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FISH AND WILDLIFE
COMPENSATION PROGRAM

PEACE BASIN

STREAMS ACTION PLAN

March 31, 2014

BC hydro FOR GENERATIONS

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Peace Streams 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.

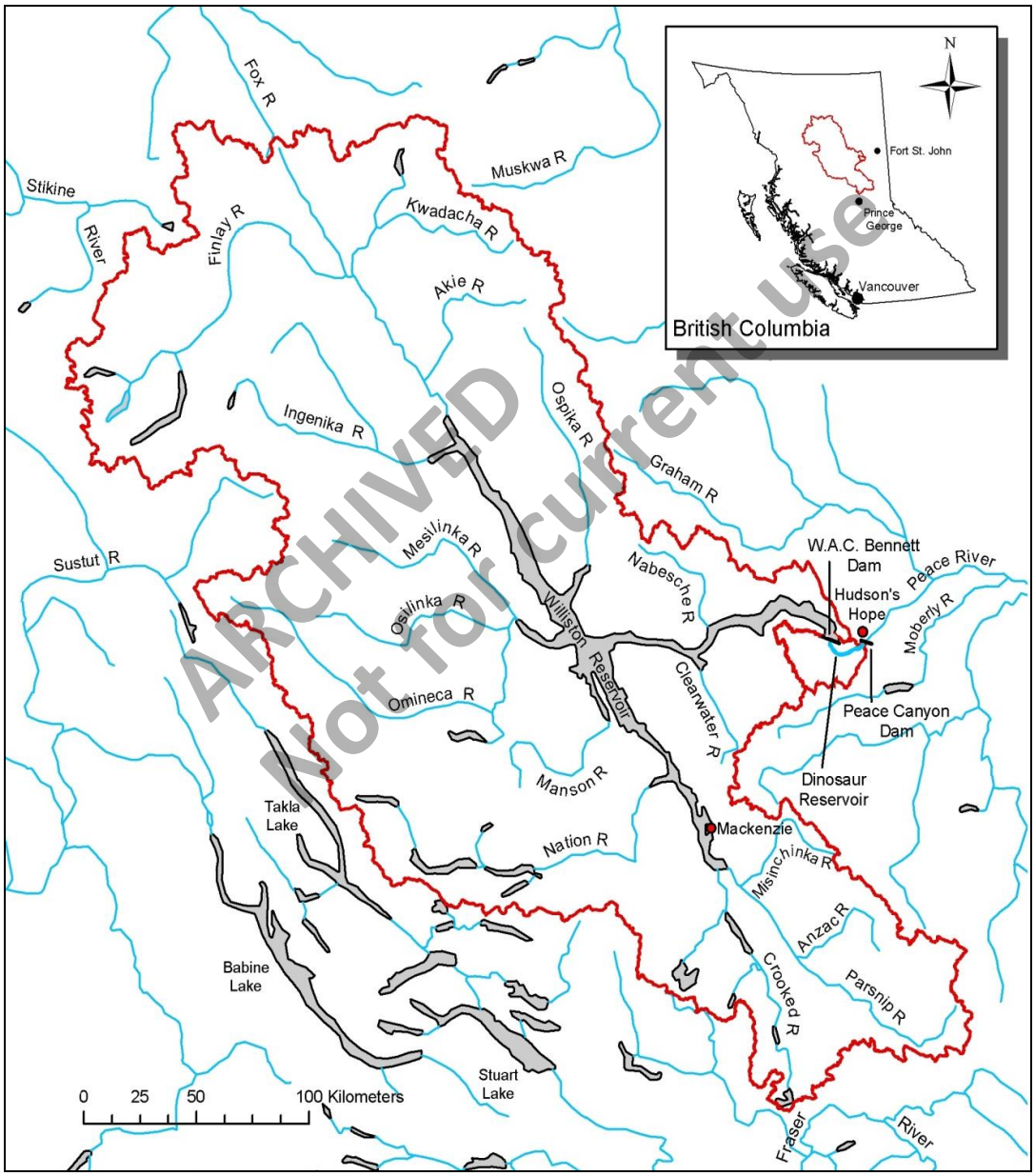

Figure 1 – The Upper Peace Basin and the FWCP-Peace Program Area

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).

