BRITISH COLUMBIA

Columbia River Treaty Review

Environmental Discussion Paper

July 2013

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About the Discussion Paper

The discussion paper focuses on those interests which may be impacted by potential alterations in reservoir elevations and discharge levels at storage facilities in the Columbia River Basin that are related to the Columbia River Treaty.

Chapter 1 of this discussion paper summarizes the various environmental interests as they relate to water management in the Columbia River Basin. Chapter 2 gives examples of past and current activities and initiatives conducted to address those interests. Chapter 3 explores how different potential water management scenarios reflecting future decision options related to the Columbia River Treaty could impact or enhance key environmental values in the Canadian Columbia Basin. Chapter 4 provides a summary of key findings and observations.

The discussion paper was commissioned by the Ministry of Energy and Mines of British Columbia and is based on the report of the consultation conducted by the Columbia River Treaty Review Team between March 2012 and October 2013, modelling and analysis conducted between August 2012 and October 2013 which is detailed in the Technical Studies Report, BC Hydro's Non-Treaty Storage Agreement consultation reports, Water Use Plans, Summary Report of local consultations conducted by the Columbia Basin Trust, and other documentation. It was prepared by Dr. Glen Hearns, of Aristos Consulting, and does not necessarily reflect the position or opinion of the Province.

Acronyms and Definitions

AOP	Assured Operating Plan	The prescribed operations of the Columbia River Treaty facilities 5 years in advance
	Canadian Entitlement	The Canadian portion of the calculated increased power benefits in the United States due to operations in Columbia River Treaty facilities in Canada
	Canadian Entity	BC Hydro, and the Province for the disposal of the Canadian Entitlement
CBT	Columbia Basin Trust	A provincial Crown Corporation with a mandate to invest in the economic, social and environmental well-being of residents in the Columbia Basin
CRT	Columbia River Treaty	An agreement between the US and Canada to build storage facilities in Canada to optimise for flood control and power generation in the US
DOP	Detailed Operating Plan	The operations of the Columbia River Treaty facilities as agreed to each year
DFO	Department of Fisheries and Oceans	Federal Agency primarily responsible for managing ocean fisheries and Species At Risk Act (SARA) listed species.
EC	Environment Canada	Federal Agency primarily responsible for protection of water resources, conservation of wildlife (under Species At Risk Act and Migratory Birds Convention Act) and prediction of weather and climate conditions
	Entrainment	Entrainment is narrowly defined in the report as the killing or physical damage of fish from turbine abrasion and/or spillways at hydro-electric facilities
kcfs	thousand cubic feet per second	Measure of volume of water flow: 1 kcfs = 28 m^3/s
m^3/s	cubic meters per second	Measure of volume of water flow: 28 m^3/s = 1 kcfs
MOE	Ministry of Environment	Provincial agency responsible for fish and wildlife management in British Columbia.
NTSA	Non-Treaty Storage Agreement	A commercial agreement between the Bonneville Power Administration and BC Hydro to address additional storage built when constructing Columbia River Treaty facilities.
SARA	Species at Risk Act	Federal legislation protecting species at risk across Canada.
TDG	Total Dissolved Gas (also TGP – Total Gas Pressure)	Level of saturation of water with gases that can occur during spill events at hydro generating stations and naturally at waterfalls and rapids
WLR	Water License Requirements	The Water Act requires BC Hydro to hold licenses for water storage and to operate facilities. These may involve operations, physical works, studies, and engagement processes. Requirements include the provision of public access and mitigation measures to address impacts to non-power interests such as fish and wildlife

Columbia River Treaty: Environmental Issues Discussion Paper

Introduction

The paper is for discussion purposes to provide a starting point for Columbia Basin residents and the Province to identify ecosystem function and environmental interests inside and outside of the scope of the Columbia River Treaty. This understanding will help to inform the provincial strategic decision around the future of the Columbia River Treaty.

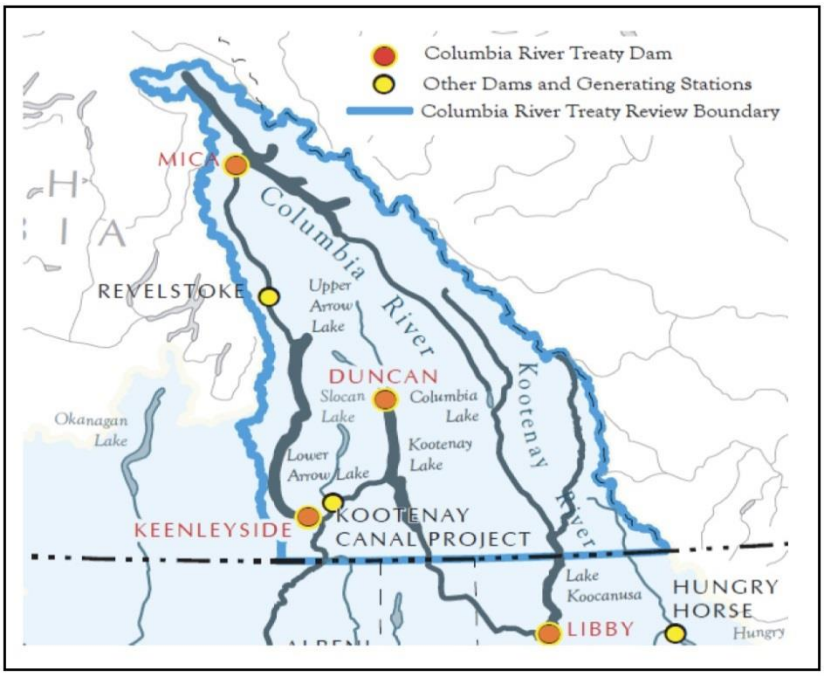
This *Discussion Paper* has been developed in stages throughout the review process and has been updated based on feedback and modelling throughout the process. The first two chapters summarize the various environmental interests as they relate to water management in the Columbia Basin and give examples of activities and initiatives conducted to address those interests. These chapters are based on a literature review focusing on BC Hydro's Non-Treaty Storage Agreement (NTSA) consultation reports, Water Use Plans (WUP), Fish and Wildlife Compensation Plan (FWCP) reports and other documentation, and public consultation undertaken by the Province in spring 2012. Chapter 3 describes how environmental interests may be affected by future operations of storage facilities under scenarios of either continuing or terminating the Columbia River Treaty. It is based on the findings of technical studies, modelling and consultation conducted between August 2012 and October 2013. The details of which are found in the *Columbia River Treaty Review Technical Studies Report*[1] and the subsequent *Addendum to the Technical Studies Report.*[2] Chapter 4 provides a summary of key findings and observations. This *Discussion Paper d*oes not necessarily reflect the position or opinion of the Province.

The Water Use Plan process, the Non-Treaty Storage Agreement and the FWCP are all based on forward looking approaches; in other words, the recognition that environmental and social impacts have occurred in the Columbia River Basin with dam building, but incremental operational changes at the hydro-electric facilities, and physical works in the Basin can be undertaken to offset some of these impacts. This report does not provide an in-depth accounting of what has been impacted, but rather a summary of the mitigation and compensation efforts to date resulting from the WUP, NTSA, FWCP and other processes.

The geographical scope of the research encompasses the main-stem of the Columbia River from Kinbasket reservoir and tributaries and the Columbia River to its headwaters, to the border with the United States; the Duncan watershed, Kootenay Lake and the lower Kootenay River to the confluence with the main stem Columbia River; the Koocanusa watershed and Kootenay River as it enters into Kootenay Lake. Okanagan Basin issues are being addressed in a separate process.

[1] The Draft Technical Studies Report was based on technical studies and modelling conducted between August 2012 and March 2013. It is available at: http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT_Technical_Report-DRAFT.pdf
[2] The Addendum was based on additional consultation, technical studies and modelling conducted between March 2013 and October 2013. It is available at: http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT-Technical-Studies-Addendum-DRAFT-Oct30.pdf

Figure 1 Columbia River Treaty Review Area Map:



The Columbia River Treaty

The Columbia River Treaty (the Treaty) is an agreement between the United States (U.S.) and Canada to develop and operate upstream storage in B.C. in order to provide a regulated flow on the Columbia and Kootenay[3] rivers, and optimise flood control and power generation in both countries. Under the agreement 15MAF of active storage would be built in Canada at Mica, Hugh Keenleyside and Duncan dams. The treaty provides for the U.S. to compensate Canada (specifically, B.C.) for the 'downstream benefits-increased power generation' the U.S. could realize (under the assumed conditions); and it permitted the U.S. to construct the Libby dam and associated Koocanusa reservoir, which extends into B.C. Most of the benefits and obligations under the Treaty were transferred to BC in the separate 1963 *Canada-BC Agreement.*

There is no official 'expiry date' of the Treaty. The Treaty can be terminated by either Canada or the U.S. by giving a minimum 10 years notice to the other. The earliest possible termination is in 2024, and therefore 2014 is the latest year that notice can be given to terminate the Treaty at its earliest date.

It is critically important therefore to review environmental interests potentially affected by the Treaty to assist the government in developing a strategy with respect to 2014.

The Non-Treaty Storage Agreement refers to the extra storage Canada built in Canada. When Mica dam was constructed and extra 5 MAF of storage was constructed. Also Revelstoke dam and was constructed but is not under the Treaty. The filling and use of the extra storage at Mica as well as the filling of the storage at Revelstoke had to be agreed to by the US and was done under the initial Non-Treaty Storage Agreement. This agreement was renegotiated periodically and a long term Non-Treaty Storage Agreement was signed in April 2012 to last until 2024.

[3] The spelling is Kootenai in the U.S.

The improved regulation (smoothing out of seasonal variations in stream flows) on the Kootenay River provided by Duncan and Libby made additional generation on the Kootenay River economic. This was provided for by the construction of the Kootenay Canal project (KCL) in parallel with Cominco's & West Kootenay Power's (WKP) existing Corra Linn, Upper Bonnington, Lower Bonnington and South Slocan projects. This more efficient BC Hydro owned project was coordinated with the existing projects under the terms of the Canal Plant Agreement (CPA) - a "one-operator" co-ordination agreement. Under the terms of this agreement, BC Hydro directs the operation of all the projects and retains the actual generation of all the projects. In return the Entitlement Parties (Cominco, FBC and CPC/CBT) receive a specified amount of electricity (capacity and energy) referred to as the Basic Supply or CPA entitlement

Chapter 1: Environmental Interests in the Columbia Basin.

This chapter examines environmental interests and values in the Columbia Basin and their relation to water management and the operations of storage facilities. Interests and values included in this chapter reflect perspectives shared during Water Use Plans, consultations for the Non-Treaty Storage Agreement, Revelstoke 5 and Mica 5/6 upgrades, and public consultation undertaken by the Province in spring 2012. Awareness and education sessions conducted by the Columbia Basin Trust in the fall of 2011, as well as a Columbia River Treaty young leader's event in winter 2012 also drew out perspectives from across the basin.[4]

1.1 Groups Involved with Environmental Interest Setting in the Columbia Basin

Various groups, agencies and levels of governments have expressed environmental interests and have participated in mitigation activities in the Columbia Basin including, but not limited to:

First Nations: First Nations have well developed and long standing interests in environmental matters and associated constitutionally protected aboriginal rights. Principles of environmental stewardship are of central and profound cultural importance for many Columbia Basin First Nations. Many express their perspective that all species and ecosystems are important to their cultures. That said they have expressly emphasised certain elements or areas that are of particular spiritual, cultural, or ceremonial significance as well as those that enable them to harvest for foods or medicines. Columbia Basin First Nations have also over the years articulated a strong desire to have anadramous salmon populations returned to historic harvesting and habitat areas in the upper Columbia River.

Local communities and: Local communities have expressed environmental interests in a number of ways, including maintaining ecosystem functioning, climate change impacts, conservation of specific species and sustainable use of resources including recreational fishing and hunting.

The Columbia Basin Trust Columbia Basin Trust (CBT) was created in 1995 and helps create and support mechanisms for Basin residents to actively and meaningfully participate in water management decisions at local and regional levels and actively participated in both the Columbia and Duncan Water Use Plans. The CBT has directly contributed to the enhancement of fish and wildlife by providing over $3 million in funding over the past five years for environmental conservation, restoration, stewardship and education projects across the Basin.

Provincial Ministry of Environment (MOE) and Ministry of Forests, Lands and Natural Resources Operations (MFLNRO): MOE and MFNLRO are the provincial natural resource agencies that manage the province`s ecological and biodiversity heritage. MOE supports BC in leading in

[4] http://gov.bc.ca/columbiarivertreaty/community-sessions/; and http://www.cbt.org/crt/assets/pdfs/2011InformationSessionSummaries_CRTSummaryReport.pdf

sustainable environment management by ensuring clean and safe water, land and air, and healthy and diverse native species and ecosystems. MFLNRO delivers integrated natural resource management services for British Columbians. It is the main agency responsible for establishing the policy and conditions for access to, and use of the province`s forest, land and natural resources (including the management of fish and wildlife for recreational purposes). The agencies' activities, with regard to species and ecosystems conservation and management, are guided by a number of strategic documents – the Conservation Framework and Program Plans for Fisheries, Wildlife and Ecosystems. MOE and MFLNRO are key partners in the Fish and Wildlife Compensation Program and participated

Federal government – Departments of Fisheries and Oceans and Environment Canada: The Federal government has environmental interests in the Columbia Basin that are executed primarily through the activities of the Department of Fisheries and Oceans and Department of Environment. Under the Fisheries Act, the Department of Fisheries and Oceans is the primary agency responsible for conserving and managing Canada's fisheries, including Pacific salmon. It does so through management and monitoring of fisheries, protection of fish habitat, and pollution prevention (note: Environment Canada administers section 36 of the Fisheries Act, the key pollution prevention provision, prohibiting the deposit of harmful substances into waters frequented by fish unless otherwise authorized under regulation). The Policy for the Management of Fish Habitat (1986) has an overall objective of "net gain" of fish habitat and helps guide the implementation of fish habitat protection through collaboration with relevant provincial agencies.

Environment Canada is the lead federal agency for implementation of the *Migratory Birds Convention Act* (MBCA) and the *Species at Risk Act* (SARA). The MBCA implements the Migratory Birds Convention (1916 Canada-U.S. treaty) and establishes Environment Canada has the lead agency for the conservation of migratory bird populations listed under the MBCA. This includes most birds, with the notable exception of raptors (hawks, eagles, falcons, owls etc.) as well as a handful of other species. Similar legislation in the United States protects birds species found in that country, with minor differences. An important mechanism for implementing bird conservation across North America are the 'joint ventures' (JV), partnerships between governments, conservation organizations, industry and others. The Canadian Intermountain Joint Venture (CIJV) covers the entirety of the Columbia Basin in Canada and includes BC Environment and many other partners. The focus of the JV is on 'all bird' (i.e. provincial and federal species) habitat conservation. BC Hydro has traditionally been a partner in the CIJV.

Responsibility for the conservation of species at risk in British Columbia is shared between the federal and provincial governments. The *Accord for the Protection of Species at Risk*, an agreement between Canada and her provinces, identifies high level commitments. Federal responsibilities for species at risk conservation are articulated in Canada's *Species at Risk Act* (SARA). The Species at Risk Act mandates species assessment, listing, protection and recovery for species listed under Schedule 1 of the act. SARA also requires, to the extent possible, consultation or cooperation with directly affected parties, particularly First Nations. Responsibilities under SARA are shared, with the Minister of Fisheries responsible for aquatic species managed under the Fisheries Act and Environment Canada or Parks Canada responsible for terrestrial species (the latter only where species at risk occur on lands under their jurisdiction, such as National Parks). In recognition of established jurisdictions, SARA contemplates provincial leadership for species that are not managed under the *Fisheries Act* or the *Migratory Bird Convention Act*, or which occur off of federal lands, but does contain mechanisms for broader application to facilitate species recovery.

The *Canada-British Columbia Agreement on Species at Risk* articulates respective roles and responsibilities and as well establishes planning, coordination and information sharing mechanisms. In most circumstances, recovery planning for species other than aquatic species or migratory birds is led by BC Environment. Provincial recovery documents are then adopted, with some modifications to meet SARA requirements, by federal agencies.

In addition to wildlife protection roles and responsibilities, Environment Canada is engaged in water management activities through implementation of a hydrometric monitoring agreement (Water Survey of Canada) and a water quality monitoring agreement with British Columbia. The Department of Environment Act specifies a role in relation to the management of boundary waters under the International Joint Commission. Also of relevance to water management responsibilities is the International River Improvements Act (IRIA). This Act provides for licensing of "improvements" on waters flowing from Canada to the U.S. (e.g. dams, obstructions, canals, reservoirs or other works that can alter trans-boundary flows). The three Canadian dams constructed under the Columbia River Treaty are licensed by Environment Canada under the IRIA, as are other non-treaty dams on the Canadian Columbia and Kootenay systems

BC Hydro. As the operator of the major storage facilities in the region BC Hydro plays a critical role addressing environmental interests. It does so primarily through funding and participating in the Fish and Wildlife Compensation Program, engaging in Water Use Planning and conducting operational changes, physical works and monitoring studies as part of water licensing requirements (WRL). BC Hydro is the Canadian Entity under the Columbia River Treaty and is able to negotiate through mutual consent with its counterparts in the United States modifications to the Assured Operating Plan (AOP) flow in the Columbia River to be able benefit environmental issues in Canada.

