Final

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Rainbow Trout (*Oncorhynchus mykiss*) in Canada (Athabasca River populations)

Athabasca Rainbow Trout

2020

Canada

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For copies of the recovery strategy, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

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Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of a recovery strategy for species listed as extirpated, endangered, or threatened and are required to report on progress five years after the publication of the final document on the Species at Risk Public Registry.

The Minister of Fisheries and Oceans and the Minister responsible for the Parks Canada Agency (PCA) are the competent ministers under SARA for the Rainbow Trout (Athabasca River populations) and have prepared this strategy, as per section 37 of SARA. In preparing this recovery strategy, the competent ministers have considered, as per section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this recovery strategy has been prepared in cooperation with Alberta Environment and Parks as per section 39(1) of SARA.

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the direction set out in this strategy and will not be achieved by Fisheries and Oceans Canada (DFO) and PCA or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Rainbow Trout (Athabasca River populations) and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Fisheries and Oceans Canada (DFO) and PCA and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

Fisheries and Oceans Canada (DFO) would like to thank the following organizations for their support in the development of the Rainbow Trout (Athabasca River populations) recovery strategy:

The Parks Canada Agency (PCA)
Alberta Environment and Parks (AEP)

DFO also extends its sincere appreciation to numerous organizations that contributed to the development of this recovery strategy and who contributed their knowledge and hard work into the development of this document. A detailed list of the contributing organizations that reviewed and/or contributed to the document is provided in the Record of Cooperation and Consultation (appendix B).

Executive summary

Rainbow Trout (*Oncorhynchus mykiss*) is a species of salmonid that is characterized by a silver body covered in black spots with a pink horizontal band. Rainbow Trout is native primarily to northeastern Siberia and western North America. In Canada there are only three drainages east of the continental divide known to contain native populations of Rainbow Trout: Peace, Liard and Athabasca rivers. The Athabasca River populations (herein Athabasca Rainbow Trout) are not considered a distinct subspecies, but qualify as a single designatable unit (COSEWIC 2014).

Athabasca Rainbow Trout were listed as Endangered under the *Species at Risk Act* (SARA) in August 2019. This recovery strategy is considered one in a series of linked documents for this species that should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (2014) and a Recovery Potential Assessment (RPA; DFO 2018). Recovery has been determined to be biologically and technically feasible.

Athabasca Rainbow Trout populations are found primarily in small cold headwater streams in the Athabasca drainage. Athabasca Rainbow Trout spawn in the spring in streams with fine gravel (free of silts and clays) and moderate flow rates. In the winter, the largest and deepest pools in any occupied stream reach are commonly used by Athabasca Rainbow Trout for overwintering habitat. Therefore, habitat connectivity is important for Athabasca Rainbow Trout. The total estimated extent of occurrence is 24,450 km^2 and the index area of occupancy is 2,560 km^2 for Athabasca Rainbow Trout.

Athabasca Rainbow Trout differ from introduced Rainbow Trout populations in Alberta in that Athabasca Rainbow Trout spawn later in the spring, have slower growth rates and mature at smaller sizes. Athabasca Rainbow Trout are uniquely adapted to small, cold and unproductive headwater streams. Their diet varies across life-stages and consists primarily of aquatic and terrestrial insects.

Athabasca Rainbow Trout are threatened by several anthropogenic factors including impacts of invasive species, introgression (that is, the transfer of genetic information from one species to another as a result of hybridization between them, and repeated back-crossing) with stocked Rainbow Trout, mortality related to fishing, sedimentation, and habitat fragmentation. Industrial development, effluents from industry, agriculture, and forest harvest, and recreational activities also threaten the persistence of Athabasca Rainbow Trout. Climatic variability and change also threaten Athabasca Rainbow Trout through altered thermal regimes, altered water quantity and delivery schedules, and effects of glacial drawdown over sequential seasons on late summer flows (COSEWIC 2014). The threats facing the species are described in section 5.

The population and distribution objectives (section 6) for the Athabasca Rainbow Trout are:

> To increase the number of Athabasca Rainbow Trout populations to self-sustaining levels, and increase the number of pure strain (that is, core) populations. This will be achieved, while maintaining or increasing population size, by improving habitat quality, connectivity, and reducing impacts of competition and genetic introgression from non-native fish species in current Athabasca Rainbow Trout range.

A description of the broad strategies to be taken to address threats to the species' survival and recovery, as well as research and management approaches needed to meet the population and

distribution objectives are included in section 7. These will help inform the development of specific recovery measures in one or more action plans.

For the Athabasca Rainbow Trout, critical habitat is identified to the extent possible, using the best available information, and provides the functions and features necessary to support the species' life-cycle processes and to achieve the species' population and distribution objectives. This recovery strategy identifies critical habitat for Athabasca Rainbow Trout as areas on which Athabasca Rainbow Trout depend directly and indirectly in order to carry out their life processes, and areas where populations of the species formerly occurred and have the potential to be reintroduced. Critical habitat encompasses riparian areas that maintain and support aquatic health necessary to support the survival and recovery of Athabasca Rainbow Trout (section 8).

This recovery strategy exempts catch-and-release angling and Indigenous subsistence harvest (section 10) from the SARA prohibitions.

An action plan will be completed within five years of posting the final recovery strategy.

Recovery feasibility summary

Recovery of the Athabasca Rainbow Trout is believed to be both biologically and technically feasible. Recovery feasibility is determined according to four criteria outlined by the Government of Canada (2009)[1]:

1. Are individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance?

Yes. Reproducing populations currently exist within the Alberta range of the species and could be used for translocations or artificial propagation if necessary.

2. Is sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration?

Yes. Suitable habitat is present at several locations with extant populations. At locations with extirpated or declining populations, suitable habitat may be made available through current and proposed restoration efforts.

3. Can significant threats to the species or its habitat be avoided or mitigated?

Yes. Significant threats such as sedimentation, and nutrient and contaminant loading can be mitigated through proposed recovery techniques. Through much of the Athabasca Rainbow Trout range, recovery efforts are already underway.

4. Do recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe?

Yes. Techniques to reduce identified threats (for example, best management practices) and restore habitats are well known and proven to be effective. The effort expended to achieve recovery will not be uniform across all populations. Locations with populations thought to be extirpated may require substantial effort to improve habitat and enact reintroductions.

Government of Canada. 2009. Species at Risk Act Policies [Draft]. Species at Risk Act, Policies and Guidelines Series. Ottawa, Ontario. Environment Canada. 48 pp.

Table of contents

Background

1 Introduction

The Athabasca River populations of Rainbow Trout (*Oncorhynchus mykiss*) were listed as Endangered under the *Species at Risk Act* (SARA) in August 2019.

This recovery strategy is part of a series of documents regarding Athabasca Rainbow Trout that should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report (COSEWIC 2014), the Science Advisory Report from the Recovery Potential Assessment (RPA; DFO 2018), the Information in support of a Recovery Potential Assessment of Rainbow Trout, Oncorhynchus mykiss (Athabasca River populations) (Sawatzky 2018), and Information for identification of critical habitat of Athabasca Rainbow Trout (*Oncorhynchus mykiss*) (DFO 2020). A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the subsequent action plan stage.

The RPA is a process undertaken by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to implement SARA, relying on the best available scientific information, data analyses and modeling, and expert opinions. The outcome of this process informs many sections of the recovery strategy. For more detailed information beyond what is presented in this recovery strategy, refer to the COSEWIC status report and the RPA Science Advisory Report.

2 COSEWIC species assessment information

Date of assessment: May 2014

Species' common name (population): Rainbow Trout (Athabasca River populations)

Scientific name: *Oncorhynchus mykiss*

Status: Endangered

Reason(s) for designation: This fish is an obligate resident of clear, cold flowing water in the upper Athabasca River drainage of Alberta. Quantitative sampling over the last two decades demonstrates that the majority of sites are declining in abundance with an estimate of >90% decline over three generations (15 years). Threats are assessed as severe due to habitat degradation associated with resource extraction and agricultural practices. Additionally, ongoing climatic change and associated altered thermal regimes and hydrology, habitat fragmentation, introgression from non-native Rainbow Trout, and fishing threaten the species. Potential impacts from invasive Brook Trout is also a concern (COSEWIC 2014).

Canadian occurrence: Alberta

Status history: Designated Endangered in May 2014

3 Species status information

Table 1. Summary of existing protection or other status designations assigned to Rainbow Trout.

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Globally	NatureServe	2016	Secure (G5)	Species
Alberta	Government of Alberta	2005	May be at risk	Population
Alberta	Government of Alberta	2014	Threatened (recommended)	Athabasca River population
Alberta	Canadian Endangered Species Conservation Council	2015	Imperiled (S2)	Jurisdictional (Alberta)
Canada	Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	2014	Endangered	Athabasca River populations
Canada	Canadian Endangered Species Conservation Council	2015	Secure (N5)	National

Jurisdiction	Authority/organization	Year(s) assessed and/or listed	Status/description	Designation level
Canada	*Species at Risk Act* (SARA)	2019	Endangered	Athabasca River populations

Upon listing as an Endangered species, genetically pure populations of Rainbow Trout (Athabasca River Populations), and populations exhibiting minimal introgression, became protected by section 32 of SARA:

> "No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." [section 32(1)]

> "No person shall possess, collect, buy, sell or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual." [section 32(2)]

Section 83 of SARA outlines general exceptions to SARA's protection provisions. Sections 73 and 74 of SARA outline conditions under which the competent ministers may enter into an agreement or issue a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or the residences of its individuals.

4 Species information

4.1 Description

The Athabasca Rainbow Trout (*Oncorhynchus mykiss*) is a member of the Salmonid family and is considered a unique ecotype (that is, a distinct form of a species) native to rivers and streams of the upper Athabasca watershed in west-central Alberta. There are two life history strategies observed within populations of Athabasca Rainbow Trout, one where individuals are "stream resident" and live in cold headwater streams, and the other where individuals are "river migrant" and live in the upper reaches of larger rivers and move into smaller streams for spawning (DFO 2018).

Athabasca Rainbow Trout exhibit several phenotypic (that is, variation in the appearance of an organism resulting from the interaction of the genotype and the environment) differences from Rainbow Trout in other locations. The largest recorded native Athabasca Rainbow Trout is an age 5+ male (58.8 cm and 2.86 kg) that was stocked as a 30 mm young of year (Wampus Creek origin) into an isolated reclaimed end pit lake. Typically, however, the maximum length of Athabasca Rainbow Trout is less than 50 cm, or approximately 1.25 kg in weight (COSEWIC 2014). Similar to other Rainbow Trout, Athabasca Rainbow Trout have a silver-coloured dorsal surface, which is covered in black spots that extend towards the fins and lateral surface (figure 1). There is a horizontal pink band at the midpoint on the dorsal surface and this band increases in colour intensity with maturation. Stream resident Athabasca Rainbow Trout tend to be bluish to greenish in colour, with yellow green to silvery sides. They also have black spots on the head, back, dorsal fin, adipose fin, and tail fin. The front tip of the pelvic, dorsal, and anal fins are whitish in color. River migrant fish may be silverish without spots or with small spots and faint coloration. Regardless of life strategy, spawning fish often have a bright reddish band along their sides, which is most noticeable in males (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Juvenile Rainbow Trout have between eight and twelve large elongated oval bluish grey “parr” marks along the lateral surface. Unlike Rainbow Trout in other systems, Athabasca Rainbow Trout often possess parr marks throughout their life cycle. Parr marks (cryptic colouration) are likely retained as an adaptation against predation in small, cold, headwater streams with gravel, boulder and cobble substrates where Athabasca Rainbow Trout reside (COSEWIC 2014).

Figure 1. Adult Athabasca Rainbow Trout. Illustration by Karl Geist (from COSEWIC 2014).

4.2 Biology

A small percentage of Athabasca Rainbow Trout females mature by age three, and approximately 50% are mature at age five. Males reach maturity as early as age one, and most are mature by age four. Fecundity is related to body size: stream resident females produce approximately 300 eggs (COSEWIC 2014), whereas the larger river migrant females produce approximately 500 eggs, and up to 730 eggs have been reported in the McLeod River (Alberta Athabasca Rainbow Trout Recovery Team 2014). Athabasca Rainbow Trout typically live to age eight (Alberta Athabasca Rainbow Trout Recovery Team 2014), and the oldest recorded individual in the Tri-Creeks watershed (Wampus, Eunice, and Deerlick creeks) was age 10 (COSEWIC 2014).

Athabasca Rainbow Trout spawn every year, with their spawning period occurring later than in most non-native Rainbow Trout found in southern Alberta. Like other salmonids, female Rainbow Trout select spawning sites in areas with sub-gravel flow. Females excavate a nest site with their caudal fin to create a depression, which causes gravel to be moved downstream by the current. During this process, the female is accompanied by a dominant male and, often, various numbers of satellite males. Once nest excavation is complete, the female and dominant male descend into it, where eggs and sperm are released simultaneously. The female then moves immediately upstream and begins excavating another nest, covering the fertilized eggs in the previous nest. The female may excavate three to four nests sequentially, forming a redd. The female guards the redd usually for less than two days and then abandons the site. Dominant males remain active and may spawn with several females (COSEWIC 2014).

Upon hatching, alevins remain in the gravel until the yolk sac has been absorbed (approximately 32 to 42 days, depending on water temperature). The reported mean length of fry at emergence is 20 mm in Wampus Creek (Sterling 1978). The emerging fry feed on larvae and nymphs of various aquatic insects along the edges of natal streams.

The diet of juvenile and adult Rainbow Trout varies with location, body size, season and time of day. Elliott (1973) examined feeding habits of Rainbow Trout in streams in the central Pyrenees Mountains which are likely similar to those in the Athabasca drainage. Elliott (1973) found that juveniles primarily feed during the night on the drifting stages of aquatic insects. Athabasca Rainbow Trout are thought to be opportunistic feeders: they binge during twilight periods and graze at other times. Diet composition was studied in the Tri-Creeks drainage, and differences were noted to correspond to substrate characteristics. In stream reaches with considerable boulder/cobble substrates (and a greater diversity of aquatic insects), the diet was primarily composed of aquatic invertebrates. In contrast, fish residing in stream reaches with finer gravel tended to have a larger proportion of terrestrial invertebrates in their diet (COSEWIC 2014).

4.3 Population abundance and distribution

Native Rainbow Trout exist in three river systems east of the continental divide (Peace, Liard and Athabasca rivers; Behnke 1992; Nelson and Paetz 1992). All three rivers flow north to the Arctic Ocean via the Mackenzie River. In British Columbia, native Rainbow Trout are found in the upper Peace and the upper Liard drainage. In Alberta, native Rainbow Trout are found only in the upper Athabasca River watershed.

Rainbow Trout in the Athabasca River system are distributed throughout the headwaters (including the major tributaries: McLeod, Berland/Wildhay, Sakwatamau and Freeman rivers; figure 2). Athabasca Rainbow Trout are found in the main stem of the Athabasca River (downstream of Athabasca falls), the lower reaches of the Snaring, Maligne, Rocky and Snake Indian rivers below major waterfalls and the majority of the Miette River watershed (COSEWIC 2014). The current distribution of Athabasca Rainbow Trout is highly correlated with elevation; Athabasca Rainbow Trout are absent in most streams with elevations less than 850 m and common in streams with elevations between 900 and 1500 m (FWMIS 2012). In the upper watersheds within the Athabasca drainage, a large portion of the area is above 1500 m and this appears to influence the distribution of Athabasca Rainbow Trout, especially in the Solomon Creek drainage. Athabasca Rainbow Trout are highly restricted and fragmented in the lower watersheds, where large portions of the area are below 800 m elevations.

In order to assess the status of Athabasca Rainbow Trout, Alberta Environment and Parks (AEP) applied the Alberta Fish Sustainability Index (FSI). The three major components of this assessment process are: i) organizing stocks into spatial units; ii) assessing the stock(s) within the spatial unit; and iii) combining those assessments into a province-level strategic information system. The spatial units used were 8-digit Hydrologic Unit Codes, or HUC8s. HUCs are “successively smaller hydrologic units that nest within larger hydrologic units, creating a hierarchical watershed boundary dataset” (AESRD 2014, p.1). The HUC system is used by the United States Geological Survey (USGS), and AEP followed a similar approach to the USGS in delineating HUCs for Athabasca Rainbow Trout, with a few modifications (AESRD 2014). A total of 19 HUC8s were delineated within the range of Athabasca Rainbow Trout (figure 3). While the HUC8 scale is used in this document, finer scale delineations (for example, HUC10, HUC12, or individual site) may be used in future efforts to assess Athabasca Rainbow Trout populations, and to plan and monitor recovery actions.

Starting in the late 1960s, detailed population assessments for streams in the upper Athabasca River watershed using electrofishing began. The purpose of the studies was to measure population densities and identify population trends of the species. Analysis of the trends over time suggest that Athabasca Rainbow Trout have decreased in abundance in many streams (COSEWIC 2014). Analysis of trends in catch per unit area also suggest Athabasca Rainbow Trout have decreased recently in many streams. For Athabasca drainage tributaries, approximately 54% have shown evidence of declines in catch per unit area in the past 15 years (three generations). Similarly, the projected rate of change over the next 15 years is estimated at −44.4%.

