FISH AND WILDLIFE
COMPENSATION PROGRAM

PEACE BASIN

RESERVOIRS ACTION PLAN

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Peace Reservoirs Action Plan

1. Introduction

The Fish and Wildlife Compensation Program (FWCP) is a partnership between BC Hydro, the Province of British Columbia and Fisheries and Oceans Canada, First Nations and local communities and groups to conserve and enhance fish, wildlife and their supporting habitats affected by the creation of BC Hydro owned and operated generation facilities in the Coastal, Columbia and Peace regions of British Columbia. The FWCP program in the Peace region (see Figure 1) was initiated in 1988 and has been investing in fish and wildlife initiatives ever since.

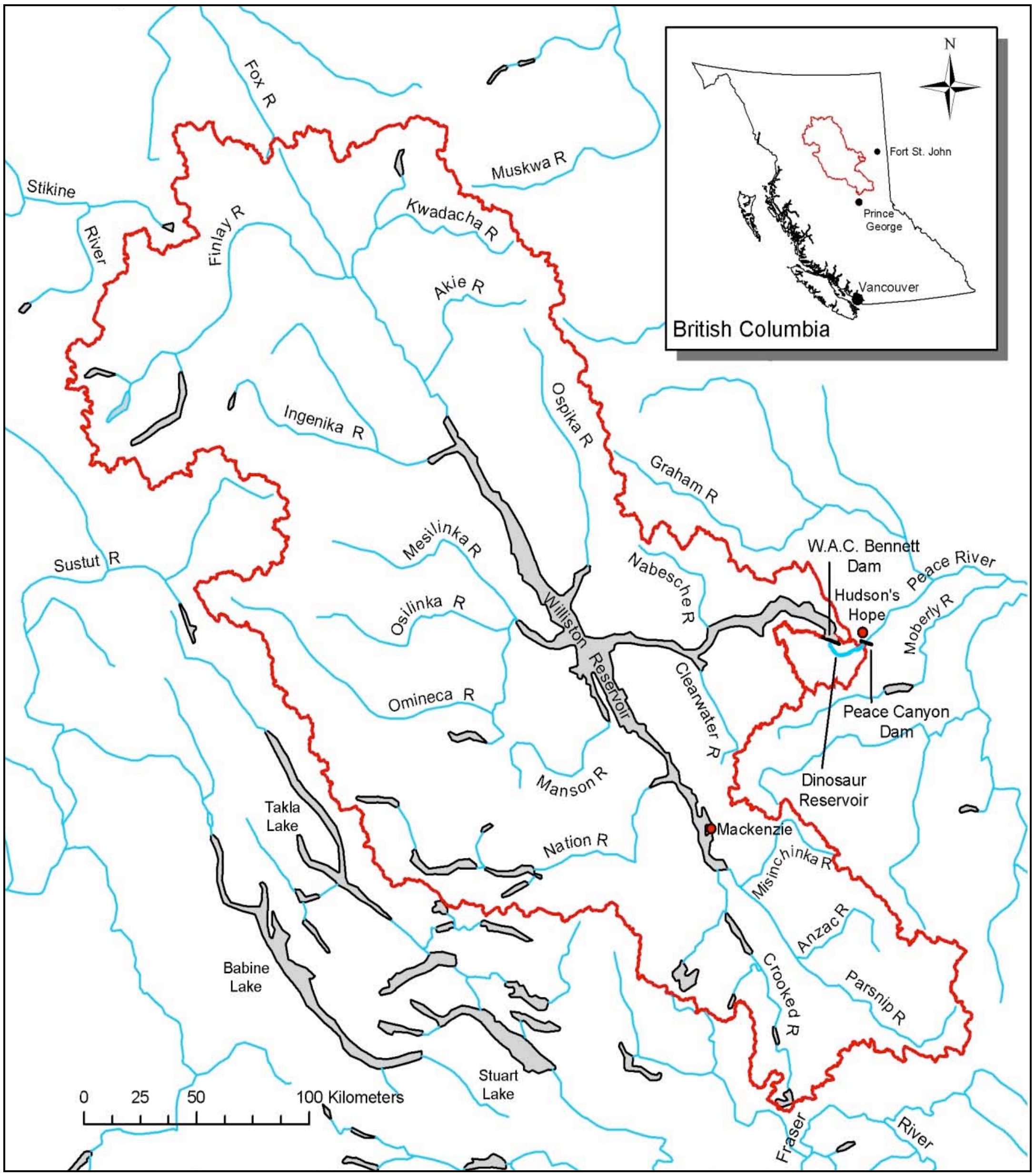

Figure 1. The Upper Peace Basin and FWCP-Peace Program Area

The FWCP developed a strategic framework that guides overall planning for compensation investments (MacDonald 2009). The framework has guided the development of strategic plans for each basin within the FWCP program area, which are in turn informing action plans that focus on specific priorities within each basin (Figure 2).

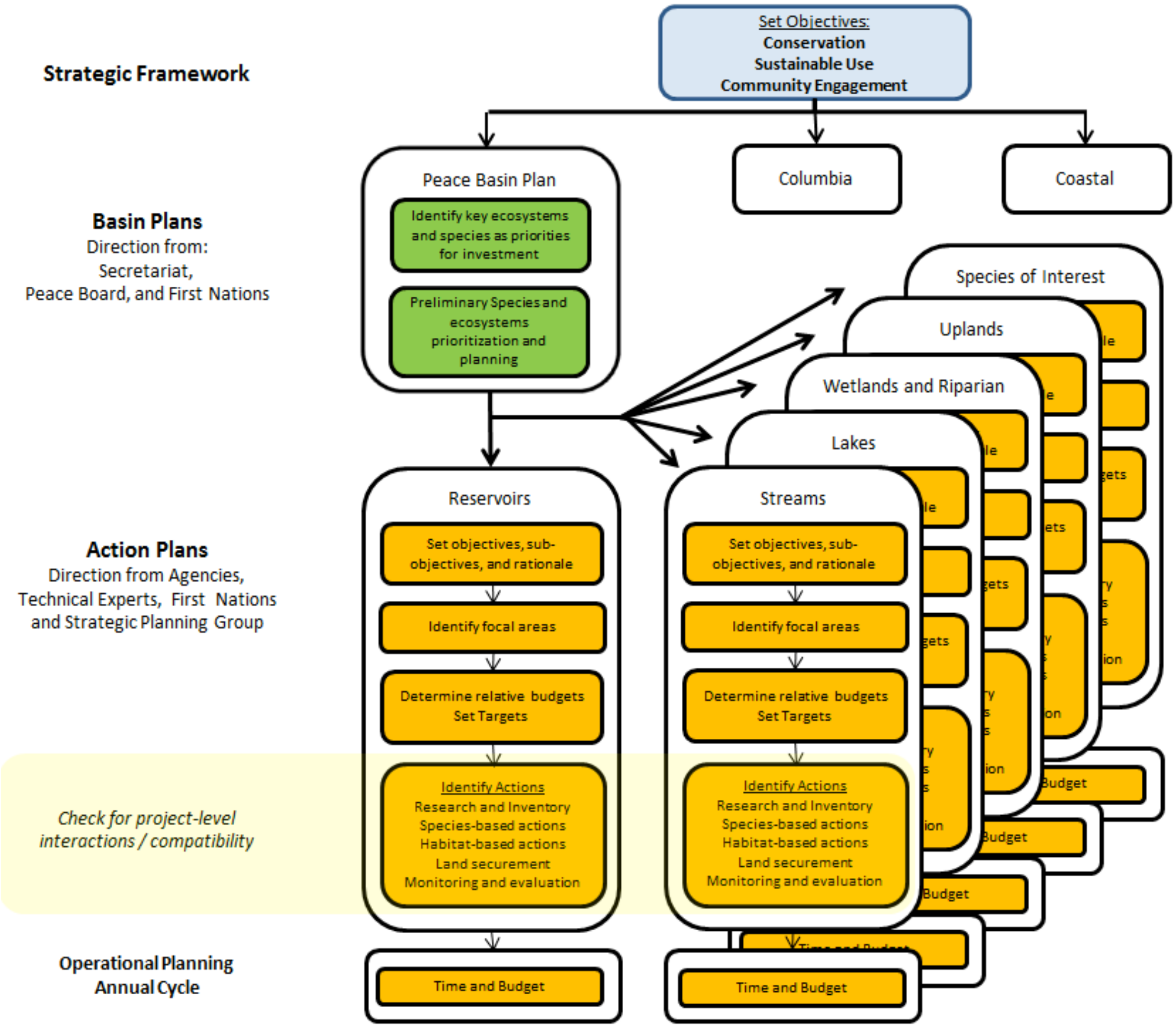

Figure 2. Relationship between the Reservoirs Action Plan and higher level planning and objectives