Columbia Operations Fisheries Advisory Committee (COFAC). COFAC was established in 1994 to provide a structured forum for the exchange of information pertaining to the coordination of activities related to the operation of hydro projects on the Columbia River system in Canada and associated fisheries issues.[5] The mandate of the committee is to share information regarding hydro-power operations in the Columbia system and associated fisheries issues; provide recommendations on project operations, identify where further agency involvement is needed and to facilitate agency approval for operational changes including communication and cooperative action to enhance the operation of the Columbia River system for the benefit of Canadians.

1.2 Regional Environmental Interests

Table 1 outlines the different interests expressed by various groups in a range of different processes. In listing regional values it should be emphasized that communities throughout the region have expressed an interest in ensuring sustainability in dealing with water management in the future.[6] In the spring 2012 public consultations conducted by the Province, many residents, particularly youth, expressed a desire for greater transboundary collaboration to enhance ecosystem function at the basin-level. In effect, there is a growing interest in a mechanism for discussing governance of ecosystems, fish and wildlife across the basin than currently exists.

The spring 2012 consultation also underscored the importance of climate change. Some climate models suggest that there may be increased winter precipitation combined with glacial recession[7] which will have implications for flood control as well affecting water levels in the Columbia Basin. The overall contribution from B.C. to the Columbia River is thus expected to increase under climate change scenarios. Residents expressed an interest to understand the implications of these changes, what adaptation strategies are being considered, and how the future of the Treaty may ensure flexibility to respond to change.

[5] Membership includes: BC Hydro (BC Hydro), the Federal Deptment of Fisheries and Oceans (DFO), and the provincial Ministry of Environment, Lands, and Parks [now the Ministry of Environment], Canadian Columbia River Inter-Tribal Fisheries Commission (CCRIFC), West Kootenay Power (now FortisBC), Columbia Power Corporation (CPC), Teck Cominco Metals Ltd. (TCML) and Okanagan Nation Alliance (ONA).
[6] CBT – Engagement and Education Report 2012.
[7] Bruce, J. M., H; Alden, M, Mortsch, L; Mills, B (2003). Implications of climate change for Canada-U.S. Boundary Water Agreements. *Report for Natural Resources Canada.* Annex A

In numerous forums and processes, a desire has been expressed to bring salmon up the Columbia if it can be technically and economically feasible. This is a key priority among First Nations.

Table 1 : Regional Interests in the Columbia Basin with Respect to Water Management

Category	Main Interest	Specific interests and values
General	Sustainability	The future of water management in the Basin should address a wide range of interests including social, economic and environmental values.
Environment and Climate Change	Climate Change	Minimize negative impacts associated with climate change. Understand and develop adaptation strategies. Ensure flexibility in the Columbia River Treaty to respond to climate change impacts.
	Ecosystem function and resilience	Maximize the diversity, productivity and resilience of the ecological systems, including supporting nutrient programs, supporting a more natural hydrograph, flooding for riparian (cottonwood) productivity, flushing flows, preservation, enhancement of wetlands etc.
	Fish and Aquatic Resources	Maximize the abundance, diversity and condition of wild, indigenous fish stocks and conservation, protection and restoration of fish habitat in the Columbia River system, including lakes and reservoirs, and rivers. In particular for rainbow trout, white sturgeon, cutthroat trout, bull trout (Dolly Varden), kokanee, whitefish, and burbot. This includes access to tributaries for spawning, minimum flows, gravel additions and stream complexing, entrainment, TGP, etc. It also includes desire to bring salmon back to the Canadian Columbia River if technically and financially feasible.
	Wildlife and vegetation	Maximize the wildlife abundance and diversity in the Columbia River system. Including shorebirds, spring nesting and fall migratory birds (in particular refuge habitat for Great Blue Heron), resident birds, amphibians, bats, reptiles and species associated with hunting interests. Maximize riparian and wetland habitat, diversity and productivity. Including floodplain ecology, grasslands, protected areas, riparian habitat and drawdown zone, wetlands, littoral productivity, and wildlife and nesting habitat. There is a special emphasis on plants for traditional use as well as herbaceous and shrub communities.
Culture and Heritage	Understand and protect cultural artefacts, and archaeological and cultural sites	Maximise understanding of sites and their location. Minimize erosion impacts on potential archaeological zones. Minimize the impact of destructive human behaviour, such as traffic and pot hunting on potential archaeological zones. Allow access to archaeological sites by appropriate people.
	Support / ensure First Nations' ability to harvest for food, cultural and ceremonial purposes.	Maximize availability of traditional plants. Maximize abundance and diversity of fish and wildlife populations to that First Nations use for harvesting and associated activities.
	Traditional transportation routes	Maximise ability to move through water system.
Flood & Erosion	Property	Minimize damage to property and injury to people.
Learning	Learning/monitoring and studies	Maximize learning about the impacts of operations on non-power objectives and understanding fisheries management plans that are in place, or that need to be developed. Understanding the process for advancing environmental interests, including what legal requirements exist in Canada and the U.S. to include ecosystem function in the Columbia River Treaty.
Recreation and transportation	Commercial transport	Minimize disruptions to commercial navigation/transport.
	Access	Maximize the community benefits from quality and diversity of

Category	Main Interest	Specific interests and values
	Aesthetic	recreation and tourism.
	Boater Safety	Maximize water and shoreline access, visual quality and boating/swimming safety
Power Generation	Provincial Revenue	Maximize the power benefits
		Maximize financial value of power.
		Maximize ancillary service capability.
		Minimize negative impacts to Kootenay Lake (IJC)
Quality of Life	Mosquitos (Duncan River)	Maximize the quality of life for residents (health and nuisance issues)

Table 1 shows the range of interests that have been expressed regarding water management in the Columbia Basin. While some of the interests overlap they have been categorized to simplify discussion and help determine the focus on environmental and learning interests (those in ***bold***). Some issues transcend different interest areas. For example flooding and erosion are generally considered as important due to the loss and damage to property; however, they also impact riparian vegetation. Erosion on the one hand may have negative consequences as banks may be removed, however, flooding can provide important vehicles for riparian production such as cottonwood forests. Also, flooding can provide flushing flows important for cleaning the substrate.[8] These situations are considered as part of **ecosystem function and resilience** and are therefore part of environmental interests.

While the environmental interests outlined in Table 1 pertain to most of the basin, there are specific interests at the local level which are addressed in Table 3 (Chapter 2). Some interests such as entrainment may occur at multiple areas such as Mica, Revelstoke and Keenleyside; whereas other interests are more localised, such as preserving habitat for Blue Heron on Waldie Island.

1.3 Trade-offs

In balancing different interests trade-offs across the system need to be considered. For example in many instances changing operations to meet the needs of fish may have impacts on power generation. In the case of Mica dam it was estimated that restricting operations for fish benefits would cost between $16M and $25M/year depending on the operational scenario. In this instance the benefits to fish and recreation were not deemed to outweigh the cost of lost power generation. The trade-offs in some cases will look different depending whether the Treaty continues or is terminated, where in others the trade-off is the same and the issue is purely a domestic one. This topic of trade-offs is discussed in detail in Chapter 3.

In some cases there are trade-offs within environmental interests, for example:

- Maintaining high water levels in the autumn to allow kokanee to access spawning channels in Arrow Lakes may negatively impact fall migratory birds.
- There is a hypothesis that burbot spawn in the Duncan reservoir at the interface between the reservoir and the tributaries. Thus stable reservoir levels (+/- 0.25 meters) are believed to be beneficial during incubation (February 15-April 15) to reduce egg loss through dewatering or suffocation from bank erosion. This is at odds with releasing flows that would benefit fish in the lower Duncan River at the same time.

In addition, as dams are interdependent, interests in one location may have negative impacts in another. The ability to manage these different interests will be different if the Treaty continues or is terminated. Examples of sine current trade-offs between locations are:

[8] These were discussed for the lower Columbia River.

- Rainbow trout flows in the lower Columbia, between April 1 and June 30, have a negative impact on reservoir vegetation and nesting habitat in the Arrow Lakes reservoir. However, they are a benefit to fall migratory birds there.
- Maintaining reservoir levels high in Duncan for tributary access of bull trout and Kokanee may negatively affect tributary access of Kokanee in the Arrow Lakes. The latter of which is a much larger population.

Chapter 2: How Environmental Interests are Currently Being Managed

This chapter outlines activities, programs and the flexibility within the Treaty that address the negative impacts on environmental interests in the Columbia Basin at both regional and localised levels.

2.1 Communication and Coordination

Dams and their operations necessarily have a great impact to the environment in the Columbia Basin. In conducting operations BC Hydro is in regular communication with the Ministry of Environment, DFO, Environment Canada, First Nations, local power producers, local communities and other groups such as the CBT. Multi-stakeholder groups, such as the Columbia Operations Fisheries Advisory Committee (COFAC), also assist in developing recommendations for operations of storage facilities with the specific interests of fish.

2.2 Fish and Wildlife Compensation Program

The Fish and Wildlife Compensation Program (FWCP) for the Columbia Basin was originally created in 1995 when several of the existing Columbia Basin fish and wildlife compensation programs were consolidated anda fund was established to provide money in perpetuity to **offset the footprint impacts of BC Hydro dams and reservoirs on fish and wildlife in the basin**.[9] An *Administrative Agreement* was signed in 1999 between the B.C. Ministry of Environment and BC Hydro to formalize the management of the program, which was developed to satisfy the obligations regarding fish and wildlife attached to the Arrow, Duncan, Mica, Seven Mile and Revelstoke project water licenses. The Department of Fisheries and Oceans is also a key partner in the Fish and Wildlife Compensation Program. First Nations and local communities participate in FWCP program planning and administration. Greater First Nation and local communities' participation is currently being sought, to ensure more active local involvement in the planning and delivery of the compensation program.

The FWCP currently not address footprint impacts in the Koocanusa Reservoir.

The Fish and Wildlife Compensation Program for the Columbia Basin invests approximately **$4.3 million[10] annually** and in perpetuity in projects - in total some $50 million to date.[11] The Fish and Wildlife Compensation Program funds the Basin Planning process and a wide variety of restoration and conservation projects including research and inventory, restoration and habitat enhancement including land acquisition, monitoring and evaluation. A significant portion of the funding in the Columbia Basin is directed toward the Aquatic Nutrient Restoration Program on Kootenay Lake and Arrow Lakes Reservoir. The nutrient restoration programs were designed to replace nutrients that are lost as a result of upstream impoundments (Duncan dam and Libby dam in the case of Kootenay Lake and Mica and Revelstoke dams in the case of Arrow Lakes), and to restore overall ecosystem productivity in the lakes.

[9] Note BC Hydro has been involved with fish and wildlife projects since the 1980's.
[10] Note that $3.2 million/annum is indexed for inflation on 1995 dollars, in 2011 the amount is $4.3 million.
[11] For a complete list of completed projects see: http://www.fwcpcolumbia.ca/

Examples of stream and river system enhancement are the development of spawning Channels (eg. Meadow Creek); in stream Habitat Complexing (eg. Sproule Creek); and gravel additions (eg. Boulder Creek). This type of restoration work is undertaken to offset the losses from dam construction. The Fish and Wildlife Compensation Program also conducts studies and work to enhance riparian areas and wetlands (eg. Yaqan Nuki Wetlands).

In addition to aquatic resources and riparian areas, the Fish and Wildlife Compensation Program has also worked with upland areas to restore habitat. This is of particular importance for enhancing winter ranges for ungulates. Conservation work also plays an important role in the projects funded by the Fish and Wildlife Compensation Program (eg. Northern Leopard frog rearing and release; painted turtle nest site protection).

2.3 Water Use Planning and Water License Requirements

BC Hydro requires licenses to store and divert water for hydropower production. As part of license requirements BC Hydro undertook extensive consultation to develop water use plans at Mica, Revelstoke, Hugh Keenleyside, Duncan, Whatshan, Seven Mile, Aberfeldie, Elko, and Spillamacheen facilities between 2000 and 2005.[12] The process was a consultative planning process involving BC Hydro, provincial and federal governments, First Nations, local communities and other interest groups. The process was conducted to make recommendations on how **incremental changes to operations of the facilities might have positive impacts on a variety of different interests**. In many circumstances benefits were achieved through physical works in lieu of changes to operations. For example wetlands in the Arrow Lakes were enhanced as opposed to meeting hard-set criteria for reservoir levels or flows at specific times of the year. Recommendations also included monitoring programs and information gathering for future decision making.

There is currently no Water Use Plan for the Kootenay River plants, although an agreed to 'minimum flow' is provided in the management of the facilities.

Following the Columbia and Duncan Water Use Plans the following constraints were placed on operations to, in part, to mitigate environmental interests:

- **Kinbasket Reservoir and Mica dam**: no operational constraints placed on either Kinbasket Reservoir or Mica dam;
- **Revelstoke Reservoir and Revelstoke dam**: no operational constraints were placed on Revelstoke Reservoir. A year round minimum flow of 5 kcfs (141.58 m^3/s) was recommended to be released at Revelstoke dam costing an estimated $3 million/annum.[13] It should be noted that First Nations have expressed an interest for minimum flows of 10-15 kcfs (Dennis, 2012). Also, an experimental flow release program (1 July and 31 August) was agreed to in the Middle Columbia (Revelstoke Reach) to benefit juvenile recruitment of sturgeon up to a cap of $5 million over a ten year period.;
- **Middle Columbia River, Arrow Lakes Reservoir and Keenleyside Dam**: There were no operational changes for the Arrow Lakes Reservoir; however, 'soft constraints' (preferred operating ranges for different interest such as fish, wildlife, vegetation, cultural and heritage, recreation and erosion that have conflicting water

[12] This report reviewed the Columbia Water Use Plan dealing with Mica, Revelstoke and Hugh Keenleyside and the Duncan Water Use Plan. In 2007, the Comptroller of Water Rights (CWR) approved the Columbia Water Use Plan (COL-Water Use Plan) including an addendum with additional recommendations to address the incremental impacts of operations due to Revelstoke Unit 5. In August 2010 the CWR approved amendments to the Columbia Water Use Plan to include monitoring programs associated with Mica Generating Unit 5 and 6 (BC Hydro, 2012b). The CWR approved of the Duncan Water Use Plan in 2007.

[13] Kcfs indicates *thousand cubic feet per second*. m^3/s indicates *cubic meters per second*. 1 kcfs = 28 m^3/s.

elevation ranges. These soft constraints help inform BC Hydro operators on impacts) are in place to balance wildlife, recreation, fisheries, culture and heritage, shore conditions, and power generation (Table 2). A conservation aquaculture program is in place for White Sturgeon in the Middle Columbia and Arrow Lakes and involves assessing the effectiveness of flow releases as opposed to providing a fixed regime. The aquaculture program is estimated to cost $0.5M /annum (Columbia-Water Use Plan, 2005 & 2007).

Table 2 Soft Constraints on Arrow Lake Reservoir-Environmental Interests[14]

Interest	Summary of soft constraint
Vegetation	If vegetation showing signs of stress (May-June) target lower reservoir levels in the fall. Preserve vegetation at/above 434 meters.
Wildlife	Make sure reservoir levels inundating bird habitat in the early summer is no worse than 1984-1999 statistics. Bird habitat for the fall should be better than 1984-1999 statistics. Draft reservoir quickly after full pool reached - target 438m (or lower) by 7 Aug.
Fish	Keep levels high enough in fall for tributary access for kokanee spawning (August-November). Levels below 434 meters could cause problems for tributary access.

- **Lower Columbia**: BC Hydro is to continue to pursue Mountain Whitefish flows (reducing outflows from Arrow Lakes during Whitefish spawning, 1 January – 31 March); and Rainbow Trout flows (avoid decreasing river levels from 1 April to 30 June) under the Treaty.
- **Duncan**: Reach full pool (576.4 meters and 576.7 meters) between 1 and 10 August. After full pool is reached or after 10 August, decrease reservoir elevation to 575.5 m and maintain within 0.3 m of this level until 5 September; 2.6 kfs (73 m^3/s) minimum year-round; 10.1 kfs (283 m^3/s) normal maximum year-round.[15]

In addition to the operational changes recommended in the Columbia and Duncan Water Use Plans, BC Hydro and its partners have undertaken a number of monitoring and physical works under management plans,[16] including:

- Kinbasket Reservoir Fish and Wildlife Information Plan -$9.9 million (total over 10 years).
- Kinbasket and Arrow reservoirs Revegetation Management Plan - $16.6 million (total over 10 years).
- Kinbasket and Arrow Recreation Management Plan - $18.6 million (total over 10 years).
- Mica Management Plan
- Revelstoke Flow Management Plan - $8.8 million (total over 10 years).
- Columbia River White Sturgeon Management Plan -$35 million (total over 10 years).
- Arrow Reservoir Operations Management Plan - $12.5 million (total over 10 years).