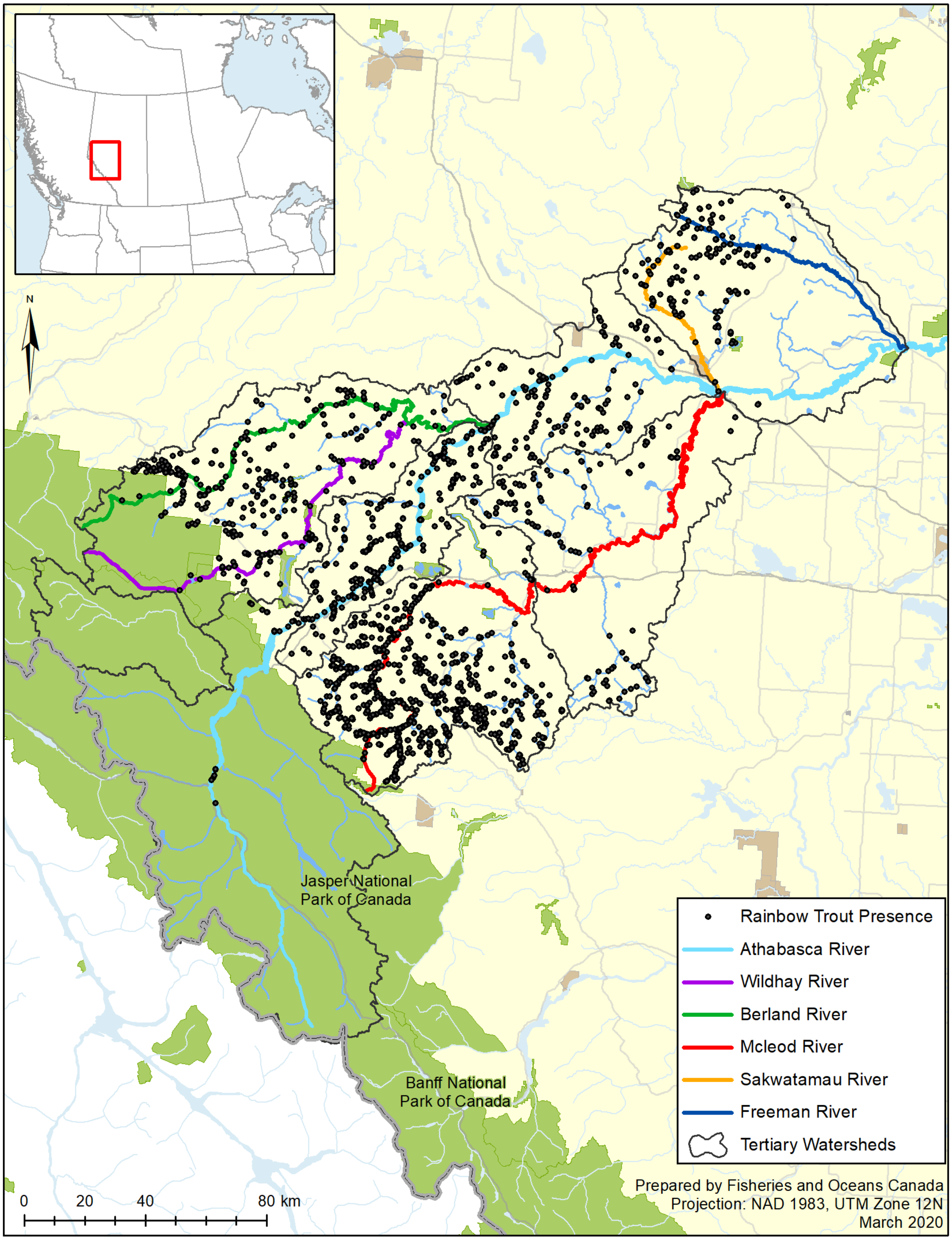

Figure 2. Distribution of Rainbow Trout (Athabasca River populations) and major rivers in the Athabasca watershed. Data points represent a sampling record where Rainbow Trout were present. Source: Fisheries and Wildlife Management Information System (FWMIS). FWMIS dataset did not include all locations of the species in Jasper National Park.

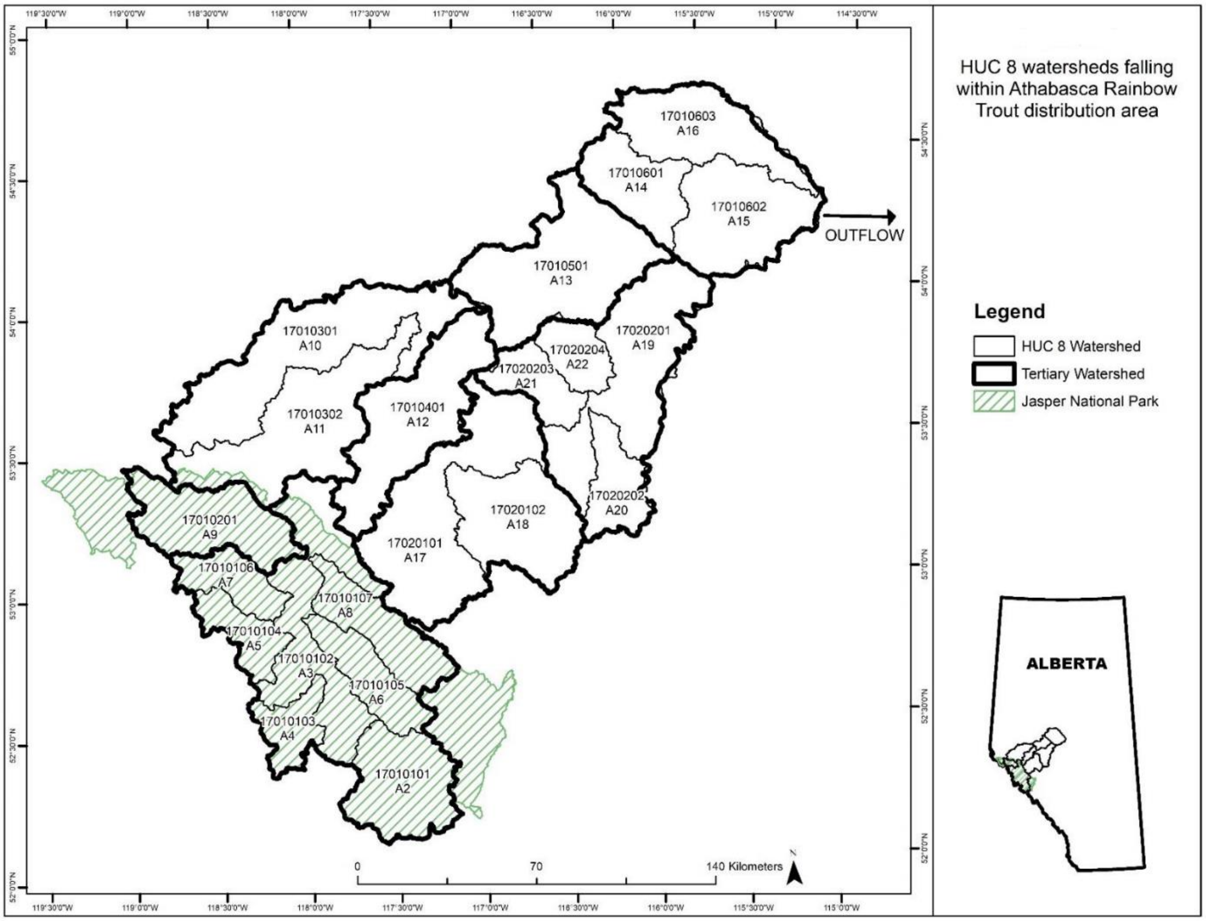

Figure 3. The 19 Athabasca Rainbow Trout 8-digit Hydrologic Unit Codes (HUC8s). HUC8 data were obtained from Alberta Environment and Parks and are based on Alberta Environment and Sustainable Resource Development (AESRD 2014); from DFO 2020.

Distribution and effect of hatchery populations of Rainbow Trout:

The first documented introduction of non-native Rainbow Trout into the Athabasca drainage occurred in 1926. These fish were widely introduced into the main stem of the Athabasca River within Jasper National Park and into numerous creeks within the McLeod drainage, in addition to several other locations in the lower reaches of the drainage. Non-native naturalized populations of Rainbow Trout are now present in the headwaters of all major drainages of the Nelson/Churchill and Mackenzie River basins including the upper Athabasca River watershed. Areas which used to be occupied by pure strain populations are now occupied by non-native populations, effectively decreasing the area where Athabasca Rainbow Trout populations occur (COSEWIC 2014).

Taylor et al. (2007) and Taylor and Yau (2013) assayed 72 populations in the upper Athabasca watershed to determine levels of genetic introgression (figure 4). They calculated an admixture coefficient (Q_i), which refers to the proportion of an individual's fish genome that was inferred to be of indigenous origin. Genetically pure Athabasca Rainbow Trout samples (defined as a Q_i value greater than or equal to 0.99) were found in many areas that had historical documentation of stocking. In most cases, the number of introduced fish is unknown (COSEWIC 2014).

In Jasper National Park, only two genetically pure populations of Athabasca Rainbow Trout have been identified. Other sampled sites showed evidence of high levels of introgression between hatchery and native fish. As per the COSEWIC (2010) manipulated population guidelines, populations with extensive evidence of introgression were excluded from the 2014 COSEWIC status assessment for the species.

This recovery strategy recognizes the importance of Jasper National Park in potential future recovery efforts for Athabasca Rainbow Trout. Pure populations in Jasper National Park receive a high level of protection from anthropogenic threats and are predicted to be least impacted by projected climate change related increases in stream temperature. Jasper National Park also contains waterbodies that may serve as candidate re-introduction locations.

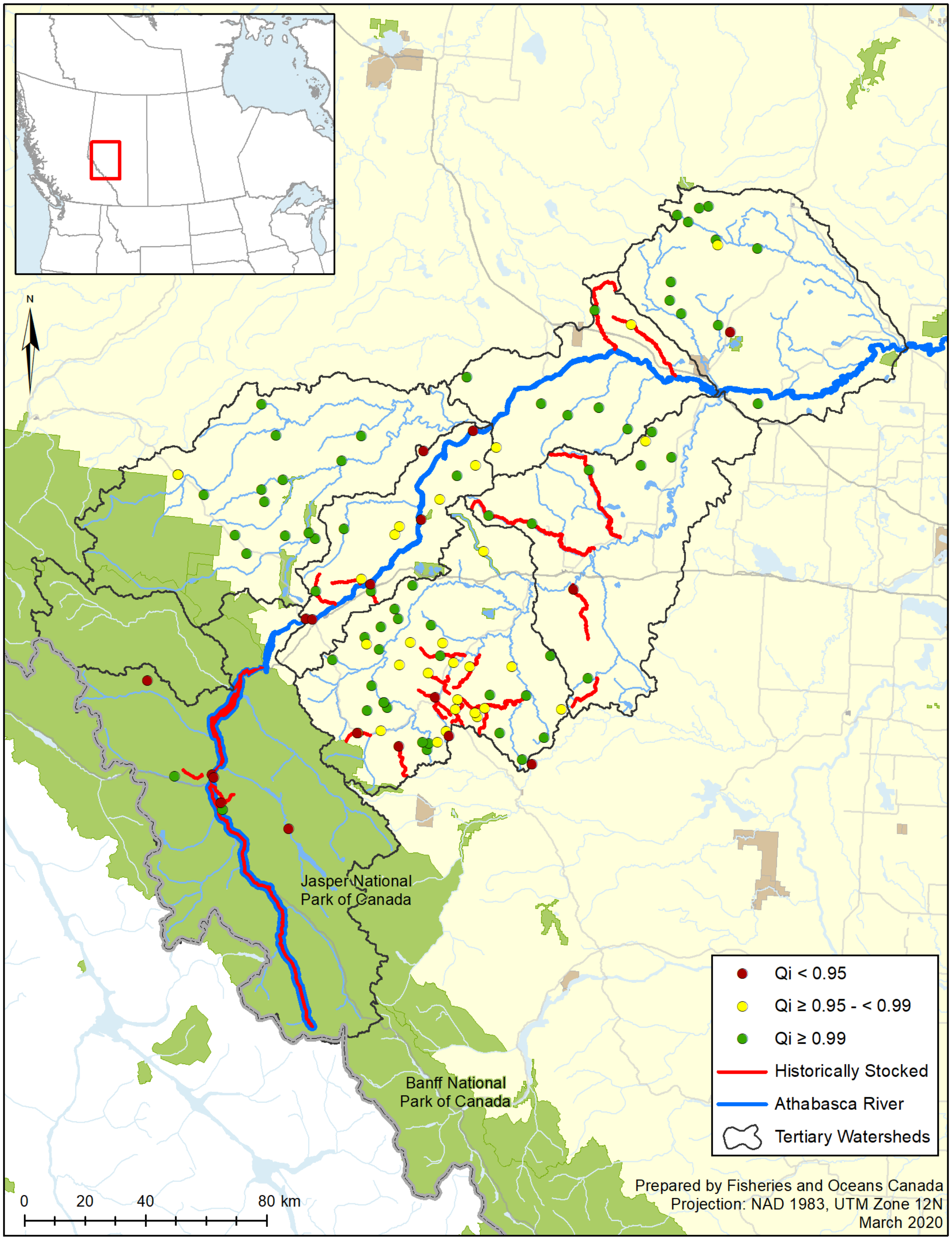

Figure 4. Sampling locations for genetic analysis to determine degree of introgression with hatchery fish. Data points represent a sample site where a genetic analysis was conducted to determine an admixture coefficient (Q_i). Genetically "pure" indigenous samples are defined as having a Q_i value greater than or equal to 0.99, and decreases in Q_i values correspond to an increase in non-native alleles.

The Alberta Athabasca Rainbow Trout Recovery Team (2014) used admixture coefficient scores to classify populations. Populations where introgression was ≤1% (Q_i ≥0.99) were considered genetically pure (Allendorf et al. 2004, Taylor and Yau 2013), populations where introgression was 1 to 5% were considered to have limited hybridization, and those where introgression was >5% (Q_i <0.95) were considered compromised (Alberta Athabasca Rainbow Trout Recovery Team 2014). Of the 72 individual populations surveyed, 38 (~54%) were considered "pure" strain Athabasca Rainbow Trout, with the remainder comprising populations with a range of introgression of non-native alleles or naturalized populations of Rainbow Trout.

Following a similar approach used by the Alberta Westslope Cutthroat Trout Recovery Plan 2012 to 2017 (2013) and adopted from approaches used in the United States for cutthroat trout subspecies, Athabasca Rainbow Trout populations were classified into three categories so that a consistent approach could be used to describe status, priority, management options, and define reaches supporting critical habitat (Alberta Athabasca Rainbow Trout Recovery Team 2014). While genetic status was a primary criterion, it was not the sole determinant for classifying conservation populations (see below), provided they were considered as potentially recoverable.

Core population: An Athabasca Rainbow Trout population with no current evidence of introgression as determined by genetic testing (that is, mean Q_i ≥0.99), may be stream resident or river migrants, must be within native range, must not have originated from stocking (that is, relocation of indigenous fish above barrier falls), and is self-sustaining, is considered a core population. Core populations are potential donors of fish and/or fertilized eggs for restoration efforts, provided there are no hybrids in the population (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Conservation population: A conservation population is a self-sustaining Athabasca Rainbow Trout population that is managed to preserve the unique ecological and behavioural traits of the strain. This may include populations with limited introgression, ideally just below Core populations (that is, mean Q_i <0.99 but ≥0.95, and >50% of individual fish are ≥0.99), but have high conservation value because specific criteria make recovery probable (for example, habitat conditions, barriers, status of non-native species). Populations may be either stream resident or river migrants, be adapted to unique environments, be the least introgressed population within a geographic area, or have distinctive phenotypes or behaviors that local experts deem important to conserve. This category may include introduced pure Athabasca Rainbow Trout populations inside and outside of native range that have high conservation value. Management options may include periodic stocking for the purposes of maintaining a genetic refuge, or when "genetic swamping" is attempted to increase the purity (that is, Q_i score) of the population (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Impure, stocked or naturalized population (ISN): A self-sustaining hybridized population, a naturalized Rainbow Trout population, or a hatchery sustained Athabasca Rainbow Trout population inside or outside native range managed primarily as a recreational fishery are considered ISN populations. Stocking to support recreational fishing typically only occurs in waters where they cannot negatively influence extant Core or Conservation populations. This category includes wild Athabasca Rainbow Trout populations that exhibit significant introgression, where mean Q_i <0.95 and >50% of individual fish are <0.95, but contain "genetically pure" (Q_i ≥0.99) individuals (for example, Athabasca River main-stem). Such populations are either significantly influenced by continuous propagule pressure from upstream naturalized Rainbow Trout populations, or contribute propagule pressure to adjacent pure, native populations. These are lower priority populations that have limited conservation value for

Athabasca Rainbow Trout at this time, but have high recreational value and may be managed to provide these benefits (Alberta Athabasca Rainbow Trout Recovery Team 2014).

The core and conservation populations of Athabasca Rainbow Trout are the focus of recovery efforts, although ISN populations may provide limited conservation value. SARA prohibitions relating to individuals only apply to genetically pure populations (core) or those populations exhibiting minimal introgression (conservation) (see section 10).

4.4 Needs of the species

4.4.1 Limiting factors

The most significant natural limiting factor for Athabasca Rainbow Trout is its habitat specificity, particularly water temperature and spawning and rearing habitat requirements (Sawatzky 2018). These habitat requirements strongly influence the distribution of Athabasca Rainbow Trout, making it vulnerable to unpredictable processes. Natural barriers (for example, waterfalls, beaver dams) may also limit its current distribution. Additionally, Athabasca Rainbow Trout do not have an outside source of individuals to repopulate (that is, there is no chance of a rescue effect) (Sawatzky 2018). While there is potential for re-colonization from fish located in other parts of the drainage, it is largely dependent on the connectivity between the populations and the suitability of connecting habitat. Therefore, overall, re-colonization is unlikely (COSEWIC 2014).

