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Abbreviations

AEP	Alberta Environment and Parks
AIS	aquatic invasive species
BSP	biologically significant period
CCME	Canadian Council of Ministers of the Environment
CEA	Canadian Environmental Assessment
CEA Agency	Canadian Environmental Assessment Agency
CEAA	*Canadian Environmental Assessment Act*
COP	Code of Practice
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch Per Unit Effort
CRA	Commercial, Recreational, and Aboriginal
DFO	Fisheries and Oceans Canada
DLO	Department License of Occupation
EIA	environmental impact assessment
EIS	Environmental Impact Statement
EPT	Ephemeroptera/Plecoptera/Trichoptera
FRL	Fish Research License
IFN	Instream Flow Needs
LAA	local assessment area
LUF	Land-Use Framework

LWD	Large Woody Debris
NPA	Navigation Protection Act
NRCB	Natural Resources Conservation Board
PDA	project development area
PoE	pathway of effects
QAES	Qualified Aquatic Environment Specialist
QEP	Qualified Environmental Professional
RAA	regional assessment area
RAP	Restricted Activity Period
ROW	right-of-way
SAR	species at risk
SARA	*Species at Risk Act*
SDI	Simpson's Diversity Index
SEI	Simpson's Evenness Index
SSRP	*South Saskatchewan Regional Plan*
TDR	technical data report
TLRU	Traditional Land and Resource Use
ToR	terms of reference
TSS	total suspended sediments
TUS	Traditional Use Study
VC	valued component

8.0 ASSESSMENT OF POTENTIAL EFFECTS ON AQUATIC ECOLOGY

Aquatic ecology, which includes fish and fish habitat, describes conditions observed in watercourses and waterbodies, including rivers, creeks and streams, lakes and ponds. Aquatic ecology is part of commercial, recreational, and Aboriginal (CRA) fisheries, or species that support such fisheries as defined by the *Fisheries Act*. Fish and fish habitat provides economic, environmental, cultural, and spiritual value to Canadians and habitats provide the areas for fish to live, migrate, feed, and reproduce. These fisheries, including recreational and Aboriginal fisheries in Elbow River, play a role in the local cultures, communities, livelihood, lifestyles, and history of Indigenous Groups and local communities. Fish and the fishery are important to socio-economic activities in the region, including Indigenous groups and local recreation.

Aquatic ecology is linked with other VCs, including vegetation and wetlands, wildlife, historical resources, traditional land and resource use. Existing conditions for the VCs listed above are incorporated into this effects assessment. This aquatic ecology assessment draws on information from the following VC assessment sections:

- Volume 3A, Section 6 Hydrology
- Volume 3A, Section 7 Water Quality

8.1 SCOPE OF THE ASSESSMENT

This aquatic ecology assessment is in accordance with the requirements of the federal Environmental Impact Statement (EIS) Guidelines and provincial Terms of Reference (ToR) issued for the Project. Concordance tables, demonstrating where EIS Guidelines and ToR requirements are addressed are provided in Volume 4, Appendix A.

A Fish Passage Report (Volume 4, Appendix M, Attachment 8A) informs the assessment of potential Project effects on fish movement and migration through construction and operation of the Elbow River bypass.

8.1.1 Regulatory and Policy Setting

Federal and provincial legislation and regulatory requirements that apply to the assessment of effects on aquatic ecology are described below.

8.1.1.1 Federal Regulatory Requirements

Fisheries Act

The *Fisheries Act* applies to projects that have the potential to cause serious harm to fish and fish habitats that are part of or support a CRA fishery. The federal *Fisheries Act* prohibits unauthorized work, undertaking, or activity that results in serious harm to fish and fish habitats that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery. The *Fisheries Act* also prohibits the deposit of a deleterious substance of any type, in water frequented by fish Common types of deleterious substances include but are not limited to: sediment, excess nutrients, contaminants, pesticides, and industrial and municipal waste discharges.

Species at Risk Act

Section 5 of *Canadian Environmental Assessment Act* (CEAA) 2012 requires an assessment of environmental effects on aquatic species defined in subsection 2(1) of *Species at Risk Act* (SARA). SARA sets out prohibitions against the killing or harming of a species listed as extirpated, endangered or threatened and the damage or destruction of their residences and destruction of critical habitat as defined in a published Recovery Strategy or Action Plan

8.1.1.2 Provincial Regulatory Requirements

Alberta Water Act

The Alberta *Water Act* supports and promotes the conservation and management of water and requires an approval for any activity with the potential to cause an effect to the aquatic environment.

Public Lands Act

The *Public Lands Act* prohibits disturbance to public lands that may result in injury to the bed and shore of any body of water. The *Act* also regulates and enforces activities affecting Crown owned bed and shores.

Alberta Fisheries Act

Recreational fishing in Alberta is regulated by the *Alberta Fisheries Act* and fisheries regulations, administered by the Fish and Wildlife Division of AEP.

8.1.1.3 Additional Guidance

The following documents, which include management frameworks, provincial and federal recovery strategies as well as guidelines related to restricted activity periods were reviewed and considered for this assessment:

- Fisheries Protection Policy Statement (DFO 2013b)
- Practitioners Guide to Risk Management Framework for DFO Habitat Management Staff (DFO 2006)
- Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO 2013b)
- Alberta Land-Use Framework
- South Saskatchewan Regional Plan
- Restricted Activity Periods

8.1.2 Engagement and Key Concerns

Alberta Transportation carried out an engagement and consultation program for the Project with both the public and Indigenous communities. Engagement summaries are presented in Volume 1, Section 6 and Section 7.

Issues and key concerns related to fish and fish habitat (aquatic ecology) raised by the public included the following:

- inquiries about the annual downstream and upstream fish passage allowance for the in-stream structure on Elbow River
- inquiries about the salvaging of fish and other aquatic organisms from impounded water
- concerns about aquatic wildlife
- inquiries about the costs for fish salvage and debris clean-up after a flood
- construction and associated works could impact gravel spawning beds for salmonids, or scoured pools that provide high quality overwintering habitat for fish.
- other areas of fish habitat within or downstream of the project area have the potential to become degraded during construction, due to sediments being washed into the river where they could settle over sensitive fish habitat such as spawning beds.
- fish migration in Elbow River may be disrupted for a portion of the construction period as the diversion structure is installed within the river channel.

Alberta Transportation's engagement with Indigenous groups began in 2014 with five Indigenous communities. In June 2016, an additional eight Indigenous communities were engaged as outlined in the Canadian Environmental Assessment Agency (CEA Agency) Guidelines. Indigenous engagement has been ongoing prior to and through the environmental impact assessment (EIA) process. Detailed information regarding the Indigenous engagement program is presented in Volume 1 Section 7.

Traditional Land and Resource Use (TLRU) information was gathered through Project-specific Traditional Use Studies (TUS) conducted by potentially affected Indigenous groups and through the results of Alberta Transportation's Indigenous engagement program. As of June 2017, Alberta Transportation had received a project-specific TUS report from Piikani Nation, as well as a joint interim TUS report from Kainai First Nation and Siksika Nation. In addition to project-specific sources, publicly-available literature was reviewed for TLRU information relevant to the Project.

TLRU information has been considered during the preparation of all aspects of the EIA, including both methods and analysis, as stipulated by the CEA Agency project guidelines. TLRU information contributed to the understanding of existing conditions and informed the assessment of potential project effects. While this information did not directly affect the significance definition it has been incorporated into the analysis of effects on which the significance determination was based. This applies equally to effects assessed for construction, dry operations, flood operations and post-flood operations. Generally, issues and concerns related to effects of industrial development on fish and fish habitat, as reported by Indigenous groups and through the review of Project-specific and publicly-available TLRU information, include:

- Spawning may be affected because the section of Elbow River affected by the Project is characterized by gravel spawning beds used by various trout species.
- Overwintering habitat may be affected because the Project area includes scoured pools in Elbow River that currently provide high quality overwintering habitat for fish.
- Fish migration in Elbow River may be disrupted for a portion of the construction period because the diversion structure is installed within the river channel.
- During dry operations, fish may be unable to travel past the diversion structure, impeding their migration.
- Fish could be carried into the diversion structure, and ultimately into the reservoir where they could be stranded when the water is released back into Elbow River.
- The diversion of Highway 22 and construction of bridges could lead to further impacts to fish and fish habitat.
- Temperature changes to Elbow River from water being released from the off-stream reservoir could be harmful to fish.
- Critical fish habitat may be destroyed as a result of changing the flow of Elbow River,

These issues and concerns have been considered in the assessment of potential project effects. Additional information regarding TLRU in relation to fisheries is discussed in Section 14.

The Tsuut'ina Nation expressed concern about the destruction of critical fish and fish habitat, impacts to spawning areas, impacts to over wintering habitat, effects of increased sediment on fish, impacts to fish migration and passage up and down Elbow River, stranding of fish in the reservoir in the event of a flood, how the changes to Highway 22 and the construction of the new bridges may affect fish, water temperature changes due to holding water in the reservoir and potential contamination of water.

The Stoney Nakoda Nation expressed concers about effects on water and wetlands for wildlife, fish, birds, and vegetation. The Stoney Nakoda Nation also expressed concerns that the "proposed SR1 project will drive away or minimize the availability of bird, fish, and wildlife and that the SR1 project will act as a barrier to the migration of wildlife and fish."

The Siksika Nation requested copies of all fish and fish habitat impact information gathered during the site investigations. The Siksika Nation also requested information on how the design of the SR1 is being done to insure during a flood event that the mortality of fish is limited.

The Piikani Nation expressed concern about the stranding of fish in the reservoir during flood events. The Piikani Nation requested copies of all fish and fish habitat impact information gathered during the site investigations. The Piikani Nation also requested information on how the design of the Projectis being done to insure during a flood event that the mortality of fish is limited.

The Kainai First Nation expressed concerns that instream work within Elbow River will impact fish and there could be temporary downstream impacts from project construction. The Kainai First Nation request copies of any fish and fish habitat impact information gathered during the site investigations. The Kainai First Nation request information on how the design of the Project is being done to insure during a flood event that the mortality of fish is limited.

As of January 1, 2018, no project-specific intangible concerns were identified with respect to aquatic ecology.

8.1.3 Potential Effects, Pathways and Measurable Parameters

The focus of this assessment is on effects that have the potential to cause harm to the aquatic environment, that includes fish habitat, as defined in Section 7(2) and Section 8(3) of the *Alberta Water Act* and effects that have the potential to cause *serious harm to fish*. *Serious harm to fish* is defined by the *Fisheries Act* as the death of fish or any permanent alteration to, or destruction of, fish habitat. This applies to work being conducted in or near waterbodies and watercourses that are part of or that support a CRA fishery.

Section 8.1 of the Fisheries Protection Policy Statement states, "the prohibition against *serious harm to fish* applies to fish and fish habitat that are part of or support commercial, recreational or Aboriginal (CRA) fisheries. Section 8.1 define **fish that are part of** and **fish that support** CRA fisheries as:

- **Fish that are part of** commercial, recreational or Aboriginal fisheries are interpreted to be those fish that fall within the scope of applicable federal or provincial fisheries regulations as well as those that can be fished by Aboriginal organizations or their members for food, social or ceremonial purposes or for purposes set out in a land claims agreement.
- **Fish that support** these fisheries are those fish that contribute to the productivity of a fishery (often, but not exclusively, as prey species). The "fish that support" may reside in water bodies that contain the commercial, recreational or Aboriginal fisheries or in water bodies that are connected by a watercourse to such water bodies."For the purposes of this document, the use of the term fish includes **fish that are part of** and **fish that support** CRA fisheries, as defined above.

Serious harm to fish includes:

- the death of fish that may affect the sustainability and ongoing productivity of a CRA fishery;
- a permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish, including fish supporting a CRA fishery, to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes or
- the destruction of fish habitat of a spatial scale, duration, or intensity that fish, including fish supporting a CRA fishery, can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.

DFO's Pathways of Effects (PoE, DFO 2014b) are used to identify potential effects on fish and fish habitat as a result of project activities through known cause-effect relationships. Potential effects identified through the PoE are evaluated for their extent to result in serious harm to fish.

8.1.3.1 Selection of Effects

The following potential project effects are assessed for fish and fish habitat:

- permanent alteration to fish habitat
- destruction of fish habitat
- death of fish

Based on requirements in the *Fisheries Act* and associated policies and regulations, changes in fish habitat may involve quantity (i.e., area) or quality (i.e., productivity), and may affect fish abundance or distribution. The assessment focuses on life history requirements of CRA fish species and available habitat. Changes in fish habitat are measurable as the net change of the quantity and quality of fish habitat from Project activities and works. This recognizes both habitat alterations or losses (e.g., related to infilling), and habitat gains (e.g., related to habitat creation or enhancement) that may have the potential to affect fish abundance or distribution.

Permanent Alteration of Fish Habitat

Permanent alteration of fish habitat includes physical changes (i.e., m^2 extent) to specific habitats, including spawning, rearing, and overwintering, as well access (i.e., staging/holding and migratory) to these habitats. This also includes changes in habitat availability due to the creation of barriers or changes in the flow regime, as well as the potential for adverse effects on habitat quality as a result of sediment deposition (e.g., infilling of substrates or deep pools).

Destruction of Fish Habitat

Destruction of fish habitat includes physical destruction (i.e., areal (m^2) extent) of specific habitats, including spawning, rearing, and overwintering, as well access (i.e., staging/holding and migratory) to these habitats. This also includes changes in habitat availability due to the creation of barriers or changes in the flow regime.

Death of Fish

Death of fish includes the likelihood of direct fatalities from instream work, (e.g., stranding of fish due to diversions or changes in flow), or changes in fish health due to changes in water quality which may lead to lower productivity of a fishery. Fish mortality includes the likelihood of direct mortalities of eggs and fry as well as mature individuals.

Change in risk of physical injury or mortality to may occur directly (e.g., burial, entrainment, impingement) or indirectly (e.g., flow disruptions that result in stranding and desiccation of fish) due to project activities.

Change in fish health can result from potential project effects on water quality related to release of contaminants that may lead to toxicity to fish. Toxins and effluent may be dispersed due to project activities and works. Uptake by fish, either directly or through consumption of contaminated prey, may result in acute or chronic declines in health.

Changes in surface water quality may result from construction, which is addressed in Section 7. For a description of the effects of changes in flow, changes in hydrology/bedload, and changes in turbidity conditions in Elbow River and the low-level outlet, see Section 6. The short-term events of sediment loading on fish are discussed in Section 8.4.2.

8.1.3.2 Selection of Measurable Parameters

Measurable parameters provide the framework for the characterization of the magnitude of potential effects. Assessment of these effects takes into consideration the factors identified in Section 8.1.2. Measurable parameters associated with each of the three potential effects are listed in Table 8-1 and can affect fish through increased localized flows, elevated sediment levels, and habitat alterations or loss.

Measurable parameters for changes to fish habitat have typically defaulted to estimating the areal extent (m^2) of the affected habitat. With the recent changes to the *Fisheries Act*, there is a move toward quantifying the effects to habitat as it relates to the productivity and sustainability of a fishery.

Headings after the Table 8-1 describe in more detail the table entries.

Table 8-1 Potential Effects, Effects Pathways and Measurable Parameters for Aquatic Ecology

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Permanent alteration of fish habitat	• Construction and dry operations could result in permanent alteration of fish habitat as a result of physical alteration of instream and riparian habitats, creation of barriers to fish passage, modification of flows, or deposition of sediment.	• area of altered habitat (m^2) • quality (i.e., productivity) of fish habitat potentially affected • period of time and when habitat is altered • change in water flow • change in water quality • change in food supply (benthic invertebrates)
Destruction of fish habitat	• Construction and dry operations could result in the destruction of fish habitat as a result of physical alteration of instream and riparian habitats, creation of barriers to fish passage, modification of flows, or deposition of sediment.	• areal extent of destroyed habitat (m^2) • change in fish migration or ability to access habitats (e.g. migration barrier) • change in water flow (see Section 6) • change in water quality

Table 8-1 Potential Effects, Effects Pathways and Measurable Parameters for Aquatic Ecology

Potential Environmental Effect	Effect Pathway	Measurable Parameter(s) and Units of Measurement
Death of fish	• Direct and/or indirect activities associated with construction and dry operations could result in fish mortality.	Risk of fish mortalities (all life stages and reduced fecundity) may be either direct measurement or qualitative. • direct mortality from evidence of a fish kill (species, numbers and age class) • change in fish condition which could reduce fish productivity (e.g., produce fewer eggs) • change in water quality such as sediment load or chemical constituents beyond the capacity for fish to survive or maintain productivity (e.g., total suspended sediments (TSS), Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment (CCME)).

Permanent Alteration of Fish Habitat

For permanent alterations in fish habitat, measurable parameters evaluate how productivity may be affected. Habitat parameters are determined both quantitatively (i.e., stream depth and velocity) and qualitatively (i.e., cover and substrate characteristics).

Habitat alterations resulting in sub-lethal effects on fish health may also be considered permanent where the change interferes with a fish life process and, in turn, affects the sustainability and ongoing productivity of a fishery (DFO 2013a, 2014b). Permanent can be either short-term or long-term in duration according to this DFO definition. For example, if instream work occurs during a spawning event and either prevents or reduces spawning success, then this would be described as a permanent alteration of fish habitat even though it may only occur over a two-week period and only as a single event.

Habitat alterations can be measured by:

- areal extent of permanently altered habitat (m^2) including change in habitat structure, wetted area or cover
- changes in food supply (e.g., benthic invertebrates)
- change in flow and passage for fish (see Section 6)
- change in water quality (see Section 7)

Destruction of Fish Habitat

For destruction of fish habitat, measurable parameters include the footprint from the construction activities and infill related to the installation of the diversion inlet and service spillway structures.