This Reservoirs Action Plan sets out priorities for the Fish and Wildlife Compensation Program to guide projects within the Peace region program area (Figure 1). Williston Reservoir has a large annual drawdown and Dinosaur Reservoir has fast throughput of water, making both reservoirs very different ecologically relative to natural lakes in the region. The Reservoirs Action Plan builds on the FWCP's strategic objectives and the FWCP-Peace Basin Plan (Fish and Wildlife Compensation Program, 2013). Action Plans have also been developed for Riparian and Wetlands, Uplands, Species of Interest, Streams, and Lakes[1]; some actions are complementary across the different plans (Note. The Lakes Action Plan focuses on natural lakes within the program area).

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[1] All of the FWCP Plans are available at: http://www.bchydro.com/about/sustainability/environmental_responsibility/compensation_programs.html

The Reservoirs Action Plan addresses the Williston and Dinosaur reservoirs. Williston Reservoir is ~140 km north of Prince George, BC. It is the largest reservoir in BC, the seventh largest in the world by volume, and has a surface area of 1,779 km^2. W.A.C. Bennett Dam was constructed between 1961 and 1968. The Peace Canyon Dam, 23 km downstream of W.A.C. Bennett Dam, was constructed in 1980 and impounds the ~8 km^2 Dinosaur Reservoir.

Early efforts by FWCP-Peace addressed dam-related impacts by focussing mainly on studies of production capacity of Williston Reservoir. This work determined that the reservoir is an ultra-oligotrophic system (Harris *et al.* 2006, Wilson and Langston 2000). A literature review and interview program revealed that most productivity enhancements would be too costly, due to the large size, low productivity, frequent flushing, and lack of effective littoral zone. In addition, several inventory surveys have collected information on fish abundances and biomass, sizes, densities, distribution, and trends in species assemblages (e.g., Johnson and Yesaki 1989; Blackman 1992; Pillipow and Langston 2002). French (1999) provided a summary of data sources for fish and fish habitat, benthos, and water quality information collected between 1959 and 1998. Some creel surveys have been conducted, but evaluations of angler use and preferences are no longer current (e.g., Blackman and Newsholme 1993).

In Dinosaur Reservoir, past work has demonstrated that local fish recruitment is limited by low productivity, entrainment, and poor littoral habitat quality. Previous studies recommended that enhancement efforts focus on improving spawning habitat in tributaries (e.g., Johnson and Gething creeks) rather than habitat within the reservoir (Pattenden and Ash 1993a). However, the addition of large woody debris (LWD) structures to the littoral zone was completed in 2002 in an attempt to improve fish habitat in the reservoir (Murphy *et al.* 2004), and there is some evidence that fish numbers are greater in these enhanced areas (Blackman and Cowie 2005). Baseline fish population information was collected in preparation for additional enhancement activities (Blackman *et al.* 2004; Murphy *et al.* 2004). Creel surveys conducted between 1984 and 1988 revealed that hatchery stock Rainbow Trout accounted for the majority of catch by anglers (Pattenden and Ash 1993b).

During public consultations for development of FWCP-Peace Action Plans, reservoir habitats were consistently ranked among the aquatic habitats of least concern and interest in comparison to streams and natural lakes. Current evidence indicates that opportunities for cost-effective habitat enhancement in Williston and Dinosaur reservoirs are limited[2]. There are, however, some useful reservoir-based activities for the FWCP-Peace program to invest in and they are described and explained in this plan.

The actions and priorities described in this action plan have been developed with input from the BC Ministry of Environment (MOE), BC Ministry of Forests, Lands and Natural Resource Operations (FLNRO), BC Hydro, First Nations and local stakeholders. It is important to understand, however, that planning priorities within action plans may not translate immediately into funded projects. Limited program funding requires that priority-setting has to also be developed across the program as a whole, not just within action plans. The process of selecting which actions will be implemented in any given year will occur during the annual implementation planning cycle.

This Action Plan proposes objectives and actions mostly focused on improving reservoir habitat conditions in the Peace Basin, in the context of the Fish and Wildlife Compensation Plan’s (FWCP) strategic framework. Feedback received during development of the Action Plans indicated that reservoir habitats are of generally lower priority for FWCP investment than aquatic habitats in streams and natural lakes.

[2] Reservoir nutrient restoration programs, such as those on Kootenay Lake and Arrow Lakes Reservoir (FWCP-Columbia region), are not financially and technically feasible for Williston and Dinosaur reservoirs.

2. Overview Context

2.1 Williston Reservoir

2.1.1 Impacts and Threats

Background — Williston Reservoir is made up of Finlay Reach to the north, Parsnip Reach to the south, and the Peace Reach extending east through the Rocky Mountains (**Figure 1**). The reservoir covers approximately 1,779 km^2 at full pool, has 1,770 km of shoreline, and has a licenced operating range of about 30 m (Environmental Services 1988; Stockner *et al.* 2001). The Peace Reach has a V-shaped basin and is much narrower and deeper than the Finlay and Parsnip reaches. Steep sloped sedimentary rock is most common in the western half of the Peace Reach. The eastern half of the Peace is lower gradient and has similar topography to the Finlay and Parsnip reaches (Stockner *et al.* 2001).

The Williston watershed has a harsh continental climate regime with long, cold winters. Ice forms on the reservoir as early as November, with complete coverage typically occurring by January. However, ice cover may be delayed or incomplete in warmer winters. Ice cover normally persists until the first week of May. Williston Reservoir has a dimictic circulation pattern, characterized by two distinct periods of deep-mixing: one in spring and another in late autumn. The onset of thermal stratification usually occurs in most basins of Williston by late May or early June, and typically lasts until late October or early November. Stratification is weakest and shortest in duration in the shallow Finlay and Parsnip reaches and strongest and longest in the much deeper Peace Reach (Stockner *et al.* 2001).

The mean depth of the reservoir is 44 m, and the maximum depth is 166 m (BC Research 1977). The reported average residence time of water in the reservoir ranges from 19 months (Hirst 1991) to 2.2 years (Fleming *et al.* 1991, unpublished data). The reservoir receives and stores most of its water from snowmelt during late May and early June (Stockner *et al.* 2001). The reservoir cycles between maximum and minimum water levels once per year, and typically reaches its maximum water level in August and September. During the winter, increased discharge and low inflow result in large drawdowns, averaging 11 m, with lowest water levels typically occurring in April or early May (Hirst 1991).