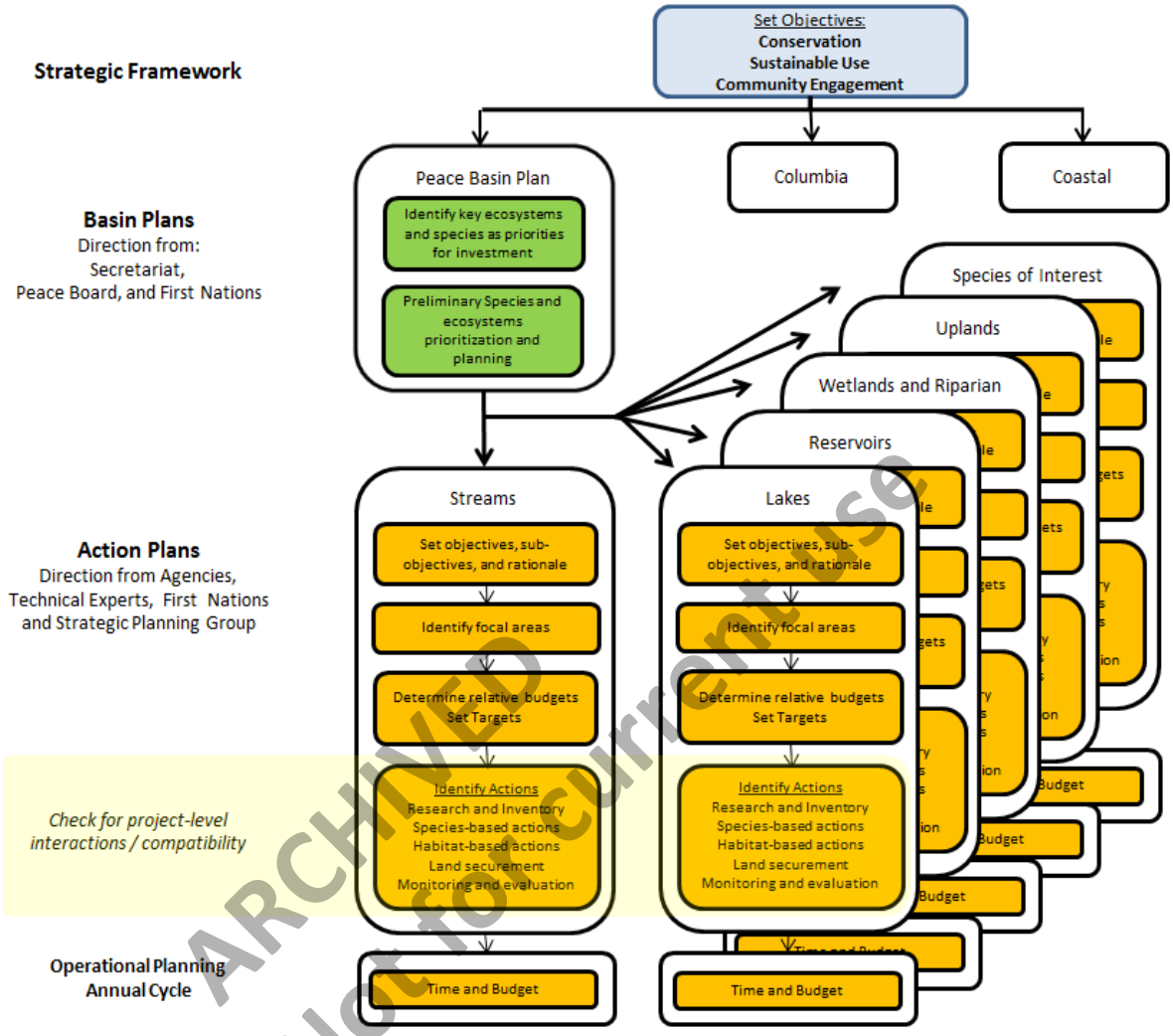

Figure 2. Relationship between the Streams Action Plan and higher level planning and objectives

This Streams Action Plan sets out priorities for the Fish and Wildlife Compensation Program to guide projects within the Peace region program area (Figure 1). The 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, Lakes, and Reservoirs[1]; some actions are complementary across the different plans.

The Streams Action Plan addresses all tributaries within the Peace Basin, including those connected to creeks or rivers that flow directly into the Williston and Dinosaur reservoirs. There is a large diversity of streams within the Peace Basin, ranging from small creeks to major river systems. The creation of the reservoirs drastically altered these systems within the basin by inundating a

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

sizable proportion of streams, which rapidly limited the habitat available for species that rely on stream habitats to carry out all or portions of their life history. There are also indirect impacts of reservoir creation, such as increased interactions with native and introduced lake-dwelling species whose abundances were favoured by reservoir creation (e.g., Kokanee) and that use streams for parts of their lifecycle (e.g., spawning). Human access created by the reservoir and associated roads has partly enabled other land uses such as forestry, mining and gas development, which have resulted in direct habitat impacts.

This Action Plan proposes objectives and actions to improve stream 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 stream habitats are of generally higher priority for FWCP investment compared to aquatic habitats in lakes and reservoirs.

