cold Water Release Facility at Kenney Dam, 2) the rehabilitation of the Murray-Cheslatta system, and 3) the management structure and implementation measures required to follow through on the other two recommendations (above). For a complete summary of these decisions and recommendations, see the report in Appendix A.

1.3 NWC Cold Water Release Facility (CWRF) Work Plan

In August 2001, a delegation from the NWC met with provincial ministers, Members of the Legislative Assembly and senior provincial staff, to commend the NEEFMC's decision to build a Cold Water Release Facility (CWRF) at Kenney Dam, and offer support and assistance to implement that decision. One outcome of these meetings was a request that the NWC prepare a work plan outlining the activities and costs required for construction of the CWRF. The resulting work plan[11] was prepared cooperatively by the NWC, the Province of British Columbia, Alcan and by the Fraser Basin Council acting on behalf of the NEEFMC. It describes 14 activities in 3 phases over an 11-year period necessary for the construction and operation of a CWRF at Kenney Dam (see Table 1-1 for a summary).

The work plan is designed to provide guidance and direction for government, Alcan, and regional, provincial and national organizations to work together to make a CWRF a reality. The NWC CWRF Work Plan is a flexible planning tool that uses the best information and knowledge available at the present time. As new information becomes available the work plan will be re-assessed and revised as required, but it is generally anticipated that the final completion date of 2012 will not be extended, and possibly shortened.

To date, Activities 1, 3 and 4 of Phase 1 of the NWC CWRF Work Plan have been completed (see Table 1-1). Some of the tasks outlined under Activities 2 and 6 of Phase 1 are still underway. One of the NWC's key deliverables under this activity is to provide advice and input on the development of the optimal post-CWRF flow regime. This report is a key step towards completing that task.

[10] Nechako Environmental Enhancement Fund Management Committee (NEEFMC). 2001. Report of the Nechako Environmental Enhancement Fund Management Committee. June 7, 2001.

[11] Nechako Watershed Council (NWC). 2002. *Nechako Watershed Council Proposed Work Plan for the Cold Water Release Facility at Kenney Dam.* Submitted to: The Honourable Rick Thorpe, Minister of Competition, Science and Enterprise. Prepared by: the Nechako Watershed Council. In Regard to: the June 2001 Report of the Nechako Environmental Enhancement Fund Management Committee. First Draft: February 2002. Revised: March 2002.

Table 1-1: Overview of Nechako Watershed Council Cold Water Release Facility (CWRF) Work Plan[12]

	Activity	*Time Frame*	*Parties Involved*
PHASE 1: PLANNING	1. Establish Management System	2002	Government of BC, Alcan, NWC (as advisor); other parties as needed
	2. NEEFMC Deliverables	Varied	Governments of BC & Canada, Alcan, Nechako Watershed Council, Nechako Fisheries Conservation Program, Fraser Basin Council, others as needed
	3. Information & Communication Program	2002-2004	Government of BC, Alcan, Nechako Watershed Council and possibly Government of Canada
	4. Compilation of Background Information	2002	Consultant, with support of Governments of BC & Canada, and Alcan
	5. Assessment of Benefits	2002-2004	Governments of BC & Canada, Alcan, Nechako Watershed Council, consultant, and community stakeholders
PHASE 2: PRE-ENGINEERING & ENVIRONMENTAL REVIEW	6. Pre-Engineering & Environmental Review	2002-2006	Technical consultants under the direction of Alcan and the Governments of BC & Canada
	7. Preliminary Engineering: Pilot Channel at Cheslatta Fan	2006-2007	CWRF consortium of engineers & environmental consultants; government agencies
	8. Preliminary Engineering: Cold Water Release Facility (CWRF)	2006-2007	CWRF consortium of engineers
	9. Environmental Review & Permitting	2007-2008	Proponent (Alcan & ?), BC Environmental Assessment Office, federal and provincial government agencies, Nechako Watershed Council
PHASE 3: IMPLMENTATION	10. Detailed Engineering & Construction: Pilot Channel at Cheslatta Fan	2008-2009	CWRF engineer(s) & environmental consultant(s); contractor; government agencies
	11. Detailed Engineering: Cold Water Release Facility	2008-2010	CWRF engineer(s) & environmental consultant(s)
	12. Cold Water Release Facility Construction	2010-2012	CWRF engineer(s) & environmental consultants; contractor; independent environmental monitor
	13. Cold Water Release Facility Commissioning	2012	CWRF engineer(s) & environmental consultants; CWRF consortium; contractor(s); government agencies; independent environmental monitor
	14. Adaptive Management of Operations	2012 and ongoing	Nechako Fisheries Conservation Program (with expanded mandate); Nechako Watershed Council

[12] Source: see previous footnote.

2 The Nechako Watershed: Hydrology & Hydroelectric Development

This chapter provides a brief overview of the Nechako Watershed, including its geography, its hydrology as well as its hydroelectric development and current management. This includes a description of current and proposed hydroelectric facilities and structures in the area (such as Alcan's existing facilities and the proposed Cold Water Release Facility at Kenney Dam).

2.1 Location of the Nechako Watershed

The Nechako Watershed, 600 kilometers north of Vancouver, is a vast river and lake system draining 14,000 square kilometers of north-central British Columbia (see Figure 2-1).

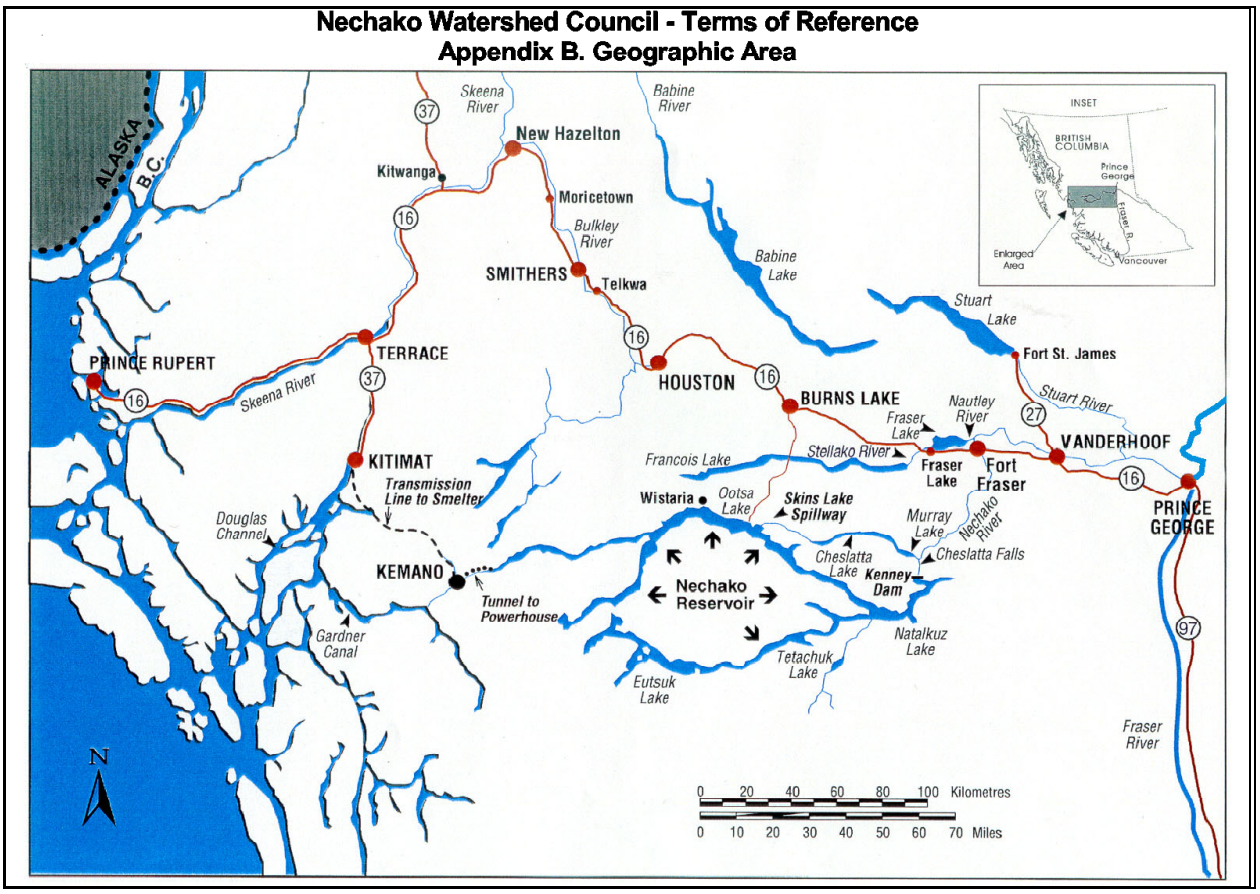

Figure 2-1: Map showing the catchment area and main stem of the Nechako River and its key tributaries[13].

The Nechako River System is a valuable and important drainage in north-central British Columbia due to its ecological attributes, and because of the social, environmental and economic benefits it provides. The system supports white sturgeon, ocean and Fraser River commercial fisheries, in-river First Nations subsistence fisheries, and recreational fisheries.

[13] Source: Nechako Watershed Council. 1998. *Terms of Reference*. Appendix B.

The Nechako River provides water for agricultural purposes, generates power, hosts various outdoor recreationalists (canoeists, river boats, etc.) and has played an important role in the history and development of this part of the province.[14]

2.2 Hydrology of the Nechako Watershed above Kenney Dam

The Nechako River is one of the largest tributaries to the Fraser River; the Fraser drains 25% of the total land area in BC. Table 2-1 summarizes some quick facts about the hydrology of the Nechako Watershed above Kenney Dam (i.e., the Nechako Reservoir and its catchment or drainage area)[15].

Table 2-1: Summary of Quick Facts about Hydrology of Nechako Reservoir

Item	*Quick Fact / Description*
Diversions	Approximately 2/3 of the inflows entering the Nechako Reservoir are diverted westward into the Kemano River for hydroelectric generation
Size of Nechako Reservoir (upstream of Kenney Dam)	A major dam in the Nechako Canyon and nine saddle dams created the reservoir. The reservoir includes Knewstubb, Natlkuz, Tetachuck, Ootsa, Whitesail and Tahtsa lakes, and Tahtsa and Intata reaches. When the reservoir is full, the water surface area is about 910 square kilometers (km^2). The length, from Tahtsa intake to the Kenney dam is 181 kilometers (km).
Other facts about the Nechako Reservoir	Maximum operational elevation = 2,800 feet above sea level Highest historical elevation = 2,800.87 feet in July 1972 Minimum operational elevation = 2,787 feet Lowest historical elevation = drawn down to 2,787.24 feet in early May of 1986 Total volume of water stored in the Nechako Reservoir = 842 billion cubic feet Live storage = 145 billion cubic feet or 17% of total water storage (live storage is all the water which can be used for generation and lies between 2,784 and 2,800 feet)
Inflow to Nechako Reservoir since 1952	Average inflow = 195-197 cubic meters per second (m^3/s) (depending on the range of years used to calculate the long-term average) Minimum inflow = 127 m^3/s in 1970 Maximum inflow = 344 m^3/s in 1976

2.2.1 Annual Inflow to the Nechako Reservoir[16]

Inflows for the Nechako Reservoir basin upstream of Kenney Dam have been recorded since January 1951. Inflows are calculated by adding the amount of water released through the Kemano powerhouse, the amount of water released through Skins Lake Spillway, and the change in the amount of water stored in the reservoir, as indicated by the change in the reservoir levels.

Inflow to the reservoir comes mainly from the melting winter snow pack during the spring/summer freshet with the largest monthly inflows typically occurring in May, June, and July. Snowmelt runoff can be increased by spring and summer rainfall, and the runoff from the eastern portion of the basin tends to peak somewhat earlier than runoff from the western

[14] Nechako White Sturgeon Recovery Initiative. 2004. Recovery Plan for Nechako White Sturgeon. Prepared by Golder Associates Ltd. Excerpt from page 13.

[15] Based on information on pages 13 to 17 of the report referenced in the previous footnote (immediately above).

[16] The information in this section is excerpted from the following report. Alcan Inc. 2002. *Tahtsa Narrows Scoping Report.* Section 4.1.1.

portion. In most years, the rainfall contribution to the volume of the annual inflow is less than snowmelt.

As Figure 2-2 shows, inflows can vary substantially from year to year. It also shows a prolonged succession of generally high inflow years, followed by a prolonged succession of generally low inflow years.

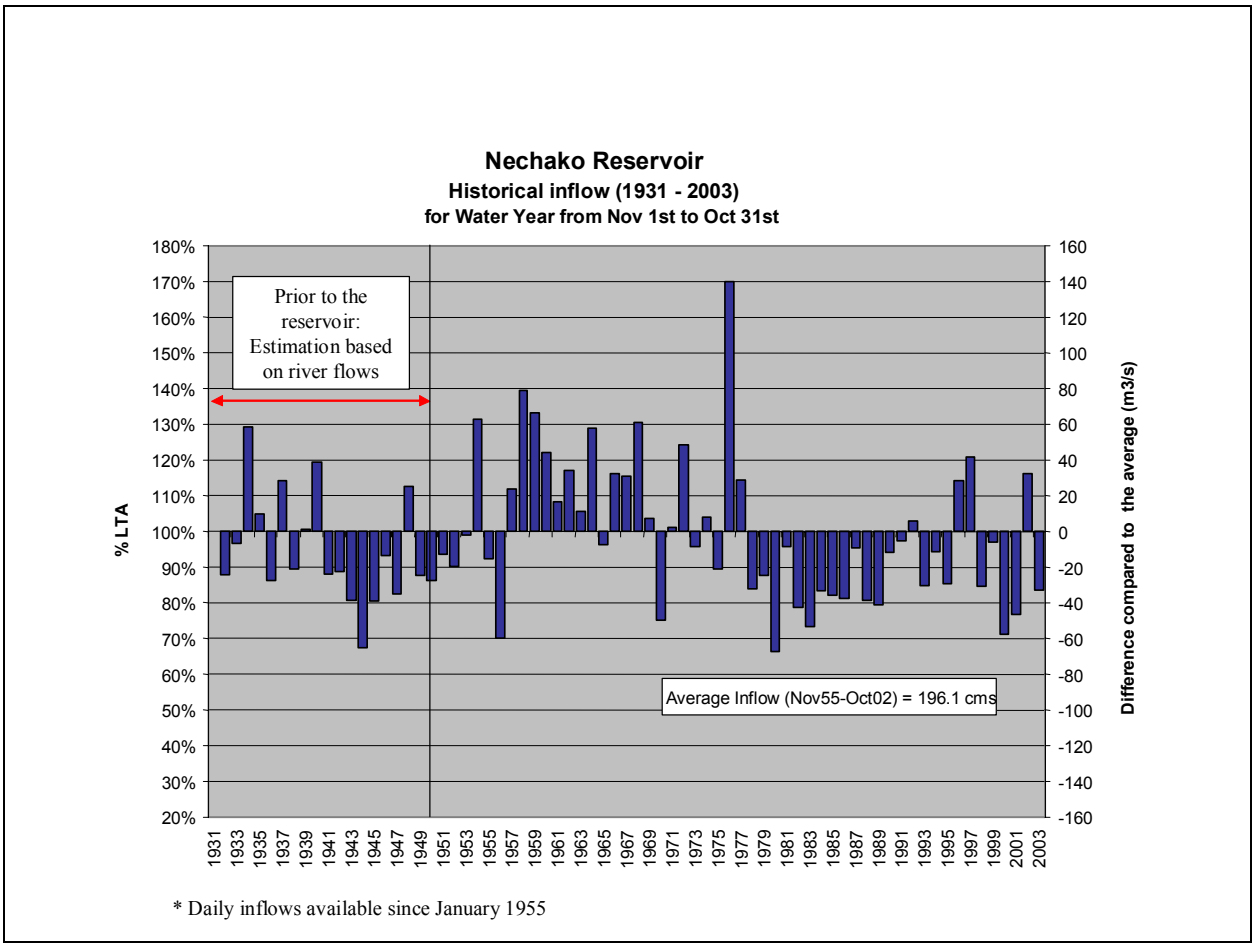

Figure 2-2: Summary of annual inflow volumes to the Nechako Reservoir for the period from 1931-2003, expressed as a percentage of long term average (LTA) inflow and also as the volumetric difference compared to LTA in cubic meters per second (m^3/s)[17].

2.2.2 Key Components of Alcan's Kemano Hydroelectric Project

Kemano is an excellent location for power generation because of its favorable geography: Kemano is approximately 15 times as high as Niagara Falls. There are only about two dozen hydro sites in the world with higher "head" (i.e., potential power), making Kemano one of the most efficient hydro generating stations in the world, producing about 6 megawatts (MW)

[17] Source: Alcan Inc. 2003.

of energy with every cubic meter per second (m^3/s) that is released from the Nechako Reservoir into the power generation facility[18].

Here is a brief overview of the key physical components of Alcan's Kitimat-Kemano project[19]:

- ***Kenney Dam***: This is one of the largest clay-core, rock-filled dams in the world. Located in the Nechako Canyon, it is approximately 93 meters (305 feet) high. Together with a small number of saddle dams, the Kenney Dam created the Nechako Reservoir. There is currently no water release facility at the dam.
- ***Skins Lake Spillway***: This is a grated, concrete control structure located about 80 kilometers (50 miles) west of Kenney dam on Ootsa Lake. All Nechako Reservoir releases in excess of power requirement as well as required fish releases are made at the Skins Lake Spillway (SLS) and routed through the Cheslatta River system to re-enter the Nechako River at Cheslatta Falls.
- ***Power Tunnel and Penstocks***: This is an arched tunnel, 7.6 meters (25 feet) wide and about 16 kilometers (10 miles) long, from Tahtsa Lake through Mt. DuBose to Kemano. Two sloping, steel-lined penstocks lead to the western end of the tunnel at an elevation of 792 meters (2,600 feet) into the Kemano powerhouse.
- ***Kemano Powerhouse***: Built inside the base of Mt. DuBose, the Kemano powerhouse contains eight turbine generator units with a total installed capacity of 1,000 megawatts. The water that passes through the generators is discharged into the Kemano River.
- ***Kemano-to-Kitimat Transmission Line***: The transmission line that transports power from Kemano to Kitimat consists of 82 kilometers (51 miles) of single and double 300-kilovolt (kV) circuits. It follows the Kemano River north from Kemano, crosses Kildala Pass to the Kildala River Valley and Kildala Arm, then crosses Green Mountain to Minette Bay and the Kitimat tidal flats to the smelter.
- ***Kitimat Works Aluminum Smelter***: The Kitimat smelter, known as Kitimat Works, has the capacity to produce 277,000 tonnes of aluminum per year. It is one of the 17 smelters in Alcan's global network that are 100% owned by Alcan. Kitimat's annual production represents about 11 per cent of the combined aluminum production capacity from those smelters.[20]

The next section describes the current flow regime in the Nechako River downstream of Kenney Dam.

2.3 Hydrology of Nechako Watershed Downstream of Kenney Dam

The impoundment of water into the Nechako Reservoir and the resultant spillway releases have altered the hydrology of the Nechako River system since 1952 (when the Kemano-Kitimat project was commissioned). Table 2-2 presents some basic facts about the *current* hydrology of the Nechako River downstream of Kenney Dam[21].

[18] Holcak, Peter. 1999. *Hydro-Electric Power Generation: Kemano Power Development.* Presentation to the Nechako Watershed Council. June 25, 1999.

[19] Alcan Inc. 2002. *Tahtsa Narrows Scoping Report.* Excerpted from Section 2.2 of the report.

[20] Alcan Inc.. 2004. *Alcan Facts 2004.* Page 17.

[21] Based on information on pages 13 to 17 of the report referenced in the previous footnote (immediately above).

Table 2-2: Summary of Quick Facts about Hydrology of Nechako River Downstream of Kenney Dam

Item	*Quick Fact / Description*
Length of Nechako River	290 kilometers (km)
Discharge of Nechako River	Average annual discharge of 9 billion cubic meters (m^3)
Drainage area of Nechako Watershed	52,000 square kilometers (km^2)
Area draining into Nechako River	32,000 square kilometers (km^2)
Area draining into Stuart & Nautley Rivers	20,000 square kilometers (km^2)
Largest tributary of the Nechako River	The Nautley River is the largest tributary to the Nechako River upstream of Vanderhoof and has a drainage area of 6,000 square kilometers (km^2)
Lakes	There are numerous large lakes and rivers throughout the basin
Flow regulation structures	There are a number of structures regulating flow of rivers in the Nechako Watershed: Nechako River – The Kenney Dam constructed in the Grand Canyon of the Nechako River in the early 1950's impounded the Nechako Reservoir for the purpose of diverting water to the power generating station at Kemano. Nautley Watershed - unregulated except for two low weirs on the outlets of Fraser and Burns Lakes. Fraser Lake - Alcan built a weir at the outlet of Fraser Lake in the 1950's using large class rock to prevent lake levels from dropping as a consequence of lower water levels in the Nechako River downstream after the construction of Kenney Dam. Burns Lake - A low weir was also built on the Endako River at the outlet of Burns Lake by the City of Burns Lake. The weir is a gravel/cobble deposit; details regarding its height and timing of construction are not known.

2.3.1 How Water is Currently Released from the Nechako Reservoir

Water from the Nechako Reservoir is released through two separate structures[22]:

- ***Power Tunnel***: Water released for power generation exits westward through the Tahtsa system into an underground tunnel to the Kemano powerhouse then into the Kemano River.
- ***Skins Lake Spillway***: Water released for fish conservation/protection or to spill excess reservoir inflow exits eastward through the Skins Lake Spillway (SLS), passing through the Cheslatta River, Cheslatta Lake, and Murray Lake and entering the Nechako River at Cheslatta Falls, nine kilometers downstream of Kenney Dam. Releases from the Skins Lake Spillway have varied since its construction, but have represented approximately one third of the average inflow into the Nechako Reservoir in the last two decades.

There is currently no water release facility at Kenney Dam. As a result, the only flow in the Nechako Canyon (Nechako River between Kenney Dam and Cheslatta Falls) is from local natural inflow. Figure 2-3 illustrates the pattern of flow in the Nechako River and its tributaries downstream of Kenney Dam.

[22] Nechako White Sturgeon Recovery Initiative. 2004. Recovery Plan for Nechako White Sturgeon. Prepared by Golder Associates Ltd. Page 14.

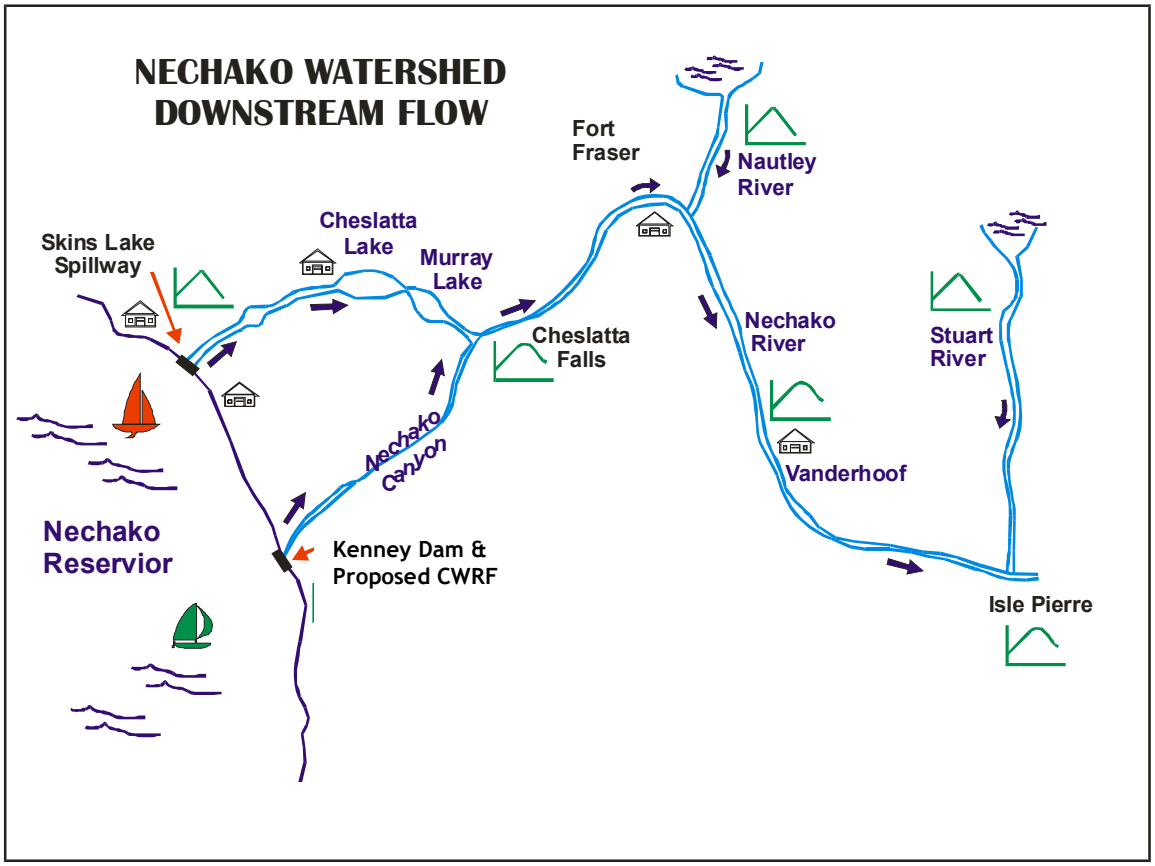

Figure 2-3: Direction of Flow in Nechako Watershed Downstream of Nechako Reservoir[23]. Note that this diagram is not drawn to scale; for example, in reality, the distance from Skins Lake Spillway to the confluence at Cheslatta Falls is much further relative to the length of the Nechako Canyon section.

2.3.2 Description of the Nechako River System Downstream of Kenney Dam

As shown in Figure 2-3, there are three key parts of the Nechako River system downstream of Kenney Dam that are impacted by the impoundment of the Nechako Reservoir: the Nechako Canyon, the Murray-Cheslatta System, and the Nechako River main stem downstream of their confluence at Cheslatta Falls. This section presents a brief overview of the current status of each[24]:

- ***Nechako Canyon*** – Since the construction of Kenney Dam in the early 1950s, the nine kilometers of the Nechako River between Kenney Dam and Cheslatta Falls (which includes the Nechako Canyon), have essentially been de-watered. Water that currently flows down the canyon results from local inflows that peak during the spring freshet or major rain events but are normally much lower in late summer. Over the last 45 years, the lack of major flows through the canyon has allowed both inorganic

[23] Source: Alcan Inc. 2003.

[24] Information for this section is excerpted from the following report. Rescan Environmental Services Ltd. 1999. *Nechako River: Summary of Existing Data*. Prepared for: Nechako Environmental Enhancement Fund. October 1999.

and organic materials to accumulate on the canyon floor and walls. Rainbow trout inhabit the pools remaining in the Canyon. As well, some juvenile Chinook salmon rear in the outflow channel across the Cheslatta Fan, which is located below the canyon and upstream from the confluence with the Murray-Cheslatta system at Cheslatta Falls.

- ***Murray-Cheslatta System*** – All fisheries and surplus flows released from the Nechako Reservoir currently pass through the Skins Lake Spillway into the Murray-Cheslatta system. Because releases through the Skins Lake Spillway have been much greater than the former natural flows in the Cheslatta River, the bed of the Cheslatta River has been scoured up to 20 meters below the former valley floor. The channel beds consist mainly of gravel and cobble material, and large gravel bars and bedrock exposures are common. Tributaries to the Cheslatta River are also deeply incised.

  The resulting sediments have been transported downstream to form a delta where the Cheslatta River enters Cheslatta Lake. Most of the sediments settle in Cheslatta Lake but some fine sediments, along with some sediments eroded from the outlets of both Cheslatta and Murray Lakes, pass through the lakes and enter the Nechako River at Cheslatta Falls. Cheslatta and Murray Lakes have higher than natural water levels and variable shorelines generally consisting of sands and gravels. The scouring of the bed of the Cheslatta River, along with the increased flushing rate of the lakes, has altered the limnology and reduced the productivity of this system.

  Salmonids in this area include rainbow trout, kokanee, bull trout char, and lake trout. Rocky Mountain and lake whitefish are also present, together with various sucker, dace and shiner species. No anadromous species occur in the area because Cheslatta Falls is a natural barrier to fish migration. Rearing and spawning habitat occurs only in about 5 of the 20 or so tributary streams that flow into Murray and Cheslatta Lakes. Habitat capability is also currently limited by such factors as fluctuating flows, turbidity, and channel structure changes.

- ***Nechako River main stem downstream of Cheslatta Falls*** – Nechako River flows come mainly from three drainages: the Eutsuk-Thahtsa (the Nechako Reservoir) flowing through the Skins Lake Spillway, the Nadina-Francois draining through the Nautley River, and the Stuart-Takla draining through the Stuart River. Only the first of these drainages is regulated (by Kenney Dam). Under the 1987 Settlement Agreement[25], Alcan is required to release certain quantities of water from the Nechako Reservoir into the Nechako River.

  The relative contributions of flows from each drainage, based on the period from 1981 to 1998, are as follows: at Isle Pierre, 54% of the flow is contributed by the Stuart-Takla drainage, a further 11% comes from the Nadina-Francois drainage, 27% comes from the Nechako Reservoir, and the remaining 8% is supplied by local inflows[26].

  In warmer years, water temperatures of the Nechako River from Fort Fraser to Prince George are known to exceed 20°C in the areas where tributary rivers that the drain

[25] Province of British Columbia, Government of Canada and Alcan Aluminum Ltd.; 1987 Settlement Agreement.

[26] Cold Water Release Facility Workshop (CWRFW). 1998. *Presentations by Alcan, Triton and Klohn-Crippen Integ.* Vanderhoof, B.C. June 28-29, 1998. As cited in the following report. Rescan Environmental Services Ltd. 1999. *Nechako River: Summary of Existing Data.* Prepared for: Nechako Environmental Enhancement Fund. October 1999.

large lake systems join the Nechako main stem[27]. As temperatures increase toward that level, fish, particularly sockeye salmon, can become progressively more stressed, more vulnerable to disease, and more prone to delay in their migration. As a consequence, they have been known to die on the way or arrive at the spawning grounds only to die before or during spawning[28]. This concern was recognized in the early 1980's and led to the provisions outlined in the 1987 Settlement Agreement[29] that established objectives for: 1) temperature monitoring of the Nechako upstream of its confluence with the Stuart River, and 2) temperature control through cooling water releases from the Nechako Reservoir during critical fish life cycle stages in the summer and early fall.

