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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
ToR	terms of reference
TSS	total suspended sediment
VC	valued component

8.0 ASSESSMENT OF POTENTIAL EFFECTS ON AQUATIC ECOLOGY

The scope of the assessment and existing conditions for aquatic ecology are presented in Volume 3A, Sections 8.1 and 8.2. This section assesses the potential effects of the Project on aquatic ecology during flood operations and post-flood operations. The temporal boundary for the flood and post-flood operations is indefinite, since the Project is a permanent installation. Volume 3C, Section 1.3.5 provides a discussion of cumulative effects; Volume 3C, Section 2.6 provides follow-up and monitoring; and accidents and malfunctions are provided in Volume 3D, Table 1-1, Section 1.5.1, Section 1.5.2, Section 1.5.6; and Section 1.7.2.

Flood operations refers to when water is diverted from Elbow River into the diversion channel, into the reservoir and the release of stored water from the reservoir. The assessment focuses on the potential effects of the diversion on the downstream fish habitat in the Elbow River, the potential to result in changes to fish migration in Elbow River, and the potential entrainment or stranding of fish in the reservoir; including potential effects to a Commercial, Recreational or Aboriginal (CRA) fishery, such as bull trout, and fish that support a CRA fishery.

Post-flood operations include partial sediment clean-up and maintenance activities required on project infrastructure (e.g., such as the diversion channel, floodplain berm, off-stream dam, access roads, low-level outlet, and bridges). This assessment discusses the potential effects of water release from the reservoir (post-flood) related to:

- hydrology in the low-level outlet and Elbow River
- potential stranding of fish in the reservoir
- suspended sediment in the low-level outlet and Elbow River
- fish habitat in the low-level outlet and Elbow River

8.1 PROJECT INTERACTIONS WITH AQUATIC ECOLOGY

Table 8-1 identifies for the project activities that might interact with aquatic ecology. These interactions are discussed in detail in Section 8.2 in the context of effects pathways, standard and project-specific mitigation, and residual effects. A justification for no interactions between project activity and aquatic ecology are provided following the table.

Table 8-1 Project-Environment Interactions with Aquatic Ecology during Flood and Post-flood Operations

Project Components and Physical Activities	Environmental Effects		
	Permanent Alteration of Fish Habitat	Destruction of Fish Habitat	Fish Mortality
Flood and Post-flood Operations			
Reservoir filling	✓	-	✓
Reservoir draining	✓	✓	✓
Reservoir sediment partial clean up	✓	-	✓
Channel maintenance	✓	✓	✓
Road and bridge maintenance	✓	✓	✓
NOTES: ✓ = Potential interaction – = No interaction			

Reservoir filling and sediment clean-up are not expected to have associated habitat destruction, but may result in an alteration of fish habitat through the release of sediment and the death of fish through degradation of habitat quality and fish health.

8.2 ASSESSMENT OF RESIDUAL ENVIRONMENTAL EFFECTS ON AQUATIC ECOLOGY

8.2.1 Analytical Assessment Techniques

Potential effects are assessed for three flood scenarios derived from hydrodynamic and sediment transport modelling predictions: design flood, 1:100 year flood, and 1:10 year flood (more detail is provided in Volume 3B, Section 6 and Volume 4, Appendix J, Hydrology TDR). The design flood has a less than 0.5% probability of occurring in any given year. The probability of a 1:100 year flood and a 1:10 year flood occurring in any given year is 1% and 10%, respectively. The design flood is based on the 2013 flood as an upper range; the 1:10 year flood is the lower range of flood flows that the Project would actively divert. The 1:100 year flood is the flow recurrence interval commonly used in floodway planning and management.

Quantification of permanent alteration to, or destruction of, fish habitat is based on an assessment of the potential effects from the diversion of flow from the Elbow River, the short-term retention of water in the reservoir, and the release of water to Elbow River through the low-level outlet.

The assessment of potential project-related effects uses DFO's PoEs (DFO 2014b). As discussed in Volume 3A Section 8.1.3, DFO's pathways of effects (PoE) diagrams illustrate potential causal relationships between project pathways and receptors in the receiving environment (DFO 2014b). DFO's PoE are used to assess the potential for project activities to result in serious harm to fish, including fish that support a CRA fishery and aquatic species at risk (e.g., bull trout). The approach:

- applies the relevant PoE for project related activities
- prescribes crossing-specific measures and mitigation to "break" the pathways that lead to PoE endpoints
- provides the opportunity to prescribe additional site-specific measures, where standard measures are not adequate or appropriate
- provides 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 listed aquatic species at risk.

Seven PoEs were identified for land and water-based activities associated with the Project. The PoEs are related to operation during flood flows; the release of stored water back to the Elbow River; and the maintenance of the proposed infrastructure after flood operations, including the removal of debris and sediment at the gates in the Elbow River and the excavation of sediment deposited in the off-stream reservoir. The PoEs and associated potential effects of the Project are presented in Table 8.2-1. Timing for flood operations is seasonal because a flood is limited to the spring and summer months. Timing for post-flood operations is regulatory because post-flood operations would have greater potential to affect residual environmental effects related to aquatic ecology during a restricted activity period.