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

2. Overview Context

2.1 Impacts and Threats

Background — The upper Peace Basin is approximately 70,000 km^2 and includes three sub-basins. The Finlay River drains the northern portion of the trench with an original mainstem length of around 295 km. The Parsnip River drains the southern portion of the trench with an original mainstem length of about 210 km. The two rivers converged at Finlay Forks to form the Peace River which flows east through the Rocky Mountains and Peace Canyon. The construction of W.A.C. Bennett Dam flooded the entire mainstem portion of the Peace River above the dam, as well as a substantial portion of the Finlay and Parsnip rivers forming the Peace, Finlay and Parsnip reaches of the reservoir. The lower portions of all of the tributaries draining into these three reaches were also flooded. The Peace Canyon dam flooded the mainstem Peace River upstream to the foot of the W.A.C. Bennett Dam

In the Williston watershed, there are 10 major rivers (drainage >1500 km^2), 7 large rivers (400-1500 km^2), 49 medium rivers (50-400 km^2) and 262 small rivers (<50 km^2) (Langston and Blackman 1993); however, detailed habitat assessments have been completed for only some of these (Langston and Blackman 1993). Of the five tributaries that flow into Dinosaur Reservoir, only two creeks (Johnson and Gething) provide spawning and rearing areas for fish (Hammond 1987).

Hydro-related Impacts — The creation of Williston Reservoir resulted in large-scale habitat change, including a reduction of river habitat and an increase in lake-like reservoir habitat. In general, this change has favoured lake-dwelling species and impacted stream species (Blackman *et al.* 1990). Changes in aquatic species abundance and distribution have likely influenced inter-specific competition and predation patterns (Beauchamp *et al.* 1995), which has likely had a positive effect on some species and a negative effect on others. For example, declines in Arctic Grayling within the basin are attributed primarily to reductions in stream habitats, and there is speculation that more abundant Longnose Sucker, Largescale Sucker, Rainbow Trout and Slimy Sculpin are out-competing grayling. Further, the higher relative abundance of adaptable Bull Trout, a species favoured by reservoir creation, may have increased predation pressure on Grayling and other fish species (Northcote 1993).

A detailed quantitative analysis of stream habitat losses that resulted from dam construction and operation has not been conducted.

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). These activities have not been specifically assessed as part of this Action Plan, but they can result in habitat loss and direct effects on fish populations. 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 stream bank vegetation can lead to reduced habitat quality, due to 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).

Drainage structures (e.g., culverts) that are poorly engineered or have exceeded their life expectancy can inhibit or completely block fish passage; however, techniques for replacing, modifying or restoring these structures are well-documented (e.g., Baker and Votapka 1990). Note that fish passage issues resulting from reservoir operations (i.e., at the confluence of tributaries with the reservoirs; (e.g., BC Hydro 2008, Seebacher *et al.* 2012) are addressed in the Reservoirs Action Plan.

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 the reservoir

via tributaries. These species interact with other stream-dwelling fish during some or all of their lifecycle and can negatively affect naturally-occurring populations (Beauchamp *et al.* 1995).

Although there is low angler pressure in the Peace Basin relative to other areas in the province, overfishing may nevertheless impact the abundance of some species in some locations in the watershed. Species that are late-maturing or that congregate in or migrate through easily targeted areas (e.g., Bull Trout), are particularly vulnerable to overfishing (Post *et al.* 2003). Increased access as a result of other developments in the basin may facilitate increased fishing pressure in certain areas.

2.2 Limiting Factors

Factors limiting the quality and availability of stream habitats fall into three broad categories:

Extent

A large amount of stream habitat has been lost through inundation. There are many kilometers of remaining tributary habitat, but only short sections are accessible due to the presence of barriers. This is generally considered the most important limiting factor for streams. For example, only short sections (500 – 600 m) remain of two tributaries to the Dinosaur Reservoir, which provide stream spawning and rearing habitat for fish. However, due to variable discharge and high sediment loading of both of these tributaries, habitat quality and quantity is further restricted (Hammond 1987).

Connectivity

Connectivity among stream habitats, and between these habitats and other habitats and features, are important for dispersal of plants and animals and for seasonal movements of some species. Distribution is directly related to extent and to land uses in other habitats. Connectivity among stream habitats has been affected by reservoir creation; for example, aquatic habitats that were formerly continuous stream habitat are now only connected via the reservoir, which may prevent or reduce movements of some fish species among these streams.