4.4.2 Habitat requirements

Rainbow Trout, in general, are a cold-water species with preferred temperatures ranging from 7 to 18°C. The upper lethal temperature for adults is approximately 27°C, and temperatures from 22 to 24°C are considered life threatening (Alberta Athabasca Rainbow Trout Recovery Team 2014). Stream resident Athabasca Rainbow Trout spend their entire lives in small headwater streams, and tagged fish have made only small (less than 500 m) movements during spawning (Sawatzky 2018). While Athabasca Rainbow Trout seldom occupy first order streams due to their ephemeral nature, first order streams with perennial flow are often inhabited solely by Athabasca Rainbow Trout (Sawatzky 2018). River migrants inhabit main stem rivers and migrate into smaller tributaries to spawn. River migrants use the same spawning habitat as stream residents, but return to the larger rivers after spawning.

Important components for the cold water habitat of Athabasca Rainbow Trout include clean, well oxygenated water, sediment-free substrates, instream cover and a variety of resting or feeding habitats with lower water velocities. Adult riverine Athabasca Rainbow Trout occupy habitat with riffles, runs, glides and pool structures and generally are present in deeper, faster moving water than juveniles (DFO 2018). Overhead cover (for example, large woody debris and riparian vegetation) is generally considered a critical component of habitat selection in small streams. Athabasca Rainbow Trout typically overwinter in larger pools that span the width of the channel in larger rivers and small streams (third and fourth order; COSEWIC 2014).

4.5 Residence

4.5.1 Location of the species' residence

SARA states that "No person shall damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada." [section 33]

Also, SARA defines residence as: "a dwelling place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". [subsection 2(1)]

The following (the residence statement) is a description of a residence for Athabasca Rainbow Trout:

Redds created by females for spawning and the initial development of eggs and alevins. As spawning gravel moves from year to year, residence locations are temporary. More details are provided below.

4.5.2 Structure, form and investment

Athabasca Rainbow Trout redds meet the SARA definition of residence. Females select spawning sites in areas with subgravel flow. Prior to spawning, the female excavates a nest by turning on her side and forcefully moving her caudal fin, causing gravel to be moved downstream by the current. A few larger stones are usually kept and used to form a pocket to hold the eggs. The female then moves immediately upstream and begins excavating another nest, covering the fertilized eggs in the previous nest. The female may excavate three to four nests sequentially, forming a redd. The eggs, and later the alevin, remain in the nest until emergence from the gravel (Alberta Athabasca Rainbow Trout Recovery Team 2014, DFO 2018).

Redds created and used by Athabasca Rainbow Trout for spawning demonstrate there is significant investment in the creation and to some extent, in the protection of the residence (the act of filling with gravel) by Athabasca Rainbow Trout. Thus, a redd is considered to be the residence of this fish. The residence is limited to the redd itself and the spawning and incubation time period during which eggs and alevins are present in the redd.

4.5.3 Occupancy and life-cycle function

Spawning habitat for Athabasca Rainbow Trout is characterized by clean, small to medium gravel beds, which are generally found upstream of riffle crests in small to medium perennial streams. Fry emerge from the redd in flowing water and establish territories in shallow water along stream margins (COSEWIC 2014).

5 Threats

5.1 Threat assessment

An assessment and prioritization of threats to survival and recovery of the species is undertaken at the Recovery Potential Assessment (RPA) stage. An explanation of the specific assessment categories and associated rankings used in table 2 are provided in appendix C.

Five broad threat categories impacting Athabasca Rainbow Trout have been identified. These include: invasive species (causing hybridization and competition); habitat loss and degradation (including fragmentation); mortality (including types of exploitation and incidental mortality); contaminants and toxic substances (including industrial and agricultural pollution); and climate change (and other factors). These threats do not occur in isolation and undoubtedly interact to have cumulative and synergistic effects (COSEWIC 2014; DFO 2018). Note that the COSEWIC (2014) assessment, the Alberta recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014) and the DFO RPA (2018) differ somewhat in the categories, terminology and the severity/rankings of some of these threats, although invasive species and habitat issues often ranked as the greatest threats. Climate change was considered a high risk in all documents.

The individual risk levels of the identified threats may vary across time and location. Certain threats are recognized to be of greater severity and of on-going concern, while other threats are identified as having potential future concern, and are therefore ranked as a lower risk to Athabasca Rainbow Trout at this time. In addition, the severity of the identified threats differs among HUCs, or watersheds, inhabited by Athabasca Rainbow Trout. Depending on the locality, some threats are non-existent or of lesser concern, while other threats have the greatest impact within that area.

Sawatzky (2018) most recently looked at threats to Athabasca Rainbow Trout and is therefore the basis for planning in this recovery document. Sawatzky (2018) determined threat levels at the HUC, watershed, and range (that is, at the designatable unit) levels. Climate change was assessed at the range level only. The highest level of risk for a given HUC was retained from each watershed, and the highest level of risk for a given watershed was retained for the range level threat. For the most part, threats were similar between HUCs. A breakdown by HUC of all threats is presented in appendix D. Range level threats are presented in table 2.

Table 2. Range-level threat risk, threat occurrence, threat frequency and threat extent. When rolled up from the Hydrologic Unit Code (HUC)-level threat risk, the highest level of risk for a given HUC was retained for the range of Athabasca Rainbow Trout (from Sawatzky 2018).

Threat	Description	Range-level threat risk	Threat occurrence	Threat frequency	Threat extent
Invasive species	Non-native Rainbow Trout	High	Historical/current/ anticipatory	Continuous	Extensive
Invasive species	Brook Trout	Low	Historical/current/ anticipatory	Continuous	Extensive
Invasive species	Whirling disease (*Myxobolus cerebralis*)	Low	Anticipatory	Continuous	Restricted/ extensive
Habitat loss and degradation	Alteration of natural flow regimes: alteration of peak flow intensity	Low	Current/anticipatory	Recurrent/ continuous	Broad

Threat	Description	Range-level threat risk	Threat occurrence	Threat frequency	Threat extent
Habitat loss and degradation	Alteration of natural flow regimes: water withdrawals	Low	Current/anticipatory	Recurrent/ continuous	Broad
Habitat loss and degradation	Alteration of stream temperature	Medium	Historical/current/ anticipatory	Recurrent	Broad
Habitat loss and degradation	Habitat fragmentation: suspended and deposited sediments	Medium	Historical/current/ anticipatory	Recurrent	Broad
Habitat loss and degradation	Habitat fragmentation: culverts	Medium	Historical/current/ anticipatory	Continuous	Broad
Habitat loss and degradation	Habitat fragmentation: dams and weirs	Low	Historical/current/ anticipatory	Continuous	Broad
Habitat loss and degradation	Habitat fragmentation: land use practice	Low	Historical/current/ anticipatory	Continuous	Broad
Habitat loss and degradation	Nutrient loading	Low	Historical/current/ anticipatory	Continuous	Extensive
Mortality	Angling mortality	Low	Historical/current/ anticipatory	Recurrent	Broad
Mortality	Unintentional/incidental mortality	Low	Historical/current/ anticipatory	Continuous	Broad
Mortality	Research mortality	Low	Historical/current/ anticipatory	Recurrent	Restricted
Other	Contaminants and toxic substances	Low	Historical/current/ anticipatory	Recurrent	Narrow
Other	Climate change	High	Historical/Current/ Anticipatory	Continuous	Extensive
Other	Interactive and cumulative effects	High	Historical/current/ anticipatory	Continuous	Extensive

5.2 Description of threats

5.2.1 Invasive species

Non-native species, including fish, aquatic invertebrates, plants and micro-organisms, have been introduced in some areas and are known to impact Athabasca Rainbow Trout by contributing to decreased resiliency (that is, the ability to resist, respond, and recover from disturbance), causing range contractions and/or acute mortality. Three subcategories of this threat are considered: hybridization and competition; algae and aquatic invertebrate species; and pathogens.

Hybridization and competition:

Between 1917 and 2012, an estimated 24 million fish of four main species (non-native Rainbow Trout, Brook Trout [*Salvelinus fontinalis*], Cutthroat Trout [*Oncorhynchus clarkii*] and Brown Trout [*Salmo trutta*]) were stocked into Alberta waters from which they could escape (that is, outflow into flowing water). There are no self-sustaining populations of Brown Trout within the range of Athabasca Rainbow Trout. The remaining three species pose a greater threat to the survival and recovery of Athabasca Rainbow Trout. Moreover, the range of these species (primarily Rainbow Trout and Brook Trout) has expanded such that they now threaten Athabasca Rainbow Trout and other native Alberta fish species in areas where they were never stocked. Besides hybridization and genetic introgression, negative impacts to Athabasca Rainbow Trout from these two species include competition, predation, replacement or displacement, and possible exposure to new parasites or diseases (Sawatzky 2018).

Non-native Rainbow Trout: Negative impacts from non-native, hatchery raised Rainbow Trout introductions are primarily related to hybridization and genetic introgression resulting in loss of pure strain Athabasca Rainbow Trout. This has resulted in a threat to the long-term persistence of the native genome in some areas (COSEWIC 2014).

Hybridization has been detected within Jasper National Park in the main stem of the Athabasca River and several tributaries. There are several naturalized lake populations of non-native Rainbow Trout above barrier falls in Jasper National Park. These populations are a source of non-native genes that may impact downstream Athabasca Rainbow Trout populations (COSEWIC 2014). Hybridization in the main stem of the Athabasca River has been confirmed down to the confluence of Nosehill Creek and in 30 tributary streams.

Current stocking practices in Athabasca Rainbow Trout range exclude lakes with outlets (although there are four exceptions to this), exclude streams, and use only 3N (that is, triploid) domestic strain Rainbow Trout within the range of Athabasca Rainbow Trout. Legal stocking practices do not take place within Jasper National Park.

Illegal stocking, however, does occur and the extent of this issue within the watersheds is poorly documented. Competition is a potential threat, but the impact depends upon the number of non-native Rainbow Trout that escape or are illegally transferred to waters supporting Athabasca Rainbow Trout (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Brook Trout: Many streams contain naturalized populations of Brook Trout, with the largest distribution in the Embarras, McLeod and Gregg River watersheds as well as small tributaries to the main stem Athabasca River upstream of the Berland River confluence. In the Wildhay River watershed, a naturalized population is present in Moberly Creek. Within Jasper National Park, Brook Trout are present in many lakes, rivers, and streams in the Athabasca drainage.

Brook Trout appear to be increasing in proportion in both stocked and colonized streams (Alberta Sustainable Resource Development and Alberta Conservation Association 2009). Competition for space and food is an important factor in community structure, as Brook Trout and Athabasca Rainbow Trout appear to function at the same trophic level (Popowich 2005), but Brook Trout grow and reproduce at a higher rate (AESRD unpubl. data in Alberta Athabasca Rainbow Trout Recovery Team 2014). Of 12 streams with trend data and sympatric populations of Brook Trout and Athabasca Rainbow Trout, 10 (83%) showed a decrease in Athabasca Rainbow Trout density associated with an increase in Brook Trout density, while only two streams showed corresponding increases in both species (figure 5 in Sawatzky 2018). This trend shows that Brook Trout are well-adapted to the habitat in the streams of the upper Athabasca watershed and suggests that replacement of Athabasca Rainbow Trout by Brook Trout poses a significant threat (Alberta Sustainable Resource Development and Alberta Conservation Association 2009).

Unlike Rainbow Trout, Brook Trout spawn in the fall and are pre-adapted to small streams (Fausch 2008). Brook Trout are known to select spawning sites with upwelling groundwater (that prevents the stream from freezing over in the winter). In comparison, Rainbow Trout spawn in the spring, and populations are strongly impacted by flood events that often occur during the spawning season. Brook Trout also exhibit rapid growth during their first two years of life and may spawn at age one and older. A higher tolerance of increased selenium levels (see section 5.2.4) coupled with an observation of increased abundances of Brook Trout in the Athabasca drainage suggest that the threat exists for some Athabasca Rainbow Trout populations to be replaced by Brook Trout (Sawatzky 2018). Therefore, Brook Trout are a large threat to the maintenance and recovery of Athabasca Rainbow Trout in some areas.

Cutthroat Trout: Self-sustaining populations of Cutthroat Trout have been established at two locations within Jasper National Park. Cutthroat Trout from the population established in Mowitch Creek have colonized Rock Creek (Wildhay River tributary), and while potential hybrids have been observed, they have not been genetically confirmed. Cutthroat Trout are also present in the Fiddle River (below Utopia Lake). The overall threat of hybridization is considered low to moderate due to the current limited distribution of Cutthroat Trout within the range of Athabasca Rainbow Trout.

Algae and aquatic invertebrate species:

Invasive invertebrate (for example, Mud Snails, Zebra Mussels) and algae species have not yet been found in Alberta and generally do not occur in cold streams, but the potential exists for them to colonize nearby areas (Sawatzky 2018). *Didymosphenia geminata*, a freshwater diatom native to North America (not considered invasive), has been found in multiple locations in the Athabasca watershed. Large blooms decrease habitat for fish and invertebrates, but are unlikely to be found in the small, cold streams inhabited by Athabasca Rainbow Trout (DFO 2018). Stockings of invertebrates have occurred in the past, and these locations are now being monitored. The introduction of algae and invertebrates into lakes via boats is identified as a potential pathway of invasion (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Pathogens:

Pathogens present in Alberta that may impact Athabasca Rainbow Trout include *Aeromonas salmonicida* (bacterium causing furunculosis), infectious pancreatic necrosis (IPN) virus, and *Myxobolus cerebralis* (parasite that causes whirling disease). All diseases could be spread by intentionally and unintentionally introduced fish. Furunculosis is highly contagious among salmonids and has been confirmed within the range of Athabasca Rainbow Trout, in Obed Lake, likely introduced with stocked trout. IPN is a highly contagious and lethal disease that mainly affects fish under six months and can often be found in hatcheries. The first case of whirling disease in Canada was confirmed in 2016 from a lake in Banff National Park. It has now been confirmed at 14 locations in that area, nine within the park itself (Sawatzky 2018). The parasite has been detected in non-host worms from Taylor Creek in the Upper McLeod River watershed and the Athabasca River at Whitecourt. Fish testing was completed on the Athabasca River and McLeod River in 2019 and all fish were negative for the parasite. It appears that the parasite has been transferred to the Athabasca drainage but has not yet become established in fish populations there. Further assessment is required to determine which populations of genetically pure Athabasca are most vulnerable and where vulnerability to whirling disease might limit where populations might be recovered in the future. It is clear that this is an emerging threat that requires increased monitoring and enhancements to public education campaigns such as

“Clean, Drain, Dry Your Gear” to highlight the importance of complying with best practices in order to minimize risk for further spread of this disease (AEP 2018).

5.2.2 Habitat loss and degradation

Various activities including residential and industrial development, mining, unmanaged grazing, agriculture, forest management, irrigation, dams, road construction and recreational development can damage or destroy habitat properties and lead to habitat fragmentation by altering natural flow regimes, increasing sediment input and/or altering stream thermal regimes. These activities may also lead to contaminant and toxic substance input and nutrient loading (Sawatzky 2018). Additional activities that may directly or indirectly affect Athabasca Rainbow Trout habitat include watercourse crossings (bridges, culverts, open cut crossings, etc.), shoreline and streambank work (for example, stabilization, shoreline protection), mineral aggregate, oil and gas exploration, extraction and/or production, instream works (for example, channel modifications, watercourse realignments, dredging, debris removal), some forest management practices, and structures in water (for example, boat launches/ramps, docks; DFO 2018).

Alteration of natural flow regimes:

Flow regime changes may be caused by natural disturbances (floods, fire, etc.), construction and operation of dams and reservoirs, forest harvesting, the removal of trees and associated vegetation for roads, pipelines, other oil and gas infrastructure, urban and agricultural development and water withdrawals in support of these developments. Impacts from various activities and water withdrawals are discussed below (Sawatzky 2018).

Alteration of peak flow intensity:

Peak flows result from spring runoff and storm events, and are fundamental components of fluvial ecosystems affecting channel morphology, sediment transport and instream habitat characteristics. Peak flow intensity increases with increasing water yield, which increases with catchment basin disturbance. The extent of disturbance depends on agricultural and urban run-off, forest harvest practices, and the ecological region (Ripley et al. 2005). Increased peak flow intensity may destabilize channels, scour gravel beds (wherein Athabasca Rainbow Trout eggs are vulnerable to scour), speed bank and riparian zone erosion, cause stream widening, dislodge stable woody debris and displace fish (particularly early life stages). Small streams are more easily impacted than large streams (Sawatzky 2018).

There are six Forest Management Areas comprising over two million hectares currently active in the range of Athabasca Rainbow Trout. A rotation age for sustainable forest management of approximately 75 to 80 years, similar to the historic fire cycle in the Upper and Lower Foothills Natural Sub-regions, is followed. Stream flow regime changes caused by forest harvesting may persist for several decades (Hartman and Scrivener 1990) before they subside, and this may not occur before the second or third cutting (Sawatzky 2018).