Table 8.2-1 Pathways of Effects for the Proposed Work

Pathways of Effects	Potential Effects (i.e., endpoints)
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
Use of industrial equipment	• Change in sediment concentration • Potential mortality of fish/eggs/ova from equipment • Change in contaminant concentrations

Table 8.2-1 Pathways of Effects for the Proposed Work

Pathways of Effects	Potential Effects (i.e., endpoints)
In Water Activities	
Water Extraction	• Direct or indirect mortality of fish
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
Dredging*	• Change in food supply • Change in habitat structure and cover • Change in sediment concentration • Change in contaminant concentration • Change in nutrient concentration
Fish Passage Issues	• Incidental entrainment, impingement, or mortality of fish • 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

NOTES:

* Excavation and dredging refer to the potential removal of accumulated sediments and debris in upland areas and from within the normal highwater mark of watercourses following a flood event.

** The change in baseflow from land-based excavation is not applicable to this phase of the project where excavation will focus on the potential removal of accumulated sediment around infrastructure following a flood event.

8.2.1.1 Assumptions and the Conservative Approach

Uncertainty arises because of the probability of flooding occurring, the potential available debris and bedload movement during flood, the natural variation in the movement of fish in the watershed, the potential for fish to be swept downstream, the potential for fish to follow water flowing out of the reservoir, and the evaluation of potential effects. Consequently, the assessment is based on conservative assumptions that lean towards larger environmental effect predictions.

8.2.1.2 Context

The intent of the Project is to mitigate downstream flood hazard to the City of Calgary by modifying the hydrology of Elbow River during high flows. This would be done by temporarily diverting water into off-stream reservoir. The Project has been designed so that flow diversion can occur when discharge exceeds 160 m^3/s in Elbow River. The aim of the diversion is to maintain 160 m^3/s in Elbow River up to flows of approximately 760 m^3/s where the diversion capacity of 600 m^3/s is met. Diversion of up to 600 m^3/s from Elbow River, and subsequent water release from the reservoir, would have a direct effect on the hydrology and suspended sediment concentration of the low-level outlet and Elbow River. However, this is a mitigation project and this hydrological interaction is intentional and expected.

The complex dynamics between flow and sediment movement in Elbow River are discussed in Volume 3B, Section 6 (Hydrology). Predicted suspended sediment concentrations during the three floods are also provided in Section 6. An assessment of the effect on suspended sediment associated water quality parameter concentrations during three floods is discussed in Volume 3B, Section 6 (Hydrology).

The main potential effects that operation would have on fisheries and aquatic ecology are related to the:

- alteration of habitat from a modification of theElbow River channel associated with reduced flood flows
- barrier to upstream fish migrations in the Elbow River, which is considered a loss (i.e., destruction) of habitat
- incidental entrainment and stranding of fish in the off-stream reservoir
- change in Elbow River flows during the release of water from the reservoir
- release of sediment in the outlet channel during release of water from the reservoir

Downstream of the proposed diversion structure, brown trout, brook trout, rainbow trout, and mountain whitefish are the most abundant sport fish species. Bull trout, which is a species at risk, is abundant upstream of the proposed diversion structure, but less abundant downstream with only a few records; likely due to natural changes in habitat associated with elevations on the Elbow River (Paul and Post 2001). Changes to habitat would primarily affect sport fish species, such as brown trout, brook trout, and mountain whitefish and coarse and forage fish that support a CRA fishery downstream of the proposed diversion structure. Pure cutthroat trout populations are not known to exist in the LAA (See Volume 3A, Section 8.2 for details on the fish community, distribution, and relative abundance in the LAA).

8.2.2 Permanent Alteration of Fish Habitat

Details of changes to flows in Elbow River and changes to sediment and bedload transport are discussed in Volume 3B, Section 6.4.2 and in Springbank Off-Stream Reservoir Project Hydrology Flood Frequency Analysis (Stantec 2015).

8.2.2.1 Project Pathways

Habitat and Structure

The diversion of flows from the river can alter habitats by reducing the flows in the river channel, and therefore, local water velocities in the Elbow River. Changes in river velocity from floods can reduce the movement of bedload, reduce scour that creates pools, reduce the mobilization and deposition of gravel that creates salmonid spawning habitat, reduce the mobilization of woody debris, and change the slope and vegetative cover on the banks (Shirvell 1994, Freeman et al. 2001).

Changes in channel morphology might occur from decreased flows resulting in physical alterations to the channel features (i.e., bed and banks, width, depth, and gradient). This process could result in reduced woody debris transport downstream and reduced bedform change. Lateral channel migration promotes habitat diversity and can be negatively affected by flow impoundment (Sheilds et al. 2000), as might occur upstream of the diversion structure during diversion. This could affect shallow side-channel and nearshore rearing habitats. The increase in bed stability and stable flows can result in the growth of aquatic macrophytes, which can improve habitat, but can also restrict fish spawning habitat, and fish and invertebrate access to clean substrates. Resultant decreases in habitat complexity may be detrimental to fish diversity, may change species composition or abundance in a portion of the river, and overall may affect the distribution of species in the Elbow River.