[14] Adapted from Columbia Water Use Plan (2005)
[15] Note this is the maximum, there are various maximum discharge levels throughout the year depending. See the Duncan Water Use Plan for more details.
[16] Detailed reports of the plans can be found at http://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior.html

- Arrow Reservoir Wildlife Management Plan - $3.8 million (total over 10 years).
- Lower Columbia River Fish Management Plan - $9.8 million (total over 10 years).
- Duncan Management Plan - $13 million (total program)

The overall value of the program in the Columbia is $120 million over 12 years. The Arrows Lakes and Lower Columbia are slated to be reviewed 5 years after implementation to evaluate the effectiveness or operations and physical works. A full review of the Columbia Water Use Plan is scheduled for 2020, and the Duncan Water Use Plan is scheduled for 2018.[17]

2.4 Species at Risk, Recovery Strategies and Management Plans

The Government of British Columbia engages in recovery planning for species at risk in cooperation with the federal government. Recovery Strategies and Management Plans have been developed for specific species, populations and ecosystems that are listed under schedule 1 of the ***Species at Risk Act*** (SARA). These documents typically address issues across a geographic range and identify specific objectives for recovery or management. These documents may include specific performance measures and targets. Recovery strategies are developed and implemented by Provincial and Federal agencies partnering with other organizations and groups.[18]

Species in the Columbia Basin that are under COSWEC and SARA include (Table 3): [19]

[17] See Columbia Water Use Plan 'Revised for Acceptance by the Comptroller of Water Rights' 11 January, 2007 and Duncan Water Use Plan 'Revised for Acceptance by the Comptroller of Water Rights'20 December, 2007.
[18] Marine Species : lead agency is DFO; Freshwater species: lead agencies are MOE and DFO; most terrestrial species: the lead agency is MOW;
[19] Copies of Provincial Government Recovery Documents are available at: http://www.env.gov.bc.ca/wld/recoveryplans/recovery_doc_table.html
Federal Government Recovery Documents are available at: http://www.sararegistry.gc.ca/default_e.cfm

Table 3 Species in the Columbia Basin that are listed under COSWEC and SARA

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
Mammals	American Badger jeffersonii subspecies	Taxidea taxus jeffersonii	E (2000)	1-E	Grassland/Shrub Steppe;Grassland/Herbaceous; Forest Needleaf; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Low (mainly terrestrial species)	Ursus arctos	SC (2012)	No Schedule	Alpine/Tundra; Forest; Grassland/Shrub Steppe; Wetland; Stream/River; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands, streams, rivers)
	Little Brown Myotis		E (2012)	No Schedule	Uses caves, hollow trees, human-made structures for resting and maternity sites; forages generally in woodlands near water. In winter, a relatively constant temperature of about 40 F and 80% relative humidity is required; uses caves, tunnels, abandoned mines	Moderate (forages near water)
	Northern Myotis	Myotis septentrionalis	E (2012)	No Schedule	Forest; Wetland; Rock/Sparsely Vegetated Rock; Subterranean; Urban	Moderate (uses wetland habitat)
	Woodland Caribou - Southern Mountain Population	Rangifer tarandus pop. 1	T (2000)	1-T	Alpine/Tundra; Forest Needle leaf; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Wolverine – Western Population	Gulo gulo luscus	SC (2003)	No Schedule	Alpine/Tundra; Forest; Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock; Shrubland	Low (mainly terrestrial species)
Birds	Barn Swallow	Hirundo rustica	T (2011)	No Schedule	Agricultural; Estuary;	Moderate (uses

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	wetlands, lakes, streams and rivers)
	Bobolink Dolichonyx	oryzivorus	T (2010)	No Schedule	Agricultural; Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands)
	Common Nighthawk	Chordeiles minor	T (2007)	1-T	Agricultural; Forest; Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands, lakes, streams, rivers)
	Flammulated Owl	Otus flammeolus	SC (2010)	1-SC	Forest; Woodland Needle leaf; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Lewis's Woodpecker	Melanerpes lewis	T (2010)	1-T	Agricultural, Cropland/Hedgerow, Old Field; Forest (Needleleaf, Broadleaf, Woodland, Snag/Hollow Tree); Grassland/Shrub Steppe; Grassland/Herbaceous; Rock/Sparsely Vegetated Rock; Wetland, Riverine/riparian	Moderate (uses wetlands, riparian)
	Long-billed Curlew	Numenius americanus	SC (2011)	1-SC	Estuary; Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses estuaries, wetlands)
	Olive-sided Flycatcher	Contopus cooperi	T (2007)	1-T	Forest; Wetland; Rock/ Sparsely Vegetated Rock	Moderate (uses wetlands)
	Peregrine Falcon anatum/tundrius	Falco peregrinus anatum/tundrius	SC (2007)	1-SC	Estuary; Rock/Sparsely Vegetated Rock	Moderate (uses wetlands)

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
	Rusty Blackbird	Euphagus carolinus	SC (2006)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetlands)
	Short-eared Owl	Asio flammeus	SC (2008)	1-SC	Agricultural; Alpine/Tundra; Estuary; Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock; Palustrine/riparian	Moderate (uses wetlands, palustrine/riparian habitat)
	Western Grebe	Aechmophorus occidentalis	Candidate (2011)	No Schedule	Estuary; Lakes; Ocean; Wetland; Stream/River; Shallow water	High (waterfowl)
	Western Screech-Owl,	macfarlanei subspecies Megascops kennicottii	T (2012)	1-T	Agricultural; Forest Mixed; Wetland; Rock/Sparsely Vegetated Rock; Shrubland; Riverine/Riparian	Moderate (uses wetlands, riverine/riparian habitat)
	Williamson's Sapsucker	Sphyrapicus thyroideus	E (2005)	1-E	Forest (Broadleaf, Needleleaf, Snag/Hollow tree; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Yellow Rail	Coturnicops noveboracensis	SC (2009)	1-SC	Agricultural; Estuary; Grassland/ Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock	Moderate (uses estuary, wetland habitat)
	Yellow-breasted Chat auricollis subspecies Southern Mountain population	Icteria virens auricollis	E (2011)	1-E	Agricultural; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetland, riverine/riparian habitat)
Reptiles	Great Basin Gophersnake	Pituophis catenifer deserticola	T (2002)	1-T	Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock;	Moderate (uses lakes, riparian, wetland habitats)

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Shrubland	
	Painted Turtle - Intermountain - Rocky Mountain Population	Chrysemys picta pop. 2	SC (2006)	1-SC	Wetland; Stream/River; Palustrine: pond, grassland; Lacustine: Deep Water, Course Woody Debris, Shallow Water	High (aquatic/semi-aquatic)
	Rubber Boa	Charina bottae	SC (2003)	1-SC	Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland	Moderate (uses wetland habitat)
	Western Skink	Plestiodon skiltonianus	SC (2002)	1-SC	Forest (Needleleaf); Grassland/Shrub Steppe; Grassland/Herbaceous; Wetland; Rock/Sparsely Vegetated Rock; Talus/Boulders; Shrubland	Moderate (uses wetland habitat)
	Western Yellow-bellied Racer	Coluber constrictor mormon	SC (2004)	1-SC	Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Shrubland; Subterranean	Moderate (uses wetland habitat)
Anthropods	Monarch	Danaus plexippus	SC (2010)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; Sand/	Moderate (uses wetland habitat)
	Vivid Dancer	Argia vivida	Candidate (2011)	No Schedule	Stream/River; Associated with cool or hot springs; Palustrine: Herbaceous Wetland	High (dependent on aquatic habitats)
Molluscs	Magnum Mantleslug	Magnipelta mycophaga	SC (2012)	No Schedule	Forest Needleleaf; Rock/Sparsely Vegetated Rock; under moist logs, pieces of bark, in depressions in moist earth and within talus in cool, moist coniferous forests	Low (mainly terrestrial species)
	Pygmy Slug	Kootenaia burkei	Candidate	No Schedule	Forest Mixed, Forest Needleleaf;	Moderate (uses

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
			(2011)		Wetland; Riverine/ Riparian; Rock/Sparsely Vegetated Rock	wetland, riverine/riparian habitat)
Amphibians	Coeur d'Alene Salamander	Plethodon idahoensis	SC (2007)	1-SC	Wetland; Stream/River; Subterranean	High (aquatic/semi-aquatic)
	Northern Leopard Frog Rocky Mountain Population	Lithobates pipiens	E (2009)	1-E	Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)
	Rocky Mountain Tailed Frog	Ascaphus montanus	E (2000)	1-E	Forest Needleleaf; Wetland; Riparian- Stream/River, Creek; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)
	Western Toad	Anaxyrus boreas	SC (2002)	1-SC	Agricultural; Forest; Grassland/Shrub Steppe; Lakes; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	High (aquatic/semi-aquatic)
Vascular Plants	Giant Helleborine	Epipactis gigantea	SC (1998)	3-SC	Seepage Slope, Forest Broadleaf, Cliff; Lakes; Wetland; Stream/River; Beach; Temporary Pool; Bog/Fen	Moderate (semi-aquatic species)
	Southern Maidenhair Fern	Adiantum capillusveneris	E (2011)	1-E	Riverine: Stream/River, Spring Brook; Rock/Sparsely Vegetated Rock	Moderate (semi-aquatic species)
	Spalding's Campion	Silene spaldingii	E (2005)	1-E	Forest; Grassland/Shrub Steppe; Rock/Sparsely Vegetated Rock	Low (mainly terrestrial species)
	Whitebark Pine	Pinus albicaulis	E (2010)	1-E	Within montane forests and on thin, rocky, cold soils at or near timberline. 1300 - 3700 meters	Low (mainly terrestrial species)

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
Mosses	Alkaline Wing-nerved Moss	Pterygoneurum kozlovii	T (2004)	1-T	Alkali Pond/Salt flat; Grassland/Shrub Steppe; Wetland; Rock/Sparsely Vegetated Rock; on soil	Moderate (grows at/near ponds, wetlands
	Banded Cord-moss	Entosthodon fascicularis	SC (2005)	1-SC	Forest; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	Moderate (grows at/near wetlands, streams, river)
	Margined Streamside Moss	Scouleria marginata	E (2012)	1-E	Forest; Wetland; Stream/River; Rock/Sparsely Vegetated Rock	Moderate (grows at/near wetlands, streams, river)
Lichens	Cryptic Paw	Nephroma occultum	SC (2006)	1-SC	Forest - Epiphytic; Old Forest; Rock/ Sparsely Vegetated Rock	Low (mainly terrestrial species)
Freshwater Fish	White Sturgeon (Kootenay River Designatable Unit)	Acipenser transmontanus	EN (2012)	1-EN	Distribution: Kootenay River, Kootenay Lake. Habitat: varies with life stage; spawning – side channels with gravel, cobble, or sand bottoms, at depths of 3.0 to 4.5 m; In regulated systems - turbulent water flowing rapidly over a clean substrate of large rocks. Adult sturgeon are typically found in deep near-shore areas, adjacent to heavy, turbulent flows, with bottoms of sand and fine gravel. In winter, the sturgeon prefers shallow, calm areas.	High (aquatic)
	White Sturgeon (Upper Columbia River Designatable Unit)	Acipenser transmontanus	EN (2012)	1-EN	Distribution: Columbia River, Arrow Lakes, 2km of Kootenay River downstream of Brilliant Dam.	High (aquatic)

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					Habitat: varies with life stage; spawning – side channels with gravel, cobble, or sand bottoms, at depths of 3.0 to 4.5 m; In regulated systems - turbulent water flowing rapidly over a clean substrate of large rocks. Adult sturgeon are typically found in deep near-shore areas, adjacent to heavy, turbulent flows, with bottoms of sand and fine gravel. In winter, the sturgeon prefers shallow, calm areas.	
	Shorthead Sculpin	**Cottus confusus**	**SC (2010)**	**1-SC**	**Distribution: Columbia River (mainstem and tributaries), Slocan River, Kettle River. Habitat: small rivers draining mountainous regions; moderate to swift current; oderately cool water; riffle habitats with stones or gravel, used for shelter and breeding.**	**High (aquatic)**
	Columbia Sculpin	**Cottus hubbsi**	**SC (2010)**	**1-SC**	**Distribution: Columbia River, Flathead River, Similkameen River, Kettle River, and small tributary streams. Habitat: rocky riffle habitats in rivers and streams, but may sometimes occur in lakes as well.**	**High (aquatic)**
	Westslope Cutthroat Trout	**Oncorhynchus clarkii lewisi**	**SC (2006)**	**1-SC**	**Distribution: Kootenay River and major tributaries (White, Lussier, Wild Horse, St. Mary, Bull, and Elk**	**High (aquatic)**

Taxon	English Name	Scientific Name	COSWEC	SARA Schedule	Habitat	Direct Sensitivity to Hydrological Changes
					rivers as well as Findlay, Skookumchuk, and Mather creeks), Moyie River, Goat River, Flathead River, Upper Columbia Headwaters and lakes, South Thompson River (specifically the Shuswap system). Habitat: large rivers and lakes, wide range of habitats; intact lotic environments; cold clean water and varied forms of cover (i.e., undercut banks, poolriffle habitat, and riparian vegetation).	
	Umat illa Dace	Rhinichthys umatilla	TH (2010)	3-SC	Distribution: Similkameen, Kettle, Columbia, Slocan and Kootenay river drainages. Habitat: riverine habitat with cobble and stone cover; fast current to prevent siltation; river banks at depths less than 1m; low elevation waters.	High (aquatic)
	Rocky Mountain Sculpin (Westslope Population)	Cottus sp.	SC (2010)	No Schedule	Distribution: Flathead River. Habitat: almost entirely unknown, but more abundant in riffle and run habitats containing rocks, rubble, and boulders.	High (aquatic)

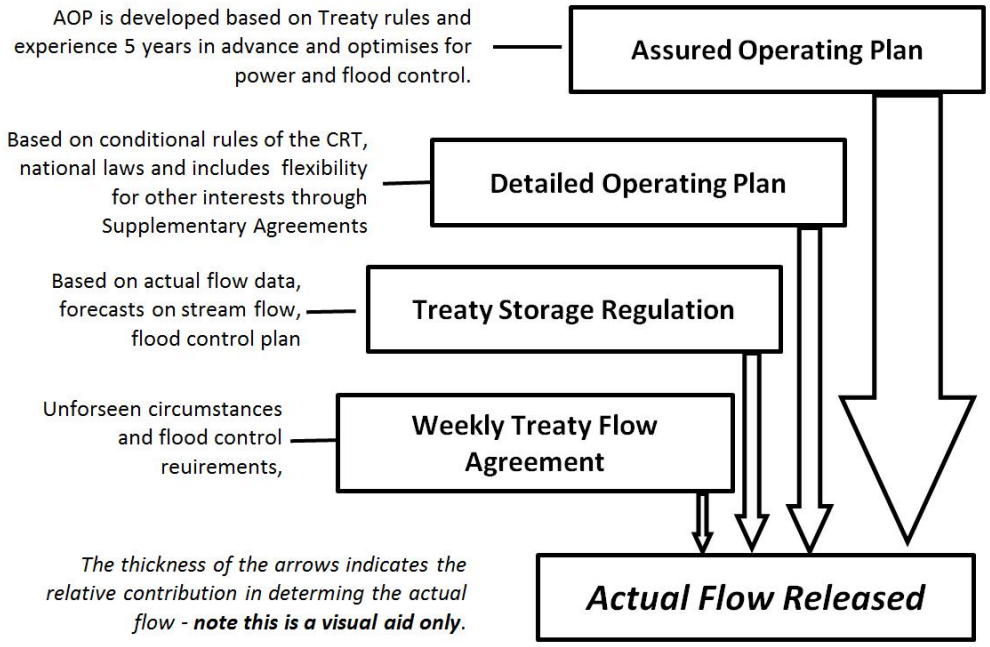
2.5 Flexibility within the Columbia River Treaty/Non-Treaty Storage Agreement

The Columbia River Treaty dictates what flows should pass across the Canada–U.S. border and what flood control capacity should exist within Canada at certain times during the year. The bulk of flow is determined through the **Assured Operating Plan** (AOP) which is developed 5 years in advance and is designed to achieve optimum power benefits and flood control. The Canadian Entitlement of downstream benefits is calculated from this. The actual flow in the river is more complicated and is determined through a number of different means (Figure 2).

The **Detailed Operating Plan** (DOP) is based on the Assured Operating Plan. The Entities may prepare an annual Detailed Operating Plan that may achieve more advantageous operation for benefits than would result under the Assured Operating Plan.[20] It must be accepted by mutual agreement of the Canadian Entity and U.S. Entity, or the Assured Operating Plan for that particular year is applied. The Detailed Operating Plan may include Supplementary Operating Agreements for non-power and non-flood control benefits (see below). The Detailed Operating Plan is implemented via **Treaty Storage Regulation** studies that determine the monthly storage rights and obligations for Duncan, Mica and Arrow/Keenleyside dams. Studies are conducted twice monthly to determine the end of month targets of the reservoir levels in the Canadian Treaty facilities. The Treaty Storage Regulation uses actual inflows to date plus the forecast stream flows, along with current reservoir conditions. The Treaty Storage Regulation specified operation can, and is often, modified by mutual agreement from the Entities.

The actual operation of the Canadian Treaty Storage facilities (Duncan, Mica and Arrow/Keenleyside), is finalized on a weekly basis through a Treaty Flow Agreement for the following week. The U.S. provides information for Libby dam at the weekly meetings for coordination operations on the Kootenay River.

Figure 2: General influence of various stages of decision making on actual flow



[20] This is explicit under Article XIV (2-K) of the Columbia River Treaty.