Destruction and / or loss of fish habitat are measured by:

- areal extent of destroyed or lost habitat (m^2)
- change in fish migration or ability to access habitats (e.g. migration barrier)
- change in flow (see Section 6)
- changes in water quality conditions with potential effects on abundance and productivity of a fishery (e.g., reduced fecundity) within the PDA (see Section 7)

Death of Fish

Death of fish measurable parameter is the likelihood of physical injury or mortality to fish species that support or are part of CRA fisheries and SAR. Likelihood of harm is a function of fish species distribution, abundance, and life stage relevant to the Project and specific sensitivities of fish to project activities in the LAA. An assessment of harm to fish that are either part of or support CRA fisheries addresses subsection 35(1) of the *Fisheries Act* and section 79 of SARA.

Mortality refers to the killing of fish, at any life stage, by any human activity other than fishing. Changes to fish health may lead to mortality, but are often not directly observed. Changes to fish health can also lead to lower productivity levels in fish such as reduced fecundity or reduced reproductive success.

Change in fish/egg mortality includes the increased risk of direct mortality to individuals (i.e., all life stages) and/or their eggs due to the intensity, duration, and timing of instream work, or through the stranding of fish as a result of a barrier creation such as reduced flows.

For change in fish health as a result of changes in surface water quality, the measurable parameters are observed water quality relative to Canadian Council of Ministers of the Environment (CCME 2002) and AEP (ESRD 2014) guidelines for protection of aquatic life and critical load exceedances (see Section 7). A change in fish health may lead to reduced fecundity, thereby affecting the productivity and sustainability of a fishery. For a description of the effects of a change in water quality in Elbow River and the low-level outlet, see Section 7.

8.1.4 Boundaries

8.1.4.1 Spatial Boundaries

Project Development Area

The PDA is an area of 1,438 ha that is the anticipated boundary that includes affected areas. The PDA includes the physical construction area of 734 ha to be cleared for the construction of the diversion structure, diversion canal, reservoir, berm, low-level outlet, and will contain the project works and related infrastructure, including the berm, weir, and low-level outlet. See Figure 8-1.

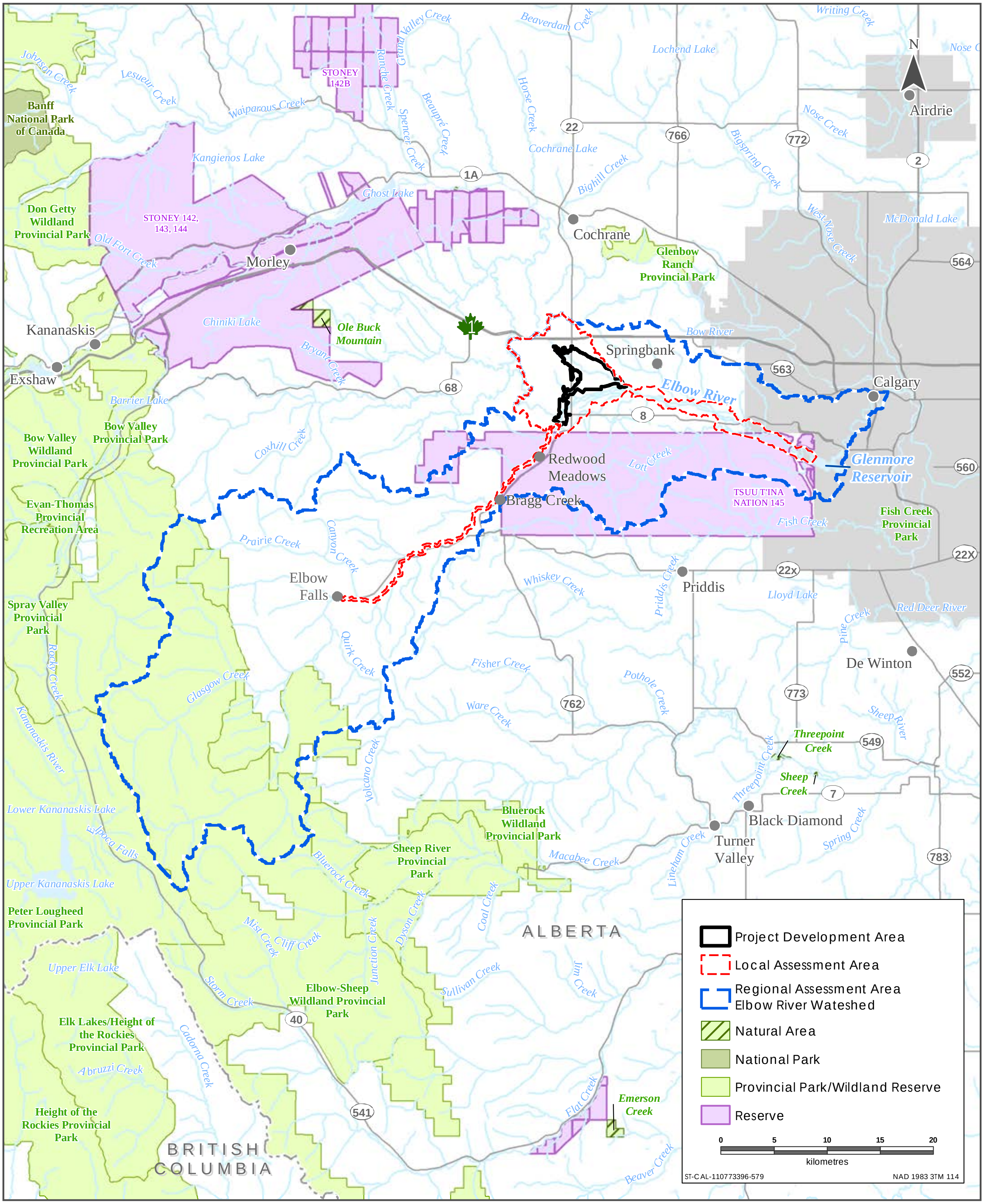
The project design estimates the project footprint within the bankfull width of the Elbow River channel as approximately 4,550 m^2. The footprint includes approximately 2,697 m^2 of work space around the gate structure and approximately 1,853 m^2 of permanent structure in Elbow River, including the gates and apron. This does not include additional temporary space that may be required in the channel for construction of the diversion inlet and service spillway and does not include instream mitigation measures such as boulder clusters.

Local Assessment Area

The LAA (Figure 8-1) for aquatic ecology includes the PDA, but also incorporates drainage basin characteristics and aquatic resources in Elbow River and tributaries that may be affected. The LAA has a total area of 10,364 ha and includes major surface water features including:

- Elbow River from Elbow Falls to the Inlet of Glenmore Reservoir (67 km, ~3,141,144 m^2; AEP 2017b)
- an unnamed tributary (ID 1350) that Highway 22 currently crosses to immediately north of Elbow River
- an unnamed tributary (ID 22259) that drain southeastward from Highway 22.

The LAA includes habitats from the falls to the inlet of the reservoir. The diversion would directly affect fish and fish habitat immediately upstream of the diversion and downstream to the inlet of Glenmore Reservoir. Elbow Falls is an upstream passage barrier and is not considered in the LAA.



Sources: Base Data - ESRI, Natural Earth, Government of Alberta, Government of Canada
Thematic Data - ERBC, Government of Alberta, Stantec Ltd

Fish and Fish Habitat Spatial Boundaries

Figure 8-1

Regional Assessment Area

The regional assessment area (RAA) is the spatial boundary for the cumulative effects assessment (CEA) for the aquatic ecology portion includes the LAA and additionally:

- The Elbow River Watershed, including Glenmore Reservoir
- Springbank Creek (ID 1659) east of the LAA
- a number of small tributaries or ephemeral watercourses (ID 175225, 21129[Pirmez Creek], 24062, 175807, 175792, & 175705).

The RAA has a total area of 125,438.4 ha including the Glenmore Reservoir. The Glenmore Reservoir is a lentic type habitat with water levels managed by the City of Calgary. These habitats differ from the upstream lotic habitat types observed in Elbow River and its tributaries. The reservoir and the lentic habitats are managed and fluctuate during flow events and water use by the City. The Elbow River watershed in the RAA has approximately 385 km of channel upstream of the Glenmore Reservoir, and approximately 6,560,646 m^2 of fish habitat (based on bankfull width; AEP 2017b)

8.1.4.2 Temporal Boundaries

Project construction would take place over a 36-month period. Assuming regulatory approval by Q4 2018, construction would commence in Q1 2019. By Q4 2020, the Project would be able to accommodate a 1:100 year flood. Construction would be complete by Q1 2022 at which time the Project would be able to accommodate water volumes equal to the 2013 flood. Dry operations will occur indefinitely (i.e., permanent installation) after construction, with periods of dry operations alternating with flood and post-flood phases.

8.1.5 Residual Effects Characterization

Table 8-2 presents definitions for residual environmental effects and criteria for aquatic ecology. The criteria describe the potential residual effects on aquatic ecology that remain after mitigation measures, including habitat offsetting, have been implemented.

Table 8-2 Characterization of Residual Effects on Aquatic Ecology

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	Positive – a residual effect that changes measurable parameters in a direction beneficial to aquatic ecology relative to existing conditions. Adverse – a residual effect that changes measurable parameters in a direction detrimental to aquatic ecology relative to existing conditions. Neutral – no net change in measurable parameters for the aquatic ecology relative to existing conditions.
Magnitude	The amount of change in measurable parameters or the VC relative to existing conditions	Negligible – no measurable change in habitat quality or quantity based on observations of habitat conditions Low – a qualitative change but within the range of natural variability (change in habitats relative to range of habitat rankings observed for existing conditions). Will not affect extent of available habitat. Moderate – change outside the range of natural variability of habitat quality and quantity based on habitat rankings and observations of habitat conditions High – change that exceeds the range in natural variability based on habitat rankings and observations of habitat conditions. Qualitative loss of habitat quality and quantity relative to existing conditions may affect long-term population viability through changes in available habitat
Geographic Extent	The geographic area in which a residual effect occurs	PDA – residual effects are restricted to the PDA LAA – residual effects extend into the LAA RAA – residual effects interact with those of other projects in the RAA
Frequency	Identifies how often the residual effect occurs and how often during the Project or in a specific phase	Single event Multiple irregular event – occurs at no set schedule Multiple regular event – occurs at regular intervals Continuous – occurs continuously
Duration	The period of time required until the measurable parameter or the VC returns to its existing condition, or the residual effect can no longer be measured or otherwise perceived	Short-term – residual effect lasts for several days Medium-term – residual effect extends through several months Long-term – residual effect extends through more than one year Permanent – the effect extends for the life of the Project

Table 8-2 Characterization of Residual Effects on Aquatic Ecology

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	Pertains to whether a measurable parameter or the VC can return to its existing condition after the project activity ceases	Reversible – the residual effect is likely to be reversed after activity completion and reclamation Irreversible – the residual effect is unlikely to be reversed
Ecological and Socio-economic Context	Existing condition and trends in the area where residual effects occur	Undisturbed – area is relatively undisturbed or not adversely affected by human activity Disturbed – area has been substantially previously disturbed by human development or human development is still present
Timing	Periods of time where residual effects from Project activities could affect the VC	Seasonality – residual effect is greater in one season than another (e.g., spring/summer vs. fall/winter) Time of day – residual effect is greater during daytime or nighttime Regulatory – provincial or federal restricted activity periods or timing windows (e.g., migration, breeding, spawning) related to the VC Not applicable – the residual effect of Project activities will have the same effect on the VC, regardless of timing

8.1.6 Significance Definition

Thresholds for significance of residual effects are defined in consideration of applicable federal and provincial regulatory requirements, standards, objectives, and guidelines to reflect the limits of an acceptable state of a fishery as defined by the *Fisheries Act* or any fish species designated under Schedule 1 of SARA. Significance thresholds address subsections 35(1) and 36(3) of the *Fisheries Act*, section 79 of SARA, and the Fisheries Protection Policy Statement (DFO 2013b). In consideration of the *Fisheries Act*, net loss of fish habitat would be assessed as a significant adverse effect (i.e., permanent alteration to or destruction of CRA fish habitat that cannot be offset). A residual effect is rated as either not significant or significant.

A significant adverse environmental effect on aquatic ecology is one that results in:

- permanent alteration of fish habitat that likely results in serious harm to fish and cannot be mitigated or offset or
- destruction of fish habitat that likely results in serious harm to fish and cannot be mitigated or offset or
- serious harm to fish due to the death of fish

8.1.6.1 Permanent Alteration to Fish Habitat

This refers to alteration of fish habitat that is of a spatial scale, duration, or intensity that it limits or diminishes the ability of fish to use or rely upon, such habitats for spawning, nursery, rearing, food, migration, or to carry out one or more other life processes affecting the productivity and sustainability of a fishery. Such changes would likely cause serious harm to fish If the results of this change in fish habitat cannot be mitigated or offset.

8.1.6.2 Destruction of Fish Habitat

Destruction of fish habitat prevents fish use of such habitats for spawning, nursery, rearing, food, migration, or to carry out one or more other life processes affecting the productivity and sustainability of a fishery. Such destruction would likely result in serious harm to fish if the results of this destruction of fish habitat cannot be mitigated or offset. Destruction of fish habitat includes barriers that prevent fish from accessing habitat.

8.1.6.3 Death of Fish

This refers to the likelihood of fish mortality (including eggs), or reductions in fish health, after mitigation measures are implemented. Such changes would occur at a level that reduces the productivity and sustainability of a fishery and cannot be offset.

8.2 EXISTING CONDITIONS FOR AQUATIC ECOLOGY

A review of aquatic ecology in Elbow River is documented in Volume 4, Appendix M, Aquatic Ecology Technical Data Report. This section is a summary of information provided there.

8.2.1 Methods

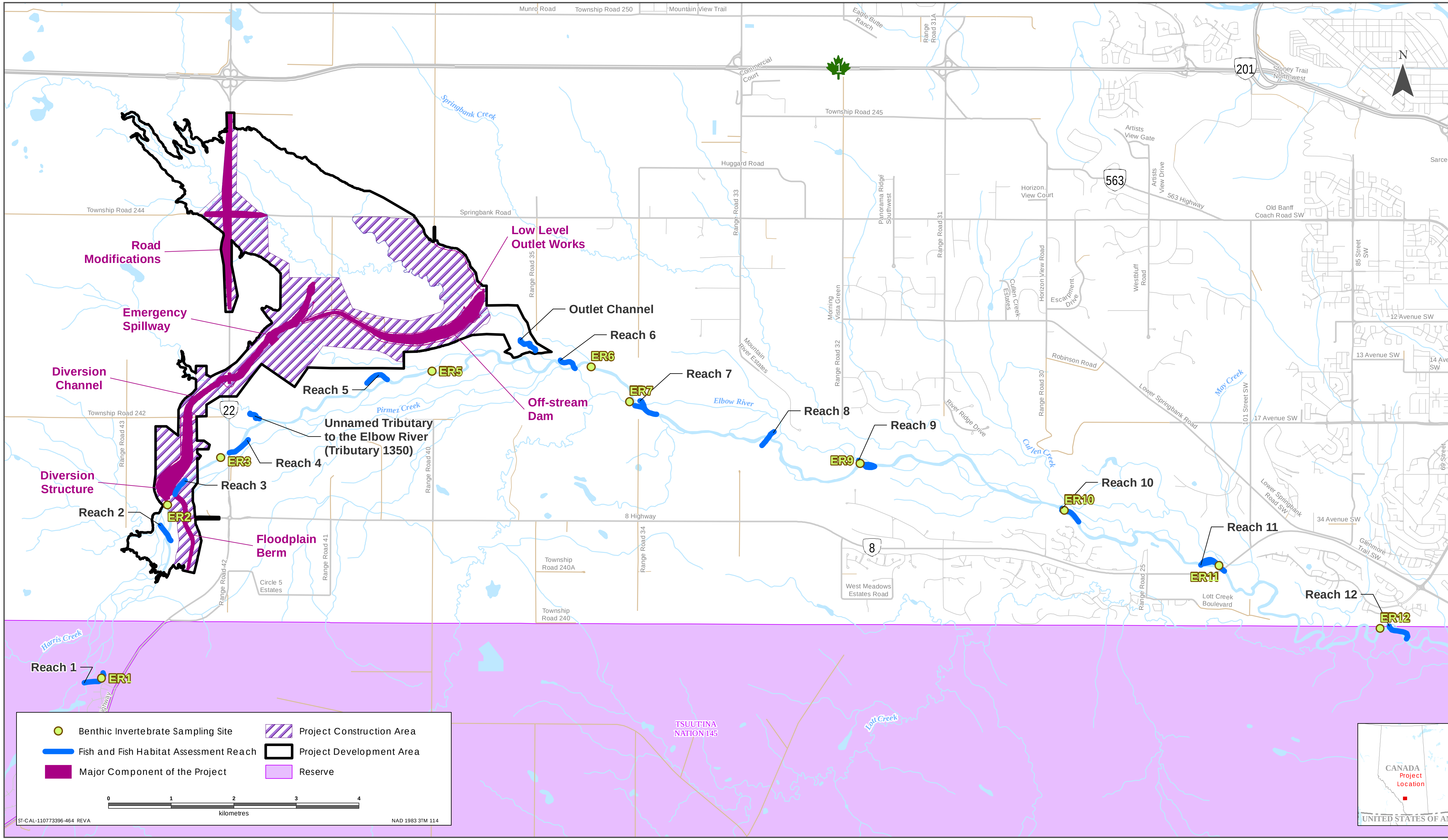
A review of existing information was conducted to provide historical context and field investigations were completed for the Project. For data sources and data processing methods, see Volume 4, Appendix M, Aquatic Ecology Technical Data Report.