Productivity

The productivity of an ecosystem is defined as its ability to grow or yield native flora and fauna. Even where stream habitats are abundant and connected several factors may influence productivity:

- Stream flow is among the most important aspects related to stream productivity. For example, flowing water maintains high-quality habitat for rearing fish and invertebrates, flushes sediment from interstitial spaces, and influences recruitment of large wood debris which provides habitat for stream species. Flows allow connectivity between river mainstem and side-channel habitats, and provide connectivity, irrigation and other necessary conditions for riparian areas and wetlands. Flow rates and timing provide important ecological cues to many species at particular times during their lifecycle (Poff *et al.* 1997). Flows in tributaries to Williston and Dinosaur reservoirs are not directly controlled by BC Hydro; however, channel structure within the drawdown zone is influenced by BC Hydro operations.

- Small changes in dissolved organic carbon (DOC) and nutrient levels can have significant influence on overall stream productivity (e.g., Stockner and MacIsaac 1996). BC Hydro operations do not directly influence nutrient levels in tributaries within Williston and Dinosaur watersheds.

- Stressors such as invasive species or disruptive human activities can affect community structure and function (e.g., Wipfli *et al.* 1998). The creation of the reservoirs has allowed some

non-native species to flourish and invade streams that are otherwise not directly affected by BC Hydro.

- Loss of specific habitat features can affect life requisites of some species, e.g., riparian vegetation, large woody debris, clean spawning gravels. For example, the current habitat conditions in two tributaries to the Dinosaur Reservoir are unknown; however, previous studies have indicated that siltation and compaction of spawning gravels limits habitat quality (Hammond 1987). Periodic debris flows in at least one tributary has limited the ability to restore habitats. Habitat features in tributaries are especially affected within the drawdown zone.

Productivity is closely related to water temperature and small changes in water temperature can affect fish growth, behaviour, and survival (Hokanson *et al.* 1977; Lee *et al.* 2003). Water temperature tolerance levels vary between fish species and between life stages (Oliver and Fidler 2001). Water temperature changes can also affect invertebrate populations through changes to the length of the growing season, and can influence fish habitat availability through altered dynamics of ice formation and melting.

2.3 Trends and Knowledge Status

Habitat Trends — The quantity of stream habitat has changed markedly from historical conditions due to hydropower development. Further, inter-specific interactions may have been affected by increased abundances of species that have benefited from the increase in lake-like habitat.

The FWCP has invested in a variety of projects in stream habitats. Many of these projects have been focused on restoration activities for certain fish species :

- Stream nutrient studies (fertilization feasibility; (Langston 1992, 1993a,b, 1995, 1996; Langston and Zemlak 1994; Koning et al. 1995; Paul et al. 1996; Zemlak and Langston 1997; Larkin et al. 1999; Wilson et al. 1999).

- Habitat assessment and/or enhancement potential (e.g., Retzer 1989; Langston 1993a; Northcote 1993; Morgan 1995 ; Mathias et al. 1998; Zemlak and Langston 1998; Blackman et al. 2004).

Stock Trends — In general, species that prefer stream habitats (e.g., Arctic Grayling, Mountain Whitefish) have declined in abundance since reservoir creation due to a substantial reduction in stream habitat (Blackman *et al.* 1990). There is limited available information on historical fish abundance within Williston Watershed streams (but see (BC Ministry of Environment 1977/78/81; Bruce and Starr 1985a) for general distribution information). Some detailed species inventories and life history studies have been conducted in streams (e.g., Slaney 1992; Hohndorf *et al.* 1993; Langston and Blackman 1993; Zemlak and Langston 1998), but knowledge of current status and trends is limited. General population trends for key species are presented below with a stream focus where possible.

Arctic Grayling – Arctic Grayling in the “South Beringia lineage,” which includes the FWCP-Peace area, are not at risk (MOE BC Species and Ecosystems Explorer 2013). 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). Recent surveys found Arctic Grayling only in tributaries to the Peace and Parsnip reaches of Williston, whereas in other areas they are considered to be “functionally extinct” (Northcote 1993; Zemlak 2000). Arctic Grayling were abundant after the reservoir was built, but the population declined and in the mid-1970s, since 1988, Arctic Grayling have essentially disappeared from the reservoir.

Bull Trout – Bull Trout are in serious decline in some parts of its range and is currently "blue listed" in BC, meaning the species is of "special concern" and considered sensitive to human activities or natural events (McPhail and Baxter 1996, BC Species and Ecosystems Explorer 2003). Bull Trout in the Peace watershed are part of the Western Arctic Population assessed as Special Concern by COSEWIC (COSEWIC 2012). Prior to hydropower development of the Peace River, stream resident and fluvial Bull Trout populations were distributed throughout most of the upper Peace, Finlay, and Parsnip watersheds (Bruce and Starr 1985). In the late 1980s, Bull Trout populations appeared to have increased since 1974-5 (Blackman 1992). The current status of Bull Trout in the watershed is not well understood (but see Hohndorf *et al.* 1993; Langston and Murphy 2008; Euchner 2011). Trends in populations within the Peace/Williston area are either unknown or mixed (e.g., Langston and Cubberley 2008; Hagen and Decker 2011). Long-term assessment and monitoring work has been undertaken on Bull Trout in the Thutade watershed associated with the Kemess mine development, including 18 years of continuous adult and juvenile assessments (Bustard 2011). This work serves as an important source of information for the region.