Related to the Columbian River Treaty is the Non-Treaty storage agreement (NTSA). In April 2012 the new NTSA was signed and will last until 2024. It does not require any particular storage space but allows for coordinated use of non-Treaty storage in Canada to shape flows within the year for fisheries benefits. It provides up to an additional 0.5 Maf to benefit fish in the lowest water conditions.[21]

Unilateral Actions

The Columbia River Treaty allows for flexibility to operate individual dams for maximum Canadian benefits, provided storage operations remain within the constraints of the Flood Control Operating Plan and flow across the Canada / U.S. border remains unchanged from the agreed flows. This flexibility allows BC Hydro to move water between Mica, Revelstoke,[22] Arrow/Keenleyside and, to some extent, Duncan in response to various power, social and environmental interests. For example:

- *Decisions entirely internal to Canada to deviate from Treaty Storage Regulations may be made with respect to flows below Mica or Revelstoke, providing discharges from Arrow are not affected and flood control is protected. For instance, negotiations may occur with DFO for flooding to improve survivability of Kokanee Red fish in certain stretches along the river above Arrow/Keenleyside*.
- *Discharges from Duncan may diverge from Treaty Storage Regulations, provided discharges from Arrow are adjusted to make up the difference at the border with the U.S*.

Mutual Consent

The Detailed Operating Plan is developed annually and spells out the operating rules that define how water will be drawn from dams and systems throughout the year. It is based on the Assured Operating Plan, but may deviate from it by mutual agreement, **and for mutual benefit[23]** either at the stage of developing the DOP, the treaty storage regulation or at the weekly level through the weekly agreement and conference call.[24] Supplemental Operating Agreements such as the *Non-power Uses Agreements* and the *Canadian/Libby Swap Agreement* have been negotiated to address primarily recreational interests but also include fisheries interests in Canada such as rainbow trout and whitefish.

The *Non-power Use Agreement* include:

- Flow management for rainbow trout spawning in the Canadian Columbia River to maintain river levels at Norns Creek Fan between 1 April and 30 June.
- The Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the 1–15 January period to reduce Arrow outflow by 20 kcfs for enhancement of Whitefish spawning.
- The Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir during the September–October period in compensation to the U.S. for lost energy benefits associated with maintaining stable minimum flows to minimize the dewatering of whitefish eggs until 31 March.

[21] See Administrators Decision Record – 2012 NTSA, signed 10 April, 2012. Maf indicates *million acre feet*.
[22] Revelstoke dam is not a Columbia River Treaty dam.
[23] Under the Treaty – deviations from the AOP are to be mutually agreed upon and for mutual benefit
[24] These include requested variances from the Columbia River Treaty Flood Control Rule Curves as laid out in the Flood Control Operating Plan, however, it is also not uncommon that small alterations to releases will be requested based on unforeseen circumstances throughout the week. Note that flood control requests can be on a daily basis, while requests dealing with power are typically done at the weekly conference call and weekly agreement.

2.6 Local Interests and Mitigation Measures

Table 4 outlines the major environmental interests and the mitigation measures which have been adopted to address them in the Columbia Basin.

Table 4: Specific Environmental interests and Mitigation Measures

General			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Ecosystem function and resilience	Species conservation	Maintaining or improving the populations and ranges of species at risk, or species of interest in the Basin.	Fish and Wildlife Compensation Program, and specific work with species at risk such as the Northern Leopard Frog project; Vaux's swift nesting habitat, etc. Conducting inventory and identification of species at risk, such as the Columbia Basin Amphibian Inventory. Establishing teams, developing and implementing recovery plans, such as the Columbia River White Sturgeon Management Plan under BC Hydro's WLR. Coordinating with other power producers, such as Columbia Power Corporation operating requirements take into account sturgeon as part of their license. These requirements are coordinated with BC Hydro.
Vegetation	Riparian and wetland habitat	Maintain or maximise the abundance and diversity of riparian and wetland habitat. Maximize effective habitat for wildlife.	Fish and Wildlife Compensation Program and physical works and operational changes under the Water Use Plans. And associated management plans: Arrow Reservoir Operations Management Plan, Arrow Reservoir Wildlife Management Plan, Kinbasket Reservoir Fish and Wildlife Information Plan, Mica Management Plan.
Fish	Total Dissolved Gas[25]	Minimize the effects of increased Total Dissolved Gas below facilities. Gas levels are normally elevated in the tailwater of any project that is spilling or within units in synchronous condense mode of operation. Provincial guidelines call for 110% as a goal, while, federal guidelines list 103% as a goal if fish reside in less than one metre of depth.	BC Hydro is undertaking a system wide review of Total Dissolved Gas and developing a strategy for mitigation. As part of the review risk assessments are being conducted and management plans are being developed in partnership with DFO, MOE, and First Nations. Reasonable efforts are made in operations to avoid prolonged periods where units spin without generating power, where the incoming water becomes supersaturated with dissolved gas, also known as sync-condense operations.
	Entrainment	Minimize the impact of fish entrainment on species.	Fish entrainment was not addressed in the Water Use Plans but is part of BC Hydro's Fish Entrainment Strategy. BC Hydro conducted a systems

[25] Also known as Total Gas Pressure (TGP) or gas supersaturation. .

General			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
			review between 2005-2006 and developed risk assessment methodologies (2007) and draft principles of operation (2007). Action planning and implementation is a technical process that has been undertaken on a case by case basis between BC Hydro, DFO, Ministry of Environment, and First Nations. **Fish Entrainment Action Plans have been completed for Mica and Revelstoke.** **Several performance measures have been developed for Arrow Lakes and these were used in the NTSA consultation.**
	Salmon	**Particularly among First Nations there is an interest to re-introduce Sockeye and Chinook salmon in upper Columbia**	**To date only studies have been conducted, for example the Upper Columbia Aquatic Management Partnership solicited a feasibility, impacts and benefit report.**

Mica Dam and Kinbasket Reservoir			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Vegetation	Riparian Habitat	Maximize riparian habitat area on Kinbasket area (i.e. vegetative growth in the drawdown zone). In general, the later the refill date is during the growing season, the greater the riparian recruitment potential there is (especially in the flat deltas in Canoe Reach, Columbia Reach and Bush Arm). With a seeding program, goal was to establish the top 7m in these areas as riparian vegetation.	WLR monitoring studies are being conducted to provide information on vegetation in the drawdown zone. Reservoir re-vegetation management plan. Re-vegetation is done with local species and there is incorporation of traditional plants in re-vegetation plan where possible (BC Hydro 2011). NTSA looked at inundation statistics.
Fish	Pelagic and Littoral Productivity	Maximize pelagic and littoral productivity in Kinbasket reservoir. Generally, an earlier filled reservoir that is kept higher and maintained during summer months is better for pelagic productivity (June 1 to Sep 30). Littoral productivity is dependent on a number of factors including stable and fuller levels through the growing season (April through October)	The costs for altering operational changes at Mica (between $16M-$25M/yr) for environmental benefits would outweigh the gains. so no operational changes are being done. Assessments of Kinbasket Kokanee population have been conducted. WRL studies are collecting photosynthetically active radiation data – and there is no significant difference in performance of the scenarios evaluated under the NTSA consultation.
	Total Dissolved Gas	Minimise negative impacts of TDG	System review and TDG Strategy being developed. Avoid prolonged periods where units spin without generating power, where the incoming water becomes supersaturated with dissolved gas, also known as sync-condense operations. At Mica this includes 30 minute flushing the supersaturated water out of the unit for 15 or 30 minutes for every 10-12 hours of sync-condense operation.
	Entrainment	Minimize fish entrainment.	Fish entrainment plans have been developed as an independent initiative on BC Hydro's Columbia system (see below). At Mica Kokanee and Bull Trout were highlighted at high and moderate risks (respectively) to entrainment

Revelstoke Dam and Reservoir, and Mid-Columbia			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Fish	General Productivity of various species	Maximizing reservoir stability (minimize frequency of events that the reservoir exceeds a threshold over the summer months). Reducing the number of events where the reservoir drops more than 0.25m over 1 and 3 day periods from Jun 1 to Sep 30.	The reservoir is operated for no more than 0.8m/day (2.5 ft/day) for draft or refill, and 1.5m/day (5ft/day) in emergencies.
	Large River species	Maximizing ecological productivity and increasing juvenile fish use. Maximizing adult fish abundance, condition, growth and fecundity. Triggering rainbow trout spawning. Minimum flows below Revelstoke were considered under the Water Use Plan to increase large river habitat in the mid-Columbia for fish (Rainbow and Bull trout, sculpins, dace and possibly sturgeon). A 5kcfs minimum flow was recommended by the Water Use Plan. First Nations recommended levels of 15 kcfs.	A 5 kcfs minimum flow below Revelstoke dam have been implemented year round. The cost of minimum flows is related to restrictions on heavy load hour (HLH) and light load hour (LLH) pricing.
	Total Dissolved Gas	Minimize the impact of TDG. Studies in 2003 showed that elevated levels of TDG levels of 150% where found directly below the tailrace, while these dropped to 120% in the plunge pool and 110% by the Revelstoke Golf Course.	Assessment being conducted under the system review and at TDG Strategy being developed. The minimum flow of 5kcfs acts to dilute and dissipate high levels of TDG.
	White Sturgeon	There is a population of White Sturgeon in the Mid-Columbia. Recruitment is a problem due to predation. It is considered that high flows at key periods of time (August) would help reduce predation. Experimental flows (30 kcfs for 4 weeks in August) combined with monitoring were recommended under the Water Use Plan.	Columbia River White Sturgeon Management Plan is being implemented. Conservation aquaculture program in Middle Columbia and Arrow Lakes to estimate effectiveness of experimental flow release (Columbia-Water Use Plan, 2005 & 2007). The actual experimental flows have not yet been implemented. High natural flows over the past 2-3 years have however allowed monitoring to be undertaken on flow levels that virtually mimic the proposed experimental flow releases. The monitoring results are helping shape the ongoing work and studies. Monitoring has indicated that spawning is occurring 6/10 years in August. Optimizing spawning in the Mid-Columbia would accompany low reservoir levels; however, such operation would be at odds with juvenile benefits of deep slow moving water (at a high reservoir).
	Entrainment	Minimize fish entrainment.	Entrainment assessment conducted. At Revelstoke Facility Kokanee and bull Trout were assessed at a high and moderate risk of entrainment respectively.

Hugh Keenleyside Dam and Arrow Lakes Reservoir

Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Primary Productivity	Dams have reduced the inflow of nutrients and primary productivity has decreased. Maximize the primary production of carbon to enhance higher trophic level production.	Arrow Lakes Reservoir Nutrient Restoration Program was initiated in 1999 and is collaboratively implemented based on several project partner contributions including, the Fish and Wildlife Compensation Program – Columbia (FWCP-Columbia), the BC Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) , the BC Ministry of Environment (MOE) and the Arrow Lakes Power Corporation (ALPC) which owns the Arrow Lakes Generating Station. ALPC is jointly owned by Columbia Power Corporation and Columbia Basin Trust. Columbia Power Corporation manages the operations of the ALPC on behalf of the joint venture. The funding is being provided as a compensatory benefit for the operations of the Arrow Lakes Generating Station on the Lower Arrow Lake. The day to day operations are implemented by FLNRO and administered through FWCP-Columbia. The FWCP program contributes $ 750K a year and CPC contributes $250K per year. The liquid fertilizer is introduced into the lake from a tank truck loaded on the ferry and dispersed in measured amounts as the ferry crosses the lake.
Fish	General Productivity of various species - pelagic and littoral	Maximize pelagic and littoral productivity in Arrow Lakes reservoirs. Generally, an earlier filled reservoir that is kept higher and maintained during summer months is better for pelagic productivity. Most promising way to boost littoral productivity was thought to be through increasing the min water surface elevation in winter. Water Use Plan determined that fertilization was more efficient that operational changes to increase carbon production and thus fish productivity.	Stabilization of the reservoir at 1438.7 ft (438.5m) during the growing season is estimated to increase the carbon production by about 10% (from 10,400 tC/yr to 11,000 tC/yr). In contrast additional fertilization to Arrow lakes Reservoir has increased production by 4000 tC/yr. Burbot life history assessment being conducted under the Arrow Lakes Reservoir Operations Management Plan.
	White Sturgeon	Build a self-sustaining population of white sturgeon. Maximize the probability of successful juvenile recruitment of white sturgeon in the mid-Columbia (see above with Revelstoke). 5kcfs min flow from Revelstoke was in part to benefit juvenile sturgeon and other fish in the Mid-Columbia.	Risk assessment of sturgeon entrainment has been assessed as a moderate risk and is under further review.

Hugh Keenleyside Dam and Arrow Lakes Reservoir

Category	Sub-Category	Specific Interests	Mitigation
	Kokanee and Bull trout tributary spawning	Maximize tributary access during kokanee and Bull trout spawning period (late Aug to early Nov). Seasonal changes in the Arrow lakes Reservoir elevation have the potential to adversely affect tributary access to critical spawning grounds during the autumn. Preliminary studies indicate that there are barriers ranging from 1418-1438ft in seven tributaries, with most occurring below 1430ft.	Soft constraints were developed for Arrow Lakes operations – need to study, but recommended minimum elevations of 434m (1424ft) from August 25 – November 15. (Col Water Use Plan). Now measuring # days when reservoir elevation is above 1430ft between August 25 and November 15 (NTSA). Multi-year study of tributary fish migration under Arrow lakes reservoir management plan continues under WLR monitoring program.
	Total Dissolved Gas	Minimise the impact of TDG. Readings of over 140% have been measured at Hugh Keenleyside	BC Hydro preferentially discharges water through the north bank, then south bank and then the spillway to minimize TDG levels during normal operations. The Arrow Lakes generating station can divert up to 1115m^3/s (40 Kcfs) away from Hugh Keenleyside dam where TDG is produced.
Wildlife and vegetation	Vegetation (riparian habitat)	The depth, timing and duration of flooding on the Revelstoke Reach affects the species composition, spatial extent and diversity of vegetation in the drawdown zone. The measurement of what is 'good' for vegetation is complex: At the Water Use Plan there was a general consensus to maintain current levels of vegetation at and above 434m (1424ft) elevation. Minimize inundation of vegetation during the growing season.	Soft constraint (in 2004) – Apr to Oct minimize water levels at or above 434m (1224ft) where preservation of 2004 levels of vegetation above 1424ft in the drawdown zone would be a priority. The NTSA consultation looked at weeks of flooding (7 consecutive days) at different elevation bands. Implementation of the Arrow Reservoir Wildlife Management Plan.
	Birds - spring nesting and fall migratory birds (Revelstoke Wetlands)	Maximize capacity of wetlands to provide habitat for spring nesting and fall migratory birds Minimizing inundation of nesting bird habitat by rising reservoir water levels Maximizing migratory bird habitat in the fall	Soft constraint – try and keep early summer elevations (Apr 30-Jun 16) at or below 434m (1424ft) which are historical levels (1984-1999). Soft constraint – ensure that availability of fall migratory bird habitat is no worse than recent averages targeting reservoir levels (draft the reservoir after full pool) target level of 438m (1438ft) or lower by Aug 7 – Oct 31. These constraints were reviewed during Rev5 and Mica 5/6 consultations.
	Shorebirds	Maximize capacity of wetlands to provide habitat for shorebirds (fall migration mid-July to mid Sept). Optimal water levels were assessed to be at 435m for retaining maximum available habitat for shorebirds during the late summer early fall. Reach at Drimmie Creek starts to flood at El 430m and becomes fully flooded at 440m.	Arrow Lake Soft Constraints (Table 2).