The next section contrasts the current and historical flow patterns in the Nechako River downstream of Kenney Dam.

2.3.3 Downstream Nechako River Flows Prior to Kenney Dam

This section illustrates how the hydrology of the Nechako River downstream of Kenney Dam has changed over time, using flows measured at Vanderhoof and Isle Pierre as specific examples.

Figure 2-4 shows three different hydrographs for Nechako River flows measured at Vanderhoof, each representing average conditions for three time periods: before 1952 (prior to the construction of Kenney Dam), 1953 to 1981 (the early years of Kenney Dam and Nechako Reservoir management), and 1982 to 2002. *Note that only three years of flow data are available for the pre-impoundment period (1949-1951). Given the high variability of flow conditions during these three years and the limited number of years of data available, this resulting hydrograph needs to be interpreted with caution and does not necessarily reflect true average conditions for the pre-impoundment period*.

The clear shift in the flow pattern in Figure 2-4 in 1981 relates to a forced change in the volume of water releases to the Nechako River. In 1980, the Fisheries and Oceans Canada ordered Alcan to release more water into the Nechako River for fisheries purposes. Alcan challenged the original order, at which point Fisheries and Ocean's Canada obtained a BC Supreme Court injunction requiring Alcan to comply with the new water flow requirements. From 1980 to 1984, Alcan and the governments of British Columbia and Canada tried to reach consensus on appropriate flows. When it became apparent that a consensus could not be reached, Alcan took the matter back to court in 1985. A tri-party agreement was reached out of court in 1987 (the "*1987 Settlement Agreement*"). The flow releases outlined in the agreement were similar to those set out in the original 1980 order from Fisheries and Oceans Canada. 1981 was the first full year when these new flow releases were implemented.[30]

[27] British Columbia Utilities Commission (BCUC). 1994. *Kemano Completion Project Review, Report and Recommendations to the Lieutenant Governor in Council.* As cited in the following report. Rescan Environmental Services Ltd. 1999. *Nechako River: Summary of Existing Data.* Prepared for: Nechako Environmental Enhancement Fund. October 1999.

[28] Same as above.

[29] Province of British Columbia, Government of Canada and Alcan Aluminum Ltd..*1987 Settlement Agreement.*

[30] The historical context provided in this paragraph is drawn from the *Report of the Nechako Environmental Enhancement Fund Management Committee* (2001), pages 4-5.

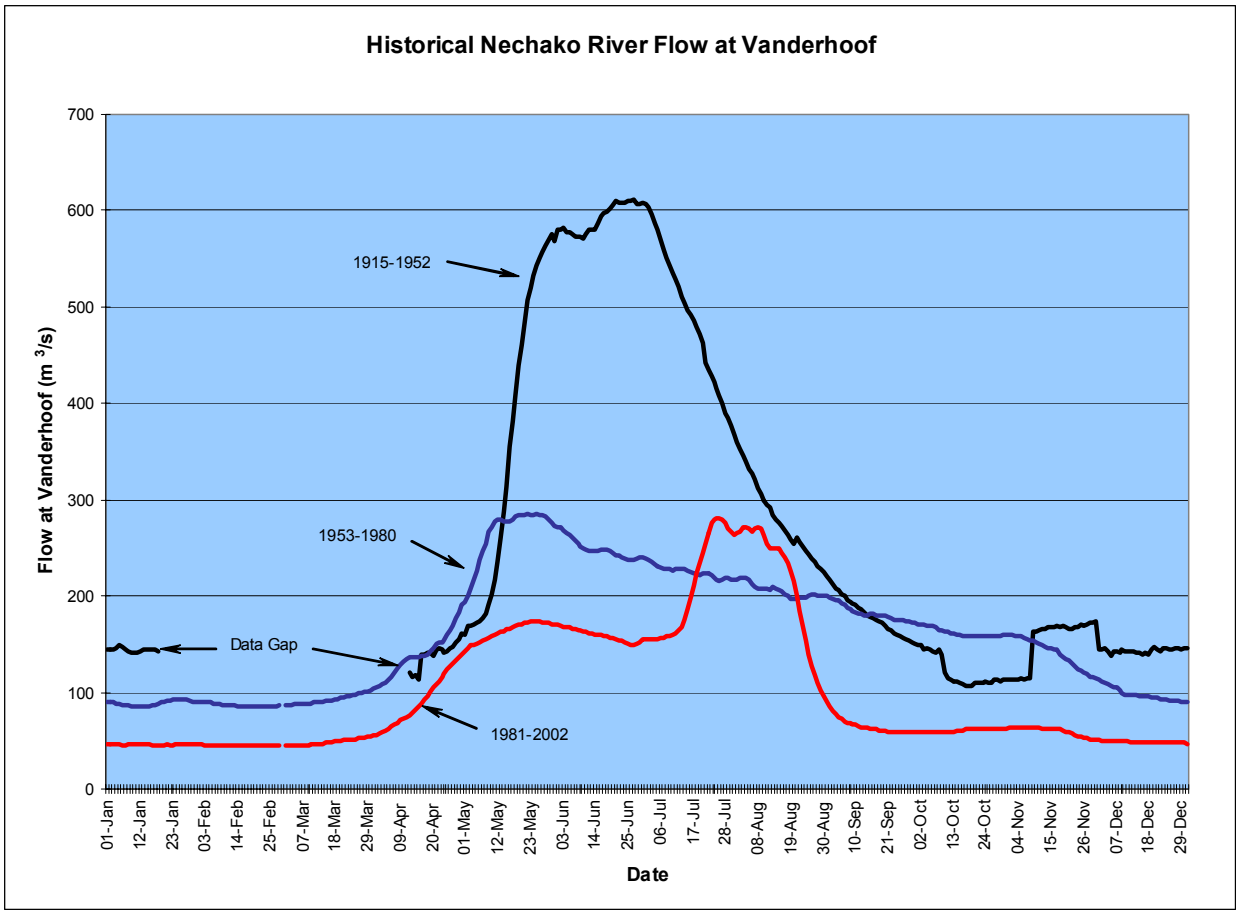

Figure 2-4: Comparison of average Nechako River flow measured at Vanderhoof for three time periods: i) from 1915 to 1952, prior to the impoundment of the construction of Kenney Dam, ii) from 1953 to 1980, and iii) from 1981 to 2002. Note that only three years of flow data are available for the pre-impoundment period (1949-1951). Given the high variability of flow conditions during these three years, this resulting hydrograph needs to be interpreted with caution and does not necessarily reflect true average conditions for the pre-impoundment period (Source: Alcan Inc., 2004)

The change in flow releases from Skins Lake Spillway before and after the implementation of the new flow requirements for fish conservation and protection (starting in 1981) is illustrated in Figure 2-5.

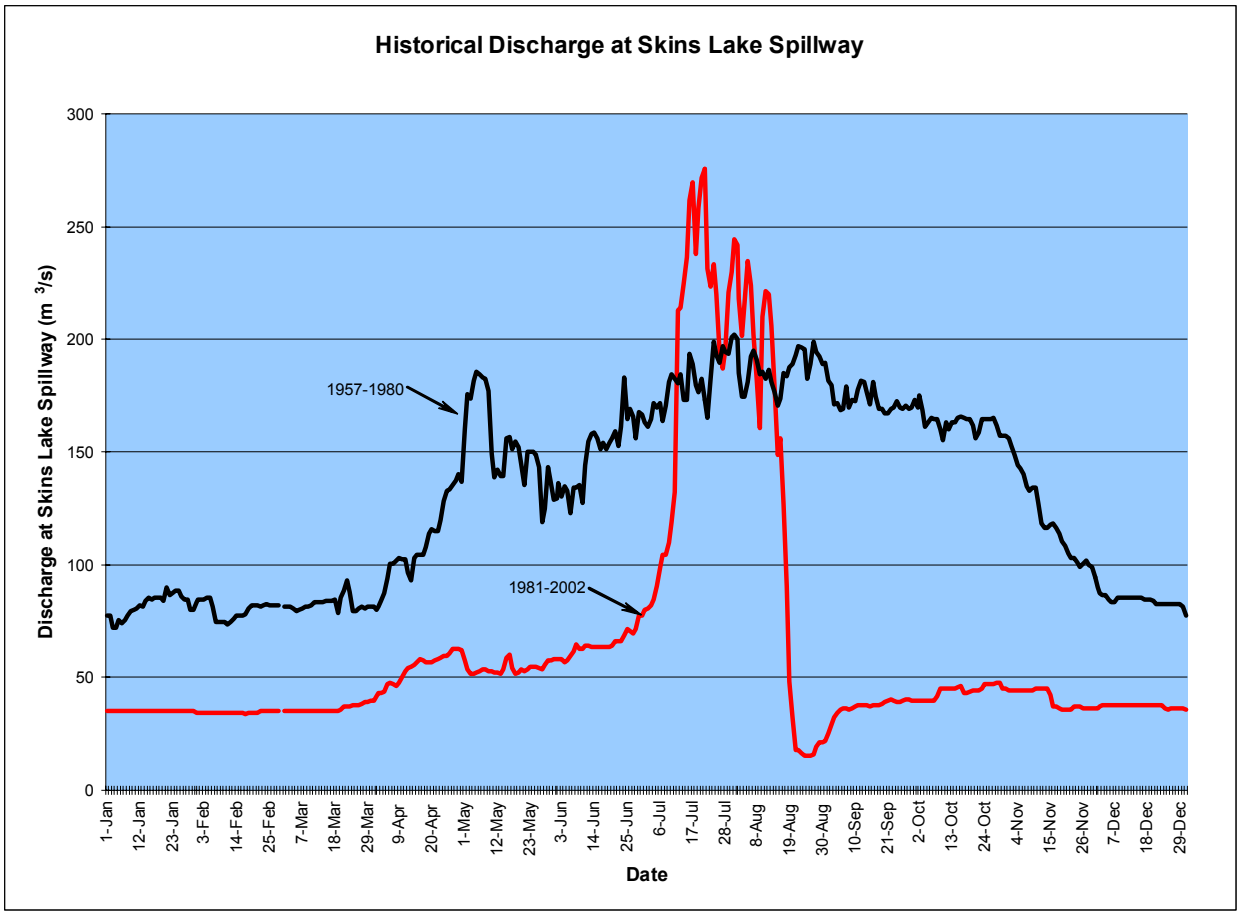

Figure 2-5: Comparison of Average Daily Flow Releases from Skins Lake Spillway for two historical periods: from 1957 to 1980, and from 1981-2002. Flow releases in the second period reflect the pattern originally ordered by Fisheries and Oceans in 1980 and later entrenched in the 1987 Settlement Agreement signed by Alcan and the Governments of British Columbia and Canada. (Source: Alcan Inc., 2004)

Figure 2-6 shows three different hydrographs for Nechako River flows measured at Isle Pierre[31], each representing average conditions for three time periods: before 1952 (prior to the construction of Kenney Dam), 1953 to 1981 (the early years of Kenney Dam and Nechako Reservoir management), and 1982 to 2002. This diagram is similar to the one created to reflect trends at Vanderhoof (Figure 2-4) where the changes in the flow pattern over time are similarly influenced by the construction of Kenney Dam as well as the subsequent changes in flow releases ordered by Fisheries and Oceans Canada starting in 1981. *Note that only two years of flow data are available for the pre-impoundment period (1950-1951). Given the high variability of flow conditions between these two years and the limited number of years of data available, the resulting hydrograph needs to be interpreted with caution and does not necessarily reflect true average conditions for the pre-impoundment period.*

[31] Source: Alcan Inc. October 2004.

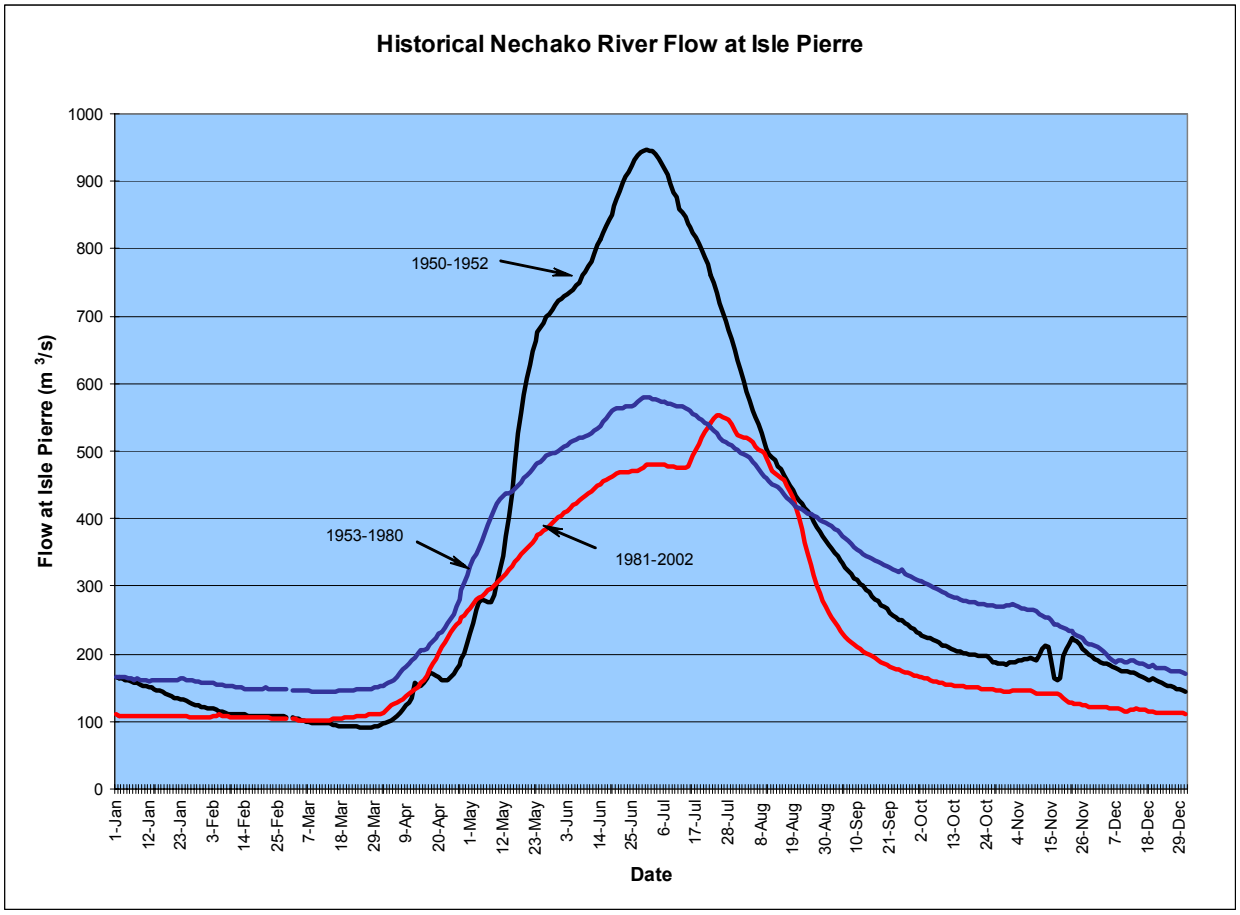

Figure 2-6: Comparison of average Nechako River flow measured at Isle Pierre for three time periods: i) from 1915 to 1952, prior to the impoundment of the construction of Kenney Dam, ii) from 1953 to 1980, and iii) from 1981 to 2002. Note that only two years of flow data are available for the pre-impoundment period (1950-1951). Given the high variability of flow conditions during these two years, the resulting hydrograph needs to be interpreted with caution and does not necessarily reflect true average conditions for the pre-impoundment period (Source: Alcan Inc., 2004)

The next section describes how water releases from the Nechako Reservoir are currently managed.

2.3.4 Priorities for Water Releases from the Nechako Reservoir

Water is currently diverted or spilled from the Nechako Reservoir (as described in Section 2.3.1) for a number of uses. At the moment, the list below summarizes the uses which are considered priorities:

- ***Dam Safety*** – The Nechako Reservoir and all spill releases from Skins Lake Spillway are managed to avoid any risk to dam safety[32].

[32] Information for this section is drawn from two documents: i) Alcan Inc. 2002. Tahtsa Narrows Scoping Report. Section 4.3. and ii) Willis, Bill. 1999. The Nechako Reservoir. Presentation delivered to Nechako Watershed Council by Bill Willis of Alcan Inc. in April 1999.

- ***Flood Management*** – Spill releases from Skins Lake Spillway can be managed to reduce the risk of flooding downstream and/or to minimize the impacts of flooding events[33].
- ***Fisheries Conservation and Protection Flows*** – In 1987, Alcan, the province of British Columbia and the federal government signed a Settlement Agreement[34], ending a dispute over the flows to be released to the Nechako River for fisheries conservation purposes. One of the stipulations of the agreement is that water be released from the Nechako Reservoir to meet two goals:
    - Conservation of the Chinook Salmon that use the Nechako River year round. These base flows are to average 36.8 cubic meters per second (m^3/s) annually.
    - Management of downstream water temperatures to protect migrating sockeye salmon. This is referred to as the Summer Temperature Management Program (STMP flows). The aim of the program is to achieve a temperature of 20°C just above the confluence of the Nechako and Stuart Rivers from late July to late August every year to support salmon spawning. The agreement stipulates the procedures and protocols to be followed in meeting this goal, rather than the quantity of water to be released. However, since 1988, STMP flows have averaged 15.9 cubic meters per second (m^3/s), varying from 12.9 to 22.1 m^3/s. These STMP flows typically begin on July 20; then by September 6, the water flow at Cheslatta Falls must be adjusted to 30 m^3/s to prepare the Nechako River for Chinook spawning.
- ***Water License Flows for Power Generation*** – There are thee main power related flow demands placed on the Nechako Reservoir. First, the Kitimat smelter, when operating at full production, requires 610 megawatts (MW) of firm power from Kemano. This means approximately 102 cubic meters per second (m^3/s) of water is needed at the Kemano powerhouse to generate 610 MW of power. Second, during the transmission of power from Kemano to Kitimat, approximately 20 MW of power is lost. Approximately 3.5 m^3/s of water is needed at the Kemano powerhouse to generate that 20 MW of power. And finally, there is the sale of power to third parties. Given the installed generating capacity at Kemano, the tunnel size, and historical inflows to the reservoir, and taking into account the needs of the Kitimat smelter and the transmission line loss, Kemano produces a power surplus of about 140 MW per year. Under a legally binding agreement, Alcan agreed to sell this surplus to BC Hydro on an annual basis. The agreement is called the Long Term Energy Purchase Agreement[35]

[33] Same as above.

[34] Province of British Columbia, Government of Canada and Alcan Aluminum Ltd..*1987 Settlement Agreement.*

[35] In 1988, Alcan signed a Memorandum of Understanding with B.C. Hydro to provide 285 megawatts of power that would have been made available by the Kemano Completion Project (KCP). Formalized in 1990, this agreement is known as the Long Term Electricity Purchase Agreement (LTEPA). It came into effect on January 1, 1995 and runs up to 2014. This contract provided Alcan with the return on investment required to proceed with KCP at a time when aluminum markets did not justify the investment. (An earlier 1950 Agreement required Alcan to develop its water rights prior to December 31, 1999.) The LTEPA also allowed B.C. Hydro to defer construction of its Site C project, which would have cost close to $2 billion. The cancellation of KCP in January, 1995 did not cancel Alcan's contract with B.C. Hydro. However, the 285 MW of power that KCP would have provided was no longer available to Alcan. In settling the issues arising from KCP's cancellation, Alcan negotiated the ability to sell all or part of the LTEPA to a third party. In late 1997, Alcan sold more than half the LTEPA, opting to use its surplus 140 MW to service the balance of the contract. In December 2004, Alcan announced a re-cal of the LTEPA at the earliest possible data allowable under the terms of the agreement: December 31, 2009. The District of Kitimat (a Member of the NWC) has challenged Alcan's right to sell power in court.

(LTEPA) and extends to 2014. Approximately 23.5 m^3/s of water is needed at Kemano to generate 140 MW of power. [36]

The total *average* annual demand on the Nechako Reservoir to address all of these interests is approximately 181.7 cubic meters per second (m^3/s) of water. This includes fisheries conservation flows (released into the Murray-Cheslatta system and Nechako River) and power generation flows (released through Kemano). Actual demand fluctuates from month to month[37].

The resulting pattern of average daily flows is illustrated in Figure 2-5 in Section 2.3.3 earlier in this chapter (see the line for the period from 1981-2002). This annual cycle of flow releases is the baseline or "base case" flow regime under which the system would continue to operated in the absence of a cold water release facility being built.

While this section outlines the ***current*** priorities considered for flow release allocation, in the future, the construction of a cold water release facility (CWRF) is expected to reduce the volume of cooling water required for the protection of sockeye salmon (the colder the water, the less water is required to achieve the same goal). Therefore, there will be a potential opportunity to redistribute the "freed up" cooling water for other water uses and at other times of year, and to consider a broader range of interests in doing so.

2.3.5 Proposed Cold Water Release Facility and its Potential Impact on Flow Releases[38]

The Cold Water Release Facility (CWRF) proposed for construction at Kenney Dam is a structure that would draw water from deeper in the Nechako Reservoir immediately upstream of Kenney Dam and discharge that water into the Nechako Canyon downstream of the Dam. The proposed CWRF (see Figure 2-7) would consist of:

- A rock-cut channel to draw surface water
- Separate intakes and pipelines to draw water from deep in the reservoir
- A high-level outlet regulating structure capable of releasing water from the surface or deep intakes, either separately or simultaneously, and a chute spillway equipped with a flip bucket energy dissipater.
- A low-level outlet capable of releasing water from the surface or deep intakes, either separately or simultaneously, and equipped with hollow cone valves for energy dissipation and dissolved gas control.

[36] Information for this section is drawn from two documents: i) Alcan Inc. 2002. Tahtsa Narrows Scoping Report. Section 4.3. and ii) Willis, Bill. 1999. The Nechako Reservoir. Presentation delivered to Nechako Watershed Council by Bill Willis of Alcan Inc. in April 1999.

[37] Information for this section is drawn from two documents: i) Alcan Inc. 2002. Tahtsa Narrows Scoping Report. Section 4.3. and ii) Willis, Bill. 1999. The Nechako Reservoir. Presentation delivered to Nechako Watershed Council by Bill Willis of Alcan Inc. in April 1999.

[38] Information for this section is excerpted from the following report. Nechako Watershed Council (NWC). 2002. Proposed Work Plan for the Cold Water Release Facility at Kenney Dam. Submitted to: The Honourable Rick Thorpe, Minister of Competition, Science and Enterprise. Prepared by the: Nechako Watershed Council. In Regard to the June 2001 Report of the Nechako Environmental Enhancement Fund Management Committee. February 2002. Revised March 2002.

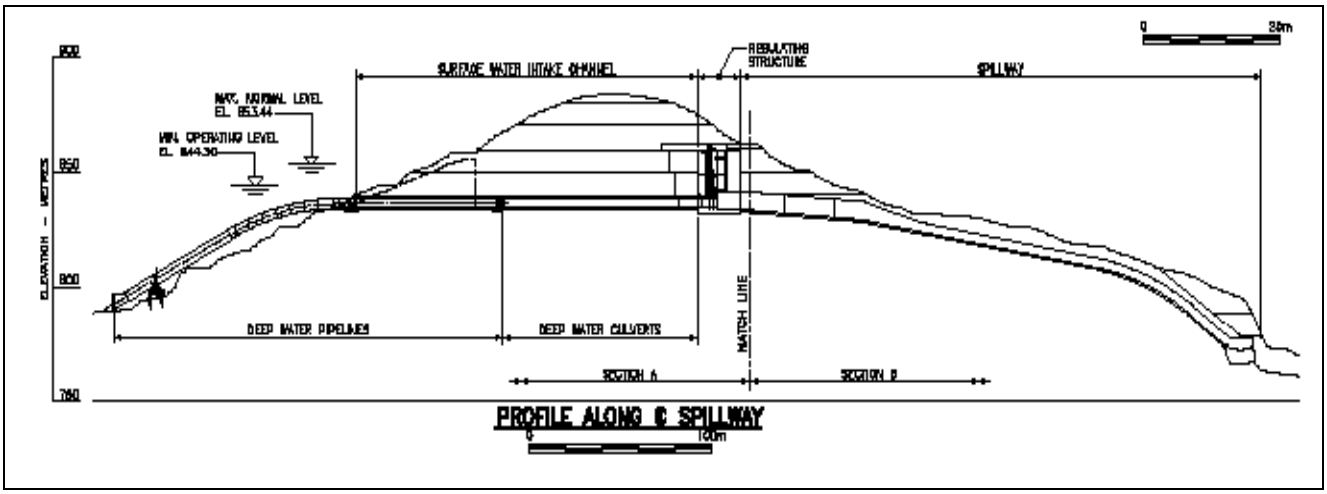

Figure 2-7: Diagram of components of Cold Water Release Facility recommended by the Nechako Environmental Enhancement Fund Management Committee[39]

The name given to the CWRF reflects its ability to release relatively cold water during the summer, thereby providing the capability to control downstream water temperatures for salmon. The capacity to draw water from two levels in the reservoir, either separately or simultaneously, will enable the facility to release water at different temperatures, depending on the season and the seasonal temperature targets for water downstream. The facility will provide an alternative to Skins Lake Spillway as a means of releasing: 1) flows for the conservation and protection of salmon in the Nechako River, and 2) excess reservoir inflows.

Since the installation of a cold water release facility would mean that less water is required to achieve fisheries conservation temperature targets downstream, this would "free up" the flows usually required for cooling. The resulting benefits of redistributing these flows for other uses and at other times of year could include:

- Decreasing flows through the Murray-Cheslatta system in the summer (and providing "naturalized" water flows that redistribute flows throughout the year to mimic a more natural annual flow pattern), thus providing the opportunity for ecological restoration of the system.
- Re-watering of the Nechako Canyon (and providing "naturalized" water flows), thus providing the opportunity for ecological restoration of the system.
- Small increases in annual power generation at Kemano
- New power generation at Kenney Dam
- Other social, environmental, and economic upstream and downstream benefits resulting more a more natural seasonal flow pattern.
- This report documents the NWC's efforts to develop an optimal post-CWRF flow regime that maximizes and balances the social, environmental and economic benefits associated with the facility's operation.

[39] Nechako Environmental Enhancement Fund Management Committee. 2001. Report of the Nechako Environmental Enhancement Fund Management Committee. Page 7.

3 Issues, Interests & Studies

This chapter provides an overview of the NWC's work in identifying key issues and interests related to how water is managed in the Nechako Watershed, and how the issues might be resolved and how the underlying interests might be met. Also included is a section that presents brief summaries of the key studies and reports commissioned to assist the NWC with their work.

3.1 Issues Identified by the Nechako Watershed Council

Between 1998 and 2000, the NWC identified and became informed about the following 24 issues throughout the watershed and along the river[40], many of which relate to flow. All the topics and issues are given equal consideration and therefore are presented in alphabetical order:

1. Aesthetic Considerations
2. Aquatic Weeds
3. Canoeing
4. Cattle Wandering
5. Changes in the Nature of the River
6. Cheslatta Fan
7. Chinook Salmon
8. Damage to the Murray-Cheslatta System
9. Diversity and Numbers of Resident Fish in the Nechako River
10. Downstream Water Licensing
11. Economic Development
12. Fish in the Murray-Cheslatta System
13. Fish in the Nechako Reservoir
14. Float Plane Operations
15. Flooding
16. Hydro-electricity Generation at Kemano
17. Hydro-electricity Generation at Kenney Dam (potential)
18. Municipal Sewage Treatment
19. Natural and Human-Induced Sedimentation
20. Other Concerns Regarding the Nechako Reservoir
21. Recreational User Safety
22. Semi-aquatic Fur Bearers along the Nechako River
23. Water Quality for Recreation
24. Water Temperatures for Migrating Sockeye Salmon

The issues represent the various stakeholder concerns over negative impacts of current management of the Nechako Watershed, some of which can be addressed through changes to the current flow regime.

In addition to identifying these issues, the NWC has also spent significant amounts of time and energy becoming informed about each one, as described in Section 3.2. Some qualitative objectives to address some of these issues have been proposed, but not yet agreed to.

It was during the discussion and exploration of these issues that the proposed CWRF began to emerge as a possible solution with the potential to address a broad range of issues.

[40] Nechako Watershed Council. 2001. *Issues Records*. 1999 with continuous updates. October 2001 version.

In its December 2000 report[41] to the Nechako Environmental Enhancement Fund Management Committee (NEEFMC), the NWC provided a summary of the issues and interests they would like to see respected in the consideration of all options for downstream enhancement of the Nechako Watershed:

- Restoration of the Murray-Cheslatta watershed
- Continuation of the flows to the Cheslatta River
- Year round flow from Kenney Dam
- Ability to reduce high summer flows
- Protection of fish resources
- Maintenance of flood management capability
- Ability to meet legal agreements
- Promotion of social, economic and environmental sustainability.

This list provides an outline of the considerations driving the development of the flow regime the NWC will ultimately recommend.

3.2 Relevant Studies & Reports

In the course of its work, the NWC has reviewed and commissioned numerous reports and studies to improve its understanding of the 24 issues identified by the NWC (listed in Section 3.1) and has consistently tracked and documented the key developments in its exploration of these issues and documented these in an *Issues Record*[42]. This record presents the key findings of each presentation, handout or report that the NWC has received, and highlights how each piece of research has contributed to the improved understanding of the issues.

A complete listing of the material that the NWC has commissioned, received and reviewed since 1998 is provided in the References for this report, as is a summary of the specific documents referenced throughout this report.

In addition, the Nechako Environmental Enhancement Fund Management Committee (NEEFMC) commissioned a summary[43] resource document on the current state (as of 1999) of knowledge of the Nechako River watershed. This document was intended to assist with discussions during the public consultation sessions hosted by the NEEFMC in late 1999 and early 2000. The material presented in the document is drawn from a fairly narrow range of readily available published data. The goal of the document was to provide a common understanding of the available technical information, and not necessarily to represent the full range of issues and opinions presented by members of the public and scientists over many years of debate on the management of the Nechako River.

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[41] Nechako Watershed Council (NWC). 2000. *Nechako Watershed Council: Third Interim Report to the Nechako Environmental Enhancement Fund Management Committee.* December 2000. Available online at: http://nechakowatershedcouncil.com/reports/3rd_report_to_neefmc.htm

[42] Nechako Watershed Council (NWC). 2001. Issues Records. 1999 with continuous updates. October 2001 version.

[43] Rescan Environmental Services Ltd. 1999. Nechako River: Summary of Existing Data. Prepared for: Nechako Environmental Enhancement Fund. October 1999.