Hydro-related Impacts — The creation of Williston Reservoir resulted in large-scale habitat change, including a reduction of river and natural lake habitat and an increase in reservoir habitat. In general, this change has favoured some lake-dwelling species and impacted stream species (Blackman *et al.* 1990). Changes in aquatic species abundance, distribution and assemblages have likely influenced inter-specific competition and prey availability, which has had a positive effect on some species and a negative effect on others (Beauchamp *et al.* 1995). For example, water level fluctuations have reduced the productivity of littoral habitat, and the food supply for species that rely on this habitat, such as lake whitefish (Blackman *et al.* 1990). On the other hand, an increase in pelagic area and stocking of Kokanee that thrive in this habitat may have increased abundance of large predators like Lake Trout.

Overall, the impact on fish populations from hydropower-related habitat changes in the Williston Reservoir is not well understood, and changes are likely still occurring. Some FWCP-Peace efforts have been initiated to address these knowledge gaps, but they have been limited by difficulties associated with monitoring fish (e.g., Kokanee) population sizes, structure, and trends in the large reservoir.

Non-Hydro Impacts — Poor land and water use practices from logging, oil and gas activities, mining, pipelines, transmission lines, railways and roads can all adversely affect fish habitat (Doyle and Havlick 2009). In the Williston Basin, these activities may have resulted in habitat loss and degradation, such as siltation of streambeds, which reduces egg survival, food production and habitat suitability for fish. Loss of streambank vegetation can lead to reduced habitat quality from increased water temperatures, reduced cover, reduced nutrient input for food production, reduced bank stability, and increased water velocities due to loss of stream complexity (Wesche *et al.* 1987). This may negatively impact reservoir species that use stream habitats for part of their life cycle (e.g., Bull Trout). Highly sought-after game fish (e.g., Rainbow Trout) are vulnerable to overharvesting (Fausch 2007), and longer-lived, top-predatory species (e.g., Lake Trout) are vulnerable to pollution (e.g., Luxon et al*.* 1987). The construction of reservoirs enabled incremental industrial development in the watershed (e.g., through better access routes) and thereby contributed both directly and indirectly to cumulative impacts.

Non-native species (e.g., Kokanee, Brook Trout) have been introduced and native species (e.g., Rainbow Trout) have been stocked in Dinosaur Reservoir and in lakes connected to Williston Reservoir. Some natural populations may have migrated from nearby lakes and established populations in the reservoir (Langston and Murphy 2008). Hybridization, competition, and predation can negatively impact naturally-occurring species and populations (Beauchamp *et al.* 1995).

2.1.2 Limiting Factors

Limiting factors for fish include natural and human-induced aspects and likely vary among species and trophic levels. Since its creation, Williston Reservoir has become a low productivity (oligotrophic) system (Harris *et al.* 2005). Other limiting factors for fish likely include habitat quantity and quality, access to habitats (i.e., passage between reservoir and tributary habitats), and predation (Sebastian *et al.* 2009).

Overall productivity within Williston Reservoir is limited by nutrient levels. The flooding of approximately 1,700 km^2 of a minimally harvested forested area created a sudden, large release of nutrients to the reservoir, which resulted in artificially high production levels during the first 5-10 yrs. However, the nutrient pulse from inundated landscapes was finite, and after 15-25 years the reservoir consumed most of these nutrients, notably phosphorus (P), via sedimentation and outflow (Stockner *et al.* 2000). "New" reservoirs typically reach equilibrium with nutrient input/output in 20 to 30 yrs. Nutrient data from the recent FWCP-Peace monitoring program in the early 2000s suggested that equilibrium conditions had been reached, with some consistency in annual nutrient input/output, sedimentation and discharge (Stockner 2001).

The reservoir forgoes large amounts of biogenic carbon production, relative to a stable lake of the same size, due to a non-functional littoral zone. Over time, repeated drawdown reduces the quality and productivity of littoral habitat, resulting in lower habitat suitability, poor productivity food input, and restricted connectivity between the reservoir and its tributaries.

2.1.3 Trends and Knowledge Status

Habitat Trends — Both the quantity and quality of aquatic habitat have changed markedly from historical levels due to hydropower development. The most notable effect is a decline in aquatic productivity on a per area basis. In addition, water level fluctuations have resulted in decreases in littoral habitat quality, availability, and productivity by severely limiting aquatic vegetation establishment and invertebrate production (Blackman 1992). Less obvious habitat changes from this development include effects to seasonal flow regimes and water levels, water temperatures, water quality, and potential shifts in the food web and competitive/predatory species interactions (Sebastian *et al.* 2009).

Stock Trends — Since the creation of Williston Reservoir, fish population trends have mirrored a pattern typical of new reservoirs: large increases in abundance occur initially, followed by decreases and eventual stabilization of a fish community. Species composition has changed from a community dominated by riverine species to one dominated by lacustrine species. Lacustrine species assemblages may also shift towards planktivores and piscivores rather than insectivores whose food source is limited by degraded littoral habitats (Blackman 1992).

Arctic Grayling – Arctic Grayling in the "South Beringia lineage," which includes the FWCP-Peace area, are not at risk. Historically, Arctic Grayling were found throughout the Peace, Finlay, and Parsnip watersheds and used both mainstem and tributary habitats. They typically do not use the reservoir habitat and have disappeared from a number of tributaries, especially in the Peace reach where stocks were likely dependent on the mainstem river or portions of tributaries that were flooded (Clarke *et al.* 2005, 2007a, b). Arctic Grayling were abundant after the reservoir was built, but the population declined and in the mid-1970s, Arctic Grayling accounted for only 1.5% of fish captured in Parsnip River tributaries and 4.1% of fish captured in the mainstem (Blackman 2001). Since 1988, Arctic Grayling have essentially disappeared from the reservoir.

Bull Trout – Currently, specific data on Bull Trout trends within the Williston Reservoir are limited. Prior to hydro-electric development of the Peace River, stream resident and fluvial Bull Trout populations were distributed throughout the majority of the entire upper Peace, Finlay, and Parsnip watersheds (Bruce and Starr 1985). They are now found in a significant number of tributaries and there is ample anecdotal evidence of popular fisheries at river mouths and embayment areas (Ted Down, MOE, personal communication).

Kokanee – Two native Kokanee populations occur in headwater lakes in the Finlay (Thutade Lake) and Parsnip (Arctic Lake) drainages (Langston and Zemlak 1998). Kokanee were found in Williston Reservoir prior to introduction of Columbia Basin Kokanee in 1990 (see below). Maturing Kokanee were found in significant numbers in the Finlay River (Fielden 1991, 1992) suggesting that they originated from the Thutade Lake stock. These fish did not develop the bright red spawning colour commonly displayed by the stocked Kokanee. The dull spawning colours observed in these fish are typical for shore-spawning Kokanee stocks. Despite being found in the reservoir and the Finlay River, the native Kokanee were apparently unsuccessful at colonizing these areas, perhaps because they are shore spawning stocks and cannot spawn effectively in a reservoir with a deep drawdown or its tributary streams.

Stream-spawning Kokanee from Arrow Reservoir (Hill Creek) and Kootenay Lake (Meadow Creek) were stocked extensively in tributaries of Williston Reservoir from 1990 to 2005 (2005 cumulative total of 1.7 million in tributaries to the Peace reach; 2.1 million in tributaries of the Parsnip reach; and 75,000 in the Finlay reach) (Langston and Murphy 2008). Reservoir creation has favoured Kokanee populations as they are a pelagic lake-dwelling species (Euchner 2011).

Since their introduction in the mid-1990s, Kokanee have been gradually increasing in abundance, and they have recently overtaken Lake Whitefish as the most abundant species in Williston Reservoir. It has been predicted that Kokanee numbers would continue to increase due to favourable conditions in the reservoir (Sebastian *et al.* 2009). In 2000 it was estimated that Kokanee comprised up to 14% of the pelagic fish abundance in Williston Reservoir. Captures from the Peace reach in 2008 revealed that Kokanee may comprise up to 90% of all pelagic species in this region of the reservoir. In 2000 the estimated Williston Reservoir Kokanee population was 0.8-1.3 million fish, and more recent estimates (2008) have been as high as 9 million (Sebastian *et al.* 2009).