Lower Columbia (*Below Hugh Keenleyside Dam*)			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Ecosystem Integrity	**Flushing flows**	**Flushing flows can be beneficial to help maintain fish habitat if they are of a significant magnitude to move and flush the substrate.**	**There has been no attempt to accommodate flushing flows as the level needed would exceed 165kcfs which is the level at which flood damage occurs.**
Fish	**Flow stability**	**Avoid sudden and significant flow fluctuations.** **Winter: Mean monthly flow changes between Jan 1 and March 31** **Summer: Mean monthly flow changes at Birchbank during June & July**	**Mean monthly flow changes are set for the winter and summer.**
	Mountain Whitefish	**Mountain whitefish spawn in the lower Columbia River between November and March.** **Priority of maintaining smooth transition of winter flows for whitefish to Minimize the number of dewatered MWF eggs. The Water Use Plan explored flow changes that could be negotiated with the U.S. each year to addresses fisheries interests in the lower Columbia.**	**Soft Constraint – winter flow restrictions (low as possible) below Keenleyside dam (identified as a high priority) during incubation (Dec – Mar) and emergence (mar to May) periods. Modelling and monitoring of whitefish egg loss was used during the NTSA consultations.** **The Whitefish Operating Agreement, which allows storage at Kinbasket and Arrow Lakes reservoirs during the 1–15 January period to reduce Arrow outflow by 20 kcfs for enhancement of Whitefish spawning.** **Lower Columbia whitefish spawning ground, egg monitoring and life history surveys under the Lower Columbia River Fish Management Plan.** **DFO and BC Hydro have developed agreed upon criteria for acceptable whitefish egg loss in the Lower Columbia Region. Modelled outcomes for Non-Treaty Storage operations suggest that early spring operations of Non-Treaty Storage are potentially adversely impacting whitefish. As such, modification to actual operations of Non-Treaty may be required to meet the agreed upon criteria.** **The Fall Provisional Storage Agreement and March Whitefish Flow Agreement, which allows for a provisional draft of Arrow Lakes Reservoir during the September–October period in compensation to the U.S. for lost energy benefits associated with maintaining stable minimum flows to minimize the dewatering of whitefish eggs until 31 March.**
	Indigenous Fish	**Improve the response of indigenous rainbow trout, burbot, whitefish and other populations to the hydrograph in the lower Columbia River.**	

Lower Columbia (*Below Hugh Keenleyside Dam*)			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
	Rainbow Trout	**Priority under the Water Use Plan was to maintain stable or increasing flows for rainbow trout between April 1 to Jun 30). The Water Use Plan explored flow changes that could be negotiated with the U.S. each year to addresses fisheries interests in the lower Columbia.** **Rainbow trout seasonal flows have a negative impact on Arrow reservoir vegetation and nesting habitat in the spring, but benefit fall migratory birds.**	**Soft Constraint – maintain spawning habitat flows (i.e. do not drop) at Norns (Pass) Creek from Apr 1 to Jun 30. Over many years this has been defined by flows around 425cms (15kcfs). Flow reductions outside of this period require management of fish stranding impacts and mitigation of dewatered redds under agreement with DFO** **The Rainbow trout seasonal flows were found to outweigh negative aspects of reservoir littoral productivity. Physical works were undertaken to mitigate the negative effects to nesting birds.**
	White Sturgeon	**High flows are thought to be important to help to facilitate recruitment. Initiate white sturgeon experimental plan to facilitate recruitment. Seasonal high flows of 200 kcsf at the border was discussed in the Water Use Plan to improve sturgeon recruitment.** **Opportunistically provide high flows.**	**Water Use Plan to improve sturgeon recruitment. Providing the flow would be costly ($15-20M), may not be agreeable to the U.S., and may damage infrastructure around Genelle/Trail. The high flow option was dropped and instead, the committee recommended opportunistic assessment of high flow events when they occur naturally (2 in 10 years) and turbidity augmentation. Subsequent to the Water Use Plan the turbidity augmentation was found to be not feasible.**
	Stranding Juvenile Fish	**Flow ramping rates may be responsible for stranding of juvenile fish. Minimize stranding of juvenile fish.**	**The subcommittee agreed that the best way to manage fish stranding was through a flow reduction protocol and standard practices. WUP studies were conducted and protocols and standard practices are now in place.**
	Total Dissolved Gas (TDG)	**Minimize TDG effects on fish. Historically TGP has been an issue at Keenleyside, but this has been partially mitigated with Arrow Lakes Generating Station (which can divert up to 40kcfs). Flows which lead to TGP levels above 115% are undesirable.**	**Flows of 40 kcfs can be diverted from Keenleyside and run through the Arrow Lakes Generating Station reducing the TGP below Keenleyside Dam. BC Hydro also has an operating protocol to reduce TGP below Keenleyside Dam. Under the Water Use Plan a performance measure for TGP based on head and flow was calculated; however, the risk is much reduced with ALGS and the performance measure was dropped.**
	Water temperature	**Water temperature released from Keenleyside is cooler than normal water during the March to August period and this may have adverse effects on stream productivity.**	**In the Water Use Plan it was recognized that any operational changes considered could not significantly influence temperatures below Hugh Keenlyside Dam. Further it was acknowledged that the Columbia River Integrated Environmental Monitoring Program (CRIEMP) is interested in long term monitoring of temperature in the Lower Columbia with respect to global warming and ecosystem health.**

Lower Columbia (*Below Hugh Keenleyside Dam*)			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Wildlife and Vegetation	**Riparian Habitat**	**Minimize impacts to riparian habitat. Riparian vegetation may be affected by large flows. There are gravel bars in the area of Genelle which are susceptible to higher flows, however these were found not to be adversely affected by flows of 160 kcfs.**	**Flood control operations keep flows below 165 kcfs.**
	Great Blue Heron – Waldie Island	**Waldie Island provides important winter refuge and foraging habitat for heron.** **Maximize winter refuge habitat (and foraging habitat) at Waldie Island.** **Important winter forage habitat at Waldie Island and Breakwater Island, especially from Nov 15 to Dec 21 - there is a desire to keep water levels at or below 1381ft (421m) (this requires discharges of < 60kcfs from Keenleyside Dam).** **Another objective was to minimize access to the island during the spring/summer period with higher water levels above 1373ft.** **Concern in high flow years with large pulse of flows from Keenleyside Dam to enhance whitefish spawning in November. Incubation of whitefish is Dec-Mar where lower flows are required.** **In low flow years it was recommended to maintain elevations at or above 418.7m from April 1 to Aug 31 to limit public access.**	**Waldie Island is being studied through the WRL monitoring program.**

Duncan Dam and Reservoir and Lower Duncan River

Category	Sub-Category	Specific Interests	Mitigation
Ecosystem Integrity	Riparian flooding flows for Cottonwoods	Inundation period during the growing season (Apr 1 to Oct 30). Decrease elevations to 573.7m or less after reaching full pool and maintain. For cottonwood recruitment in the lower river, generally want to follow a more natural hydrograph once every 5 yrs. which includes: peak flows in July (basically defined above 250cms), recession flows by late Aug and lower base flows till next freshet	Riparian and wetland habitat in the Lower Duncan River were considered of high value. Cottonwood forests were chosen as an indicator of riparian success since cottonwood establishment is highly sensitive to flow. The 'cottonwood hydrograph' sought was natural reductions in flows during ramp downs, maximum flows of 250 cms over the fall and early winter, and peak flows in early to mid-summer. The cottonwood hydrograph alternative was treated independently from the other alternatives in the Water Use Plan as it was to be required on an infrequent basis (about every fifth year on average) to achieve the recruitment benefits. Analysis indicated that there were only four years in the 33 year record where inflows were high enough to achieve the cottonwood flows and avoid negative impacts on other performance measures. The average cost of implementing the cottonwood flows was $10M/yr. The committee dropped the cottonwood alternative as it would negatively impact recreation and financial revenue, and the preferred alternative performed relatively well for the cottonwood interests. The cost includes impacts at Arrow Lakes Generating Station and on the Kootenay system (approximately $2 million). The cost at Arrow Lakes under Treaty termination potentially could be less.
Fish	General reservoir species	Maximize littoral productivity. Maximize pelagic productivity. Minimize fish stranding. Minimize egg mortality associated with tributary backwatering. Minimize entrainment risk. Maximize white sturgeon populations. Maximize bull trout populations. Maximize nutrient loading in the North Arm of Kootenay.	Implementation of Water Use Plan recommendations.
	White Sturgeon (reservoir)	White sturgeon are found in the reservoir. As a SARA listed species it is important to examine how they can be conserved.	The Water Use Plan fish technical committee assumed the position of MOE that the Duncan reservoir population is part of the Kootenay Lake population and the Duncan system cannot sustain a sturgeon population under any operational regime.

Duncan Dam and Reservoir and Lower Duncan River

Category	Sub-Category	Specific Interests	Mitigation
	Burbot (reservoir)	Maximize burbot spawning success. There is a hypothesis that burbot spawn in the Duncan reservoir at the interface between the reservoir and the tributaries. Thus stable reservoir levels (+/- 0.25m) are believed to be beneficial during incubation (Feb 15-Apr 15) to reduce egg loss through dewatering or suffocation from bank erosion. This is at odds with flows that would benefit fish in the lower Duncan River at the same time (see below). There is a lack of understanding on the specifics of burbot spawning.	Burbot spawning was not included in the Water Use Plan deliberations and a 10 year WLR monitoring study has been developed to help address uncertainties. The study is in year 4 of its term.
	Kokanee and Bull trout tributary spawning (reservoir)	Maximize tributary access to spawning tributaries When reservoir levels are too low certain species, such as kokanee and bull trout, cannot access spawning areas.	A study was conducted and concluded that the operating alternatives for Duncan did not hinder tributary access for Bull trout and further studies are being done to focus on spawning of Kokanee.
	River species (kokanee, bull trout, rainbow trout etc.	Water is stored in the reservoir to augment natural flows up to the minimum flow levels in the spring. There is a direct trade-off between what benefits fish in the lower river and power benefits to the system. Duncan does not generate power, but there is less water to generate power in the Lower Kootenay and there is a need to increase flows from Hugh Keenleyside (no power) to meet Treaty requirements. <u>Lower Duncan River</u> Minimize fish stranding risk – related to the stability of side channel flows. Minimize temperature effects Maximize tributary access Maximize habitat suitability Maximize food availability Minimize any fish passage issues in the main stem Setting a min flow of 73cms year round was considered beneficial for the productive capacity of main stem and side channel habitats, especially for Kokanee (as there is a distinct population of Kokanee).	The alternative decided by the Water Use Plan targeted level flows in the lower Duncan river of 73cms (below confluence with Lardeau River) from Sep 15 to Nov 15 . Alternatives considered had impacts to power of $300k to $500k/year. Maintaining the maximum flow targets in the lower Duncan River 250m^3/s between 22 December to 9 April. Stranding protocol has been developed. Temperature effects were shown not to be significant in a 2003 report. Fish passage - Duncan dam is operated to allow bull trout in and out of the reservoir. In lower Duncan autumn flows have been protected for spawning and incubation of whitefish and kokanee.
	Total Dissolved Gas	Monitoring has shown that spill events greater than 114 m3/s result Total Gas Pressure levels of 115 %.	Monitoring of spill events.

Duncan Dam and Reservoir and Lower Duncan River			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Wildlife and vegetation	**Reservoir species**	**Bear Trap Creek Flats and the low gradient portions of creek fans in the drawdown zone were viewed as good areas to focus on for improving the reservoir riparian area. A performance measure was developed. There was a trade-off between recreation and riparian productivity in the reservoir. Generally, higher reservoir levels (after reaching full pool in the summer that benefited recreation interests, July 15-Sept 1) were worse for riparian communities in the reservoir.**	**The recommended alternative from the Water Use Plan has the reservoir reaching full pool between Aug 1-10 and drafts 1-1.5m (3-5ft) by the end of labour day.**
	Various species	**Maximize the quality and quantity of available habitat area for wildlife.** **Maximize riparian (wetland) production for breeding and migration habitat.** **Maintain a diversity (species and age classes) of riparian habitats in the lower Duncan River using cottonwood as an indicator.** **Maximize herbaceous and shrub communities in the Duncan Reservoir.** **Inundation period during the growing season (Apr 1 to Oct 30). Decrease elevations to 573.7m or less after reaching full pool and maintain.** **For cottonwood recruitment in the lower river, generally want to follow a more natural hydrograph once every 5 yrs. which includes: peak flows in July (basically defined above 250cms), recession flows by late Aug and lower base flows till next freshet**	**Riparian and wetland habitat in the Lower Duncan River were considered of high value. Cottonwood forests were chosen as an indicator of riparian success since cottonwood establishment is highly sensitive to flow. See the above discussion.**

Kootenay Lake and lower Kootenay River			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Ecosystem Integrity	**Primary Productivity**	**Duncan and Libby dams have reduced the inflow of nutrients and primary productivity has decreased. Maximize the primary production of carbon to enhance higher trophic level production.**	**Kootenay Lake Nutrient Restoration Program was initiated in the North Arm in 1992 and the South Arm in 2003 under the Fish and Wildlife Compensation Program. The operations at Libby dam, Duncan dam, and outlet Corra Linn and Kootenay Canal can influence pelagic productivity. There was a nutrient retention performance measure that was used to determine compensation of nutrient loss associated with Duncan Dam operations.** **The Kootenay Lake Nutrient Restoration Program is collaboratively implemented based on several project partner contributions including Bonneville Power Administration, Northwest Power and Conservation** **Council's Columbia Basin Fish and Wildlife Program, Kootenai Tribe of Idaho (KTOI), the Fish and Wildlife Compensation Program - Columbia (FWCP - Columbia), the BC Ministry of Forests, Lands, and Natural Resource Operations (FLNRO) and the BC Ministry of Environment (MOE). The day to day operations are implemented by FLNRO and administered through FWCP-Columbia, KTOI and British Columbia Conservation Foundation (BCCF). FWCP-Columbia contributes approximately 750K/year. The Kootenai Tribe of Idaho receives funding from the Bonneville Power Administration through the Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program of approximately $740K US/year.**
Fish	**General Productivity of various species pelagic and littoral**	**Minimize fish strandings by Duncan Delta.** **Minimize Total Dissolved Gas effects below Brilliant, Lower Bonnington, and Keenleyside dams.** **Minimize stranding effects below Brilliant dam** **Avoid impacts to Columbia River white fish and rainbow trout flows.** **Minimize entrainment through Keenleyside dam.** **Avoid unintended negative impacts to fish associated with VarQ flows**	**During the Water Use Plan these issues were hypothesized and while a preliminary review did not identify any measurable effects of significance from potential operational changes at Duncan, they did not consider changes as a result of different Treaty conditions nor as a result of flow changes from Libby dam.** **Gerrard- Rainbow Trout monitoring and studies in spawning channels.** **Rainbow trout are known to spawn in the headpond of Upper Bonnington below Corra Linn. Studies with Fort are being done to assess fish**

Kootenay Lake and lower Kootenay River			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
		from Libby dam.	**stranding.**
		Minimise impacts to Mountain Whitefish spawning in Lower Kootenay River between November and March.	**Assessment of Kootenay Lake West Arm shoal spawning and incubation success for recommendations for Kootenay Lake operating regime.**
			Burbot Conservation Strategy for Kootenay Lake and Kootenai River is being developed and some hypothesis tested regarding washing out of redds in Idaho. Operations at Libby dam and Kootenay Lake levels will influence redds. Note burbot are Red Listed in the Kootenays and are of particular interest to First Nations.
	White Sturgeon		**Development of draft Sturgeon Management Plan for the Columbia.**
Wildlife and vegetation	**Riparian Habitat**	**Minimize losses of riparian habitat in drawdown zone (and corresponding increase in sand dune areas around Kootenay Lake)**	**Maintain water levels to the upper portions of the drawdown zone**
	Wetland Areas	**Minimize losses of marsh wetland areas around Kootenay Lake**	**Upper portions of the drawdown zone**

Koocanusa Region and Kootenay River			
Category	**Sub-Category**	**Specific Interests**	**Mitigation**
Ecosystem Integrity	Backwatering	When reservoir levels drop below about 2400 ft there is no backwatering effect on the Canadian side of the border.	
Fish	Bull Trout (threatened) Cutthroat Trout	Maximize the abundance, diversity and condition priority species Minimize possible negative effects on other resident fish and their habitats on CDN side of the border.	
	White Sturgeon	Enhance the recruitment of the white Sturgeon population in the Kootenay River below Libby dam.	VarQ flood control strategy is currently being implemented by the US Army Corp. of Engineers. The strategy involves a spring pulse to assist in sturgeon migration followed by a summer and fall flow regime to promote improved sturgeon spawning and rearing requirements as a result of increased volume and a more appropriate temperature regime. Bull trout and cutthroat trout also benefit from the flow increases.
Wildlife and vegetation	Riparian Habitat and Littoral Productivity	Opportunity to initiate greater restoration activities.	Operating Koocanusa Reservoir to a lower annual maximum elevation, with infrequent exceedances, could provide for increased riparian, wetland, and floodplain habitats.
	Grassland	Loss of grassland at Northern end of reservoir due to higher water levels in the spring time during VarQ flows.	No specific mitigation.
	Floodplain ecology	Improvements to ecological functioning of the flood plain (Creston Valley)	There are higher and more natural flows for certain periods under VarQ.
	Protected Areas Nesting Habitat	Flooding impacts of protected areas (e.g. Wildlife Management Areas) or other important habitats (Northern Leopard Frog breeding grounds) Kootenay River Region (Duck Lake) Preferred elevation range 1744' – 1746' (Spring) Detrimental elevation(s) >1749', <1744' (May 15 – Aug 31)	No specific mitigation but there is collaboration with US Army Corps.

Chapter 3 – How Environmental Interests may be affected by potential Treaty decisions

3.1 Introduction to chapter 3

The previous chapters identified the ecological and environmental interests in the Columbia Basin and how those interests have been addressed over the past two decades. This Chapter describes how those interests may be affected by future operations of storage facilities under scenarios of either continuing or terminating the Columbia River Treaty (the Treaty). It does not suggest how to best operate the dams under any given scenario. Rather it discusses the likely limits of possible operations to explore their potential impacts on environmental and other interests.

This Chapter is based on the findings of technical studies and modelling conducted between August 2012 and March 2013, which are available in the *Columbia River Treaty Review Technical Studies Report –Draft*[26] and on subsequent consultations and modelling conducted between March and October 2013 which are detailed in the *Addendum to the Technical Studies Report.*[27]

The Technical Studies report and Addendum detail and evaluate how environmental and social values in BC may be affected by the potential strategic decisions regarding the future of the Treaty. The evaluations were conducted through modelling similar to the Water Use Planning for the Columbia system,[28] and indeed employing many of the performance indicators developed in that process.