Finally, the Nechako Enhancement Society commissioned a comprehensive bibliography[44] of relevant sources of information relating to the assessment, design and construction of the proposed cold water release facility at Kenney Dam. There has been more than fifty years of research, assessments, and conceptual designs associated with the Kenney Dam and the Nechako River. There has also been a long history of work associated with the Kemano Completion Project. The focus of the bibliography is to document the existing environmental work completed on the Nechako River, Kenney Dam Release Facility and related structures proposed in the Kemano Completion Project, as well as studies subsequent to the BC Utilities Commission report of 1994[45], and all relevant reports by the Nechako Fisheries Conservation Program (NFCP), Nechako Watershed Council (NWC), and the Nechako Environmental Enhancement Fund Management Committee (NEEFMC).

3.3 Summary of NWC Work on Issues, Interests & Studies

To date, the NWC has:

- Identified and become informed on about 24 key issues and interests throughout the watershed and along the river, focusing on flow related issues
- Translated some of these objectives into specific flow targets (i.e., flow volumes required to meet these interests throughout the year)
- Reviewed and commissioned studies in the process of completing the tasks above.

The NWC is seeking to reach consensus-based agreement on a post-CWRF flow regime, and has not yet determined how to address flow objectives, particularly if all interests cannot be accommodated.

[44] Environmental Dynamics Inc. 2003. *Nechako River Cold Water Release Facility Bibliography.* Prepared for: Nechako Enhancement Society. Prepared by: K.M. Bradley of EDI Environmental Dynamics Inc. and N.M. Peterson of Western Ecological Services Ltd. EDI Project No.: 905-01. March 2003.

[45] British Columbia Utilities Commission (BCUC). 1994. *Kemano Completion Project Review, Report and Recommendations to the Lieutenant Governor in Council.*

4 Computer Models & Flow Regimes Modeled

This chapter provides an overview of three key computer models that have assisted the NWC in developing a better understanding of the possible flow regimes that could be followed if a cold water release facility (CWRF) is built at Kenney Dam, and how these different flow regimes might (or might not) address various interests identified by the NWC (as outlined in Chapter 3).

4.1 Nechako Water Balance & Flow Modeling Exercise

4.1.1 Translating NWC Interests into Specific Flow Targets

Between 2000 and 2002, with the assistance of Glen Davidson (of the former Water Management Branch of the BC Ministry of Environment Land and Parks), the NWC made substantial progress on translating its stakeholder issues into specific flow targets that would be expected to provide benefits for specific interests. Through discussion with NWC members and other community stakeholders, Glen was able to identify preferred or ideal average annual flows in each case.

4.1.1.1 Monthly Downstream Flow Targets

Table 4-1 (on the next page) summarizes the specific monthly flow targets developed. While each organization (or constituency) identified their desired flow levels at locations on the river most relevant to them, all of those desired flow levels were eventually translated into an equivalent flow target as measured at Cheslatta Falls as a common reference point (unless otherwise specified).

Depending on the interest, some of the targets are expressed as maximum constraints on flow (i.e., they should not be exceeded in that month), some are expressed as minimum constraints (i.e., flows should not go lower than that level in that month), while others are expressed as targets (i.e., flows should aim to be as close to that level as possible throughout the month). In other cases, it is the annual/seasonal flow pattern (i.e., the shape of the annual hydrograph) that matters more than the volume in any given month.

For some of the interests, there are a number of months in the year where there are no desired constraints specified (i.e., no change required from current flows to satisfy that interest); for others, there are targets specified for each month.

Table 4-1: Monthly Flow Targets Designed to Meet Nechako Watershed Council Interests

#	Issue	Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1	Aesthetic Considerations	tar	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Aquatic Weeds	non	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Canoeing	min	-	-	-	-	60	60	60	60	48	40	-	-	-
4	Cattle Wandering	min	-	-	-	-	50	50	50	50	50	-	-	-	-
5	Changes in nature of river	sha	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Cheslatta Fan	non	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Damage-Murray/Cheslatta	tar*	6.1	5.7	5.2	6.7	28.6	44.9	31.0	18.7	11.5	8.0	7.2	6.5	15.0
8	Downstream Licensing (Irrigation)	min	-	-	-	-	23	0	28	13	-	-	-	-	-
9a	Economic Development-Nechako	non	-	-	-	-	-	-	-	-	-	-	-	-	-
9b	Economic Development - NWCom														
10	Economic Development-Southside	tar*	6.1	5.7	5.2	6.7	28.6	44.9	31.0	18.7	11.5	8.0	7.2	6.5	15.0
11	Fish - Murray/Cheslatta	tar*	6.1	5.7	5.2	6.7	28.6	44.9	31.0	18.7	11.5	8.0	7.2	6.5	15.0
12	Fish - Nechako Reservoir	non	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Float Plane Operations	min	-	-	-	-	31.7	31.7	31.7	31.7	31.7	31.7	-	-	-
14	Flooding	max	55	55	55	283	283	283	283	283	283	55	55	55	-
15	Hydroelectric - Alcan	max	-	-	-	-	-	-	-	-	-	-	-	-	51.7
16	Hydroelectric - Kenney Dam	min*	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
17	Municipal Sewage Treatment	non	-	-	-	-	-	-	-	-	-	-	-	-	-
18	Nechako Reservoir Levels		-	-	-	-	-	-	-	-	-	-	-	-	-
19	Recreational User Safety	non	-	-	-	-	-	-	-	-	-	-	-	-	-
20	Resident Fish - Nechako	min	-	-	-	-	104	-	-	-	-	-	-	-	-
21	Sedimentation	min	-	-	-	-	-		-	-	-	-	-	-	-
22	Semi-aquatic Fur Bearers	sha	-	-	-	-	-	-	-	-	-	-	-	-	-
23	Water Quality - Recreation	non	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Water Temperature - Sockeye	min	-	-	-	-	-	-	87/111	75/92	-	-	-	-	-
25	Water Volume - Chinook	max	85	85	85	85	85	283	283	283	125	125	85	85	-
	NFCP Directed Flows	min*	30	30	30	35	49	49	49	49	30	30	30	30	36.8
	NFCP Directed Flows plus inflows	min	30.8	30.6	30.7	41.2	65.3	59.2	54.2	50.8	31.8	31.7	31.7	30.9	40.8

NOTES:

***** Flows for these issues are specified at a location other than the Cheslatta gauge.

non = Refers to a non flow related issue

min = Refers to an issue with a minimum flow limitation

max = refers to an issue with a maximum flow limitation

tar = target flow for this issue

"-" = there are no flow limitations for this issue during this month

sha = Refers to the shape of the hydrograph which will address the issue; specific volume less important

8 - Downstream Licensing (Irrigation) - Note that these targets represent desired flow levels in the river in order to ensure access to water for irrigation; the targets do not represent the volume of water targeted for withdrawal, which would be more in the order of 1-2 cms.

9b - Economic Development - NW Communities - No downstream target is shown for this interest; however a request to retain 5 cms of the flows freed up by the proposed CWRF in the Nechako Reservoir has been made by the Northwest Communities Coalition (NCC). For more details, see the middle row of the table on the next page.

4.1.1.2 Proposals for Allocation of Freed-Up Flows to the Nechako Reservoir for Economic Development

While the initial NWC water balance and flow modeling exercise was being carried out and potential downstream flow targets were being developed, there were proposals put forward by various NWC members outlining the potential value of allocating some of the freed-up flows to the Nechako Reservoir on an ongoing basis. Each proposal was based on different interests and rationales, as outlined below (in no particular order). One of the key issues underlying some of the proposals is economic development, and more specifically the stability of the local economy in the future. The far-right hand column of the table indicates if and how this proposal was incorporated into the NWC water balance & flow modeling exercise.

Proposal for Allocation of Freed-Up Flows to Nechako Reservoir	**Submitted how? By whom? When?**	**Incorporated into NWC Flow Modeling Exercise?**
Proposal: Alcan requested 5 m^3/s of the freed-up flows. Potential Value: Maintaining adequate levels in the Nechako Reservoir.	Presented verbally by Alcan representative(s) for the first time at the March 2001 meeting of the NWC (noted in the draft minutes for that meeting).	The 51.7 m^3/s mean annual downstream flow target developed for the "15 - Hydroelectric – Alcan" interest listed in Table 4-1 is a maximum average based on Alcan's request for an additional 5 m^3/s of the freed-up flows to be retained annually in the Nechako Reservoir. This average was calculated by subtracting Alcan's request for an additional 5 m^3/s from required NFCP flows, as well as existing cooling flows and natural inflows (not including spills).
Proposal: Acceptance of Alcan's proposal to withhold 0-5 m^3/s of the freed-up flows. On the understanding that as it becomes necessary to withhold freed-up flows for the purpose of maintaining reservoir levels, Alcan would reduce appropriate flow volumes through Kemano in a corresponding manner. Potential Value: More desirable reservoir levels and environmental enhancement of the Nechako Reservoir are maintained during consecutive years of less than average annual inflows.	Submitted by Vanderhoof District Chamber of Commerce (Henry Klassen) and Regional District of Bulkley/Nechako, Area F (Jerry Petersen) in a briefing note distributed to the NWC at their meeting in Burns Lake on February 28, 2003.	See first row above.
Proposal: Request for approximately 5 m^3/s or equivalent benefit. *Note: this request is separate and in addition to Alcan's proposal for retention of 5 m^3/s outlined immediately above.* Potential Value: Support economic development and job creation in Kitimat.	This proposal was originally put forward by the District of Kitimat & the Northwest Communities Coalition (NCC) in 2000, and since that time, the NCC has submitted a series of related briefing notes[46].	The Kitimat/NCC proposal was not incorporated in the remainder of the NWC Flow Modeling Exercise.

[46] District of Kitimat, Chambers of Commerce of Kitimat and Terrace, Northwest Communities Coalition, and City of Terrace. 2000. *Briefing note in follow-up to Nechako Watershed Council Meeting of October 20-21/2000 in Smithers.*

Northwest Communities Coalition. 2001. *Draft-NWC Discussion Paper (#3) – A New Direction.* April 9, 2001.

Northwest Communities Coalition. 2001. *Draft-NWC Discussion Paper Proposal for Variable Release of Freed-Up Water.* March 6, 2001.

Whicher, Carl. 2002. *Letter to the Nechako Watershed Council regarding the Northwest Communities Coalition's request for 5 cms of tolled water flow through Kemano.* February 4, 2002.

4.1.2 Comparing Flow Targets with Preliminary Post-CWRF Flow Scenarios

Based on this information, a hydrograph (Figure 4-1) was created depicting the average monthly flows in the Nechako River at Cheslatta Falls for two specific annual flow release patterns:

- one representing the current annualized flow of 56.7 m^3/s with larger releases throughout the summer in June, July and August, and
- another representing a proposed annualized flow of 51.7 m^3/s with flow releases that mimic a more natural downstream flow pattern.

The hydrograph also shows the NWC flow targets from Table 4-1 (shown in dashed and heavy bolded lines) to see which targets could be achieved under each of the current and proposed annualized flow releases from the Nechako Reservoir.

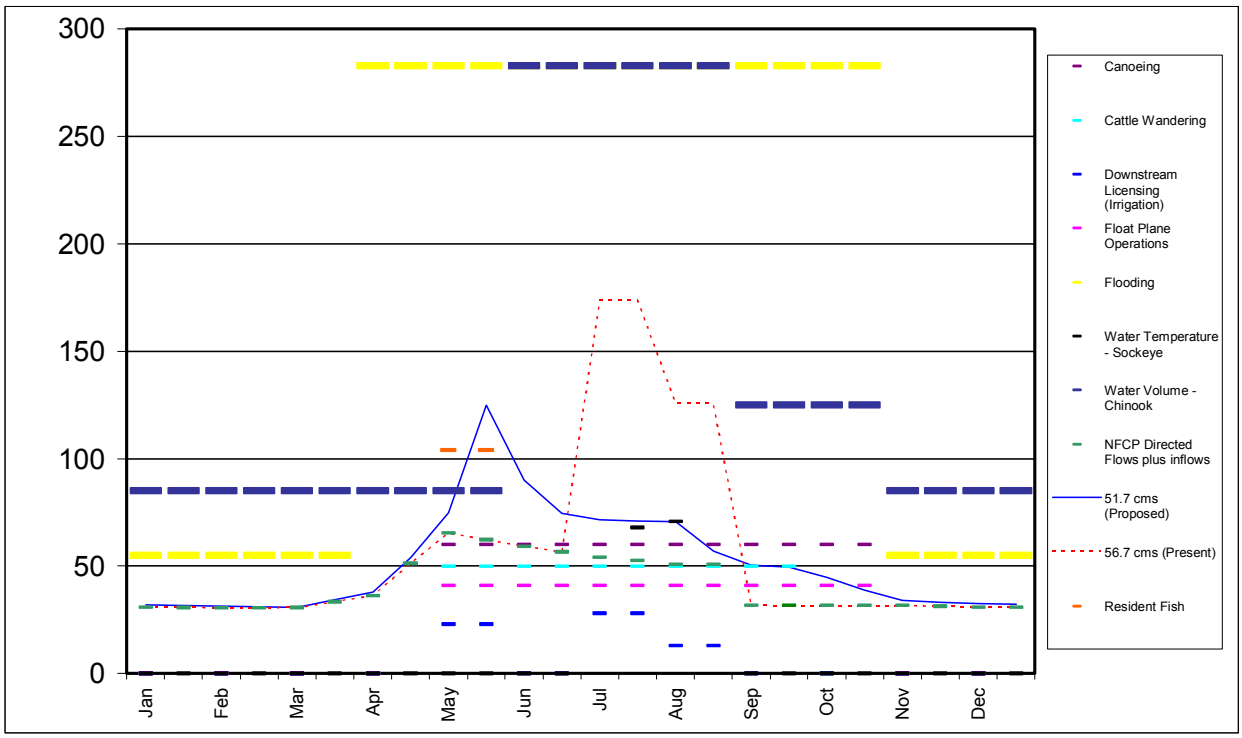


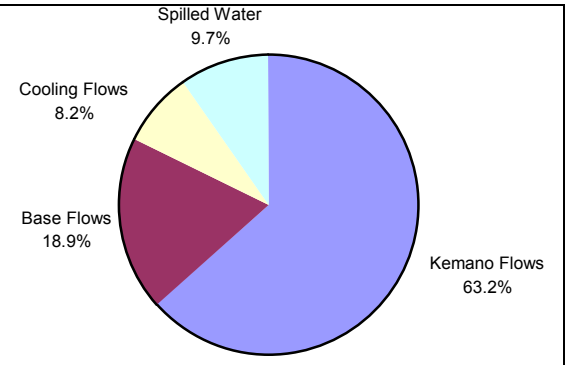
Figure 4-1: Hydrograph showing current annualized for of 56.7 m3/s (thin dashed line) with large releases is summer months, and proposed annualized flow of 51.7 m3/s (thin solid line) with a more natural seasonal flow release pattern. The horizontal dashed lines and heavy bold lines represent various minimum, maximum and target flow limitation designed to meet NWC interests.

4.1.3 Post-CWRF Nechako Reservoir Water Balance: Allocation of Annual Reservoir Outflow

During this initial flow modeling exercise, the NWC went on to compare how flow releases from the Nechako Reservoir could be allocated differently if a cold water release facility (CWRF) has been built at Kenney Dam (i.e., taking into account the availability of "freed up flows"). Figure 4-2 presents a water balance for the Nechako Reservoir, contrasting the annual reservoir outflow (flow releases) under current operations and under simulated naturalized post-CWRF operations for years when the reservoir inflows are at average levels.

Present Average Distribution

Reservoir Inflow	**195.0 m³/s**
Kemano Flows (LTA)	123.3
Base Flows	36.8
Cooling Flows	16.0
Spilled Water (LTA)	18.9
Total Outflow	**195.0 m³/s**
Cheslatta Inflow	3.8
Total Nechako downstream	**75.5 m³/s**



Post-CWRF Average Distribution

Reservoir Inflow	**195.0 m³/s**
Kemano Flows (LTA)	123.3
Base Flows	36.8
Cooling Flows	3.0
Spilled Water (LTA)	18.9
Freed-up Flows	13.0
Total	**195.0 m³/s**
Cheslatta Inflow	3.8
Total Nechako downstream	**62.5 to 75.5 m³/s**

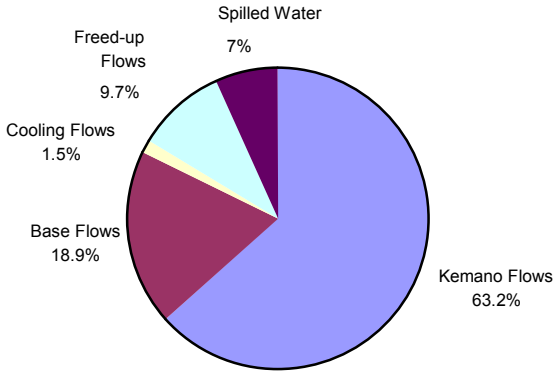


Figure 4-2: Nechako Reservoir Water Balance. Comparison of distribution of average annual reservoir outflow under current operations and under simulated naturalized operations if a cold water release facility has been built at Kenney Dam (assuming average reservoir inflow conditions)[47]

4.1.4 Impact of Year-to-Year Variability in Nechako Reservoir Inflow

Another key finding of this initial work on the Nechako Reservoir water balance was that the annual variation in inflow to the Nechako Reservoir would have an impact on the volume of outflow available for allocation to meet various NWC flow-related interests.

Table 4-2 shows the impact that the natural year-to-year variation in Nechako Reservoir inflow volume could have on the distribution of reservoir outflow if a CWRF were constructed at Kenney Dam. The 'reservoir maintenance' flows (i.e., the amount of water allocated to remain in the Nechako Reservoir instead of being released to the Nechako River) as presented in the table represent only one of many flow-sharing scenarios. Other possible scenarios are discussed later in this chapter, in Sections 4.2 and 4.3.

[47] Davidson, Glen. 2001. "*Nechako Reservoir Water Balance*". Prepared for the Nechako Watershed Council.

Table 4-2: Average distribution of post-CWRF flow releases from Nechako Reservoir under various inflow conditions (expressed as a percentage of the long-term average or % LTA)[48]

Post-CWRF Average Distribution (3)							
Reservoir Inflow (%LTA)	**70%**	**80%**	**90%**	**100%**	**110%**	**120%**	**130%**
Reservoir Inflow (cms)	**136.5**	**156.0**	**175.5**	**195.0**	**214.5**	**234.0**	**253.5**
Kemano Flows (2)	96.7	116.2	129.0	129.0	129.0	129.0	129.0
Base Flows	36.8	36.8	36.8	36.8	36.8	36.8	36.8
Cooling Flows	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Reservoir Maintenance	0.0	0.0	0.0	10.0	10.0	10.0	10.0
Redistributed Flows	0.0	0.0	6.7	16.2	35.7	55.2	74.7
Total Outflow	**136.5**	**156.0**	**175.5**	**195.0**	**214.5**	**234.0**	**253.5**
Cheslatta Lake Inflow (1)	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Total Nechako downstream	**43.6**	**43.6**	**50.3**	**59.8**	**79.3**	**98.8**	**118.3**

Notes:

1. Actual observed Cheslatta Lake inflow is 3.8 m^3/s
2. Kemano (powerhouse) flow based on 1990 - 2000 average and may not reflect Alcan's future use.
3. All flows specified in cubic meters per second (m^3/s)
4. Long-term average reservoir inflow of 195 m^3/s based on 30 year period from 1961 - 1990

The impact of the natural year-to-year variation of inflows the Nechako Reservoir on the availability of water for post-CWRF flow distribution would later lead the NWC to discuss the potential to develop flow regimes capable of accommodating variable (rather than fixed) annual formulas for sharing flows between the Nechako Reservoir and the Nechako River (see Section 4.3 for more detail).

4.1.5 Comparing Flow Targets with Refined Post-CWRF Flow Scenarios

Based on all of the analysis performed throughout the initial water balance and flow modeling exercise, the final step was to produce a more detailed hydrograph (Figure 4-4) showing the average monthly flows in the Nechako River at Cheslatta Falls for a range of annual "naturalized[49]" flow releases to the river of between 40 and 120 cubic meters per second (m^3/s or cms), depending on the annual precipitation or inflow to the reservoir (i.e. low, average or high inflow conditions). The hydrograph also shows the flow targets designed to meet NWC interests to see which of these targets could be achieved under the different annualized flow releases from the Nechako Reservoir.

[48] Developed by Glen Davidson (Land & Water BC Inc.). 2002.

[49] A "naturalized" hydrograph is one that imitates the natural annual flow pattern expected for that river system (vs. the "unnatural" flow pattern experienced when a river is actively managed using physical structures such as diversions, dams and spillways).

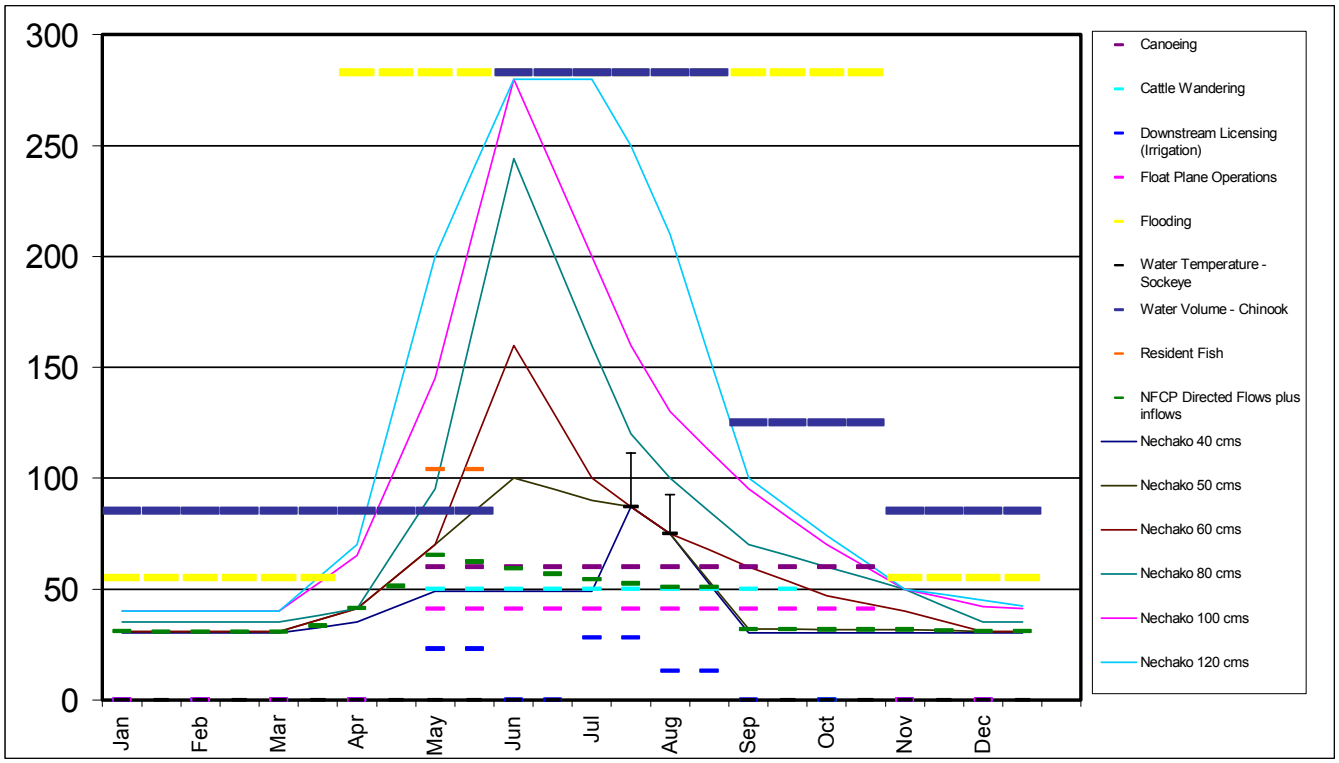


Figure 4-3: Hydrograph of simulated "naturalized" post-CWRF flow patterns (thin lines) representing a range of annualized flow volumes at Cheslatta Falls (40 to 120 m^3/s). The coloured horizontal dashed lines and heavy bold lines represent various minimum, maximum and target flow limitation designed to meet NWC interests.

4.1.6 What the NWC Learned from the Initial Water Balance & Flow Modeling Exercise

The main conclusions that could be drawn based on this initial flow modeling & water balance exercise are that:

- There are many different flow-related interests represented by the NWC, and it is difficult to quantify some of these and to develop flow targets for them.
- The modified flow delivery schedules that are possible if a cold water release facility is constructed at Kenney Dam have the potential to simultaneously address many (although not all) of the flow-related interests identified by the NWC.
- It may not be possible to address all NWC interests all of the time, but there appears to be a greater potential to address a variety of them simultaneously than was originally expected.

This initial water balance exercise does not address the ability to adjust and manage the allocation flow releases from both Kenney Dam and the Skins Lake Spillway (and the impact that would have on the ability to meet a greater range of interests simultaneously).

This exercise was a very important first step in the NWC's analysis of potential flow regimes, but it also highlighted the need to develop more realistic modeling tools that could

incorporate the impact of year-to-year fluctuations in Nechako Reservoir inflows on the availability of water for releases to the Nechako River if a cold water release facility is built at Kenney Dam.

4.2 Nechako Downstream Allocation Model (N-DAM)

The Nechako Downstream Allocation Model (N-DAM) is a tool developed by Dan Bouillon (Alcan Inc.) for the Nechako Watershed Council and the Nechako River White Sturgeon Recovery Initiative to provide a more accurate representation of proposed flow changes at various locations along the Nechako River downstream of Kenney Dam and downstream of the Skins Lake Spillway. It was developed in response to the need identified during the initial water balance and flow modeling exercise (Section 4.1) for a more complex and realistic modeling. N-DAM provides a way to compare alternative scenarios of flow sharing between Skins Lake Spillway (SLS) and the Kenney Dam (KD) after a cold water release facility (CWRF) is constructed at Kenney Dam.

4.2.1 Assumptions & Methodology[50]

N-DAM generates possible flow 'solutions' designed to balance various NWC interests, while recognizing several principles (listed below) that are applied to guide water allocation for all flow scenarios simulated using the model.

1. Naturalize the hydrograph of the Nechako River.
2. Naturalize the hydrograph of the Cheslatta River.
3. Re-water the Nechako Canyon year-round, and naturalize the hydrograph where possible.
4. At a minimum, achieve Nechako Fisheries Conservation Program (NFCP) releases for fish.
5. Supply base Skins Lake Spillway (SLS) release using NFCP fish flows (i.e. guarantee SLS release schedule).
6. Redistribute Freed-Up Flow (FUF) to maximize resolution of issues identified by NWC.
7. Maximize beneficial timing and volume of releases for Nechako River White Sturgeon.
8. Provide year-round stable water supply for power generation at Kenney Dam.
9. Maximize economic benefits for all concerned (i.e., including upstream, power and downstream benefits).

N-DAM adds outflows from Skins Lake Spillway (SLS), the proposed Kenney Dam (KD) Hydroelectric Facility, and the proposed cold water release facility (CWRF) to estimate the flows that will be delivered to Cheslatta Falls. The model determines the amount of cooling flow required to be delivered to the Nechako River at Cheslatta Falls in order to meet downstream temperature targets of fisheries conservation and protection. The model then uses that amount to calculate the resultant amount of cooling water that is freed up by building the CWRF ((known as "freed up flow" or FUF[51]). The FUF can then be distributed to either the river or remain in the reservoir for diversion and power generation.

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[50] Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC.

[51] Since the installation of a cold water release facility (CWRF) would mean that less water is required to achieve fisheries protection temperature targets downstream, this would "free up" the flows usually required for cooling. These flows could then be redistributed throughout the year to achieve a greater range of objectives of interest to the NWC.

Here is an overview of how the model works. N-DAM assumes that 60 m^3/s base cooling flows are available for allocation to all uses if a cold-water release facility has been built at Kenney Dam[52]. The model then allows users to manipulate four input variables:

- Annual Skins Lake Spillway Release (SLS) (in cubic meters per second or m^3/s). If the CWRF is constructed, the key driver of the amount and timing of SLS flows would be preferences relating to ecological benefits in the Murray-Cheslatta Lake system.
- Kenney Dam (KD) Constant Daily Release (in m^3/s).
- Temperature Target for water released from the cold water release facility (in degrees Celsius or °C). The target temperature determines both the amount of cooling flow required, and the resultant freed up flows that will remain.
- Freed up flows (in m^3/s) to remain in the reservoir.

There are two key calculations in the model which are used to create two different hydrographs or 'solutions' for each flow scenario.

- The 'N-DAM Solution' is the sum of stakeholder interests, defined as the Skins Lake Spillway release, the Kenney Dam release, the cooling flow release and the Murray-Cheslatta inflow. The hydrograph produced based on the N-DAM solution may or may not mimic the pattern of a "natural" hydrograph.
- The 'Naturalized Solution' is generated by redistributing the total annual flows in the N-DAM solution to mimic a more natural seasonal flow pattern. The naturalized solution takes into account the required NFCP (Nechako Fisheries Conservation Program) flows, the cooling flow releases, and the Murray-Cheslatta inflow, plus the guaranteed freed up flows, and then adjusts these to mimic the seasonal pattern of the historical Nechako Reservoir natural inflow hydrograph.

For a more detailed description of N-DAM, see Appendix B.

4.2.2 Third Party Review of the N-DAM Model

In 2003, Ecofish Research Ltd. was retained by the Nechako Watershed Council (NWC) to review the Nechako Downstream Allocation Model (N-DAM) and to provide recommendations for its improvement. The resulting report[53] identified and discussed several issues related to the model concept, design, interpretation, and the NWC's decision-making process based on the results of downstream flow scenarios generated by the model. Here is a summary of the reviewer's key comments on the model concept and design:

- The model is presently independent from the Nechako Reservoir Operation Model. Although this creates some limitations, given the existing scope and intended use of the model, this platform is adequate.
- The model is logical and the overall structure of the model is sound.
- The model uses appropriate and consistent data sources (monthly hydrological time series).

[52] At the present time, a minimum of 60 m3/s base flow must be delivered to the Nechako River at Cheslatta Falls during the sockeye migration and annual Summer Temperature Management Period (STMP) from July 10 to August 20. Modeling for the Nechako Environmental Enhancement Fund Management Committee [NEEFMC] by Triton Environmental Consultants Ltd. showed that cooling flows are usually delivered 60% in the July period and 40% in the August period.

[53] Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC.

- The model contains some redundant components, which could be removed to simplify it without affecting the output or conclusions.
- The user interface could be redesigned to simplify operation and to reduce operating error.