8.2.1.1 Background Research

The existing fish and other aquatic resources (e.g., algae and benthic invertebrates) is described in Volume 4, Appendix M, Aquatic Technical Data Report. The review of aquatic resources was used to identify species composition, species at risk, distribution, relative abundance, status, movements, habitat use and life history parameters.

8.2.1.2 Field Survey Methods

Fish and fish habitat data were collected at 12 Elbow River reaches and within local tributary sites; benthic invertebrate sampling was conducted at 10 sites located within or adjacent to fish and fish habitat surveyed reaches. The Elbow River reaches and invertebrate sampling sites are shown in Figure 8-2.



Sources: Base Data - Government of Alberta, Government of Canada. Thematic Data - Stantec Ltd.

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Fish and Fish Habitat Assessment Reaches and Benthic Invertebrate Sampling Sites

Figure 8-2

For field survey methods, see Volume 4, Appendix M, Aquatic Technical Data Report.

8.2.1.3 Fish Passage Assessment

A fish passage flow analysis was conducted to identify two types of flows; the 3 day, 10 year maximum daily mean flow (3Q10max), and the 3 day, 10 year minimum daily-mean flow (minimum flow) (3Q10min) four biologically sensitive periods. At each of these four periods, hydraulic modeling was completed to assess the water velocity and depth in Elbow River during existing conditions and the after the construction of the proposed project. Resultant water velocities and depths were then compared to fish swim speeds and suitable depths for migration. For further information on flows used during the fish passage analysis, see Appendix M, Attachment A.

8.2.2 Overview

Elbow River flows from the headwaters (Elbow Lake) in the Rocky Mountains, for approximately 100 km, to the confluence with the Bow River in the City of Calgary.

The river has three major channel sections separated by two impassible barriers for fish movement: the section above Elbow Falls; Elbow Falls to Glenmore Reservoir; and below Glenmore Reservoir to the confluence with the Bow River.

Major surface water features in the LAA are:

- Elbow River
- an unnamed tributary to Elbow River (ID 1350) that Highway 22 currently crosses immediately north of Elbow River
- an unnamed tributary of Elbow River (ID 2259) that drains southeastward from Highway 22. During construction, this tributary would be designed to function as the low-level outlet

Based on a review of satellite imagery (ESRI 2014) and historical fish habitat information (ESRD 2012), tributaries to Elbow River in the LAA appear to be ephemeral (seasonal) in nature and are unlikely to contain sensitive or life stage dependent fish habitat. This observation is further supported by the Class D (low sensitivity) designations of the unnamed tributaries to Elbow River (2259 and 1350), under the COP for Watercourse Crossings (ESRD 2013). However, lower reaches of the tributaries (i.e., within 2 km of Elbow River) may support Elbow River fisheries and those habitats are accordingly designated Class C under the Code (ESRD 2013). No historical fish records were identified from these Elbow River tributaries (ESRD 2014).

Suitable spawning, rearing, food production, migration, and overwintering habitats for Elbow River representative fish species (i.e., brown trout, rainbow trout, mountain whitefish, and white sucker) are present in the LAA.

For a description of existing turbidity conditions in Elbow River and the low-level outlet based on continuously collected data since 2015, see Section 6.

For a description of existing water quality conditions in Elbow River and the low-level outlet, see Section 7.

8.2.2.1 Fishery

Details on use of the fishery can be found in the Section 12. Use by Indigenous groups of the fishery is discussed in Section 14.

Elbow River supports a recreational fishery that has been a part of known local and national fishing culture from the early 1900s. Mitchell and Prepas (1990) indicated that the Glenmore Reservoir is a popular sport fishing location for northern pike, trout, and perch. McLennan (1996) indicated that Elbow River is an “underrated and underfished stream” that holds good-sized bull and brown trout. There are no known commercial fisheries on Elbow River, nor are there commercial fishing licenses on any lakes within the LAA or RAA (AEP 2018).

Sport Fish

Sport fish are targeted by recreational anglers, as well as desired in commercial and Aboriginal fisheries. These fish species are typically desired for their taste or ability to fight. There are often specific regulations in each jurisdiction regarding the recreational harvest and pursuit of these species (e.g., trout, pike). Sport fish in Elbow River include the *Salmonidae* (trout and whitefish), *Esocidae* (pike), *Gadidae* (cod), and *Percidae* (perches and darters). Sport fish are generally at a high trophic level and include from piscivorous specialists, such as bull trout, and trophic generalists, such as brown trout. Details on sport fish species in the LAA can be found in Volume 4, Appendix M, Aquatic Technical Data Report.

Coarse Fish

Coarse fish are species of fish often not sought after for recreational angling, but valuable for subsistence fisheries. Typically, large bodied fish such as suckers, some coregonids, and large cyprinids (e.g., common carp, pikeminnows). These fish are often caught during netting events and used to support commercial and subsistence fisheries where they are present. Coarse fish in Elbow River include the *Catostomidae* (suckers). Details on sucker species and habitat use in the LAA can be found in Volume 4, Appendix M, Aquatic Technical Data Report.

Forage Fish

These species are generally small-bodied fish that are typically not harvested for subsistence. Forage fish species are defined by DFO as: “a species which is below the top of an aquatic food chain, is an important source of food for at least some predators, and experiences high predation mortality" (DFO 2009). In riverine ecosystems, they are important for transferring energy from lower trophic levels up the food chain to the higher levels. Because many higher trophic feeders (piscivores) (such as bull trout, rainbow trout and northern pike) require a forge fish prey base, it is assumed that the presence of piscivorous fish indicates suitable habitats for forage fish. Generally, they can be more adaptable to a larger range of environmental conditions and less sensitive to perturbations in water quality, such as temperature and turbidity.

Forage fish communities in Alberta can be broken down into simple and complex. Simple forage fish communities might consist of a single species that is very resilient to changes in its environment, such as brook stickleback or fathead minnows. Complex forage fish communities can be very sensitive to changes in their environment. Fish such as longnose dace and sculpin species require clean cold water and clean substrates. Fish such as the western silvery minnow, while forage fish species, are protected under the federal *Species at Risk Act*. Forage fish in Elbow River include species *Cyprinidae* (minnows), *Gasterosteidae* (stickleback), and *Percopsidae* (trout-perch).

8.2.2.2 Fish Habitat

As Elbow River flows towards Glenmore Reservoir. The river and its tributaries transition from a steep, generally single-channel mountain stream with pool-riffle sequences to a weakly braided/wandering pattern contained within a broad floodplain with low gradients and typically poorly-defined tributaries. Elbow River in the LAA is an irregularly meandering channel with sediment deposition across a wide valley. Elbow River is one of the steepest rivers over the average length, in Alberta (Kellerhals et al. 1972), with an overall gradient of approximately 0.9% (Figure 8.2-1). The steepest gradients are in the headwaters upstream from Elbow Falls (upstream from the LAA) at approximately 1.54%. Between Elbow Falls and Bragg Creek, the gradient decreases to less than 0.8%. Where Elbow River transitions to the Alberta Plains near the project site, gradients decrease to 0.4%. The gradients further decrease to approximately 0.2% where Elbow River enters Glenmore Reservoir (Figure 8.2-1).

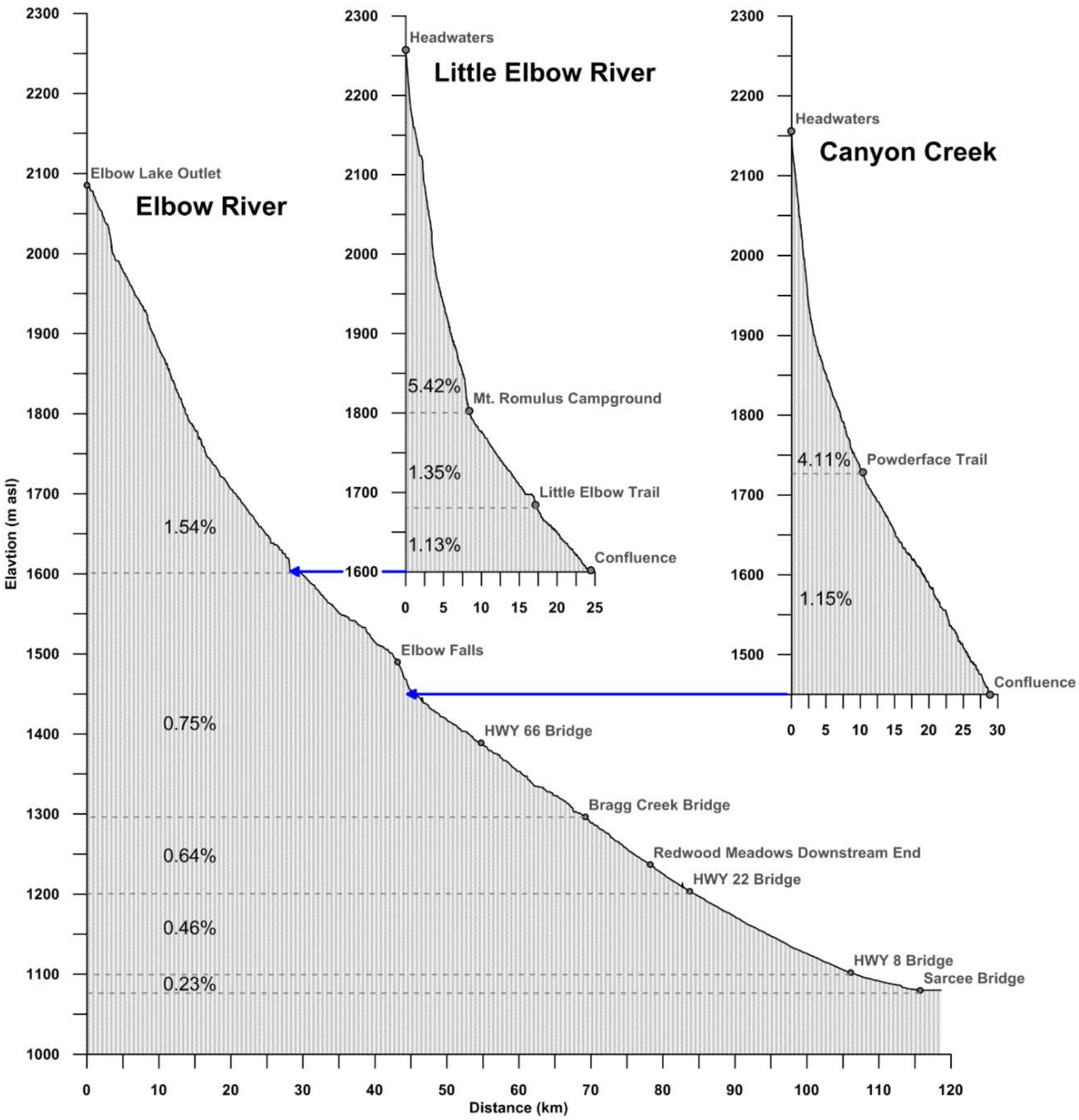


Figure 8.2-1 Gradient of Elbow River and Major Tributaries

The substrate reflects the averaged substrate size within each survey, and then is averaged across the three river sections, upstream of Elbow Falls, Elbow Falls to the project site and downstream of project site. Cobbles dominate the substrate in Elbow River above the project site, while the lower gradient below the project site has resulted in more fine material, including silt and sand, on the bed of the river (Table 8.2-1).

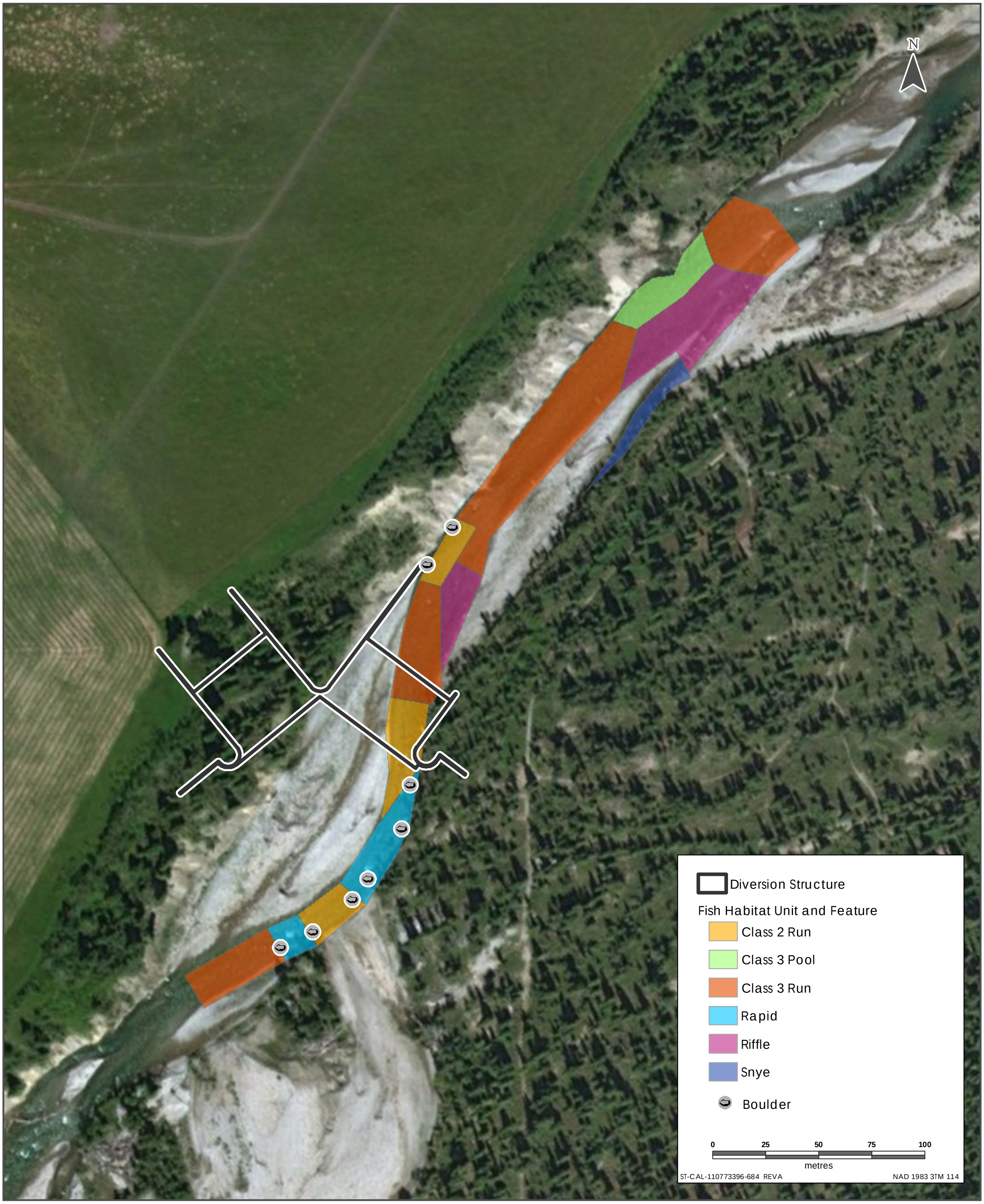
Table 8.2-1 Average Substrate Composition by Percent of Each River Segment

River Section	Fines	Small Gravels	Large Gravels	Cobbles	Boulders	Bedrock
Above Elbow Falls	5.2	1.5	23.0	52.8	0.48	0.48
Elbow Falls to SR1	3.38	5.1	9.8	54.3	0.50	0.50
Below SR1	39.4	17.3	4.6	37.2	0.19	0.19
SOURCE: AEP 2017b						

Aquatic ecology field work was conducted in the fall of 2016 (see Figure 8.2-2). Habitat at the diversion structure consists of a slight meander with deeper run on the east, outside bend and shallower riffle on the inside of the bend (Figure 8.2-2). Rapids break up the channel at locations of steeper gradient. Details on the habitat at the diversion location are presented in the description of Reach 3 in the Aquatic Ecology Technical Data Report (Volume 4, Appendix M). Coarse substrate dominates the reach, with boulders providing instream cover throughout the run. On the east inside bend, there is a side channel that cuts through the alluvial material of the gravel point bar. High valley walls border the channel with coniferous vegetation dominant in upland species, while shrubs and grasses dominate the riparian zone.

The river downstream of the diversion site consists of infrequent islands and occasional sediment bars with channel widths ranging from 13 m to 100 m and channel depths ranging from 0.1 m to 1.2 m. Fish habitat in Elbow River is rated as primarily "good" run habitats, interspersed with riffle and pool habitats. Overhead is related to undercut banks and overhanging vegetation. Instream cover is mostly woody debris and large-sized substrate (boulder and cobble). Substrate composition throughout this downstream reach of Elbow River consists of cobble and pebble, with smaller amounts of gravels and sand.

Within Elbow River reaches sampled in 2016, spawning, overwintering, and rearing habitats are rated as moderate-good for 8 of 12 reaches. Habitat is rated as poor-moderate for four reaches, including Reach 1 and 2, located upstream of Highway 22, and downstream in Reaches 9 and 10.



Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Fish Habitat Map for the Elbow River at the Proposed Diversion Site

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Figure 8.2-2

The lack of spawning habitat for forage fish may limit spawning potential in Reaches 1 and 2. High velocities may limit spawning habitat for species in Reaches 9 and 10. The lack of pools and high channel velocities, limit overwintering habitat for fish species in Reaches 1, 2, 9, and 10.

