

# Mid-Columbia Ecosystem Enhancement Project Catalogue

## DRAFT 3 for Public Review – August 15, 2016

### Note to Reviewers

*Thank you for taking time to provide your input on this draft catalogue.*

Please review this catalogue then go to the survey [HERE](#) to provide your input.

If you would like to add your revisions to a WORD version of this document, or to discuss this project, please contact Cindy Pearce, the Project Team Lead at [cindypearce@telus.net](mailto:cindypearce@telus.net) or 250 837-8505.

## Table of Contents

Purpose .....	1
Mid- Columbia Area .....	2
Hydropower Dams and Reservoirs .....	2
Ecological Impacts of Dams and Reservoirs.....	3
General Impacts .....	3
Specific Geographic Impacts .....	4
• Revelstoke Reach/Flats/Drawdown Zone.....	4
• Bridges to Revelstoke Dam .....	5
• Lake Revelstoke.....	6
Catalogue of Potential Projects .....	6
Location Maps for Potential Projects.....	13
Mica Dam to Downie Loop.....	13
Downie Loop to Revelstoke Dam .....	14
Revelstoke Reach .....	15

## Purpose

The construction and operation of hydropower dams have highly modified the natural environments in the mid-Columbia River region between Shelter Bay and the Mica dam where this catalogue is focused. There have been permanent changes to a substantial area of upland, riparian, wetland and aquatic ecosystems, with impacts to fish and wildlife habitats.

Community groups and the general public in the Revelstoke area as well as First Nations that include this area in their traditional territory are supportive of on-site stewardship, conservation and restoration projects in this area to improve ecosystem function and habitats. Funding is available for these projects from the Columbia Fish and Wildlife Compensation Program, Columbia Basin Trust and other sources however few proposals for this area are received by these potential funders.

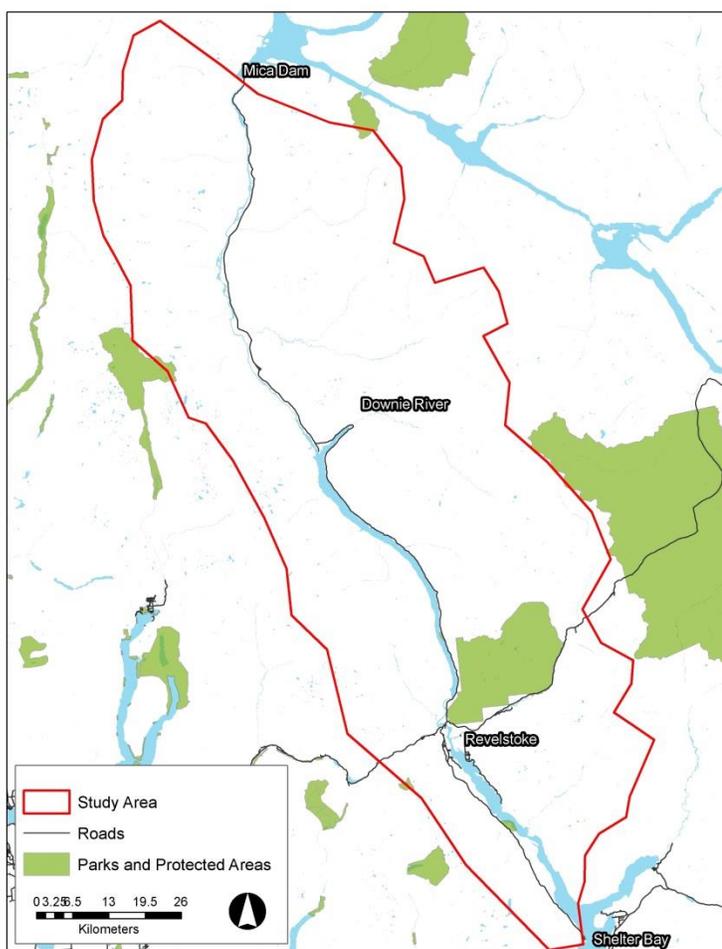
Although there are over 40 scientific reports that describe the environmental impacts of reservoirs and hydropower operations in this area, with some suggesting potential ecosystem projects and priorities, much of this information is not readily available to or understood by non-technical readers. As well, interested groups do not have relationships in place to partner on projects. These barriers have slowed the development of on-site projects. This catalogue aims to reduce these barriers by compiling the scientific information and local perspectives on potential projects to enhance access to this information and facilitate funding applications for ecosystem enhancement projects over time.