Effects to overwintering areas and spawning substrates were noted to be of concern by Tsuut'ina Nation. During the winter, Cunjak (1996) indicates that stream resident salmonids, juveniles may shift their preference to slower habitat and school together in suitable habitats. Because of the tendency for trout to form schools in slower water, at areas of suitable substrate, depth, and cover, the cleaning action of scouring of gravel substrates and pool habitats is an important function of flooding in rivers (Clarke et al 2008). A clean, suitable sized substrate is also important for overwintering trout, such as brown trout, because they may burrow under coarse material (Cunjak 1996). Periodic natural bed scouring flows are needed to rejuvenate the food web that supports fish and other higher trophic levels (Clarke et al 2008).

Sediment Concentration

The Blood Tribe, Piikani Nation, and Tsuut'ina Nation expressed concerns regarding potential sedimentation in the Elbow River during operations. Based on Sediment Transport Capacity modelling (see Section 6 and Volume 4, Appendix J Hydrology TDR), operation of the diversion structure during highwater scenarios may result in the deposition of sediments in the channel upstream of the diversion structure and immediately downstream. Sediment removal is likely to involve ongoing maintenance in the diversion channel and from upstream of the auxiliary spillway and diversion structure and potential removal in the reservoir to maintain internal drainage.

The moderation of flows during active diversion of water would limit flows in Elbow River to 160 m^3/s from the diversion downstream to the low-level outlet. In this portion of the river channel, the suspended sediment levels would be dependent on background levels flowing downstream through the diversion structure.

When the flow in Elbow River is over 160 m^3/s, flows would be directed into the reservoir through the diversion channel. Water would be drained from the reservoir (after a period of retention) through the low-level outlet channel. Section 6 indicates that high magnitude changes to geomorphology are expected in the low-level outlet. The majority of the mobilized bed material would remain in the low-level outlet with expected minimal interaction with Elbow River. However, when water is released down the low-level outlet from the reservoir, there would be channel erosion in the low-level outlet channel and re-suspension of sediment from the reservoir. There would be a temporary increase in turbidity in the outlet channel and in the Elbow River downstream of the low-level outlet during the release of water retained in the reservoir following a flood.

Contaminant Concentrations

Hydrocarbons, anti-icing agents (e.g., calcium chloride), fertilizers, and herbicides have the potential to be released through leaks and spills during maintenance and operation, vegetation management, including weed control, road management and reclamation, and re-fueling, leaks, exposed grease, or accidental spills from equipment operating in or around the watercourses during structure maintenance and debris clean-up. Substances on dry ground can be washed to the river during rain and snowmelt, or may run directly to watercourses. Introducing a toxic substance can cause serious harm to fish, by compromising the health of primary, benthic, and fish communities (e.g. Schulz and Dabrowski 2001, Reynaud and Deschaux 2006).

Temperature

Tsuut'ina Nation expressed concerns over the change in temperature from water released from the reservoir. Temperature could change in the retained waters of the reservoir (Wetzel 1975, Clarke et al 2008). Changes in water temperature may result in direct mortality as well as a variety of sublethal or stress related effects on fish, including behavioural, bioenergetic, or physiological effects (DFO 2014a). Incubating eggs and spawning adults are more susceptible to temperature changes.

Nutrient Concentrations

Flooding of upland areas can lead to increased nutrient concentrations including the submersion and decomposition of riparian or aquatic vegetation, the use of herbicides and fertilizer, organic debris management, and maintenance activities such as removing deposited sediment (DFO 2014b). Increasing nutrient concentrations can lead to eutrophication, which can have undesirable effects on fish. Eutrophic systems are more likely to produce algal blooms and have indirect impacts on fish through reduction of dissolved oxygen, and other habitat impacts such as changes to aquatic macrophytes and benthic fauna (Dodds 2006). Oligotrophic systems such as Elbow River which can have low levels of nutrients are more efficient at converting phytoplankton (i.e., primary production) to fish production. In many species, total fish production, total fish biomass, and growth are positively related to small or moderate increases in nutrient concentrations. The productivity of fisheries is strongly influenced by primary production at the base of the food web, which is typically limited by phosphorus (P) or nitrogen (N). However, some species are intolerant of nutrient enrichment and other impacts that may result from eutrophication.

Intolerant taxa such as Ephemeroptera, which are grazers feeding principally on algae and detrital material and Trichoptera many of which are filter feeders and herbivores (Merritt and Cummins 1996), are suited to mild nutrient enrichment, when oxygen is maintained in the system (Hynes 1960; Roback 1974). In low oxygen conditions, the community structure may change such that organisms tolerant of low oxygen levels (such as Chironomidae and Oligochaeta) dominate the community and intolerant organisms (such as the Ephemeroptera, Plecoptera and Trichoptera group) are eliminated over time (Hynes 1960).

Food Supply

Floods introduce terrestrial invertebrates from flooded riparian areas to the river, increasing the availability of invertebrates as fish food. With the diversion of water into the reservoir, some fish food items in Elbow River, including invertebrates and smaller fish, would be diverted into the reservoir. These food items would not be available for fish remaining in the river. As water is released from the reservoir, flooded terrestrial items from the reservoir and food items in the reservoir, may flow down the low-level outlet and into Elbow River, potentially changing the quantity and availability of food items in Elbow River. Periodic high flow events are also required to scour the bed and restore substrate conditions that produce benthic organisms that support lower trophic levels in the food web (Clarke et al 2008, Matthews et al 2014).