In Reaches 1, 2, and 10, rearing habitat is limited by lack of bank cover features, habitat diversity, and complexity.

Migration is rated as good throughout 12 reaches in Elbow River with no obstructions to fish movement. The habitat surveys conclude that overall, Elbow River in the LAA provides good habitat for forage, coarse, and sport fish. Details regarding habitat characteristics are in Volume 4, Appendix M, Aquatic Ecology Technical Data Report.

Periphytic algal density is limited at the sites sampled in Elbow River upstream of Highway 22, but was observed at moderate densities in downstream sites. Site ER10 (Reach 10, located just downstream of the Glencoe Golf Course) had a moderate to heavy growth of periphytic algae.

Two tributaries to Elbow River had defined channels with standing pools of water and no flow during September–October 2016. Both tributaries had poor habitat for fish and likely provide run, riffle, and pool habitats in the lower reaches during spring freshet or elevated rain events.

A summary table of the fish and fish habitat data collected from the reaches are presented in Aquatic Ecology Technical Data Report (TDR) (Volume 4, Appendix M), Section 6.6.1.1. Fish and benthic field data, including representative site photographs showing habitat features at the time of the assessment, are provided in the TDR in Sections 6.6.1.2 and 6.6.2.1.

8.2.2.3 Fish Species

Elbow River in the RAA contains a variety of fish species, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), bull trout (*Salvelinus confluentus*), burbot (*Lota lota*), cutthroat trout (*Oncorhynchus clarkii*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), white sucker (*Catostomus commersonii*), longnose sucker (*Catostomus catostomus*), and mountain sucker (*Catostomus platyrhynchus*). Details on fish species in the LAA are presented in the Aquatic Ecology Technical Data Report (TDR) (Volume 4, Appendix M). Bull trout and cutthroat trout are considered species of conservation concern in Alberta (ESRD 2012 GOC 2017a; COSEWIC 2012). Table 8-3 lists fish species in the RAA and their provincial and federal status. Table 8-4 lists fisheries resources in the RAA identified through Indigenous engagement.

Table 8-3 Status of documented fish species in the LAA in Elbow River between Elbow Falls and the Glenmore Reservoir

Species Information				Legislated Protection		Scientific Review or Recommendation	
Family[1]	Common Name[1]	Scientific Name[1]	Species Code	*SARA*[2] (Federal)	*Wildlife Act*[3] (Provincial)	COSEWIC[4] (Federal)	General Status[5] (Provincial)
Catostomidae (suckers)	longnose sucker	*Catostomus catostomus*	LNSC	No status	Not listed	Not assessed	Secure
	mountain sucker (Saskatchewan River populations)	*Catostomus platyrhynchus*	MNSC	No status	Not listed	Not at risk	Secure
	white sucker	*Catostomus commersonii*	WHSC	No status	Not listed	Not assessed	Secure
Cyprinidae (carps and minnows)	fathead minnow	*Pimephales promelas*	FTMN	No status	Not listed	Not assessed	Secure
	lake chub	*Couesius plumbeus*	LKCH	No status	Not listed	Not assessed	Secure
	longnose dace	*Rhinichthys cataractae*	LNDC	No status	Not listed	Not assessed	Secure
	pearl dace	*Margariscus margarita*	PRDC	No status	Not listed	Not assessed	Undetermined
	spottail shiner	*Notropis hudsonius*	SPSH	No status	Not listed	Not assessed	Secure
Esocidae (pikes)	northern pike*	*Esox lucius*	NRPK	No status	Not listed	Not assessed	Secure
Gadidae (cods)	burbot*	*Lota*	BURB	No status	Not listed	Not assessed	Secure
Gasterosteidae (sticklebacks)	brook stickleback	*Culaea inconstans*	BRST	No status	Not listed	Not assessed	Secure
Percidae (perches and darters)	yellow perch*	*Perca flavescens*	YLPR	No status	Not listed	Not assessed	Secure
Percopsidae (trout-perches)	trout-perch	*Percopsis omiscomaycus*	TRPR	No status	Not listed	Not assessed	Secure

Table 8-3 Status of documented fish species in the LAA in Elbow River between Elbow Falls and the Glenmore Reservoir

Species Information				Legislated Protection		Scientific Review or Recommendation	
Family[1]	**Common Name[1]**	**Scientific Name[1]**	**Species Code**	***SARA*[2] (Federal)**	***Wildlife Act*[3] (Provincial)**	**COSEWIC[4] (Federal)**	**General Status[5] (Provincial)**
Salmonidae (trout, char, salmon and whitefish)	brook trout*	*Salvelinus fontinalis*	BKTR	No status	Not listed	Not assessed	Exotic/alien
	brown trout*	*Salmo trutta*	BNTR	No status	Not listed	Not assessed	Exotic/alien
	bull trout* (Saskatchewan - Nelson Rivers populations)	*Salvelinus confluentus*	BLTR	No status	Threatened	Threatened	Sensitive
	mountain whitefish*	*Prosopium williamsoni*	MNWH	No status	Not listed	Not assessed	Secure
	rainbow trout*	*Oncorhynchus mykiss*	RNTR	No status	Not listed	Not assessed	Secure
	Westslope Cutthroat trout*[6]	*Oncorhynchus clarkii lewisi*	WSCT	Threatened	Threatened	Threatened	At risk

NOTES:

1 Common and Scientific Names of Fishes from the United States, Canada, and Mexico (Page et al. 2013)

2 Species at Risk Act (SARA 2002) (GoC 2017a)

3 Wildlife Act – Wildlife Regulation (1997)

4 Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (GoC 2017b)

5 General Status of Alberta Wild Species (ESRD 2012)

6 Cutthroat trout in the mainstem of Elbow River are not genetically pure populations of Westslope Cutthroat trout (Oncorhynchus clarkii lewisi) due to hybridization with rainbow trout. As such, cutthroat trout (hybrids) in the LAA are not classified under the SARA, Alberta's Wildlife Act, or the General Status of Alberta Wild Species.

* Denotes sportfish species

Table 8-4 Traditional fisheries resources within the Regional Assessment Area[1]

Species	Indigenous Group												
	Kainai First Nation	Ermineskin Cree Nation	Foothills Ojibway First Nation	Ktunaxa First Nation	Louis Bull Tribe	Métis Nation of Alberta, Region 3	Métis Nation British Columbia	Montana First Nation	Piikani First Nation	Samson Cree Nation	Siksika Nation	Stoney Nakoda Nations	Tsuut'ina Nation
Burbot		✓		✓			✓					✓	
Minnow (various species)				✓									
Perch		✓				✓				✓			
Northern Pike		✓		✓		✓	✓			✓		✓	
Trout (including bull, cutthroat, rainbow)	✓	✓		✓	✓		✓	✓		✓		✓	
Sucker		✓		✓	✓		✓	✓		✓		✓	
Mountain Whitefish		✓		✓	✓	✓	✓	✓		✓		✓	

NOTE:
[1] For details, see Volume 3A, Section 14.2.4, Traditional Land and Resource Use

Fish Species at Risk

Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) is protected under Schedule 1 as *threatened* under *SARA* (2002); listed as *threatened* under the Alberta *Wildlife Act*; and *at risk* under Alberta's General Status of Wild Species 2015 (AEP 2017a). Westslope cutthroat trout are generally found in cold, high elevation and with well-connected, structurally diverse habitat that maintain relatively consistent water flows. Genetically pure (non-hybridized with rainbow trout) Westslope cutthroat trout stocks are not expected to be present in the LAA, downstream of Bragg Creek, given the presence of introduced rainbow trout and the low-gradient habitat that is more suitable for rainbow trout and brown trout.

Bull trout are listed as *threatened* under the Alberta *Wildlife Act* and as *at risk* in Alberta's General Status of Wild Species 2015 (AEP 2017a). Based on redd survey data, bull trout spawning populations appear to fluctuate in the Elbow River mainstem (ASRD 2012) with the population at high risk, with a moderate recovery potential. Bull trout are commonly found in the upper Elbow River above Elbow Falls and redd surveys indicate spawning sites between Canyon Creek and Elbow Falls (ASRD 2012); however, bull trout are uncommon in the lower gradient sections near the diversion structure, as well as further downstream (AEP 2017b). Bull trout are generally found in cold, high-elevation streams with access to suitable pools or connected water bodies for overwintering. Bull trout spawning usually occurs in late August through September, over coarse substrates in areas influenced by groundwater (Nelson and Paetz 1992; Scott and Crossman 1998; ASRD/ACA 2009).

Clipperton (et al. 2003), indicates a number of biologically significant periods (BSPs) for fish species of value in the Bow River between the WID weir and the Carselend Weir. Katapodis (2003) undertook a case study review of instream flow modelling for fish habitat in prairie rivers, including a look at the Highwood IFN (Clipperton et al. 2002). The BSP are adapted from Clipperton et al. (2002), Clipperton et al. (2003), and Katapodis (2003), which identify Bow River BSPs and the BSPs from the Highwood River drainage (this drainage has similar climatic and temperature conditions as Elbow River). This information is based on migration timing and fish spawning periods (Table 8-5) in Elbow River. Each of the BSPs have an associated 3-day, 10-year maximum daily mean flow (3Q10max) and 3-day, 10-year minimum daily-mean flow (minimum flow) (3Q10min) (See Volume 4, Appendix M, Attachment A).

Table 8-5 Migration and Spawning Period and Habitat of Selected Fish in Elbow River

Species	Upstream Migration Times	Spawning Period	Riverine Spawning Habitats	Rearing Habitats	Overwintering Habitats
Burbot	Dec – Jan	Jan – Feb	Deep pools	Large coarse substrates, undercuts, woody debris, and vegetation mats (Langhorne et al. 2001)	Deep low velocity areas
Northern pike	April	April - May	Emergent and submergent vegetation	Nearshore areas of lakes and rivers, but generally require vegetation and cover, and are almost always found near either emergent vegetation or boulders (Langhorne et al 2001)	Deep low velocity areas (Inskip 1982)
Rainbow trout	March – May	April - June	Riffles and runs with gravel and cobble substrates	Roots, boulders, logjams, riffles, undercuts, Prefer pool margins, interstitial space between rocks, shallow rocky substrate, margins of river (Nelson and Paetz 1992)	Deeper pools, upwellings
Cutthroat trout (hybrids)	April – June	April - July	Riffles and runs with gravel and cobble substrates	Slower backwaters with woody debris, boulders, or overhanging vegetation for cover	Pools, upwellings
Sucker species	May – June	May – July	Broadcast spawning within shallow, gravel-bottom sections of streams, such as riffles. Runs with gravel and cobble substrates, inlet and outlet of pools, shoals.	Large coarse substrates and submergent and emergent vegetation	Large, deep pools
Bull trout	July – Aug	Sept - Oct	Riffles and runs with gravel and cobble substrates	shallow, slower water with interstitial cover, moving to deeper water as they age	Larger pools and deeper water

Table 8-5 Migration and Spawning Period and Habitat of Selected Fish in Elbow River

Species	Upstream Migration Times	Spawning Period	Riverine Spawning Habitats	Rearing Habitats	Overwintering Habitats
Brook trout	Sept	Sept - Oct	Riffles and runs with small gravel substrates, most likely in tributaries	Prefer extensive overhead cover and woody debris in shallow areas (Roberge et al. 2002)	Pools and areas of upwellings
Mountain whitefish	Sept	Sept – Oct	Runs with coarse substrates, inlet and outlet of pools, shoals.	Shallow backwaters and side channel, and near large woody debris cover in shallow areas (R.L. & L. Environmental Services Ltd. 1996)	Well oxygenated deep, larger pools
Brown trout	October	Oct – Nov	Riffles and runs with gravel and cobble substrates	Large woody debris, undercut banks in slower water	Deeper pools and larger water

The BSPs and the minimum and maximum flows during each BSP for Elbow River are:

- **BSP-1**: 02 April – 15 June (bull trout: incubation, fry, juvenile, adult brown trout: fry, juvenile, adult; rainbow trout: incubation, fry, juvenile, adult, migration, spawning; mountain whitefish: fry, juvenile, adult)
  - 3Q10min**:** 2.8 m^3/s, 3Q10Max: 75.7 m^3/s
- **BSP-2**: 16 June – 25 September (bull trout: migration, spawning, incubation, juvenile, adult; brown trout: fry, juvenile, adult; rainbow trout: incubation, fry, juvenile, adult; mountain whitefish: fry, juvenile, adult)
  - 3Q10min**:** 3.47 m^3/s, 3Q10Max: 69.5 m^3/s
- **BSP-3**: 26 September – 01 December (bull trout: incubation, adult, migration, spawning; brown trout: incubation, fry, juvenile, adult, migration, spawning; rainbow trout: fry, juvenile, adult; mountain whitefish: incubation, fry, juvenile, adult, spawning)
  - 3Q10min**:** 2.38 m^3/s, 3Q10Max: 15 m^3/s
- **BSP-4**: 02 December – 01 April (bull trout: incubation, fry, adult; brown trout: incubation, fry, juvenile, adult; rainbow trout: fry, juvenile, adult; mountain whitefish: incubation, fry, juvenile, adult)
  - 3Q10min**:** 0.8 m^3/s, 3Q10Max: 9.81 m^3/s

Four fish species and benthic invertebrate metrics were chosen as indicators of aquatic ecology and habitat quantity and quality in Elbow River (Table 8-6). The selected fish species represent species using typical mid-sized river coldwater ecosystems in Alberta, including introduced sport fish, spring and fall spawners, broadcast spawners, and a top trophic level piscivores. Cutthroat trout in Elbow River have become hybridized with rainbow trout and are not present as a genetically pure cutthroat trout population. Therefore, rainbow trout, which are more common at and below the diversion structure, are selected as an indicator species. Several benthic invertebrate metrics were chosen to assess the community structure and biodiversity in Elbow River (Table 8-6).

Table 8-6 Aquatic Key Indicator Species and Metrics

Species/Metric	Rational
Bull trout	Native, migratory piscivore
Rainbow trout	Non-native, spring spawning top level trophic species.
Brown trout	Non-native, fall spawning top level trophic species (trophic generalist)
Mountain whitefish	Native, fall spawning, broadcast spawning, mid-level trophic species
Benthic Invertebrate - Richness	Number of species, a measure of community composition – can decrease with stressors
Benthic Invertebrate - Density	Relative abundance of organisms – can increase or decrease with stressors
Benthic invertebrate – EPT Index	Percent of the total community made up of the EPT (intolerant species, sensitive to change)
Benthic Invertebrate - % Chironomidae and % Oligochaeta	Percent of the total community made up of the Chironomidae and Oligochaeta (tolerant species, less sensitive to change)
EPT/Chironomidae ratio	The ratio of the density of the intolerant EPT to the generally tolerant Chironomidae
Simpson's Evenness Ratio (SEI)	SEI expresses how evenly organisms are distributed in the community (calculated by the proportion of total organisms contributed by each taxon). A SEI value of 1 indicates that there are equal numbers of individuals of each species, while a lower value, as in this case, indicates that some species have higher numbers of individuals than other species.
Simpson's Diversity Index (SDI)	SDI uses both abundance and taxonomic diversity to estimate species richness of the community (calculated by the proportion of total organisms contributed by each taxon). A higher SDI, relative to a lower value, indicates that a site has a more diverse community

8.2.2.4 Fish Distribution and Relative Abundance

The distribution and relative abundance of fish species is based on 155 electrofishing events over 37 years available (Table 8.2-2) in Alberta Environment and Parks' (AEP) online Fisheries and Wildlife Management Information System (FWMIS) database (AEP 2017b).

Table 8.2-2 Electrofishing Records Available from Elbow River Upstream of Glenmore Reservoir

Area	Number of Electrofishing Surveys	Sampling Dates
Above Elbow Falls	23	1978-2011
Elbow Falls to SR1	75	1978-2014
Below SR1	57	1988-2015
Total	**155**	**1978-2015**
SOURCE: AEP 2017b		

The relative abundance in Elbow River is calculated by the percent of the catch per unit effort of the electrofishing sampling events (Figure 8.2-3)

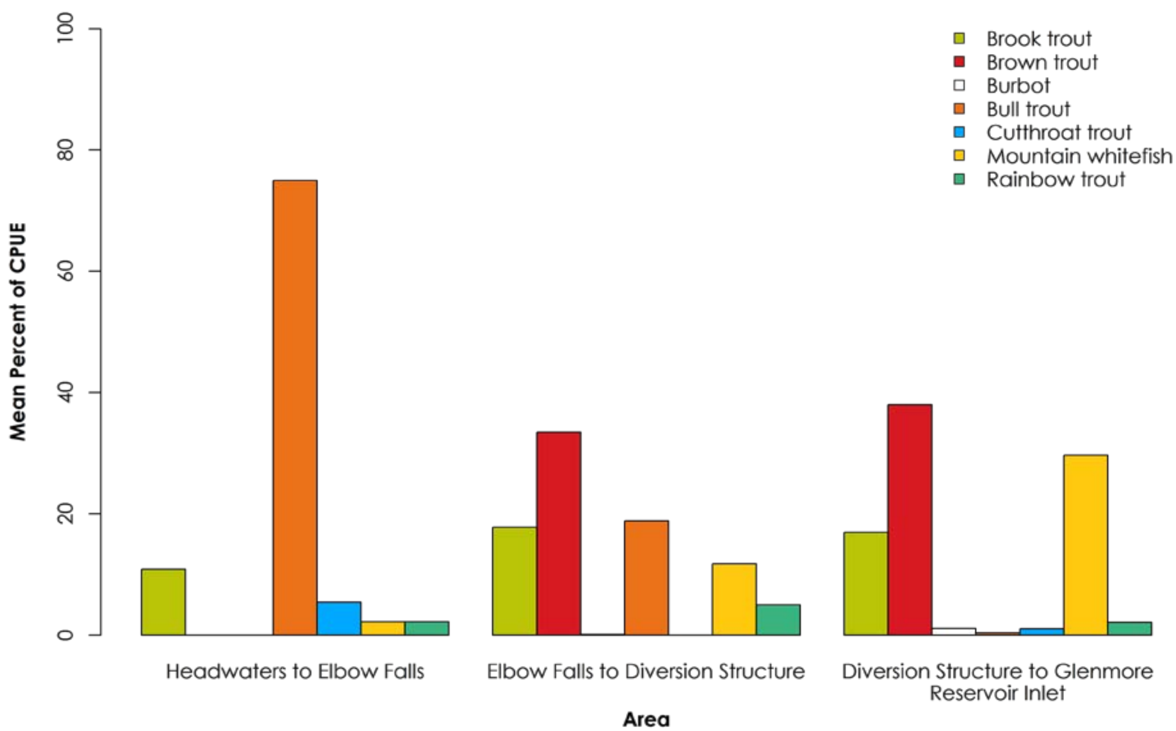

Figure 8.2-3 Relative Distribution of Sport Fish Species in Elbow River Separated into Three River Segments

Fish species distribution in the LAA reflects the change in channel size, substrates, and gradient as the river habitats change from steep, higher elevation, and erosional channels to lower elevation depositional channels (Figure 8.2-1). Northern pike and burbot are found in the lower gradient channel near the Glenmore Reservoir, while cutthroat trout (and hybrids) are found in the colder and steeper headwater channels; pure-strain westslope cutthroat trout are not present within the RAA/LAA. To provide a site-specific review of relative abundance and distribution, fish species are sorted into three river segments on Elbow River based on areas of gradient change: Below the project site, project site to Elbow Falls, and above Elbow Falls.