## Mid- Columbia Area

This catalogue covers the area from Shelter Bay to Mica dam, as shown in the map on the right.

## Hydropower Dams and Reservoirs

The Hugh Keenleyside dam was built in 1968. This dam created the Arrow Lakes Reservoir upstream of the dam which raised the level of the two natural Arrow Lakes, and extended the extent of ponded waters to 230 kilometers from near Castlegar (downstream) to Revelstoke (upstream). This reservoir was created to store water to reduce flooding of downstream communities and for release to the U.S. under the Columbia River Treaty and other agreements for flood control, power production and, more recently, fish management. This results in water level fluctuations of 12 metres (40 feet) during most years, on average, with sometimes significant differences in water levels from year to year.



The Revelstoke Dam, located just upstream of the City, was completed in 1984 with four turbines. Hydropower is produced at this dam to meet electricity demands during the highest daily and seasonal 'peak' periods. Lake Revelstoke reservoir is 130 kilometres long, ending at Mica Dam. This reservoir stores water for release during the peak demand periods. Water levels normally fluctuate within 1.5 metres (five feet).

The Mica dam was completed in 1973, creating the Kinbasket Reservoir, which begins north of Golden and continues 216 kilometres north to Valemount. This dam is the key headwaters storage dam under the Columbia River Treaty and an important hydropower generator for B.C. Together the Revelstoke and Kinbasket dams generate almost half of the hydropower produced by BC Hydro. Water is released from Mica Dam into Lake Revelstoke based on flood control and hydropower needs as well as the requirements of the Treaty and other agreements.

## Ecological Impacts of Dams and Reservoirs

There are a number of common initial ecological impacts resulting from dam and reservoir construction (known as 'footprint' impacts) as well as ongoing ecological impacts from the changes in water flows and reservoir levels resulting from dam operations. Some of these impacts have occurred throughout the mid-Columbia area, while others are specific to defined geographic areas. This section provides a brief overview of the general ecological impacts throughout the Mid-Columbia area, followed summaries of the specific impacts in three geographic areas – the Revelstoke reach/the 'flats' or the drawdown zone; above the bridges to the Revelstoke dam; and Lake Revelstoke. Key references with more details about these impacts are listed at the end of this section.

### General Impacts

A widespread early impact in Canada from hydropower development on the Columbia River happened in 1942 when fish migration, including annual salmon runs, was blocked by the construction of the Grand Coulee dam in the U.S., just below the Canada/US border. Before this barrier was created, salmon had historically spawned and then died along the main-stem of the Columbia River and in some tributaries, thus fertilizing local ecosystems with rich ocean-based nutrients. This nutrient flow was stopped by this barrier. The migratory pathways of resident fish species (e.g., bull and rainbow trout) were also blocked by this early and substantial dam.

The subsequent construction and operation of the three dams in Canada have caused four general ecological impacts within the reservoirs in the mid-Columbia area:

1. **Reduced nutrient flows** - The much slower water flows within each reservoir allows nutrients to settle out and consequently they are not transported downstream to enrich lower ecosystems.
2. **Altered primary biological productivity** – Reduced nutrient flows and changes in water depth, temperature and other conditions within each reservoir alters the ecological processes that define the basic level of biological productivity in each reservoir.
3. **Much reduced fish spawning habitats** – Spawning habitats are critical to fish populations. White sturgeon, now an endangered species, spawns in habitats within the main riverbed. Kokanee, bull trout (also an endangered species), rainbow trout (including the rare yellowfin variety), burbot, whitefish and a variety of minnow, sucker and sculpin species spawn in tributaries with appropriate conditions. Dams blocked fish movement to spawning habitats, reservoirs flooded many of these habitats and the remaining habitat can be impacted by fluctuating water levels and soil/gravel deposits that block fish access.
4. **Diminished riparian and wetland habitats** – These biologically rich ecosystems along the original riverbed are now flooded and subjected to continuously fluctuating water levels.

These areas were critical habitats for wildlife and fish, including salmon historically. The loss of these habitats has altered fish and wildlife populations.

Many of these impacts were examined during the Columbia River Water Use Plan, which was implemented in 2007, and are now being further examined in a series of studies directed by this plan.

An additional impact that is often referenced locally is warming of local, low elevation climates due to the heat trapped in and released from the new reservoirs. Scientists have not been able to confirm this impact because the reservoirs were created at a time while the climate was warming regionally and globally and locally.