Flow Modification

An increase of flows can reduce the growth rates in fish by increasing activity costs rather than reducing the feeding rate (e.g. Fausch 1983) as well as by reducing efficiency in feeding for sight feeders in increased turbidity (e.g. Sweka and Hartman 2001, Sweka and Hartman 2003). A change in flow in the outlet channel may reduce the suitability of habitat use for fish. Flows in Elbow River will be decreased while the diversion structure is in operation, but will remain at a level within the normal variation of flow for the channel. The decrease in flow will affect the movement of bedload.

8.2.2.2 Mitigation

Environmental protection would be managed during operation through Alberta Transportation's Environmental Construction Operations (ECO) Plan process (see Volume 4, Part 1, Supporting Documentation, Document 4). Measures to mitigate effects on aquatic ecology have been developed based on best management practices described in the Fish Habitat Manual (Alberta Transportation 2001), the COP for Watercourse Crossings (ESRD 2013), and DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2013). The mitigation measures are presented in terms of Project design, timing of operations, activities, erosion and sediment control, water management, stream isolation, reclamation, and structure operation and maintenance. The mitigation addresses the environmental effects that may result in a permanent alteration of habitat predicted on aquatic ecology for the Project.

Potential contaminant-related effects will be mitigated through project design (e.g., road water runoff management), implementing a spill containment and response plan, using appropriate sediment and erosion control measures, limiting the use of and following best management practices for herbicides and fertilizers in the dry reservoir or near waterbodies, and using non-toxic biodegradable hydraulic fluids in equipment for any required instream works.

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.

Potential effects of erosion and sedimentation during operation of the diversion and reservoir could be minimized by reducing flows down the outlet channel.

Related to operation and maintenance of the structure during floods and in the post-flood period, operational procedures will reduce the potential effects of the project on the aquatic environment, including effects on fish that support a CRA fishery. These procedures include maintenance plans that are based on best management practices for working around water. Structures will be designed so that storm water runoff and wash water from the access roads, decks, side slopes, and approaches are directed into a retention pond or vegetated area to remove suspended solids, dissipate velocity, and prevent sediment and other deleterious substances from entering watercourses. The cleaning and removal of debris and sediment from drainage devices will be conducted in a manner that would prevent materials from entering the waterbody. Paint or protective coatings will be removed in a manner that prevents any paints, paint flakes, primers, blasting abrasives, rust, solvents, degreasers, or other waste material from entering the watercourse.

Where debris removal on the structure 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 (i.e., risk of structure failure). Large woody debris pieces, such as wood over 50 cm in diameter, will be collected at the diversion structure or in the reservoir, retained and relocated in the river downstream of the diversion structure.

8.2.2.3 Project Residual Effects

Volume 3B, Section 6 (Hydrology) indicates that changes in morphology in Elbow River may result in reduced mobilization on bar heads and a decrease degradation and aggradation. Modelling (see Section 6) shows that for the 1:10 year flood, the pattern of erosion of bar heads and subsequent deposition downstream would be maintained during active diversion, albeit with a moderate reduction in magnitude of approximately 24%. For the 1:100 year flood, the pattern of erosion of bar heads and subsequent deposition downstream would be maintained during active diversion, albeit with a reduction in magnitude of 5%. For the design flood, the pattern of erosion of bar heads and subsequent deposition downstream would be maintained during active diversion, albeit with an expected high reduction in magnitude of approximately 65%.

High magnitude changes to geomorphology are expected in the low-level outlet, However, most the mobilized bed material is predicted to remain within the low-level outlet and minimal interaction with Elbow River is expected. There would be channel erosion in the outlet channel and re-suspension of sediment from the reservoir. There would be increased turbidity in the outlet channel and in the Elbow River downstream of the low-level outlet. Increased erosion in the outlet channel and the potential requirement for maintenance could result in alterations to fish habitat in the outlet channel. Increased turbidity and the deposition of sediment on substrates could affect the quality of fish habitat in the low-level outlet channel and in Elbow River downstream of the low-level outlet.

During floods, flows of approximately 160 m^3/s, which are close to the 1:10 year flood would continue in Elbow River downstream of the diversion structure. These flows are considered channel forming and would shift bed materials which would maintain overwintering and spawning habitat and shallow side-channel and nearshore rearing habitats. Given the low probability of the design flood and the 1:100 year flood, the reduction in magnitude of erosion and deposition is unlikely to occur at a frequency to negatively affect overwintering habitat, such as the scouring of pools and deeper runs for trout species, nor negatively affect spawning habitat in the in Elbow River. Sediment removal is likely to be an ongoing maintenance concern in the diversion channel and in the Elbow River immediately upstream from the auxiliary spillway and diversion structure.

The reduction in floods over 160 m^3/s may cause a stabilization of banks and a corresponding increase in directly overhanging vegetation, However, due to the limited nature of this interaction and the presence of channel forming flows up to the 1:10 flood (160 m^3/s), the effect is likely to be not significant.

Given that channel forming flows up to 160 m^3/s would occur in Elbow River downstream of the diversion structure, it is unlikely that there would be an increase in aquatic macrophyte growth (e.g., Chambers et al. 1991).

The regulation of water flow can affect the quantity of invertebrate drift and the food supply for fish. During flood flows, fish take cover in flooded riparian or terrestrial lands (Schwartz and Herricks 2005), and it may be assumed that this may provide fish with increased access to terrestrial invertebrates that become flooded. Rocaspana et al (2016), found that brown trout do not feed during high hydropeak flows, but the highest prey consumption was observed immediately after hydropeaking because of the increase in benthic invertebrate drift rates.