Salmonids are the most abundant fish species caught in the three sections, with Brown trout being the most abundant salmonid in the lower section and bull trout being the most abundant in the sections from the project site to Elbow Falls, and above Elbow Falls. Brook trout and rainbow trout are found consistently throughout the three river segments.

Upstream of Elbow Falls

Relative fish abundance in Elbow River upstream of Elbow Falls was calculated by the percent of the catch per unit effort of 23 electrofishing sampling events from 1978 to 2011 (AEP 2017b). Bull trout were the largest percentage of fish caught, while other fish species were present in much lower percentages (Figure 8.2-4).

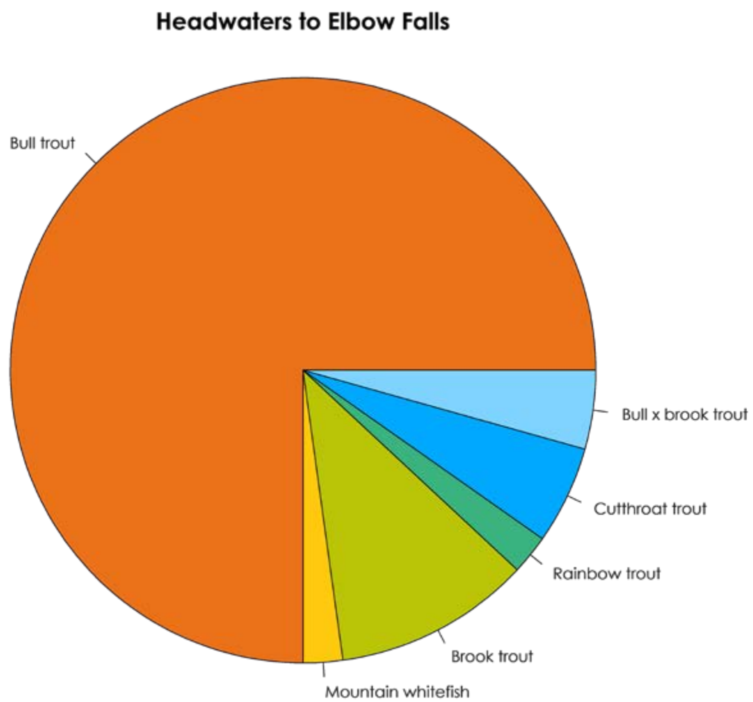

Figure 8.2-4 Relative Abundance of fish in Elbow River, between the Headwaters and Elbow Falls

Upstream of the Diversion Structure to Elbow Falls

Relative fish abundance in Elbow River between Elbow Falls and the diversion structure was calculated by the percent of the catch per unit effort of 75 electrofishing sampling events from 1978 to 2014 (AEP 2017b). Brown trout were the largest percentage of fish caught, followed by bull trout (Figure 8.2-5).

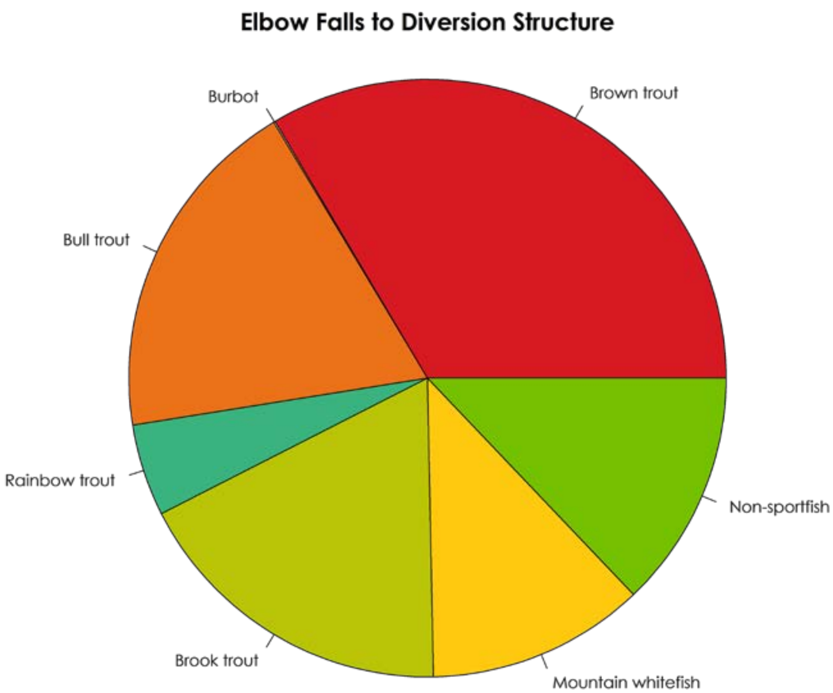

Figure 8.2-5 Relative Abundance of Fish in Elbow River between Elbow Falls and the Diversion Structure

Downstream of the Diversion Structure

Relative fish abundance in Elbow River from the diversion structure downstream to the inlet of the Glenmore Reservoir is calculated by the percent of the catch per unit effort of 57 electrofishing sampling events from 1988 to 2015 (AEP 2017b). Brown trout were the largest percentage of fish caught, followed by mountain whitefish (Figure 8.2-6).

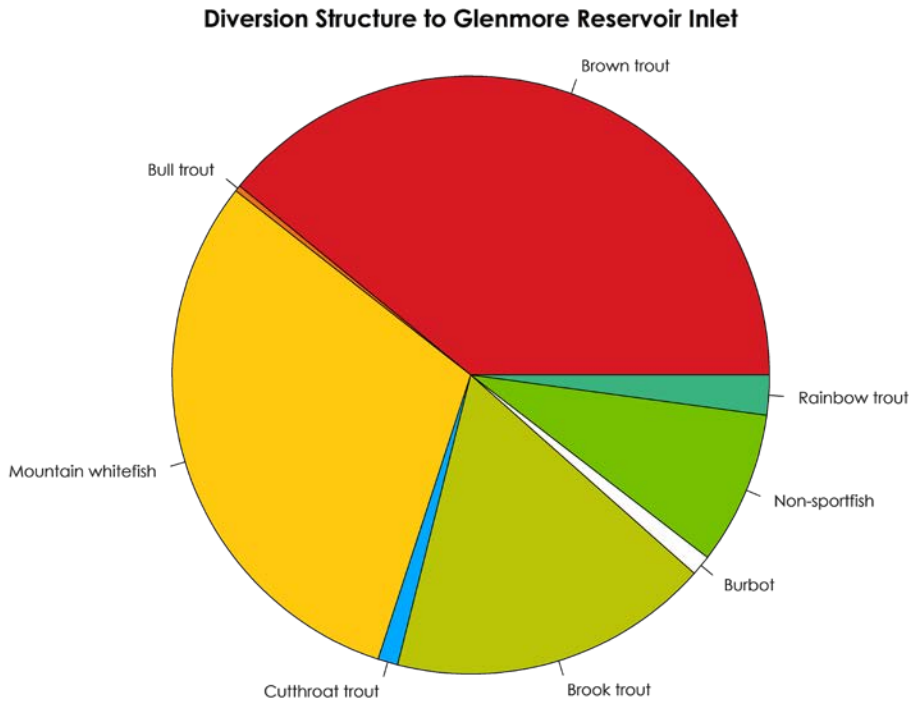

Figure 8.2-6 Relative Abundance of Fish in Elbow River between the Diversion Structure and the Glenmore Reservoir Inlet

8.2.2.5 Benthic Invertebrates

In total, 112 benthic invertebrate taxa were identified from data collected at the Elbow River sites in October 2016 (Volume 4, Appendix M, Aquatic Technical Data Report). Most taxa were identified to the genus level (93), while 13 were identified to the family level, 4 to the order level and 2 to the phylum level. None of the benthic invertebrate species from the samples collected from Elbow River were identified as being a SAR (GoC 2017a, 2017b; ESRD 2012).

The mean total richness at Elbow River sites ranged from 42 to 60 taxa, comprised mainly of Insecta – EPT, Diptera – Chironomidae, and other Insecta. The Arachnida/Crustacea and Oligochaeta/Nematoda groups, which were identified to a higher taxonomic level, had fewer taxa. Sites ER1, ER5 and ER11 (see Figure 8-2) had slightly lower taxa richness than the other sites on Elbow River, mainly due to a lower number of other Insecta taxa.

The mean total density at sites on Elbow River ranged from 28,458 to 788,356 organisms/m^2, comprised mainly of Chironomidae, EPT and Oligochaeta/Nematoda. These three groups made up greater than 94% of the total density. The highest densities were found at Sites ER6 and ER10 with intermediate densities at Sites ER3, ER7 and ER12.

The SEI at sites on Elbow River ranged from 0.07 to 0.22 and the SDI ranged from 0.75 to 0.91. The SEI indicates that the organisms are not evenly distributed in the community at most sites, while the SDI indicates that the sites have a fairly high diverse community. Sites ER1, ER2 and ER5 had slightly higher evenness and diversity compared to the other sites.

Diptera are considered to be one of the most abundant insect orders because of their large number of species and individuals, particularly the Chironomidae (chironomids) found in various types of aquatic habitats (Clifford 1991). Most of the Chironomidae density in Elbow River consisted of four genera: *Micropsectra* sp., *Stempellinella* sp., *Tanytarsus* sp., and *Cricotopus/Orthocladius* spp.

EPT are common aquatic insects found in great diversity in streams and can be an important food item for fish (Clifford 1991, Rader and Belish 1999). Of the EPT, Ephemeroptera (mayflies) had the highest density in Elbow River. Most of the Ephemeroptera density consisted of two genera: *Baetis* sp. and *Cinygmula* sp. (generally greater than 10% of the total density).

Oligochaeta (aquatic worms) of the family Naididae and Tubificidae are also common in various types of aquatic habitats and feed on organic matter, with Tubificidae being more numerous in organically enriched habitats (Clifford 1991). Most of the Oligochaeta density in Elbow River comprises the Naididae family.

Some benthic invertebrates such as the EPT are intolerant to poor water quality conditions and can withstand only minor changes in their habitat, while Diptera and Oligochaeta tend to be tolerant of poor water quality conditions and can withstand relatively large changes in their habitat (Hynes 1972; Bothwell and Stockner 1980; Rabeni et al. 1985; Noton et al. 1989; Anderson 1989; Gazendam et al. 2011). Although these two types of benthic invertebrates commonly cohabit, a deterioration or improvement in water quality will usually result in a shift in the proportional representation of each group. The EPT/Chironomidae Index at Elbow River sites ranged from 0.06 to 0.45. The higher index values at Sites ER1, ER2 and ER5 indicate that the benthic invertebrate community in these reaches have a higher density of sensitive intolerant taxa, while the other downstream reaches have a higher density of tolerant taxa and lower density of intolerant taxa. This may indicate that poorer water quality exists in the downstream reaches, compared to the upstream reaches.

The shift in the benthic invertebrate communities in the downstream reaches is likely a result of changes in land use and nutrient enrichment, particularly near golf courses. Increasing concentrations of nutrients (phosphorus and nitrogen) in streams often result in nutrient enrichment that increases the biomass of algae, aquatic macrophytes and benthic invertebrates (Wetzel 1983). Nutrient enrichment increases the food energy available in a system and is usually accompanied by an increased oxygen demand by organisms using the additional food energy resources (Pearson and Rosenberg 1978; Rabeni et al. 1985; Noton et al. 1989; Lenat et al. 1980). However, there was no indication of low oxygen levels in the downstream reaches and along with riffle habitat maintaining these oxygen levels; the nutrient enrichment was considered to be mild to moderate. A study in October 2015, indicated that changes in abiotic parameters (dissolved ions and nutrients) and changes in land use throughout the watershed decreased benthic invertebrate biotic indices in Elbow River from upstream to downstream areas, which suggests adverse effects on populations (Benoit et al. 2016).

8.3 PROJECT INTERACTIONS WITH AQUATIC ECOLOGY

Table 8-7 lists the potential interaction of project activities with aquatic ecology. These interactions are discussed in detail in Section 8.4 in the context of effects pathways, standard and project-specific mitigation, and residual effects. A justification for no interaction is provided following the table.

Table 8-7 Project-Environment Interactions with Aquatic Ecology during Construction and Dry Operations

Project Components and Physical Activities	Environmental Effects		
	Permanent alteration of fish habitat	Destruction of fish habitat	Death of Fish
Construction			
Clearing	✓	-	✓
Channel excavation	✓	✓	✓
Water diversion construction	✓	✓	✓
Dam and berm construction	✓	✓	✓
Outlet works construction	✓	✓	✓
Road construction	✓	-	✓
Bridge construction	✓	✓	✓
Lay down areas	-	-	✓
Borrow extraction	-	-	✓
Reclamation	✓	✓	✓
Dry Operations			
Maintenance	✓	✓	✓
Operation	✓	✓	✓
NOTES: ✓ = Potential interaction – = No interaction			

Clearing, road construction, lay down areas, borrow extraction, and utility realignments are not expected to have associated habitat destruction, but may result in an alteration of fish habitat and the death of fish through degradation of habitat quality and fish health.

8.4 ASSESSMENT OF RESIDUAL ENVIRONMENTAL EFFECTS ON AQUATIC ECOLOGY

8.4.1 Analytical Assessment Techniques

The analytical approach to the assessment of residual effects relies on the *Practitioners Guide to the Risk Management Framework for DFO Habitat Management Staff* (DFO 2006), DFO's Pathways of Effects (PoE) (DFO 2014b), and DFO's Measures to Avoid Causing Harm to Fish and Fish Habitat Including Aquatic Species at Risk (DFO 2016). These presents the types of activities for each phase of the Project, known stressors associated with each activity, and the pathways and potential effects on fish and fish habitat. As discussed in Section 8.1.3, DFO's PoE diagram illustrates potential causal relationships between project pathways and receptors in the receiving environment (DFO 2014b).

Quantification of permanent alteration to, or destruction of, fish habitat is based on an assessment of the permanent and temporary footprints of the Project. A detailed description of each potential effect as it relates to fish and fish habitat is provided in Section 8.4.2. An evaluation of residual effects for each potential effect is provided in Section 8.4.4. Although small-scale effects may be anticipated in some case, they would not necessarily lead to serious harm to fish. The criteria of timing is seasonal and related to restricted activity periods.

DFO's PoE (accessed at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html) were considered to assess the potential for project activities to result in residual serious harm to fish. Project activities were reviewed to determine the potential for project-related effects.

8.4.1.1 Assumptions and the Conservative Approach

Uncertainty arises as a result of natural variation in the sampling approach, the evaluation of potential effects, and the likelihood that some degree of modification to the engineering and design will occur and may change expected effects. Consequently, the assessment takes a conservative approach.

8.4.2 Project Pathways

This assessment uses DFO's PoEs (DFO 2014b) by:

- applying the relevant PoE for project related activities
- prescribing crossing-specific measures and mitigation to "break" the pathways that lead to PoE endpoints;
- providing the opportunity to prescribe additional site-specific measures, where standard measures are not adequate or appropriate
- providing guidance and criteria to help determine if an activity is likely to result in serious harm to fish, including fish that support a CRA fishery, or prohibited effects on listed aquatic species at risk.

A total of 10 PoEs were identified for land and water-based activities associated with the Project. The PoEs and associated potential effects of the Project are presented in Table 8.4-1. Mitigation for each potential effect is provided in Section 8.4.3.