Gething Creek is the only tributary to Dinosaur Reservoir used by Bull Trout for spawning (Pattenden and Ash 1993). A Bull Trout translocation project in the Gething Creek Basin upstream of an impassable falls was conducted in the 1990s in an attempt to increase spawning and rearing success of Bull Trout and increase their population size in the reservoir. The benefits of this project for Bull Trout in the Dinosaur Basin have not been quantified (Langston and Murphy 2008).

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 first introduction in the 1990s, Kokanee have been gradually increasing in abundance, and they have recently overtaken Lake Whitefish as the most abundant species in Williston Reservoir.

Since the stocking program, Kokanee populations appear to be increasing in the Dinosaur Reservoir and in the Peace reach of the Williston Reservoir; data are more limited for the Finlay and Parsnip reaches. With funding from FWCP, 25 tributaries to Williston Reservoir have been surveyed for spawning Kokanee since 2002. During this time, the lowest numbers were recorded in 2002 (81,000), and highest numbers in 2006 (1.0 million). It is anticipated that spawning numbers will continue to vary as Kokanee colonize new areas (Sebastian *et al.* 2009). Kokanee were not observed spawning in tributaries to Dinosaur Reservoir during 1983-86 surveys (Hammond 1987), but have been observed spawning in two tributaries, with small numbers observed in 1999 increasing to several hundred in 2010 (Euchner 2011).

Mountain Whitefish – 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. However, their numbers have declined dramatically since reservoir creation (Langston and Blackman 1993). The total impact on Mountain Whitefish populations from hydropower-related habitat changes has been negative with a substantial reduction in river-dwelling forms and very low numbers of adfluvial Mountain Whitefish in the Williston Reservoir since at least 1975 (e.g., Blackman 1992).

Rainbow Trout – There are unique populations of native Rainbow Trout in the Peace watershed; the great majority of Rainbow Trout populations are in rivers flowing into the Pacific Ocean. Rainbow Trout have been stocked extensively throughout the Williston drainage, with the majority occurring in the Parsnip Reach (1962-2005 cumulative total of almost 3 million), and some occurring in the Peace and Finlay reaches (early 1980s-2005 cumulative total of 133,500 and 32,500, respectively) (Langston and Murphy 2008). Both river- and lake-resident Rainbow Trout are found in the Williston Basin. River resident stocks are found mainly in the boulder/riffle habitat of a few smaller tributaries. Rainbow Trout are not abundant in Williston Basin rivers, and river-resident rainbow trout declined between 1974-75 and 1988 (Blackman 1992). Surveys of Rainbow Trout spawners in a tributary to Dinosaur Reservoir indicated that abundances were similar between 1983 and 2006 (Newsholme and Euchner 2006). More recent trends in river-resident abundances are not known.

Knowledge Gaps — There have been several studies of the ecology and enhancement potential of some Peace Basin streams (e.g., Langston 1992; Slaney 1992; Northcote 1993), but there remain substantial knowledge gaps, particularly with respect to important habitat (e.g., spawning habitat locations and quality), trends in abundance of several species (e.g., Bull Trout, Rainbow Trout, Mountain Whitefish), 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 and compensation efforts.

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 Stream 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 Arctic Grayling and improve understanding of limiting factors

Sub-Objective 1c. Conserve and enhance Bull Trout and improve understanding of limiting factors

Sub-Objective 1d. Conserve and enhance the productivity of aquatic habitats

Rationale – Williston and Dinosaur reservoirs inundated river and tributary habitat, which triggered 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. Specific sub-objectives have been identified for Arctic Grayling and Bull Trout; however, projects may be developed for other high priority native species under Sub-Objective 1a.

The restoration and enhancement of stream habitats will support stream species and ecosystems within Williston and Dinosaur watersheds. Several tributaries to Williston and Dinosaur reservoirs have been inventoried and some are being monitored in advance of conducting enhancement activities under BC Hydro's Water Licence Requirements program (e.g., LeRuez 2011a,b; Seebacher *et al.* 2012; Roscoe *et al.* 2013). Future on-the-ground work requires the identification and prioritization of candidate streams and areas for restoration and enhancement activities.