## **Specific Geographic Impacts**

- **Revelstoke Reach/Flats/Drawdown Zone**

Shelter Bay is located along what was formerly the northern shore of Upper Arrow Lake. Before the reservoir was filled the Columbia River flowed freely through the wide, rich valley bottom area between the lake and the City of Revelstoke. This area is now known as 'Revelstoke Reach' or locally as 'the flats' or the drawdown zone.

Historically many fish bearing streams flowed into the river and the diversity of wetland, riparian and forested habitats supported a variety of wildlife. First Nations spent time on this land fishing, hunting, gathering and conducting cultural and spiritual activities in this abundant and spectacular landscape. Beginning in the late 1800s, Europeans settled many farms and small communities, attracted by the rich soils.

The creation of the Arrow Lakes Reservoir had a very large impact on the ecological processes in the valley. Several thousands of hectares of productive, diverse wetland and upland habitats were cleared and flooded. In addition, over thirteen hundred hectares of settled lands were flooded. The aquatic ecosystems in the area were also disrupted.

These areas continue to be impacted by ongoing hydro operations. In most years during the winter when the reservoir level is low, the valley floor along the river channel is not flooded and the river flows within its original channel. Exposed soils can be wind-eroded though extensive grass plantations have stabilized soils in the higher elevations of the reservoir drawdown zone.

As spring run-off is stored in the Arrow Lakes reservoir, water levels rise and the valley is flooded, beginning at the lowest elevations and often rising to near the maximum permitted level – or 'full pool' – typically reached in mid-summer. Over the late summer, fall and winter the reservoir level declines as the stored water is released until the river flows again within its original channel.

Although much of this area is often flooded annually, it retains some ecological functions. The timing and duration of flooding defines what type of vegetation can survive within this area, with simple plant communities of sedges at the lowest elevations where vegetation can survive, and more complex vegetation communities including herbs, shrubs and trees at the very highest elevations. The increasing complexity of habitats at higher elevations with less frequent flooding supports increasing diversity of wildlife, including migratory birds and species at risk such as the western painted turtle. While the distribution of wildlife in this area is largely shaped by the habitats that develop based on water levels, wildlife can also be directly affected by the timing and duration of

changes in water levels – for example, some bird species nest in areas that are not flooded in the early spring, but are flooded later in the spring, leading to poor reproductive success.

This area also includes many wetland features that despite frequent flooding continue to be of great regional importance for the western painted turtle, aquatic mammals such as beavers and a high diversity of wetland birds, especially when the reservoir is drawn down. Seasonal flooding of these wetlands through ongoing operations commonly submerges many of these wetlands, often making them temporarily unavailable to wildlife.

There are concerns that recreational uses on the flats can damage fragile vegetation and disturb wildlife.

Fluctuating water levels and erosion also change aquatic ecosystems within the river and tributary streams. This results in loss, fragmentation and degradation of aquatic habitats, leading to population fragmentation and declines for some fish and other species. Of special note, this area provides very isolated, known spawning habitat for white sturgeon and thus is designated as part of the Arrow Lakes target area for sturgeon recovery in B.C. Stocking of yearling sturgeon and ongoing monitoring juvenile movement and growth occur in support of sturgeon recovery. Alternatively, some fish species may benefit from these changes.

When the Arrow Lakes Reservoir water levels are relatively low, the upper areas of the Revelstoke Reach also experience hydropeaking impacts, which are discussed below.

- **Bridges to Revelstoke Dam**

There is a relatively short stretch of river upstream of the Trans-Canada Highway and railway bridges in Revelstoke to the Revelstoke Dam that is essentially free-flowing, though water levels fluctuate greatly almost daily based on the operations at the Revelstoke Dam. Water flows through this dam change often twice a day to produce electricity during peak demand periods (“hydropeaking”). Flows may also be increased to move stored water from Kinbasket Reservoir behind Mica Dam into the Arrow Lakes Reservoir. The level and timing of high and low flows, the rate of the increase and reduction in flow (‘ramp’ rate), and the duration of changed flows can impact ecosystems. These impacts include erosion and aquatic and shoreline habitat degradation as well as reduced food web productivity due to rapid nutrient flushing, with concurrent impacts on fish productivity, and increased risk of fish stranding.