Roads: Road stream crossings typically contribute higher loads of fine sediments to streams than all other land use activities combined. Temporary crossings (< 3-year life-span) constructed during exploration or forest harvesting on small, intermittent and ephemeral headwater streams often cause the greatest number of problems because of their high density. Roads capture and concentrate surface and subsurface water flow into ditches, increasing delivery of water and sediment to stream channels. This increases the magnitude and frequency of high flows and siltation events. Road density location (hillside vs. valley bottom), watershed characteristics (topography, soils, geology) and watershed size influence the magnitude of impact. Smaller tributary watersheds are more easily affected. Sediment contributions are highest during construction and remain so until vegetation can be re-established. Notwithstanding sediment inputs from sources such as roads, existing erosion throughout much of the range of Athabasca Rainbow Trout is very high due to the surficial geology of the region (Sawatzky 2018).

Dams and hydro: There are no major dams within the range of Athabasca Rainbow Trout, and none are currently proposed. Dams fragment habitat and alter natural flow regimes and the littoral zone in reservoirs through seasonal draw down and reservoir filling. Future dam construction at any site within the range of Athabasca Rainbow Trout would be significantly detrimental to the entire fish community. Run of the river facilities and low-head dams also pose a threat to Athabasca Rainbow Trout. Pumped hydro facilities are present in the Athabasca drainage, where water is removed from the Athabasca River and put into a reservoir. From there, it is pumped uphill to another reservoir, and electricity is created when the water runs back downhill. These are generally closed systems and there are currently four proposed facilities (as of 2016), one of which is in the Canyon Creek area. Impacts to the watershed may include water loss to evaporation and potential reservoir breaches that result in sediment loading (Sawatzky 2018).

Water withdrawal:

As of 2012, there were 69 Water Act Licenses and 1,474 Water Act Registrations registered within the range of Athabasca Rainbow Trout, totaling approximately 131 million m^3. Annually, approximately 26% of this volume is reported as consumed. AEP guidelines recommend avoidance of fourth-order or smaller streams, and reduced pumping rates in winter. The guidelines also require mandatory reporting of usage for Temporary Diversion Licenses >1000 m^3 of surface water for road dust control, well drilling, hydrostatic testing and well fracturing. The total annual use of surface water by Temporary Diversion Licensees is unknown. Although not identified as a current problem, water withdrawal within the range of Athabasca Rainbow Trout is a future concern (Sawatzky 2018).

Alteration of stream temperature:

Athabasca Rainbow Trout require cold water for survival of all life stages and are therefore susceptible to watershed disturbances that contribute to increased water temperature. Temperature increases are directly proportional to the area of the stream exposed to sunlight and inversely proportional to stream discharge. Groundwater or hyporheic influences may moderate the effects of disturbances that lead to increases in water temperature. Disturbances to this area, such as during forest harvesting, road development, the presence of culverts and unmanaged grazing on riparian vegetation, may increase water temperatures. The greatest changes occur when riparian vegetation alongside small streams is removed, particularly during early summer (Sawatzky 2018).

Following forest harvesting, riparian canopy removal and understory disturbance in the Tri-Creeks study area, increases in mean annual water temperature and summer maximum temperatures up to near lethal (23°C) levels were observed (Sterling et al. 2016). Marginal temperature increases may improve productivity, but may also increase the risk of invasion of introduced species with higher temperature tolerances than Athabasca Rainbow Trout, alter egg and juvenile development, slow growth, decrease survival, impact timing of life history events, block upstream migrations and increase disease (for example, whirling disease). Additionally, negative impacts to groundwater (for example, reduced groundwater causes lower water temperatures in winter) pose a threat to Athabasca Rainbow Trout (Sawatzky 2018).

Forest harvesting practices in Alberta stipulate the retention of buffers based on stream classification and this may or may not include the riparian zone. In upland areas of Alberta, harvesting practices follow natural disturbance models that mimic fire frequency. Intact riparian zones provide shade and thus reduce the surface area of water exposed to sunlight. Moreover, removal of riparian vegetation exposes soil adjacent to the water which, by conducting heat, contributes to an increase in water temperature (Sawatzky 2018).

Suspended and deposited sediments:

Excess fine sediment decreases ecosystem productivity, promotes invasive species, damages habitats (both fish and invertebrate) and has lethal and sub-lethal effects on fish. The severity of impact depends on timing, quantity of sediment and size of the affected stream. Sedimentation increases mortality, particularly for young-of-the-year and incubating eggs (through entombment). In the Tri-Creeks study area, a doubling of fine sediment in spawning areas decreased Athabasca Rainbow Trout embryo survival by more than seven-fold (Sawatzky 2018).

In addition to roads, off-highway vehicle (OHV) trail crossings and traffic along and within streambeds is a major issue in Alberta. It erodes banks and disturbs streambeds, increasing the levels of suspended sediment. High levels of OHV use cause stream channels to widen, shallow and braid, which decreases habitat quality. Some areas along the eastern slopes in Alberta have required reclamation from the effects of OHV use (for example, Wapiabi Creek, Ruby Lake, Cardinal River). OHV use also directly destroy redds through crushing (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Unmanaged livestock grazing/watering in riparian areas also contributes to sediment loading and may directly destroy riparian vegetation and redds through trampling.

Habitat fragmentation:

Connectivity (that is, unobstructed passage through watersheds) is a key habitat requirement for migratory Athabasca Rainbow Trout. It is important in linking spawning, rearing and overwintering habitats and in linking populations to facilitate gene flow and aid in the reestablishment of declining populations, despite how short the movements of some Athabasca Rainbow Trout may be (DFO 2018).

Habitat fragmentation is caused by the creation of migratory barriers, including elevated or undersized culverts (creating a water velocity barrier) and land use practices (for example, mining and forest harvest) that negatively impact habitat, making it uninhabitable for Athabasca Rainbow Trout. The prevalence of forest harvesting, oil and gas production and exploration, mining and agriculture, along with the roads associated with these activities, has direct impacts on streams through sedimentation, channel alterations and outright fish barriers (COSEWIC 2014). Barriers (such as hanging culverts or water velocity issues) may result in range contractions and population declines of Athabasca Rainbow Trout and can impede or preclude population recovery following a disturbance. In some cases, if habitat fragmentation was reduced, it would allow recolonization in the event of local extirpations; however, it may also allow other competing species (for example, non-native Rainbow Trout, Brook Trout) access to the same habitat resulting in increased competition and/or hybridization (DFO 2018).

Culverts: If the streambed below the downstream end of a culvert erodes, it can create an elevated or hanging outfall that most fish are unable to enter. This can occur when the downstream streambed is inadequately armoured or when culverts are undersized or improperly installed. Where culverts are elevated above the downstream water level, they are often impassable to fish, blocking upstream movements of spawners and removing access of juveniles to seasonal refuges from anchor ice, floods or invasive predators. Steeply sloped culverts may create velocity barriers, increase downstream sedimentation and disrupt the transport of large woody debris. This is a province-wide issue in Alberta, the scope of which continues to increase as the road network expands. Park et al. (2008) found that half of the culverts surveyed (187 of 374) in four watersheds in Alberta (outside of the range of Athabasca Rainbow Trout) were hanging and thus represented barriers to upstream movement of fishes (Sawatzky 2018).

Dams and weirs: Dams that do not have fish passage facilities create barriers to upstream fish passage, blocking access to spawning and rearing habitat and isolating populations. Dams may also alter or withhold flows from areas that may otherwise have been accessible. There are no major dams present or proposed within the range of Athabasca Rainbow Trout and none of the current dams and weirs represent barriers to Athabasca Rainbow Trout (Sawatzky 2018).

Land use practices:

Open pit coal mining is expanding in the range of Athabasca Rainbow Trout. Active coal mining operations have caused the loss of nearly 15 km of Athabasca Rainbow Trout spawning and early rearing habitat in the Embarras, Erith, upper McLeod and Gregg River watersheds (Sawatzky 2018). Most end pit lakes (that is, a feature retained on the mining landscape following reclamation and including excess water) do not provide adequate habitat for all life stages of Athabasca Rainbow Trout and are thus not considered habitat compensation .

Nutrient loading:

Increases in nutrients from sources such as agricultural runoff, intensive livestock operations, unmanaged livestock grazing/watering, pulp and paper mills, mountain pine beetle management, train derailments, sewage treatment plants and other municipal sources can speed eutrophication, thereby causing algal blooms which lead to decreased concentrations of dissolved oxygen (DO) as the blooms die. Low concentrations of DO impact fish survival and reproduction by increasing susceptibility to disease, slowing growth, decreasing swimming ability and changing survival behaviours (for example, predator avoidance, feeding). Furthermore, the acute toxicity of most contaminants is increased under low dissolved oxygen conditions. Increased nitrogen and phosphorous can increase the biodegradation of petrochemicals, aromatic hydrocarbons and pesticides in aquatic ecosystems and can be associated with outbreaks of parasites. DO levels generally decrease naturally during winter in ice-covered rivers such as the Athabasca; however, effluents have caused marked “sags” in DO below discharge areas and have contributed to increased rates of DO decline over tens to hundreds of kilometres (Chambers et al. 1997). There are four major urban centers, two large pulp mills, one newsprint mill, four hamlets and several gas plants within the range of Athabasca Rainbow Trout. Combined, these discharge an estimated 53.807 million m^3 of effluents per year into rivers and streams (Sawatzky 2018).

5.2.3 Mortality

Angling mortality:

Post-release angling mortality rates for Athabasca Rainbow Trout are unknown, but data for other salmonid populations in Alberta suggests a mortality rate of 3 to 5% or higher (possibly up to 25% when water temperatures are high or the fish is hooked deeply). Empirical evidence from the Tri-Creeks study area suggests that streams with angling closures have much higher densities of Athabasca Rainbow Trout than adjacent streams with restrictive regulations (Rasmussen and Taylor 2009). High angling mortality, even with catch-and-release regulations, may result in population-level effects (Post et al. 2003; Mogensen et al. 2014); therefore, the high catchability and low densities of Athabasca Rainbow Trout in most streams may result in significant population-level impacts. Indigenous fishing within the range of Athabasca Rainbow Trout occurs in specific lakes that support Lake Whitefish and non-salmonids and is not considered a risk to Athabasca Rainbow Trout (DFO 2018).

Unintentional or incidental mortality:

Industrial and construction activities (for example, road building) have the potential to increase mortality of Athabasca Rainbow Trout. Channel realignment, dewatering, pumping of water and infrastructure development related to various types of industrial activities have the potential to kill Athabasca Rainbow Trout in the construction or operation stages. Approvals and permits under various provincial and federal legislation provide mitigation and best management practices to minimize effects of these activities on the aquatic environment.

As discussed above, off-highway vehicle use can directly destroy redds through crushing, as can unmanaged livestock grazing/watering in riparian areas.

If harvest quotas for Brook Trout were increased to reduce competition with Athabasca Rainbow Trout, the increased angling pressure, potential for misidentification and, therefore, mortality could pose a threat to Athabasca Rainbow Trout (DFO 2018).

Illegal harvest mortality:

Intentional harvest of Athabasca Rainbow Trout has been prohibited, with the exception of Indigenous subsistence harvest, in all streams and rivers throughout their range since 2012 (excluding Jasper National Park). Within Jasper National Park, anglers are permitted the harvest of two fish per day from hybridized ISN populations. The park’s two genetically pure populations receive no angling activity.

Illegal harvest of pure populations throughout the range of Athabasca Rainbow Trout, however, does occur and the impacts to small, isolated populations could be severe. Based on angler checks in three Enforcement Districts in the Upper Athabasca Region over five years, 8% of 660 verbal notices/warnings/prosecutions issued were directly related to the retention of protected species or size of fish, 64% of verbal notices/warnings/prosecutions were issued for gear violations (for example, use of prohibited bait, use of a barbed hook), and 28% of notices/warnings/prosecutions were issued for failing to be licensed properly (for example, fishing without authorization, failing to produce). Non-compliance with species and/or size restrictions and the resulting potential impacts from a few non-compliant anglers to small, isolated populations could be severe (Sawatzky 2018).

Research mortality:

Scientific sampling is a very low risk threat, but it is a potential source of mortality. Lethal sampling may be required to better understand some specific management strategy, but would likely only be considered where populations are at low risk. Research activity is controlled by permitting and sampling protocols must be followed (DFO 2018).

5.2.4 Contaminants and toxic substances

Contaminants, whether from point, non-point, industrial, or agricultural origins, may have lethal or sub-lethal effects on Athabasca Rainbow Trout. Sub-lethal effects can include decreased egg production, reduced survival, behavioural changes, reduced growth, impaired osmoregulation, and many subtle endocrine, immune and cellular changes. Sub-lethal effects most often occur from land use practices (for example, agriculture, residential/urban, mining, industrial effluent, unmanaged livestock grazing and forest harvest) and are the result of pesticides, persistent organic pollutants, mercury and endocrine disrupting substances. Contaminants and toxic substances may also indirectly harm Athabasca Rainbow Trout by reducing prey availability. Lethal effects are most often caused by spills (Sawatzky 2018).

Contaminant concerns at active mine sites include chronic effects of metals, bioaccumulation, sediment contamination and endocrine disruption. Abandoned or closed mine sites are also a source of contaminant input to local water systems. Coal mining within the range of Athabasca Rainbow Trout has caused widespread selenium loading to surface waters in the upper McLeod watershed (COSEWIC 2014). Selenium is an essential nutrient but is toxic at concentrations only slightly higher than the required amount. Embryonic deformities have been documented in Rainbow Trout in the upper Athabasca River watershed. As Rainbow Trout may be more sensitive to selenium than Cutthroat or Brook Trout (DFO 2018), increased selenium levels may give an advantage to these introduced species.

Oil spills/leaks (for example, pipeline leaks, train derailments) and mine tailings pond failures are potential threats. Hydraulic fracturing (“fracking”) has the potential to impact surface and ground-water quality. Impacts may occur from the spilling of chemicals and/or fracking fluid during transport, storage or use, accidental release of flowback water from the well, leakage of methane gas into groundwater caused by deteriorating wellbore seals, and inadequate storage, treatment or disposal of flowback and/or produced waters (COSEWIC 2014; DFO 2018).

Herbicide use is common in silviculture practice in Canada, with glyphosate being the most common active ingredient. Amphibians, fish, zooplankton and aquatic plants are sensitive to glyphosate. Risks to aquatic environments are minimized by establishing protective buffers. In Ontario, toxicologically significant amounts of glyphosate were not found beyond approximately 30 to 50 m outside of target zone boundaries, confirming the protective value of 60 to 120 m buffers imposed to protect aquatic ecosystems. The “no deposition” buffer for aerial spraying of glyphosate in Alberta is 5.0 m (Alberta Athabasca Rainbow Trout Recovery Team 2014). Provincial guidelines ensure the application of herbicides within, or adjacent to, riparian zones that are managed primarily for wildlife and biodiversity values reflects the vegetation management priorities and objectives of those zones (Alberta Sustainable Resource Development 2004). For example, under the Environmental Code of Practice for Pesticides, herbicides are not deposited within 30 horizontal metres of an open body of water unless the herbicide application is conducted by ground application equipment only (Alberta Government, 2010).

5.2.5 Climate change and other factors

A more variable and warmer climate will alter the habitat and biotic interactions of Athabasca Rainbow Trout, resulting in a potential contraction of range to predominantly higher elevation, cooler streams and/or a shift in competitive advantage to non-native species (MacDonald et al. 2014). Climate change may affect Athabasca Rainbow Trout through altered thermal regimes (and corresponding oxygen levels), altered water volume and delivery schedules that affect snow pack (winter delivery and/or spring freshet) and/or heavy precipitation events that cause flooding (increases sediment and phosphorous inputs) and habitat scouring, and effects of late summer flows as a result of glacial drawdown over sequential seasons (COSEWIC 2014). Streams with healthy, intact riparian zones and/or groundwater inputs are less likely to be impacted by warmer air temperatures, and genetic diversity in populations may offer resilience to the effects of climate warming.

In parts of Alberta, the mean temperatures of the warmest month have increased by at least 1°C, the frost-free period has increased by close to 20 days and growing-degree-days (GDD) have increased by up to 200 GDD > 5°C. Precipitation-as-snow is stable, or possibly declining, in most regions. With little to no increase in precipitation and warmer temperatures, the amount of water being lost to evaporation is not being replaced at the same rate. The worst-case scenario of the Environment Canada Community Earth System Model v.2 downscaled to Alberta predicts that the impacts of climate change will cause the extirpation of Athabasca Rainbow Trout within 100 years (Sawatzky 2018). Thus, while not an immediate threat to Athabasca Rainbow Trout, on its current trajectory, climate change is a potentially significant future threat.

Interactive and cumulative effects:

Cumulative environmental effects result from the incremental effect of an action added to past, present and reasonably foreseeable future actions. Climate change can interact with other stressors by affecting the timing, spatial extent and/or intensity of effects of those stressors and may limit the ability of an ecosystem to recover following a disturbance. Some stressors may make ecosystems more vulnerable to climate change. Additionally, land use often changes in response to climate change. Water withdrawals for agricultural and industrial purposes may increase with reduced precipitation or drought, further exacerbating impacts of climate change on freshwater systems (Sawatzky 2018).

Recovery

6 Population and distribution objectives

Population and distribution objectives establish, to the extent possible, the number of individuals and/or populations, and their geographic distribution, that is necessary for the recovery of the species. Population data for most Athabasca Rainbow Trout populations, including those of known pure populations, are lacking, as are the data to determine the feasibility of expanding many populations in light of the numerous threats Athabasca Rainbow Trout now face. It is therefore very difficult to determine precise numbers of individuals or populations. The population and distribution objective for this recovery strategy is adapted from the Alberta recovery plan, where it is stated as the recovery goal (Alberta Athabasca Rainbow Trout Recovery Team 2014):

> To protect, maintain and enhance self-sustaining, native populations of Athabasca Rainbow Trout within the Athabasca River drainage, which will allow for sustainable use.