Potential improvements that could be made without changing the key components of the model include: 1) expand N-DAM to consider all years (i.e., high and low inflow years, not just average inflow years), and 2) expanding N-DAM to consider daily flows (instead of monthly flows).

For the complete version of the N-DAM review report, see Appendix B.

4.2.3 Flow Scenarios Considered

In April 2003, after many exploratory simulations to understand the potential solutions possible and a number of presentations to the NWC, the results of eight specific draft flow scenarios generated with the N-DAM model were presented to the NWC for their review. The scenarios were developed and presented to illustrate the effect of changing the sharing formula of freed up flows (i.e. the annual sharing of flows between the Nechako Reservoir and the Nechako River). Table 4-3 summarizes how an annualized freed up flow of 12.9 cubic meters per second (m^3/s) could be shared between the Nechako River and Nechako Reservoir under average reservoir inflow conditions in eight different simulated scenarios.

Table 4-3: Summary of Allocation of Nechako Reservoir Outflow under Eight Flow Scenarios Modeled with the Nechako Downstream Allocation Model (N-DAM)[54]

Flow Scenario	*#1*	*#2*	*#3*	*#4*	*#5*	*#6*	*#7*	*#8*
Freed up Flow (FUF) Allocated to Reservoir (in m^3/s)	0	2	3.5	4	6	8	9.5	10
Freed Up Flow (FUF) Allocated to River (in m^3/s)	12.9	10.9	9.4	8.9	6.9	4.9	3.4	2.9

Notes:

The scenario with 10 m^3/s FUF to the reservoir does not "work" as the model indicates there is not enough total water to supply all required interests. This is because the base releases to the Skins Lake Spillway (SLS) and Kenney Dam (KD) actually use up some of the expected FUF on an annual basis (remember that the required delivery to the river on an annual basis is 36.8 m^3/s but the total of SLS plus KD = 40 m^3/s in these scenarios). There is enough FUF to the river in all the other scenarios to compensate for this because there is at least 3.2 m^3/s to the river to cover these demands. This is a good illustration of one of the tradeoffs of choosing the base flows at the SLS and KD.

During a recent update of the N-DAM results[55], Scenario #4 was modelled with a 3.9/9 flow split instead of the 4/8.9 split shown above.

[54] Dan Bouillon (Alcan Inc.). 2003. *Nechako Downstream Allocation Model (N-DAM): DRAFT Simulation Results*. April 23, 2003.

[55] Dan Bouillon (Alcan Inc.). 2004. *Nechako Downstream Allocation Model (N-DAM): DRAFT Simulation Results*. November 4, 2004.

4.2.4 Key Model Assumptions

The are a few key assumptions underlying each of the eight flow scenarios modelled to date using the Nechako Downstream Allocation Model (N-DAM):

- There are ***60 cubic meters per second (m^3/s) in annualized base flows*** available for allocation to all uses if a cold water release facility (CWRF) has been constructed at Kenney Dam[56].
- Each scenario assumes a ***temperature target for flow releases of 12°C during the period from July 20 to August 20 each year*** (i.e., the duration of the current Summer Temperature Management Program administered by the Nechako Fisheries Conservation Program). This is a conservative estimate of the temperature of flow release require to achieve the downstream temperature target of 21.7°C just above the confluence of the Nechako River and the Stuart River based on the other assumptions made in the model about the amount and timing of flow releases (e.g., Skins Lake Spillway flow releases and Kenney Dam flow releases) [57].
- Each flow scenarios projects an ***annualized release from Skins Lake Spillway (SLS) of 15 m^3/s based on a "naturalized" hydrograph*** that redistributes flow releases to mimic the seasonal flow pattern of the Stellako River. There are two underlying assumptions here:
    1. The amount of annualized flow that would be delivered by the SLS to the Cheslatta River has been discussed by the Cheslatta First Nation and the Nechako Watershed Council. Flows of 5 to 30 m^3/s have been considered, with 15 m^3/s identified as a reasonable target.[58] This flow would be delivered as a minimum mean annual (i.e. the annual release would not be less than the target but could be exceeded when the Kenney Dam Release could not handle unusually high flows).
    2. The appropriateness of the Stellako as a template depends on the NWC's objective in re-distributing monthly flows. If the goal is mimicking natural flow, the Nechako Reservoir inflow hydrograph would be the most appropriate to mimic. If the goal is matching the timing of local inflow downstream of the reservoir, then the Stellako hydrograph is more appropriate.[59]
- Each flow scenario projects an ***annualized release from Kenney Dam of 25 m^3/s for a hypothetical hydroelectric power generation unit***.[60] This is intended to ensure

[56] At the present time, a minimum of 60 m3/s base flow must be delivered to the Nechako River at Cheslatta Falls during the sockeye migration and annual Summer Temperature Management Period (STMP) from July 10 to August 20. Modeling for the Nechako Environmental Enhancement Fund Management Committee [NEEFMC] by Triton Environmental Consultants Ltd. showed that cooling flows are usually delivered 60% in the July period and 40% in the August period.

[57] This estimate is based on information from Fisheries and Oceans Canada and the Nechako Fisheries Conservation Program

[58] At the time of writing, Triton Environmental Consultants Ltd. is currently preparing a report that will summarize the work done by Alcan on the analysis of the implications of choosing different levels of annualized flow release from Skins Lake Spillway , and work the Nechako Watershed Council has done to communicate with the Cheslatta and Ootsa First Nations people to consider their preferences. Some of this communication included helicopter over-flights, visits to the river at various flows and a canoe party paddling the river at one flow, and the chief of the Cheslatta First Nation visiting the river at one of the proposed flows to give his opinion.

[59] Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC. Section 2.4

[60] This number was chosen based on analysis conducted by Klohn-Crippen (an engineering firm) as outlined in a letter report from Chris Wilson (Klohn-Crippen) entitled "*Hydroelectric Power Generation at a Water Release Facility at Kenney Dam*" submitted to K.Haun, P.Eng., Nechako Watershed Council Member on October 10, 2000. This analysis was also presented to the Nechako

enough flow to make power generation at Kenney Dam economically viable based on an initial analysis of flow requirements for the power generators available in 2000. It is possible that more recent versions of those power generators may be able to generate the same power output more efficiently, therefore requiring less water.

It is the combination of all these assumptions that results in the calculation of the available volume of freed up flows being 12.9 m^3/s under average reservoir inflow conditions.

The NWC has not yet specifically discussed whether it is in full agreement about the validity of each of these key assumptions.

During a recent update of the N-DAM results[61], the impact of changing two of these assumptions was tested. In general, here is what the results show:

- ***Lowering the temperature target for flow releases*** from the proposed CWRF at Kenney Dam from 12°C to 10°C can provide a bit more freed up flow (i.e., more than 12.9 m^3/s on average) that can be released to the river. The model outcomes are generally otherwise unaffected.
- ***Increasing the targeted annualized release for hypothetical power generation at Kenney Dam*** from 25 m^3/s to 26.4 m^3/s has the effect of increasing the winter flows somewhat, with an equivalent decrease in the summer flows. The percentage change impacts, however, appears small and as a result, the model outcomes are generally unaffected.

No sensitivity analysis has been conducted on the impact of changing the assumed volume and timing of releases from Skins Lake Spillway given that the NWC appear to be in emerging agreement about the appropriateness of those assumed releases (although as noted above, agreement has not yet been formally tested).

4.2.5 Measuring the Impact of Flow Scenarios on NWC Interests[62]

For each flow scenario it simulates, N-DAM conducts 13 tests to measure the success of a given scenario in meeting the interests/needs of stakeholders:

1. NFCP Column I Flows
2. NFCP Historical Monthly Flows
3. Sturgeon Conservation Flows at Cheslatta
4. Sturgeon Conservation Flows at Vanderhoof
5. Sturgeon Conservation Flows at Isle Pierre
6. NWC Murray-Cheslatta Fish &
7. NWC Kenney Dam Power & Economic Development Flows
8. NWC Fencing Flows for Cattle
9. NWC Float Plane flows
10. NWC Canoe Flows
11. NWC Irrigation Flows
12. NWC Required Flow before Flooding
13. N-DAM Solution vs. Naturalized Solution ("Test of Fit")

Watershed Council by a representative of Klohn-Crippen at an NWC meeting on October 20, 2000 ("Some Key Issues Related to the Feasibility of Hydro Generation at Water Release Facility at Kenney Dam".

[61] Dan Bouillon (Alcan Inc.). 2004. *Nechako Downstream Allocation Model (N-DAM): DRAFT Simulation Results.* November 4, 2004.

[62] Most information in this section (including graphs and figures) is excerpted from the following report. Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC.

Economic Interests

The tests are specified as flow thresholds, based on the flow targets established during the initial water balance & flow modeling exercise (see Section 4.1). The tests evaluate success by comparing the N-DAM solution flows to the target flows for each test in each month. For each flow scenario, the model records whether a test is passed; if it is not passed, it records the shortfall below the target flow. The total number of tests passed and the shortfall in flow is presented as the overall test of a particular flow alternative.

The tests are of two general types of tests: threshold tests (#1-12) and the "test of fit", described in the following two sections.

4.2.5.1 Threshold Tests (#1-12)

The primary type of test is a threshold mean monthly flow that must be met in each month of the year for a test to succeed. This category includes Tests #1 through #12, listed above. For example, Nechako Fisheries Conservation Program (NFCP) Column 1 Flows for each month, specified in the 1987 Settlement Agreement, must be met or exceeded in any given month for a particular alternative to pass Test #1. Also included in this category are those tests that specify mean monthly flows for only part of the year. For example, flows for fencing cattle (Test #8) and canoeing flows (Test #10) are required from May through September only, and float plane flows are required from May through October only (Test #9).

The results of these tests can be presented in a number of ways. The first way is as a hydrograph comparing the N-DAM 'solution' flow pattern with the targeted flow pattern for that interest. Figure 4-4 provides an example using Test #3 and compares of the simulated N-DAM solution with targeted flows for canoeing (as measured at Cheslatta Falls[63]). The test passes in 10 out of 12 months and fails in 2 months (August and September) as noted in Table 4-4. The flow pattern solution simulated by N-DAM falls short of meeting the ideal flow target levels identified by canoeists by about 2.6 m^3/s in August and 21.9 m^3/s in September. The result is total annual shortfall of about 25 m^3/s, as shown in Table 4-5. Note that Figure 4-4 is only one graph representing the results of one Test for one flow scenario. Since there are 12 Tests and 8 flow scenarios were modeled, a total of 96 graphs (including this one) have been generated using N-DAM.

[63] As noted in Section 4.1, all of the annualized flow targets designed to meet specific NWC objectives have all been translated into flow requirements as measured at Cheslatta Falls as the common reference point (even if this is not the specific location where the equivalent flow level is desired by that particular interest). This was done so that the N-DAM model could generate simulated flow results for a single location and these could be used to understand the implications across all interests.

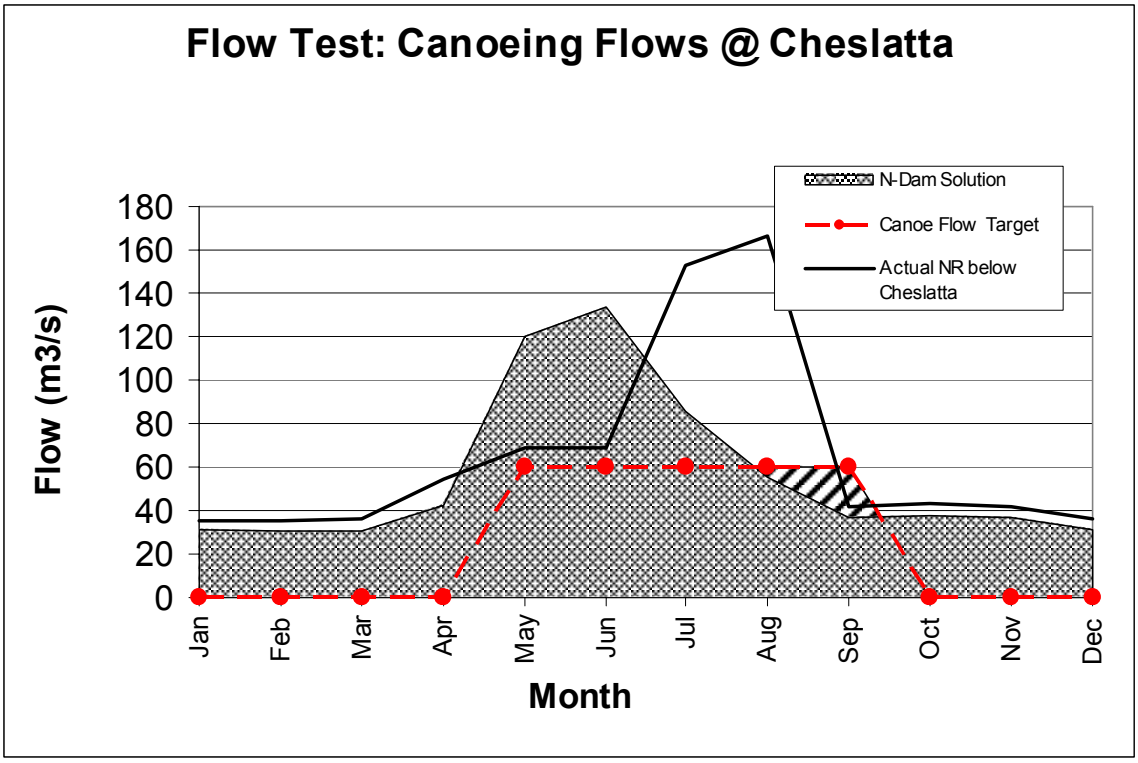

Figure 4-4: Example of flow test. Comparison of the N-DAM solution (large shaded area) with canoeing target flows (dashed line with dots) as measured at Cheslatta Falls. The small area with the diagonal lines shows the shortfall between the N-DAM solution and the target flows in the months of August and September when the targets are not achieved. The solid black line shows average flow conditions in the Nechako River under the current flow regime based on recent historical data.

Each of the N-DAM model generates test results for each of the 12 tests for all 8 scenarios, which means there 96 graphs like the ones shown in Figures 4-4 and 4-5. While each of these graphs tells a useful story about the implications of a particular flow scenario for a specific interest, it is not possible to use these graphs to compare the results of the test across interests and across flow scenarios at the same time.

A different way of looking at the results is in summary tables like Tables 4-4 and 4-5. These tables record the number of monthly failures and the total annual flow shortfall (the difference between the N-DAM solution flow pattern and the targeted flow pattern for that interest for all the months when the target flow is not met). These tables allow for a comparison of test scores across the eight flow scenarios. In Table 4-4, the lower the number of monthly failures the better; in Table 4-5, the lower the amount of the annual shortfall the better (i.e., zero is the best score in both tables). The bottom row in each table provides summary statistics for across all interests for each flow scenario. In Table 4-4, this summary statistic is expressed as the percentage of monthly tests that are passed across all interests for each flow scenario.

Table 4-4: N-DAM Test scores (expressed as monthly failures) for eight flow scenarios. Each of the test scores below represents the number of months when the simulated N-DAM flows did not meet the targeted flows for a particular objective or interest. The final row summarizes these results as the percentage of monthly tests for all interests that are passed for each flow scenario.

NUMBER OF MONTHLY FAILURES FOR EACH TEST (lower score is better)	***POST-CWRF FLOW SCENARIO***							
	#1	***#2***	***#3***	***#4***	***#5***	***#6***	***#7***	***#8***
Test 1 - NFCP Column 1 Flows	1	1	1	1	1	1	1	1
Test 2 - NFCP Historical Monthly Flows	0	0	0	0	0	0	0	0
Test 3 - Sturgeon Conservation Flows at Cheslatta	12	12	12	12	12	12	12	12
Test 4 - Sturgeon Conservation Flows at Vanderhoof	8	8	9	9	10	10	10	10
Test 5 - Sturgeon Conservation Flows at Isle Pierre	0	0	1	1	1	1	1	1
Test 6 - NWC Murray-Cheslatta Fish & Economic Interests	0	0	0	0	0	0	0	0
Test 7 - NWC Kenney Dam Power & Economic Development Flows	0	0	0	0	0	0	0	0
Test 8 - NWC Fencing Flows for Cattle	1	1	1	1	1	1	1	1
Test 9 - NWC Float Plane flows	2	2	2	2	2	2	2	2
Test 10 NWC Canoe Flows	2	2	2	2	2	2	2	2
Test 11- NWC Irrigation Flows	0	0	0	0	0	0	0	0
Test 12- NWC Required Flow before Flooding	0	0	0	0	0	0	0	0
Percentage (%) of Total Monthly Tests Passed for All Interests	**95**	**95**	**94**	**94**	**94**	**94**	**94**	**94**

The results in Table 4-4 suggest that the more freed up flow is allocated to the Nechako River (instead of to the Nechako River) on an annual basis, the more NWC interests can be met.

Table 4-5: N-DAM Test scores (expressed as flow shortfalls) for eight flow scenarios. Each of the test scores below represents the total annual sum of the shortfall or difference between the simulated N-DAM flows and the targeted flows for each month when the N-DAM flows fell short of the target. All the scores are presented as flow shortfalls expressed in cubic meters per second (m^3/s). The row at the bottom of the table provides a summary statistic expressed as the average monthly shortfall for each monthly test failed across interests for that flow scenario)

TOTAL ANNUAL SUM OF MONTHLY SHORTFALLS FOR FAILURES OF EACH TEST	*POST-CWRF FLOW SCENARIO*							
	#1	*#2*	*#3*	*#4*	*#5*	*#6*	*#7*	*#8*
Test 1 - NFCP Column 1 Flows	13	14	15	15	17	17	17	17
Test 2 - NFCP Historical Monthly Flows	-	-	-	-	-	-	-	-
Test 3 - Sturgeon Conservation Flows at Cheslatta	340	364	381	389	412	436	454	460
Test 4 - Sturgeon Conservation Flows at Vanderhoof	110	128	145	150	173	197	215	221
Test 5 - Sturgeon Conservation Flows at Isle Pierre	-	-	3	5	14	25	34	37
Test 6 - NWC Murray-Cheslatta Fish & Economic Interests	-	-	-	-	-	-	-	-
Test 7 - NWC Kenney Dam Power & Economic Development Flows	-	-	-	-	-	-	-	-
Test 8 - NWC Fencing Flows for Cattle	12	12	12	12	12	12	12	12
Test 9 - NWC Float Plane flows	9	8	9	9	9	9	9	9
Test 10 NWC Canoe Flows	25	25	25	25	25	25	25	25
Test 11- NWC Irrigation Flows	-	-	-	-	-	-	-	-
Test 12- NWC Required Flow before Flooding	-	-	-	-	-	-	-	-
Average Monthly Shortfall per Monthly Test Failed (m^3/s)	**9**	**9**	**8**	**8**	**10**	**12**	**13**	**14**

As with Table 4-4, the results in Table 4-5 also suggest that the more freed up flow is allocated to the Nechako River (instead of to the Nechako Reservoir) on an annual basis, the more interests can be met.

In summary, the N-DAM tests determine success by comparing the N-DAM solution to the test flows of interest on each calendar month. When the N-DAM solution is less than the flow target, the model notes a failure has occurred and sums this, along with each successful test, to calculate the percentage of tests passed. With 12 tests scored for each of the eight flow scenarios, a total of 96 sets of test results are generated. The model also records the magnitude of test failure. The difference between the N-DAM solution and the test of interest is calculated each month for each test. The total shortfall is summed for all tests and presented in units of cubic meters per second (m^3/s or cms).

Special Case: A Note on Sturgeon Flow Targets (Tests #3, 4 and 5)

Figure 4-5 shows the most extreme case of failure to meet flow targets. In this case, the example concerns the results Test #3 for targeted sturgeon flows (as measured at Cheslatta Falls) in Flow Scenario #8. Again, the N-DAM solution is in cubic meters per second (m^3/s) by month, denoted by the shaded grey area. The sturgeon target flows (as measured at

Cheslatta Falls) are shown as the red line with pink shaded area (above the shaded green area). For comparison, the existing flows at Cheslatta Falls are also shown (black line). The N-DAM solution fails to meet this target in all twelve months (as noted in Table 4-4), and the total annualized shortfall is 460 m^3/s (as noted in Table 4-5). *Note that the ideal or targeted Cheslatta sturgeon flows are a theoretical calculation of the amount of water required for survival based on an assumption that the Cheslatta Falls portion of the Nechako River is important sturgeon habitat and that sturgeon need a minimum percentage of historical flows to survive. Neither of these assumptions has been substantiated scientifically at this point.*

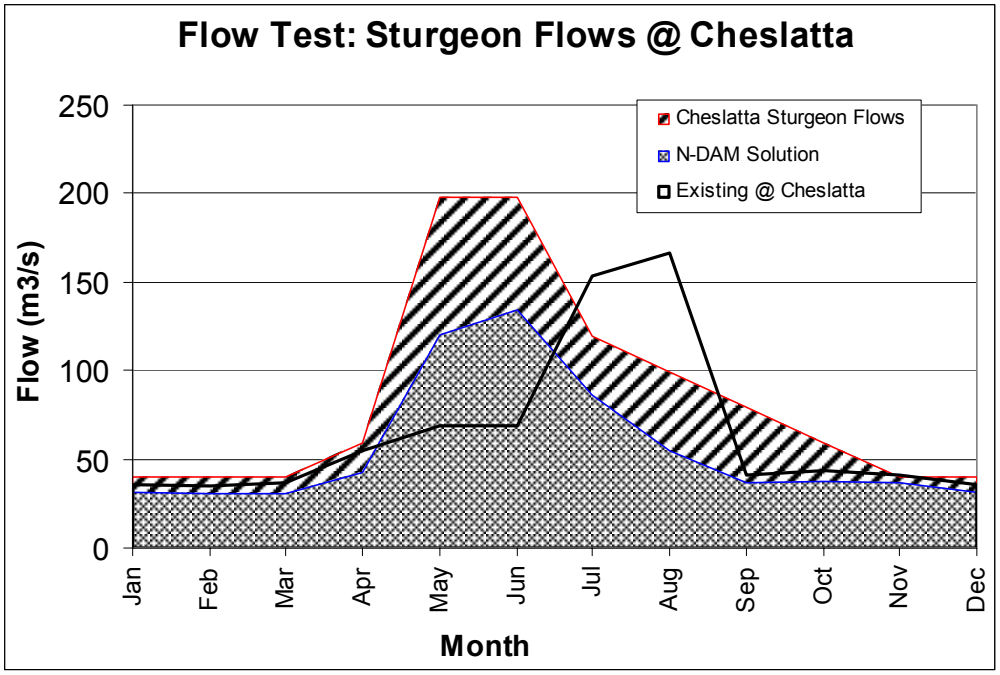

Figure 4-5: Example of flow test: comparison of the N-DAM solution (large shaded area at the bottom of the graph) with targeted Cheslatta sturgeon flows, where the area filled with diagonal line pattern shows the difference between the two flow regimes. The black line shows average flow conditions in the Nechako River at Cheslatta Falls under the current flow regime based on recent historical data.

The percentage of historical flows (also know as Mean Annual Discharge or MAD) required for sturgeon survival is calculated based primarily on studies of salmon in the Nechako River, not sturgeon, and therefore the results should be interpreted with caution. There is currently no specific information available regarding scientifically proven flow requirements for Sturgeon in the Nechako River system. The Nechako Sturgeon Recovery Team has been working on developing recommended flows for the Nechako Sturgeon, but given the current lack of information, they have only been able to provided a set of generalized flow principles for the redistribution of flows that the team generally believes is beneficial to sturgeon based on their best collective professional judgement[64]. These flow principles are generally respected in the flow scenarios modeled to date using the Nechako Downstream Allocation Model (N-DAM).

[64] Nechako River White Sturgeon Recovery Initiative. November 2004. *Flow Principles to Guide Nechako River Hydrograph Development*. Prepared by the Nechako Sturgeon Recovery Team. Distributed to the NWC at their meeting on November 19, 2004 in Smithers, BC.

4.2.5.2 Comparison with Naturalized Solution ("Test of Fit" or Test #13)

The second type of N-DAM test is that used to compare the fit of the N-DAM solution and the naturalized solution (Test #13). The naturalized solution has the same mean annual flow as the N-DAM solution, but has a different distribution of flow between months. N-DAM creates a naturalized hydrograph by summing the total flow of water delivered to the Nechako River just below Cheslatta Falls. The model then re-distributes this flow monthly using the hydrograph of the average natural inflow to the Nechako Reservoir as a template to generate a corresponding natural seasonal flow pattern for the Nechako River downstream[65]. The "fit" or the difference between the N-DAM solution and the naturalized hydrograph is calculated by adding together differences in flow each month. Both N-DAM monthly flow under and over the naturalized solution contribute to the difference between the two regimes.

The results of these tests can be presented in a number of ways. The first way is as a hydrograph comparing the N-DAM solution flow pattern with the naturalized flow pattern for that interest. Figure 4-6 provides an example. In this comparison, the two flow regimes (i.e., the initial N-DAM flow scenario and a second scenario where the flows are redistributed to mimic a more natural hydrograph) are similar, with differences shown in the shaded area between the two lines. The regimes differ slightly in each month, but the outcome depicted here shows a very high similarity between the N-DAM solution and the best possible theoretical naturalized solution if all constraints on monthly flow distribution were removed. When looking at "test of fit" results as hydrograph, the better the fit to the "naturalized" redistribution, generally the better the modeled outcome mimics a natural rive hydrograph.

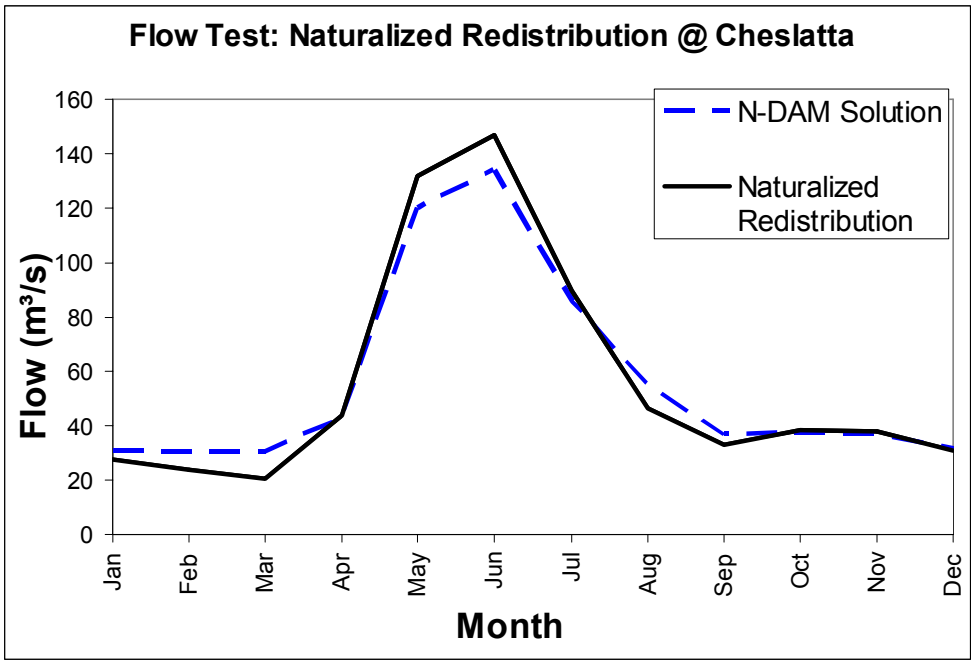

Figure 4-6: Example of flow test. Comparison of the N-DAM solution (dashed line) with naturalized redistribution at Cheslatta (solid line) to mimic a natural river hydrograph. The area between the two lines is the difference between the two flow regimes.

[65] The Natural Reservoir Inflow template differs from that used to distribute the Skins Lake Spillway (SLS) hydrograph, though it is not specified why in the N-DAM model. The SLS hydrograph has been naturalized with a different template hydrograph than the naturalized alternative, implying that the two regimes will not match unless the two templates are identical.

Since it can be difficult to visually compare the differences between test results across all eight flow scenarios when looking at hydrographs, the results are also summarized for the eight N-DAM flow scenarios in Table 4-6. This table presents a summary statistic that paints a picture of the "fit" or difference between N-DAM solution hydrograph and the naturalized hydrograph. The score represents the sum of the monthly flow differences between the N-DAM simulated flows and the theoretical naturalized flows (i.e., the equivalent of the shaded area on the hydrograph in Figure 4-6). Unlike Table 4-5 where only the shortfalls are included (i.e., the difference between N-DAM flows and the targets only for the months when the target is not achieved), Table 4-6 includes the difference between monthly flows both over and under the naturalized flow.

Table 4-6: N-DAM "Test of Fit" scores expressed as the annual total of all the monthly differences between the simulated N-DAM flows and the naturalized flows.

TEST OF FIT	*POST-CWRF FLOW SCENARIO*							
	#1	*#2*	*#3*	*#4*	*#5*	*#6*	*#7*	*#8*
Test 13 - Annual sum of monthly differences between simulated N-DAM flows & naturalized flows	79	92	101	105	119	142	163	170

A lower score is better and indicates less difference between the N-DAM simulated flow and the naturalized flow, meaning a better "fit".

As with Tables 4-4 and 4-5, the results in Table 4-6 also suggests that the more freed up flow is allocated to the Nechako River on an annual basis, the more effectively a broad range of interests can be met.

For a more detailed summary of the hydrographs and test results for each of the eight flow scenarios modelled to date using N-DAM, see Appendix C.

4.2.6 Learning from the N-DAM Results

N-DAM is a useful tool for comparing alternative downstream flow allocation scenarios and their impact on specific flow-related interests. However, it does have two key limitations:

- N-DAM uses monthly averages which limits the quality of detail.
- N-DAM does not incorporate reservoir level or predicted inflow, and therefore does not allow assessment of impact of choices on reservoir level.

That being said, some valuable conclusions can be drawn from the N-DAM simulations:

- Under a wide variety of freed up flow sharing solutions, many of the NWC flow interests can be substantially met.
- In many cases, the hydrograph shape developed under average conditions also appears to be robust for low and high flow conditions (i.e., a more naturalized hydrograph could be achieved even in high and low inflow years).
- Some interests cannot be met under any realistic combination of the choices modeled to date (e.g. cattle and float plane needs in October).
- The greater the amount of freed up flow allocated for releases the Nechako River, the more effectively NWC interests can be met.