Table 8.4-1 Pathways of Effects for the Proposed Work

Pathways of Effects	Potential Effects
Land Based Activities	
Cleaning or maintenance of bridges or other structures	• Change in sediment concentration • Change in contaminant concentration
Excavation	• Change in baseflow • Change in water temperature • Change in sediment concentrations
Grading	• Change in sediment concentration • Change in habitat structure and cover
Use of industrial equipment	• Change in sediment concentration • Potential mortality of fish/eggs/ova from equipment • Change in contaminant concentrations
Vegetation Clearing	• Change in sediment concentration • Change in habitat structure and cover • Change in nutrient concentration • Change in food supply • Change in water temperature • Change in contaminant concentration

Table 8.4-1 Pathways of Effects for the Proposed Work

Pathways of Effects	Potential Effects
In Water Activities	
Change in Timing, Duration and Frequency of Flow	• Change in migration patterns • Displacement or stranding of fish • Change in sediment concentration • Change in habitat structure and cover • Change in nutrient concentration • Change in food supply • Change in water temperature • Change in contaminant concentration
Fish Passage Issues	• Incidental entrainment, impingement or mortality of resident species • Change in thermal cues or temperature barriers • Change in access to habitats/migration
Organic Debris Management	• Change in nutrient concentration • Change in habitat structure and cover • Change in food supply • Change in contaminant concentration • Change in sediment concentration
Placement of Materials or Structures in Water	• Change in habitat structure and cover • Change in nutrient concentration • Change in food supply • Change in sediment concentration • Change in baseflow and hydro dynamics • Change in contaminant concentration

Habitat alteration can occur on a scale of severity of effect, from minor changes to habitat features that have the potential to impact the use or function of habitat to the destruction of habitat where it can no longer be used. Because many effect pathways and endpoints that have the potential to result in the alteration or destruction to habitat also occur on a scale of severity, they are discussed together in Section 8.4.2.1 to allow for meaningful evaluation of the scale of potential effects of the Project. Project effect pathways and endpoints that have the potential to result in the death of fish is discussed separately in Section 8.4.2.2.

8.4.2.1 Alteration or Destruction of Fish Habitat

Construction activities in the PDA have the potential effects, including a change in sediment concentrations, water temperatures, habitat structure, nutrient concentrations and food supply, and fish access in Elbow River and tributaries in the LAA. These changes have the potential to result in permanent alteration or destruction of fish habitat, including habitats of fish supporting CRA fisheries, which can affect the distribution and abundance of fish in the LAA.

Sediment Concentration

A change in sediment concentration can result from increases in suspended sediment in the water column from disturbance to the stream bank or streambed, both of which can interfere with various biological and/or physiological functions to fish (DFO 2014a). Instream construction activities, such as instream excavation and the placement of materials, may cause the release of sediment into Elbow River and its tributaries. Land-based construction activities, such as riparian vegetation removal, road construction, or grading may increase erosion potential from exposed soils, resulting in mobilization of sediments to downslope waterbodies. Construction of the reservoir on the low-level outlet could result in sediment transport downstream to existing fish habitat. Following construction, the Project could result in increased sedimentation in the waterbodies if exposed soils are transported into the water or if erosion develops because of a change in runoff to channels and waterbodies. Operational activities such as cleaning or maintenance of bridges or the water diversion structure may also result in increased sedimentation that could alter or destroy fish habitat.

There have been numerous reviews of the effects of suspended and deposited sediments on aquatic ecosystems, including Newcombe and Macdonald (1991), Kerr (1995), Berry et al. (2003), and Robertson et al. (2006). In particular, fine sediment loading can impact lotic ecosystems in the form of either suspended and/or deposited materials (Chapman et al., 2014). The effects of fine sediments on fish movement, feeding, reproduction, and assemblage structure have been well-documented through qualitative syntheses (Lloyd, 1987; Ryan, 1991; Kerr, 1995; Waters, 1995; Henley et al., 2000; Kemp et al., 2011). Quantitative reviews focused on modeling fish responses (Newcombe and Jensen, 1996; Newcombe, 2003) are generally focused on a single group of fishes, most notably salmonids, including brook trout, brown trout, rainbow trout, mountain whitefish, and other salmonid species (Lloyd, 1987; Jensen et al., 2009). In particular, Roberston et al. (2006) concluded that the greatest impact of sedimentation is on incubating eggs and larval fish, noting that survival of brown trout and brook trout eggs decreased as percentage of fine sediments in the substrate increased; where smaller sediments (less than 0.84 mm) are the most detrimental to developing eggs from steelhead trout and chinook salmon (Reiser and White 1988). Chapman (1988) comments that, "survival to emergence usually relates negatively to percentages of small fines." Physiological effects on fish include altered blood chemistry (Servizi and Martens 1987), clogging and abrasion of gills (Goldes et al. 1988; Reynolds et al., 1989), altered territorial and foraging behavior (Berg and

Northcote, 1985), reduced resistance to disease (Singleton 1985), impaired feeding and growth (McLeay et al. 1987; Sigler et al. 1984; Reynolds et al. 1989), increased respiration rates and quicker loss of equilibrium (Reid et al. 2003), and decreased survival and (or) reproduction (CCME 2002). These effects appear to be related to fish size (i.e., larger fish are more tolerant than smaller fish) and can be affected by temperature (i.e., temperatures approaching 0^{o} C reduce tolerance to sediment) (McLeay et al. 1987; Servizi and Martens 1987). Where studies have been conducted on other fishes, the results are generally consistent with those from salmonids; the exceptions are fishes that use soft sediments, which can be more abundant in streams with increased turbidity (DFO 2014a).

The potential effects from increased sedimentation can also result in a change in food supply and nutrient concentrations through: the creation of low light conditions that reduce photosynthetic activity; sediment deposition that smothers aquatic plants and benthic invertebrates, or changes to streambed conditions (e.g., in-filling pools and reducing the size of riffle areas) (Singleton 1985; Golder 1998; Robertson et al. 2006).

In, summary, short-term (i.e., hours, days) and infrequent exposure to small increases in suspended sediment may result in sublethal effects (i.e., physiological and behavioural) on individual fish, including brook trout, brown trout, rainbow trout, mountain whitefish, and other salmonid species. However, these effects are usually temporary and are reversible when sediment levels return to background levels (Robertson et al. 2006).

Contaminant Concentration

Deleterious substances such as hydrocarbons, anti-icing agents (e.g., calcium chloride), and herbicides have the potential to be released through structure construction, maintenance, and operation, vegetation management, re-fueling, leaks, exposed grease, or accidental spills from equipment operating in or around the watercourses. Introducing a toxic substance can cause serious harm to fish, by compromising the health of primary, benthic, and fish communities.

Temperature

Changes in water temperature may result in direct mortality, as well as a variety of sublethal effects including behavioural, bioenergetic, or physiological effects (DFO 2014a). Construction activities in the PDA with the potential to directly cause a local change in water temperature, include loss or gain in cover through riparian and aquatic vegetation removal and the addition or removal of channel shading features and structures. Temperature may also be indirectly affected through the release of suspended sediments, release of nutrients (i.e., algal blooms), or contaminants. Temperature may also be affected by activities that have the potential to affect water depth or hydrodynamics (e.g., isolation and water diversion) also affect water temperature (e.g., holding ponds).

Al-Chokhachy et al (2016) found that brown trout preferred temperatures between 12 °C and 14 °C, while bull trout were generally found to prefer mean August temperature below 10 °C, but were declining, rare, or absent from most sites with temperatures exceeding 10 °C. This indicates that changes in temperature affects the population dynamics of the distribution and relative abundance of salmonids in Elbow River. Incubating eggs and spawning adults are more susceptible to temperature changes. In areas with high tree crown closure, the loss of overhanging cover vegetation may result in a greater temperature change. Overhanging vegetation is important as it moderates water temperature through shading (Johansen et al., 2005; Smokorowski and Pratt 2007 and references therein).

Nutrient Concentration

Some construction activities can lead to increased nutrient concentrations (phosphorus and nitrogen). These activities include the removal of riparian or aquatic vegetation, the use of herbicides and fertilizer in site reclamation, organic debris management, industrial wastewater management, sediment erosion, and a change in habitat and structure (e.g., instream excavation and the removal of organic debris, such as logs (DFO 2014a).

Leaves and branches falling into a watercourse from the riparian zone provide nutrients to the stream ecosystem (Smokorowski and Pratt 2006). Hydrocarbon releases through equipment failures and spills can also result in a change in nutrient concentrations (Reid and Anderson 1999; Reid et al. 2002a; 2002b). Finally, the use of herbicides during the restoration and revegetation of riparian areas, during activities near water, can lead to changes in nutrient concentrations.

Increasing nutrient concentrations can lead to a change in nutrient status and eventually to system eutrophication. Nutrient enrichment can increase the biomass of algae, aquatic macrophytes and associated biota such as benthic invertebrates (Wetzel 1983) and can have a number of undesirable direct and indirect effects on fish. Nutrient enrichment increases the food energy available in a system and is usually accompanied by an increased oxygen demand by organisms utilizing the additional food energy resources (Hynes 1960).

Intolerant invertebrate taxa such as the EPT can be suited to mild nutrient enrichment, where there is no change in oxygen demand or when oxygen is maintained by a series of riffles in the system (Hynes 1960, Roback 1974). The tolerant invertebrate taxa such as the Chironomidae and Oligochaeta (Naididae and particularly Tubificidae) have been found to be reliable indicators of nutrient enrichment (Hynes 1960, Brinkhurst and Cook 1974). In low oxygen conditions, the community structure may change such that organisms tolerant of low levels dominate the community and intolerant organisms are eliminated over time (Hynes 1960; Pearson and Rosenberg 1978; Rabeni et al. 1985; Noton et al. 1989; Lenat et al. 1980).

River systems with increasing levels of nutrients and those considered eutrophic systems, are more likely to have indirect impacts on fish through reduction of dissolved oxygen, and other habitat impacts such as changes to algal blooms, aquatic macrophytes and benthic fauna. Oligotrophic systems can have low concentrations of nutrients and nutrients are therefore often limiting for primary production of periphyton and other algae and have been associated in constraining the total fish production (Biggs et al. 2000).

There have been indications of increased algal growth and a shift in benthic invertebrate communities in the downstream reaches of Elbow River to more tolerant groups. These effects may be linked to changes in land use (such as agricultural) and subsequent mild to moderate nutrient enrichment, particularly in the vicinity of the golf courses.

In many species, total fish production, fish biomass, and somatic growth are positively related to small or moderate increases in nutrient concentrations. The productivity of a CRA fishery can be strongly influenced by primary production, which is typically limited by phosphorus or nitrogen. However, some species are intolerant of nutrient enrichment and other impacts that may result from eutrophication.

Food Supply

Construction activities that can lead to a change in food supply include riparian and aquatic vegetation removal, altered water flow, instream excavation, sediment erosion, or the placement of materials or structures in water. In addition, the disruption of fish passage can limit coarse and forage fish populations that support sport fish. Benthic invertebrate abundance can be reduced when riparian vegetation is removed and not adequately replaced; reducing the amount of food available for fish (Denbeste and McCart 1984; Johansen et al. 2005).

Productivity responses to changes in food supply are not simple or direct, and are often affected by nutrients, temperature, and algae growth (Bowlby and Roff 1986). Cramer and Ackerman (2009), found that salmonid, specifically rainbow trout, density was related to invertebrate density on riffles, but not to invertebrate density in pools. Typically, productivity at the base of the food web leading to an increase in food supply (i.e., prey density) is caused by nutrient enrichment. This can lead to an increase in fish production, biomass, and growth. However, the reduction or preferred prey items (i.e., food quality) can reduce productivity in a manner similar to a reduction of food quantity (Allan 2004).

Instream excavation activities temporarily disturb the channel substrate and can produce a shift in invertebrate species (Armitage and Gunn 1996), a decrease in invertebrate standing crop and diversity at the crossing site (Tsui and McCart 1981), and an increase in benthic invertebrate drift density and standing crop downstream of construction (Young and Mackie 1991; Reid and Anderson 1999), which can last for one to several years. However, these effects can be short term (e.g., 5 weeks following construction activities) and be no longer apparent following the spring freshet (Young and Mackie 1991).

Increased sedimentation can also lead to decreases in benthic invertebrate standing crop and diversity (Golder 1998; Robertson et al. 2006). Where unacceptable levels of sedimentation were observed, benthic invertebrate abundance decreased; although, this was only for certain distances downstream and was a function of river flow, size, time of year, as well as other criteria and these effects were not noted further downstream (Denbeste and McCart 1984).

A reduction in water flow (e.g., improperly installed isolation) can also lead to a decrease in invertebrate standing crop and diversity through a decrease in the mobilization and drift (or supply) of individuals. Benthic invertebrates, including mayflies, are an important food resource for salmonids and because diversions may have effects on mayflies, there may be effects on trout feeding (Rader and Belish 1999).

The benthic invertebrates found in Elbow River are an important part of the aquatic food chain. Many invertebrates feed on algae and bacteria, while others eat plant material and/or organic matter. They play an important role in the natural flow of energy and nutrients in an aquatic system.

Habitat Structure and Cover

Changes to habitat from construction can include effects to overwintering areas and spawning substrates that were noted to be of concern by Tsuut'ina Nation during the engagement program. A change in fish habitat structural heterogeneity results from projects that reduce habitat complexity (DFO 2014a). Structure and cover provide critical elements of fish habitat for various life history stages and the spatial arrangement of habitat types and the complexity of the aquatic ecosystems are important environmental drivers of fish distributions and diversity. At the individual level, structure and cover provide protection against predators, can reduce competition via visual barriers, and provide shelter against environmental elements (e.g., hydraulic forces in rivers) (DFO 2014a). Bull trout and cutthroat trout are known to hide below coarse substrates for cover during the winter and in areas where there is less available instream cover such as boulders or woody debris (Bonneau and Scarnecchia 1998). Slower velocity habitats are considered important for juvenile bull trout (Warnock and Rasmussen 2013), and the change in distribution or abundance of these habitats could affect species use.

Quantifying the effects of changes in structure and cover remains elusive because the response of fish species to habitat change can depend on a number of factors including (but not limited to) geographic region, temperature, season, life stage, the presence or absence of other species and relative availability of habitat as well as compensatory responses (e.g. changes in growth, fecundity, age-at-maturity and sex ratio) when fish are stressed, which make population-level changes difficult to detect (Smokorowski and Pratt 2006).

Changes in channel morphology might occur from increased flows associated with construction isolation bypass measures and physical alterations to the channel features (i.e., bed and banks, width, depth, and gradient) associated with the construction of the diversion inlet structure and service spillway, diversion channel, and works on the low-level outlet. Riprap riverbank armouring would prevent erosion and scour on the banks and in Elbow River. The spaces between the rock may provide cover for small fish and reduce sediment mobilized by erosion; however, riprap prevents the natural stream process and limits available habitat (Schmetterling et al. 2001). Riprap on banks often prevents the establishment of woody vegetation that provides cover, such as shade and protection from avian predators. Riprap also reduces the available input of bank material and nutrients from organic matter. Streambanks may be naturally erosion resistant (because of the character of the native bank materials and the binding effects of dense vegetation) or highly erodible because of weak soils, geotechnical instability, or the removal of riparian vegetation (Thorne and Osman 1988). The use of heavy machinery along stream banks can compact soil, which in turn decreases infiltration and increases runoff, as well as restricting plant roots to penetrate and stabilize the soil (Cott and Moore 2003). Excavation activities can also increase the potential for erosion and bank instability, leading potentially to a change in habit structure and cover if the excavation is not effectively restored, revegetated, and erosion control measures are not appropriately chosen and effectively installed (Martz and Campbell 1980).

The construction of the diversion structure can result in temporarily increased flows in a narrower channel, increased scour resulting in erosion adjacent to the isolated channel portion and increased suspended sediment and deposition downstream.

The placement of rock material in the channel to maintain fish passage through the diversion structure would create a rough channel, increasing water depth and slowing velocity. This placement of material would alter the substrate from the native cobble, replacing it with boulder and cobbles, which should not have a negative effect on fish populations. To facilitate passage, this rock would alter habitat by creating deeper, slower flow downstream of the diversion structure.

Woody debris is expected to pass through the diversion structure during dry operations; any debris that does become caught on the gates would be removed. If the majority of woody debris is not passed through the gates, the loss of woody debris in Elbow River to habitats below the structure may result in reduced habitat complexity, reduced nutrient input, and lower the habitat quality for rearing cover, feeding, spawning, and overwintering. Resultant decreases in habitat complexity may be detrimental to fish diversity and may change species composition (Smokorowski and Pratt 2006). The alteration of bank structure and removal of bank vegetation can occur directly through the clearing and construction activities within the watercourse's riparian area and usual high-water mark. The permanent loss of vegetation is a loss of natural habitat-forming complex material, overhead cover and shade and organic carbon (Thompson 2002).

Baseflow and Hydro Dynamics

Activities with the potential to result in changes in baseflow and hydrodynamics include instream excavations, temporary vehicle crossings (e.g., culverts), and the removal of riparian vegetation and destabilization of stream banks. The potential effects to fish and fish habitat from a change in baseflow and hydrodynamics include changes in total gas pressure, access to habitat, fish bioenergetics, water temperature, nutrient concentrations, food supply, and erosion and deposition (Clarke et al. 2008 and references therein). Flow management has generally been shown to have a negative impact on fish populations (Richter et al. 2003) and can result in direct mortality from stranding of fish due to reductions in flow (Clarke et al. 2008). Stranding can result in beaching, when fish are completely out of the water, or trapping, when fish are isolated in small pockets of water completely separate from the flowing river (Hunter 1992). Rate and range of change and duration; time of day (light); season and/or temperature; fish species, life stage (i.e., size) and behaviour; and the morphology and substrate character of the stream appear to be the most influential factors determining the potential for stranding (Steele and Smokorowski 2000; Halleraker et al. 2003).