Note that tributary connectivity issues resulting from reservoir operations (i.e., at the confluence of tributaries with the reservoirs) are addressed in the Reservoirs Action Plan.

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 in the Reservoirs Action Plan.

OBJECTIVE 3. SUSTAIN OR ENHANCE OPPORTUNITIES FOR HUMAN USE OF FISH

Sub-objective 3a. Enhance sustenance resource uses based on input from First Nations and agency partners

Sub-objective 3b. 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. Streams have been deemed the most highly used ecosystems in the basin for sustenance use and angling, compared to lakes and reservoirs. 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. These responsibilities are dealt with through the ongoing process of decision-making, which is not a formal part of this FWCP plan. Fish stocking as a species-based enhancement is not an appropriate action for interior streams as it has proven ineffective at increasing the number of fish available for harvest in most cases and can have undesirable consequences if the fish invade unintended areas. The provincial stocking program focusses primarily on small lakes where the risks are more manageable and the benefits are predictable.

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 Streams Action Plan focuses on other action categories because they are considered more effective for streams. Actions to improve the status of certain species or a community of species include projects to understand sustainable use opportunities;
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 stream 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 the Reservoirs Action Plan.
   The introduction of Kokanee is affecting stream ecosystems in the Peace Basin, potentially through the introduction of additional nutrients and prey biomass in areas where Kokanee are spawning. The impacts (positive and/or negative) are not well understood but may include disruptions of nutrient dynamics (e.g., removal of periphyton from substrate) and competition with other species (e.g., for spawning space). 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.
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.

4.2 Actions

Actions for stream 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					

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
1a-1	Support research projects to review existing information, identify important data gaps and undertake additional biodiversity research on lesser known species and populations towards the identification and development of specific habitat-based actions	The purpose of this action is to fill data gaps for lesser known species (primarily non-game fish species) in the FWCP area. Several species-, population- and habitat-based studies have been conducted within the Peace Basin (e.g., Retzer 1989, Clarke *et al.* 2005). Some species have been identified as high-priority candidates for biodiversity review/research, including: Burbot, Brassy Minnow, Pygmy Whitefish, sucker spp., and mussels. 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.	1	Open	na
	Land securement				
1a-2	Partner with organizations to purchase land or establish covenants.	Purchasing private land for conservation purposes, or establishing conservation-related covenants on private land, can protect important habitats from conversion to other uses or degradation through changes in land management. Typically this is not a very effective strategy for streams unless there is a localized portion of a stream that has very high habitat values that are at risk from localized land disturbance activities. Land purchases (and subsequent management agreements with third parties) and negotiations of legal covenants can be expensive and areas protected are usually small. Partnerships with other organizations to finance purchases or own fee-simple lands will be required. Opportunities for private land purchase or management are limited in the Peace Basin because most of the area is provincial crown land. First Nations land claims in the region are an important consideration regarding private land purchase and	2	Directed	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		management in the Peace Basin.			

Sub-objective 1b: Conserve and enhance Arctic Grayling and improve understanding of limiting factors.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
1b-1	Review existing information (including provincial management plan), summarize status and trends of Arctic Grayling and its habitats, undertake actions that are within the FWCP scope and lead directly to the development of conservation and enhancement actions, and develop a cost-effective monitoring program to assess status and trends.	Arctic Grayling spend the majority of their life in streams and were substantially affected by the creation of Williston and Dinosaur reservoirs (British Columbia Ministry of Water Land and Air Protection (BCMWLAP) 2002). Several studies have been conducted on Arctic Grayling populations within the Peace Basin (e.g., (Blackman 2001; Blackman and Hunter 2001). At the time of completion of this Action Plan, the provincial Arctic Grayling management plan was in development. It will be necessary to work with the responsible agencies to identify appropriate conservation and enhancement actions. Before feasible actions and targets can be established for Arctic Grayling conservation or enhancement, further research on this species and its habitat within the Peace Basin may be required to determine current status and identify potential enhancement actions. This information will also help inform the development of a monitoring program. The monitoring program will consider information collected to date, select indicators, develop methods, define action triggers/reference points, possible actions, and coordinate with other monitoring efforts. There must be a clear linkage to how the monitoring program will lead to the development of future on-the-ground habitat-based actions.	1	Directed	na
Habitat-based actions					
1b-2	Implement high priority habitat restoration options for Arctic	Restoration of important habitats for Arctic Grayling will help ensure their conservation within the Peace Basin.	1	Open	1b-1