Public engagement was conducted with basin residents and stakeholders, as well as consultation with First Nations. A technical workshop was held in Nelson in March 2013 to present the findings of the technical studies and solicit direct input. Additional input was sought at community sessions in Jaffray, Creston, Revelstoke, Valemont, Trail, Nakusp, Castlegar and Fauquier, and at the hosting of a special workshop in Fauquier on the impacts and benefits of the Treaty.[29]

During the third round of consultation basin residents and stakeholders requested additional information regarding what the effects might be of the Arrow Lakes reservoir being stabilised at mid-level elevations. There was additional interest throughout the basin, including First Nations, as to the potential effects of dam operations that focussed on ecosystem benefits. These two potential operating alternatives are highlighted in this report as they represent the merging of environmental stakeholder interests to date.

Also, an alternative for Okanagan Sockeye Salmon is also being developed in collaboration with the Okanagan Nation Alliance and once completed will be summarized in a separate report.

Two committees participated in the technical studies. The Environmental Advisory Committee (EAC) was formed to provide policy and technical input to the design, evaluation, and dissemination of the results of the technical studies. The EAC has representatives from the Ministry of Energy, Mines and Natural Gas; the Ministry of Environment; Ministry of Forests Lands and Natural Resources Operations; Department of Natural Resources Canada; Environment Canada; and Fisheries and Oceans Canada as well as BC Hydro.

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[26] The March 2013 Draft Technical Studies Report is available at http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT_Technical_Report-DRAFT.pdf
[27] http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT-Technical-Studies-Addendum-DRAFT-Oct30.pdf
[28] See section 2.3
[29] http://blog.gov.bc.ca/columbiarivertreaty/files/2013/09/CRT-Public-Consultation-Report-Working-Draft_r3.pdf

The Columbia River Treaty Fish and Wildlife Technical Committee (FWTC) provided technical support, input on designing modelling alternatives, and a review of the results. The FWTC is made up of technical advisors and experts with experience and knowledge on Columbia and Kootenay river systems. It includes representatives from Environment Canada; Fisheries and Oceans Canada; BC Hydro; Ministry of Forests, Lands, and Natural Resources Operations; Ministry of Environment; the Canadian Columbia River Inter-Tribal Fish Commission; the Ktunaxa First Nation and Sexqeltkamc te Sewepemc First Nation and Environmental Consultants.

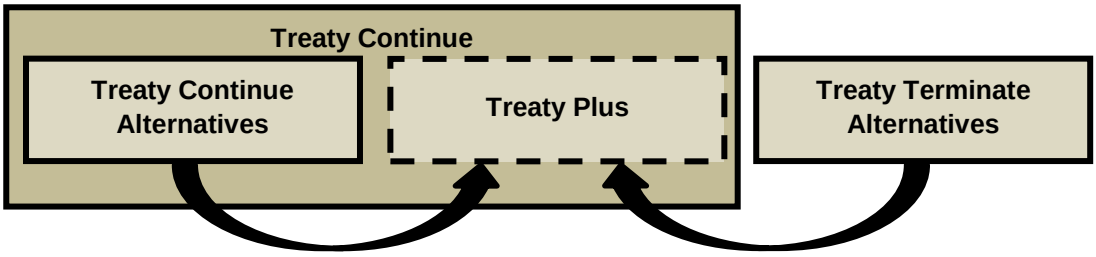
In exploring potential future operations and their impacts, not all possible outcomes could be examined as the possible alternatives are too numerous. Instead, the limits of the potential alternatives were explored to assess the range in possible outcomes to help inform us of what lies between those limits. In this case two scenarios were evaluated:

i) The **Treaty Continues** (TC) in its current state including the existing flexibility and actions taken to enhance environmental interests as explained in Chapter 2; and

ii) The **Treaty Terminates** (TT) where greater flexibility would exist for Canada to operate the dams but which includes certain obligations related to 'Called Upon' flood control, as well physical and system constraints associated with the existing dams.

A third scenario lies somewhere between the two in which the Treaty could continue but with modifications to the current Treaty (Figure 3). This "Treaty Plus" scenario requires further consideration of what areas both the U.S. and Canada wish to change and assess their compatibility as any Treaty Plus alternative will need agreement from both the U.S. and Canada.

Figure 3: Major Treaty Scenarios Under Review



3.2 What changes if the Columbia River Treaty is continued or terminated?

The Columbia River Treaty is a legal document outlining the methods of operating the treaty dams in Canada and the sharing of benefits associated with those operations. Should the Treaty continue in its present form the following occurs:

- The cooperation between BC Hydro and its U.S. counterparts regarding operation of storage facilities in Canada, and Libby in U.S. will continue.
- The benefits Canada receives from increased power in the U.S. (Canadian Entitlement) will continue.
- The flood control provisions change in 2024 from the current 'assured' annual flood control under the Annual Operating Plan (AOP) to a 'Called Upon' flood control.[30]
- The flexibility to address social and environmental issues as currently available would continue.

[30] Under Article IV (3) of the Columbia River Treaty Canada must provide 'Called Upon' flood control for the useful life of the storage facilities in Canada. However, the U.S. would need to make use of all its available flood control first and would need to compensate Canada when it 'calls upon' Canada to provide additional flood control.

- The Non-Treaty Storage Agreement (NTSA) dealing with the 5 MAF of extra storage that was constructed at Kinbasket is in effect until September 2024. The NTSA could be extended or a new NTSA developed.

Either Canada or the U.S. can terminate the Treaty as early as September 2024 or at any time after that, by giving 10 years notice.[31] Should the Treaty be terminated the following would occur:

- Coordination between BC Hydro and its U.S. counterparts (Entities) on the operation of storage facilities in Canada would not continue as it does now. There would not be an AOP and thus the storage could be operated only for Canadian interests, with the one exception of 'Called Upon' flood control.
- Canada would still be required to provide 'Called Upon' flood control subject to the limitations outlined in the Treaty (see above).
- The obligation to coordinate operations of Libby dam would continue for the useful life of the dam. Also, Canada would continue to make available the land required for the Koocanusa reservoir.[32]
- There would be no need to coordinate with the U.S. regarding the 5 MAF of additional storage at Kinbasket, which is referred to as Non-Treaty Storage. All storage in Canada would be used to address Canadian interests.
- The Columbia River would not be without international legal agreements. The relevant provisions of the *Boundary Waters Treaty* (1909) would apply; some provisions of the Treaty survive after termination, such as the coordination of Libby dam and provision of 'Called Upon' flood control. Also, the Kootenay Lake Order would remain in effect.[33]

Regardless of whether the CRT continues or is terminated, the flood control provisions change in 2024 from the current 'assured' annual flood control to a 'Called Upon' flood control. This could be revised under a 'Treaty-Plus' scenario.

Exactly how Canada or the U.S. would operate its facilities differently should the Treaty be terminated is still being explored. Indeed, the Columbia River Treaty review, this and other papers and the discussion that they generate will help inform decision makers as to how the facilities on the Columbia River might be operated to best meet Canadian interests, and if those interests are best achieved by terminating the Treaty.

As the flow in the Kootenay River system is primarily influenced by operations at Libby dam it is difficult to anticipate how it might change in the future. With the shift to 'Called Upon' flood control it is likely the U.S. will need to draft Koocanusa deeper more often in the spring. The U.S. will almost certainly continue operating Libby to meet Species at Risk legislation to protect sturgeon, bull trout and salmon (in the lower Columbia River of the U.S.).

3.3 Assessing the Impacts on Environmental Interests

Modelling was conducted to determine the potential impacts of a range of possible future operations. 60 years (1929-1999) of real inflow data was used to assess possible operating alternatives under each of the Treaty Continue and Treaty Terminate scenarios.

[31] September 2014 is the earliest point that either country could give notice to terminate.
[32] This is outlined in articles XII and XIX (3) of the Columbia River Treaty.
[33] This is an Order issued by the International Joint Commission controlling operation of Cora Linn dam to maintain prescribed maximum lake levels from April to September for flood control. The Columbia River Treaty requires operations of Libby to be consistent with the Order.

Modelling did not explore all possible future operating alternatives but rather focused on those that illustrate the range in possible outcomes to help inform us of what lies between those limits.

Due to the complexity of the systems, impacts on environmental interests were assessed by examining the systems separately:

i. The Columbia River: Kinbasket Reservoir, mid-Columbia, through Arrow Lakes, including the Lower Columbia to the border; and

ii. The Kootenay System from Libby dam through Kootenay Lake and the lower Kootenay River to the confluence of the Columbia River.

In the system model used to access the Columbia River the electrical demand is met in the most economical manner by using i) fixed generation from the Kootenay system and other small generating stations ii) dispatching BC Hydro large generation on the Columbia and Peace rivers; iii) dispatching gas-fired generation and iv) imports and exports of electricity over transmission lines connecting BC to Alberta and the U.S.. As such, additional inputs included market price forecast, electrical demand, and the projected mix of resources needed.

Assessing impacts on environmental and social interests is not straightforward and many of the interests identified in Table 1 cannot be directly measured. For example it is difficult to calculate 'ecosystem health' or how fish or bird populations will be affected by certain operations. It is however possible to calculate how often a reservoir is likely to flood an area where birds are known to nest or what the flow in a section of the river may be during the period that whitefish are spawning. These quantifiable parameters are termed 'Performance Measures' to help represent the impact on the real interests. In total some 40 performance measure were used to calculate impacts on environmental, social, and economic interests in the Columbia River and a further ten new performance measures were developed for the Kootenay system.[34]

Climate change scenarios were not specifically modelled. However, variability between year-to-year inflows is incorporated by utilizing the long data set of 60 years. Climate change scenarios are predicted to result in stream flows that are within range of variability seen in the historical dataset used.[35] Consequently, the 60 year data set used is within the range of predicted future variability for the next 60 years.

[34] Note that apart from the Duncan reservoir, the Kootenay system did not undergo a WUP and new performance measures were developed.

[35] http://www.bchydro.com/content/dam/hydro/medialib/internet/documents/about/climate_change_report_2012.pdf

3.4 The Columbia River

Specific operating alternatives were developed under each of the Treaty Continue and Treaty Terminate scenarios. Under the Treaty Continue scenario these included the current operations as a reference, an alternative to enhance wildlife and vegetation (for example by holding Arrow Lakes reservoir lower until mid-July) and one to enhance recreation interests, navigation and reduce dust in Kinbasket (by not reducing the reservoir below a minimum water level). As these operating alternatives were modelled under the Treaty Continue scenario they all maintained the 'border flow'[36] required under the Treaty. These alternatives built upon similar operational alternatives explored in great detail under the Columbia WUP process.[37]

Parallel alternatives were assessed under the Treaty Termination scenario where there would be greater flexibility in operations. In addition alternatives were also generated that provided short flushing flows in the spring in the Lower Columbia to help move sediment; and extended high flows for sturgeon (Sturgeon flow) in the summer.

In addition to these parallel alternatives two additional alternatives were developed based on the Third round of consultations in 2013.

i. **Stable Arrow Lakes alternative**: This alternative attempts to keep Arrow Lakes within 5 ft of a chosen target level (two target levels were modelled at 1425 ft and 1420 ft).[38] This holds Arrow Lakes lower than optimal for hydro power generation year round to allow vegetation to extend into lower elevations. It provides improved habitat for nesting birds, increases the length of the flowing Middle Columbia River in some seasons, and provides shore based recreation in Revelstoke reach.

A stable Arrow Lakes alternative would help to mimic a natural lake allowing for riparian vegetation to establish itself in some of the area that currently experiences drawdown. It would also potentially allow for enhancing tributary access for kokanee if existing obstacles are removed as drawdown fluctuations would be negligible.

ii. **Ecosystem alternative**: Specific modelling constraints for the Ecosystem alternative were proposed by the Canadian Columbia River Intertribal Fisheries Commission (CRIFIC) and reviewed by the Fish and Wildlife Technical Committee. The alternative is an attempt to explore different possibilities for potential ecosystem benefits of the system as it exists with the dam facilities in place. It does not necessarily focus on mimicking a natural hydrograph or optimizing ecosystem function but looks at ecosystem benefits in general. It is based on:

   a) Benefit riparian/wetland function and vegetation, birds and other wildlife by reducing Kinbasket high elevation in 80% of years to enhance littoral productivity, increase river habitat, enhance riparian vegetation and promote wildlife. The top 15 ft of the reservoirs are only used in high volume years (20% of the time).

[36] The term 'Border Flow' is used throughout the document to refer to the regulated flow out of Canada (i.e. Arrow + Duncan discharge). Physical water flow at the border also depends on Libby operation, Kootenay Lake regulation, the unregulated Slocan River, flows from the Pend d' Oreille River that joins the Columbia just upstream of the border, and other local inflow that enters the Columbia River in Canada

[37] Columbia WUP (2005). In the WUP some 17 operating alternatives were examined all complying with the Columbia River Treaty. During the Columbia River Treaty Review additional work was also conducted to assess fish interests below Arrow Lakes reservoir.

[38] Only the 1425 ft alternative is discussed in this report as the 1420 ft alternative had large impacts on navigation and recreation.

b) Reduce reservoir drawdown of Kinbasket in the winter to support higher flow in the freshet.

c) Stabilize Arrow Lakes within 5 ft of 1425 ft to benefit riparian/wetland function and vegetation, birds and other wildlife. Flooding above that will occur in high water years (approximately 20% of the time) for periodic wetland flooding.

d) Benefit riverine fish communities by providing fish friendly flow downstream of Arrow to the U.S. border. Specifically, the flow between February and March will be operated to minimise any reductions to target whitefish spawning; and increasing flows will be maintained from April to June for Rainbow trout.

An Ecosystem alternative was designed to potentially increase environmental benefits throughout the system taking into account the existence of the dam facilities.

Wildlife and vegetation were assessed in terms of how well riparian and wetlands are being preserved or available. This was calculated primarily through the frequency and duration of flooding of these areas over the course of the growing season. Bird habitat for spring nesting birds and autumn migratory birds in the Mid-Columbia were assessed based on the percentage of usable habitat (habitat that was not inundated) over specified periods of time.[39]

Fish and aquatic resources were assessed by different mechanisms in different locations depending on the system and our understanding of the major influences on productivity in that system.[40]

- In Kinbasket aquatic productivity was assessed by estimating algal and zooplankton productivity based on the residence time of water in the upper layers of the reservoir.
- In the mid-Columbia below Revelstoke fish and aquatic resources were assessed by calculating the functional length of river that is not inundated by Arrow Lakes; and availability of specific habitat in that reach during the sturgeon larval rearing period (15 July-30 Aug).
- In Arrow Lakes aquatic resources were assessed based on tributary access for kokanee from late August to mid-November; and aquatic productivity was based on residence time in the upper layer (top 20 meters) of the reservoir.
- Aquatic resources for the lower Columbia were assessed based on total dissolved gas (TDG), the ability to provide sturgeon pulse flows, and mechanisms that drive bio-mass growth for whitefish and trout.[41]

Ecosystem heath and resilience can be inferred from fish and aquatic resources; and wetland and riparian productivity.

Findings from the modelling of the Columbia River

Table 5 shows a summary of the modelling results of the potential operating alternatives that were explored under the different scenarios of Treaty Continue and Treaty Terminate. Under the Stabilised Arrow Lakes alternative only the results of the modelling at 1425 ft elevation are shown as the results of modelling at 1420 ft were thought to have overly significant impacts on navigation and recreation. The results are all **relative to current operations** to illustrate how potential operations might vary from the present, including the estimated power value ($ Million/year).

[39] Eight groups of birds were assessed. Short-eared Owls were used as representative of the spring nesting birds and shorebirds were used as representative of the fall migration. These were the same metrics used during the NTSA process. See Appendix G of the Draft Technical Studies Report.
[40] See Appendix G of the Draft Technical Studies Report.
[41] See Annex H of the Draft Technical Studies Report.

Table 5: Summary of the environmental impacts of a range of potential operation compared to current operations

← Range of Operating Alternatives Explored →

The potential operating alternatives are compared against current operations	Treaty Continue		Treaty Terminate In general Arrow Lakes are kept higher than current operations						
	Arrow Lakes lower in early summer for vegetation	Minimum level at Kinbasket (Treaty constraints)	Keep Arrow Lakes high	Arrow Lakes lower in early summer	Minimum level at Kinbasket	Short flushing flows in Lower Columbia	Sturgeon flows in Lower Columbia	Stable Arrow Lakes (1425 ft)	Ecosystem
Kinbasket Reservoir									
Fish and aquatic productivity									
Wildlife and vegetation									
Mid-Columbia River									
Aquatic river habitat									
Sturgeon habitat									
Vegetation flooding									
Spring nesting birds									
Fall migratory birds									
Arrows Lakes Reservoir.									
Kokanee access									
Aquatic productivity									
Lower Columbia River									
Whitefish and trout									
Sturgeon									
Power Value $M/yr	-22	-181	-180	-186	-350	-181	-201	-203	-456

% Change from Current Operation	-20% ←	-19% ←→ -10%	-9% ←→ +9%	+10% ←→+19%	→+20%

As expected from a system as complicated as the Columbia no single operating alternative shines above the rest. Each has its pluses and minuses relative to current operations and management.

Under the Treaty Continue scenario there is a clear linkage between the operations of Kinbasket and those of Arrow Lakes. Constraints placed on one will impact operations on the other as specific border flows need to be maintained under the Treaty. Consequently, when Arrow Lakes are purposefully keep lower to benefit wildlife and vegetation interests in the Mid-Columbia this has the effect of keeping the Kinbasket reservoir higher and is consequently less beneficial for vegetation there. It is likewise the case that the lower levels in Arrow Lakes are also thought to potentially benefit vegetation and river habitat for fish in the Mid-Columbia.