Given that it may take years to achieve this population and distribution objective (see section 9 for performance indicators toward achieving the objective), this recovery strategy also adopts the following objectives for the first five years, as adapted from the Alberta recovery plan:

> To increase the number of Athabasca Rainbow Trout populations to self-sustaining levels, and increase the number of pure strain (that is, core) populations. This will be achieved, while maintaining or increasing population size, by improving habitat quality, connectivity, and reducing impacts of competition and genetic introgression from non-native fish species in current Athabasca Rainbow Trout range.

Alberta's cumulative effects model and FSI provide a standardized foundation from which, with the addition of other information, recovery actions may be assessed and prioritized. Recovery efforts may focus on populations with the highest chances of achieving improvements and where measurable changes can be made.

While the HUC8 scale is used to describe populations in this recovery document, finer scale delineations (for example, HUC10, HUC12, or individual site) may be used in future efforts to assess populations, and to plan and monitor recovery actions. It is also recognized that some genetically pure local populations might retain high conservation value despite being part of a HUC8 with a low FSI score.

7 Broad strategies and general approaches to meet objectives

7.1 Actions already completed or currently underway

Various activities and regulatory tools already support Athabasca Rainbow Trout conservation in Alberta. As per the actions recommended in this recovery strategy, most of these regulations require modifications to more fully recognize and support Athabasca Rainbow Trout recovery and conservation. The following list of actions already taken are primarily from the Alberta Athabasca Rainbow Trout recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014).

1. Fisheries management and inventory:
   - Recreational angling is restricted to catch-and-release only for Athabasca Rainbow Trout since 2012
   - Harvest of Athabasca Rainbow Trout is prohibited in all streams and rivers throughout their range since 2012 (except for Indigenous subsistence harvest and areas where Jasper National Park permits harvest of fish from ISN populations)
   - Alberta has completely banned the use of bait to reduce hooking mortality among all species as of 2016
   - McKenzie Creek in the upper McLeod is closed to angling
   - Population inventories have been conducted throughout most of the Athabasca Rainbow Trout range
   - Genetic analyses have been conducted on many populations
   - Experimentation with raising Athabasca Rainbow Trout brood stock is ongoing

- Stocking programs have been changed, where only triploid (3N) fish that have been certified disease-free are stocked, and there is no stocking in waters with outflow (note: statistically, only 97% of fish are 3N, which can still pose a risk of hybridization when millions of fish are stocked)
- Increased public education to reduce misidentification and increase awareness of regulations

2. Provincial regulations that help to protect water courses (water quality, streamflow, etc.) include:
   - *Environmental and Enhancement Act* (EPEA; pesticide application guidelines, ambient water quality objectives and loading, etc.)
   - *Water Act* (codes of practise for crossings, stream setbacks, etc.)
   - *Forest Act* (reforestation, riparian buffers on most streams, maximum forest cover removal targets, etc.)
   - *Public Lands Act* (for example, stream crossings)
   - Provincial policy tools (for example, Water For Life)

3. Federal legislation and regulations that help to protect water courses:
   - *Canadian Environmental Protection Act*
   - *Pulp and Paper Effluent Regulations* (pursuant to the *Fisheries Act*)
   - *Wastewater Systems Effluent Regulations* (pursuant to the *Fisheries Act*)
   - *Metal and Diamond Mining Effluent Regulations* (pursuant to the *Fisheries Act*)
   - *Canada National Parks Act*
   - *Fisheries Act*
   - *Species at Risk Act*

7.2 Strategic direction for recovery

Strategic approaches proposed to address the identified threats and to guide appropriate research and management activities to meet the population and distribution objectives are discussed under the broad strategies of:

1. stewardship and education
2. population assessment, monitoring and research
3. habitat assessment and monitoring
4. management and regulatory actions

Each strategy has been designed to assess, mitigate, or eliminate specific threats to the species. All strategies have been thoroughly discussed in the Alberta recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014) and some have been discussed in supporting documents (for example, in DFO 2018) to address information deficiencies that might otherwise inhibit species recovery or to contribute to the species' recovery in general. Subsequent action planning for Athabasca Rainbow Trout will use the strategies outlined in this recovery strategy and Alberta's recovery plan to prioritize recovery actions within and across watersheds.

Recovery approaches will:

- communicate the need for and the content of the recovery strategy to promote understanding and support within the province and elsewhere

- monitor, assess, identify, restore and protect Athabasca Rainbow Trout populations and their habitat, and monitor human activities to assess, minimize, and mitigate ongoing and newly emerging threats
- assess, align, refine, and effectively implement legislation, regulation and policy to minimize and mitigate ongoing and newly identified threats
- manage the mortality of Athabasca Rainbow Trout resulting from direct and indirect human-caused sources on a sustainable basis and to establish guidelines for these activities as needed
- fill knowledge gaps on Athabasca Rainbow Trout biology, ecology and environment (including interactions with introduced species) to inform prioritization and implementation of recovery actions

These strategies are summarized by approach in table 3. The strategies proposed address the identified threats and guide appropriate conservation and management activities to meet the recovery goal and objectives. These will help inform the development of specific recovery measures in one or more action plans.

Table 3. Recovery planning table

Broad Strategy #	General description of research and management approaches	Threat or concern addressed
1	Establish education and outreach messaging and programming to promote a high standard of practice for catch-and-release fishing. Involve affected anglers in project development and implementation. Deter illegal harvest using enhanced education and enforcement.	Mortality
2	Continue to monitor current populations for a change in population status and to determine if populations respond to recovery measures. In areas with a lack of data, conduct sampling to determine population status and identify areas for potential range expansion.	Population status
2	Work to limit hybridization and non-native species in areas where possible. Continue to monitor for whirling disease and complete a risk analysis to better understand and characterize the future threat of whirling disease in Athabasca Rainbow Trout.	Invasive species
3	Address fragmentation due to human-caused barriers as much as possible by working with partners and government agencies to remove or remediate existing barriers. Ensure there is a common understanding of the priority of addressing fish passage issues. Minimize human-caused sediment by addressing legacy infrastructure and point source sedimentation issues.	Habitat loss and degradation
4	Develop and maintain regulatory measures to ensure both sedimentation and fragmentation are managed effectively.	Habitat loss and degradation
4	Conduct research to better characterize fishing pressure in Athabasca Rainbow Trout habitat and understand the impact of catch-and-release fishing on Athabasca Rainbow Trout.	Mortality
4	Work with regulators to develop a multi-departmental process to review regulations, planning, guidelines and compliance monitoring used to manage human-caused priority threats.	Habitat loss and degradation, mortality

7.3 Narrative to support the recovery table

7.3.1 Stewardship and education

Educating the general public, resource users, recreationalists, industry, and governments is essential to gain acceptance of, and compliance with, the overall recovery strategy. Public education addresses all threats to some extent, and is essential through stewardship and outreach. Public support can be gained through increased awareness of this recovery strategy and involvement in stewardship programs.

Public education about the recovery strategy:

It is essential to provide information about Athabasca Rainbow Trout conservation to anglers. Education is a priority to minimize the risks to Athabasca Rainbow Trout associated with non-compliance of regulations including illegal transfer of introduced species. In addition, more generalized messages will be directed at the public, landowners and industry to increase awareness about Athabasca Rainbow Trout conservation. This strategy supports several other strategies and its success will be measured, indirectly, by reduced damage to Athabasca Rainbow Trout habitat and an increase in outreach materials and resources available on Athabasca Rainbow Trout.

7.3.2 Population assessment, monitoring and research

Recovery efforts for Athabasca Rainbow Trout must be based on the best available information. Research is required to inform actions related to the number of pure Athabasca Rainbow Trout populations, and interactions between Athabasca Rainbow Trout and invasive species such as Brook Trout, and therefore is considered a high priority. Currently, some information on Athabasca Rainbow Trout relies on limited or inferred information from other populations. Information gaps exist regarding population status, biological knowledge, and the impacts of invasive species and their management, and interactive and cumulative effects on Athabasca Rainbow Trout. These gaps need to be addressed to refine the recovery strategy and ensure that the population is adequately protected.

Population status:

The population status and trends of Athabasca Rainbow Trout at the watershed scale require additional research to better plan recovery efforts. Population sampling and assessments will result in better understanding of the distribution of the Athabasca Rainbow Trout and its habitats. Completing genetic analysis of all populations so that core, conservation, and ISN populations can be identified will allow for prioritization of recovery actions. Developing criteria to identify populations at high risk of extirpation will also help inform recovery efforts.

Biological knowledge:

Knowledge gaps need to be addressed to inform priority recovery actions, especially those pertaining to habitat and invasive species. Information on basic life history, population structure, abundance, seasonal distribution and habitat requirements in the Athabasca River drainage is required from a broader spatial area, as current information is generally derived from a single watershed. Increased understanding of smaller scale biological productivity differences may allow for tailored recovery efforts in specific watercourses.

Invasive species management/monitoring:

Research and monitoring of populations to determine how they respond to invasive species management is imperative in recovery efforts. Additional research to understand the effects of potential (for example, whirling disease) as well as established (for example, Brook Trout) invasive species on Athabasca Rainbow Trout will better prepare or establish management and monitoring. Supported by fisheries management, research and monitoring of invasive species management will allow recovery efforts to better target this threat to Athabasca Rainbow Trout.

7.3.3 Habitat assessment, management and monitoring

Once baseline information has been collected, regular monitoring with appropriate frequency, intensity, and methodology is necessary to establish trends in Athabasca Rainbow Trout and the species' habitat. This will determine changes in Athabasca Rainbow Trout distribution and abundance, as well as describe the availability of critical habitat once completely identified. An effective habitat monitoring program will help to inform research and identify mechanisms that are affecting the population with respect to habitat loss and degradation.

Habitat loss and degradation:

Maintaining quantity, quality and connectivity of Athabasca Rainbow Trout habitat is essential for recovery. Existing human-cased barriers to migration may be removed or remediated as part of a concerted effort among partners and government agencies to improve habitat connectivity and fish passage. Stewardship efforts to restore or re-establish habitat will protect areas on which Athabasca Rainbow Trout directly and indirectly depend upon, and may also increase public awareness of the species. Improved information is also required on the sources of sediment and industry effluents and their impact on degradation of Athabasca Rainbow Trout habitat.

7.3.4 Management and regulatory actions

Some new or revised management and regulatory actions may be necessary to protect Athabasca Rainbow Trout and their habitat. Such actions will assist in reducing or eliminating identified human-induced threats, including habitat loss and degradation, and the introduction of invasive species. The recovery strategy is focused on both maintenance and recovery, and efforts will focus on ways to maintain and protect the species, as well as re-establish populations in historic range. This includes the development and implementation of a multi-departmental compliance plan that includes important collaborative strategies (for example, outreach and education/shared stewardship, intelligence-led enforcement, compliance partnerships, strategic prosecutions) to support recovery objectives. Compliance promotion activities will advance mitigations to reduce human-induced threats and mortality, habitat-related threats, and activities likely to cause destruction to critical habitat.

Human-induced threats and mortality:

Human-caused mortality will be addressed primarily through fisheries management activities by ensuring that stocking and fishing regulations are conducive to Athabasca Rainbow Trout recovery, and engaging regulatory and enforcement actions to support this effort. Improved management and regulatory actions are required to understand the impacts of catch-and-release mortality and angling pressure, as population-scale effects may occur when population numbers are low and angler numbers are high. Sediment inputs and habitat fragmentation may be addressed by revising regulations to mitigate impacts to habitat for Athabasca Rainbow Trout.

Re-establishment of populations:

Pending the success of other recovery actions, it may be necessary, possible and desirable to re-establish extirpated populations within the historic range of the Athabasca Rainbow Trout. Recovery efforts may include the development of a plan to select candidate sites, and identify parental or donor stock population. Re-established populations will be monitored to determine the success of these recovery efforts.

Threats related to Athabasca Rainbow Trout habitat are diverse and cumulative in nature. Management of these threats must be well-informed, coordinated and cooperative by engaging government, Indigenous communities, industry, communities, landowners, and the public. Effective regulations and increased monitoring and enforcement are required to support most of these broad strategies.

8 Critical habitat

8.1 Identification of the species' critical habitat

8.1.1 General description of the species' critical habitat

Critical habitat is defined in SARA as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." [subsection 2(1)]

Also, SARA defines habitat for aquatic species as "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [subsection 2(1)]

For Athabasca Rainbow Trout, critical habitat is identified to the extent possible, using the best available information, and provides the functions, features and attributes necessary to support the species' life-cycle processes and to achieve the species' population and distribution objectives.

This recovery strategy defines critical habitat of Athabasca Rainbow Trout as areas on which Athabasca Rainbow Trout depend directly and indirectly (for example, riparian areas) in order to carry out their life processes and areas where populations of the species formerly occurred and has the potential to be reintroduced. Critical habitat encompasses riparian areas that provide large woody debris, which is important in defining and maintaining channel configuration and habitat structure and maintains and supports aquatic health necessary to support the survival and recovery of Athabasca Rainbow Trout (Sawatzky 2018; DFO 2020).

Athabasca Rainbow Trout critical habitat is designated using Ecologically Significant Habitat (ESH) identified in the Provincial recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014) as well as in areas upstream that provide direct and indirect habitat to ESH and areas downstream that have habitat features for spawning or overwintering for both life history forms (DFO 2020). Critical habitat maps for Athabasca Rainbow Trout can be found in appendix E.

It is unknown if the critical habitat identified in this recovery strategy is sufficient to achieve the species' population and distribution objectives at this time. The Schedule of studies (section 8.2) outlines the research required to evaluate whether the identified critical habitat is sufficient to achieve the species' population and distribution objective and, if not, to identify additional critical habitat.

8.1.2 Information and methods used to identify critical habitat

For the Athabasca Rainbow Trout, critical habitat was identified to the extent possible using the best available information and using the ESH established by the Alberta Athabasca Rainbow Trout Recovery Team (2014). ESH is defined as the "habitat components necessary for the survival and recovery of Athabasca Rainbow Trout". Genetic analysis and recovery feasibility were considered in the identification of critical habitat for Athabasca Rainbow Trout.

All streams where Athabasca Rainbow Trout were determined to have an average admixture coefficient or proportion indigenous (Q_i) scores of ≥ 0.99 were identified as critical habitat. Critical habitat is also identified in areas where pure Athabasca Rainbow Trout formerly occurred and have a high potential for recovery. Areas identified with a high potential for recovery were identified as those with near-pure populations (mean Q_i score ≥ 0.95 and < 0.99) that had a mean Q_i score ≥ 0.98 (n ≥ 15) or had a high proportion of pure individuals in a sample (≥ 90% of individuals with Q_i ≥ 0.99) (DFO 2020). Areas of known hybridization (mean Q_i <0.95) or with mean Q_i scores <0.98 and lower proportions of pure individuals (<90% pure individuals) were not identified as critical habitat.

Critical habitat for aquatic species may include riparian areas on both stream banks for the entire length of the stream segments identified as critical habitat. Riparian areas and instream structures contribute to stream complexity, creation of refugia, stabilization of stream banks, maintenance of colder stream temperatures by reducing insolation, and are a source of terrestrial invertebrates. Using a reasonable and precautionary approach, a width of 30 m from the high water mark on both stream banks and areas of groundwater recharge outside of the 30 m buffer and within 100 m of the high water mark are included in Athabasca Rainbow Trout critical habitat (DFO 2020).

Athabasca Rainbow Trout ESH is typically confined within second to fourth order streams above 900 m above sea level in Athabasca Rainbow Trout native range. However, some exceptions do occur; for example, large first order channels that flow directly into large main stem rivers; and small fifth order streams that retain appropriately sized spawning gravels while supporting overwintering habitat for stream-resident and river-migrant populations. This recovery strategy identifies critical habitat for Athabasca Rainbow Trout as all areas currently occupied by non-stocked pure-strain populations within the original Athabasca Rainbow Trout distribution. Areas where genetically pure Athabasca Rainbow Trout formerly occurred and have the potential to be re-introduced are also identified as critical habitat. Areas upstream that provide direct and indirect habitat to ESH and areas downstream that have habitat features for spawning or overwintering for both life history forms are included as critical habitat. Additional critical habitat may be identified in future iterations of the recovery strategy.

8.1.3 Identification of critical habitat

Geographic information:

For the Athabasca Rainbow Trout, critical habitat is identified as those locations containing the functions, features and attributes identified in table 5 that are associated with non-stocked pure-strain populations within the original distribution of the species and areas where genetically pure populations formerly occurred and have the potential to be re-introduced, found within the HUC8s identified in figure 3.

The location of critical habitat has been identified using a Bounding Box approach. The Bounding Box approach is a useful approach when habitat features and their attributes can be described but their exact location varies yearly or knowledge of their specific location is not available. In order for a particular site to be identified as critical habitat, it must be within the bounding box and represent the described function, features, and attributes within the bounding box as described in table 5 and is defined by the coordinates in table 4. Critical habitat is not comprised of the entire area within the identified boundaries but only those areas within the identified geographical boundaries where the described biophysical feature and the function it supports occur, as described in table 5. It is not possible to identify all specific locations within the boundaries that have the functions, features and attributes of critical habitat. A Schedule of studies has been included in section 8.2 to address these knowledge gaps.