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
	Grayling.	Note that this action is partially dependent on Arctic Grayling monitoring actions.			
Monitoring and adaptive management					
1b-3	Undertake Arctic Grayling monitoring as per recommendations of the monitoring program and develop specific, prioritized recommendations for habitat-based actions which correspond to the monitoring results.	The status and trends of Arctic Grayling populations within the Peace Basin are largely unknown (but see British Columbia Ministry of Water Land and Air Protection (BCMWLAP) 2002). As such, it is important to implement a long-term monitoring program, which will ultimately inform on-the-ground conservation and enhancement activities for Arctic Grayling. Note that this action is dependent on the collation of existing information on Arctic Grayling in the region and the development of a monitoring plan.	1	Open	na
1b-4	Review Arctic Grayling monitoring results, refine and implement specific plans in response, as needed. Identify limiting factors to direct conservation and enhancement efforts.	There is little information on the limiting factors (e.g., habitat needs, competition with other species, historical information gaps, access constraints) for Arctic Grayling in the Peace Basin. Monitoring can help identify these factors, and inform the development of on-the-ground conservation and enhancement activities. Note that this action is dependent on the implementation of the monitoring program.	1	Either	1b-3

Sub-objective 1c: Conserve and enhance Bull Trout and improve understanding of limiting factors.

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
1c-1	Review existing information (including provincial management plan), summarize status and trends of Bull Trout and its habitats, undertake actions that are within the FWCP scope and lead directly to the development of conservation and enhancement actions, and develop a cost-effective	Bull Trout require access to small headwater streams and cool water temperatures to complete their lifecycle (McPhail and Baxter 1996). Several studies have been conducted on Bull Trout populations within the Peace Basin (e.g., O'Brien and Zimmerman 2001; Langston and Cubberley 2008). Trends in populations within the Peace Basin are either unknown or mixed (e.g., Baxter 1995, Langston and	1	Directed	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
	monitoring program to assess status and trends.	Cubberley 2008; Euchner 2011). It will be necessary to work with the responsible agencies to identify appropriate conservation and enhancement actions. Before feasible actions and targets can be established for Bull Trout, further research on this species and its habitat within the Peace Basin may be required to determine current status and identify potential enhancement actions. This information will also help inform the development of a monitoring program. The monitoring program will consider information collected to date, select indicators, develop methods, define action triggers/reference points, possible actions, and coordinate with other monitoring efforts. There must be a clear linkage to how the monitoring program will lead to the development of future on-the-ground habitat-based actions.			
Habitat-based actions					
1c-2	Implement high priority habitat restoration options for Bull Trout.	Restoration of important habitats for Bull Trout will help ensure their conservation within the Peace Basin. This action is partially dependent on Bull Trout monitoring actions. Note that the FWCP-Peace has initiated projects benefitting Bull Trout including: the Gething Creek Bull Trout translocations (Langston and Murphy 2008) and annual monitoring of spawning redds in select index streams (e.g., Langston and Cubberley 2008)	1	Open	1c-1
Monitoring and adaptive management					
1c-3	Undertake Bull Trout monitoring as per recommendations of the monitoring program and develop specific, prioritized recommendations for habitat-based actions which correspond to the monitoring results.	The status and trends of Bull Trout populations within the Peace Basin are largely unknown. As such, it is important to implement a long-term monitoring program, which will ultimately inform on-the-ground conservation and enhancement activities for Bull Trout. Note that this action is dependent on the collation of existing information on Bull Trout in the region and the development of a monitoring plan.	1	Open	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
1c-4	Review Bull Trout monitoring results, refine and implement specific plans in response, as needed; Identify limiting factors to direct conservation and enhancement efforts.	There is little information on the limiting factors (e.g., habitat needs, competition with other species, historical information gaps, and access constraints) for Bull Trout in the Peace Basin. Monitoring can help identify these factors, and inform the development of on-the-ground conservation and enhancement activities. Note that this action is dependent on the implementation of the monitoring program.	1	Either	1c-3

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

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
1d-1	Review existing information on stream restoration/enhancement opportunities, inventory enhancement opportunities, and provide prioritized enhancement recommendations.	Various restoration/enhancement activities and inventories have been conducted throughout the basin (e.g.,(Langston 1993a; Koning *et al.* 1995; Morgan 1995) that may provide insight to enhance or conserve habitat in the program area. A review of these recommended actions is important to ensure valuable historical information is effectively used in the context of current FWCP priorities. Intended Outputs: 1) Review existing historical plans and recommendations found in FWCP documentation to restore and enhance priority stream habitat using available survey and local and historical knowledge in the context of current FWCP priorities. 2) Partner with communities, local organizations and the public to make local improvements to stream habitat. 3) Work with local groups to organize stream and lake clean-up activities that promote healthy habitats. 4) Review existing FWCP, government and BC Hydro (e.g., Water Use Plan) documentation to identify relevant specific opportunities for habitat enhancement including culvert removal/restoration, road deactivation, habitat complexing, erosion control, riparian revegetation, flow restoration, nutrient enrichment, side channel	1	Either	na