Changes to habitat from flow moderations could include effects to overwintering areas and spawning substrates that were noted to be of concern by Tsuut'ina Nation during the engagement program. During dry operations, the hydrological modeling (Section 6.5.2 and Section 6.5.3), suggests that effective discharges, those above the channel forming flow range, which is normally below 1:2 flood for sediment transport in Elbow River, are also maintained and, therefore, no interactions are anticipated during dry operation and this effect pathway is not discussed further.

Access to Habitat and Migration

The public and Indigenous communities, including Tsuut’ina Nation, identified concerns with the Project potentially effecting fish migrations in the Elbow River. A change in access to habitat can result from a physical barrier, change in water temperature or thermal cue, changes in hydraulic conditions, or other factors; impacts linked to change in access to habitat include infilling, footprint, changes in flows/water levels and permanent watercourse alteration (DFO 2014a). Changing flow or channel shape, or temporarily obstructing the river can cause temporary disruption of fish movement and migration past the site. Flows in Elbow River would be unaffected during construction, but water velocities may change at the diversion site because of channel constriction during construction and changes to the shape of the channel after construction.

During dry operations, the physical structure may be a barrier to upstream fish migration for large fish by creating an area of shallow water over the concrete gates, with depths shallower than 18 cm, that may impede the upstream movement of large fish such as bull trout, brown trout, or mountain whitefish, during late summer spawning migrations. The transition from the concrete gates to the spilling basin may also create a drop that is too tall for small fish to jump up.

Fish that are unable to access preferred spawning habitat or where their spawning areas are disturbed can be forced to spawn in undesirable locations (Cott et al. 2010), may abandon their spawn (re-absorbing eggs; Auer 1996), or be subject to increased predation while holding (Brown et al. 2003). Long-term potential effects include habitat fragmentation and overall habitat loss (Park et al. 2008; MacPherson et al. 2012).

Katopodis and Gervais (2016) describe distances that various fish groups can swim at various water velocities. By constricting the Elbow River channel through the gates, water velocities during dry operations may be increased, causing a barrier for fish moving upstream in Elbow River.

Unnamed tributary [ID 1350] will be diverted into the diversion channel, which will eliminate flows in approximately 1,200 m of stream channel. The tributary has a drainage area of 7.21 km^2, with only intermittent flows. However, the lower 300 m of the unnamed tributary has defined bed and banks and would be considered fish habitat, although poor quality. The lower portion would function as refugia habitat during high water events in Elbow River, providing cover from high velocities, as well as rearing habitat for fish, such as juvenile brown trout, mountain whitefish, and rainbow trout.

8.4.2.2 Death of Fish

DFO (2014) defined direct mortality as the killing of fish, at any life stage, by any human induced mechanism other than fishing. Typically, this can occur through rapid increases in pressure, crushing, entrainment/impingement, stranding and/or lethal changes in oxygen, temperature, sediments or nutrient enrichment (DFO 2014a).

Potential Mortality of Fish/Eggs/Ova

Change in fish/egg mortality includes the increased risk of direct mortality to individuals (i.e., all life stages) and/or their eggs due to increased sedimentation from on-land construction activity, the intensity, duration, and timing of instream work, or through the stranding of fish as a result of a barrier creation, such as reduced flows. Piikani Nation and Tsuut’ina Nation identified concerns with stranding of fish during work. These changes have the potential to result in the death of fish, including fish supporting CRA fisheries, which can affect the distribution and abundance of fish in the LAA.

Displacement or Stranding of Fish and Incidental Entrainment or Impingement

There is potential for fish to be stranded during dewatering, resulting in fish mortality or stress. The operation of pumps can also result in the death of fish through impingement against the intake and into the pump. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. The operation of equipment in the watercourse and the placement of materials can also cause the direct injury or mortality of fish and aquatic organisms that support the CRA fishery.

8.4.3 Mitigation Measures

Environmental protection will be managed during construction through Alberta Transportation's Environmental Construction Operations (ECO) Plan framework (Volume 4, Supporting Documentation, Document 4). Mitigation measures to reduce the effects on aquatic environment and CRA fisheries have been developed based on best management practices described in the Fish Habitat Manual (Alberta Transportation 2009), the COP for Watercourse Crossings (ESRD 2013), and DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016). The mitigation measures are presented in terms of timing of activities, operation of machinery, handling of deleterious substances, erosion and sediment control, water management, stream isolation, reclamation, and structure operation and maintenance.

8.4.3.1 Timing

Works in water will be timed with respect to the restricted activity periods (RAPs) wherever possible. For Elbow River, the RAP is May 01 – July 15 and September 16 – April 15. Condition and use of restricted activity periods will be provided within further project permitting and authorization under the *Fisheries Act.* For planning purposes, the Elbow River RAP will be applied as an avoidance and mitigation measure.

8.4.3.2 In-stream Works that would be Isolated Prior to Construction, and Operation of Machinery

- Machinery would arrive on site in a clean condition and be maintained free of fluid leaks, invasive species, and noxious weeds.
- Washing, refueling, and servicing of machinery and the storage of fuel and other materials will be away from the watercourses in manner to prevent hazardous and deleterious substances from entering the water.
- Maintain a minimum 100 m setback between stored fuels and lubricants and rivers, streams and surface water bodies.
- Equipment will be inspected, maintained, and repaired immediately, to prevent leaks.

- Use construction equipment that is mechanically sound with no oil leaks, fuel or fluid leaks. Inspect equipment daily and immediately repair any leaks.
- Employ persons qualified to handle Construction Equipment fuels and lubricants to perform repairs.
- Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse.
- Stream bank and bed protection methods (e.g., swamp mats, pads) will be used if rutting is likely to occur during access to the bed and shore. Temporary access structures will be used where steep and highly erodible banks are present.
- Whenever possible, machinery will be operated on land above the high-water mark in a manner that reduces disturbance to the banks and bed of the watercourses.
- Where instream works are required, non-toxic and biodegradable hydraulic fluids will be used in machinery.

8.4.3.3 Handling of Deleterious Substances

- Building material used in watercourses, including concrete, will be handled and treated in a manner that prevents the release or leaching of substances that may be deleterious to fish into the water.
- Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse.

8.4.3.4 Erosion and Sediment Control

A site-specific Erosion and Sediment Control Plan will be developed by the selected construction contractor as part of the project-specific ECO Plan, and implemented during the various phases of construction and should include site-specific mitigation measures to suit the site and finalized design and construction plans. The plan would include, but not be limited to, the following practices where applicable:

- Erosion and sediment control measures will be installed before starting work to prevent sediment from entering the water body.
- Erosion and sediment control measures will be regularly inspected daily and maintained during construction.
- Erosion and sediment control measures will be repaired immediately if damage occurs.

- Non-biodegradable erosion and sediment control materials will be removed once the site is stabilized.
- Sediment and erosion control devices will be constructed to withstand anticipated flows during construction. If necessary, the outside face of granular berms may be lined with heavy poly-plastic to make them impermeable to water.
- Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site will be implemented such that sediment is filtered out before the water enters a waterbody (e.g., silt fences, turbidity barriers, pumping/diverting water to a vegetated area, constructing a settling basin, or other filtration system).
- Excavated materials and debris will be stockpiled above the highwater mark and in such a way as they do not enter the watercourse. Silt fences will be used to contain soil erosion.
- Isolation materials will be designed to reduce disturbance of the bed and banks of Elbow River and other watercourses.
- Clearing of riparian vegetation will be kept to a minimum.
- Weeds will be controlled during construction through multiple measures, such as herbicide, mowing, wicking, and hand picking. After construction, disturbed areas will be stabilized and reclaimed.
- Erosion and sediment control measures will be monitored until vegetation has become sufficiently reestablished.

8.4.3.5 Water Management

- Flows in Elbow River will be maintained downstream of the Project (e.g., bypass channel).
- Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site will be implemented such that sediment is filtered out before the water enters a waterbody (e.g., silt fences, turbidity barriers, pumping/diverting water to a vegetated area, constructing a settling basin, or other filtration system).
- Sediment laden dewatering discharge will be pumped into a vegetated area or settling basin to allow sediment to settle out before returning it to the water body. Silt fences, turbidity barriers and clean granular berms will be used to contain the sediment and other deleterious substances and to prevent it from entering a watercourse or water body.
- Energy dissipaters will be used at pump outlets to prevent erosion.

8.4.3.6 Stream Isolation

- The location of any in-stream works will be isolated from the watercourses by the use of silt fences, turbidity barriers and clean granular berms.
- Isolation materials will be designed to reduce disturbance of the bed and banks of Elbow River and other watercourses.
- Clean granular fill with less than 5% fines passing the 80um sieve size will be used for instream work such as cofferdams, causeways, access ramps, Bailey bridges, river channel diversions. Fine grained soils may be used, provided only clean granular fill is exposed to the river at any time during construction and restoration operations.
- Before isolation and dewatering works commence, a qualified environmental professional (QEP) will be retained to obtain applicable permits for relocating fish and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters.
- Pump discharge area(s) will be isolated to prevent erosion and the release of suspended sediments downstream. Any sediment build-up will be removed when the work is completed.
- Water intakes pipes will be screened to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. Screens are to comply with DFO's "Freshwater Intake End-of-Pipe Fish Screen Guidelines".
- Accumulated sediment and spoil build up within the isolated areas will be removed prior to removal of the isolation barriers.
- When removing the isolation barriers, the downstream isolation barriers will be gradually removed first, to equalize water levels inside and outside of the isolated area and to allow suspended sediments to settle prior to removing the upstream isolation materials.

8.4.3.7 Reclamation

- The top substrate from a wetted channel will be stripped and stockpiled for later use as the top layer of reclaimed instream substrate to improve the recolonization rate and maintain average mobile substrate sizes.
- Rootwads and large boulders that have to been removed will be stored on-site for subsequent placement on reclaimed instream cover or for bank protection.
- Fertilization of reclaimed areas in the immediate vicinity of a watercourse will not be allowed unless approved by DFO and AEP.
- Streambanks and approach slopes will be revegetated using an appropriate native seed mix or erosion control mix.

8.4.3.8 Fish Passage

- Boulders will be added to increase the bed roughness of the channel immediately downstream of the diversion structure, which will increase water depths and reduce velocities.
- Boulder V-weir structures will be constructed in the channel downstream of the gates to provide slower velocity and deeper resting zones.
- A monitoring program will be undertaken to identify if fish passage is impeded for migratory salmonids or other fish species.

8.4.3.9 Structure Operation and Maintenance

- Structures will be designed so that storm water runoff and wash water from the access roads, decks, side slopes, and approaches will be directed into a retention pond or vegetated area to remove suspended solids, dissipate velocity, and prevent sediment and other deleterious substances from entering the watercourse.
- Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse.
- The cleaning and removal of debris and sediment from sediment and erosion control devices will be conducted in a manner that will prevent materials from entering the water body.
- Large woody debris pieces such as rootballs and logs over 50 cm in diameter, will be retained and relocated in the river downstream of the structure.
- Where debris removal from the structures is required, debris removal will be timed to avoid disruption to sensitive fish life stages (i.e., outside the RAP), unless the debris and its accumulation is immediately threatening to the integrity of the structure or relates to an emergency situation (i.e., risk of structure failure).

8.4.4 Project Residual Effects

8.4.4.1 Permanent Alteration of Fish Habitat

Permanent alterations to habitat as a result of construction activities and channel realignments related to the installation of the diversion structure could affect fish, including fish that support CRA fisheries, through increased localized flows, elevated sediment levels, and habitat alterations. This could affect the distribution and abundance of fish species in Elbow River.

Site preparation during construction involves the removal of riparian habitat and the clearing and grading of the site, resulting in areas of exposed soils that have the potential to create sediment-laden water during runoff. Site preparation also involves the removal of aquatic habitat of a portion of Elbow River during the instream construction to construct the diversion structure. The total footprint of the project, which includes temporary site preparation areas and the permanent diversion structure within the bankfull of Elbow River, is 4,550 m^2. The permanent diversion structure footprint of 1,854 m^2 on class 2 and class 3 run type fish habitat.

Within the active construction area in the PDA, portions of the river would be dewatered for construction, excavated, and covered by the concrete diversion structure and/or riprap. The area that is dewatered for construction would be temporarily unavailable for use by fish, but the habitat is not limiting, passage would be maintained, and the effects on the bed should be reversible. Temporary instream works might reduce the abundance of benthic invertebrates and adversely affect food availability for fish, but the changes should be reversible.

The low-level outlet would be altered during construction of the reservoir dam and outlet, as well as grading, construction, and expansion of roads, and linear ROWs, although the alterations are upstream of the limits of viable fish habitat.

Construction changes to habitat structure and cover would result in a direct permanent alteration of 1,854 m^2, of habitat that would be caused by the construction of the diversion structure in Elbow River (Figure 8.2-2). This change would result in the modification of cobble substrate run habitat into a smooth concrete bed and riprap armour, potentially changing the use of habitat by fish species, including those fish that support a CRA fishery, in Elbow River, reducing the quality of rearing habitat, feeding habitat, and potentially affecting migration for small-bodied fish, which has the potential to affect the distribution of these fish. Forage fish species, such as longnose dace, that prefer coarse (gravel and cobble) substrates, may lose habitat. Sucker species in the LAA, including longnose and white suckers prefer deeper and slower habitat for foraging, but utilize runs, such as that found at the proposed diversion site. Coarse substrate habitats (runs, pools, and riffles) are abundant throughout Elbow River in the 67 km (approx. 3,100,000 m^2 of available habitat) within the LAA, and there should be no effect to the sustainability of forage or coarse fish populations.

The 1,854 m^2 of run habitat that would be altered from construction would be generally suitable habitat for trout species for forging, including mountain whitefish, brown trout, and rainbow trout adults and juveniles. Species found at higher elevations such as bull trout may occasionally occur in the PDA, but are relatively less abundant than species typically found at lower elevations, such as brown trout. The cobble would provide habitat for invertebrates commonly found in rocky runs in Elbow River (see Volume 4, Appendix M, Aquatic Ecology Technical Data Report). This habitat would likely not be suitable for overwintering by large bodied sport fish, but would provide food and cover during winter periods and during early winter when the water surface is not covered by ice.

Mitigation for fish passage, including boulder clusters and v-weirs, would be constructed downstream of the structure gates, and would include features that mimic natural fish habitats in cobble bed rivers, such as those altered during the construction of the diversion structure.

During dry operations, there would be no changes to flows in Elbow River and no changes to the pattern of erosion and deposition in bars or pools (see Section 6.5.3 for details on hydrological changes to Elbow River), this indicates that there would be no changes to the maintenance of spawning or overwintering habitat in Elbow River for salmonid species, including bull trout or brown trout, which are the most abundant trout species in the LAA downstream of the diversion structure (Section 8.2.2). Hydrological modelling also indicates that there would be no significant changes in sediment transport (see Section 6.5.3) and, therefore, would be no alterations to the quality of fish habitat, including for fish that support a CRA fishery, including the deposition of sediment on fish spawning habitats such as those used by brown trout, bull trout, rainbow trout, or mountain whitefish.

Potential effects of erosion and sedimentation during construction can be avoided or mitigated for the Project through scheduling (e.g., avoidance of wet periods), reducing instream and riparian works, isolation of instream work areas, proper construction staging practices, use of sediment and erosion control measures, and bank/riparian reclamation, including revegetation.

Mitigation to directly reduce temperature effects include limiting overall changes to cover in riparian vegetation, aquatic vegetation, or shading structures at the crossing location, and maintaining natural flow downstream of an isolated area.

Potential nutrient-related and food supply effects can be mitigated through project design (e.g., road water runoff management), reducing instream works, implementing proper construction staging, and using appropriate sediment and erosion control measures.

Potential contaminant-related effects can be mitigated through project design (e.g., road water runoff management), reducing instream works, implementing proper construction staging, using appropriate sediment and erosion control measures, prohibiting the use of herbicides near water bodies, and using non-toxic biodegradable hydraulic fluids for instream works.

Many changes to habitat structure can be mitigated through project design (e.g., isolation measure design), reducing instream works, limiting overall changes to riparian vegetation or shading structures, implementing proper construction staging practices, maintaining natural flow and velocities downstream of an isolated area, utilizing fish-friendly bioengineering erosion protection, and using appropriate sediment and erosion control measures.

During dry operations, woody debris may get caught on the gates and be removed, but larger debris would be retained and relocated downstream in the river to maintain complex woody debris fish habitats. To reduce the effects of dry operation changes to habitat structure and cover, the diversion structure should be designed to allow woody debris pass through the gates during dry operation. If woody debris does not pass through the diversion structure, large wood debris that builds up at the structure should be manually moved to downstream of the diversion structure to maintain a natural amount of woody debris in the river channel.

With mitigation, dry operations is unlikely to result in permanent alterations to fish habitat that could affect fish, including fish that support CRA fisheries, or their distribution or abundance in Elbow River. Construction of the permanent diversion structure will result in the permanent alteration of 1,854 m^2 in Elbow River; however, this is expected to have a not significant effect on the abundance or distribution of fish or reduce the sustainability of fish that support a CRA fishery or species at risk.

8.4.4.2 Destruction of Fish Habitat

Destruction of fish habitat as a result of construction activities related to the installation of the permanent diversion structure would affect fish, including the distribution and abundance of fish, including fish that support a CRA fishery, through habitat loss and change in access to fish passage. During construction, fish passage concerns would be mitigated with passage around the site.

During construction, the footprint within the bankfull water level may result in a temporary infill of habitat for the area that is not submerged during flows at the 1:2 flood level.