Lake Trout – The large-scale habitat change associated with the creation of the Williston Reservoir has favoured Lake Trout (Euchner 2011). As of 2008, Lake Trout have not been stocked in the Williston Reservoir, and the source of present populations in the reservoir is thought be migration from nearby lakes (Langston and Murphy 2008). Catch studies suggest there may have been a recent increase in Lake Trout abundance, but threats including overharvesting may limit abundance (e.g., Luxon et al. 1987).

Lake Whitefish – Lake Whitefish were likely a minor component of the riverine fish community prior to reservoir creation. Lake Whitefish are now the second most abundant fish (behind Kokanee) in Williston Reservoir, with previous estimates of up to 11 million fish distributed across the Finlay, Parsnip, and Peace reaches collectively (Sebastien et al. 2003). The creation of Williston Reservoir dramatically altered Lake Whitefish habitat in the Peace/Williston region, and numbers initially increased; however, recent surveys in the Peace Reach found that Lake Whitefish abundance declined from 2000-08.

Mountain Whitefish – Mountain Whitefish were likely the most abundant and had the greatest biomass within the riverine fish community prior to reservoir creation. Mountain Whitefish abundance has declined as a result of reservoir creation, likely due to loss of benthic invertebrate and larval insect habitat. Prior to hydropower development of the Peace River, stream resident and/or fluvial mountain whitefish populations were likely distributed throughout the majority of the entire upper Peace, Finlay, and Parsnip watersheds. Currently, mountain whitefish spawners are common in the tributaries of Williston Reservoir. Trends in lacustrine or adfluvial forms within the reservoir indicate an overall decline of this species, with very low numbers reported since 1975 (Blackman 1992).

Rainbow Trout – Rainbow Trout have declined in dam-affected waterbodies since the creation of the reservoir. Overall, Rainbow Trout make up a small proportion of pelagic fish abundance in Williston Reservoir (Blackman 1992). Rainbow Trout are not abundant in Williston basin rivers, and the river-resident form declined between 1974-75 and 1988 (Blackman *et al.* 1990). Older age classes of lake-resident Rainbow Trout have declined in the Peace Reach between 2000 and 2008, possibly due to overfishing (Sebastian *et al.* 2009). Currently, specific data on Rainbow Trout distributions within the Williston watershed are limited and recent population trends are largely unknown.

Knowledge Gaps — There have been several studies on the ecology of Williston Reservoir (e.g., Stockner and Langston 2000; Wilson and Langston 2000; Harris et al. 2006), but there remain substantial knowledge gaps, particularly with respect to important habitat (e.g., spawning locations of Lake Trout), trends in abundance of several species (e.g., Bull Trout, Rainbow Trout), and the understanding of ecological impacts of the shifts in species compositions that accompanied reservoir creation. There is a need to synthesize existing data, clearly identify knowledge gaps, and use this to inform the framework of future actions. This information is important for informing fisheries management decisions with respect to compensation efforts.

2.2 Dinosaur Reservoir

2.2.1 Impacts and Threats

Background — Peace Canyon Dam was constructed in 1979, 23 km downstream of W.A.C. Bennett Dam and created Dinosaur Reservoir. This narrow, steep-sided reservoir impounds 805 ha of water in bedrock canyon extending to the W.A.C. Bennett Dam tailrace. It forms a run-of-river reservoir with a three-day water retention period and has minimal water level fluctuations (<2 m) under normal operating conditions (Pattenden and Ash 1993a; Murphy and Blackman 2004). The mean and maximum depths of the reservoir are 53.2 m and 200 m, respectively (Hammond 1984). Dinosaur Reservoir has low productivity, limited littoral zone, and a small amount of accessible tributary habitat (Pattenden and Ash 1993a; Euchner 2011).

Oxygen, temperature and nutrient regimes are related to water releases from W.A.C. Bennett Dam, which occur from the depths (i.e., hypolimnion) of the Williston Reservoir. Dissolved oxygen levels are close to saturation and the temperature remains fairly constant (i.e., isothermal) throughout the year. Thermal stratification does not occur. Discharged water temperatures from Peace Canyon Dam normally range between 4°C and 14°C (Pattenden 1992), and temperatures are >10°C only from mid-July to early November (Pattenden and Ash 1993a).

Hydro-related Impacts — Much like the Williston Reservoir, the creation of the Dinosaur Reservoir resulted in large-scale habitat change, due to the reduction in river habitat and increase in reservoir habitat. The fish community has changed in response to this shift, and due to recruitment of fish into Dinosaur Reservoir from entrainment at W.A.C. Bennet Dam (Euchner 2011). Fish entrainment at Peace Canyon Dam is thought to be a major factor limiting fish abundance within Dinosaur Reservoir (Pattenden and Ash 1993a).

***Non-Hydro Impacts* —** Logging activity has resulted in siltation and subsequent degradation of spawning and rearing habitat in tributaries to Dinosaur Reservoir (AIM Ecological Consultants Ltd. 2000). Of the five tributaries entering Dinosaur Reservoir, only two creeks provide spawning and rearing areas for fish. Johnson Creek is the primary spawning habitat for Rainbow Trout. It has a small watershed and its banks are prone to erosion; spawning and rearing habitat quality in the creek is limited by fluctuating sediment loads, turbidity and flow, as well as siltation of interstitial spaces, substrate compaction, and movement of suitable gravel within the creek. Gething Creek is the primary spawning habitat for Bull Trout (Hammond 1987), but it is mostly not suitable for spawning and rearing. Other tributaries entering Dinosaur Reservoir (Moosebar, Starfish, and Mogul creeks and an artificial drainage channel near Bullrun Flats) have limited spawning and rearing habitat due to intermittent flow and barriers to fish migration (Pattenden and Ash 1993a).

2.2.2 Limiting Factors

The steep topography, short water retention time, and fluctuating water levels in Dinosaur Reservoir limit reservoir productivity and the quantity of suitable rearing habitat. Due to limited spawning habitat within the Dinosaur Basin, competition may also be a limiting factor for some species.

The littoral zone of Dinosaur Reservoir is limited by steep topography. This results in minimal benthic invertebrate production and minimal aquatic vegetation, which in turn limits food and rearing habitat for fish (Pattenden and Ash 1993 #72, AIM 2000). Planktivores in Dinosaur Reservoir, such as Rainbow Trout, Lake Whitefish and Kokanee, consume mainly large zooplankton during the summer. Since the short water retention time of the reservoir limits zookplankton production, sources of this food are mainly inputs from Williston Reservoir (Pattenden and Ash 1993a). When the W.A.C. Bennett Dam spillway is operational there is a substantial increase in zooplankton density (Hammond 1986); however, the spillway is rarely used. Abundance and growth of Rainbow Trout are likely limited by the quantity of zooplankton in the reservoir (Pattenden and Ash 1993a).

The bathymetry of Dinosaur Reservoir is very steep, so spawning and littoral rearing habitat is limited. Only short sections (500 – 600 m) of two tributaries provide stream spawning and rearing habitat for fish. The current habitat conditions in these creeks are unknown; however, previous studies have indicated that siltation and compaction of spawning gravels severely limits habitat quality in Johnston Creek (Hammond 1987) and poor substrate and canyon morphology limit habitat quality in Gething Creek. Competition with other species (e.g., Longnose Suckers, Slimy Sculpins) may limit spawning and rearing success of trout through physical displacement of spawners, redd disruption, competition for food and predation (Pattenden and Ash 1993a).