4.3 Nechako Reservoir Operation Model

The Nechako Reservoir Operation Model was designed by Louise Remillard (Alcan Inc.) to help the NWC develop a better understanding of the availability of stored water in the Nechako Reservoir under different inflow conditions. This model acknowledges that it may not always be possible to achieve the NWC's optimal flow targets and meet all of Alcan's annual commitments to deliver power from Kemano every year or at certain times of the year depending on the availability of water stored in the Nechako Reservoir[66]. The Nechako Reservoir Operation Model also highlights some of the difficult choices that the NWC may have to make in designing a flow regime that balances flow-related interests in low inflow years.

The value of the model was mainly to provide information regarding the impact of different freed up flow (FUF) flow sharing scenarios on the reservoir elevation and Kemano generation. The NWC's use of this model also has raised the possibility that linking downstream flow choices to reservoir inflows and/or levels could result in the development of variable flow release schedule that better achieves the collective interests of the NWC. The model was helpful in determining the probability of the annual average releases to the Nechako River for the flow scenarios based on a variable flow sharing formula (see Section 4.3.3), or in other words, how frequently (in how many years) all the freed up flow could be released to the Nechako River (vs. the Kemano River), and how often a smaller portion of the freed up flow could be released to the Nechako River.

4.3.1 Methodology and Assumptions[67]

The Nechako Reservoir Operation Model attempts to reflect the day-to-day operation of the reservoir (i.e., it uses daily inflow data as an input, and generates daily outflow data as an output). Although we have no way to predict the future, we can make a general assumption that inflows in the future will be similar to those experienced in the past – at least in terms of year-to-year variability which is a key factor when looking at potential future outcomes. Therefore, the Nechako Reservoir Operation Model uses the 48 years of daily reservoir inflow data[68] available for the period from 1955 to 2002 to simulate what would happen under those inflow conditions under different scenarios for allocating freed up flows. This is a way of projecting what could happen once a CWRF is constructed at Kenney Dam under realistic reservoir inflow conditions (based on historical data).

These simulations mirror actual day-to-day operation with updated operational constraints, including:

- Reservoir elevation restrictions (safety and legal)
- Power generation commitments (to meet the needs of the Kitimat Smelter, transmission line losses, and long term firm energy sales contracts)
- Spillway release requirements to provide flows for fish conservation & protection (as outlined in the 1987 Settlement Agreement).

For the post-CWRF scenarios, the monthly releases to the Nechako River were based on simulations using the Nechako Downstream Allocation Model (N-DAM) described in Section 4.2.

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[66] The simulated results of the Reservoir Operation Model (described later in this section) show that it should always be possible to respect the minimum releases to the Nechako River, even in low inflow years, but that in order to supply those flows, Alcan might have to reduce its generation at the Kemano powerhouse and would therefore not be able to respect the energy commitments.

[67] Information in this section (including graphs and figures) are all drawn from work completed by Louise Remillard (Alcan Inc.) presented to the NWC at a variety of meetings. .

[68] Kemano releases, Skins Lake releases and resultant reservoir elevation

In other words, the results (output) of the N-DAM simulations were used as inputs to the Nechako Reservoir Operation Model.

The Nechako Reservoir Operation model treats each of the annualized level of freed up flow allocated to the Nechako River (e.g., 0, 2, 5, 8, 10 m^3/s) as a fixed constraint; in other words, the model finds a "solution" of flow releases that always delivers that amount of freed up flow to the Nechako River, even if that requires decreasing power generation at Kemano. In arriving at a "solution" for each scenario, the model also simulates forced spills (which are released in addition to the base flow and the freed up flow allocated to the river) to ensure dam safety. The Nechako Reservoir Operation Model also takes into account the hydraulic characteristics of the system (e.g., reservoir storage curve, generation curve) in making its calculations.

Figure 4-7 provides a schematic diagram outlining the inputs to the model (historical inflow data), the constraints applied to operations and flow releases (outlined in the bullets above), and the outputs of the model (projected volume of water available for release from the reservoir)[69].

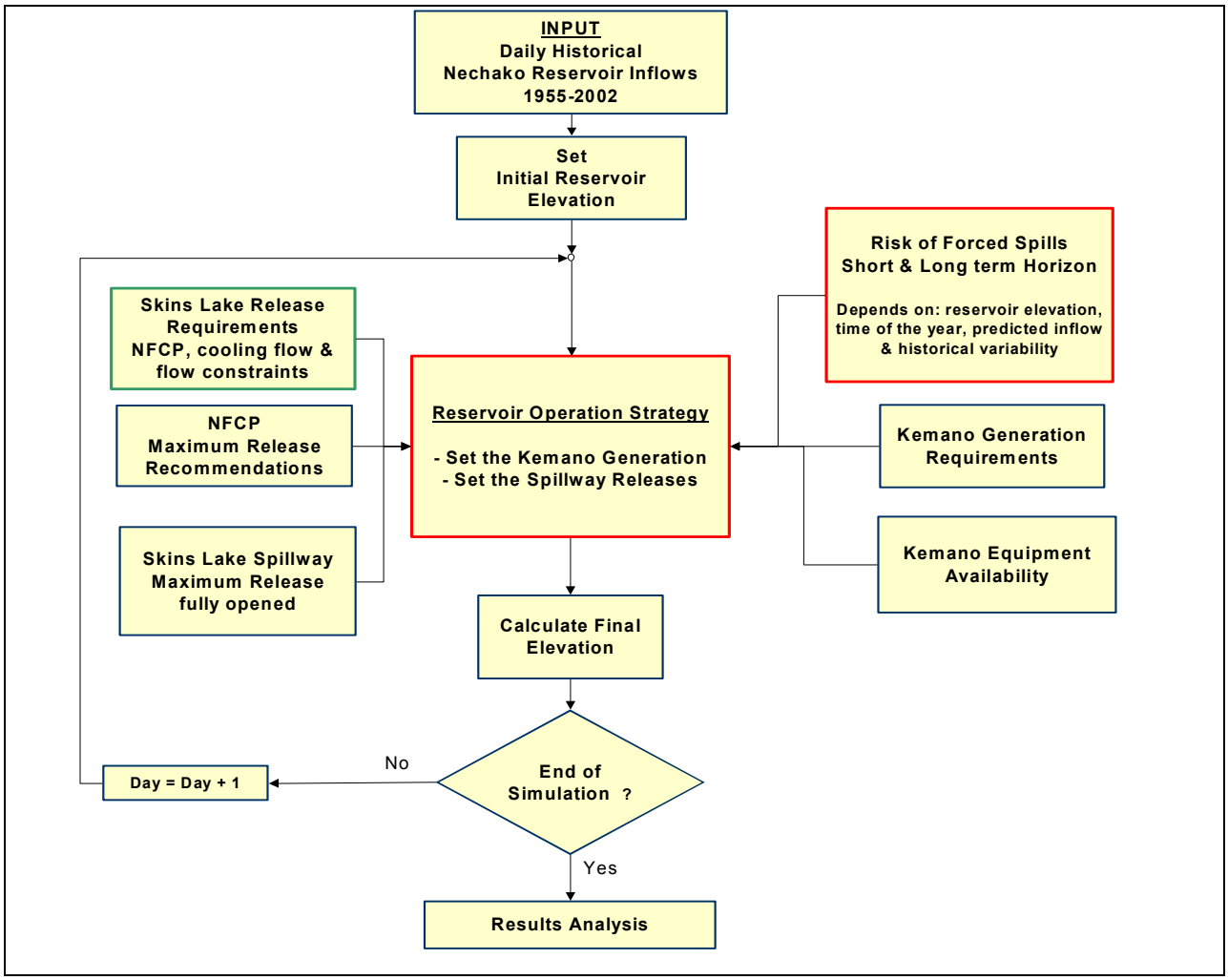

Figure 4-7: Schematic of the Nechako Reservoir Operation Model

[69] Diagram provided by Louise Remillard (Alcan Inc.) 2004.

Two main categories of simulations were performed using the Nechako Reservoir Operation Model, based on different flow formulas:

- Fixed Flow Sharing Formula – Some of the scenarios that were modelled involved setting a fixed ratio for allocating freed up flows between the Nechako Reservoir and the Nechako River (i.e., the amount of water allocated is the same each year).
- Variable Flow Sharing Formula – One scenario involved allowing the ratio of freed up flows allocated to the Nechako Reservoir versus the Nechako River to vary from year to year based on reservoir elevations and inflow conditions.

The next two sections describe the results of the simulations based on each of these formulas.

4.3.2 Results of the Model under Fixed Scenarios for Sharing Freed Up Flow[70]

Five fixed scenarios were modeled using the Nechako Reservoir Operation Model. Each scenario assumes a different amount of annualized freed up flow stays in the reservoir (0, 2, 5, 8, and 10 m^3/s). Unless the Reservoir would be high enough to release more water, then the simulated annual average releases to the Nechako River and to the Kemano River were calculated for each scenario. The results under a range of Nechako Reservoir inflow conditions (minimum, average and maximum) are summarized in Tables 4-7 and 4-8 respectively.

Table 4-7: Simulated annual average releases to the Nechako River under fixed flow sharing scenarios based on historical reservoir inflow

Nechako Reservoir Inflow Conditions	Simulated annual average releases to the Nechako River (m^3/s)					
	Without CWRF (1)	0 m^3/s in the reservoir (2)	2 m^3/s in the reservoir	5 m^3/s in the reservoir	8 m^3/s in the reservoir	10 m^3/s in the reservoir
Minimum (3)	52.5	52.4	50.4	47.4	44.4	42.4
Average (4)	70.2	69.5	68.4	67.3	65.8	65.0
Maximum (5)	181.8	180.8	182.5	184.5	184.5	185.1

Notes:

1. Included for comparison purposes.
2. This means that all of the freed up flow is being released to the Nechako River.
3. This is the minimum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).
4. This is the average flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).
5. This is the maximum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).

In essence, the Nechako Reservoir Operation Model uses real historical reservoir inflow data and shows how much freed up flow would have been available for release to the Nechako River for each flow sharing scenario under a range of reservoir inflow conditions if a cold water release facility had been built in the 1950's. For example, if the NWC chose to set a

[70] Information in this section (including graphs and figures) are all drawn from a power point presentation delivered by Louise Remillard (Alcan Inc.) to the Nechako Watershed Council in June 2003.

fixed flow sharing scenario that allowed 5 m^3/s to remain in the Nechako Reservoir each year, then 67.3 m^3/s of flow (including base flows, cooling flows, freed-up flows and additional spills required for flood and reservoir elevation control) would be available for release to the Nechako River if there was average inflow to the Nechako Reservoir that year. Or, another way of reading the results in the table is that if the NWC chose to set a fixed flow sharing scenario that allowed 5 m^3/s to remain in the Nechako Reservoir each year, then between 47.4 m^3/s and 184.5 m^3/s (including base, cooling, and free-up flows and required spills) would be available for release to the Nechako River that year depending on Nechako Reservoir levels and inflows that year.

Similarly, reading the corresponding information in Table 4-8, if the NWC chose to set a fixed flow sharing scenario that allowed 5 m^3/s to remain in the Nechako Reservoir each year, then between 96.7 m^3/s and 137.8 m^3/s would be available for release to the Kemano River (through the powerhouse) that year depending on the amount of inflow to the Nechako Reservoir that year.

Table 4-8: Simulated annual average releases to the Kemano River under fixed flow sharing scenarios based on historical data

Nechako Reservoir Inflow Conditions	Simulated annual average releases to the Kemano River (m^3/s)					
	Without CWRF (1)	0 m^3/s in the reservoir (2)	2 m^3/s in the reservoir	5 m^3/s in the reservoir	8 m^3/s in the reservoir	10 m^3/s in the reservoir
Minimum (3)	93.9	93.9	93.9	96.7	99.8	103.0
Average (4)	125.5	126.2	127.3	128.4	129.9	129.8
Maximum (5)	137.6	137.7	137.7	137.8	137.8	137.8

Notes:

1. Included for comparison purposes.
2. This means that all of the freed up flow is being released to the Nechako River.
3. This is the minimum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).
4. This is the average flow release observed for all the 48 years of simulated data.
5. This is the maximum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).

When the modelers compare the expected releases to the Nechako River (summarized in Table 4-7) against the monthly flow targets developed to meet various interests (from Table 4-1 earlier in this chapter), the results show that none of the fixed flow sharing scenarios is able to meet all of the flow targets, and optimally address the underlying interests.[71] However, in general, the more freed up flow is allocated to the Nechako River, the more successful the scenario is in addressing a variety of interests. This is demonstrated in the following series of figures.

[71] Bouillon, Dan. October 2004. Personal communication.

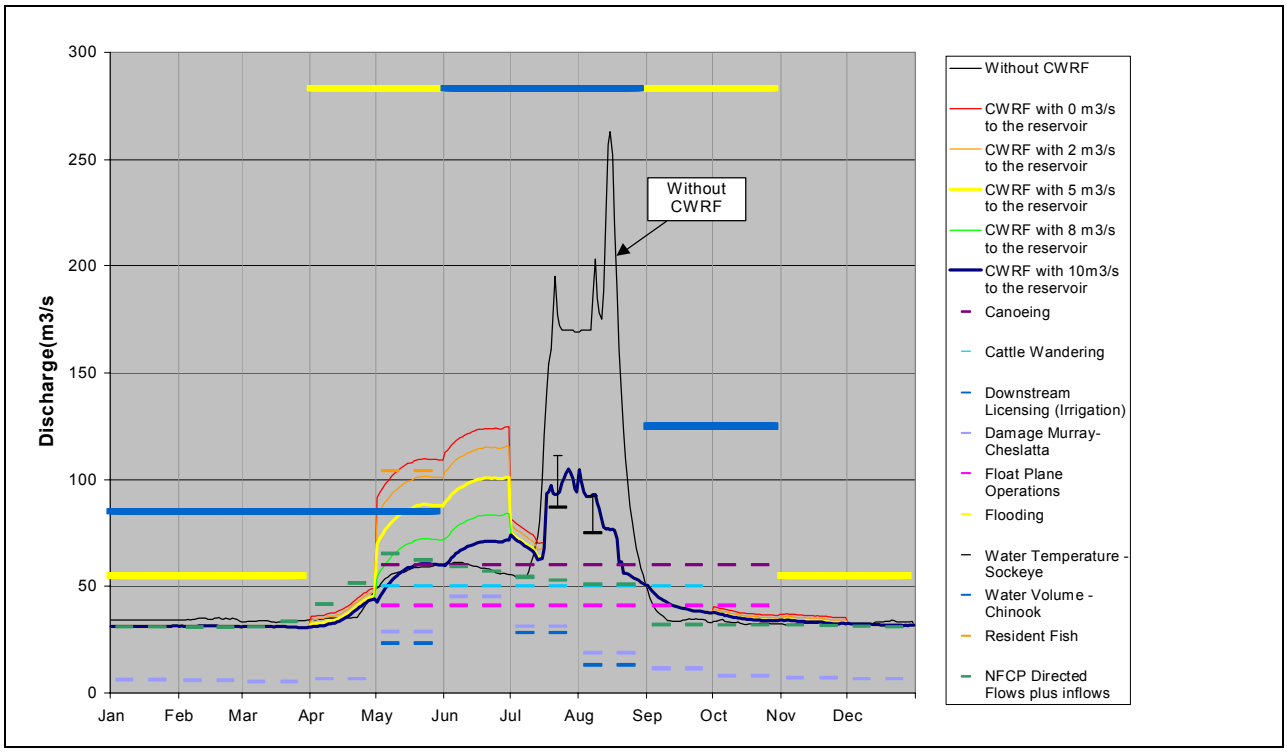

Figure 4-8: Nechako Reservoir Operations Model simulation results for Nechako River Discharge at Cheslatta Falls. One of the hydrograph lines is labeled to show expected flow conditions downstream in the absence of a cold water release facility (CWRF). The other hydrograph lines each represent a different fixed flow scenario that could be implemented if a CWRF were constructed. They range from allowing all freed up flow to be released downstream (labeled "CWRF with O m^3/s to the reservoir") to allowing only 3 m^3/s of freed up flow to be released downstream (labeled "CWRF with 10 m^3/s to the reservoir"). The horizontal dashed lines and heavy bold lines represent various minimum, maximum and target flow limitation designed to meet NWC interests. The biggest difference in the impact of the flow scenarios is seen in the months of May and June. In those months, the greater the amount of freed up flow released downstream (the less is held in the reservoir), the greater the likelihood of accomodating all NWC interests.[72]

[72] Source: Louise Remillard (Alcan Inc.). 2004.

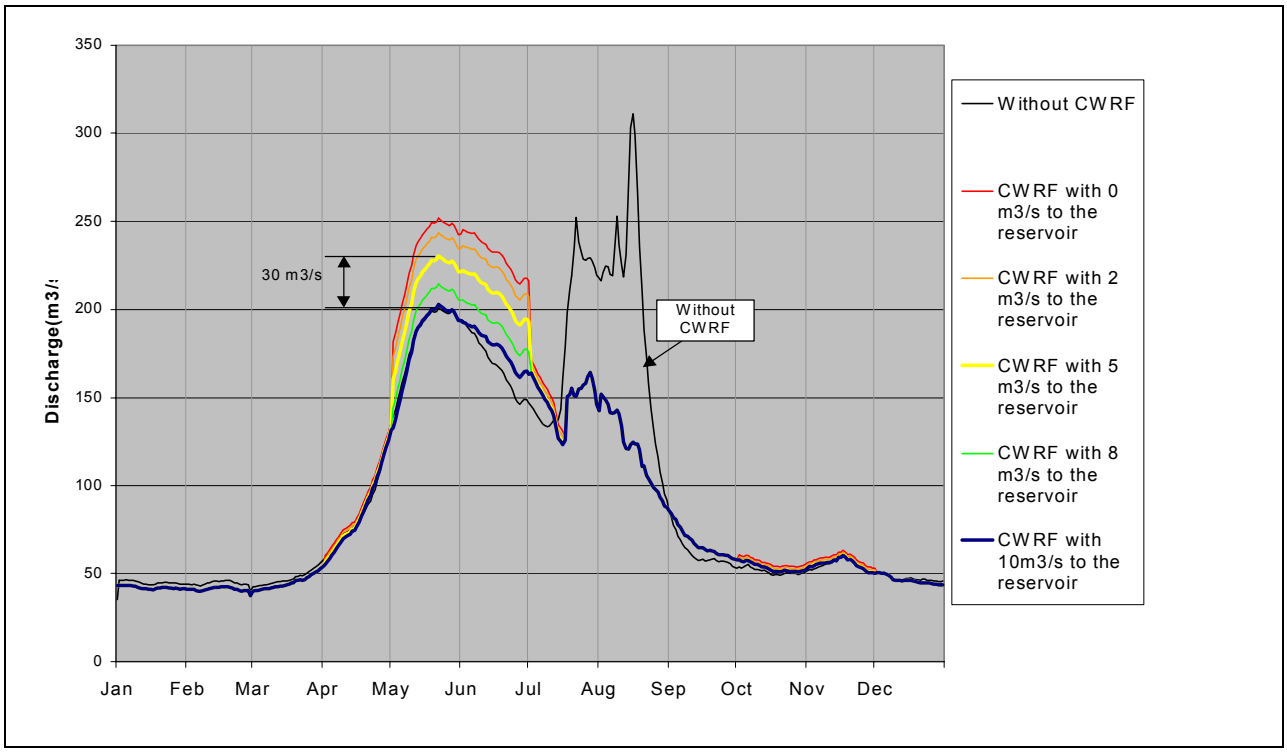

Figure 4-9: Nechako Reservoir Operations Model simulation results for Nechako River Discharge at Vanderhoof. One of the hydrograph lines is labeled to show expected flow conditions downstream in the absence of a cold water release facility (CWRF). The other hydrograph lines each represent a different fixed flow scenario that could be implemented if a CWRF were constructed. They range from allowing all freed up flow to be released downstream (labeled "CWRF with O m^3/s to the reservoir") to allowing only 3 m^3/s of freed up flow to be released downstream (labeled "CWRF with 10 m^3/s to the reservoir"). The biggest difference between the scenarios is in the flow levels for the months of May and June (i.e., the more water is released downstream – or the less is held in the reservoir – the higher the expected flows in those two months).

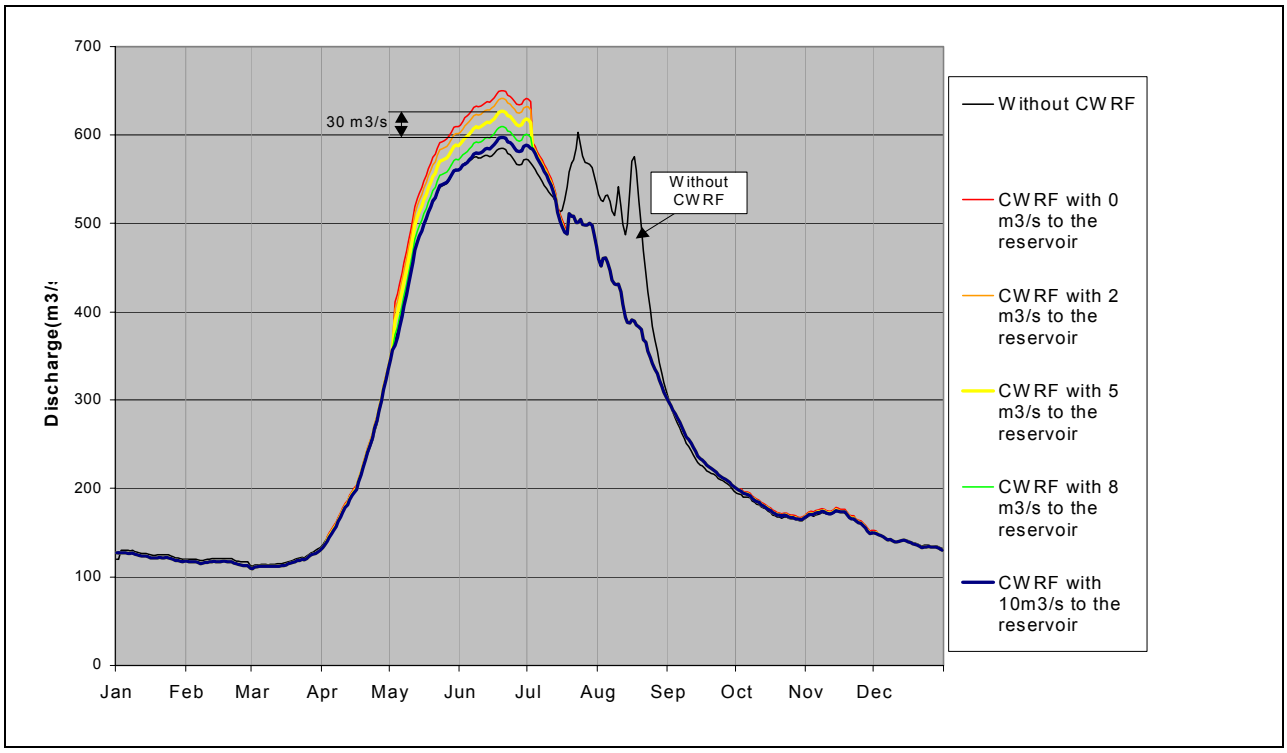

Figure 4-10: Nechako Reservoir Operations Model simulation results for Nechako River Discharge at Isle Pierre. One of the hydrograph lines is labeled to show expected flow conditions downstream in the absence of a cold water release facility (CWRF). The other hydrograph lines each represent a different fixed flow scenario that could be implemented if a CWRF were constructed. They range from allowing all freed up flow to be released downstream (labeled "CWRF with O m^3/s to the reservoir") to allowing only 3 m^3/s of freed up flow to be released downstream (labeled "CWRF with 10 m^3/s to the reservoir").

4.3.3 Results of the Model under Variable Scenario for Sharing Freed Up Flow[73]

Based on the results of the fixed scenario modeling (outlined in the previous section), the modelers and NWC members began to ask: *might there be a different way of sharing the freed up flows that could optimize the achievement of interests downstream and upstream?* In response, the variable flow sharing concept was put forward.

It was determined that a practical way - from a reservoir management point of view - to link freed up flow allocation with variable reservoir conditions (levels and inflows) was to use the observed reservoir level on May 1st each year and the predicted inflow from May 1st to August 31st (May 1st is the earliest date a reliable prediction can be made of the expected summer inflow based on accumulated snow pack and reservoir level). The decision would be made based on the projected elevation for September 1st. The resulting variable formula allows for the sharing of freed up flows between the Nechako Reservoir and the Nechako River to vary depending on the hydrological conditions in the reservoir (current elevation & inflow forecast) according to the following criteria:

[73] Information in this section (including graphs and figures) are drawn from a power point presentation delivered by Louise Remillard (Alcan Inc.) to the Nechako Watershed Council in June 2003. Clarifications were added through personal communication in October 2004.

- All the freed up flow is returned to the Nechako River if the risk of major spilling is greater than 5%.
- Between 0 and 5 m^3/s of freed up flow is kept in the Nechako Reservoir to maintain the reservoir in the normal zone of operation (the zone where the risk of forced spilling and the risk of having to decrease power generation are both acceptable).
- Between 5 and 10 m^3/s of freed up flow are kept in the Nechako Reservoir to avoid the risk of having to decrease power generation at Kemano (i.e., not being able to meet Alcan's minimum long-term energy commitments).
- A maximum of 10 m^3/s would be kept in the Nechako Reservoir only in very critical conditions (i.e., low reservoir levels combined with low inflows).

Assuming similar year-to-year variability of future inflows and historical inflows to the Nechako Reservoir, then based on the criteria outlined above, there would be a need for flows to remain in the reservoir according on the frequencies illustrated in Figure 4-11 below.

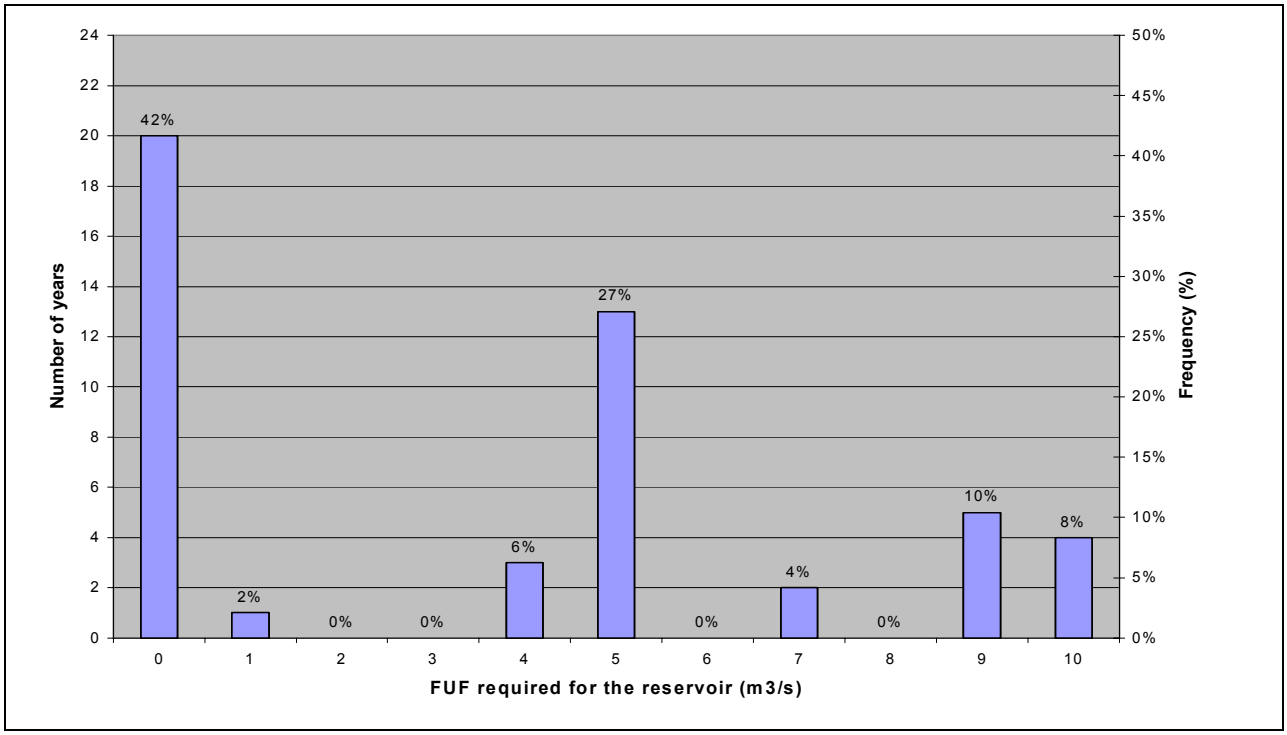

Figure 4-11: Share of freed up flow allocated to remain in the Nechako Reservoir (ranging from 0 to 10 m^3/s) under a variable flow sharing formula, measured in terms of frequency (number of years and percentage of years over 48 years).

These results show that in 42% of simulated future years, there was an abundance of water in the reservoir and/or in predicted natural inflows, and therefore in these years all freed up flow could be delivered to the Nechako River downstream.

As with the fixed flow scenarios (Section 4.3.2), the Nechako Reservoir Operation Model also uses real historical reservoir inflow data and the corresponding historical releases to Kemano to model the outcome of the variable flow scenario. The results of these model simulations assume: 1) that the last 54 years of inflow data are repeated in the next 54 years, 2) that current power generation levels and fisheries protection flow releases must be provided, and 3) that the facility is operated according to a variable flow scenario that allows releases from

the Nechako Reservoir to change from year to year to respect inflow conditions. Under those conditions, we could expect to see the range of simulated annual average releases to the Nechako River and to the Kemano River shown in Table 4-9.

Table 4-9: Minimum, average and maximum simulated annual average releases to the Nechako River and to the Kemano River – as well as simulated sharing of freed up flows between the Nechako Reservoir and the downstream releases - under a variable flow sharing formula. Based on modeling conducted with the Nechako Reservoir Operations Model using historical data for Nechako Reservoir inflows and Kemano releases.

Nechako Reservoir Inflow Conditions	Simulated annual average releases to the Nechako River (m^3/s)		Simulated annual average releases to the Kemano River (m^3/s)		Simulated annual flow sharing of FUF between reservoir & river (m^3/s)	
	Without CWRF (1)	0 to 10 m^3/s kept in the Reservoir (2)	Without CWRF (1)	0 to 10 m^3/s kept in the Reservoir (2)	FUF to the Nechako Reservoir	FUF to the Nechako River
Minimum (3)	52.5	42.4	93.9	102.8	0	3.0
Average (4)	70.2	65.9	125.5	129.8	3.9	9.1
Maximum (5)	181.8	184.6	137.6	137.8	10.0	13.0

Notes:

1. Included for comparison purposes.
2. The specific amount varies depending on the hydrological conditions (reservoir elevation & inflow forecast).
3. This is the minimum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).
4. This is the average flow release observed for all the 48 years of simulated data.
5. This is the maximum flow release observed for all the 48 years of simulated data (and it is not necessarily the same year for each column or scenario).