Table 4: Locations identified as critical habitat for Athabasca Rainbow Trout. Coordinate system is in decimal degrees using WGS 1984.

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Mink Creek	54.142056	-115.446439	1	17010602	Athabasca River Above Freeman River
Mink Creek	54.099414	-115.502651	2	17010602	Athabasca River Above Freeman River
Chickadee Creek	54.189080	-115.924483	1	17010501	Athabasca River Above Whitecourt
Chickadee Creek	54.338082	-116.301197	2	17010501	Athabasca River Above Whitecourt
Marsh Head Creek	54.171812	-116.790164	1	17010501	Athabasca River Above Whitecourt
Marsh Head Creek	54.062353	-117.046936	2	17010501	Athabasca River Above Whitecourt
Oldman Creek	54.086735	-116.144308	1	17010501	Athabasca River Above Whitecourt
Oldman Creek	53.944208	-116.291942	2	17010501	Athabasca River Above Whitecourt

[2] Certain waterbodies list only one critical habitat point in areas where one starting point has multiple end points located in different waterbodies.

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Pine Creek	54.075794	-116.605518	1	17010501	Athabasca River Above Whitecourt
Pine Creek	53.915017	-116.558730	2	17010501	Athabasca River Above Whitecourt
Two Creek	54.353487	-116.367889	1	17010501	Athabasca River Above Whitecourt
Two Creek	54.424149	-116.271618	2	17010501	Athabasca River Above Whitecourt
Windfall Creek	54.089296	-116.411399	1	17010501	Athabasca River Above Whitecourt
Windfall Creek	53.924543	-116.562969	2	17010501	Athabasca River Above Whitecourt
Adams Creek	53.690942	-118.553882	1	17010301	Berland River
Adams Creek	53.734830	-118.641062	2	17010301	Berland River
Beaver Creek	54.022590	-117.336007	1	17010301	Berland River
Beaver Creek	53.857097	-117.733374	2	17010301	Berland River
Big Creek	53.850969	-118.121666	1	17010301	Berland River
Big Creek	53.827538	-118.487520	2	17010301	Berland River
Broad Creek	53.571081	-118.328612	1	17010301	Berland River
Cabin Creek	53.768879	-118.351478	1	17010301	Berland River
Cabin Creek	53.735499	-118.635334	2	17010301	Berland River
Colt Creek	53.964640	-118.211908	1	17010301	Berland River
Crescent Creek	53.578412	-118.523727	1	17010301	Berland River
Evans Creek	53.591342	-118.232951	1	17010301	Berland River
Fox Creek	53.620729	-118.386471	1	17010301	Berland River
Hendrickson Creek	53.825252	-118.518591	1	17010301	Berland River
Home Creek	54.002785	-117.030321	1	17010301	Berland River
Home Creek	54.088395	-117.165512	2	17010301	Berland River
Horse Creek	53.999782	-117.996331	1	17010301	Berland River
Horse Creek	53.889682	-118.296577	2	17010301	Berland River
Little Berland River	53.719558	-118.241428	1	17010301	Berland River
Little Berland River	53.563310	-118.357358	2	17010301	Berland River
Moon Creek	53.748399	-118.359874	1	17010301	Berland River
Moon Creek	53.572674	-118.457861	2	17010301	Berland River

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Pasture Creek	53.773005	-118.284279	1	17010301	Berland River
Smith Creek	53.906088	-118.069673	1	17010301	Berland River
Smith Creek	53.824949	-118.079310	2	17010301	Berland River
South Cabin Creek	53.727181	-118.596018	1	17010301	Berland River
Tom Creek	53.841422	-118.312623	1	17010301	Berland River
Vogel Creek	53.811731	-118.524366	1	17010301	Berland River
Edson River	53.659253	-116.284117	1	17020203	Edson River
Edson River	53.746528	-116.911844	2	17020203	Edson River
Bacon Creek	53.161864	-116.767570	1	17020102	Embarras River
Bacon Creek	53.117035	-116.834118	2	17020102	Embarras River
Baril Creek	53.437281	-117.024604	1	17020102	Embarras River
Chance Creek	53.182123	-117.015099	1	17020102	Embarras River
Chance Creek	53.227593	-117.114633	2	17020102	Embarras River
Dummy Creek	53.170480	-117.008096	1	17020102	Embarras River
Dummy Creek	53.112370	-116.932807	2	17020102	Embarras River
Hanlan Creek	53.227464	-116.554824	1	17020102	Embarras River
Hanlan Creek	53.043963	-116.522764	2	17020102	Embarras River
Hay Creek	53.237107	-116.956333	1	17020102	Embarras River
Hay Creek	53.204332	-116.923320	2	17020102	Embarras River
Jackson Creek	53.187136	-117.011277	1	17020102	Embarras River
Jackson Creek	53.200814	-117.049694	2	17020102	Embarras River
Lambert Creek	53.368837	-116.808692	1	17020102	Embarras River
Lambert Creek	53.443574	-117.057238	2	17020102	Embarras River
Lendrum Creek	53.199445	-116.579856	1	17020102	Embarras River
Lendrum Creek	53.082244	-116.750942	2	17020102	Embarras River
Lost Creek	53.161647	-117.008532	1	17020102	Embarras River
Lost Creek	53.168892	-117.084839	2	17020102	Embarras River
Lund Creek	53.011503	-116.602219	1	17020102	Embarras River
McNeill Creek	53.338090	-117.118732	1	17020102	Embarras River
Prest Creek	53.313694	-116.884858	1	17020102	Embarras River
Prest Creek	53.319055	-117.098538	2	17020102	Embarras River
Raven Creek	53.317677	-116.635361	1	17020102	Embarras River
Raven Creek	53.118878	-116.403605	2	17020102	Embarras River

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Wickham Creek	53.188240	-116.666859	1	17020102	Embarras River
Wickham Creek	53.190886	-116.801409	2	17020102	Embarras River
Freeman River	54.592830	-115.640665	1	17010603	Freeman River
Freeman River	54.687459	-116.080328	2	17010603	Freeman River
Layla Creek	54.604009	-115.858239	1	17010603	Freeman River
Louise Creek	54.587910	-115.568633	1	17010603	Freeman River
Louise Creek	54.507473	-115.692778	2	17010603	Freeman River
Louise Creek	54.506294	-115.810056	3	17010603	Freeman River
Groat Creek	54.017057	-116.009221	1	17020201	Lower Mcleod River
Groat Creek	53.935537	-116.137869	2	17020201	Lower Mcleod River
Rodney Creek	53.420947	-116.651713	1	17020201	Lower Mcleod River
Rodney Creek	53.268842	-116.372991	2	17020201	Lower Mcleod River
Minaga Creek	52.865935	-118.240644	1	17010104	Miette River
Minaga Creek	52.977834	-118.443774	2	17010104	Miette River
Bear Creek	54.483146	-116.048396	1	17010601	Sakwatamau River
Carson Creek	54.236885	-115.806708	1	17010601	Sakwatamau River
Carson Creek	54.496166	-115.734676	2	17010601	Sakwatamau River
Hope Creek	54.510662	-115.893666	1	17010601	Sakwatamau River
Sakwatamau River	54.360157	-115.931542	1	17010601	Sakwatamau River
Sakwatamau River	54.594133	-115.958613	2	17010601	Sakwatamau River
Cricks Creek	53.928678	-116.218928	1	17020204	Trout Creek
Middle Creek	53.946042	-116.314245	1	17020204	Trout Creek
Trout Creek	53.813059	-116.278384	1	17020204	Trout Creek
Trout Creek	53.923572	-116.549079	2	17020204	Trout Creek
Buffalo Prairie Creek	52.804004	-118.016274	1	17010102	Upper Athabasca And Brule Lake
Buffalo Prairie Creek	52.751274	-117.843503	2	17010102	Upper Athabasca And Brule Lake
Apetowun Creek	53.645972	-117.263577	1	17010401	Upper Athabasca And Oldman Creek
Apetowun Creek	53.595388	-117.431071	2	17010401	Upper Athabasca And Oldman Creek
Baseline Creek	53.531862	-117.349313	1	17010401	Upper Athabasca And Oldman Creek

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Baseline Creek	53.550889	-117.511313	2	17010401	Upper Athabasca And Oldman Creek
Canyon Creek	53.509642	-117.456484	1	17010401	Upper Athabasca And Oldman Creek
Canyon Creek	53.515809	-117.593186	2	17010401	Upper Athabasca And Oldman Creek
Centre Creek	53.443466	-117.520722	1	17010401	Upper Athabasca And Oldman Creek
Centre Creek	53.492657	-117.608994	2	17010401	Upper Athabasca And Oldman Creek
Cold Creek	53.339183	-117.648829	1	17010401	Upper Athabasca And Oldman Creek
Cold Creek	53.304973	-117.521867	2	17010401	Upper Athabasca And Oldman Creek
Emerson Creek	53.713116	-117.119651	1	17010401	Upper Athabasca And Oldman Creek
Emerson Creek	53.653428	-117.023629	2	17010401	Upper Athabasca And Oldman Creek
Felix Creek	53.746710	-117.366605	1	17010401	Upper Athabasca And Oldman Creek
Felix Creek	53.688045	-117.364683	2	17010401	Upper Athabasca And Oldman Creek
Fish Creek	53.432121	-117.546942	1	17010401	Upper Athabasca And Oldman Creek
Fish Creek	53.517553	-117.636652	2	17010401	Upper Athabasca And Oldman Creek
Gorge Creek	53.603679	-117.261294	1	17010401	Upper Athabasca And Oldman Creek
Gorge Creek	53.589647	-117.365778	2	17010401	Upper Athabasca And Oldman Creek
Hardisty Creek	53.424914	-117.571229	1	17010401	Upper Athabasca And Oldman Creek
Hardisty Creek	53.322817	-117.492976	2	17010401	Upper Athabasca And Oldman Creek
Hunt Creek	53.499694	-117.417260	1	17010401	Upper Athabasca And Oldman Creek
Hunt Creek	53.431223	-117.379373	2	17010401	Upper Athabasca And Oldman Creek
Jackpine Creek	53.984993	-116.875399	1	17010401	Upper Athabasca And Oldman Creek

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Jackpine Creek	53.924040	-116.854704	2	17010401	Upper Athabasca And Oldman Creek
Lynx Creek	53.910308	-117.074630	1	17010401	Upper Athabasca And Oldman Creek
Lynx Creek	53.785845	-116.963464	2	17010401	Upper Athabasca And Oldman Creek
Marsh Creek	53.674395	-117.385841	1	17010401	Upper Athabasca And Oldman Creek
Maskuta Creek	53.295796	-117.709706	1	17010401	Upper Athabasca And Oldman Creek
Maskuta Creek	53.208481	-117.692311	2	17010401	Upper Athabasca And Oldman Creek
Nosehill Creek	53.877783	-116.925672	1	17010401	Upper Athabasca And Oldman Creek
Nosehill Creek	53.809558	-116.822347	2	17010401	Upper Athabasca And Oldman Creek
Obed Creek	53.644886	-117.159617	1	17010401	Upper Athabasca And Oldman Creek
Obed Creek	53.574486	-117.088734	2	17010401	Upper Athabasca And Oldman Creek
Oldman Creek	53.744209	-117.419447	1	17010401	Upper Athabasca And Oldman Creek
Oldman Creek	53.506167	-117.734411	2	17010401	Upper Athabasca And Oldman Creek
Orchard Creek	53.371469	-117.746611	1	17010401	Upper Athabasca And Oldman Creek
Orchard Creek	53.418692	-117.719940	2	17010401	Upper Athabasca And Oldman Creek
Ponoka Creek	53.557397	-117.305217	1	17010401	Upper Athabasca And Oldman Creek
Ponoka Creek	53.477803	-117.265103	2	17010401	Upper Athabasca And Oldman Creek
Rooster Creek	53.609293	-117.254800	1	17010401	Upper Athabasca And Oldman Creek
Rooster Creek	53.506140	-117.257782	2	17010401	Upper Athabasca And Oldman Creek
Roundcroft Creek	53.522829	-117.365182	1	17010401	Upper Athabasca And Oldman Creek
Roundcroft Creek	53.465617	-117.304207	2	17010401	Upper Athabasca And Oldman Creek

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Sandstone Creek	53.486337	-117.376340	1	17010401	Upper Athabasca And Oldman Creek
Sandstone Creek	53.442197	-117.342482	2	17010401	Upper Athabasca And Oldman Creek
Seabolt Creek	53.231903	-117.631369	1	17010401	Upper Athabasca And Oldman Creek
Still Creek	53.283259	-117.603160	1	17010401	Upper Athabasca And Oldman Creek
Trail Creek	53.463784	-117.468886	1	17010401	Upper Athabasca And Oldman Creek
Trail Creek	53.414168	-117.420773	2	17010401	Upper Athabasca And Oldman Creek
Whiskeyjack Creek	53.366807	-117.505699	1	17010401	Upper Athabasca And Oldman Creek
Anderson Creek	53.310494	-117.286451	1	17020101	Upper Mcleod River
Anderson Creek	53.321770	-117.542229	2	17020101	Upper Mcleod River
Antler Creek	53.210059	-117.331336	1	17020101	Upper Mcleod River
Antler Creek	53.129242	-117.472884	2	17020101	Upper Mcleod River
Beaverdam Creek	53.079458	-117.015526	1	17020101	Upper Mcleod River
Beaverdam Creek	52.995370	-116.975787	2	17020101	Upper Mcleod River
Chief Creek	53.085582	-117.024695	1	17020101	Upper Mcleod River
Chief Creek	53.095678	-116.992598	2	17020101	Upper Mcleod River
Corral Creek	53.483904	-117.126152	1	17020101	Upper Mcleod River
Corral Creek	53.477704	-117.257657	2	17020101	Upper Mcleod River
Deerlick Creek	53.158691	-117.248608	1	17020101	Upper Mcleod River
Deerlick Creek	53.090702	-117.275213	2	17020101	Upper Mcleod River
Drinnan Creek	53.180793	-117.516252	1	17020101	Upper Mcleod River
Drinnan Creek	53.148696	-117.665928	2	17020101	Upper Mcleod River
Erickson Creek	53.066742	-116.967382	1	17020101	Upper Mcleod River
Eunice Creek	53.158470	-117.230713	1	17020101	Upper Mcleod River
Eunice Creek	53.107027	-117.186526	2	17020101	Upper Mcleod River
Felton Creek	53.283378	-117.266969	1	17020101	Upper Mcleod River
Felton Creek	53.194810	-117.111328	2	17020101	Upper Mcleod River
Folding Mountain Creek	53.208793	-117.704491	1	17020101	Upper Mcleod River

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Gregg River	53.189518	-117.507449	1	17020101	Upper Mcleod River
Gregg River	53.089885	-117.436231	2	17020101	Upper Mcleod River
Mary Gregg Creek	53.177712	-117.299568	1	17020101	Upper Mcleod River
Mary Gregg Creek	53.110517	-117.446191	2	17020101	Upper Mcleod River
McCardell Creek	53.247371	-117.318598	1	17020101	Upper Mcleod River
McCardell Creek	53.206916	-117.205697	2	17020101	Upper Mcleod River
McPherson Creek	53.364099	-117.223767	1	17020101	Upper Mcleod River
McPherson Creek	53.357835	-117.491392	2	17020101	Upper Mcleod River
Mercoal Creek	53.164370	-117.185419	1	17020101	Upper Mcleod River
Mercoal Creek	53.112334	-117.001414	2	17020101	Upper Mcleod River
Nice Creek	53.174912	-117.472519	1	17020101	Upper Mcleod River
Quigley Creek	53.328807	-117.275753	1	17020101	Upper Mcleod River
Quigley Creek	53.350687	-117.486665	2	17020101	Upper Mcleod River
Rainbow Creek	53.085541	-117.084622	1	17020101	Upper Mcleod River
Rainbow Creek	52.981216	-117.060186	2	17020101	Upper Mcleod River
South Drinnan Creek	53.063703	-117.561238	1	17020101	Upper Mcleod River
Sphinx Creek	53.058590	-117.522365	1	17020101	Upper Mcleod River
Taylor Creek	52.996286	-116.990540	1	17020101	Upper Mcleod River
Teepee Creek	53.250871	-117.447985	1	17020101	Upper Mcleod River
Teepee Creek	53.246366	-117.578646	2	17020101	Upper Mcleod River
Thompson Creek	53.075044	-117.059858	1	17020101	Upper Mcleod River
Thompson Creek	53.014624	-117.065018	2	17020101	Upper Mcleod River
Trapper Creek	53.082599	-117.384420	1	17020101	Upper Mcleod River
Wampus Creek	53.160566	-117.261724	1	17020101	Upper Mcleod River
Wampus Creek	53.077972	-117.302478	2	17020101	Upper Mcleod River
Warden Creek	53.200896	-117.500899	1	17020101	Upper Mcleod River
Warden Creek	53.199187	-117.670417	2	17020101	Upper Mcleod River
Watson Creek	53.075643	-117.242061	1	17020101	Upper Mcleod River
Watson Creek	52.998217	-117.285778	2	17020101	Upper Mcleod River
White Creek	53.334556	-117.155077	1	17020101	Upper Mcleod River
White Creek	53.231621	-117.115067	2	17020101	Upper Mcleod River