Before 2010, there was no minimum flow requirement for the Revelstoke Dam. An outcome of the Columbia Water Use Plan was to establish a required minimum flow which must be met at all times. In 2010 a fifth turbine was activated at this dam, and a proposed sixth turbine is under environmental review. As each turbine is added, more water will flow through the dam to meet peak electricity demands, with increasing concerns about the ecological impacts of these ‘hydropeaking’ operations. When the fifth turbine was activated, maximum flows increased by about 30%, and the sixth turbine may further increase maximum flows by approximately 25%. Several studies are underway as part of the Revelstoke Flow Management Plan to monitor the ecological effects of the minimum flow and new hydropeaking operations with the fifth turbine.

Beyond the impacts on habitats, within this area fish passage upstream is blocked by the dam, and downstream movement is limited by fish losses within the turbines (entrainment)

- **Lake Revelstoke**

Almost 11,500 hectares of primarily upland ecosystems, floodplains and streams were flooded by the creation of Lake Revelstoke when the Revelstoke Dam first became operational. Loss of complex river habitats in the main-stem of the Columbia River, and changes to tributary streams both affected biological productivity and fish communities. The historically rich river environment, with a complexity of aquatic habitats including rapids, deep pools and shallow slack water, was replaced by a simpler lake environment. Lake Revelstoke has very low productivity in part due to the short time that water stays in the reservoir (water residence time). This low productivity limits the populations of key fish species such as kokanee, bull trout and rainbow trout. Fish populations are further impacted by losses through entrainment at Mica Dam.

### Key Technical References

**Dam Footprint Impact Summary BC Hydro Dams in the Columbia Basin (2011)**

[http://www.sgrc.selkirk.ca/bioatlas/pdf/FWCP-CB\\_Impacts\\_Summary.pdf](http://www.sgrc.selkirk.ca/bioatlas/pdf/FWCP-CB_Impacts_Summary.pdf)

**Columbia River Water Use Plan**

[https://www.bchydro.com/about/sustainability/conservation/water\\_use\\_planning/southern\\_interior/columbia\\_river.html](https://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river.html)

**Revelstoke Flow Management Plan**

[https://www.bchydro.com/about/sustainability/conservation/water\\_use\\_planning/southern\\_interior/columbia\\_river/revelstoke-flow.html](https://www.bchydro.com/about/sustainability/conservation/water_use_planning/southern_interior/columbia_river/revelstoke-flow.html)

The majority of the productive valley bottom cottonwood and coniferous riparian areas as well as forested wetlands were flooded when Lake Revelstoke was created, reducing the historical complexity of the habitats in this area and removing high value habitat for species that rely on these ecosystems. Portions of the upland ecosystems were important seasonal habitat for mountain caribou, which is now a species at risk.

Because Lake Revelstoke only fluctuates within a 1.5 metre (five feet) range, the ongoing ecological impacts of water level fluctuations are much less than those experienced in the Arrow Lakes Reservoir.

### Catalogue of Potential Projects

The listing below is based on a scan of over 40 documents including original research, project reports and strategic action plans (see the annotated literature listing [HERE](#)).

These projects include actions for areas that are directly impacted by the hydropower system (i.e. removing barriers to fish passage that develop in streams within a reservoir) as well as actions in areas that were not directly impacted by the hydropower system to offset the impacts (i.e. removing barriers to fish passage in streams beyond the reservoirs to increase functioning fish habitat in the area).

Potential projects for specific sites are listed in the table below, in geographic order from north to south.

In addition to the projects included on this list, there are opportunities to reduce invasive species within the Mid-Columbia area. As the information about invasive species changes rapidly, rather than including specific projects, readers are encouraged to check the provincial map display of <http://maps.gov.bc.ca/ess/hm/iapp/> or contact the Columbia Shuswap Invasive Species Society at: <http://columbiashuswapinvasives.org/>.

<b>Site Specific Project Info</b>	
<b>Project ID Number</b> - Each project has been assigned an ID Number. The location of each project is shown using the ID number in the sub-area maps starting on Page 13.	
<b>Sub-Area</b> - 1= Revelstoke Reach 2= Revelstoke dam to Downie Loop 3= Downie Loop – Mica Dam	
<b>Reference document</b> – This is the source of project suggestion. These references are described in the Mid-Columbia Ecosystem Enhancement Project Catalogue Annotated Bibliography <a href="#">HERE</a> .	