Given that flood flows would only be regulated above the 1:10 year flood flows and that fish may suspend feeding during peak flows, and that food sources should remain abundant, it is unlikely that changes to flow would negatively affect food availability and fish feeding patterns in Elbow River.

As the water from the reservoir is released, it would mix with Elbow River water. Generally, temperature in the river can increase as a result of this release and dissolved oxygen concentrations can decrease. The effect on dissolved oxygen is expected to be localized because of rapid aeration of water. During an Elbow River flood without the Project in place, water temperatures would increase and dissolved oxygen concentrations decrease as floodwaters reach Elbow River floodplains or the Glenmore Reservoir. Compared to these conditions, the effect of the Project during a flood is anticipated to be of low magnitude, temporary and localized to the area where the outlet channel meets the Elbow River. The Project is not anticipated to affect temperature and dissolved oxygen in the Elbow River. For additional details on changes in temperature and dissolved oxygen, see Volume 3B, Section 7.4.3.

With flood water dilution, the draining of the reservoir would not likely alter nutrient levels to the extent that serious harm to fish may occur in Elbow River. The reservoir is expected to remain vegetated during all stages of operation to avoid areas of exposed soils. (Exposed soils are more likely to add nutrients into the river during post-flood operations to drain the reservoir.)

The estimated low and high methylmercury concentrations in all floods are below the CCME Canadian Water Quality Guideline for the Protection of Aquatic Life (Volume 3B, Section 7.4.4). Because the guideline concentration is not exceeded, no toxicological effects on aquatic life are anticipated.

The increased turbidity and the deposition of sediment on substrates could affect the quality of fish habitat in the low-level outlet channel and in Elbow River downstream of the low-level outlet. Given the low probability of diversion occurrence and with the implementation of mitigation measures, the potential change in sediment and turbidity that may result downstream is not anticipated to result in residual effects on aquatic ecology, given the slow rate of draining of the reservoir.

8.2.3 Destruction of Fish Habitat

8.2.3.1 Project Pathways

Access to Habitats or Migration Patterns

The public and Indigenous communities, including Tsuut'ina Nation, identified concerns with the Project potentially affecting fish migrations in Elbow River. Fish movements in the Elbow River may be restricted due to increased velocities at the structure, turbidity, and debris movement attributed to the flood discharge.

In post-flood operations, debris on the diversion structure may impede fish passage in the Elbow River. In addition, erosion in the Elbow River, immediately downstream of the diversion structure may create a pool and drop that impedes fish movement.

8.2.3.2 Mitigation

Mitigation for the potential destruction of fish habitat is included in the measures presented in Section 8.2.2.2. To maintain upstream fish passage after a flood has occurred, debris will be cleaned from the structure gates after a flood recedes to allow unimpeded fish passage upstream over the structure. Maintenance, debris removal on the structure, and on the fish passage structures will occur immediately to accommodate fish passage.

8.2.3.3 Project Residual Effects

Flood operation of the diversion structure occurs at approximately the 1:10 year flood, below which passage should be accommodated with no more than a three-day delay. This standard has been used in Alberta (Alberta Transportation and Utilities and Forestry, Lands and Wildlife 1992) and equates to a 0.1% probability of fish passage being blocked by high flows in any given year, for three consecutive days, during the periods of fish migration, up to a 1:10 year flood. Because flows in Elbow River would be less during active water diversion (compared to flows without the Project), fish migration in Elbow River at the diversion structure should not be impeded any more than during the dry operation condition. Above the design flood, additional flow over 160 m^3/s may affect fish migrations, but these velocities were not modelled because of the extreme nature and low probability of that magnitude of flood in a given year.

For floods greater than the 1:10 year flood, fish movements in the main channel of Elbow River may be restricted due to turbidity and debris movement attributed to the flood discharge, as well as local flow conditions including water velocity.

With maintenance on the structure and mitigations, upstream movement in post-flood operations should not differ from upstream movement during dry operations.

The destruction of fish habitat from the barrier of upstream fish passage during flood and post-flood operations is predicted to be not significant and should not result in a change to fish distribution in the Elbow River.

8.2.4 Fish Mortality

8.2.4.1 Project Pathways

In an undisturbed fishery and natural population of fish, fish recruitment often balances natural fish mortality to maintain viable fish populations. When additional mortality occurs in the population, the number of adults, subsequent reproduction and juvenile recruitment may be reduced. Natural mortality in Elbow River includes direct and indirect impacts (e.g., predation, age, disease, natural floods), while additional impacts (e.g., angling, bodily harm in the Project canals, and entrainment in the reservoir) may result in additional fish mortality and affect the fish population (e.g., Roberts and Rahel 2008). If food and habitat resources are readily available, surviving fish in the river may compensate by growing faster, increasing fecundity if habitat is suitable, or have decreased natural mortality related to lower population densities. The consequences of additional Project-related fish mortality may affect long-term viability through reduce survival and productivity beyond what the natural populations can compensate for in fish that support a CRA fishery in the Elbow River. This may result in changes to fish species abundance and distribution in the River.