Entrainment of fish through the W.A.C. Bennett and Peace Canyon dams is thought to be another factor constraining fish abundance within Dinosaur Reservoir. Williston Reservoir is the source of most fish in Dinosaur Reservoir (e.g., Lake Trout, Lake Whitefish) (Pattenden and Ash 1993a), and these individuals may be subsequently entrained through the Peace Canyon Dam.

2.2.3 Trends and Knowledge Status

***Habitat Trends* —** The physical habitat conditions of the area have changed dramatically as a result of reservoir creation. Dinosaur Reservoir flooded previously low-gradient sections of the Peace River tributaries that originally provided spawning and rearing habitat for fish, and flooded riparian areas adjacent to the tributaries that were important for food production and rearing habitat for some species (AIM Ecological Consultants Ltd. 2000). In addition to decreases in aquatic productivity, hydroelectric development has led to changes in water temperatures, water quality, and likely shifts in the food web and competitive/predatory species interactions.

In 2002 and 2003, a FWCP-Peace program initiated additions of large woody debris to sheltered bays of the reservoir in an attempt to improve littoral rearing habitat conditions for fish. Fish numbers were almost five times higher in woody debris vs. control sites during 2004 monitoring, with Bull Trout and Mountain Whitefish showing an especially high affinity for enhanced sites (Blackman and Cowie 2005). It's not clear whether overall fish productivity improved or if fish were simply attracted to these new structures.

Stock Trends — Pre- and post-impoundment creel surveys provide an indication of shifts in species abundances and assemblages as a result of reservoir creation. For example, pre-impoundment capture abundances were as follows: Rainbow Trout (36%), Lake Whitefish (29%), Mountain Whitefish (14%), Bull Trout (5%), Arctic Grayling (4%), and Northern Pike (2%). Previous studies showed Rainbow Trout and Mountain Whitefish to be the two most abundant species in the reservoir (Hirst 1991). Based on this sampling, the total population estimate of fish in the reservoir was 186,000 (Murphy *et al.* 2004). Mountain Whitefish are believed to be not common at present (Ted Down, MOE, personal communication).

Arctic Grayling – Small numbers of Arctic Grayling were present during sampling in the 1980s, shortly after impoundment. Numbers have likely declined since the reservoir was created due to the lack of suitable riverine spawning and rearing habitat (Pattenden and Ash 1993a). No Arctic Grayling were captured during fish sampling in more recent years (Blackman *et al.* 2004; Murphy and Blackman 2004; Murphy *et al.* 2004; Blackman and Cowie 2005).

Bull Trout – A small population of Bull trout occurs in Dinosaur Reservoir (Pattenden and Ash 1993a), but trends are unknown. It is unclear whether the fish, which primarily use Gething Creek for spawning, represent the original stock or are regularly supplemented by entrainment from Williston.

Kokanee – Small numbers of Kokanee occur in Dinosaur Reservoir, resulting from upstream entrainment, but numbers have not increased significantly since they were first encountered in 1984 (Pattenden and Ash 1993a; Murphy *et al.* 2004).

Lake Trout –Lake Trout have not been stocked in Dinosaur Reservoir, and the source of present populations in the reservoirs is thought be entrainment from Williston Reservoir (Pattenden and Ash 1993a). Some concerns have been expressed that Lake Trout are having a negative effect on Bull Trout in Dinosaur Reservoir; however, very limited information exists on the trends and habitat of Lake Trout here (Euchner 2006).

Lake Whitefish – Limited information is available for Lake Whitefish in Dinosaur Reservoir. In the late 1980s they were thought to be the second most abundant species in the reservoir. The population is likely maintained by entrainment from the Williston Reservoir (Pattenden and Ash 1993a).

Mountain Whitefish – Mountain Whitefish are the second most abundant species in the reservoir (behind Rainbow Trout), and represented 19% of the catch in a 2002 study (Murphy *et al.* 2004). Mountain Whitefish abundances have likely declined since the reservoir was created (Pattenden and Ash 1993a).

Rainbow Trout – Rainbow Trout are the most abundant species in Dinosaur Reservoir, and represented 41% of the catch in a 2002 study (Murphy *et al.* 2004). Extensive stocking of rainbow trout has occurred (Pattenden and Ash 1993a). Initially, stock was obtained from Johnson Creek, a tributary to the reservoir and from Blackwater Creek in the Parsnip River drainage. However, since 1988, non-native Tunkwa (near Kamloops, BC) Rainbow Trout have been stocked in the Dinosaur Reservoir, likely due to the difficulty in obtaining adequate stock from local sources (Pattenden and Ash 1993b).

Other species – Longnose Sucker is the predominant non-sportfish present in Dinosaur Reservoir. They, along with Lake Whitefish, made up the majority of the fish community during 1983-84 surveys, but their abundance had declined by 1986 (Hammond 1987). Current status is unknown. Northern Pikeminnow is not known to be consistently present in the reservoir; during 2002-03 sampling of littoral sites that had been enhanced with woody debris, only one Northern Pikeminnow was observed (Blackman *et al.* 2004).

Knowledge Gaps — The largest knowledge gaps are long-term abundance trends of the main fish species of interest. The historical habitat losses are generally described (Pattenden and Ash 1993a), but the direct and indirect implications for a variety of species are less well understood. There is a need to synthesize existing data, clearly identify knowledge gaps, and use this to inform future actions for FWCP-Peace.

3. Action Plan Objectives, Measures and Targets

Clear and realistic management objectives are necessary to guide information acquisition and prioritize restoration actions. Priority actions and information needs will change as improvements to the system are realized and information is gained. The current plan reflects current information and opinion collected through:

- Interviews with BC Hydro staff, First Nations community members, agency biologists and FWCP board members;
- FWCP strategic planning meetings: Strategic Planning Group, Fisheries Technical Working Group, First Nations Working Group;
- Public feedback received during three public sessions held in June 2013 and through an on-line public survey carried out through most of June; and,
- Survey of past FWCP reports and Water Use Plan program reports.

3.1 Objective and Target Setting

The following definitions are used for setting objectives in this report:

Objectives:	Objectives are high-level statements of desired future conditions (outcomes), consistent with FWCP partner mandates and policies.
Sub-objectives:	Sub-objectives are detailed statements of desired future conditions within objectives, from which status indicators can be derived and alternative management actions evaluated. They may be arranged hierarchically within objectives, and usually indicate conditions necessary to attain the objective to which they refer.
Performance Measures:	Measures are specific metrics that indicate the degree to which desired future conditions have been achieved.
Targets:	Targets are the value of the performance measure that indicates the attainment of a desired condition.
Actions:	Actions are management activities, plans or policies for achieving the objectives.

Objectives are the “ends” or the outcomes we ultimately care about. Actions are the “means,” or the things we do to achieve them. This report focuses on describing the actions required to achieve the objectives in relation to Williston and Dinosaur reservoirs. Complementary actions may also be identified in other aquatic and terrestrial Action Plans.

Current information was insufficient to establish performance measures and targets as part of the Action Plans; however, implementation of proposed actions could lead to the development of clear performance measures and targets in future iterations of the Action Plans.

3.2 Objectives and Sub-Objectives

The FWCP program has the following over-arching strategic objectives:

1. **Conservation** - Maintain or improve the status of species or ecosystems of concern

2. **Conservation** - Maintain or improve integrity and productivity of ecosystems and habitats
3. **Sustainable Use** - Maintain or improve opportunities for sustainable use, including harvesting and other uses
4. **Community Engagement** - Build and maintain relationships with stakeholders and aboriginal communities

Based on input from partners, First Nations and stakeholders, the following objectives and sub-objectives were identified for reservoir habitats in the Peace Basin.