<b>Site-specific projects</b>		
<b>Project ID Number</b>	<b>Sub-Area</b>	<b>Project details</b>
1	1	<p><b>Alkolkolex cutthroat trout habitat enhancement planning and actions</b></p> <p>Reference document – FWCP (Streams Action Plan) 2012</p> <p>GPS location/land ownership – Alkolkolex River</p> <p>Environmental values to be enhanced – cutthroat trout habitat</p> <p>Actions – development of regional plan for future enhancement, conduct actions identified in plan, conduct habitat complexing to create pools</p> <p>Notes –</p>
2	1	<p><b>Alkolkolex River fertilization for resident salmonids</b></p> <p>Reference document – Moody et al. 2007, p129.</p> <p>GPS location/land ownership – 50.835507, -118.032190 Alkolkolex River, no exact location</p> <p>Environmental values to be enhanced – Production and quality of salmonids</p> <p>Actions – Apply slow-release P fertilizer</p> <p>Notes – ensure coordination with other planning and actions on the Alkolkolex</p>
3	1	<p><b>Drimmie Creek fish passage enhancement</b></p> <p>Reference document – Hawkes and Dreischner 2012</p>

		<p>GPS location/land ownership – Drimmie Creek</p> <p>Environmental values to be enhanced – improved access to spawning areas for Kokanee (<i>Oncorhynchus nerka</i>), Bull Trout (<i>Salvelinus confluentus</i>), and Rainbow Trout (<i>O. mykiss</i>).</p> <p>Actions – decrease shallow braiding, increase deep pools and scoured areas through habitat enhancement with use of riprap, large woody debris, or anchored wooden features</p> <p>Notes –</p>
4	1	<p><b>Airport Marsh nesting habitat enhancement</b></p> <p>Reference document – van Oort and Cooper 2015, Bird and van Oort 2015</p> <p>GPS location/land ownership – Airport Marsh – City of Revelstoke, CSRD, Revelstoke Airport</p> <p>Environmental values to be enhanced – protection of regionally-important nesting habitat for numerous species of birds</p> <p>Actions – prevent inundation of Airport Marsh, perhaps by dyking</p> <p>Notes – many species that nest here were identified as having high or very high impact from dam creation (Utzig and Schmidt 2011)</p>
5	1	<p><b>Montana Slough and Cartier Bay floating turtle platforms</b></p> <p>Reference document – Wood and Hawkes 2015.</p> <p>GPS location/land ownership – 50.949005, -118.168781. Crown land/CSRD/BC Hydro</p> <p>Environmental values to be enhanced – Endangered western painted turtle basking habitat</p> <p>Actions – Install anchored floating islands in known turtle area</p> <p>Notes – there is already one floating platform in Montana Bay; no documented use by turtles yet. Larger Cartier Bay platforms considered and rejected by BC Hydro. Project planning underway for platforms in Airport Marsh.</p>
6	1	<p><b>Red Devil Hill turtle habitat enhancement</b></p> <p>Reference document – Wood and Hawkes 2015, Maltby 2000</p> <p>GPS location/land ownership: 50.970295, -118.183907. Crown land/Ministry of Highways</p> <p>Environmental values to be enhanced – Endangered western painted turtle breeding habitat</p> <p>Actions – Cut down encroaching trees on the downhill side of the road to reduce</p>

		<p>shade and return soil temperatures to levels that meet the needs for turtle nesting.</p> <p>Notes – Might fit for wildfire fighter chainsaw training area - contact Columbia Fire Base.</p>
7	1	<p><b>Revelstoke area white sturgeon habitat enhancement research</b></p> <p>Reference document – Crossman and Hildebrand 2012</p> <p>GPS location/land ownership – Columbia River near Revelstoke Golf Course</p> <p>Environmental values to be enhanced – White Sturgeon spawning habitat</p> <p>Actions – research into the impacts/benefits of the existing substrate enhancement in this area on other life stages of White Sturgeon; eventual application of technique to other areas</p> <p>Notes – research is recommended prior to further enhancement activities</p>
8	2 3	<p><b>Laforme, Horne, Pat, and Soards in-stream fish habitat enhancement</b></p> <p>Reference document – Triton Environmental 1991, 1992</p> <p>GPS location/land ownership – Laforme, Horne, Pat, Soards Creeks</p> <p>Environmental values to be enhanced – increased in-stream habitat for resident fish species</p> <p>Actions – habitat complexing to create pools and retain gravel, revegetation or structural erosion control</p> <p>Notes –</p>
9	2	<p><b>Carnes Creek side channels for juvenile bull trout</b></p> <p>Reference document – Hagen 2008, Triton 1992</p> <p>GPS location/land ownership – Carnes Creek</p> <p>Environmental values to be enhanced – increase juvenile bull trout production by creation of juvenile rearing habitat</p> <p>Actions – create and maintain a side channel for spawning and rearing</p> <p>Notes – this potential project was identified in earlier work (Triton 1992); side channels require regular maintenance. Bull Trout populations may be on the increase in Carnes Creek (1992)</p>
10	3	<p><b>Park, Hoskins, and Nagel Creeks bull trout spawning access barrier removal</b></p> <p>Reference document – Hagen 2008, Triton Environmental 1991, 1992</p> <p>GPS location/land ownership – Park, Hoskins, and Nagel Creeks</p> <p>Environmental values to be enhanced – Increased access to spawning habitat for bull trout and other resident fish species</p> <p>Actions – remove barriers to fish passage</p>