Waterbody name	Latitude (DD)	Longitude (DD)	Critical Habitat Point[2]	HUC 8 number	HUC Name
Wigwam Creek	53.273008	-117.591477	1	17020101	Upper Mcleod River
Barbara Creek	53.634547	-117.709969	1	17010302	Wildhay River
Barbara Creek	53.552560	-117.661458	2	17010302	Wildhay River
Collie Creek	53.505696	-118.121280	1	17010302	Wildhay River
Collie Creek	53.543580	-118.239491	2	17010302	Wildhay River
Doctor Creek	53.512555	-118.060361	1	17010302	Wildhay River
Doctor Creek	53.559766	-118.131527	2	17010302	Wildhay River
Fred Creek	53.589163	-118.130069	1	17010302	Wildhay River
Hightower Creek	53.665822	-118.216524	1	17010302	Wildhay River
Ice Water Creek	53.478722	-118.006879	1	17010302	Wildhay River
Ice Water Creek	53.436540	-118.063446	2	17010302	Wildhay River
Jarvis Creek	53.633701	-117.709494	1	17010302	Wildhay River
Jarvis Creek	53.542809	-117.797451	2	17010302	Wildhay River
Maria Creek	53.655554	-117.807153	1	17010302	Wildhay River
Moberly Creek	53.556817	-117.930141	1	17010302	Wildhay River
Moberly Creek	53.570066	-118.306494	2	17010302	Wildhay River
Pinto Creek	53.788701	-117.824124	1	17010302	Wildhay River
Pinto Creek	53.638446	-118.233978	2	17010302	Wildhay River
Teitge Creek	53.599535	-118.160602	1	17010302	Wildhay River
Twelve Mile Creek	53.563187	-117.890368	1	17010302	Wildhay River
Twelve Mile Creek	53.460460	-117.918516	2	17010302	Wildhay River
Wildcat Creek	53.670165	-118.103944	1	17010302	Wildhay River
Wroe Creek	53.678380	-117.974921	1	17010302	Wildhay River
Wolf Creek	53.364149	-116.122719	1	17020202	Wolf Creek
Wolf Creek	53.214688	-116.085201	2	17020202	Wolf Creek

Biophysical functions, features and attributes:

Table 5 summarizes the best available knowledge of the functions, features and attributes for each life stage of the Athabasca Rainbow Trout (refer to section 4.4 “Needs of the species”). Note that not all attributes in table 5 must be present for a location to be identified as critical habitat. If the features as described in table 5 are present and capable of supporting the associated function(s), the location is identified as critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

The habitat required for each life stage of Athabasca Rainbow Trout is characterized by a function that corresponds to a known biological requirement, and features that consider the structural component of the habitat. Habitat attributes describe how features support the function for each life stage of Athabasca Rainbow Trout in river migrant and stream resident populations (Alberta Athabasca Rainbow Trout Recovery Team 2014, Sawatzky 2018). Habitat attributes associated with current records may differ from optimal habitat, as Athabasca Rainbow Trout may be occupying sub-optimal habitat where optimal habitat is unavailable (DFO 2018).

Fluvial channels less than Strahler Order (that is, the hierarchy of stream tributaries with 1 being the smallest used to define stream size) 2 have stream flows that generally lack sufficient stream power to transport, sort, and deposit appropriately sized spawning gravels, or create overwintering pools for resident Athabasca Rainbow Trout. Fluvial channels greater than order 4, while supporting overwintering habitat, generally have stream flows with too much stream power to retain appropriately sized spawning gravels for either stream resident or river migrant life history types of Athabasca Rainbow Trout. Critical habitat tends to be confined within second to fourth order stream channels above 900 m above sea level within the native range, although exceptions include larger first order channels that provide indirect upstream habitat and small fifth order streams that have downstream habitat features for spawning or overwintering. Within individual reaches, critical habitat may vary following stream flow events that cause bed load movement and channel reconfigurations (Alberta Athabasca Rainbow Trout Recovery Team 2014).

Three life stages and associated habitats were identified by the Alberta recovery team (Alberta Athabasca Rainbow Trout Recovery Team 2014) that form the basis for the definition and subsequent delineation of ecologically significant habitat (provincial) and critical habitat (federal). The three life stage habitats are spawning and incubation habitat for stream resident and river migrant life history types; nursery cover for fry and parr of both life history types; and overwintering habitat for stream resident life history fish. Spawning and incubation habitat, and nursery cover were similar for stream resident and river migrant types and tended to be confined to fluvial streams classed second-to-fourth Strahler Order. The attributes of nursery cover for fry and parr were similar to the spawning and incubation habitat attributes for both life history forms (river migrant and stream resident). Given the crossover of habitat attributes among life history forms, three habitat components have been identified as significant for population sustainability (and recovery):

1. spawning and incubation habitat for stream-resident and river-migrant populations
2. nursery cover for fry and parr of stream-resident and river-migrant populations
3. overwintering habitat for stream-resident populations

Maintaining the attributes of spawning and incubation habitat is essential, and maintaining these habitat features provides the attributes necessary for nursery cover. Deep pools and runs within second to fourth order stream channels are also significant, as they provide habitat for all life stages of overwintering stream resident Athabasca Rainbow Trout. River migrant Athabasca Rainbow Trout overwinter in fifth order or larger rivers. There is generally no lack of suitably deep pools and runs to support overwintering, and therefore this habitat feature is not considered limiting to this life history form of Athabasca Rainbow Trout (Alberta Athabasca Rainbow Trout Recovery Team 2014).

It is important to protect stream width to the high water mark and associated riparian habitat (see AESRD 2012). This habitat provides large woody debris, which is important in defining and maintaining channel configuration and habitat structure, and maintains and supports aquatic health (Alberta Athabasca Rainbow Trout Recovery Team 2014) necessary to support the survival and recovery of Athabasca Rainbow Trout. The width of the riparian area that is required to protect the attributes of critical habitat must be sufficient in size to maintain clean and cold water, sediment and silt free substrates, and provide terrestrial food inputs and woody debris into the aquatic environment. As noted in section 8.1.2., as a reasonable and precautionary approach, a width of 30 m from the high water mark on both stream banks within areas designated as critical habitat for Athabasca Rainbow Trout is also identified as critical habitat (DFO 2020).

Table 5. General summary of the biophysical functions, features, attributes and location of critical habitat necessary for a species' survival or recovery (from Sawatzky 2018).

Life stage	Function[3]	Feature(s)[4]	Attribute(s)[5]
Egg/Embryo spawning through emergence for stream resident (non-migratory) and river migrant (migratory) types	Spawning Incubation and early rearing (mid-May to mid-August)	Clean, small to medium gravel; gravel beds generally found upstream of riffle crests in small to medium perennial streams (often Strahler Order 2 to 4) Redds are often constructed in areas with sub-gravel flow	• Gravel beds with rounded or angular gravel with mean particle sizes ranging from 4 to 15 mm • Water depth over gravel beds ranging from 5 to 40 cm, where flow is non-turbulent with velocities ranging from 12 to 70 cm/s • Fine sediment and silt (< 2.0 mm) in spawning gravels does not exceed 15 to 20% • Optimum dissolved oxygen (DO) saturation > 90% and minimum optimum DO concentration > 8 mg/L • Mean water temperatures during the spawning period range from 6 to 10°C • Optimum water temperature during incubation ranges from 8 to 12°C • Unimpeded access to spawning areas for fluvial Athabasca Rainbow Trout
Fry (Young-of-the-year to age 1) for resident and fluvial types	Nursery	A variety of habitats with reduced water velocity in small to medium perennial streams (often Strahler Order 2 to 4) including riffles, riffle crests, stream	• Optimum growth temperature ranges from 10 to 15°C • Shallow stream margins with a variety of abundant cover (overhead vegetation, aquatic vegetation or woody debris), non-embedded (free of fine sands, silts and clays < 2 mm diameter)

[3] Function: A life-cycle process of the listed species taking place in critical habitat (for example, spawning, nursery, rearing, feeding and migration).
[4] Feature(s): A feature describes the essential structural component that provides the requisite function(s) to meet the species' needs. Features may change over time and are usually comprised of more than one part, or attribute. A change or disruption to the feature or any of its attributes may affect the function and its ability to meet the biological needs of the species. Not all features will have the proper attributes to function as habitat.
[5] Attribute: Attributes are measurable properties or characteristics of a feature. Attributes describe how the identified features support the identified functions necessary for the species' life processes (for example, particle size in spawning bed, preferred temperature for that life stage).

Life stage	Function[3]	Feature(s)[4]	Attribute(s)[5]
		margins, boulders, riparian vegetation and large woody debris	large gravel to medium cobble sized substrate and reduced flow velocities
Juvenile Adult	Feeding Cover	Small to medium perennial streams (often Strahler Order 2 to 4) with riffles, runs, glides and pools and cover (large woody debris or aquatic vegetation) Adults tend to occupy deeper and faster-moving water than juveniles	• Preferred water temperatures range from 7 to 18°C • Recommended oxygen concentration for Rainbow Trout in general: 7 mg/L if < 15°C; > 9 mg/L if > 15°C • Preferred water velocity for Rainbow Trout in general ranges from 0.20 to 0.30 m/s • Substrates dominated by medium sized (64 to 255 mm) cobble • Cover: large woody debris (also important for channel structure) or riparian vegetation (Rainbow Trout in general)
Fry Juvenile Adult	Over-wintering	Primary pools (complex pools that span the entire channel width), beaver ponds and areas of hyporheic flow in perennial streams	• Primary pools with a mean pre-freeze-up minimum depth of 0.65 m and volume of 7.2 m^3 (Tri-Creeks) • Large cobble, free of fine sands, silts and clays in regions of hyporheic flow • Unimpeded access to/from additional overwintering areas • Water temperatures between 4°C and 15°C; lower temperatures may be tolerated • Water velocities ranging from: 0.01 to 1.0 m/s • Second- to fourth-order streams for stream residents; fifth-order or larger rivers where overwintering habitat is not considered limiting for river migrants • Groundwater flow • Sufficient/abundant invertebrate prey

Summary of critical habitat relative to population and distribution objectives:

These are areas that, based on current best available information, the Minister of Fisheries and Oceans (DFO) and the Minister responsible for the Parks Canada Agency (PCA) consider necessary to partially achieve the species' population and distribution objectives required for the survival/recovery of the species. Additional critical habitat may be identified in future updates to the recovery strategy.

8.2 Schedule of studies to identify critical habitat

Further research is required to refine the boundaries of the currently identified critical habitat. There is a need to further refine the understanding of the functions, features and attributes of the currently identified critical habitat. This additional work includes the following studies outlined in table 6:

Table 6. Schedule of studies to identify/refine critical habitat

Description of study	Rationale	Timeline
Studies to identify and describe life history, movement and habitat use by life-stage (including quality of habitats), including improvement of understanding and delineation of critical habitat	It is assumed that the habitats containing pure-strain fish contain all of the necessary habitat types to complete their life-cycle, but little work has been completed to map and confirm habitat use by life stage, quality, or whether there are sufficient amounts of habitats available to grow populations. Identifying and protecting these habitats will help survival and recovery.	2020 to 2025
Determine if the life history parameters for river migrant fish are different than stream resident life history parameters (survival rates, growth, etc.)	More information needed about different life history type habitat requirements to understand current population trends.	2020 to 2025
Studies to identify suitable habitats and determine feasibility for recovering genetically pure Athabasca Rainbow Trout (outside current areas occupied by pure-strain populations)	It is unknown if the current amount of critical habitat will be sufficient for recovery of this species. This work will help identify additional candidate sites for re-establishment of genetically pure fish and add critical habitat where considered necessary.	Ongoing

8.3 Examples of activities likely to result in the destruction of critical habitat

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For the Athabasca Rainbow Trout critical habitat, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will invoke the prohibition in subsection 58(1) against the destruction of any part of the identified critical habitat.

For those areas of critical habitat located within Jasper National Park, within 90 days from when this recovery strategy is included in the Species at Risk Public Registry, the Minister responsible for PCA must publish in the *Canada Gazette* a description of the portion of critical habitat located in the park. Ninety days following that, the prohibition against destruction in any part of the critical habitat in subsection 58(1) applies to those lands.

The examples of activities likely to result in the destruction of critical habitat (table 7) are based on known human activities that are likely to occur in and around critical habitat and are likely to result in the destruction of critical habitat if unmitigated. The list of activities is neither exhaustive nor exclusive and has been guided by the threats described in section 5. Only those threats resulting in an overall threat significance of high, as described in section 3.0 of the Alberta recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014), for the species are considered as activities likely to result in the destruction of critical habitat.

Every activity must be assessed on its potential impact to the species a case-by-case basis and the assessment must consider adverse effects after the implementation of feasible mitigations. Where information is available, quantitative estimates have been developed for critical habitat attributes to better inform management and regulatory decision making. However, in many cases, knowledge of a species and its critical habitat's thresholds of tolerance to disturbance from human activities is lacking and must be acquired.

The absence of a specific human activity from table 7 does not preclude or restrict the competent ministers' ability to regulate that activity under the SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition since it is the destruction of critical habitat that is prohibited, not the activity.

Table 7. Examples of activities likely to result in the destruction of critical habitat

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
Habitat loss and/or degradation	Channel diversions (including impoundment, road building, stream crossings)	Changes in channel morphology following the introduction of fine sand, silt and clay; sedimentation	Spawning, nursery, feeding, cover, over-wintering	Pool tail-outs, stream margins, pools, runs, riffles	• Gravel beds with rounded or angular gravel with mean particle sizes ranging from 4 to 15 mm • Water depth over gravel beds ranging from 5 to 40 cm, where flow is non-turbulent with velocities ranging from 12 to 70 cm/s • Fine sediment and silt (< 2.0 mm) in spawning gravels does not exceed 15 to 20% • Optimum dissolved oxygen (DO) saturation > 90% and minimum optimum DO concentration > 8 mg/L • Mean water temperatures during the spawning period range from 6 to 10°C • Optimum water temperature during incubation ranges from 8 to 12°C • Sufficient/abundant invertebrate prey • Primary pools with a with a mean pre-freeze up minimum depth of 0.65 m and volume of 7.2 m^3 (Tri-Creeks) • Large cobble, free of fine sands, silts and clays in regions of hyporheic flow
Habitat loss and/or degradation	Construction of poorly designed culvert stream crossings	Fragmented habitat caused by accelerated water velocities in crossing structure resulting in the creation of plunge pools, degradation of the stream channel and elevated culvert outlets; sedimentation	All	All	• Unimpeded access to spawning areas for fluvial Athabasca Rainbow Trout • Unimpeded access to/from additional overwintering areas
Habitat loss and/or degradation	Water extraction, dam or reservoir creation and operation; unmanaged grazing; forest harvest; spills	Reduction in available habitats, fragmented habitat, alteration of natural flow regimes or alteration of peak flow intensity	All	Riffles, pools, runs, backwaters, riparian habitat	• Water velocities ranging from: 0.01 to 1.0 m/s • Fine sediment and silt (< 2.0 mm) in spawning gravels does not exceed 15 to 20% • Gravel beds with rounded or angular gravel with mean particle sizes ranging from 3 to 31 mm

Threat	Activity	Effect-pathway	Function affected	Feature affected	Attribute affected
	from oil and gas exploration				• Substrates dominated by medium sized (64 to 255 mm) cobble • Cover: large woody debris (also important for channel structure) or riparian vegetation (Rainbow Trout in general) • Mean water temperatures during the spawning period range from 6 to 10°C • Optimum water temperature during incubation ranges from 8 to 12°C • Shallow stream margins with a variety of abundant cover (overhead vegetation, aquatic vegetation or woody debris), non-embedded (free of fine sands, silts and clays < 2 mm diameter) large gravel to medium cobble sized substrate and reduced flow velocities • Sufficient/abundant invertebrate prey • Undercut banks
Sedimentation	Forest harvest, linear disturbance (road, trail or pipeline construction and maintenance or lack of maintenance, etc.), urbanization, mining, unmanaged grazing, high intensity or frequent off-highway vehicle use, recreational access, instream construction	Reduction in available habitats	All	Riffles, pools, runs, backwaters, food availability, riparian habitat	• Water depth over gravel beds ranging from 5 to 68 cm, where flow is non-turbulent with velocities ranging from 7 to 70 cm/s • Optimum water temperature during incubation ranges from 8 to 12°C • Optimum growth temperature ranges from 10 to 15°C • Optimum dissolved oxygen (DO) saturation > 90% and minimum optimum DO concentration > 8 mg/L • Sufficient/abundant invertebrate prey

9 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. A successful recovery program will achieve the overall aim of increasing the number of Athabasca Rainbow Trout populations to self-sustaining levels and increasing the number of pure strain (that is, core) populations.

Progress towards meeting the population and distribution objectives will be measured every five years and detailed in the Report on the Progress of Recovery Strategy Implementation. Some of the performance indicators will include:

- an overall increase in the number of Athabasca Rainbow Trout populations that are genetically determined to be core populations
- an increase in the number of Athabasca Rainbow Trout populations that are free of competition from invasive species such as Brook Trout
- a decline in all existing human threats and their effects on populations of Athabasca Rainbow Trout whether through mitigation or overall reduction due to best practices or legislation
- an increase in the identification and refinement of the description of critical habitat that will make protection of the habitat more effective and meaningful to the species
- an increase in the distribution and the number of Athabasca Rainbow Trout populations whether through introductions into new areas, re-introduction into formerly populated areas, or discovery of new populations

10 Activities permitted by the recovery strategy

SARA states that “subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71.” [section 83(4)].

Regulations for catch-and-release angling:

The Province of Alberta administers fishery regulations and manages catch-and-release angling for Athabasca Rainbow Trout in Alberta, except in national parks, where PCA has jurisdiction.