Potential Mortality of Fish/Eggs/Ova, Indirect and Direct Mortality

Change in fish/egg mortality includes the increased risk of indirect and direct mortality to individuals (i.e., all life stages) and/or their eggs due to the intensity, duration, and timing of work near a waterbody, through bodily harm caused to fish transported in the flood flow conveyance canal, or through the stranding of fish because of habitat fragmentation caused by declining flow in the canal and outlet channel and declining water level in the reservoir.

Change in contaminant concentration in relation to mortality includes changes to various water quality parameters outlined in the CCME Guidelines, as well as the introduction of a toxic substance, as it relates to effects to fish health leading to potential indirect or direct mortality. . Deleterious substances such as hydrocarbons, anti-icing agents (e.g., calcium chloride), fertilizers, and herbicides have the potential to be released through 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, which could indirectly lead to the mortality of fish through cumulative stressors or to direct mortality in high concentrations. Details of changes to water quality in Elbow River are discussed in Volume 3B, Section 7.4.

A change in contaminates, temperature, flow conditions or interspecies interaction could result in a change in fish health that may lead to reduced fecundity thereby affecting the productivity and sustainability of a fishery. Where fish that are transported in fast flow enter a body of standing water, there may be increased predation on fish that have not found cover (Walters et al 2012).

Displacement, Stranding, Entrainment, or Impingement of fish

The entrainment of fish would depend on the frequency of flood operation, water levels in the reservoir, and the portion of Elbow River flow diverted into the reservoir. The number of fish also diverted into the reservoir during flood operation, would depend on the percentage of the flow diverted, the distribution, and size of fish moving or swept downstream, and potential that the fish species would be mobile during flood flows, rather than using local shelter habitats. Species that exhibit migratory movements during diversion events would have a greater chance of encountering the structure than resident fish that are not migrating during the diversion (Carlson and Rahel 2007). Structures that divert a higher percentage of the flow of a river have a higher potential of entraining fish (Gale et al 2008). Given that flows up to 160 m^3/s would remain in the Elbow River, while flows above 160 m^3/s up to 760 m^3/s would be diverted into the reservoir, up to approximately 80% of the flow could be going into the diversion canal during a design flood. During the diversion of flood water from Elbow River to the off-stream reservoir, it is assumed that fish, at any of their lifestages present, would encounter the diversion structure. This could result in the entrainment of 80% of the fish that are upstream and near the diversion structure or being swept downstream during flooding.

Entrainment of fish into the reservoir during flood operation may cause bodily harm to fish as they are transported along the canal and into the reservoir.

Piikani Nation and Tsuut'ina Nation identified concerns with stranding of fish in the reservoir. There is potential for fish to be stranded during water release and dewatering of the reservoir, resulting in fish stress or mortality. After construction of the Project, most of the reservoir would remain undisturbed ground, with selected areas graded for drainage, borrow, and energy dissipation at the outlet of the diversion channel. Without landscaping designed to collect water and direct it to a concentrated area, isolated deeper areas or pools may develop that have the potential to strand fish after flood operations and as the reservoir drains. Extended periods of trapping in isolated pools can lead to death by asphyxiation, elevated temperatures, starvation, or increased predation. The mortality from the entrainment is dependent on the number of fish entering the reservoir during flood operation and those returned to Elbow River during draining of reservoir.

Changes in downstream flows can also result in changes to natural conditions that strand fish in Elbow River or the low-level outlet. In-river stranding is the separation of fish from flowing water because of the decline in discharge. A river reach, such as Elbow River from Highway 22 downstream to the Glenmore Reservoir, with side channels, deep pools, low-gradient gravel bars, or with substantial braiding would have a greater natural potential for stranding than a river reach with a single, uniform channel, such as the low-level outlet channel.

Elbow River would return to normal flow patterns over the summer period. Sportfish spawning coincides in Elbow River with spring flows. Sucker and minnow fish species however often spawn during flow periods when the river flows are lowering following natural spring floods during June and July. Sucker and minnow species may spawn in the low-level outlet during the June - July period of declining flows and sucker and minnow eggs may become trapped or exposed.

Small bodied fish, including juvenile salmonids and fish that support CRA fisheries, may use the low-level outlet as rearing habitat during the period of return flows. As flows decline, fish may become trapped in isolated pools and interstitial spaces between cobbles in the low-level outlet. Conversely, fry over gravel substrates are more mobile, often in schools, and as flow declined they retreated with the water margin (Clarke et al. 2008).

8.2.4.2 Mitigation

Mitigation for the potential fish mortality by the Project is included in the measures presented in Section 8.2.2.2. The water flows in the canal will be gradually reduced and the reservoir slowly drained to facilitate the movement of fish from the reservoir, back to the Elbow River with the receding water. The outlet will be designed and operated in a manner that allows fish egress out of the reservoir, downstream into the outlet channel. Drainage areas within the reservoir will be graded to reduce stranding of fish during release of stored flood water from the reservoir. During draining of the reservoir, monitoring will be undertaken to identify isolated pools and the potential that fish may become stranded. If potential fish stranding is identified, further action will be taken to reduce the potential mortality of fish.