The analysis of these results revealed that while some of the key downstream flow issues would be resolved under a variety of fixed flow sharing formulas, a variable flow sharing formula had additional merits over some fixed sharing formulas since it can address the variability of reservoir conditions in a way that could provide a more flexible, and potentially more optimal, balance between upstream and downstream benefits from sharing of the freed up flows.

4.3.4 Learning from the Nechako Reservoir Operation Model Results[74]

Some of the conclusions that can be drawn from the Nechako Reservoir Operation Model simulations are:

- None of the fixed or variable flow sharing scenarios simulated to date is able to satisfy all stakeholder interests optimally all of the time.
- Fixed annual flow sharing scenarios could resolve many downstream interests but don't allow for the flexibility to address the full range of possible reservoir conditions (i.e., the impact of high and low inflow years) without decreasing benefits for upstream interests when a better balance might be possible.

[74] Information in this section (including graphs and figures) were provided by Louise Remillard (Alcan Inc.) in 2004, but were presented at a variety of NWC meetings in 2002 and 2003.

- The additional water kept in the reservoir under a variable flow sharing scenario was shown to have the added benefit of reducing the impact of a low inflow period on Kemano generation. Simulation results showed that the probability of failure (not being able to support the minimum energy requirements) would be significantly less with the variable scenario 0 to 10 m^3/s compared to the fixed scenario of 5 m^3/s, even though the actual annualized amount of water retained in the reservoir over the long term would be closer to 3.9 m^3/s.

4.4 Link between Nechako Downstream Allocation Model (N-DAM) and Nechako Reservoir Operations Model

The purpose of the Nechako Reservoir Operations Model is to simulate the reservoir operations that correspond to the various scenarios simulated using the Nechako Downstream Allocation Model (N-DAM). The Nechako Reservoir Operations Model provides the NWC with a better understanding of the impact of the range of N-DAM fixed flow sharing scenarios (i.e., N-DAM Flow Scenarios #1-8 described in Table 4-3 in Section 4.2.3) on the reservoir elevation and the Kemano generation when the natural variability of inflows to the Nechako Reservoir is factored in.

For the post-CWRF scenarios generated using the Nechako Reservoir Operations Model, the monthly releases to the Nechako River were based on simulations using the Nechako Downstream Allocation Model (N-DAM). In other words, the results (output) of the N-DAM simulations were used as inputs to the Reservoir Operation Model.

When the variable sharing scenarios were being modeled, once a specific volume of freed up flow is allocated to the Nechako Reservoir (e.g., 5 m^3/s) for a given year using the rules coded into the Nechako Reservoir Operation Model (as outlined in Section 4.3.3), then the downstream conditions can be estimated using the simulated results from the N-DAM scenarios.

In summary, N-DAM tries to answer the following two questions:

- What happens to flows downstream under different flow scenarios when specific amounts of freed-up flows are released?
- What would be the impact on NWC interests under each flow scenario?

In contrast, the Nechako Reservoir Operations mode tries to answer the following two sets of questions:

- Given the existing demands on the Nechako Reservoir, how will reservoir levels be impacted by providing a specific amount of the freed-up flow (i.e., under a fixed flow scenario) year after year given that inflows to the reservoir change from year to year? How often could specific levels of fixed flow be provided? How often would there not be enough water in the system to provide those fixed flows? In other words, what is the probability of being able to provide each of the flows modeled using N-DAM on an ongoing basis?
- Similarly, given the existing demands on the Nechako Reservoir, how will reservoir levels - and the availability of freed-up flows for release downstream – be impacted by providing a variable amount of the freed-up flow instead (i.e. under a variable flow scenario)?

4.5 Summary of NWC Work on Modeling Flow Scenarios

To date, the NWC has developed three different flow modeling tools: the initial NWC Flow Model, the Nechako Downstream Allocation Model (N-DAM), and the Nechako Reservoir Operation Model. The models have become progressively more sophisticated in their ability to incorporate the real life complexities of water management in the Nechako Watershed. Each of these modeling tools have helped the NWC develop a better understanding of: possible downstream flow allocation options, the impact of those flow allocation options on a variety of interests, and the impact of the variability of reservoir inflows on the ability to meet desired downstream flow targets.

Based on the results of modeling simulations completed to date, the following conclusions can be drawn:

- All freed up flow sharing scenarios (whether fixed or variable) provide positive benefits for a greater range of interests than under the current flow regime.
- None of the fixed or variable flow sharing scenarios simulated to date is able to satisfy all stakeholder interests optimally all of the time. The biggest challenge in meeting all interests comes in the fall season. By trying to mimic a more "naturalized" flow release pattern to address a number of ecological interests, more water is released in June and July, and less in September and October, at a time when some interests might prefer to see it higher.
- Fixed annual flow sharing scenarios could resolve many interests but don't allow for the flexibility to address the impacts on reservoir operations under a full range of possible reservoir conditions (i.e., the impact of high and low inflow years).
- A variable flow sharing scenario may provide an opportunity to balance upstream and downstream interests in light of the natural variability of reservoir inflows.

The NWC has not yet decided whether to design its optimal post-CWRF flow regime based on a fixed or variable flow sharing formula. Regardless, further work will still be required to refine specific flow regime, simulate the predicted consequences of that flow regime for all affected interests, and communicate an understanding of the rationale for recommending the preferred flow regime to the public at large.

5 Assessment of Social, Environmental and Economic Benefits & Impacts

While the NWC agrees (and also believes that there is broad stakeholder agreement) that constructing a Cold Water Release Facility (CWRF) at Kenney Dam is the best option for meeting the region's needs and objectives, a full assessment of its expected benefits and impacts has not yet been made by the parties engaged in its implementation. Part of the reason for this is that an optimal post-CWRF flow regime has not yet been developed and recommended by the NWC. Until a manageable number of preferred flow regime scenarios are identified, it will not be meaningful to evaluate the full range of upstream and downstream benefits that are anticipated as a result of the construction and operation of a CWRF. While a large number of possible flow scenarios could be assessed, this would be an expensive exercise, and the differences between many of those scenarios would not be large, such that the benefits of choosing one scenario over another would be very difficult to identify.

This chapter discusses the NWC's efforts to date to select and tailor an appropriate assessment framework and associated indicators to achieve its objectives of:

- Developing an optimal flow regime (in the short-term).
- Providing decision-makers with a comprehensive analysis of benefits to support well-informed financial decisions related to the construction of a CWRF along with its associated flow regime (in the mid-term).
- Informing the environmental assessment process (in the longer-term).

This chapter outlines the NWC's efforts to date to develop a framework for assessing the social, environmental and economic benefits and impacts of the construction and operation of a cold water release facility at Kenney Dam, including the consequences of adopting different possible flow regimes.

5.1 Choosing a Framework to Assess the Benefits of a CWRF

Early in its work together in the fall of 2001, the NWC retained a consulting economist[75] and identified the need to undertake a benefits assessment of any major project or initiative aimed at addressing issues and interests in the watershed. This is reflected in the NWC's Cold Water Release Facility (CWRF) Work Plan[76], which notes that:

> *"To fully understand and appreciate the social, economic and environmental benefits, it may be necessary to assess the upstream and downstream benefits through a variety of methods . . . traditional cost-benefit monetary assessment methods could be used to evaluate the economic benefits. The more difficult-to-quantify social and environmental benefits may require alternative assessment tools."*

[75] Gary Holman.

[76] Nechako Watershed Council (NWC). 2002. *Proposed Work Plan for the Cold Water Release Facility at Kenney Dam.* Submitted to: The Honourable Rick Thorpe, Minister of Competition, Science and Enterprise. Prepared by the: Nechako Watershed Council. In Regard to the June 2001 Report of the Nechako Environmental Enhancement Fund Management Committee. February 2002. Revised March 2002. Page 14.

The NWC's next step in working towards the selection of an appropriate assessment framework was to commission a review of different evaluation methods and frameworks available[77] (see Appendix D for a copy of the full report).

Table 5-1 summarizes the three alternative evaluation methodologies reviewed, including their strengths and weaknesses.

Table 5-1: Summary of evaluation methodologies that could be applied to the assessment of benefits of constructing and operating a Cold Water Release Facility at Kenney Dam [78]

Evaluation Methodology	*General Description & Strengths of Methodology*	*Criticisms & Limitation of Methodology*
Cost-Benefit Analysis (CBA) or Monetization of all Benefits & Costs	This is a technique for estimating the overall net benefits (benefits minus costs) to society of policies, programs or projects. It has been extensively applied at the provincial and federal level. The emphasis in CBA is on impacts that can be "monetized" or expressed as dollar values. The final result of this analysis is a single "answer" or cost-benefit ratio for each project or option being considered.	This method has been criticized for inadequately addressing non-commercial, environmental and social impacts that are difficult to quantify because of data and other limitations. However, it does allow for inclusion of qualitative information. Typically, CBA compares the dollar net benefits of alternatives and then adjusts this comparison for a qualitative assessment of non-monetizable impacts. The challenge for such adjustments is that they must be transparent and well-documented for decision-makers, as opposed to being embedded in the analysis. CBA also does not explicitly address the distribution of benefits and costs, for example, between regions, levels of government, or between industries and other stakeholders.
Multiple Accounts Analysis (MAA) or Multiple Account Evaluation (MAE)	This method builds on the CBA approach by also taking account a number of other valid evaluation perspectives. Compared to CBA, this method has the advantage of expressing benefits and impacts that cannot be easily monetized in their "natural" units of measurement – that is, in quantitative (physical units) or qualitative (descriptive terms). It also addresses distribution of benefits and costs between regions, levels of government, or between stakeholders. MAA has been used extensively in a variety of provincial resource management applications to summarize information on the impacts of planning or project alternatives on environmental, social and economic objectives.	One of the criticisms of MAA is that because it does not rely on a single indicator (e.g., a cost-benefit ratio), it can be used to rationalize almost any policy choice or project. While this is a valid concern, the use of different accounts also ensure that the potential trade-offs resulting from any policy choice (e.g., commercial versus non-commercial values) are explicitly addressed.
Multi-Attribute Tradeoff Analysis (MATA)	This method has the advantage of quantifying and summing up value judgements of participants for various, and sometimes conflicting objectives (e.g., regarding the impacts of alternative water flows and levels on indicators such as fish habitat and hydropower).	The weakness of this approach lies in the difficulty of comparing and summing subjective values that may or may not reflect accurate information on the magnitude and significance of actual resource impacts. For example, while an objective might be to maintain water flows and levels within a certain range in order to reduce flooding but at the same time achieve fisheries

[77] "A Review of Methodologies for Evaluating the Benefits of a Cold Water Release Facility at Kenney Dam". Submitted to the Nechako Watershed Council. Prepared by Gary Holman, Consulting Economist. February 18, 2002.

[78] "A Review of Methodologies for Evaluating the Benefits of a Cold Water Release Facility at Kenney Dam". Submitted to the Nechako Watershed Council. Prepared by Gary Holman, Consulting Economist. February 18, 2002.

Evaluation Methodology	*General Description & Strengths of Methodology*	*Criticisms & Limitation of Methodology*
	MATA has been applied in land and water use planning as part of a structured process for identifying and valuing the objectives of various stakeholders affected by particular resource management decisions. MATA can assist in developing a consensus among stakeholders by "providing an answer" to the question of which operating regime optimizes the value of sometimes competing objectives.	and recreation objectives, MATA does not provide stakeholders with the estimated value of these various outcomes. Also, while this approach may be of some use in developing and justifying the optimal design and operating regime for a CWRF, it is unlikely to be acceptable to federal and provincial agencies as the sole basis for funding and regulatory approval of the whole facility.

Here is a summary of the final recommendations offered in that same report to help guide the NWC's selection and customization of an evaluation framework for benefits assessment[79]:

- It is recommended that the provincial government's Multiple Accounts Analysis (MAA) evaluation framework be adopted since it has the advantage of incorporating cost-benefit analysis as one of the "accounts" (i.e., categories of interests impacted by the project), but better ensures that all relevant social, economic, environmental and distribution issues (including government finances) are explicitly addressed. For purposes of simplicity, it is suggested that some of the accounts be combined (e.g., regional and provincial).
- It is recommended that the focus of the economic efficiency component of the evaluation should be an analysis of the quantifiable monetized benefits and costs of the CWRF.
- If the NWC cannot reach consensus on the optimal flow regime prior to an assessment being undertaken, the evaluation could include several scenarios in order to assess the range of benefits associated with different flow regimes which emphasize different objectives.
- It is recommended that the focus of the evaluation, at least initially, be directed at an assessment of facility benefits for purposes of developing funding proposals (vs. for the purposes of preparing for an environmental assessment process).
- It is recommended that the NWC seek some additional advice on specific methodologies and data requirements for some of the most important biophysical impacts of the CWRF in order to identify and address any key data gaps as soon as possible.
- If the economic, social and environmental costs of past decisions which have impacted the Nechako and Murray-Cheslatta watersheds are addressed in the evaluation – at the very least qualitatively – the rationale for the CWRF facility would likely be strengthened. Therefore, the NWC should consider including in the terms of reference for the evaluation, a discussion of the nature and significance of impacts resulting from historical resource development and management decisions.

Based on these recommendations, the Nechako Enhancement Society (NES) commissioned a report[80] detailing a proposed Multiple Accounts Analysis (MAA) framework to identify and

[79] Pages 10-11 of the report referenced in the previous footnote.

[80] Robinson Consulting and Associates Ltd. (RCA). 2003. Activity 5: Assessment of Benefits. Framework for Assessing the Benefits of the Proposed Nechako Cold Water Release Facility. (April 2003).

evaluate the benefits from the proposed Cold Water Release Facility. For a complete version of the report, see Appendix E.

5.2 Choosing a Framework to Assess and Compare the Benefits of Different Post-CWRF Flow Regimes

The NWC adopted the Multiple Accounts Analysis (MAA) in principle as its preferred evaluation method at its April 2002 meeting[81], and decided to deal with the remaining five recommendations outlined in Gary Holman's report (see the bullets at the end of Section 5.1 above) as part of Activity 5 in the CWRF Work Plan.

As explained in detail in Chapter 4, Alcan has also assisted the group in generating a range of potential flow alternatives and used the Nechako Downstream Allocation Model (N-DAM) and Nechako Reservoir Operations Model to simulate the outcomes of each (see Section 4.2 and 4.3 for more details). In the process of simulating a particular downstream flow scenario, N-DAM runs a series of 13 "tests" designed to show how well that scenario meets a set of flow targets designed to meet the various interests of the NWC (see Section 4.1). The "test" results reveal during how many months of the year[82] the flow target is missed (i.e., the number of monthly failures) and the expected shortfall between N-DAM's simulated monthly flow and the NWC's monthly flow targets. This provides an initial assessment of which of the 8 flow scenarios generated using N-DAM are best/worst at meeting the NWC's objectives.

However, a third party review[83] of N-DAM outlined a number of limitations to this approach, and suggested a number of ways to improve the NWC's use of indicators to better assess the impacts and benefits of different possible flow scenarios.

At this time, it is unclear whether the NWC intends to use the Alcan modeling exclusively to arrive at an agreed-upon flow regime, or to also rely on a Multiple Accounts Analysis (MAA) or methodology to assess the advantages and disadvantages of a range of possible post-CWRF flow regimes, and to help the group identify their preferred flow regime(s).

5.3 Summary of NWC Work to Date on Assessment of CWRF and an Optimal Flow Regime

The NWC CWRF Work Plan (Activity #5) calls for a benefits assessment to be undertaken in order to "support key decisions related to investment" in the CWRF[84]. To date, the NWC has made the following progress on developing appropriate assessment frameworks and indicators for assessing the expected consequences (primarily benefits) of constructing a CWRF and implementing an optimal post-CWRF flow regime.

- The NWC commissioned a review of different evaluation methods and assessment frameworks available.

[81] As recorded in the minutes for that meeting.

[82] In a year when inflows the Nechako Reservoir are average.

[83] Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC.

[84] Nechako Watershed Council. 2002. Nechako Watershed Council Cold Water Release Facility Work Plan. Page 16.

- Based on these recommendations, the Nechako Enhancement Society (NES) commissioned a report[85] detailing a proposed Multiple Accounts Analysis (MAA) framework to identify and evaluate the benefits from the proposed Cold Water Release Facility.
- The NWC has chosen the Multiple Accounts Analysis framework as its preferred method for evaluating the potential benefits of constructing a CWRF.
- In order to compare the benefits of a variety of post-CWRF flow regimes (vs. the benefits of the CWRF project as a whole), the NWC has explored the use of some evaluation tests conducted during the Nechako Downstream Allocation Model (N-DAM) simulations.

Further work is required by the NWC to clarify which combination of assessment frameworks/models and assessment indicators it will use to assist with the development and selection of an optimal post-CWRF flow regime.

[85] Robinson Consulting and Associates Ltd. (RCA). 2003. Activity 5: Assessment of Benefits. Framework for Assessing the Benefits of the Proposed Nechako Cold Water Release Facility. (April 2003).

6 Developing a Preferred Post-CWRF Flow Regime: Areas of Agreement, Unresolved Issues & Information Gaps

In December 2000, the NWC stated its intention to work towards reaching a consensus on the reallocation of flows that would be freed up if a cold water release facility (CWRF) were constructed at Kenney Dam[86], including developing recommendations about:

- the distribution of releases from Skins Lake Spillway and from a CWRF at Kenney Dam
- mechanisms under which those releases could be implemented and managed.

This chapter outlines the NWC's discussion of each of these topics to date, highlighting any areas of emerging agreement, as well as any unresolved issues and data gaps.

6.1 Flow Principles

As a starting point for discussion, the NWC began by developing a set of draft flow regime principles (most recent draft presented below). These principles are intended to serve as a guide for the development of flow regimes for the Nechako River downstream of the Skins Lake Spillway and the proposed Cold Water Release Facility (CWRF) at Kenney Dam.

Nechako Flow Regime Principles – Post Cold Water Release Facility (*May 2004)*

With a water release facility at Kenney Dam, the volume of cooling flows required for migrating Sockeye salmon each summer will generally be reduced. The reduction in flows represents the freed-up flows resulting from the water release facility.

The members of the Nechako Watershed Council recognize that the freed-up flows could be used to satisfy a number of identified interests, depending on how the freed-up flows are used and allocated.

These Principles are intended to provide a basis for distributing the freed-up flow. These principles do not apply to forced spills. Determination of the optimal allocation of the freed-up flows is based on the following principles:

- Public safety, including flood control and the integrity of works at Kenney Dam, Skins Lake Spillway and the proposed Cold Water Release Facility is paramount.
- While recognizing that the Nechako River is a managed river, the ecological integrity and long-term health and viability of the watershed is an important driver in the reallocation of freed-up flows and establishment of a more natural flow regime.
- Legal interests, agreements and obligations are respected.
- Nechako watershed downstream enhancement and rehabilitation of the Murray-Cheslatta system are essential objectives to be achieved.
- All interests and communities that depend upon the Nechako watershed are considered and balanced when determining the optimal allocation of freed-up flows and the release distribution of the flows.
- Decisions are made in an open, transparent and consensus-based manner.
- The effects of reservoir levels, inflow forecasts and snow pack in years of high, average and low precipitation, are considered in the determination of the annual freed-up flow scheduling. On a long-term basis, the majority of freed-up flow is allocated downstream.

This draft (dated May 2004) is still considered a work in progress. Consensus agreement has not yet been reached on the final content and wording of these principles.

[86] Nechako Watershed Council (NWC). 2000. *Nechako Watershed Council: Third Interim Report to the Nechako Environmental Enhancement Fund Management Committee.* December 2000.

6.2 Distribution of Releases from Skins Lake Spillway and from Cold Water Release Facility at Kenney Dam

As a starting point for moving towards consensus on the distribution of flow releases from Skins Lake Spillway from a CWRF at Kenney Dam in a post-CWRF future,

6.2.1 Emerging Areas of Agreement about Flow Releases

At the NWC meeting held on November 19, 2004 in Smithers, the members who attended identified the following as general areas of agreement about the distribution of flow releases in post-CWRF future.

- ***Approach and methodologies of the Nechako Downstream Allocation Model (N-DAM) and the Nechako Reservoir Operations Model***. There is general comfort with – and confidence in - these computer models (described in Section 4.2 and 4.3) as useful tools to assist the NWC in their exploration of the impacts of different flow distribution scenarios.
- ***Downstream Flow Targets***. There is general agreement on trying to achieve the downstream monthly flow targets identified earlier in the NWC's work (see Section 4.1), modified by more recent learning about the impact of annual variability of reservoir inflows (i.e., reflecting what has been learned from the Nechako Reservoir Operations Model).

To date, the NWC has not yet tested agreement on specific post-CWRF flow regimes.

6.2.2 Unresolved Issues & Critical Information Gaps Require to Inform Further Discussion

In October 2003, the NWC Flow Committee drafted a briefing note for the NWC outlining some issues to be addressed to further the work on post-CWRF flow regimes, and providing recommendations for moving forward. In a number of cases, those recommendations have already been implemented; in other cases, the issues have yet to be resolved. In addition, there were also a number of additional data gaps identified by attendees at the NWC meeting on November 19, 2004.

All of these unresolved issues and data gaps are summarized in the table below, along with a description of either the NWC Flow Committee's recommendations for moving forward, and/or the Nechako Enhancement Society's current plans to address them. In many cases, the Nechako Enhancement Society has initiated (or will soon initiate) studies to fill key data gaps.

Description of Unresolved Issue or Data Gap	**Plans for Moving Forward** ***(NWC Flow Committee Recommendations and/or NES Plans)***	**Status**
Record of NWC Issues & Objectives - During the review of draft versions of this report by the NWC on November 19, 2004, the group clarified that there is not currently consensus agreement on the definition of each of the NWC's 24 issues or on the objectives related to each of the issues.	While this has been identified as an area of unresolved issues, no specific plans have been identified for moving forward.	**No action currently underway**
Draft Flow Principles - Although the NWC has had several discussions on flow principles, uncertainty remains. Do the draft flow principles apply only to the freed-up flows or to all flows? When and for what purpose would the principles be used? As well, overlap is perceived between the draft flow principles and the principles or objectives used in the Nechako Downstream Allocation Model (N-DAM), which only considers the freed-up flows.	The Flow Committee has recommended that the NWC set aside time at a meeting to finalize the flow principles by: • confirming the need and/or desire for a set of principles • comparing the draft flow principles with the principles used in the downstream model (N-DAM) • identifying the advantages and disadvantages of applying the draft flow principles to only the freed-up flows or applying them to all flows • seeking consensus as to the application of the flow principles • seeking a consensus on the wording of the flow principles.	**No action currently underway**
Flow Requirements for Sturgeon - The flow requirements for white sturgeon are still unknown. However, the Recovery Team of the Nechako River White Sturgeon Recovery Initiative provided suggestions to the NWC as to how to incorporate sturgeon needs in developing flow regimes ("*Flow Principles to Guide Nechako River Hydrograph Development*"; November 2004). This advice is based on the Team's best information to date, and acknowledges that it may be several years before ecologically based target flows can be developed. Until that information is available, the Recovery Team suggested the following two principle: *1) Produce a hydrograph at Vanderhoof with discrete ascending and descending limbs in the spring of the year.* *2) Release of discharge should be timed to produce maximum possible peak spring flow at Vanderhoof.*	The Recovery Team will continue to attend NWC meetings and participate in discussions on potential flow regimes. The Nechako Watershed Council will continue to ask the Recovery Team for clarity as to when the ecologically-based target flows may be available.	**Ongoing action underway** (but data gap will not be filled within timeframe for develop-ment of optimal post-CWRF flow regime)
Temperature of Water Released by a CWRF - The NWC does not know what temperature will be selected for the water released through the proposed Cold Water Release Facility (CWRF). Current expectations are that the target will be between 10°C and 12°C. The difference in temperature means a difference of about 2 m^3/s of annualized freed-up flow, which affects the outcome of the computer flow modeling. Refining the choice in temperature target will help narrow the number of possible flow scenarios to be considered.	The Nechako Enhancement Society (NES) retained consultants (Triton Environmental) to study this issue and provide recommendations. The Final Report was submitted to the NES in November 2004.	**Complete**

Description of Unresolved Issue or Data Gap	**Plans for Moving Forward** ***(NWC Flow Committee Recommendations and/or NES Plans)***	**Status**
Reservoir Hydro-Thermal Structure - The computer simulation of the hydrothermal regime of the Nechako Reservoir is required to determine whether the reservoir can provide the necessary amounts of water on a seasonal/annual basis given the targeted temperature for CWRF releases. A draft report on Hydro-thermal Characteristics of the Nechako Reservoir was commissioned and completed by Drs. Greg Lawrence and Roger Peiters of UBC in November 2004.	A Final Report is to be completed in Spring 2005. Review and decisions taken after NES/NWC review of the report's recommendations will determine the extent of future reservoir hydro-thermal data collection modeling that needs to be undertaken. This could potentially be a significant and costly exercise and take up to two more years.	**Action underway** **May be more action required post-2005**
Feasibility of Hydro-electricity Generation at Kenney Dam - The NWC has obtained some initial information on the feasibility of generating electricity at Kenney Dam, as part of the installation of a CWRF. The information was provided in reports by Columbia Power Trust and Klohn-Crippen. However, further study is needed to explore the financial and technical feasibility in greater detail. One question specifically related to future flow regimes is whether it is possible to have flexibility in the timing and volumes in flows for electricity generation. To date the NWC has included a minimum constant flow for electricity generation (25 m^3/s) in its work, which is used in the downstream river model. To refine the possible flows to the River, and to optimize the resolution of all interests, the NWC will need a better understanding of the monthly minimum and optimal needs of a potential hydro-generating facility.	The NWC Flow Committee recommends that the NWC discuss with the NES the possibility of it conducting a detailed study on the financial and technical feasibility of generating electricity at Kenney Dam; with particular attention to the flow schedule that would be required and the implications for meeting other interests' needs through various flow regimes.	**Action required**
Flows for Murray-Cheslatta – Part 1 – The Cheslatta Carrier Nation and residents of Southside identified an annualized flow of 15 cms to be released through the Skins Lake Spillway (SLS), distributed in a naturalized pattern over the year similar to that of the Stellako River. Although the Cheslatta and Southside residents have been clear about their preferred flow, there are other First Nations in the area - Nee Tahi Buhn and Skin Tyee - who have not provided input. In addition, there have been initial indications from the Department of Fisheries and Oceans that from a federal regulatory perspective, an appropriate flow regime for the Murray-Cheslatta system would involve flows of no less than 14 m^3/s daily and 15 m^3/s annualized.	The Flow Committee recommends that the NWC confirm with the Cheslatta Carrier Nation and Southside residents their preferred flow of 15 m^3/s on an annualized basis. The Flow Committee recommends that the NWC contact Nee Tahi Buhn and Skin Tyee to determine if they perceive their interests to be affected, and if so obtain their input on the proposed flows for the Murray-Cheslatta system.[87] The NES is seeking confirmation from the Department of Fisheries and Oceans of that agency's flow requirements for the Murray-Cheslatta system.	**Action underway & further action required**
Flows for Murray Cheslatta – Part 2 – Given the uncertainty about the flows required to meet ecological goals for the Murray Cheslatta system, an **Assessment of Alternatives Flows through the Skins Lake Spillway** would be helpful, especially if DFO collaborated on the technical work & ensuing discussions.	This unresolved issue has been identified, but no action has yet been initiated.	**No action currently underway**

[87] At the time of writing, Triton Environmental has been contracted to produce a report that among other things, will document the work that Alcan (Dan Bouillon) has done on the analysis of choices, and the work the NWC did to communicate with the Cheslatta and Ootsa people to consider options. Some of this communication included helicopter over-flights, visit to the river at various flows and a canoe party paddling the river at one flow, and the chief of the Cheslatta First Nation visiting the river at one of the proposed flows to give his opinion.

Description of Unresolved Issue or Data Gap	**Plans for Moving Forward** ***(NWC Flow Committee Recommendations and/or NES Plans)***	**Status**
Review of Cheslatta Fan Pilot Concept and Nechako Canyon Flushing: If a CWRF is constructed and used to release water downstream, this will involve moving water through two areas that currently experience very low flow: 1) the Cheslatta Fan, and 2) the Nechako Canyon. There are concerns about the potential negative impacts to Chinook salmon spawning beds downstream if sediments are moved from these two erodible areas and deposited downstream. In 2003, Environmental Dynamics Inc. completed a review of the environmental implications of flowing water through the Cheslatta Fan, and the Nechako Canyon.	Given that there will be implications for downstream sedimentation once the CWRF is commissioned, the NES is (at the time of writing) seeking to engage the Department of Fisheries and Oceans in discussions on this issue, with the intent of having that agency: 1) review the report and potential alternative scenarios, and 2) provide appropriate input prior to the NES embarking on future pre-engineering work (i.e., to clarify what level of downstream sedimentation DFO would consider acceptable as a result of the construction of a CWRF and increased flow across the Cheslatta Fan).	**Action underway**
Total Gas Pressure (TGP): There is a need to determine whether the TGP of the water in the Nechako Reservoir will meet downstream targets and/or how the CWRF facility would need to be designed to meet the targets given the TGP profile of the Nechako Reservoir.	An interim consultant's report by Triton Environmental is due December 2004. It will require another field season to collect the data to complete the report, so a final report is not expected until Fall 2005.	**Action underway**
Fish Entrainment at CWRF: If a CWRF is built at Kenney Dam, this may result in increased fish mortality from entrainment. Study is required to explore the potential impact of fish entrainment on resident fish populations in the Nechako Reservoir, and to explore opportunities for mitigation.	A draft report by Triton Environmental is due December 2004, with a Final Report to be completed in Spring 2005.	**Action underway**
Assessment of Benefits: To fully understand and appreciate the potential social, economic and environmental benefits of constructing a CWRF (including implementing a post-CWRF flow regime), it will be necessary to assess the upstream and downstream benefits through a variety of methods (e.g., traditional cost-benefit monetary assessment methods and/or alternative assessment tools). This may also include addressing some of the relevant recommendations made in the "*Nechako Downstream Allocation Model: Review and Recommendations*" report commissioned by the NWC in 2003; for example, the recommendation to develop indicators that are good measures of social, environmental and economic benefits, and to develop those indicators so that provide a sense of the relative magnitude of significance.	At the time of writing, the Draft Terms of Reference are under development and will be reviewed by NWC in at their meeting in February 2005. The intent is to hire a consultant to complete this assessment work by March 2006 at the latest.	**Action underway**
Pre-impoundment downstream flows – There is no historical data available documenting pre-impoundment flow levels in the Nechako River downstream of Kenney Dam. It would be possible to generate simulated data for the period from 1930-1950 to create a picture of pre-impoundment trends.	This data gap has been identified, but no action has yet been initiated.	**No action currently underway**

Description of Unresolved Issue or Data Gap	Plans for Moving Forward *(NWC Flow Committee Recommendations and/or NES Plans)*	Status
Request for retention and use of 5 cms of freed up flows for northwest community economic development. Both the District of Kitimat and the Northwest Communities Coalition (NCC) have put forward proposals outlining a request for approximately 5 m^3/s of the flows that would be freed up by the proposed CWRF. Their desire would be to see that water (or its equivalent economic benefit if it were used to produce hydropower) used to support economic development and job creation in Kitimat. The proposal was originally put forward by the District of Kitimat and the NCC in 2000, and since that time, the NCC has submitted a series of related briefing notes[88]. To date, the NWC has not tested agreement on these proposals, and the flow regime modeling completed to date has not simulated the potential impact of retaining 5 m^3/s in the Nechako Reservoir on an annual basis to support community economic development.	This data gap has been identified, but no action has yet been planned or initiated.	**No action currently underway**

6.3 Implementation and Management of Flow Releases

To date, the NWC has focused most of its attention and energy on the development of an optimal post-CWRF flow regime, and less on the mechanisms under which those flows would be implemented and managed. Given the limited amount of attention this subject has received to date, no specific areas of agreement have been identified yet. The following two sections outline the current management structure and protocol for annual flow allocation, and the unresolved issues related to this topic that have been identified to date.