When Kinbasket is keep above minimum levels under the Treaty Continue scenario it has the effect of keeping Arrow Lakes lower again benefiting the wildlife and vegetation in the Mid-Columbia. Interestingly, despite maintaining minimum reservoir levels vegetation is not negatively affected in Kinbasket as this alternative involves an autumn drawdown reducing the inundation period of vegetated areas. In both cases the lower Arrow Lakes levels negatively affect kokanee access to tributaries in the autumn and also reduce aquatic productivity in Kinbasket because of reduced residence time of surface waters where carbon production occurs through photosynthesis. This Arrow-Kinbasket 'see-saw' effect is absent under the Treaty Terminate scenario, however, some trades-offs remain and new ones are formed.

In general, under the Treaty Terminate alternatives explored, the performance measure for vegetation in Kinbasket may be worse as there are greater areas that are inundated due to slightly higher reservoir levels in August through September. Even under the Ecosystem alternative there is only a marginal potential improvement in vegetation despite being designed to increase riparian vegetation by reducing drawdown and avoiding using the top 15 ft throughout the year. This is because in the ecosystem alternative although the reservoir levels are lower than current operations in the August – September period they are significantly higher in the May and June period as the winter drawdown is limited to allow for more water release during the spring freshet. This is similar for the alternative that keeps a minimum reservoir level at Kinbasket under the Treaty Continue scenario. Under the Treaty Terminate scenario the alternative which maintains a minimum drawdown level in Kinbasket keeps the reservoir higher throughout the year inundating more area and thus having a poor effect on the vegetation performance measure.

The effects on vegetation need to be considered in light of the performance measure used. The performance measure for vegetation in Kinbasket is specifically based on 2m levels which are inundated for more than 18 weeks during the growing season. However, vegetation is complex and would be based on a number of factors including substrate, slope, and groundwater, amongst others. Periodic inundation in the top 15 ft, as designed in the Ecosystem alternative, could result in a progression of vegetation from grasses and sedges to cottonwoods with a resulting better value for wildlife. This potential increase in more stable vegetation and habitat due to more stable levels is not adequately captured in the current performance measure for vegetation.

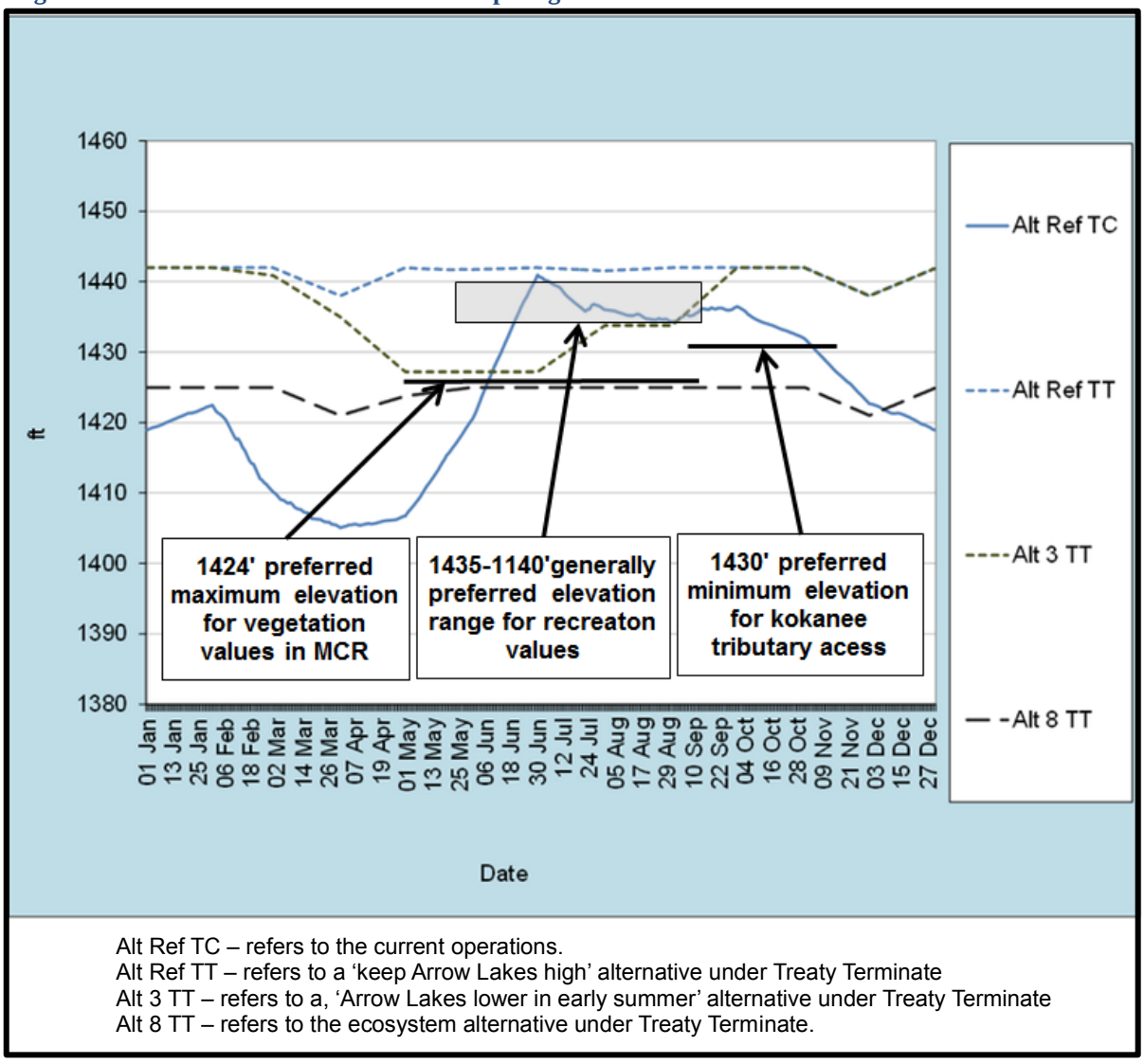
Aquatic productivity in Kinbasket reservoir is measured in residence time over the growing season which is related to reservoir levels. The higher the level, the greater the residence time will be, and thus productivity. Consequently, the Ecosystem alternative shows significantly poorer performance in aquatic productivity as it does not use the top 15 ft of the reservoir. This is despite its intention to promote environmental benefits. It must be noted however, that the aquatic productivity performance measure does not account for the potential benefits of a more stable reservoir in that there may be greater productivity in the littoral zone as well as additional benefits provided by higher value riparian vegetation.

One of the main trade-offs that will continue under the Treaty Terminate scenario is between wildlife and vegetation in the Mid-Columbia and aquatic resources in Arrow Lakes (Figure 3). As Arrow

Lakes are, in general kept higher under the Treaty Terminate scenario, we expect the river habitat and wildlife and vegetation to be worse off in the Mid-Columbia river. In the alternative designed to keep Arrow lower under Treaty Terminate, the vegetation higher in the reservoir would likely develop more diversity, while the lower vegetation would disappear as it is inundated throughout the year. The alternative with large releases in the lower Columbia for Sturgeon also has the effect of lowering Arrow Lake levels sufficiently to benefit the Mid-Columbia wild-life and vegetation. The lowering, however, is not enough to benefit the aquatic river habitat, which is negatively impacted by almost all the Treaty Terminate alternatives explored. Conversely, kokanee access benefits from the generally higher level in Arrow Lakes.

Consequently, the Mid-Columbia fish and wildlife interests are generally at odds with Arrow Lake kokanee spawning. This is particularly evident when looking at fall migratory bird habitat as both prefer specific reservoir levels over similar periods between late August through October. Kokanee prefer the elevation to be above 1430 ft. while fall migratory birds prefer it to be less than 1437 ft. (Figure 4). The alternative of keeping Arrow Lakes lower in the spring under the Treaty Terminate scenario has the effect of maintaining the reservoir between this narrow range over that period and thus benefiting both interests. Other alternatives did not.

Figure 4: Elevation of Arrow Lakes and competing interests



Alt Ref TC – refers to the current operations.
Alt Ref TT – refers to a 'keep Arrow Lakes high' alternative under Treaty Terminate
Alt 3 TT – refers to a, 'Arrow Lakes lower in early summer' alternative under Treaty Terminate
Alt 8 TT – refers to the ecosystem alternative under Treaty Terminate.

The Stable Arrow Lakes and the Ecosystem alternatives behave similarly for the Mid-Columbia and Arrow Lakes as they maintain Arrow Lakes at approximately 1425 ft except in high water years. In this regard they have similar potential effects on aquatic river habitat as the current operations, but marked improvements for both vegetation and fall and migratory bird habitat. Again, what is not captured in the performance measure is the type and quality of riparian habitat potentially created by periodic flooding of the top 15 ft under the Ecosystem alternative, nor the potential improvements of aquatic river habitat with a more stable system.

In terms of kokanee access, the Stable Arrow Lakes and the Ecosystem alternatives perform poorly because reservoir levels are kept below 1430 ft under both alternatives (Table 5). It is important to understand, however, that the performance measure for kokanee access is based on elevations over 1430 ft during kokanee spawning between September and November. This was derived from an assessment of barriers and impediments at different elevations. If Arrow Lakes was kept more stable the access for kokanee to their spawning areas could potentially be improved over time through physical works and natural erosion as there would not be the impact of continual drawdown and inundation.

This trade-off between Mid-Columbia environmental interests and aquatic resource interests in Arrow Lakes (Figure 4) was explored extensively in the Columbia WUP which arrived at recommendations of the 'soft constraints' outlined in Table 2 (Chapter 1). The 'soft constraints' are operating ranges for different interests such as fish, wildlife, vegetation, cultural and heritage, recreation and erosion that have conflicting preferred water elevation ranges.[42] It is worth noting that of the alternatives explored in this review the current operating system is the only one on average to meet the intent of the soft constraints

Aquatic productivity in Arrow Lakes was estimated to be worse in the Treaty Terminate scenario as the residence time is generally reduced for the top layer of water where photosynthesis occurs.[43] This is particularly true for the Ecosystem and Stable Arrow Lakes alternatives as they generally pass more water through in spring. As with the Kinbasket reservoir, it is uncertain how a more stable reservoir would compensate in terms of littoral productivity and riparian vegetation. It is worthwhile to remind readers that during the WUP process that the fish technical sub-committee found that the fertilization program was a more effective way to increase aquatic carbon production than was attempting to do so through operations of the reservoirs.[44]

The estimation of the impact on whitefish and Rainbow trout in the Lower Columbia was conducted by experts assessing how different flows would affect spawning and survival rates based on six different factors.[45] The Ecosystem alternative increases the discharge from Arrow in the spring and has the effect of significantly improving whitefish and trout flows; however, the flows are not sufficient to benefit sturgeon. It should be noted that the increased flows could increase flood risk in high water years.

The alternative releasing flow for sturgeon spawning and incubation in June through to August is the only alternative that provides the estimated flows that may benefit sturgeon recruitment, and consequently the only alternative that shows any improvement.

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[42] The 'soft constraints' developed for the Arrows Lakes include: If vegetation showing signs of stress (May-June) target lower reservoir levels in the fall. Preserve vegetation at/above 434 meters.// Make sure reservoir levels inundating bird habitat in the early summer is no worse than 1984-1999 statistics. Bird habitat for the fall should be better than 1984-1999 statistics. Draft reservoir quickly after full pool reached - target 438m (or lower) by 7 Aug.// Keep levels high enough in fall for tributary access for kokanee spawning (August-November). Levels below 434 meters (1430 feet) could cause problems for tributary access.

[43] Note the effect of residence time on Arrow Lakes and Kinbasket are different as there are different intake structures which affect the residence time of the surface layer in each reservoir. See Appendix F of the Technical Studies Report.

[44] See Section 2.6, Table 3.

[45] See Appendix E of Draft Technical Studies Report March 2013.

It should be noted that there is a high level of uncertainty associated with the benefits of sturgeon flow. High natural flows over the last two years that have mimicked the proposed sturgeon hydrograph have allowed some monitoring to be undertaken to assess recruitment success. However, conclusions from the monitoring will take some time as the experts assess the sturgeon response to the flows.

While the alternatives explored do not constitute an exhaustive list of possibilities under the Treaty Terminate scenario they help provide insight into the ways in which various interests are likely impacted by different operations of the facilities.

Also, it is important to note that there may be potential benefits to the environment from some of the alternatives which have not been captured in the performance measures. For example in the Ecosystem alternative there may be benefits or negative impacts in the US which have not been accounted for in the current modelling.

3.5 Kootenay system

Operations at Libby dam largely influence the Kootenay system. As the coordination of the Libby dam will continue, and the change to 'Called Upon' flood control will occur in 2024 regardless of whether the Treaty continues or is terminated examining impacts of different operating alternatives was approached differently than in the in the Columbia River. Instead of developing alternatives under the Treaty Continue and Treaty Terminate scenarios, the current operations were compared against the previous operation prior to the U.S. making changes for their own fisheries, and a new alternative that addressed Canadian recreational and fish interests in the Koocanusa area.

Understanding how the future Kootenay system might be operated and the impacts on the environment under different alternatives is important to:

i. Understand the implications associated with 'Called Upon' flood control; and,

ii. To inform potential discussions on the Treaty to influence coordination between Canada and the U.S. on operations at Libby dam.

The Columbia River Treaty review opens up the possibility to include discussions regarding the coordination of Libby to better address Canadian interests. However, it must be remembered that different interests are often at odds with each other, and that the U.S. would unlikely operate Libby in a way that is contrary to their domestic legislation to protect endangered species.

Ten performance measures where developed for the first time to estimate Canadian interests from Koocanusa reservoir down to the confluence of the Columbia River.

The current VarQ flood control regime was used as a reference for other alternatives. This regime draws down the reservoir to allow for flood control until about April when it begins to refill with the spring freshet to its highest level between late July and August. It also adheres to U.S. Endangered Species Act objectives for fish releasing extra flows in the spring, for sturgeon and bull trout spawning in the Kootenay River below Libby, and also in the early autumn, for salmon in the US portion of the Columbia River.

The alternative representing the standard flood control operation that was in place prior to the changes for U.S. fisheries in the Kootenay River involved drawing the reservoir deeper in spring for power and flood control. The reservoir is also drafted in August for salmon in the US portion of the Columbia River.

Other alternatives explored Canadian fish and recreational interests in the Koocanusa reservoir by filling the reservoir earlier. The most plausible of these examined attempted to fill the reservoir by June 30.

As no WUP had been conducted for the Kootenay system (apart from Duncan Dam) new performance measures to assess the impacts of various operations were developed. Duncan Dam will be specifically discussed in a subsequent section.

Findings from modelling the Kootenay system

The following discussion describes the results of the modelling in comparison to current operations.

As with the Columbia River there are trade-offs between the different alternatives. Fish and aquatic production in the Koocanusa reservoir were assessed in terms of algal and zooplankton availability which benefit from stable reservoir levels in general. Consequently, the deeper spring drawdown associated with standard flood control operation is worse for the aquatic ecosystem in the reservoir. However, the fish and aquatic production in the reservoir was only seen to benefit marginally from the having the reservoir 'fill by June 30'. This is likely because current operations generally fill the reservoir by mid-July so the difference is only in two weeks.

The deeper spring drafting of the standard flood control operation improves wildlife and vegetation in the Koocanusa reservoir as less riparian areas are inundated for long periods of time. If managed correctly, this has the potential to create vegetation communities in the areas of Sand Creek, Gold Creek and Elk River similar to high value riparian areas near Revelstoke on the Middle Columbia. Wildlife and vegetation were slightly worse under the 'fill by June 30' alternative.

Other wetlands of great significance on the system are those found in Creston Valley. However, due to the series of dykes and impoundments associated with the area it was found that there was little difference in impact between the different alternatives modelled.

Likewise, perhaps due to its size, there was little to no difference between the alternatives modelled on the aquatic production and fish in Kootenay Lake. In this case fish and aquatic productivity in Kootenay Lake were assessed not by algal and zooplankton production, but rather through relating flow and Mysis transport to predict kokanee size.[46] Interestingly, both the new modelled alternatives reduced the risk of flooding in Kootenay Lake by about half of the risk under the current operations.[47]

The Kootenay River below Cora Linn dam benefited markedly from the deeper spring drawdowns in Koocanusa associated with the standard flood control operation. Inundation of the Bird Creek wetland area below Cora Linn dam was significantly reduced (25% less) than current operations. Also, the days where TDG levels where dangerously high in the river were also estimated to be significantly reduced (as much as 35%). The 'fill by June 30' alternative also significantly reduced TDG levels in this section of the river.

As there are power generating facilities below Kootenay Lake, estimations were done on the value of power production. The standard flood control operation enhances power production value on the Kootenay system by $19M/yr. while the Koocanusa 'fill by June 30' alternative increased power value by $4.6M/yr.

In general, there could be improvements to some Canadian interests (lower TDG levels in the lower Kootenay River, increased angling access on Koocanusa, as well as reducing flooding potential in Kootenay Lake) in moving to a 'fill by June 30' operating alternative, with only small adverse impacts on other interests. However, it is important to note is that the current operations at Libby is the only alternative modelled that likely meets the sturgeon, bull trout and salmon requirements in the U.S.