OBJECTIVE 1. CONSERVE OR ENHANCE HIGH PRIORITY SPECIES AND HABITATS

Sub-objective 1a. Conserve native species and prevent those of concern from becoming further at-risk

Sub-objective 1b. Conserve and enhance reservoir connectivity to tributaries and between littoral and riparian

Sub-objective 1c. Conserve and enhance the productivity of aquatic habitats

Rationale – The creation of Williston and Dinosaur reservoirs resulted in a shift in species from those preferring riverine habitats (e.g., Arctic Grayling) to those adapted to large lake environments (e.g., Lake Trout). Despite a general understanding of these effects, there are significant gaps in information around the status, trends and limiting factors of high priority native species and habitats (i.e., those that have high ecosystem- and/or human use-based value) (Euchner 2011). This objective addresses overall ecosystem integrity and productivity and directs compensation activities to developing productive, useable aquatic habitats. Where cost-effective opportunities exist, compensation works will be aimed at aiding multiple fish species and habitats. Collating and reviewing existing information is regarded as a critical early step in identifying opportunities to restore or enhance native species. A better understanding of status and trends will facilitate development of feasible performance measures, targets and actions. Although species-specific sub-objectives have not been identified for reservoirs, projects may be developed for high priority native species under Sub-Objective 1a.

Habitat connectivity is important for access to spawning and rearing stream habitat (e.g., (Sheer, M.B., Steel 2006; Cloern 2007). Reservoir operation alters the frequency and magnitude of natural water level fluctuations, which can influence connectivity through build-up of sediment and debris (e.g., LWD piles) at the mouths of tributaries entering the reservoirs, and limiting vegetation establishment in near-shore areas (and subsequent plant and invertebrate food for species that use these areas). Stream connections are important for several reservoir fish species, so efforts should be directed at restoring and/or conserving access in affected areas.

Due to the large size of the reservoirs, cost-effective restoration and enhancement may not be feasible. No specific actions have been identified for conservation and enhancement of reservoir productivity at this time.

OBJECTIVE 2. IMPROVE UNDERSTANDING OF STATUS AND TRENDS OF AQUATIC ECOSYSTEM HEALTH

Sub-objective 2a. Understand the effects of Kokanee introductions on the aquatic food web

Sub-objective 2b. Monitor status and trends of aquatic ecosystem health, review results and develop specific plans in response to results

Rationale – The status and trends of many habitats and species (native and introduced) have shifted since the reservoirs were created, and a better understanding of these changes will facilitate effective enhancement. This work will require review of existing information, developing a cost-effective monitoring program, and monitoring key indicators of ecosystem health (i.e., species and/or habitats). The sub-objective related to Kokanee introductions is described in detail within this Action Plan.

OBJECTIVE 3. UNDERSTAND CONCENTRATIONS AND PATHWAYS OF MERCURY AND OTHER CONTAMINANTS RELATED TO RESERVOIR CREATION, AND SUPPORT DEFINING RISKS FOR HUMANS AND THE BROADER ECOSYSTEM

Sub-objective 3a. Improve understanding of mercury concentrations, contamination pathways, and potential effects on human health and the broader ecosystem.

Sub-objective 3b. Improve understanding of concentrations, contamination pathways, and potential effects of other contaminants directly related to reservoir creation on human health and the broader ecosystem

Rationale – This objective highlights the key concerns that local communities have around mercury contamination in fish species within the reservoir. The inundation of terrestrial areas when a reservoir is created converts inorganic mercury into methyl mercury, and ultimately results in elevated levels of mercury in the aquatic environment, especially in the first few years following reservoir creation. Mercury concentrations typically return to background levels 20-30 years later. Many local First Nations communities rely on fish species for sustenance, some of which are long-lived, top predators (e.g., Bull Trout) with a high propensity for bioaccumulation of toxins (British Columbia Ministry of Water Land and Air Protection (BCMWLAP) 2002).

There is also concern around the effects of other contaminants on humans and the broader ecosystem; however, no specific actions have been identified under this sub-objective. Note that this sub-objective relates only to contamination issues stemming <u>directly</u> from reservoir creation (e.g., mines that were inundated by the reservoirs).

OBJECTIVE 4. SUSTAIN OR ENHANCE OPPORTUNITIES FOR HUMAN USE OF FISH

Sub-objective 4a. Enhance sustenance resource uses based on input from First Nations and agency partners

Sub-objective 4b. Enhance angling based on input from First Nations, angler groups, general public and agency partners

Rationale – This objective reflects the important sustainable use benefits that can be derived from a healthy fish population. Enhancement activities in these systems should have a habitat-focus, and be developed in collaboration with agency partners, First Nations and all interested stakeholders. As additional context, it should be noted that fisheries management agencies have an overall responsibility to manage the fisheries resource at a level of abundance and distribution to support First Nations' traditional uses and rights (BC Ministry of Environment 2007). These responsibilities are dealt with through the ongoing process of decision-making, which is not a formal part of this FWCP plan. Species-based enhancements (e.g., stocking) are considered ineffective for reservoirs and are therefore not included in the Reservoirs Action Plan.

4. Action Plan

4.1 Overview

The Action Plan outlines individual actions by objective and sub-objective. Actions are assigned priorities from 1-3, based on their estimated feasibility, cost-effectiveness, and alignment with FWCP strategic objectives. The priority ratings are provided to guide investment planning efforts, but it should be noted that low priority actions are not included in the plan. The accepted proposal method is also identified for each action, and includes either 'open' proposal invitations, 'directed' contracts, or 'either'. Proponents are encouraged to develop their own proposals to address some or all components of 'open' projects; whereas, directed proposals will be developed by FWCP staff and partners and released as RFPs for proponents to bid on.

Actions are stratified into five action categories:

1. **Research and information acquisition** - actions to inventory resources or research critical effect pathways and relationships;
2. **Habitat-based actions** - actions focused on improving general habitat conditions or ecosystem function;
3. **Species-based actions** - actions that directly enhance abundance of particular species or life stages. The Reservoirs Action Plan focuses on other action categories because they are considered more effective for reservoirs;
4. **Land securement** – actions that contribute to establishment of easements or covenants or purchase of private land for conservation purposes; or,
5. **Monitoring and adaptive management** – actions that assess status and trends of key species and habitats, assess the outcomes of management actions, and develop management responses to this information.

Action categories (along with the action rationale text) provide a general guide for the sequencing of actions. In general for each sub-objective, research and information acquisition actions will occur first in sequence. Habitat- and species-based actions typically occur following prioritization and recommendations from research- and/or monitoring-based actions, and monitoring and adaptive management may occur before, during and/or after the implementation of on-the-ground actions. Land securement actions are mostly independent of other action categories, although post-securement monitoring activities may occur within an acquired area. In the tables below, the 'pre-requisite" column highlights those actions that should not be carried out until the identified preceding actions have been completed.

It should be noted that community involvement and education activities are encouraged where there are opportunities in the identified actions outlined in the Action Plans. In addition, there is a separate Stewardship and Education category (described in Section 4.3 of the Peace Basin Plan) that provides another avenue for interested proponents.

4.1.1. Cross-Plan Actions

Several broad 'cross plan' actions are relevant to all terrestrial and aquatic Action Plans, but are not readily nested under any particular sub-objective:

1. **Conduct a high-level review of past FWCP-Peace projects.** Existing data consolidation and summarization is a top priority across all Action Plans. An understanding of the work that has been done in the past, results, recommendations, and information gaps are necessary for developing new actions and avoiding repetition of ineffective past actions.

Capturing "institutional memory" from published reports and past program staff will be an important exercise for ensuring that historical information is retained in a concise and accessible format for informing future projects.

2. **Evaluate success of FWCP projects.** An independent performance audit will serve to evaluate the success of each FWCP-Peace project. This action is designed to assess the effectiveness of the program in meeting its objectives.