8.2.4.3 Project Residual Effects

The mortality from entrainment is dependent on the number of fish entering the reservoir and those fish returned to Elbow River during draining of reservoir. The number of fish entrained in the canal depends on the timing of the flood event, although, because the peak flows will be in mid-spring, the diversion structure will likely be operational before spring spawned trout fry (rainbow trout, cutthroat trout) emerge from gravel and drift downstream, avoiding the entrainment of young trout.

Entrainment of fish into the reservoir during active diversion may cause bodily harm to fish as they are transported along the canal. There is potential for fish to be stranded during dewatering of the reservoir, resulting in fish stress or mortality. During natural flooding, fish species may seek side channels and lower velocity flooded riparian areas, then return to the main river channel as flood water recedes (Roberts et Rahel 2008). With gradually reducing water levels in the reservoir and grading that avoids the formation of pooled areas, fish should be able to move out of the reservoir with receding water.

Based on the relative abundance of fish found in the LAA (Figure 8.2-1), the majority of fish that could be entrained in the diversion canal would be brown trout, followed by mountain whitefish and brook trout. Brown trout, brook trout, and mountain whitefish spawn in the fall, and therefore should not be undergoing migration movements during the potential operational period of the diversion structure (May-June of a flood year), although immature individuals may encounter the diversion when young disperse to rearing habitats.

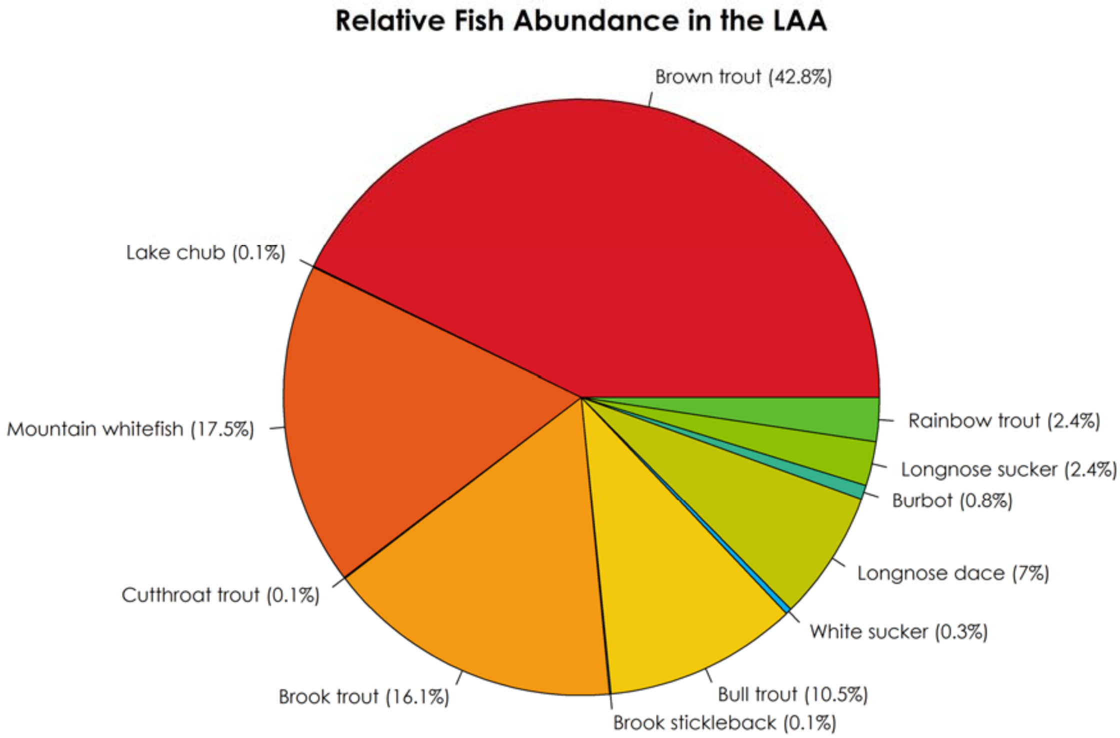

Figure 8.2-1 Relative Abundance of Fish in the LAA that may Encounter the Diversion Structure during Flood Operations

Fish entrained in the reservoir are expected to seek egress as the flood water recedes, and given slow reductions in water level, should be able to move downstream out of the reservoir (Roberts et Rahel 2008). If fish cannot escape the reservoir during draining, it is likely that fish mortality would occur due to stranding. Changes in downstream flows can also result in fish stranding in the low-level outlet or Elbow River depending on the extent of shallow habitat features like small pools.

During post-flood operations, stranding in the reservoir is expected to cause mortality of fish that do not swim out of the reservoir during post-flood draining. In canal entrainment for a diversion on the Bow River, Post et al (2006), found that the mortality from fish lost in the canal was low relative to the natural mortality of fish in the Bow River. Although the percent of the flow being diverted was less in that scenario, the diversion was operational from April to October, significantly increasing the potential that fish were entrained. It is likely with the low probability of operation in a given year (at flows over the 1:10 year flood event) and the short duration of operation, that entrainment will not result in a significant fish mortality that would affect the long-term persistence or viability of aquatic species and fish of management concern in the RAA. The number of fish potentially lost is unpredictable and is based on the ability to rescue fish, which is related to reservoir ponding areas, drawdown rate, and sediment deposition in the reservoir.

8.2.5 Summary of Project Residual Effects

Table 8-2 summarizes the residual environmental effects on aquatic ecology during flood and post-flood operations.