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[46] See Appendix G – Technical Studies Report at http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/CRT_Technical_Report-DRAFT.pdf

[47] Probability of lake levels rising above 1752 ft. Currently, this is about 14% and modeled alternatives calculated this to be between 6-8%.

under their environmental legislation. These requirements greatly limit the range of possible operating alternatives available at Libby dam.

Duncan Dam

Different Duncan Dam operating alternatives were not explicitly modelled as part of this study but discussions surrounding its potential post 2024 operations were supported with information provided by the Duncan WUP Consultative Committee Report. As such, operating constraints limiting the use of the top 15 ft of the reservoir, similar to the Ecosystem alternative on the Columbia, were contemplated.

This would generally move more water into the Kootenay system in the spring period. While it would likely be of benefit for riparian vegetation in the reservoir and cottonwood requirement downstream in the Duncan River, it would not meet the current recreation targets and may increase the risk of downstream flooding, particularly in Kootenay Lake.

Chapter 4: Key Findings and Conclusions

It is worthwhile to remind ourselves that the Treaty Review is to help inform the provincial strategic decision around the future of the Columbia River Treaty. The purpose of this discussion paper is to help inform basin residents and others in the province on the key issues discussed during the community engagement process under the Treaty Review. As such it makes no recommendations with regard to continuing or terminating the Treaty, but rather seeks to clarify the issues both at a basin level, where the major impacts of dam building have taken place, and at a wider perspective.

4.1 Successes to date

In looking to the future it helps to look to the past and review the improvements and advances with respect to addressing environmental interests achieved over the past two decades by the activities described in Chapter 2.

Historical dam construction and altered flow regimes in the Columbia Basin impacted fish habitat, resulting in decreased fish populations. The construction of the dams also resulted in ongoing inundation of the valley bottoms, resulting in the loss of wildlife habitat. However, several species of fish have rebounded since the original construction of the dams. This is largely due to the mitigation measures for the dam impacts, imposed by the Provincial and Federal Regulatory Agencies, and the two major environmental initiatives that were undertaken to improve the fish and wildlife habitat: a) BC Hydro's implementation of the operational changes under the Columbia Water Use Plan; and, b) the Fish and Wildlife Compensation Program (FWCP) having implemented a variety of habitat improvement projects focused on compensating for fish and wildlife losses.[48] Some examples of the positive population trends observed are:

- Kinbasket Reservoir: Kokanee are more abundant than before dam construction. The species is monitored on an annual basis and there are no concerns for population levels. Bull Trout and Burbot are also abundant and not threatened.
- Arrow Reservoir: Nutrient enrichment has increased the kokanee biomass in the Arrow Reservoir by 300% compared to pre-nutrient biomass levels. Results have varied from year to year and biologists from the Ministry of Forests, Lands, and Natural Resources Operations and FWCP are investigating options for performance improvements and optimization.

[48] See sections 2.2 and 2.3

- Columbia sturgeon: The Columbia Sturgeon population is listed as endangered under SARA. A Recovery Plan including hatchery augmentation of juvenile sturgeon is implemented and hatchery juveniles are showing good survival.
- Lower Columbia Rainbow trout and whitefish: WUP flows and stranding protocols have resulted in stable population levels of Rainbow trout and whitefish in the Lower Columbia River.
- Gerrard Rainbow trout: Very large Gerrard Rainbow (10 to 20 pounds) are common within the Kootenay system.
- Bull trout: Harvest rates for Bull Trout are very high and younger smaller Bull Trout are abundant.
- Kokanee: Kokanee have been very abundant in recent years in Kootenay Lake due to the spawning channels and the nutrient enrichment program. Kootenay lake fish populations are not threatened.
- Ungulates: Population levels for ungulates such as deer and elk have not declined in general, and in many areas have actually been increased over the last decade.

Recognizing that the dams will remain in place in the foreseeable future, it will not be possible to return to pre-dam environmental conditions in the Columbia Basin. However, the efforts to date to minimize the impacts through Water Use Planning and the FWCP have shown that environmental conditions can be improved, while still maintaining essential electrical energy production.

4.2 Thinking about the future

As explained in Chapter 3, different operating alternatives will have different impacts on different environmental interests within the Columbia and Kootenay systems. While it is important to focus on these, it is also important to recognise that decisions made with respect to the Columbia Basin will have ramifications in the rest of the province and beyond. Consequently, assessing what potential advantages there may be within the Columbia River system to terminate the Treaty cannot be examined in isolation from the rest of BC's power generation and environmental implications elsewhere.

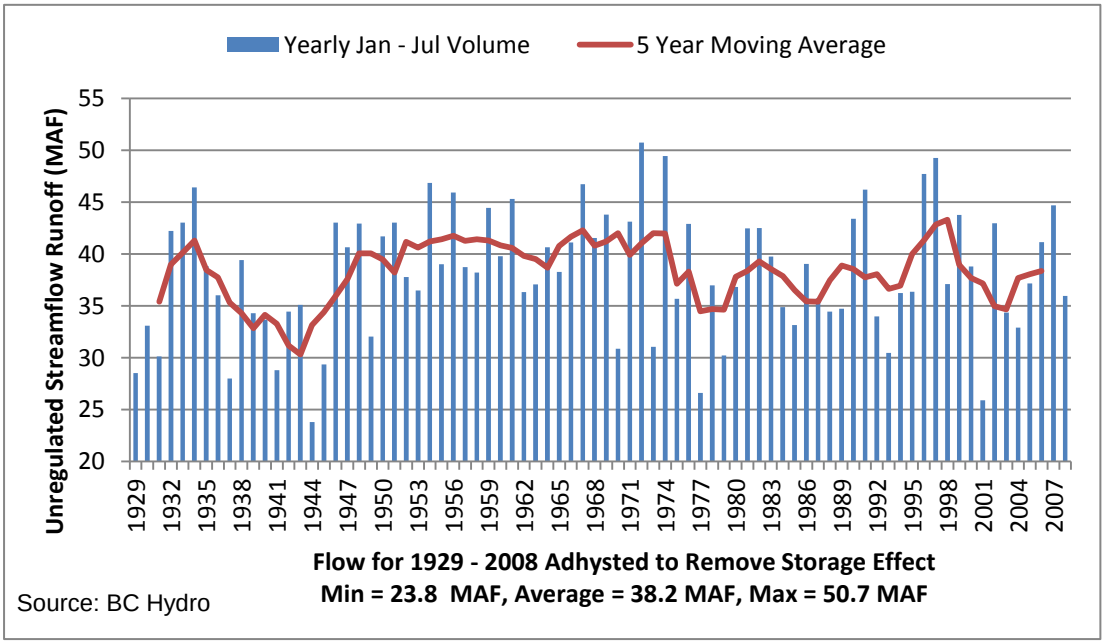
Mica and Revelstoke generation facilities will represent approximately 1/3 of the provinces energy generation (and 50% of BC Hydro's capacity) in 2024. Changes in the production at these facilities must be compensated for through other power sources, and could affect operations in the rest of the BC Hydro system.

Also, deficits in firm power generation in BC from certain operating alternatives on the Columbia system will necessarily have to be made up by building additional energy generation. New generation projects have their own environmental and social issues associated with the facilities and transmission as well as economic impacts in terms of costs. Depending on the amount of new generation required, gas-fired generation could be required to firm any significant additions of new alternative energy.

Climate Change Considerations

The Columbia River is a highly variable river. Figure 4 shows the inter-annual variability at Murphy Creek emphasising the range of flows that the Columbia experiences. Variability in water conditions were taken into account by using actual inflow data from 1929 to 2007.

Figure 5: Inter-annual variability in Runoff as measured at Murphy Creek



Source: BC Hydro

Adapting to climate change was noted as a particularly important interest area in the community engagement process that was conducted in the spring of 2012 (Table 1). In addressing 'adaptation measures' for climate change it should be noted, that current practices provide a high level of 'adaptive management' to address inter-annual variability in flows through:

- Using the historic record in developing the operating plans;[49]
- Management of the additional storage through the NTSA, and
- Flexibility accounted for in the supplementary agreements to the Treaty.

This detailed coordination and planning between Canada and the U.S. would be eliminated with the termination of the Treaty.

Consideration of climate change concerns should not be limited to hydraulic variability within the Columbia system. If choices are made that require the development of new firm energy sources, such as gas fired generation, then consideration should be given to the added effect on green-house gas emissions of producing this energy.

Impact on Costs

All the alternatives modelled for the Columbia system have a negative effect on revenues (Table 4). In the case of Treaty Continuation the potential impact on the value of power ranges from -22 to -181 $ million/year. The latter being when a minimum drawdown level constrains the Kinbasket reservoir during the winter.

The impact to costs on revenues under the Treaty Terminate scenario ranges from -180 $M/yr for the Keep Arrow Lakes High alternative to -456 $M/yr under the Ecosystem Alternative. These large losses are in part due to the loss of the Canadian Entitlement to downstream power benefits which is estimated at approximately $100-200 million/year. Under the operating alternatives explored, this can be partially mitigated by greater flexibility and maintaining reservoir levels higher to generate an

[49] Section 2.5

additional $10-20 million/year through operational benefits at Keenleyside and Mica dams if Arrow Lakes is kept high.

4.3 To Terminate or not to Terminate; that is the question?

This is the question facing decision makers and which the Treaty Review process is asking the people of the Columbia Basin to consider. Under the treaty terminate scenario there is greater flexibility to operate the system. However, even with greater flexibility to operate the system there is no perfect way to operate the facilities to improve all the interests.

Under the Treaty choices made at Arrow Lakes will have an impact on Kinbasket and *visa versa*. Simply put if Arrows is kept low in the spring Kinbasket would need to be higher. This is needed to maintain the border flows required under the Treaty. With Treaty Termination the strength of this linkage is diminished. Arrow Lake reservoir levels can change without the same impact to Kinbasket. Thus Arrow could be operated for other interests.

***Key Message 1*: With Treaty Termination, Arrow Lakes operational choices become less linked to choices made at Kinbasket.**

The generating facilities at Mica and Revelstoke represent significant contributions to the provinces generating capacity. In either scenario constraining operations at Kinbasket for other interests comes at a high cost to power and could be as much as a loss of $180 million/year if Kinbasket is kept above a minimum level. Consequently, while the Treaty Terminate scenario offers more potential to address recreational and other interests it does not mitigate the costs associated with constraining operations at Kinbasket.

***Key Message 2:* Operating constraints on Kinbasket reservoir will have the highest costs, and potentially increased GHG if thermal generation is needed to replace the loss of firm energy.**

In general, value trade-offs at Arrow Lakes Reservoir will remain regardless of the Treaty's future. The current preferred levels for wildlife and vegetation interests in the Mid-Columbia conflict with the kokanee spawning levels in the fall. However, it is possible that a more stable operating regime could meet both wildlife and vegetation goals as well as those for kokanee spawning. Trade-offs would nevertheless remain between other interests around the lake such as recreation and downstream interests including fisheries and flood control.

In examining alternatives under the treaty continue scenario the current system of operation provides a balance of the many interests in comparison to other alternatives which favour either wildlife and vegetation in the Mid-Columbia or higher levels in Arrow Lakes for kokanee. That the current operating scenario performs well should come as no surprise. Extensive examination was given to developing the current operating alternative under the Columbia River Treaty in the Columbia WUP which meets the soft constraints for Arrow Lakes (Table 2 of section 2.3)

Key Message 3: **Operations at Arrow Lakes will have trade-offs under any scenario. Benefits to vegetation, bird and wildlife benefits in the Mid-Columbia River are at odds with recreation, flood control, power generation at Hugh Keenleyside and potentially kokanee access to tributaries.**

The alternative that best meets the Arrow Lakes 'soft constraints' is the current operating alternative.

The Treaty Terminate scenario provides for greater flexibility introducing the possibility of new operating alternatives with new and different trade-offs. For example under the Treaty BC Hydro is able to provide whitefish spawning flows between January and June, however this results in higher Arrow reservoir levels in the spring which can impact wildlife and vegetation in the Mid-Columbia River. This effect could be diminished under the Treaty Terminate scenario as prescribed border flows would not need to be met. Nevertheless, the additional flexibility creates other potential ways to operate for fisheries below Hugh Keenlyside dam witch create different trade-offs between the reservoir and downstream interests.

During the consultation in March 2013, it was proposed that under a stable Arrows Lake (or Ecosystem alternative) there could be a filling of the reservoir to meet flood control protection in early spring and then a quick drafting (with 2 weeks) to meet nesting objectives and at the same time provide a wetland function. This however, would require high discharges of 200 kcfs which would cause flood damage downstream. Indeed, while the full storage potential of Arrow Lakes could be used in high water years, more studies are needed to specifically understand the risk to downstream communities.

Key Message 4: **Terminating the Treaty will open up new operating alternatives for the Columbia River facilities, and create new trade-offs, particularly between Arrow Lakes and the Lower Columbia River. While these can be somewhat mitigated, as shown in the Ecosystem alternative, they come at a large cost in lost power revenue and potentially higher flood risk.**

The Treaty Terminate scenario does not mean that there are 'no constraints' on Canadian operations. There are both physical and safety constraints related to operation of the facilities which have been accounted for in the modelling. 'Called Upon' flood control operation could also impact the operation of the Canadian reservoirs. The Canadian and U.S. Entities currently have differing views about the rights and obligations under 'Called Upon" flood control and thus its impacts are not entirely clear.[50]

Key Message 5: **Even under the Treaty Terminate scenario there are constraints to operating the facilities on the Columbia River.**

[50] BC Hydro, *Canadian Entity View of Columbia River Post-2024 Called Upon Procedure.* February 14, 2013 http://blog.gov.bc.ca/columbiarivertreaty/files/2012/07/130214-CanadianEntity_View_CRT_Post-2024_CU-FINAL4.pdf

Key Message 6: **Regardless of whether the CRT continues in its present form or is terminated the flood control regime will switch to "Called Upon" flood control and will likely impact operations at Libby.**

On the Kootenay system fish and aquatic ecosystem health, and recreation interests on Koocanusa are at odds with wildlife and vegetation interests in the reservoir. Deeper drafting of Libby in the spring significantly enhances wildlife and vegetation and aquatic resources below Cora Linn as well providing better flood control for Kootenay Lake. However, it is significantly worse for fish and recreation on Koocanusa reservoir.

Key Message 7: **Deeper spring drafts at Libby over current operations improves some Canadian interests while worsens others.**

There are potential changes to operations at Libby that could be made to improve a wide range of Canadian interests, such as energy production, reducing flood risk in Kootenay Lake, and increasing kokanee angling in Koocanusa, with minor impact to other interests. However these changes would unlikely meet U.S. regulations for fish.

Key Message 8: **While benefits to Canada could be achieved by different operations at Libby they are unlikely to meet U.S. regulations for fish in US waters.**

Coordination of Libby dam between the U.S. and Canada will continue for the useful life of the dam. Despite the apparent limited potential for changes to operations at Libby, the Columbia River Treaty Review opens up the possibility to include Libby operations in further discussions of the system as a whole providing insight into what might constitute a 'Treaty-Plus' scenario.

While Duncan Dam alternatives were not specifically modelled in this study it was discussed in terms of different possibilities including removal of the dam or adding a generating facility. A Kootenay ecosystem alternative could possibly be developed, however, only Duncan would be fully within Canadian control in a Treaty Terminate scenario. An ecosystem alternative for Duncan would likely involve releasing more water in the spring which may increase flood risk in Kootenay Lake and further downstream.

4.4 Treaty Plus Scenario

In a Treaty Plus scenario it is possible to imagine that the major benefits that Canada and the U.S. enjoy from cooperation under the Treaty could be preserved while allowing for more environmental and social interests to be addressed.

At this stage modelling this scenario is not possible as there are too many uncertainties in terms of what the U.S. interests are and what might be mutually agreed to. Nevertheless, the modelling conducted under the Treaty Continue and Treaty Terminate scenarios show the bookends of possibilities that can help inform potential discussions around a Treaty-Plus scenario.

Furthermore, a Treaty-Plus scenario could potentially address the Columbia and Kootenay system as a whole to further advance a number of environmental and social issues, and re-evaluate mutual

benefits between the U.S. and Canada. This however does not suggest that local and system wide trade-offs could be avoided, but rather that the Treaty Review could provide an opportunity to reassess benefits in terms of current social, economic and environmental interests.

4.5 Concluding thoughts

The purpose of this paper is to help forward discussions around whether or not there are greater benefits for Canada to terminate the Treaty, continue it in its current state, or continue it with some modifications.

Since the treaty does provide flexibility for Canada to make domestic decisions (section 2.5), the key question is whether there are social/environmental benefits that cannot be achieved under the Treaty that outweigh the benefits of maintaining the Treaty.

If the answer to this is 'yes', then we need to ask if these environmental and social values could be accommodated under a Treaty Plus scenario. If not then the option would be to terminate the Treaty.

In thinking about power benefits it is important to remember that any alternatives that significantly reduce the production of firm energy from the Columbia system will require the replacement of firm energy from another source. These other sources will have cost implications as well environmental impacts associated with them.

Ultimately, the decision to terminate or continue the Columbia River Treaty will come down to value trade-offs between possible future options. The work of the Review Team is to inform and engage the communities in the Columbia Basin around the Treaty. In this way decision-makers can make future decisions in the most informed manner possible.