During construction of the diversion channel, the unnamed tributary (ID 1350) would be diverted into the diversion channel. Approximately 1,200 m of the tributary would be destroyed, with the lowest 300 m (less than 1 m wide channel) being fish habitat that would be lost. In addition to the direct loss of 300 m^2, the tributary effects of flow entering Elbow River would be lost, which permanently alters the use by fish, including the ability to support rearing, and cover for small-bodied fish. The loss of the 300 m^2 of habitat in the tributary could be offset by the enhancement or construction of side channel habitat on Elbow River that could provide rearing habitat for salmonids and cover for small-bodied fish.

Modelling for fish passage velocities was completed up to the expected maximum 3-day delay of a 1:10 year magnitude high flow flood (3Q10max) and the 1:10 year magnitude low water flood (3Q10min). The 3Q10 provides the basis for velocities and depths that fish can pass a structure during the 1:10 flows, without a 3-day delay during the relevant BSPs. Whereas, the 3Q10min should provide velocities and depths that are suitable under extreme low flow situations for specific BSPs.

Modelled results for water depth and velocities (See Volume 4, Appendix M, Attachment 8A) indicate that the water velocities in Elbow River change slightly in spatial and temporal patterns from pre-construction velocities to post-construction velocities. The change is primarily related to the post-construction alteration of the run habitat at and downstream of the structure, and loss of complexity of habitat over the structure, primarily the rough cobble substrate. The model results showed that velocities and flow patterns post-construction are similar to the pre-construction state.

The velocities predicted by the model are averaged for each channel area (cell), and may overestimate the velocity that small fish may experience and the microhabitats on the bed boundary layers that are used for fish movement and migration (Katopodis and Gervais 2016). Based on the results of the model, at 0.8 m^3/s (BSP4-3Q10min), flows are concentrated in the channel resulting in a narrower channel and a small increase in velocities, although velocities remain below 0.75 m/s and most of the channel velocities below 0.25 m/s. Fish movement in the channel during these flows should be maintained, with even 25 mm salmonids being able to move about 5 m in water velocities of 0.25 m/s, discounting the slower boundary layer along the channel bed (Katopodis and Gervais 2016).

Discharges at 2.38 m^3/s (BSP3-3Q10min), 2.8 m^3/s (BSP1-3Q10min), 3.47 m^3/s (BSP2-3Q10min), and 9.81 m^3/s (BSP4-3Q10max) would result in the loss of the pool 50 m downstream of the structure, although velocities appear to remain similar, pre- and post-construction. The resting areas with water velocities less than 0.75 m/s would provide passage for salmonids with lengths of at least 150 mm. At water velocities of 0.75 m/s, Katopodis and Gervais (2016), show that the mean length 250 mm salmonid could swim for over 50 m, farther than the distance between resting areas of less than 0.5 m/s. Depths in the channel exceed 20 cm, providing suitable depth for spawning sized salmonids, such as rainbow trout, bull trout, and brown trout, during upstream migrations. During BSP4, burbot might be moving past the structure, downstream to deep pools for spawning. Downstream burbot movements should not be impeded, although upstream movements at this time might be to low velocity areas along the channel margin.

Discharges at 15 m^3/s (BSP3-3Q10max) would result in water velocities exceeding 1 m/s in the main portion of the channel for greater than 20 m, although there are slow water zones in the margins and with depths around 20 cm and velocities ranging from 0 m/s to 1 m/s. These zones would allow fish passage by small-bodied fish migrating during the fall with less than a 3-day delay at the 1:10 year magnitude flood.

During discharges at 69.5 m^3/s (BSP2-3Q10max) coarse fish, such as suckers, and forage fish would be moving to spawning areas in the river. Modelled water velocities in the existing and post-construction river exceed 2.5 m/s in portions of the main channel, but velocities under 0.5 m/s persist along the margins and spaced throughout the reach. Fish movement would be possible over the structure along the margins and in slower areas in the center portion of the channel. Coarse fish species such as suckers, should be able to migrate over the structure, so there should be no effect on the movement or connection of sucker species between the portions of the river upstream of the diversion and downstream of the diversion.

Discharges at 75.7 m^3/s (BSP1-3Q10max), would result in spring migrating salmonids encountering velocities greater than 3.5 m/s in the natural channel downstream of the structure. At the site of the structure, the model shows that at existing conditions, velocities do not exceed 2.75 m/s and slower water (0 m/s to 0.5 m/s) persists along the margins and in deeper pooled areas. The modelling of the post-construction channel shows water velocity areas of 0 m/s to 0.5 m/s persisting throughout the site, with connectivity along the margins. At water velocities of 1 m/s, Katopodis and Gervais (2016), show that the mean 250 mm salmonid could swim for over 15 m, farther than the distance between resting areas of less than 0.5 m/s.

The construction of boulder V-weirs in the channel downstream of the gates would result in slower water resting areas, as well as an increase in depths that would mitigate the loss of the pool downstream of the gates and provide resting areas for migrating fish. With mitigation, fish migrations past the structure would not be impeded in a manner that would affect the sustainability of the fish populations, the distribution, or abundance of fish, including fish that support a CRA fishery, in the LAA.

8.4.4.3 Death of Fish

Potential harm to fish can be mitigated through project design (e.g., reducing instream work areas), reducing instream works, using pump screening designed to protect fish at pump flow rates (DFO 1995), implementing a fish rescue plan in isolated work areas, and using sediment and erosion control measures.

After mitigation measures are implemented, it is unlikely that fish mortality (including eggs), or reductions in fish health, would occur at a level that affects the abundance or distribution of fish or reduces the productivity and sustainability of a CRA fishery.

8.4.4.4 Summary of Project Residual Effects

Table 8-8 summarizes the residual environmental effects on aquatic ecology.

The residual effect of construction on causing a permanent alteration to fish habitat is adverse in direction, low in magnitude, restricted to the PDA, permanent in duration, and a single event in frequency. Due to the permanence of the project structures in the river, the effect is irreversible.

The residual effect of construction on causing the destruction of fish habitat is adverse in direction, low in magnitude, restricted to the PDA, permanent in duration, and as a single event in frequency. Due to the permanence of the structure in the river, the effect is irreversible.

The residual effect of construction causing death of fish is adverse in direction, low in magnitude, restricted to the PDA, and as an irregular event in frequency. Given the low potential and the small portion of the fish population that could be affected, the effect is considered to be not significant and reversible.

The effect of dry operation on aquatic ecology through a destruction of fish habitat, considering passage mitigation measures and monitoring, is adverse in direction, low in magnitude, extends to Elbow River through the LAA, permanent in duration, and would occur during spawning migrations at an irregular, but continuous frequency. Due to the permanence of the structure in the river, the effect is irreversible.

Table 8-8 Project Residual Effects on Aquatic Ecology during Construction and Dry Operations

Residual Effect	Residual Effects Characterization								
	Project Phase	**Timing**	**Direction**	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological and Socio-economic Context**
Permanent alteration of fish habitat	C	S/R	A	L	PDA	P	S	I	U
Permanent alteration of fish habitat	O	R	N	L	LAA	P	IR	R	U
Destruction of fish habitat	C	S/R	A	L	PDA	P	S	I	U
Destruction of fish habitat	O	R	A	L	LAA	P	C	I	D
Death of Fish	C	S/R	N	N	PDA	N/A	IR	I	U

KEY
See Table 8-2 for detailed definitions

Project Phase
C: Construction
O: Dry Operation

Timing Consideration
S: Seasonality
T: Time of day
R: Regulatory

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project Development Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short-term;
MT: Medium-term
LT: Long-term
P: Permanent

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

8.5 DETERMINATION OF SIGNIFICANCE

The residual effects on change in habitat, movement, and mortality risk are unlikely to pose a long-term threat to the persistence or viability of a fish species, including SAR, in the RAA.

With the application of mitigation and environmental protection measures, residual effects on aquatic ecology are predicted to be not significant.

8.6 PREDICTION CONFIDENCE

Prediction confidence of construction effects on the aquatic environment is high because the effects on hydrology from construction involving earthworks and instream work are generally known and the mitigation measures are well established.

Although the Elbow River flows are unaltered during dry operations, the prediction confidence of dry operation effects on hydrology is moderate because of uncertainty related to fish movement and fish passage and mitigation measures at the structure to allow passage during dry operations.

8.7 CONCLUSIONS

The footprint of the project, including the permanent diversion structure and temporary construction area within the bankfull of Elbow River, is 4,550 m^2. This area includes the permanent diversion structure footprint in the bankfull of approximately 1,854 m^2, that would result in the permanent alteration and loss of habitat that would affect fish that support CRA fishery. Approximately 1,200 m of stream length of a tributary would be cut off and diverted by the diversion channel, although only the lowest 300 m^2 would be fish habitat.

8.7.1 Permanent Alteration of Fish Habitat

There would be an alteration of approximately 4,550 m^2 on the bed and banks of Elbow River at the planned gate structures and tailrace, including the 1,854 m^2 permanent alteration of class 2 and 3 run type, fish habitat from the footprint of the gate and temporary habitat alteration of 2,696 m^2 of rapid and class 2 and 3 run fish habitat types from temporary work areas between the gate and diversion canal.

At river flows below the operation of the diversion structure, there are unlikely to be any residual effects to changes of flow from the Project.

The Project would result in direct and indirect alteration of fish habitat during construction and dry operations; however, the amount of fish habitat permanently affected is relatively small compared to the availability of fish habitat remaining in the RAA.

8.7.2 Destruction of Fish Habitat

Approximately 300 m^2 of fish habitat would be destroyed by the interception of the Unnamed tributary (ID1359).

Water velocities that have been modeled through the structure match the water velocities in the natural channel upstream and downstream of the diversion structure. With mitigation, there should be little to no effect on fish passage up to a 3-day delay at the 1:10 year magnitude flood.

The Project would result in direct and indirect loss of fish habitat during construction; however, the amount of fish habitat destroyed is relatively small compared to the availability of fish habitat remaining in the RAA.

8.7.3 Death of Fish

The Project would not result in the death of fish that would threaten the long-term persistence or viability of aquatic species of management concern in the RAA because of proposed mitigation during the construction phase. During dry operations, it is expected that mortality risk would be reduced to levels similar to existing conditions.

8.8 REFERENCES

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8.9 GLOSSARY

Aboriginal (in relation to a fishery)	Fish that is harvested by an Indigenous organization or any of its members for the purpose of using the fish as food, for social or ceremonial purposes or for purposes set out in a land claims agreement entered into with the Indigenous organization.
Aquatic environment	The components of the earth related to, living in or located in, or on water, or the beds or shores of a water body, including, but not limited to: • All organic and inorganic matter; and • Living organisms and their habitats, including fish habitat. (Alberta *Water Act*)
Avoidance	Measures to completely prevent adverse impacts to fish and fish habitat.
Bed and Shore	The land covered so long by water as to wrest it from vegetation or as to mark a distinct character on the vegetation where it extends into the water or on the soil itself (Alberta *Surveys Act*)
Commercial, in relation to a fishery	Fish is harvested under the authority of a licence for the purpose of sale, trade or barter.
contaminant	A substance that, in a sufficient concentration, will render water, land, fish, or other things unusable or harmful.
contribution (of relevant fish)	The role of the relevant fish or fish habitat in the overall productivity of a commercial, recreational or Aboriginal fishery that could be affected by a given project.
coarse fish	Species of fish harvested with or without the authority of a licence for the purpose of sale, trade or barter, but rarely sought for sport.

criteria	Numerical value(s) or narrative statement for a physical, chemical, or biological characteristic of water, biota, soil, or sediment that must not be exceeded to protect, maintain, and improve the specific uses of soil, sediment, and water.
deleterious substance	1. Any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water. 2. Any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water. Source: Fisheries Act (1985)
Destruction of fish habitat	Elimination of habitat of a spatial scale, duration, and intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.
Death of fish	Fish mortality.
discharge	Rate at which a volume of water passes a given point
drainage basin	See ‘watershed’
effluent	1. The liquid waste of municipalities, industries, or agricultural operations. Usually the term refers to a treated liquid released from a wastewater treatment process. 2. The release from any on-site sewage treatment component.

Fish	Includes (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
Fish habitat	Spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.
Fish that are part of	Fish that may be fished as part of a commercial, recreational or Aboriginal fishery.
Fish that support	Fish that contribute to the productivity of a commercial, recreational or Aboriginal fishery.
Fishery	Includes the area, locality, place or station in or on which a pound, seine, net, weir or other fishing appliance is used, set, placed or located, and the area, tract or stretch of water in or from which fish may be taken by the said pound, seine, net, weir or other fishing appliance, and also the pound, seine, net, weir, or other fishing appliance used in connection therewith.
flow	See 'discharge'
forage fish	
guideline	Generic numerical concentrations or narrative statements that are recommended as upper limits to protect and maintain the specified uses of air, water, sediment, soil, or wildlife. These values are not legally binding.
limit	An enforceable concentration in an approval, permit or licence; for example, a limit specified in an *Environmental Protection and Enhancement Act* (2000) approval for sedimentation ponds.
Mitigation	A measure used to reduce the spatial scale, duration, or intensity of adverse effects to fish and fish habitat that cannot be completely avoided.

Mitigation measures	Measures for the elimination, reduction or control of the adverse environmental effects of a designated project, and includes restitution for any damage to the environment caused by those effects through replacement, restoration, compensation or any other means. (CEAA 2012 section 2)
Navigable Waters	Includes canals and any other bodies of water created or altered as a result of the construction of any work. For purposes of the (*Navigation Protection Act*) NPA, navigable waters are those waterways where the public has a right to navigate the water as a highway.
objective	A numerical concentration or narrative statement that has been established by taking into account site-specific conditions to protect and maintain a specified use of a resource, such as water, soil, sediment, or tissue, at a particular site.
Obstruction	Slide, dam or other thing impeding wholly or partially the free passage of fish.
Ongoing productivity	The potential sustained yield of all fish populations and their habitat that are part of or support commercial, recreational and Aboriginal fisheries. Yield is a function of fish production. Production rate is the growth in population biomass per unit area per unit time. Determined by vital rates & life history characteristics.
Permanent alteration to fish habitat	Alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes.
pollutant	See ‘substance’

Qualified Aquatic Environment Specialist (QAES)	Means a person who: (i) possesses (A) a post-secondary degree in biological sciences, (B) a technical diploma in biological sciences, or (C) educational equivalencies; (ii) has a detailed knowledge of the aquatic environment, including fish and fish habitat, management and assessment; and (iii) is currently experienced with (A) fisheries and aquatic environment assessment methods, and (B) the determination of mitigation measures required to maintain the productive capacity of the aquatic environment, including fish habitats in Alberta that may be adversely affected by the carrying out of works in and adjacent to the water, bed and shore of water bodies.
Qualified Environmental Professional (QEP)	Professional that is able to advise on how to proceed with projects while also protecting fish and fish habitat by providing technical advice on appropriate project design and measures to avoid and or reduce impacts. QEPs are often referred to as a: natural resource consultant, environment consultant, aquatic biologist or a fisheries biologist
reach	A group of river segments with similar biophysical characteristics. Most river reaches represent simple streams and rivers, while some reaches represent the shorelines of wide rivers, lakes and coastlines.
Recreational (in relation to a fishery)	Fish is harvested under the authority of a licence for personal use of the fish or for sport.

release	A 'release' includes to spill, discharge, dispose of, spray, inject, inoculate, abandon, deposit, leak, seep, pour, emit, empty, throw, dump, place and exhaust
Relevant fish	All fish that are involved (either as part of the fishery or in a supporting role) in a commercial, recreational or Aboriginal fishery, and that could be affected by a given project.
Residual effect	Effect that remains after the implementation of mitigation measures.
river basin	An area of land drained by a river and its associated streams or tributaries. Alberta's *Water Act* identifies seven Major River Basins within the province: (1) Peace/Slave River Basin, (2) Athabasca River Basin, (3) North Saskatchewan River Basin, (4) South Saskatchewan River Basin, (5) Milk River Basin, (6) Beaver River Basin, and (7) Hay River Basin.
Serious harm to fish	The death of fish or any permanent alteration to, or destruction of fish habitat that are part of or that support a CRA fishery.
Species At Risk (SAR)	Fish species listed on Schedule1 of the *Species at Risk Act* (SARA) as extirpated, endangered, threatened species, or a species of special concern.
sport fish	Species of fish harvested under the authority of a licence for personal use of the fish or for sport
standard	A legally enforceable numerical limit or narrative statement, such as in a regulation, statute, contract, or other legally binding document, that has been adopted from a criterion or an objective. Source: CCME (1999)
substance	Any matter that is capable of becoming dispersed in the environment, or is capable of becoming transformed in the environment into matter that is capable of becoming dispersed in the environment.

water body	Any man-made or natural body of water defined by either a defined bed and banks or vegetation that requires wetland or seasonally inundated ground. 1. Location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood 2. For the purpose of the Codes of Practice, a water body with defined bed and banks, whether or not water is continuously present, but does not include fish bearing lakes
watercourse	A natural channel with defined bed and banks where water flows continuously, intermittently, or ephemerally. 1. A river, brook, stream or other natural water channel and the bed along which this flows 2. The bed and shore of a river, stream, lake, creek, lagoon, swamp, marsh or other natural body of water, or a canal, ditch, reservoir or other artificial surface feature made by humans, whether it contains or conveys water continuously or intermittently.
watershed	The area of land that catches precipitation and drains into a larger body of water such as a marsh, stream, river, or lake. A watershed is often made up of a number of sub-watersheds that contribute to its overall drainage.
water quality	In Canada, “water quality” is a term most identified by society to describe the physical, chemical, and biological characteristics and conditions of water and aquatic ecosystems, which influence the ability of water to support the uses designated for it.