6.3.1 Current Management Structure and Protocol for Annual Flow Allocation[89]

Since the 1987 Settlement Agreement was signed between Alcan and the federal government and the BC provincial government, the Nechako Fisheries Conservation Program (NFCP) Technical Committee has been responsible for making decisions regarding the release of the Annual Water Allocation in any applicable water year[90]. The membership of the Technical Committee includes representatives of Alcan, Fisheries and Oceans Canada, and the BC Ministry of Water, Land and Air Protection. The NFCP Technical Committee is overseen by the NFCP Steering Committee (made up of more senior representatives from the same organizations), whose primary role is to give the Technical Committee policy direction and to approve annual budgets. The Steering Committee only gets involved in flow release decisions

[88] District of Kitimat, Chambers of Commerce of Kitimat and Terrace, Northwest Communities Coalition, and City of Terrace. 2000. Briefing note in follow-up to Nechako Watershed Council Meeting of October 20-21/2000 in Smithers.

Northwest Communities Coalition. 2001. Draft-NWC Discussion Paper (#3) – A New Direction. April 9, 2001.

Northwest Communities Coalition. 2001. Draft-NWC Discussion Paper Proposal for Variable Release of Freed-Up Water. March 6, 2001.

Whicher, Carl. 2002. Letter to the Nechako Watershed Council regarding the Northwest Communities Coalition's request for 5 cms of tolled water flow through Kemano. February 4, 2002.

[89] The information contained in this section was obtained through personal communication with Clyde Mitchell of Triton Environmental (e-mail dated September 15, 2004). Mr. Mitchell currently represents Alcan on the Nechako Fisheries Conservation Program (NFCP) Technical Committee.

[90] Province of British Columbia and Alcan Aluminum Ltd. BC/Alcan 1997 Agreement. August 5, 1997. Section 3.3 (e) i).

if the Technical Committee is unable to reach consensus on the decision to be made. To date, the Technical Committee has always reached consensus although some related issues have occasionally been referred to the Steering Committee for guidance and direction.

The NFCP is mandated by the 1987 Settlement Agreement to use as a guide the 12 monthly Skins Lake Spillway releases reproduced in the table below:

Table 6-1: Schedule of Water Releases for Nechako Reservoir[91].

Month	*Nechako Reservoir Release (mean monthly)*	
	(in cubic meters per second or m3/s)	*(in cubic feet per second or cfs)*
January	29.2	1031
February	29.3	1035
March	29.4	1038
April	54.6	1928
May	47.2	1667
June	40.9	1444
July	45.6 *	1610
August	50.4 *	1780
September	27.6	975
October	28.6	1010
November	28.8	1017
December	29.1	1028
Annual Mean	36.8	1300
** plus additional flows as are determined to be required for cooling purposes.*		

Early in the life of the Technical Committee (in 1988), a protocol or set of principles were agreed to for reaching flow related decisions[92]. In the following year, the Technical Committee realized that following this protocol for allocating water in the short term would result in multiple gate changes at the Skins Lake Spillway and not likely result in the desired enhancements in Chinook production. The protocol was originally intended for use following the Kemano Completion Project (KCP). Now that KCP has been cancelled, it is unlikely this protocol will be invoked (unless the Technical Committee deems it useful if a cold water release facility is built at Kenney Dam).

Currently the NFCP Technical Committee makes two decisions each year to ensure the beneficial release of the Annual Water Allocation (which is an annualized flow of 36.8 m^3/s):

- The first decision is made in April, when releases from the Skins Lake Spillway are increased from winter values to those thought suitable for juvenile rearing in the Nechako River. The timing of the change is dictated by the opening of an ice lead around Murray and Cheslatta Lakes (a protocol developed as a result of discussions with the local trappers and guides). This typically happens in the third week of April but can vary from mid-April to the last week (April 25). The rate of release is typically set at 49 m^3/s unless there is a fall limit requested by Alcan for construction or maintenance reasons at the spillway. The spring flow is maintained throughout May, June, and is a base flow in July and August.

[91] Source: Column I of Schedule "C" of *1987 Settlement Agreement* between Alcan and the Provincial and Federal Governments.

[92] Source: NFCP 1989/90 Annual report.

- The Summer Temperature Management Program dictates the total releases from July 11 to August 20 and the "base flow" is dropped in late August to 14.2 m^3/s to drop the Nechako River flow to the fall spawning and winter incubation release. This lower release rate is set to use up the remainder of the annual water allocation by the end of March (the following spring). The winter incubation flow has almost always been the same as the spawning release to limit the risk of redd freezing.

The only exceptions to these general rules occur when Alcan needs to release excess water to manage reservoir levels. Decisions are reached in these cases in joint discussions with the BC Provincial Water Comptrollers' office, the NFCP Technical Committee and Alcan. The Technical Committee has a set of desired limits on the release of excess water.

6.3.2 Work to Date on Management & Implementation

In 2001, Rick Krehbiel prepared a short document outlining a draft version of some of the possible provisions of a formal agreement for management of freed up flows through the proposed CWRF at Kenney Dam[93]. However, this document has not been adopted by the NWC, and remains a draft for further discussion.

6.3.3 Unresolved Issues & Data Gaps Related to Management & Implementation

In October 2003, the NWC Flow Committee drafted a briefing note for the NWC outlining some remaining issues to be addressed. One of those issues related to implementation and management and is described in the table below, along with the Flow Committee's recommendations for moving forward on this issue.

Description of Unresolved Issue	NWC Flow Committee Recommendation
Timing of decision-making for downstream releases - The NWC is seeking an explanation of the current decision-making process for releasing water downstream depending on reservoir levels, in order to better understand how this process might need to be altered in a post-CWRF scenario. For example, when the NWC has agreed upon a new flow regime, is it possible to make such a decision process work? How does the timing affect setting a flow regime? What are the risks if a decision proves to be the wrong choice; for example if there are major changes in precipitation?	The NWC Flow Committee recommended that the NWC request a presentation from the Nechako Fisheries Conservation Program (NFCP) to: 1) learn how the existing decision-making process works for setting and/or changing flows into the River; and 2) discuss how a future decision-making process might work to implement the new flow regimes.

6.4 Possible Next Steps

At the NWC Meeting held on November 19-20, 2004 in Smithers, the members who attended suggested that the following would be a possible sequence of steps to follow moving forward:

- Reach agreement on Flow Principles (see Section 6.1.1 for current draft).
- Address unresolved issues and fill data gaps where possible (see NWC Flow Committee recommendations outlined in Sections 6.1.2 and 6.2.3)
- With the aid of the computer simulation and modeling tools applied to date (described in Chapter 4), develop flow scenarios proposing how water gets allocated downstream under: average, below average and above average reservoir inflow conditions.
- Test agreement on these flow scenarios with the full NWC membership.

[93] Krehbiel, Rick. 2001. *Draft Elements of a 'Freed Up Flows' Management Agreement.* Prepared for discussion purposes. April 26, 2001. Rick is an independent consultant in the areas of treaty negotiations, First Nation land management, environmental assessment and strategic planning. Rick has also taught Environmental Law and First Nations Studies courses at the University of Northern British Columbia.

6.5 Summary of Progress on Developing a Consensus-Based Recommendation on a Post-CWRF Flow Regime

The NWC is working towards reaching consensus on the reallocation of flows that would be freed up if a CWRF were constructed at Kenney Dam, including developing recommendations in two key areas. A summary of the NWC's progress in each area is outlined below:

- ***Flow releases from the Nechako Reservoir***. As a starting point, the NWC began by developing a set of draft flow regime principles. These are still under discussion, and the NWC continues to build consensus on the final content and wording of these principles. Two other emerging areas of agreement are: 1) the NWC's general comfort with – and confidence in – the approach and methodologies of the Nechako Downstream Allocation Model (N-DAM) and the Nechako Reservoir Operations Model, and 2) the desire to try to achieve the monthly flow targets established to address a variety of interests (modified by more recent learning about the impact of annual variability of reservoir inflows) when designing an optimal post-CWRF flow regime. To date, the NWC has not yet tested support for specific post-CWRF flow regimes, such as specific proposals about the volume and timing of releases from Skins Lake Spillway and the proposed CWRF at Kenney Dam. The NWC has, however, identified a number of remaining unresolved issues and data gaps to be addressed to aid in the development of feasible flow regimes. Many of these are being addressed by studies that are currently being coordinated and managed by the Nechako Enhancement Society.
- ***Mechanisms under which those releases could be implemented and managed***. To date, the NWC has focused primarily on developing an optimal post-CWRF flow regime, and less on the mechanisms for implementing and managing those flows. Since little discussion of this topic has occurred, no specific areas of agreement have yet emerged.

Possible next steps for moving forward with consensus-building in these two areas include: 1) reaching agreement on the draft Flow Principles, 2) addressing unresolved issues and filling data gaps, 3) developing a small range of flow scenarios proposing how water gets allocated downstream under average, below average and above average reservoir inflow conditions, and 4) testing agreement on that range of flow scenarios with the full NWC membership.

7 Consultant's Recommendations for Moving Forward

As requested by the Nechako Watershed Council and the Nechako Enhancement Society, this chapter contains a description of a series of "high-level" recommendations for moving forward with further consensus building on post-CWRF flow regimes designed to address a variety of interests. In this context, high-level means the recommendations do not specify the timeframe or the estimated costs, and instead, focus on the content of the suggested steps and tasks.

7.1 Chapter Outline

The next section of this chapter (**Section 7.2**) describes the approach and assumptions underlying the recommendations.

Sections 7.3 through 7.9 each focus on a particular recommendation. The basis for each recommendation is described, along with an indication of previous or current NWC or NES work that can built on, and the future work required in moving forward.

Section 7.10 provides a table summarizing the recommendations outlined in Sections 7.3 through 7.9.

Section 7.11 raises some additional considerations.

Section 7.12 outlines a possible timeline for implementation, highlighting potential synergies between recommended tasks and work that is already underway or being planned.

7.2 Background – Consultant's Approach

Before diving into the recommendations, I would like to offer a few opening comments, some relating to the progress made by the NWC to date, and some relating to my approach to developing my recommendations.

7.2.1 Building on the NWC's Progress to Date Using Targeted Iteration

In December 2000, the NWC made a commitment to work towards reaching a consensus on the reallocation of flows that would be freed up if a cold water release facility (CWRF) is constructed at Kenney Dam[94]. This would include developing recommendations about: the distribution of releases from Skins Lake Spillway and from the proposed CWRF at Kenney Dam, and mechanisms under which those releases could be implemented and managed. This is both an important task, and a complex one. During the last few years, the NWC has made significant progress towards that goal, as documented in the earlier chapters in this report.

In any planning process, there comes a time when the planning group reaches a "stuck" place. This is a good time to take stock, look back and see what the group has achieved (which is exactly what this group did in commissioning this report). The next step is often to see which steps of the planning process the group is now ready to review and refine with fresh insight gained along the way: this is what I would call "targeted iteration". The

[94] Nechako Watershed Council (NWC). 2000. *Nechako Watershed Council: Third Interim Report to the Nechako Environmental Enhancement Fund Management Committee.* December 2000.

"targeted" part refers to the need to make careful choices about what to focus future efforts on, keeping the NWC's end goal in mind. The "iteration" part refers to the opportunity to review, refine, and build on work to date using the enhanced understanding the group has gained along the way in order to propel the process forward again.

7.2.2 Making Efficient Use of Time, Resources & Dollars

I recognize that the NWC and NES are operating in an environment where time, human resources, and funds are relatively scarce and need to be used wisely. In developing my recommendations, I looked for ways to build on the NWC's work to date and combine proposed future tasks with those already planned for implementation by the NWC and NES.

7.2.3 Value of Using Provincial Water Use Plan Guidelines as Map for the Process

Many of the recommendations contained in this chapter are based on the Provincial *Water Use Plan Guidelines*[95] (*"Guidelines"*) as a map or framework for the development of a recommended post-CWRF flow regime.

NOTE: My *intent is* not to encourage the NWC or NES to initiate and complete an official Water Use Plan process (i.e., to complete all 13 steps outlined in the *Guidelines*), but rather *to follow the steps that could assist the NWC in building consensus on a recommended post-CWRF flow regime and documenting its work (i.e., Steps 2 & 4 thru 8).*

The recommendation to use the *Guidelines* as a framework moving forward is based on the following considerations:

- The *Guidelines* are specifically designed to set out the steps and components of collaborative decision-making processes like the one already being undertaken by the NWC. The framework was developed to help multi-stakeholder groups work towards consensus on operating rules for water management facilities that satisfy the full range of water use interests at stake, while respecting legislative and other boundaries. As such, ***the Guidelines are ideally suited for application to the NWC's process of developing an optimal post-CWRF flow regime***.
- ***The effectiveness of the water use planning process has been tested and proven*** over the last five or six years during BC Hydro's application of the guidelines at each of its hydroelectric facilities around the province. Having now completed 23 Water Use Plan processes, BC Hydro has indicated that it achieved full or near consensus[96] on recommendations from participants in 22 out of those 23 processes.
- The Water Use Plan process is designed to be sufficiently flexible to meet the needs of different facilities and owners/operators. While each step in the *Guidelines* should be followed, ***the NWC can adapt the approach to - and the extent of effort at each step - to suit its circumstances***. While BC Hydro chose to devote significant financial and human resources to its Water Use Planning Program in order to complete its consultative processes on an aggressive time schedule, the provincial *Guidelines* state no requirement for that level of resources to be committed nor for the process to be completed on a given timeline.

[95] Province of British Columbia. 1998. *Water Use Plan Guidelines.*

[96] In some of BC Hydro's Water Use Plan processes, specific parties who participated chose not to sign off on final recommendations for political or legal reasons, even if they agreed in principle with the recommendations.

- ***Using this framework, the NWC can build on scientific and technical analysis completed by others***. For each of its 23 Water Use Plan processes, BC Hydro has created comprehensive public documentation of the process, as well as the scientific and technical analysis used as a basis for discussion. For example, for each of its facilities, BC Hydro documented how it developed performance measures (assessment indicators) for a range of interests. While these would need to be adapted to suit the NWC's needs, they nonetheless represent a valuable source of information and learning that is freely accessible for direct adaptation and use.
- Not only is the Water Use Plan process one way for people to work efficiently together towards consensus on water management decisions; it also ***provides a logical, organized, clear and transparent framework for the NWC to explain to others how they arrived at their final recommendations***. This could be useful both in communicating with provincial and federal regulatory agencies, but also in communicating with other stakeholders in the Nechako Watershed. While NWC members are actively representing a variety of constituencies during the development of a recommended post-CWRF flow regime, there is also a broader community in the Nechako Watershed that will want to: 1) learn how the NWC developed any recommendations, 2) how their interests were taken into account, and 3) possibly provide additional input. Using a logical, clear and transparent framework like that outlined in the *Water Use Plan Guidelines* is a valuable tool for communicating with regulators and the broader constituency in the Nechako Watershed.
- ***Completing the process now while it can serve a dual purpose (of assisting with consensus-building efforts and meeting possible future requirements) could save the NWC and the NES time and funds in the long run***. If a cold water release facility (CWRF) is constructed at Kenney Dam, it is entirely possible that the provincial government (Comptroller of Water Rights) could request the completion of a Water Use Plan process for the facility before making any related to changes to Alcan's existing water licence under the B.C. *Water Act*. The *Guidelines* state that a the Comptroller "*may require that a Water Use Plan be prepared for any existing licence . . . [and] proponents seeking new licences [including those for an expansion to existing licensed rights] for larger-scale operations . . . or for works located on particularly valuable or sensitive streams should anticipate that plans may be required as a condition of their licences.*[97]"

Starting below in Section 7.3 and through to Section 7.9, I outline a series of recommendations for moving forward.

7.3 Recommendation – Confirm a Process to Guide NWC through Development of Preferred Flow Regime

The most important next step the NWC can take is to clarify how it will proceed.

7.3.1 Previous or Current NWC & NES Work Related to this Step

To date, the NWC has already:

- ***Clearly defined the overall scope of the process***. In December 2000, the NWC made a commitment to work towards reaching a consensus on the allocation of flows that would be freed up if a cold water release facility (CWRF) were constructed at Kenney

[97] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Section 2.3, Page 9.

Dam[98]. This includes developing recommendations about: 1) the distribution of releases from Skins Lake Spillway, 2) the distribution of releases from a CWRF at Kenney Dam, and 3) mechanisms under which those releases could be implemented and managed.

7.3.2 Specific Tasks for Moving Forward

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Confirm the scope of the process***. Since it has been 4 years since the NWC established the scope for the process, it would be useful to confirm whether the scope is still the same in everyone's mind.
- Design and ***reach agreement on a clear, transparent process (i.e., a set of steps and work plan) for developing the NWC's final consensus-based recommendations***. The remaining steps in this chapter outline a process that the NWC could adopt. A more detailed work plan is not included, but could be developed. The process proposed here is based on Steps 2 and 4 to 9 of the provincial *Water Use Plan Guidelines*, for the reasons explained in Section 7.2.3.
- ***Develop and reach agreement on a list of specific items related to flow regimes that the NWC is committed to reaching consensus on*** (vs. items that the NWC is able to agree to disagree on). Some examples of items which might be included on this list of items requiring consensus are outlined in the table below.

Topic	*Potential Item Requiring NWC Consensus*
Sharing of freed-up flows between Nechako Reservoir & Nechako River	Whether to use: - a fixed flow sharing formula (i.e., a set amount that doesn't change from year to year), or - a variable flow sharing formula (i.e., amounts will change from year to year based on the elevation of the reservoir and the inflow to the reservoir that year) to determine how much of the freed-up flows will stay in the Nechako Reservoir and how much will be released on an annual basis.
	If a fixed sharing formula is used, the portion of freed up flows allocated for annual release to the Nechako River should be _____ m^3/s.
	If a variable flow sharing formula is used, then the specific formula should be _____ (e.g., the formula used to date during simulations with the Nechako Reservoir Operations Model as described in Section 4.3.3? Or a different formula?)
Sharing of freed-up flows between the Skins Lake Spillway (SLS) and the CWRF at Kenney Dam	Once the amount of water that will be released to the Nechako River in a given year has been determined, the amount (or percentage) of flow that will be released through the Skins Lake Spillway (SLS) will be _____ and the amount (or percentage) that will be released through the CWRF at Kenney Dam will be _____.
Flow releases from Skins Lake Spillway (SLS)	The minimum annualized flow release through Skins Lake Spillway will be _____ m^3/s.
	The maximum annualized flow release through Skins Lake Spillway will be _____ m^3/s.
	The target annualized flow release through Skins Lake Spillway will be

[98] Nechako Watershed Council (NWC). 2000. *Nechako Watershed Council: Third Interim Report to the Nechako Environmental Enhancement Fund Management Committee*. December 2000.

Topic	*Potential Item Requiring NWC Consensus*
	_____ m^3/s.
	Flow releases from Skins Lake Spillway should be distributed throughout the year to mimic a "naturalized" hydrograph that is based on _____ (e.g., the annual hydrograph of the Stellako River? The annual hydrograph of historical reservoir inflow? Other?)
	Are there any months when there are any additional specific minimum, maximum, or target flow release requirements?
Flow releases from CWRF at Kenney Dam	The minimum annualized flow release through the CWRF at Kenney Dam will be _____ m^3/s.
	The maximum annualized flow release through the CWRF at Kenney Dam will be _____ m^3/s.
	The target annualized flow release through the CWRF at Kenney Dam will be _____ m^3/s.
	Flow releases from the CWRF at Kenney Dam should be distributed throughout the year to mimic a "naturalized" hydrograph that is based on _____ (e.g., the annual hydrograph of the Stellako River? The annual hydrograph of historical reservoir inflow? Other?)
	Are there any months when there are any additional specific minimum, maximum, or target flow release requirements?
"Phase In" or Transition Strategies	If a CWRF is constructed at Kenney Dam and a preferred flow regime has been designed, how will the transition be made from the current flow regime to the new preferred flow regime during the initial "phase-in" period?
Mechanisms under which flow releases are implemented and managed	The decision-making body who will make annual decisions who will make annual decisions about the volume of flow releases from the Skins Lake Spillway and the CWRF at Kenney Dam (once the proposed CWRF is operational) should be: _____ (e.g., NFCP? Comptroller of Water Rights? Other?)
	The NWC's role in relation to that decision-maker would be _____ (e.g., advisory?)

7.4 Recommendation: Clarify Interests & Develop Performance Measures

This recommendation is based on Steps 2 and 4 in the provincial *Water Use Plan Guidelines*[99], summarized below.

Step 2 - Scope the water use issues and interests.

The licensee or proponent will meet with regulatory agencies, First Nations, local governments and key interested parties to:

- Identify issues and interests associated with water management.

- Review and summarize available information on water flows and their impacts on flood control, fish and aquatic ecosystems, and other water use interests. Impacts include the consequences both downstream and upstream of water control facilities.

- Identify gaps in information and the need for further studies to develop a Water Use Plan (i.e., flow regime).

Step 4 - Confirm water use interests and develop performance measures.

Participants will:

- Define specific interests. Identify "what matters" when comparing alternative operating (flow)

[99] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 2, 20 and 23..

regimes for the facility on the basis of their water use impacts.

- Define quantitative and/or descriptive measures for assessing how well those interests are met under each flow regime. For example, in the case of fisheries, one interest might be the protection of fish habitat. Possible measures could include the amount, type and quality of usable habitat.

7.4.1 Previous or Current NWC & NES Work Related to this Step

To date, the NWC has:

- ***Created a list of issues***. This NWC has developed a list of 24 issues of concern to its various members and the broader Nechako Watershed community. While consensus has been reached on the list of issues, consensus has not been reached on the description and framing of the issues.
- ***Reviewed available information***. The NWC has reviewed numerous reports and presentations about the relationship between water flows and each of the 24 issues identified (see Section 8.2 and 8.3 for lists of specific documents).
- ***Identified information gaps***. Along the way, the NWC identified a number of related information gaps and in some cases, undertook studies (see Section 8.2) or consulted experts to learn more (see the "Issues Record" described in Section 3 as well as the list of presentations received by the NWC in Section 8.3).
- ***Developed initial performance measures: N-DAM "tests" showing how well each flow scenario meets flow targets***. As explained in detail in Chapter 4, Alcan has assisted the group in generating a range of potential flow alternatives and used the Nechako Downstream Allocation Model (N-DAM) and Nechako Reservoir Operations Model to simulate the outcomes of each (see Section 4.2 and 4.3 for more details). In the process of simulating a particular downstream flow scenario, N-DAM runs a series of 13 "tests" designed to show how well that scenario meets a set of flow targets designed to meet the various interests of the NWC (see Section 4.1). The "test" results reveal during how many months of the year[100] the flow target is missed (i.e., the number of monthly failures) and the expected shortfall between N-DAM's simulated monthly flow and the NWC's monthly flow targets. This provides an initial assessment of which of the flow scenarios simulated using N-DAM are best/worst at providing benefits for a variety of interests.
- However, a ***third party review[101] of N-DAM*** (commissioned by the NWC) outlined a number of limitations to this approach, and ***suggested a number of ways to improve the NWC's use of performance measures*** (indicators) to better assess the impacts and benefits of different possible flow scenarios.
- ***Developed other potential performance measures***. In the process on one of its other tasks (completing a Benefits Assessment of the potential CWRF at Kenney Dam), the NWC commissioned a report that outlined a number of potential performance measures (assessment indicators) that could be adapted for the purpose of evaluating potential flow regimes.

[100] In a year when inflows the Nechako Reservoir are average and the provision of the full annualized amount of downstream flow modeled in a given flow scenario can be guaranteed.

[101] Lewis, A. F. J. 2003. *Nechako Downstream Allocation Model (N-DAM): Review and Recommendations.* Consultant's report prepared by Ecofish Research Ltd., 9086 Keith Wagner Way, Denman Island, BC.

7.4.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Clarify NWC interests***. The NWC could benefit from framing the list of issues in terms of interests, which can be expressed as needs, desires, hopes, concerns, fears[102]. Interests describe what matters to an individual or organization or constituency; interests are the things we care about, and want to see protected, maintained, increased or enhanced. *There is no need for the NWC to reach consensus on a shared set of interests*; instead, interests can be attributed to specific members (individuals, organizations or constituencies) with the understanding that all members respect the interests of others and will work towards mutual gain. Here are some of the kinds of questions the NWC could ask to ensure that it arrives at a complete list of interests[103]:

Compose a wish list. Describe as completely as you can everything that you could ever want from your decision. What would make you really happy?
Think about the worst possible outcome. What do you most want to avoid?
Consider the decision's possible impact on others. What do you wish for them?
Consider a great – even if unfeasible – alternative. What's so good about it?
Consider a terrible alternative. What makes it so bad?
Think about how you would explain your decision to someone else. How would you justify it? This answer to this question might uncover additional concerns or interests.

  The final part of this exercise would be to ensure that interests are clearly distinguished from any positions (which are specific ways of meeting those interests or possible solutions).

- ***Define quantitative and/or descriptive measures for assessing how well those interests can be met by different flow regimes.*** Performance measures are also sometimes called criteria, attributes, or assessment indicators. They are measures of success; they are either a measurement or a description of how your interest will either benefit or be impacted under a particular flow regime. There is an opportunity to combine this work with the "Benefits Assessment" project that is currently being initiated to save time & money, as outlined in Section 7.12. There are also opportunities to benefit from the work of others in this area. For example, during the 23 water use planning processes conducted at each of its facilities, BC Hydro developed a series of performance measures to measure the expected benefits for the range of interests that were represented on the consultative committee formed for each process (e.g., fisheries, recreation, flood control, industry, power generation, etc.). All of the assumptions and methodologies underlying those measures are fully documented in publicly available reports that are easily obtained upon request.

7.5 Recommendation: Gather Additional Information as Planned

This recommendation is based on Step 5 in the provincial *Water Use Plan Guidelines*[104], as summarized below.

Step 5 - Gather additional information on the impacts of water flows on each interest.

[102] Fisher, Roger and William Ury. 1991. *Getting to Yes: Negotiating Agreement Without Giving In.* Page 40.

[103] Hammond, Johns. And Ralph L. Keeney and Howard Raiffa. 1999. Smart Choices: A Practical Guide to Making Better Decisions. Harvard Business School Press: Boston, Massachusetts. Page 38.

[104] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 2 and 24-25.

- Conduct technical studies and gather/analyze information. The most helpful studies will be those that help to establish the link and relationship between different flow levels and benefits/impacts across a range of interests. It is important for participants to consider all information provided (including not only technical and quantitative studies, but also anecdotal and qualitative information). "Experts" are not only those with technical or professional training, but also those who have first hand experience of the impacts of the river on their interest.

- Document remaining "data gaps" that can not be filled within the timeframe for developing the flow regime, and develop research program to fill them in the future (i.e., after the implementation of the recommended flow regime has begun).

7.5.1 Previous or Current NWC & NES Work Related to this Step

To date, the NWC & NES have already:

- ***Conducted numerous technical studies***. The NWC has reviewed and commissioned numerous relevant and informative technical studies (see Section 8.2 and 8.3 for complete lists) in the course of implementing the CWRF Work Plan.
- ***Developed flow targets for various water use interests***. The development of flow targets to address the various issues raised by NWC members and the broader Nechako Watershed community made an important contribution to the NWC's discussions of preferred post-CWRF flow regimes. The targets created a clear link between flow levels and the various interests in the watershed. Having identified these initial targets allowed the NWC to get a high-level picture of how well different flow regimes can meet a broad range of interests. This also created a common language or currency, allowing different interests to be compared in the same units. However, there is another side of the story the targets do not tell. For example, what is the impact of which is the not meeting the target? Does a 1 m^3/s shortfall have the same impact on one interest as another? Does a 1 m^3/s shortfall have the same impact in each month of the year? These are the kinds of questions which will be addressed during the development of performance measures in Step 4 (see Section 7.4.1 and 7.4.2). As a final note, it would be helpful if members, organizations, and constituencies represented at the NWC table treated the targets as useful – but not restrictive – guidelines when they eventually tackle the following tough question during Step 7 (Section 7.7.2): *could the representatives of a particular interest accept and adapt to slightly less flow than their target suggests if it means that a broader range of interests is addressed?*

7.5.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Gather additional information as planned***. The NES is actively working to implement the CWRF Work Plan which requires the completion of a number of additional technical studies, many of which have been initiated or will be shortly.
- ***Clarify what information is needed before proceeding with any further flow modeling***. Some of the technical studies that are currently planned or already underway will provide key information about constraints that will define what flow regimes are feasible (see Section 6.2.2 for examples). It would be helpful to fill any information needs that could affect flow modeling constraints before simulating or refining any of the flow scenarios in Step 6 (Section 7.6.2)

- ***During STEP 5 or STEP 8 - document remaining "data gaps" that can not be filled within the time frame*** for developing a recommended flow regime and develop a research program to fill them in the future. This is where the opportunity for adaptive management may enter the discussion, particularly when it comes to benefits and impacts for fisheries interests. Rather than completing this task at this step in the process, it may also be more appropriate to return to it once the preferred flow regime has been selected, and instead ask: *what information do we need to collect to determine whether the benefits we anticipate are actually realized? What information do we need to collect to determine how to further optimize the flow regime for the affected interests?*

7.6 Recommendation: Refine Flow Regimes for Mutual Gain

This recommendation is based on Step 6 in the provincial *Water Use Plan Guidelines*[105], as summarized below.