There are several 'cross-plan' actions that are relevant to two or more Action Plans and will require the consideration of multiple ecosystems. The details of such actions are presented in other Action Plans, but those that address objectives and sub-objectives defined for reservoir ecosystems are summarized below:

1. **Undertake a Kokanee assessment study to summarize status, trends, and aquatic and terrestrial ecosystem impacts and potential ecological risks associated with Kokanee introductions. Develop appropriate recommendations for actions, as needed.** This action is described in this Action Plan.
   The introduction of Kokanee is affecting reservoir ecosystems in the Peace Basin through interactions with other species. The impacts (positive and/or negative) are not well understood but they could be competing with other species (e.g., for plankton food source) or providing a food source for larger piscivores (e.g., Lake Trout). This project is common to all Action Plans and is designed to gain a basin-wide understanding of the effects Kokanee introductions, and to develop and evaluate potential responses, as needed. This will be either an open or directed study.
2. **Partner with other organizations to assess cumulative effects (Uplands Action Plan).** The construction of reservoirs enabled incremental industrial development in the reservoirs by improving access to formerly remote areas. Subsequent development has likely led to unintended cumulative impacts. FWCP cannot influence the tenuring or permitting of crown land, but can partner with other organizations to understand cumulative effects in the Peace Basin in order to more clearly define future priorities that would be eligible for funding through the FWCP. This will be an open proposal invitation.

4.2 Actions

Actions for reservoir habitats in the Peace Basin are presented in the following tables. Proposals will be sought through either an open call for proposals or through a directed call for quote to pre-qualified bidders. Separate tables are provided for each objective and sub-objective.

Objective 1: Conserve or enhance high priority species and habitats.

Sub-objective 1a: Conserve native species and prevent those of concern from becoming further at-risk.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
1a-1	Support research projects to review existing information, identify important data gaps	The purpose of this action is to fill data gaps for lesser known species (primarily non-game fish species) in the FWCP	2	Open	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
	and undertake additional biodiversity research on lesser known species and populations towards the identification and development of specific habitat-based actions.	area. Several species-, population- and habitat-based studies have been conducted within the Peace Basin (e.g., Blackman et al. 2004, Harris et al. 2006). Some species have been identified as high-priority candidates for biodiversity review/research in the watershed, including: Burbot, Brassy Minnow, Pygmy Whitefish, sucker spp., and mussels. Reservoir-specific studies may include studies to better understand competitive interactions between Lake Trout and Bull Trout and what might be the long term implications for Bull Trout. This work may lead to development of enhancement actions, but that is not required. These are expected to be occasional, relatively short-duration and low-cost studies that provide specific information on distribution, ecology, or similar data gaps. There must be a clear linkage to how the information collected will lead to better understanding of status, trends, limiting factors, or the development of future on-the-ground habitat-based actions. Proponents are encouraged to understand biodiversity-related actions in other plans, and to coordinate efforts where applicable.			

Sub-objective 1b: Conserve and enhance reservoir connectivity to tributaries and between littoral and riparian.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
1b-1	Improve connectivity between reservoirs and their tributaries.	Erosion, sediment build-up and debris accumulations at some tributary outlets to the reservoirs has occurred. The potential indications are impediments to stream access, unstable or eroding banks and lack of vegetation, all of which can be potentially mitigated. These issues degrade habitat connectivity, which may limit access to important habitat areas (e.g., Sheer, M.B., Steel 2006; Cloern 2007). Both connectivity issues are primarily the result of large, annual water level fluctuations. Several tributaries to	1	Open	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		Williston and Dinosaur reservoirs have been inventoried and some are being monitored in advance of conducting enhancement activities under the Water Use Plan program (e.g., BC Hydro 2008; Knight Piesold Consulting 2010). Intended outputs include: - Review of existing information to identify opportunities to improve connectivity between reservoir and tributaries (e.g., addressing sediment concerns, stabilizing banks, or creating opportunities for natural revegetation). - Support for projects that improve connectivity between the reservoir and their tributaries			
Habitat-based actions					
1b-2	Undertake recommendations from inventory of connectivity restoration and enhancement opportunities, following a prioritized approach.	Restoration of tributary and littoral-riparian connectivity will be an important part of supporting the conservation of species that use these areas for portions of their life history. It will be important to consider whether fish passage improvements influence invasions of species that did not historically occur in the stream. Note that this action is partly dependent on the identification of priority areas for habitat restoration. There might also be the opportunity to leverage WUP-sponsored work on tributary connectivity restoration (e.g., Knight Piesold Consulting 2010).	1	Open	1b-1
Monitoring and adaptive management					
1b-3	Conduct monitoring of connectivity improvements.	It will be important to conduct monitoring of connectivity improvements and regularly review monitoring results. The outcome(s) of the review may require adaptive actions (e.g., to maintain or alter restoration measures; expand or limit the extent of monitoring; etc.).	1	Open	1b-1, 1b-2

Sub-objective 1c: Conserve and enhance the productivity of aquatic habitats.

Conservation and enhancement of reservoir productivity was identified as a key goal of the FWCP-Peace. No specific actions have been defined under this sub-objective, but some actions may arise as an outcome of monitoring. Note that several enhancement projects have been conducted under the FWCP-Peace in the past (e.g., Dinosaur Reservoir aquatic plant enhancement project (AIM Ecological Consultants Ltd. 2000); addition of woody debris to embayment areas of Dinosaur Reservoir (Blackman *et al.* 2004). In general, on-the-ground work relating to this sub-objective will require the identification and prioritization of candidate areas and techniques for restoration and enhancement activities.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Habitat-based actions					
1c-1	Undertake habitat based enhancements based on identified priorities.	Enhancements of reservoir habitats may serve to conserve or enhance species and habitats that are important for the maintenance of overall ecosystem health. At this time, no specific actions have been identified, but could conceivably be developed from monitoring or other information sources (e.g., habitat enhancements in embayment areas).	2	Open	strong rationale based on other studies and outcomes (e.g., 1b-3)

Objective 2: Improve understanding of status and trends of aquatic ecosystem health.

Sub-objective 2a: Understand the effects of Kokanee introductions on the aquatic food web.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
2a-1	Undertake a Kokanee assessment study to summarize status, trends, and aquatic and terrestrial ecosystem impacts and potential risks of Kokanee introductions. Develop appropriate recommendations for actions, as needed.	Introduced species can pose a significant risk to the biodiversity and food-web dynamics of ecosystems (e.g., Vander Zanden et al. 1999). Although there are two native Kokanee populations (i.e., Arctic and Thutade lakes) in the Parsnip and Finlay region (Mclean and Blackman 1991), the majority of Kokanee in the basin are descended from those introduced to Williston Reservoir (Langston and Murphy 2008). The direct and indirect effects of this introduction on aquatic and terrestrial ecosystems are unknown.	1	Directed	coordinate with other aquatic action plans

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		This study will be a broad synopsis applied across Streams, Lakes, Reservoirs, Riparian and Wetlands, and Uplands Action Plans. It will include a summary of the status and trends of Kokanee abundance, distribution, life history timing, etc., and of the likely past and future costs (e.g., competitive interactions) and benefits (e.g., food provisions for piscivorous fish) of Kokanee introduction. It will also be important to identify the risks of Kokanee migrations to areas that are currently not used by Kokanee. This study should assess Kokanee interactions with other species and the nutrient levels in all impacted ecosystems associated with kokanee spawning migrations. The study will identify uncertainties, and explore the efficacy of different management actions. First Nations input and evaluation will be a critical component of this study. The impacts of Kokanee introductions may be positive or negative, and may span multiple ecosystem types. Some examples of focus areas specific to Action Plans are to assess: use of Kokanee as a food source for larger-bodied piscivorous fish species (e.g., Lake Trout, Bull Trout) in reservoirs; potential and realized risks of incursions to natural lakes; effects on nutrient dynamics and inter-species competition in streams; and alterations of predator-prey relationships or vegetation communities in upland, riparian and wetland ecosystems.			