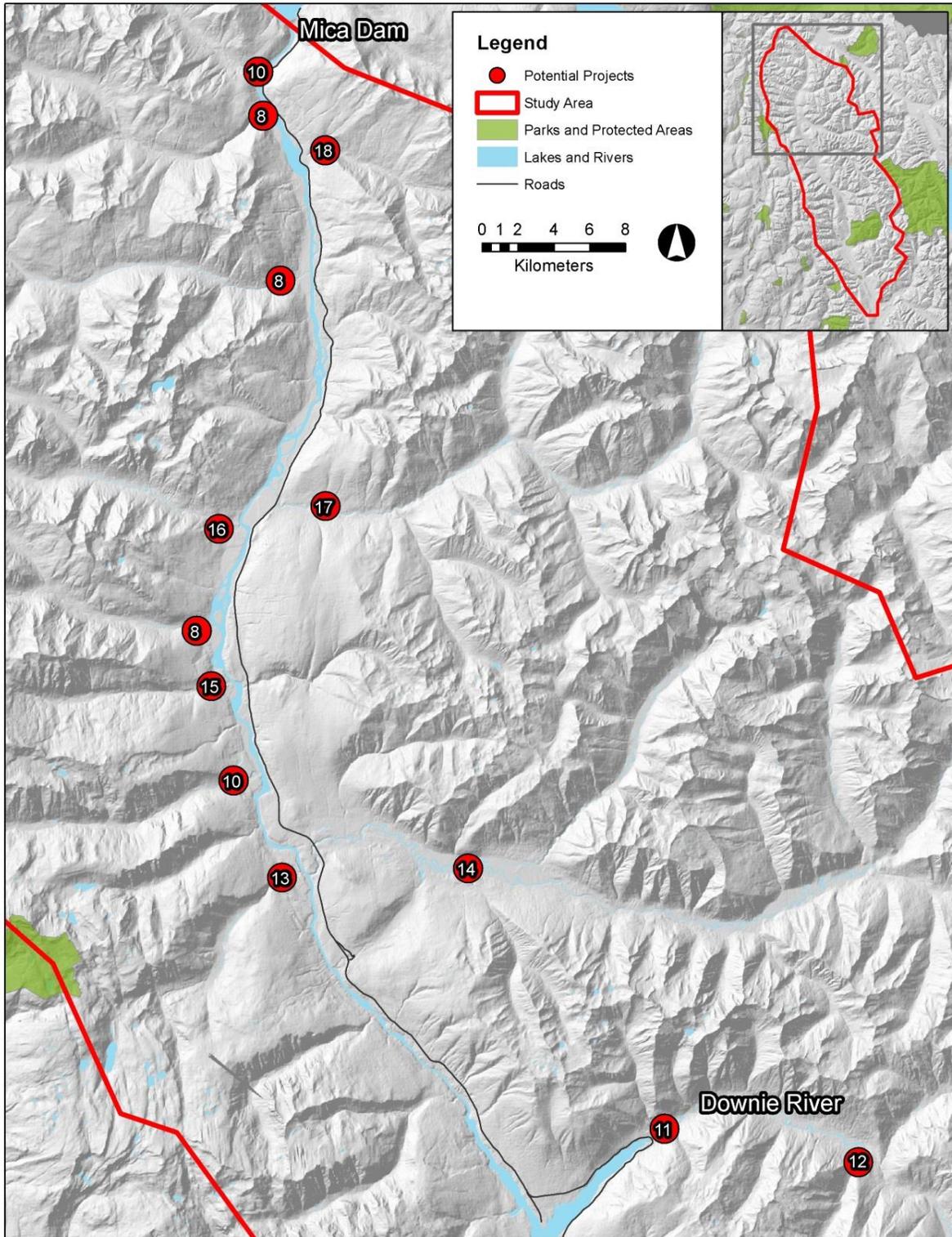
		Notes – these creeks were first identified in earlier work (Triton 1992)
11	2	<p><b>Downie Creek fish habitat enhancement</b></p> <p>Reference document – Hagen 2008, Triton Environmental 1992</p> <p>GPS location/land ownership – Downie Creek</p> <p>Environmental values to be enhanced – increased access to spawning habitat, increased juvenile production of Bull and Rainbow Trout.</p> <p>Actions – habitat rehabilitation, removal of barriers, side channel development</p> <p>Notes –</p>
12	3	<p><b>Standard Creek fish habitat enhancement and spawning/rearing channel feasibility study</b></p> <p>Reference document – Lister and Wood 1994</p> <p>GPS location/land ownership – Standard Creek</p> <p>Environmental values to be enhanced – spawning and rearing habitat for kokanee and trout</p> <p>Actions – removal of log jam barriers, study the need for and impacts of creation of an artificial channel for spawning and rearing habitat in lower 1.2 km of creek</p> <p>Notes –</p>
13	3	<p><b>Kirbyville Creek fish habitat research and enhancement</b></p> <p>Reference document – Triton Environmental 1992</p> <p>GPS location/land ownership – Kirbyville Creek</p> <p>Environmental values to be enhanced – increase juvenile production of Bull and Rainbow Trout by improving in-stream habitat</p> <p>Actions – research to determine limiting factors. Bank stabilization to reduce erosion. Potential side channel creation. Enhancement of the lagoon at the mouth by shoreline and sedge revegetation, installation of floating cover objects.</p> <p>Notes – report includes detailed information on Kirbyville Creek</p>
14	3	<p><b>Goldstream (including lower Goldstream Creek, Brewster, Old Camp, and McCulloch) fish habitat research and enhancement</b></p> <p>Reference document – Golder Associates 1998, Triton Environmental 1992</p> <p>GPS location/land ownership – Goldstream Creek (including lower Goldstream Creek, Brewster, Old Camp, and McCulloch)</p> <p>Environmental values to be enhanced – increased juvenile production of cutthroat trout, increased access of bull and rainbow trout to spawning and rearing habitat; improved fish habitat</p> <p>Actions – research to determine importance of marshes and beaver ponds to</p>