Step 6 - Create operating alternatives (flow regimes) for regulating water use to meet different interests.

- Define a diverse set of alternative operating (flow) regimes to compare the impacts on water use interests. The alternatives should reflect a variety of choices of operating conditions consistent with the multiple interests being considered. The range of operating alternatives should be forward-looking, recognizing facilities as they exist and the need for operational improvements to balance multiple uses.

- One of the alternatives developed for comparison purposes should be the "status quo" (no change in operations).

7.6.1 Previous or Current NWC & NES Work Related to this Step

To date, the NWC has already:

- ***Modeled a range of downstream flow regimes***. The NWC has now modeled a variety of annual flow regimes using first the Initial Spreadsheet Exercise and then the Nechako Downstream Allocation Model (N-DAM) (see Chapter 4).
- ***Calculated the probability of being able to provide those flows under different combinations of elevation and inflow conditions in the Nechako Reservoir***. The NWC has also explored whether it is possible to maintain the flow levels for each flow regime given the annual variation in inflows to the Nechako Reservoir.

7.6.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Define and model the "status quo" or "base case" alternative, for comparison purposes***. The NWC has not yet characterized and modeled a "base case" scenario using the N-DAM model. This will be needed as a point of comparison, both to assist the NWC in selecting a preferred post-CWRF flow regime, but also to complete the "Benefits Assessment" of the CWRF (Activity #5 in the CWRF Work Plan). <u>There is an opportunity to combine this work with the "Benefits Assessment" project that is currently being initiated to save time & money, as outlined in Section 7.12.</u>

[105] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 3 and 26.

- ***Refine and model (simulate) a range of post-CWRF flow regimes designed for mutual gain***. The initial modeling conducted to date has given the NWC important insight into the general opportunities to meet a broad range of interests. Once the additional technical studies and information collection activities that are currently underway (or planned) are completed in Step 5 (Section 7.5.2), there will be new information available about constraints on downstream flows (see Section 6.1.2 in this report for a description of efforts to fill existing data gaps). The NWC will then want to refine some of the initial alternatives to reflect these new constraints and/or design new flow regimes to increase mutual gains.
- ***OPTIONAL – Perform sensitivity analysis***. There are a number of factors that could affect some of the basic assumptions underlying this post-CWRF flow planning process. One of the most important is the unknown impact that climate change and global warming could have on the water balance in the Nechako watershed. It might be prudent to conduct some sensitivity analysis on 2-3 preferred flow regimes to determine how significantly they would be affected by changes in inflows to the system (e.g., if average inflows began decreasing over time). This could also lead to a preliminary discussion of how the NWC might want to handle that possibility: what process could be put in place to monitor and address that risk over time?
- ***OPTIONAL - Build in contingency planning and explore non-CWRF flow regimes for mutual gain***. While the NWC and NES are actively working on the implementation of the CWRF Work Plan, there is always the possibility that the CWRF may not proceed, or at least not on the expected time frame. Given this possibility, and given the NWC's ultimate goal of promoting the enhancement of the Nechako Watershed, it would be prudent to build in a contingency and also explore non-CWRF flow scenarios (i.e., through Skins Lake Spillway only) designed to meet a broader range of NWC interests than are currently met. There are a number of compelling reasons to do this now:
  - It will be a ***more efficient use of time and money*** to do this during the current planning process, while additional flow scenario modeling is already underway.
  - The findings of the modeling of non-CWRF flow scenario will likely ***help to build the argument for the CWRF*** (since the results will likely show it is easier to generate benefits for a broader range of interests under the post-CWRF scenarios than any non-CWRF scenarios). This will be ***useful information to share with both regulatory agencies and the broader Nechako Watershed community*** during any future communication and consultation processes.
  - The exploration of non-CWRF scenarios will ***ensure that the NWC has still made progress even if its preferred route to enhancement does not proceed or is delayed***. Contingency planning could lead to the development of an interim flow regime for implementation in the event that the CWRF does not proceed (or at least not on the expected time frame), without the NWC having to retrace its steps later.

7.7 Recommendation: Assess & Evaluate Flow Regimes in terms of Interests, Using Performance Measures

This recommendation is based on Step 7 in the provincial *Water Use Plan Guidelines*[106], as summarized below.

[106] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 3 and 27.

Step 7 - Assess the differences between operating alternatives (flow regimes) in terms of interests.

- Compare and evaluate the relative advantages and disadvantages of each operating alternative (flow regime) using the information on water use impacts gained from Step 5.

- Participants discuss how to achieve benefits for the greatest number of interests given the range of possible flow regimes. If possible, participants choose a preferred or recommended flow regime. The flow regime must respect all bounds set by legislation, regulations, policy, and constitutional rights.

- Analytical tools (such as Multiple Account Evaluation) can assist with the assessment and evaluation of operating alternatives (flow regimes).

7.7.1 Previous or Current NWC & NES Work Related to this Step

See Section 7.4.1.

7.7.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Calculate performance measures results for each simulated flow regime using the performance measures developed in Step 4***. These performance measures results will translate the flow conditions for each flow regime into numerical or descriptive scores that will show how each interest benefits or is impacted under those flows.
- ***Assess & evaluate flow regimes in terms of interests using performance measure results from benefits assessment***. Compare the performance measure results for various interests across the range of flow regimes (e.g., using a matrix or "consequence table" which has the alternatives listed in columns across the top of table, and performance measures listed in the rows down the side of the table). Compare and evaluate the relative advantages and disadvantages of each flow regime using this information.
- ***OPTIONAL - Conduct additional public consultation with broader community of stakeholders***. If the NWC would like to incorporate input from the broader Nechako Watershed community in their selection of a preferred flow regime, this would be an appropriate time to seek that input, before the NWC convenes for its final consensus-based decision-making session(s). At this stage, the NWC will be in a position to share clear information about the implications of different flow regimes for a variety of community interests.
- ***Discuss how to achieve benefits for the greatest number of interests given the range of possible flow regimes***. This is the stage where the NWC will need to engage in interest-based consensus-building discussions about solutions that would be acceptable to all members. These discussions can draw on all the information it has received about the relative advantage and disadvantages of a variety of feasible flow regimes (e.g., performance measure results), and also by the information it has received from the broader community.

7.8 Recommendation: Determine & Document Areas of Consensus and Disagreement

This recommendation is based on Step 8 in the provincial *Water Use Plan Guidelines*[107], as summarized below.

Step 8 - Determine and document the areas of consensus and disagreement.

- Draft a report documenting: the planning process, water use interests and objectives, performance measures, technical information gathered, operating alternatives (flow regimes) developed for consideration, comparison and evaluation of flow regimes, discussions among participants, areas of agreement and disagreement, and any consensus-based recommendations regarding a preferred flow regime (or range of acceptable flow regimes).
- Have all participants sign-off on the report and make the document public.

7.8.1 Previous or Current NWC & NES Work Related to this Step

The NWC has already:

- ***Documented a few areas of untested agreement related to the distribution of freed up flows*** through Skins Lake Spillway and the proposed CWRF at Kenney Dam (see Section 6.1.1 of this report).

There has not been enough specific discussion of possible implementation and management mechanisms for any areas of agreement to emerge yet on that topic.

7.8.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- ***Test and document levels of agreement*** on each specific flow-related item on the list that the NWC has committed to reaching consensus on (see Section 7.3.2). Document all areas of specific agreement. Identify any areas of disagreement and seek to understand and resolve differences using interest-based discussion.
- ***Draft a report*** documenting: 1) the process, 2) areas of agreement and disagreement, and the reasons for disagreement, and 3) any resulting recommendations.
- ***OPTIONAL - Have all participants sign-off on the report***. While there may be agreement around that NWC table that a particular flow regime is acceptable all members, there may be members who choose not to sign-off on the report or recommendations for legitimate legal or political reasons. For example, a First Nation might choose not to sign-off in order to respect their constitutionally-protected rights and titles.
- ***Make the document public***. This report will become an important public record, and may also be submitted to federal and regulatory agencies during environmental assessment processes or other review and approval processes related to the construction of the proposed CWRF.

[107] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 3 and 28.

7.9 Recommendation: Draft a Water Use Plan

This recommendation is based on Step 9 in the provincial *Water Use Plan Guidelines*[108]:

[108] Province of British Columbia. 1998. *Water Use Plan Guidelines.* Pages 3 and 29-31.

Step 9 - Prepare a draft Water Use Plan.

- Draft a concise technical document (Water Use Plan) detailing the operating parameters required to achieve the recommended operating (flow) regime, or the range of acceptable flow regimes. If adopted and approved by the provincial and federal regulatory agencies, these operating parameters could later become the actual constrains within which the facility owner/manager would make daily operating decisions.

- The Plan should describe how the operating parameters are intended to help meet the range of objectives identified by participants. It should also contain: 1) measures for monitoring operational compliance with the Plan, 2) notification procedures for spills and emergencies, 3) proposed future research to fill remaining data gaps, and 4) the proposed timing for review of the plan, including issues that might trigger such a review.

- If consensus is achieved on a preferred operating regime, then a signatory page could be added indicating agreement by the participants.

7.9.1 Previous or Current NWC & NES Work Related to this Step

No work completed on this to date since the NWC has not yet reached this stage in the process.

7.9.2 Specific Recommended Tasks

In order to fulfill the broader recommendation, the following tasks are recommended:

- Draft a concise technical document (a Water Use Plan) detailing the operating parameters required to achieve the recommended flow regime. See the information in the table above, that describes Step 9.

7.10 Summary of Recommendations

Table 7-1 summarizes:

- the steps outlined in the provincial Water Use Plan Guidelines that are proposed as a map for the NWC process moving forward
- the progress the NWC has already made towards completing each step
- recommendations for moving forward to complete each step.

As noted in Section 7.1, all recommendations are designed to build on previous, current and planned NWC/NES work and make efficient use of time, human resources and funding.

Table 7-1: Summary of Consultant's Recommendations for Moving Forward

#	Description of Recommended Step	Progress to Date: Previous or current NWC & NES work related to this step	Specific Recommended Tasks for Moving Forward	For more detail, see:
1	***Confirm a process and work plan to guide the NWC through the development of a preferred post-CWRF flow regime.***	***Clearly defined the scope of the process.*** The NWC has defined the overall scope of the process: the NWC committed itself (in its report to NEEFMC dated December 2000) to work towards reaching consensus on the reallocation of flows that would be freed up if a cold water release facility (CWRF) were constructed at Kenney Dam. This will include developing recommendations about: 1) distribution (amount and timing) of releases from Skins Lake Spillway and from a CWRF at Kenney Dam, and 2) the mechanisms under which those releases could be implemented and managed.	***Confirm the scope of the process.*** Since it has been 4 years since the NWC established the scope for the process in its 2000 report to the NEEFMC, it would be useful to clarify whether the scope is still the same in everyone's mind. ***Design and reach agreement on a clear, transparent process (i.e., a set of steps and work plan) for developing the NWC's final consensus-based recommendations.*** The remaining steps in this table (which are based on Steps 2 and 4 to 9 of the Provincial Water Use Plan Guidelines) outline a process that the NWC could adopt. ***Develop and reach agreement on a list of specific items related to flow regimes that the NWC is committed to reaching consensus on*** (vs. items that the NWC is able to agree to disagree on). The group will return to this list during its discussions in Step 7 (see below).	Section 7.3
2 and 4	***Confirm water use issues & interests in and develop performance measures.***	***Created a list of issues.*** This NWC has developed a list of 24 issues of concern to its various members. Consensus has been reached on the list of issues, but not on the framing and description of the issues. ***Reviewed available information.*** The NWC has reviewed available information related to the relationship between water flows and each of the issues identified. ***Identified information gaps.*** Along the way, the NWC identified a number of related information gaps and in some cases, undertook studies or consulted experts to learn more. ***Developed initial performance measures: N-DAM "tests".*** See description under Step 6 in this table. ***Solicited 3rd party recommendations for improving performance measures. Solicited recommendations for improving performance measures.*** A 3rd party review of N-DAM (commissioned by the NWC) outlined a number of limitations to the N-DAM "test" approach, and suggested a ways to improve the NWC's use of performance measures to better assess the impacts and benefits of flow scenarios. ***Developed other potential performance measures.*** In the process on working on one of its other CWRF Work Plan tasks (Activity 5: Benefits Assessment of the potential CWRF at Kenney Dam), the NWC commissioned a report that outlined a number of potential performance measures (indicators) that could be adapted for the purpose of evaluating potential flow regimes.	***Clarify NWC interests.*** The NWC could benefit from framing the list of issues in terms of interests, which are needs, desires, concerns, fears. Interests describe what matters to an individual or organization; interests are the things we care about, and want to see protected, maintained, increased or enhanced. *There is no need for the NWC to reach consensus on a shared set of interests*; instead, interests can be attributed to specific members (individuals, organizations or constituencies) with the understanding that all members respect the interests of others and will work towards mutual gain. ***Define quantitative and/or descriptive measures for assessing how well each interest can be met by different flow regimes.*** Performance measures are also sometimes called criteria, attributes, or assessment indicators. They are measures of success; they are either a measurement or a description of how your interest will either benefit or be impacted under a particular flow regime. There is an opportunity to save time & money by combining this work with the "Benefits Assessment" project that is currently being initiated.	Section 7.4

#	Description of Recommended Step	Progress to Date: Previous or current NWC & NES work related to this step	Specific Recommended Tasks for Moving Forward	For more detail, see:
5	***Gather additional information on the impacts of water flows on each objective.***	***Conducted numerous technical studies.*** The NWC has reviewed and commissioned numerous relevant and informative technical studies (see Section 8.2 & 8.3) in the course of implementing the CWRF Work Plan. ***Developed flow targets for various water use interests.*** The development of flow targets to address the various issues raised by NWC members and the broader Nechako Watershed community made an important contribution to the NWC's discussions of preferred post-CWRF flow regimes. The targets created a clear link between flow levels and the various interests in the watershed. Having identified these initial targets allowed the NWC to get a high-level picture of how well different flow regimes can meet a broad range of interests.	***Gather additional information as planned.*** The NES is actively working to implement the NWC's CWRF Work Plan which requires the completion of a number of additional technical studies, many of which have been initiated or will be shortly. ***Clarify what information is needed before proceeding with any further flow modeling.*** Some of the technical studies will provide information about constraints that will define what flow regimes are feasible. For that reason, it would be helpful to fill any information needs that could affect flow modeling constraints before simulating or refining any of the flow scenarios in Step 6. ***During Step 5 and/or Step 8: Document remaining "data gaps" that can not be filled within the time frame*** for developing a recommended flow regime and design a research program to fill them in the future. For example, w*hat information needs to be collected to: 1) test the assumptions used to develop the flow scenarios?* 2) *determine whether the anticipated benefits are actually realized? 3) determine how to further optimize the flow regime for the affected interests in the future?*	Section 7.5
6	***Create operating alternatives (flow regimes) for regulating water use to meet different interests.***	***Modeled a range of downstream flow regimes.*** The NWC has now modeled a variety of annual flow regimes using first the Initial water balance exercise (Section 4.1) and then the Nechako Downstream Allocation Model (Section 4.2). ***Calculated the probability of being able to provide those flows under different combinations of elevation and inflow conditions in the Nechako Reservoir.*** The NWC has also explored whether it is possible to maintain the flow levels for each flow regime given the annual variation in inflows to the Nechako Reservoir using the Nechako Reservoir Operations Model (Section 4.3).	***Define and model the "status quo" or "base case" alternative, for comparison purposes.*** The NWC has not yet characterized and modeled a "base case" scenario. This will be needed as a point of comparison, both to assist the NWC in selecting a preferred post-CWRF flow regime, but also to complete the "Benefits Assessment" of the CWRF. <u>There is an opportunity to save time & money by combining this work with the "Benefits Assessment" project that is currently being initiated.</u> ***Refine and model (simulate) a range of post-CWRF flow regimes designed for mutual gain.*** The initial modeling conducted to date has given the NWC important insight into the general opportunities to meet a broad range of interests. Once the additional technical studies and information collection activities that are currently underway or planned (see Section 6.1.2) are completed during Step 5, there will be new information available about any additional constraints on downstream flows. The NWC will then want to refine some of the initial alternatives to reflect these new constraints and/or design new flow regimes to increase mutual gains.	Section 7.6

#	Description of Recommended Step	Progress to Date: Previous or current NWC & NES work related to this step	Specific Recommended Tasks for Moving Forward	For more detail, see:
			OPTIONAL – Perform sensitivity analysis. There are a number of factors that could affect the basic assumptions underlying this post-CWRF flow planning process; for example, climate change. It might be prudent to conduct some sensitivity analysis on 2-3 preferred flow regimes to determine how significantly they would be affected by changes in inflows to the system (e.g., if average inflows began decreasing over time). ***OPTIONAL – Build in contingency planning and explore non-CWRF flow regimes for mutual gain.*** While the NWC and NES are actively working on the implementation of the CWRF Work Plan, there is always the possibility that the CWRF may not proceed, or at least not on the expected time frame. Given this possibility, and given the NWC's ultimate goal of promoting the enhancement of the Nechako Watershed, it would be prudent to build in a contingency and also explore non-CWRF flow scenarios (i.e., through Skins Lake Spillway only) designed to meet a broader range of NWC interests than are currently met.	
7	***Assess differences between operating alternatives (flow regimes) in terms of objectives (using performance measures).***	***Calculated "test" results showing how well each N-DAM flow scenario meets flow targets.*** The Nechako Downstream Allocation Model (N-DAM) has been used to simulate the outcomes of a variety of flow regimes (see Section 4.2 in this report). In the process of simulating a particular downstream flow scenario, N-DAM runs a series of 13 "tests" designed to show how well that scenario meets a set of flow targets designed to meet the various interests of the NWC (see Section 4.1). The "test" results reveal during how many months of the year the flow target is missed (i.e., the number of monthly failures) and the expected shortfall between N-DAM's simulated monthly flow and the NWC's monthly flow targets. This provides an initial assessment of which of the 8 flow scenarios generated using N-DAM are best/worst at meeting the NWC's objectives.	***Calculate performance measures for each simulated flow regime using the performance measures developed in Step 4.*** These performance measures results will translate the flow conditions for each flow regime into numerical or descriptive scores that will show how each interest benefits or is impacted under those flows. ***Assess & evaluate flow regimes in terms of objectives using performance measure results from benefits assessment.*** Compare the performance measure results for various interests across the range of flow regimes (e.g., using a matrix or "consequence table"). Compare and evaluate the relative advantages and disadvantages of each flow regime using this information. ***OPTIONAL – Conduct additional public consultation with broader community of stakeholders.*** If the NWC would like to incorporate input from the broader community in their selection of a preferred flow regime, this would be an appropriate time to seek that input, before the NWC convenes for its final consensus-based decision-making sessions. At this stage, the NWC will be in a position to share clear information about the implications of different flow regimes for a variety of community interests.	Section 7.7

#	Description of Recommended Step	Progress to Date: Previous or current NWC & NES work related to this step	Specific Recommended Tasks for Moving Forward	For more detail, see:
			Discuss how to achieve benefits for the greatest number of interests given the range of possible flow regimes. This is the stage where the NWC will need to engage in interest-based consensus-building discussions about solutions that would be acceptable to all members. These discussions will be informed by all the information it has received about the relative advantage and disadvantages of a variety of feasible flow regimes, and also by any input it has received from the broader community.	
8	***Determine and document areas of consensus & disagreement.***	***Documented a few general areas of untested agreement related to the distribution of freed up flows*** through Skins Lake Spillway and the proposed CWRF at Kenney Dam (see Section 6.1.1 of this report). There has not been enough specific discussion of possible implementation and management mechanisms for any areas of agreement to emerge yet on that topic.	***Test and document levels of agreement on each specific flow-related item on the list that the NWC has committed to reaching consensus on (see Step 1 earlier in this table).*** Document all areas of specific agreement. Identify any areas of disagreement and seek to understand and resolve differences using interest-based discussion. ***Draft a report documenting:*** 1) the process, 2) areas of agreement and disagreement, and the reasons for disagreement, and 3) any resulting recommendations. ***OPTIONAL - Have all participants sign-off on the report.*** While there may be agreement around that NWC table that a particular flow regime is acceptable all members, there may still be members who choose not to sign-off on the report or recommendations for legitimate legal or political reasons. ***Make the document public.*** This report will become an important public record, and may also be submitted to federal and regulatory agencies during environmental assessment processes or other review and approval processes related to the construction of the proposed CWRF.	Section 7.8
9	***Prepare a draft Water Use Plan.***	No work completed on this to date since this stage of the process has not yet been reached.	***Draft a concise technical document (Water Use Plan) detailing the operating parameters required to achieve the recommended flow regime.*** If adopted and approved by the provincial and federal regulatory agencies, these operating parameters could later become the actual constrains within which the facility owner/manager would make daily operating decisions. The Water Use Plan should describe how the operating parameters are intended to help meet the range of objectives identified by participants. It should also contain: 1) measures for monitoring operational compliance with the Plan, 2) notification procedures for spills and emergencies, 3) proposed future research to fill remaining data gaps, and 4) the proposed timing for review of the plan, including issues that might trigger a review.	Section 7.9

7.11 Additional Considerations

The items I raise in this section are not necessarily presented as recommendations, but rather as topics for consideration by the NWC as they move forward.

7.11.1 Provisions for Failure to Reach Consensus

The Nechako Watershed Council's Terms of Reference clearly state that all of the Council's decisions are made by consensus. While the consensus-based model clearly aligns with the values of the Council, and it may be possible to achieve a consensus agreement on a preferred post-CWRF flow regime, this way of operating may also be a risk. Insisting on 100% unanimous agreement allows for the possibility of process paralysis, which would be a shame after all of the time and effort that has been invested in this planning project to date. This is a dilemma that the NWC will need to grapple with.

One option would be to set some parameters around the flow regime development process (whether that be the budget or the time frame), strive for consensus on as many items as possible within that time and budget, and to choose a 3rd party to make the final decision on items that the group could not reach consensus on.

7.11.2 Operating Procedures

I have noticed that at the two meetings that I have attended (in September and November of 2004), approximately half of the NWC members were not in attendance. While this is understandable given the multiple commitments facing many of the NWC members and also given the challenges of traveling in the winter, this does pose a risk to progress on consensus-building once the NWC gets closer to testing agreement on various aspects of a preferred post-CWRF flow regime. While a number of the steps and tasks that I have recommended can be completed in a way that keeps non-attending members informed without requiring their input necessarily, there will come a point during the later steps when fuller participation is required and/or clear and practical procedures will need to be developed in order to respect the spirit of the NWC's commitment to consensus.

This may involve developing and clearly documenting operating procedures that outline how key decisions will be made without full attendance, and also to deal with any concerns raised by absentees after the fact. It would be helpful to develop these well in advance of a need for them so that everyone understands the procedures once they are being implemented.

7.11.3 Comments on the Draft Flow Regime Principles

In Section 6.1, there is a copy of the most recent version of the *Draft Flow Regime Principles*. I would like to offer some observations that may be helpful to the NWC if it chooses to continue refining the draft. From my perspective, the principles as they are currently drafted include a mix of:

- ***Interests*** or needs, desires, concerns, fears. Interests describe what matters to an individual, organization or constituency. Interests are the things we care about, and want to see maintained, protected, increased or enhanced. Examples of the interests I see mentioned in the Draft Flow Regime Principles include: dam safety, public safety, ecological integrity and enhancement of the Murray-Cheslatta system. What is noteworthy is that some interests are specifically highlighted (like those I just mentioned), while others are referred to in general terms (e.g., "all interests and communities"). To the outside reader, this can suggest that some interests are considered to be more important than others.

- ***Decision rules*** that establish clear rules about how decisions should be made in particular situations. For example, a decision rule might address what happens if inflows are below average and there is not enough water available to meet everyone's interest. In that case, a decision rule might specify which interests are given priority, or it might specify a way of distributing the impacts equitably across all interests. *While I don't consider any of the draft principles to be decision rules*, they use language that suggests a hierarchy of priorities (e.g., "paramount", "important", "essential") and can create confusion for an outside reader. If none of the principles are intended to be decision rules, the NWC might consider stating that explicitly in the pre-amble and rewording to avoid words that suggest implicit priorities. If, on the other hand, the document is intended to provide clear guidance (i.e., decision rules that could easily be interpreted by the operator of the facility in making operating decisions in different situations), then it would be helpful to work on making the document more specific and precise.
- ***Process objectives*** that describe how a decisions will be made. For example: *"Decisions are made in an open, transparent and consensus-based manner."* This answers the question: how will the decision get made? This is different from answering the question: what factors should guide the decision? (which is what the rest of the document focuses on). It might be helpful to separate any process objectives from the remainder of the text in some way.

7.12 Preliminary Schedule for Implementation

While I was only asked to develop high-level recommendations for moving forward without specifying the timeframe or the estimated costs, I have taken the liberty of proposing a preliminary schedule for implementation of some of the initial steps that reflects what I believe might be the approximate level of effort required to complete each of the proposed recommendations.

Note that there is one immediate opportunity for synergy between tasks. At the time of writing, the NES is drafting a Terms of Reference for a contract with a consultant to perform a Benefits Assessment of the proposed CWRF at Kenney Dam. This will require the development of a base case and performance measures (assessment indicators). While the base case and performance measures for the CWRF benefits assessment will be slightly different than the base case and performance measures for the assessment of flow regimes, there will be significant overlap. Further, both tasks will require similar skills and experience in a consultant. If the Terms of Reference were broadened slightly, the contract could yield a double benefit for the NWC.

Step / Task	*Possible Time Frame*	*Suggested Human Resources Required*
Initial discussion of next steps – possibly develop draft terms of reference for a contract with a facilitator to assist the group through the remainder of the flow regime selection process.	NWC meeting on February 11	N/a
Step 1 – Design & confirm the process for moving forwards (including list of specific flow-related items to reach consensus on by the end of the process)	2-day NWC meeting in spring (April 2005?)	Facilitator with a background in interest-based negotiation and resource planning

Step / Task	***Possible Time Frame***	***Suggested Human Resources Required***
Step 2 – Clarify interests	1-day NWC meeting in early summer (June 2005?)	Facilitator with a background in interest-based negotiation and resource planning
Step 4 – Develop performance measures *** combine with work on Benefits Assessment (CWRF Work Plan Activity 5)*	Summer 2005	Consultant(s) with experience with both economic and environmental assessment
Step 6 – Develop Base Case *** combine with work on Benefits Assessment (CWRF Work Plan Activity 5)*	Spring/summer 2005	Consultant(s) with experience with both economic and environmental assessment working with Dan Bouillon, Louise Remillard, and confirming with NWC
Step 5 – Gather additional information	Ongoing	Various external consultants as planned by NES
Step 6 – Develop refined flow regimes for increased mutual gain	Once all relevant studies from Step 5 are complete (NWC meeting in early 2006?)	Dan Bouillon & Louise Remillard with input from NWC at a facilitated meeting
Step 7 – Assess differences between operating alternatives (flow regimes) in terms of interests (using performance measures)	Fall 2005 for base case and existing flow scenarios Winter/spring 2006 for new/refined flow scenarios	Consultant(s) with experience with both economic and environmental assessment (same as for Task 4) to generate results Facilitator to lead discussion of results and implications at NWC meeting(s)
Step 7 – OPTIONAL – Conduct additional public consultation with broader community of Nechako Watershed stakeholders	Late spring or early summer 2006	Consultants with experience in public consultation (e.g., Praxis)
Step 8 – Test and document areas of agreement & disagreement	Fall 2006	Facilitator
Step 9 – Draft a technical document outlining the operating parameters of the recommended flow regime	Winter 2006/07	Facilitator

7.13 Closing Comments

It has been a pleasure to work with a group with as much perseverance and determination as the Nechako Watershed Council. In the short time that I have spent with the group, I have caught a glimpse of the big strides the group has made since it first formed in the late 1990's. I'm glad to have been part of the NWC's journey forward towards its ambitious goals for enhancing the Nechako Watershed, and look forward to our paths crossing again.

8 References

This section contains separate lists of:

- Documents referenced in this report
- Reports reviewed and commissioned by the Nechako Watershed Council
- Presentation materials, briefing notes, proposals and handouts distributed to the Nechako Watershed Council at their meetings.

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9 Glossary of Acronyms & Technical Terms

Anadromous	Fish (such as salmon) that ascend freshwater streams from the sea to spawn.
Base flows	The minimum volume of water running through a river system at any given time.
BCEAA	British Columbia Environmental Assessment Act
BCUC	British Columbia Utilities Commission
CDN	Canadian Dollars
CEAA	Canadian Environmental Assessment Act
Confluence	The place where flowing bodies of water such as streams or rivers join.
CWRF	Cold Water Release Facility
Deep water intake (on a water release facility)	The physical structure on a water release facility that withdraws water from deep within the reservoir to ensure that the water is always cold (± 10°C in the reservoir).
Flip bucket spillway	A spillway equipped with a flip bucket energy dissipater at the downstream end, which is shaped so that water flowing down at a high velocity is deflected upward in an arc.
Flow regime	The pattern of water volume, depth and velocity over an annual cycle at a given point on a river or stream.
Hydrograph	A graphic representation of stage, flow, velocity, or other characteristics of water at a given point over time.
KCP	Kemano Completion Project
KDRF	Kenney Dam Release Facility
Meander	Sharp, sinuous loop or curve in a stream, usually part of a series.
Nechako Watershed Area	This encompasses all tributaries of the Nechako, the reservoir and the river to its confluence with the Fraser River at Prince George.
NEEF	Nechako Environmental Enhancement Fund
NEEFMC	Nechako Environmental Enhancement Fund Management Committee
NES	Nechako Enhancement Society
NFCP	Nechako Fisheries Conservation Program
NWC	Nechako Watershed Council
Rehabilitation	Restoration of the historic ecological functions of an area that has been subject to environment degradation (i.e., efforts to make it more natural).

Spillway	A structure over or through which water flows or is discharged from a reservoir.
Surface water intake (on a water release facility)	Withdraws water from the surface of the reservoir, therefore water temperature varies depending on the time of year.
Temperature profile	A graphic representation of temperatures as it changes with water depth (e.g., from the surface to the bottom of the Nechako Reservoir).
Temperature shear	The contact between a stream of colder water and a stream of warmer water before mixing of the two occurs resulting in a sudden and substantial change in temperature.
Total Gas Pressure (TGP)	A measure of the total concentration of dissolved gases in water.
USD	United States Dollars