Sub-objective 2b: Monitor status and trends of aquatic ecosystem health, review results and develop specific plans in response to results.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
2b-1	Review existing information and summarize status and trends of species and habitats for which there is sufficient information or for which there are species-specific	Several species- and habitat-based studies have been conducted within the Williston and Dinosaur reservoirs (e.g., Blackman *et al.* 2004; Harris *et al.* 2005) and province-wide management objectives exist for several species.	2	Directed	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
	management objectives in provincial fisheries plans and develop a cost-effective monitoring program to assess aquatic ecosystem health.	This information will help inform the development of a general (i.e., not necessarily specific to a single species) monitoring program for status and trends in ecosystem health. The monitoring program will consider information collected to date, select indicators, develop methods, define action triggers/reference points, identify possible future actions, and coordinate with other monitoring efforts. There must be a clear linkage to how the information collected during the review process will lead to the development of future on-the-ground habitat-based actions.			
2b-2	Manage existing habitat structures in the Dinosaur Reservoir.	Large woody debris structures were added to embayments of the Dinosaur Reservoir in an attempt to enhance fish habitat (e.g., Blackman et al 2004)). These enhancement structures need to be surveyed annually to ensure they are safely secured, and any necessary repairs need to be made. A plan must be developed and implemented for structure management, improvement, and where necessary, removal, over the next 5 years.	2	Directed	2b-1
Monitoring and adaptive management					
2b-3	Undertake monitoring as per recommendations of the monitoring program.	The status and trends of reservoir ecosystem health in the Peace Basin are not well understood. When indicators of ecosystem health are selected and a monitoring program has been designed, the program can be implemented.	2	Open	2b-1
2b-4	Review monitoring results, refine and implement specific plans in response, as needed.	It will be important to regularly review ecosystem health monitoring results, which should be scheduled in the monitoring program. The outcome(s) of the review may require adaptive actions related to monitoring (e.g., to expand or limit the extent of monitoring) or to specific management actions for species or habitats.	2	Either	2b-1, 2b-3

Objective 3: Understand concentrations and pathways of mercury and other contaminants related to reservoir creation, and support defining risks for humans and the broader ecosystem.

Sub-objective 3a: Improve understanding of mercury concentrations, contamination pathways, and potential effects on human health and the broader ecosystem.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
3a-1	Develop a Terms of Reference for an appropriate Mercury Impacts Assessment Study in collaboration with First Nations and regulatory agencies.	There is a desire to assess the potential impacts of mercury methylation (as a result of reservoir creation), both on humans (though consumption of fish) and on the broader ecosystem. The scope of this action (e.g., engagement with local communities) should be addressed before a comprehensive review is undertaken. As human health concerns relate to species used for sustenance use, it will be essential to collaborate with First Nations to ensure the goals of this action are clear. Liaison with appropriate agencies (e.g., Provincial and federal health authorities) will be important for identifying potential supporting roles and partnerships to the FWCP.	1	Directed	na
3a-2	Support and/or carry out Mercury Impacts Assessment Study.	As assessment of the possible human and ecosystem impacts of mercury methylation and bioaccumulation should be carried out according to the terms of reference described in the action above. This impact assessment study may require the review and compilation of existing information on mercury contamination within the reservoirs. Some research has been done around mercury and metals in the Williston Reservoir (e.g., (Baker *et al.* 2002, 2012). This (and other available) information should be critically reviewed, knowledge gaps should be identified, and methods for addressing data needs should be developed, as required. Specific, prioritized recommendations for addressing mercury-related issues should be a deliverable of this action.	1	Directed	3a-1
3a-3	Carryout high priority recommendations from Mercury Study.	If the Mercury Impact Assessment Study identifies high levels of contamination risk for humans and/or	1	Directed	3a-1, 3a-2

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		ecosystem components, recommendations for dealing with these issues will be provided within the study results and will require implementation.			

Sub-objective 3b: Improve understanding of concentrations, contamination pathways, and potential effects of other contaminants directly related to reservoir creation on human health and the broader ecosystem.

Some concern has been identified around the potential negative impacts of other contaminants on humans and the broader ecosystem. However, no actions have been defined under this sub-objective. As such, no priority ranking or proposal method has been assigned under this sub-objective. Note that future actions under this sub-objective must be related to contamination issues stemming directly from reservoir creation (e.g., mines that were inundated by the reservoirs). A strong link to BC Hydro footprint effects will likely be required to be considered in scope for the FWCP-Peace.

Objective 4: Sustain or enhance opportunities for human use of fish.

Sub-objective 4a: Enhance sustenance resource uses based on input from First Nations and agency partners.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
4a-1	Work with First Nations and appropriate agencies to characterize priority species, habitats, locations and methods for sustenance use enhancement.	Priority species, habitats and locations for sustenance use enhancement have already been identified by First Nations. Therefore, this information will have to be incorporated in collaboration with the appropriate First Nations and agency partners to inform enhancement activities. Note that there will be regional variation in priorities.	2	Open	na
Habitat-based actions					
4a-2	Undertake habitat based enhancements based on identified priorities.	Although many stream areas used traditionally for sustenance harvest were inundated by reservoir creation, reservoir areas provide important habitat for species used for sustenance harvest. Enhancements of reservoir habitats may serve to conserve or enhance species and habitats that are important for sustenance use. At this	2	Open	4a-1

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		time, no specific actions have been identified, but could conceivably be developed from monitoring or other information sources. Note that this action requires coordination with activities under the angling sub-objective to ensure compatibility and to prevent redundancies.			

Sub-objective 4b: Enhance angling based on input from First Nations, angler groups, general public and agency partners.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
4b-1	Work with First Nations, angler groups and appropriate agencies to characterize priority species, habitats, locations and methods for angling enhancement.	Angler use patterns and preferences are not well understood in the Peace Basin. Priority species, habitats and locations for angling enhancement need to be identified in collaboration with the appropriate First Nations and agency partners to inform enhancement activities. It may also be possible to use information on use patterns (e.g., creel surveys, mail-out surveys, fish head collection) as cost-effective stock assessment techniques in the reservoirs. Note that several creel surveys have been conducted in the Williston and Dinosaur reservoirs (e.g., Blackman and Newsholme 1993; Joslin 2001b).	2	Open	coordinate with 4a-1, 4a-2
Habitat-based actions					
4b-2	Undertake habitat based enhancements based on identified priorities.	Reservoirs provide important habitat for species and fishing grounds for angling. Enhancements of reservoir habitats may serve to conserve or enhance species and habitats that are important for angling. At this time, no specific actions have been identified, but could conceivably be developed from monitoring or other information sources. Note that this action requires coordination with activities under the sustenance use sub-objective to ensure compatibility and to prevent redundancies.	3	Open	4b-1

5. Conclusion

This Action Plan for reservoir ecosystems in the Peace Basin identifies objectives, sub-objectives and actions to address FWCP's strategic objectives. A variety of FWCP- and WUP-projects have addressed inventory requirements in the past and have implemented a number of actions to improve ecosystem function. The proposed actions in this Action Plan build on those projects and leverage their results to address outstanding needs in the Peace Basin. The expected outcomes of the Action Plan include:

1. Understanding the current distribution, function, and connectivity of ecologically important reservoir habitats and populations, and identifying opportunities to conserve and restore function;
2. Improved ecological functions of reservoirs through habitat improvements;
3. Understanding the effects of mercury and other contaminants on human health and the broader ecosystem, and addressing any potential effects in partnership with appropriate agencies;
4. Improved sustenance use and angling opportunities; and
5. Improved coordination with existing planning and management activities in the Peace Basin.

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