		<p>juvenile cutthroat, identify tributaries used for spawning, in-stream complexing of Old Camp Creek, stream rehabilitation of Brewster and McCullough Creeks, ensure culverts at road crossings are passable by fish, removal of barriers, development of a distinct channel by hand/machine excavation, addition of in-stream cover and creation of pools using rock weirs or root wads.</p> <p>Notes – Goldstream Creek is not be confused with the Goldstream River, just north of Goldstream Creek</p>
15	3	<p><b>Ruddock Creek fish habitat research and enhancement</b></p> <p>Reference document – Triton Environmental 1992</p> <p>GPS location/land ownership – Ruddock Creek</p> <p>Environmental values to be enhanced – increase production of Bull Trout by improving in-stream habitat</p> <p>Actions – research to determine if the creek is at carrying capacity. Creation of spawning channel or side channel development if habitat is limiting.</p> <p>Notes – report includes detailed information on Ruddock Creek</p>
16	3	<p><b>Scrip Creek fish habitat research and enhancement</b></p> <p>Reference document – Triton Environmental 1992</p> <p>GPS location/land ownership – Scrip Creek</p> <p>Environmental values to be enhanced – recruitment of Bull and Rainbow Trout by improving in-stream habitat</p> <p>Actions – research to determine limiting factors. Creation of juvenile rearing habitat, or in-stream fertilization to increase food availability.</p> <p>Notes – report includes detailed information on Scrip Creek</p>
17	3	<p><b>Bigmouth Creek fish habitat enhancement</b></p> <p>Reference document – Triton Environmental 1992</p> <p>GPS location/land ownership – Bigmouth Creek</p> <p>Environmental values to be enhanced – improve bull trout habitat</p> <p>Actions – Identification and rehabilitation of small tributaries to Bigmouth that could provide bull trout habitat. Removal or modification of barriers (culverts, log jams), revegetation for bank stabilization. Estuary development at mouth of Bigmouth, with establishment of native shrubs and sedges.</p> <p>Notes – report includes detailed information on Bigmouth Creek</p>
18	3	<p><b>Birch Creek fish passage improvements/monitoring and habitat enhancement</b></p> <p>Reference document – Golder Associates 1998</p> <p>GPS location/land ownership – Birch Creek</p>