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
		development, spawning channel development, etc.			
Habitat-based actions					
1d-2	Undertake habitat based enhancements based on identified priorities.	The conditions of certain stream habitat areas may be compromised by various natural- (e.g., flooding) and human-induced (e.g., roads) activities. Loss of habitat complexity, erosion, altered flows, and changes in vegetation cover, may affect stream productivity. There are a variety of opportunities for restoration and enhancements of such habitats. Note that this action is partly dependent on inventory and prioritization of candidate areas for enhancement. Note also that culvert-specific enhancement activities are covered under a separate habitat-based action.	2	Either	1d-1
1d-3	Restore fish passage in streams.	This action should focus on improvements around manmade obstructions. Restoring upstream access will benefit fish populations. Perched culverts are the main reason fish access is limited. The FWCP is interested in supporting the improvement of fish access where the culvert does not have existing ownership or responsibility, and in partnership with local interest groups who provide in-kind or volunteer support. This action could involve the removal, restoration or replacement of existing culverts.	1	Either	1d-1

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

This sub-objective is described in detail in the Reservoirs Action Plan.

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

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
Research and information acquisition					
2b-1	Review existing information and summarize status and trends of biological communities, species and habitats for which there is sufficient information or for which there are species-specific management objectives in provincial fisheries plans and develop a cost-effective monitoring program to assess aquatic ecosystem health.	Several species- and habitat-based studies have been conducted within select Peace Basin streams (e.g., Euchner 2011) and province-wide management objectives exist for several species. 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. Note that the monitoring program may utilize information collected from species-specific monitoring programs (e.g., Arctic Grayling; Bull Trout). The monitoring program will focus on biological communities (e.g., Reference Condition Approach) 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. The monitoring program could follow a number of possible approaches, the details of which will be developed as part of the contract.	1	Directed	na
Habitat-based actions					
2b-2	Undertake habitat-based enhancements based on identified priorities.	Enhancements of stream habitats may serve to conserve or enhance species and habitats that are important for the maintenance of overall ecosystem health. This action is dependent on the identification of priorities through monitoring. Further, monitoring may identify declines in ecosystem health, and such issues may require intervention.	1	Open	2b-1
Monitoring and adaptive management					
2b-3	Undertake monitoring as per recommendations of the monitoring program and develop specific, prioritized recommendations for habitat-based actions which	The status and trends of stream 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	1	Open	2b-1

ID	Action	Rationale	Priority	Proposal Method	Pre-Requisite
	correspond to the monitoring results.	implemented.			
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 (e.g., to expand or limit the extent of monitoring).	1	Either	2b-1, 2b-3

Objective 3: Sustain or enhance opportunities for human use of fish

Sub-objective 3a: 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					
3a-1	Work with First Nations and appropriate agencies to characterize priority species, habitats, locations and methods for sustenance use enhancement.	Species of local interest to First Nations communities include those that are traditionally used for food and cultural purposes but may have a local low abundance. The intended output of this action is to support projects that work with First Nations to identify opportunities to enhance species of local traditional or cultural interest by enhancing habitats or other means in an around streams.	1	Open	na
Habitat-based actions					
3a-2	Undertake habitat-based enhancements based on identified priorities.	Streams provide important habitat for species and traditional fishing grounds for sustenance harvest. Enhancements of stream habitats may serve to conserve or enhance species and habitats that are important for sustenance use. This action is dependent on development of methods for enhancement. Note that this action requires coordination with activities under the angling sub-objective to ensure compatibility and to prevent redundancies.	1	Open	3a-1

Sub-objective 3b: 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					
3b-1	Work with First Nations, angler groups and appropriate agencies to assess current fisheries, 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, angler groups and agency partners to inform enhancement activities.	2	Open	coord-inate with 3a-1 and 3a-2
Habitat-based actions					
3b-2	Undertake habitat-based enhancements based on identified priorities.	Streams provide important habitat for species and fishing grounds for angling. Enhancements of stream habitats may serve to conserve or enhance species and habitats that are important for angling. This action is dependent on development of methods for enhancement. Note that this action requires coordination with activities under the sustenance use sub-objective to ensure compatibility and to prevent redundancies.	2	Open	3b-1

5. Conclusion

This Action Plan for stream 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 current distribution, function, and connectivity of ecologically important stream habitats and populations, and identifying opportunities to conserve and restore function;
2. Improved ecological functions of streams through habitat improvements;
3. Improved sustenance use and angling opportunities; and
4. Improved coordination with existing planning and management activities in the Peace Basin.

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