Table 8-2 Project Residual Effects on Aquatic Ecology during Flood and Post-flood Operations

	Residual Effects Characterization								
Environmental Effect	**Project Phase**	**Timing**	**Direction**	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological and Socio-economic Context**
Permanent alteration of fish habitat	F/PF	S/R	A	M	LAA	LT	IR	R	D
Destruction of fish habitat	F/PF	S/R	N	L	PDA	ST	IR	R	D
Fish Mortality	F/PF	S/R	A	H	LAA	LT	IR	R	D

KEY

See Table 8-2 in Volume 3A for detailed definitions

Project Phase
F: Flood Operations
PF: Post-Flood Operations

Timing Consideration
T: Time of day
S: Seasonality
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

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

8.3 DETERMINATION OF SIGNIFICANCE

As defined in Section 8.1.6 of Volume 3a, 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.
- Destruction of fish habitat that likely results in serious harm to fish and cannot be mitigated or offset or the obstruction of indicator fish passage for longer than a three-day delay at the 1:10 year flood.
- Residual serious harm to fish due to fish mortality occurs when fishery productivity or sustainability is adversely affected and where recovery to baseline levels is uncertain.

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 Species at risk or fish that support a CRA fishery, in the RAA.

With the application of mitigation and environmental protection measures, residual effects associated with flood and post-flood operations on aquatic ecology are predicted to be not significant.

8.4 PREDICTION CONFIDENCE

Prediction confidence on the effects of direct and indirect alteration of fish habitat during flood and post-flood operations is moderate as modelling results indicate that only the magnitude of aggradation and degradation during diverted floods would be affected. Confidence in the prediction that the Project effects on the destruction of fish habitat would be not significant is high because the assessment found that upstream movement of fish during post-flood operations would not differ from upstream movement during dry operations.

However, confidence in the prediction that the Project effects on fish mortality during flood and post-flood operations is lower than that for effects on alteration or destruction of fish habitat. This is because of uncertainty on the effects of flooding on the fish populations in the LAA, the unpredictable nature of movement of fish diverted into the reservoir, and the prediction of species and density of fish potentially stranded in the reservoir during post flood operations. Monitoring of fish during reservoir draining and post-flood operations and a fish rescue plan would increase the predictive confidence regarding Project effects on fish mortality.

8.5 CONCLUSIONS

8.5.1 Permanent Alteration of Fish Habitat

The Project would result in direct and indirect alteration of fish habitat during flood and post-flood operations.

Due to the nature of these interactions, the residual effects on fish habitat, as a function of bedload movement in Elbow River and low-level outlet, have been assessed to be high. The duration of the effect is likely to be short- to long-term, depending on flood magnitude and the extent of subsequent non-diverted flows. However, Volume 3B, Section 6 predicts channel planform and bedload movement would be maintained and only the magnitude of aggradation and degradation during diverted floods would be affected.

Increased suspended sediment concentrations and the deposition of sediment on substrates could affect the quality of fish habitat in the low-level outlet channel and in Elbow River downstream of the low-level outlet. During release, most of the mobilized bed material is predicted to remain within the low-level outlet and minimal interaction with Elbow River would occur (Volume 3B, Section 6). This indicates that fish habitat in the low-level outlet channel would likely be altered considerably during release, whereas fish habitat alteration downstream of the low-level outlet, in Elbow River, would be small.

Given infrequency of diversion and with the implementation of mitigation measures, the potential change in suspended sediment concentrations downstream is not anticipated to result in residual effects on aquatic ecology.

This indicates that the effects on fish habitat are not significant.

8.5.2 Destruction of Fish Habitat

The Project would not result in a destruction of fish habitat by preventing fish passage during flood and post-flood operations. With maintenance on the diversion structure and mitigation, upstream movement of fish during post-flood operations would not differ from upstream movement during dry operations.

8.5.3 Fish Mortality

The Project may result in fish mortality that can threaten the long-term persistence and / or viability of aquatic species and fish that support a CRA fishery in the RAA. During post-flood operations, stranding in the reservoir is expected to cause mortality of fish that do not swim out of the reservoir during post-flood draining. The potential level of fish mortality is not known, and the ability to rescue stranded fish depends on extent of areas ponded, reservoir drawdown rate, and sediment deposition in the reservoir which effects drainage and fish movement.

The diversion structure and reservoir are planned and designed as mitigation measures to limit the effects of floods in the Elbow River. Fish often move into sheltered habitats which experience reduced flows during floods, potentially including the reservoir. The low frequency of floods, design of diversion structure, depth of water held in the reservoir, grading of the reservoir, rate of downdraw in the reservoir, and monitoring and contingency plans for stranded fish would be used to avoid and limit fish mortality. This indicates that the effects on fish mortality is not fully known, but could be mitigated if necessary steps to rescue fish are taken if identified during monitoring of receding flood water. The residual serious harm to fish due to fish mortality from entrainment and stranding in the reservoir is likely not significant if fish rescues are undertaken to relocate stranded fish.

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8.7 GLOSSARY

Aboriginal (in relation to a fishery)	Fish that is harvested by an Aboriginal 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 Aboriginal 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.
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.

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.
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.
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.
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 and 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.

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.

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.
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.
sport fish	Species of fish harvested under the authority of a licence for personal use of the fish or for sport
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.