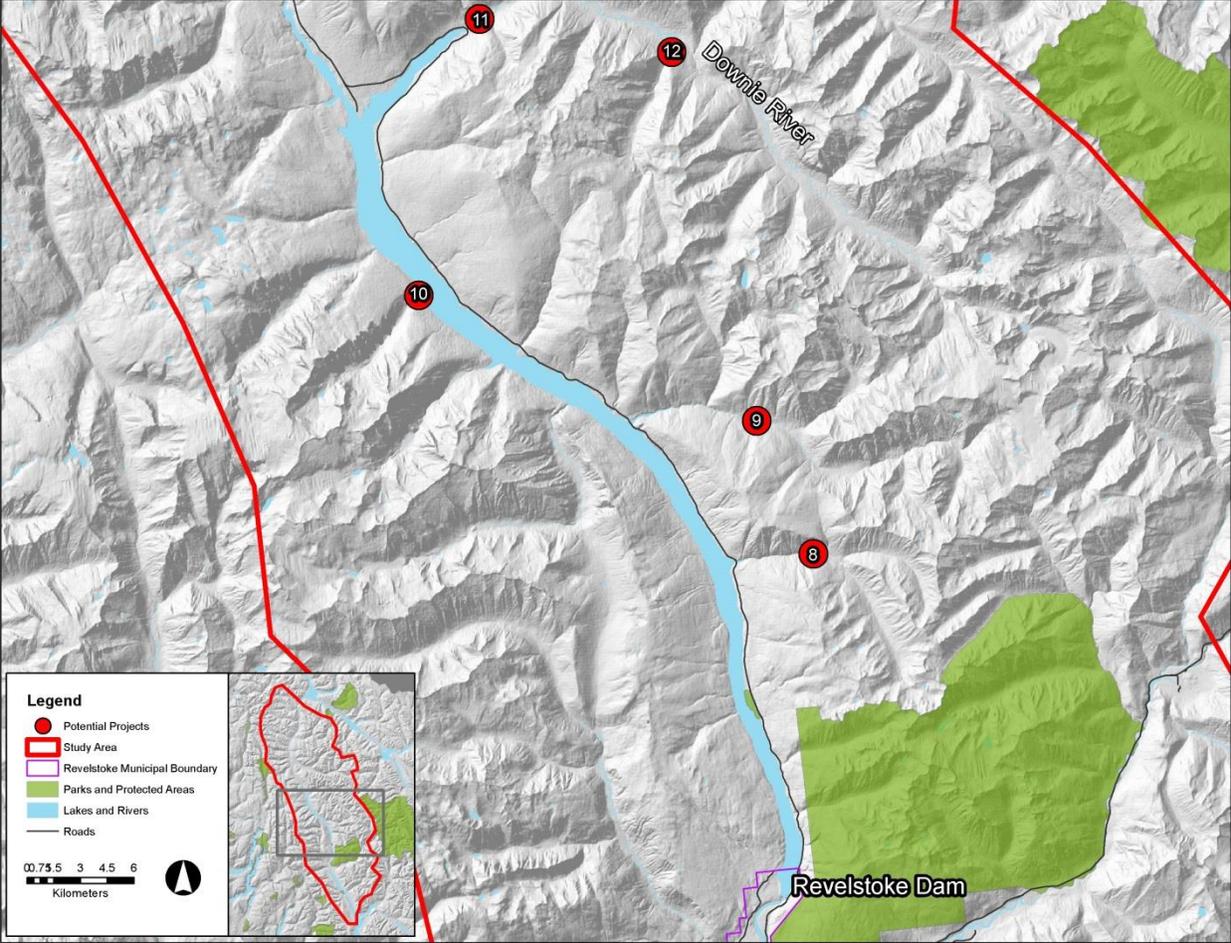
		<p>Environmental values to be enhanced – increase access of bull trout to upstream spawning and rearing habitat; improved fish habitat</p> <p>Actions – removal of debris jam barriers, monitoring effects of the removal of barriers. Creation of pools and resting areas with the addition of boulder groupings.</p> <p>Notes –</p>
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# Location Maps for Potential Projects

## Mica Dam to Downie Loop



# Downie Loop to Revelstoke Dam



# Revelstoke Reach