In accordance with subsection 83(4) of SARA, this recovery strategy authorizes incidental catch-and-release angling, and Indigenous subsistence harvest of Athabasca Rainbow Trout populations that would otherwise be prohibited under section 32 of SARA (see sections 3 and 4.3). This exemption is subject to the following conditions:

a. in areas outside of national parks, angling is carried out:
    i. in accordance with a licence for sportfishing issued under the authority of the *Alberta Fishery Regulations*, 1998, SOR/98-246

ii. in accordance with a licence issued to an Indigenous person[6] under the authority of section 13(3) of the *Alberta Fishery Regulations*, 1998, SOR/98-246 to engage in fishing solely for the purpose of catching fish for food for their personal use or for the use of their immediate family
iii. by an Indigenous person[5] engaged in sportfishing under the authority of section 13(2) of the *Alberta Fishery Regulations*, 1998, SOR/98-246

b. for areas in national parks, angling is carried out in accordance with a licence issued under the provisions of the *National Parks of Canada Fishing Regulations*, C.R.C., c.1120

c. individual Athabasca Rainbow Trout captured in the catch-and-release recreational fishery shall be released without delay to the waters from which they were caught in a manner that causes the least harm to the fish.

Generally, fishing pressure is believed to be low across the species' current range (DFO 2018), especially where genetically pure populations occur, although there are some populations that have direct road access. A provincial ban on targeted fishing and restrictions to bait fishing contribute directly to lowering angling mortality. In addition, numerous streams are not easily accessible, are very small, are densely treed, and most have limited angling seasons (two to three months) and are therefore not attractive to anglers. Furthermore, many individual Athabasca Rainbow Trout within these populations do not grow to a very large size (<30 cm), which also makes them less attractive to anglers.

In considering whether to permit catch-and-release angling throughout the range of Athabasca Rainbow Trout, allowable harm to Athabasca Rainbow Trout was considered. Allowable harm is defined as harm to the population that will not jeopardize population recovery or survival (DFO 2018). DFO (2018) identifies a range for allowable harm to Athabasca Rainbow Trout. Options for the management of the fisheries by the Province of Alberta may include complete closures of angling, partial closures, or specific stream closures depending on impacts thought to be occurring as a result of angling pressure. Mortality from incidental catch-and-release angling on pure Athabasca Rainbow Trout populations is currently not fully understood, as data is lacking on angling effort, catch and hooking mortality rates. However, angling restrictions will continue to be evaluated by the Province of Alberta to ensure recovery can occur for Athabasca Rainbow Trout. The catch-and-release fishery will continue to be monitored to ensure the survival and recovery of Athabasca Rainbow Trout. Both mortality from catch-and-release fishing and the results of cumulative effects modelling are considered by the Province of Alberta in the development and implementation of their fishing regulations; therefore, the exemption to the SARA prohibitions is not anticipated to jeopardize survival or recovery of Athabasca Rainbow Trout in Alberta.

The concepts of core, conservation and ISN populations discussed in the Alberta recovery plan (Alberta Athabasca Rainbow Trout Recovery Team 2014) were developed to allow for the recovery of Athabasca Rainbow Trout in their jurisdiction, while also maintaining fishing

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[6] The Regulations use the term "Indian" because it is a reference to that term as it is used in the *Alberta Natural Resources Transfer Agreement*, dated December 14, 1929, between Canada and Alberta (confirmed by the *Constitution Act, 1930*); however, it is considered an outdated term and has been replaced for the purposes of this recovery strategy. This recovery strategy does not change the application of the Regulations as they apply to this exemption.

opportunities in some areas. While the term ISN was applied to populations that are managed primarily for the benefit of recreational fisheries, the plan stated that these definitions did not imply that the other categories of populations would not be open to angling opportunities at some point in time, and that this would be determined on a population specific basis (Alberta Athabasca Rainbow Trout Recovery Team 2014). However, since the publication of the Alberta recovery plan, Alberta has kept the intentional harvest of Athabasca Rainbow Trout closed (Sawatzky 2018).

For activities not listed above that are likely to interact with Athabasca Rainbow Trout, in a manner prohibited by SARA, permits under section 73 or 74 of SARA may be sought by contacting the appropriate authority (for example, regional DFO office or PCA).

11 Statement on action plans

The federal government's approach to recovery planning is a two-part approach: the first part involves developing the recovery strategy, and the second part involves developing the action plan. An action plan contains specific recovery measures or activities required to meet the objectives outlined in the recovery strategy.

This recovery strategy will be updated if and when any new critical habitat is identified and when the Alberta Athabasca Rainbow Trout recovery plan or equivalent is updated. An action plan for Athabasca Rainbow Trout will be completed within five years after the posting of the final recovery strategy.

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Appendix A: Effects on the environment and other species

A Strategic Environmental Assessment (SEA) is conducted on all *Species at Risk Act* (SARA) recovery planning documents in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the Federal Sustainable Development Strategy's goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies and critical habitat identified may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of the Athabasca Rainbow Trout. Other native fish species such as Bull Trout (*Salvelinus confluentus*) and Rocky Mountain Whitefish (*Prosopium williamsoni*) will also likely benefit from recovery activities associated with this strategy. The potential for the strategy to inadvertently lead to adverse effects on other species was considered and this strategy will not result in any significant adverse effects to the physical environment. However, recovery efforts have and will continue to result in impacts (mortality) to other non-native fish species such as Rainbow Trout and Brook Trout. Careful consideration will be given to potential effects to other species before implementing any actions should they be proposed (for example, barrier placement to prevent hybridization).

Appendix B: Record of cooperation and consultation

Recovery strategies are to be prepared in cooperation and consultation with other jurisdictions, organizations, affected parties and others as outlined in the *Species at Risk Act* (SARA) section 39. Fisheries and Oceans Canada has utilized inter-governmental collaboration to seek input to the development of this recovery strategy. Information on participation is included below.

Contributing organizations
Fisheries and Oceans Canada, Species at Risk Program
Fisheries and Oceans Canada, Science
Parks Canada Agency
Alberta Environment and Parks
Alberta Agriculture and Forestry
Alberta Energy

The development of this federal recovery strategy has been undertaken in large part by incorporating the concepts and information developed in the Alberta Athabasca Rainbow Trout Recovery Plan 2014-2019, whose recovery team membership included AEP, Alberta Forest Products Association, PCA, Athabasca Bioregional Society, Alberta Fish and Game Association, Trout Unlimited Canada, DFO, University of Lethbridge, Coal Valley, and the Canadian Association of Petroleum Producers. In addition to incorporating components of the provincial recovery plan, a process of review and input was undertaken on the draft federal recovery strategy that included DFO, AEP, and PCA that occurred between 2019 and 2020. Proposed critical habitat was identified through a science-based process, coordinated through the DFO Canadian Science Advisory Secretariat (CSAS) (DFO 2020). The CSAS process included participation and provision of information from DFO and AEP.

In addition, consultation on the draft recovery strategy occurred through emails, letters, and meetings with the Province of Alberta, municipalities, stakeholders, industry groups, environmental non-governmental organizations, and Indigenous communities within the range of Athabasca Rainbow Trout. Additional stakeholder, Indigenous, and public input was sought through the publication of the proposed document on the Species at Risk Public Registry for a 60-day public comment period. All feedback received was considered in the finalization of the Recovery Strategy. Suggestions and concerns related to the implementation of recovery measures for Athabasca Rainbow Trout will be considered in the Action Plan that will be developed.

Appendix C: Threat assessment categories

Likelihood of occurrence	Definition
Known or very likely to occur	This threat has been recorded to occur in 91 to 100% of cases
Likely to occur	There is 51 to 90% chance that this threat is or will be occurring
Unlikely	There is 11 to 50% chance that this threat is or will be occurring
Remote	There is 1 to 10% or less chance that this threat is or will be occurring
Unknown	There are no data or prior knowledge of this threat occurring now or in the future

Level of impact	Definition
Extreme	Severe population decline (for example, 71 to 100%) with the potential for extirpation
High	Substantial loss of population (31 to 70%) or Threat would jeopardize the survival or recovery of the population
Medium	Moderate loss of population (11 to 30%) or Threat is likely to jeopardize the survival or recovery of the population
Low	Little change in population (1 to 10%) or Threat is unlikely to jeopardize the survival or recovery of the population
Unknown	No prior knowledge, literature or data to guide the assessment of threat severity on population

Causal certainty	Definition
Very high	Very strong evidence that threat is occurring and the magnitude of the impact to the population can be quantified
High	Substantial evidence of a causal link between threat and population decline or jeopardy to survival or recovery
Medium	There is some evidence linking the threat to population decline or jeopardy to survival or recovery
Low	There is a theoretical link with limited evidence that threat is leading to a population decline or jeopardy to survival or recovery
Very low	There is a plausible link with no evidence that the threat is leading to a population decline or jeopardy to survival or recovery

Threat occurrence	Definition
Historical	A threat that is known to have occurred in the past and negatively impacted the population.
Current	A threat that is ongoing, and is currently negatively impacting the population.
Anticipatory	A threat that is anticipated to occur in the future, and will negatively impact the population.

Threat frequency	Definition
Single	The threat occurs once.
Recurrent	The threat occurs periodically, or repeatedly.
Continuous	The threat occurs without interruption.

Threat extent	Definition
Extensive	71 to 100% of the population is affected by the threat.
Broad	31 to 70% of the population is affected by the threat.
Narrow	11 to 30% of the population is affected by the threat.
Restricted	1 to 10% of the population is affected by the threat.

Appendix D: Hydrologic Unit Code (HUC)-level threat

Threat, likelihood of occurrence, threat impact, causal certainty, threat risk, threat occurrence, threat frequency and threat extent. Climate change assessed at the HUC8 spatial level (from Sawatzky 2018).

1. HUC8: 17010102 – Upper Athabasca River and Brule Lake (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: Alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: Water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: Culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: Dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: Land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

2. HUC8: 17010103 – Whirlpool River (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/Current/ Anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipate d	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipate d	Recurrent/ continuous	Broad
Alteration of stream temperature	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Suspended and Deposited Sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/Incid ental Mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

3. HUC8: 17010104 – Miette River (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

4. HUC8: 17010105 – Maligne River (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: Alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

5. HUC8: 17010106 – Snaring River (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: Culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: Land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

6. HUC8: 17010201 – Snake Indian River (Jasper National Park)

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: Culverts	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	High	High	High	High	Historical/current/ anticipated	Continuous	Extensive

7. HUC8: 17010301 – Berland River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/Current/ Anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Extensive

8. HUC8: 17010302 – Wildhay River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Unlikely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	High	High	High	Historical/current/ anticipated	Continuous	Extensive

9. HUC8: 17010401 – Upper Athabasca River and Oldman Creek

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

10. HUC8: 17010501 – Athabasca River above Whitecourt

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: Culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

11. HUC8: 17020101 – Upper McLeod River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Likely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

12. HUC8: 17020102 – Embarras and Erith Rivers

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Likely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: Dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

13. HUC8: 17020201 – Lower McLeod River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very High	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Likely	Low	Very High	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

14. HUC8: 17020202 – Wolf Creek

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	High	High	High	Historical/current/ anticipated	Continuous	Extensive

15. HUC8: 17020203 – Edson River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	High	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: Alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	High	High	High	Historical/current/ anticipated	Continuous	Extensive

16. HUC8: 17020204 – Trout Creek

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	High	High	High	Historical/current/ anticipated	Continuous	Extensive

17. HUC8: 17020601 – Sakwatamau River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Likely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Likely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	High	High	High	Historical/current/ anticipated	Continuous	Extensive

18. HUC8: 17020602 – Athabasca River above Freeman

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Known	High	Very high	High	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

19. HUC8: 17020603 – Freeman River

Threat	Likelihood of occurrence	Threat impact	Causal certainty	Threat risk	Threat occurrence	Threat frequency	Threat extent
Non-native Rainbow Trout	Likely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Brook Trout	Unlikely	Low	Very high	Low	Historical/current/ anticipated	Continuous	Extensive
Myxobolus cerebralis	Unlikely	Low	High	Low	Anticipated	Continuous	Restricted/ extensive
Alteration of natural flow regimes: alteration of peak flow intensity	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of natural flow regimes: water withdrawals	Likely	Low	High	Low	Current/anticipated	Recurrent/ continuous	Broad
Alteration of stream temperature	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Suspended and deposited sediments	Known	Medium	High	Medium	Historical/current/ anticipated	Recurrent	Broad
Habitat fragmentation: culverts	Known	Medium	High	Medium	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: dams and weirs	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Habitat fragmentation: land use practices	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Nutrient loading	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Extensive
Angling mortality	Likely	Low	High	Low	Historical/current/ anticipated	Recurrent	Broad
Unintentional/incidental mortality	Unlikely	Low	High	Low	Historical/current/ anticipated	Continuous	Broad
Research mortality	Remote	Low	High	Low	Historical/current/ anticipated	Recurrent	Restricted
Contaminants and toxic substances	Unlikely	Low	High	Low	Historical/current/ anticipated	Recurrent	Narrow
Interactive and cumulative effects	Known	Extreme	High	High	Historical/current/ anticipated	Continuous	Extensive

Appendix E: critical habitat maps

The following critical habitat maps depict the areas of critical habitat for Rainbow Trout (Athabasca River populations) (red watercourse segments). For the most up-to-date maps, please visit DFO's Aquatic species at risk map webpage.

To assist with identifying where critical habitat occurs in headwater areas, geo-referenced location points (P1, P2; Decimal Degrees [WGS 1984]) have been added in some locations in each HUC in addition to the red line segments. These points are meant to help users identify the watercourses that may contain critical habitat upstream or downstream of these points. Coordinates for these points can be found in table 4. These points represent the locations of the areas within which critical habitat (indicated by the red lines) is found within a watercourse. For more information, refer to the legend of each map or DFO's Aquatic species at risk map webpage.

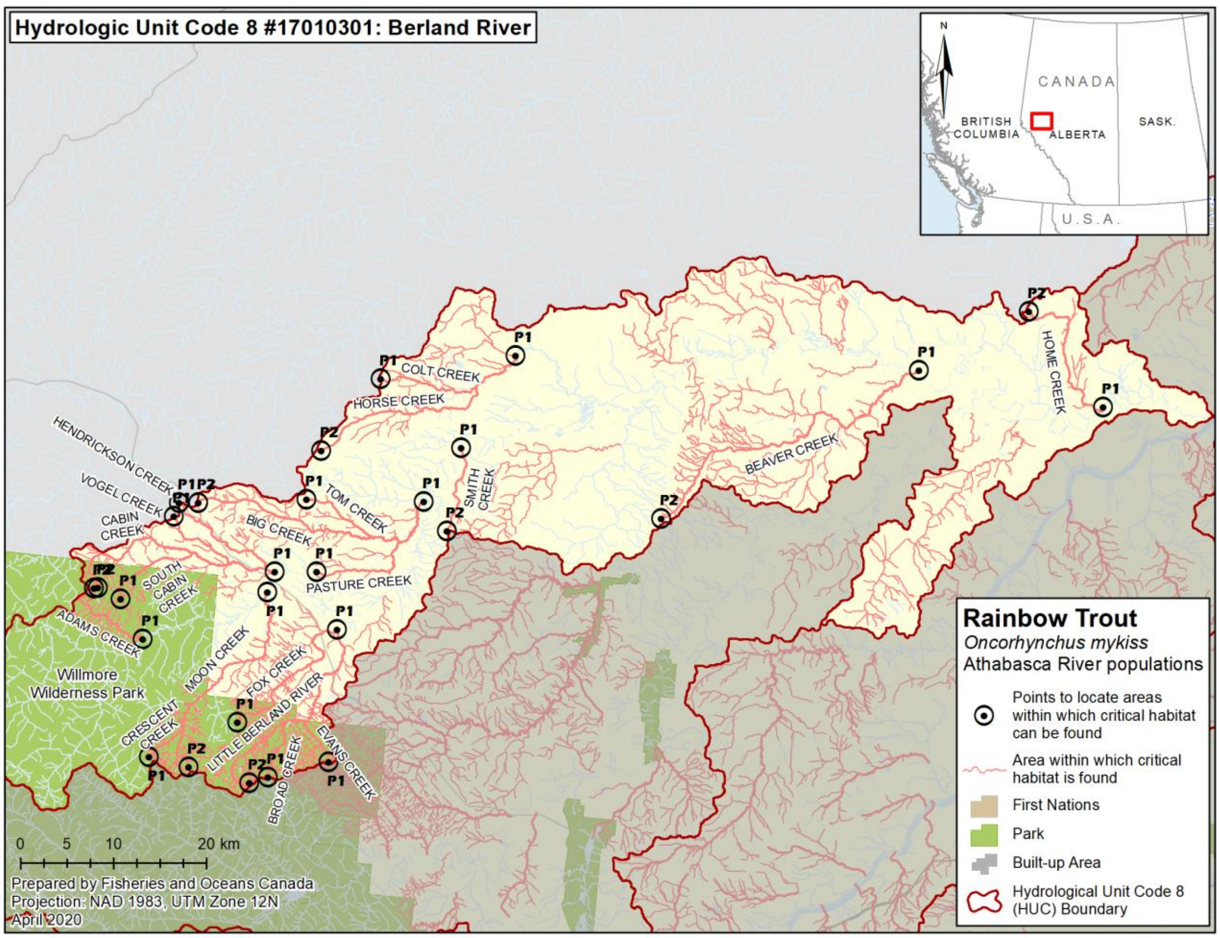

Figure A1. Athabasca Rainbow Trout critical habitat within HUC 8 17010301 (Berland River).

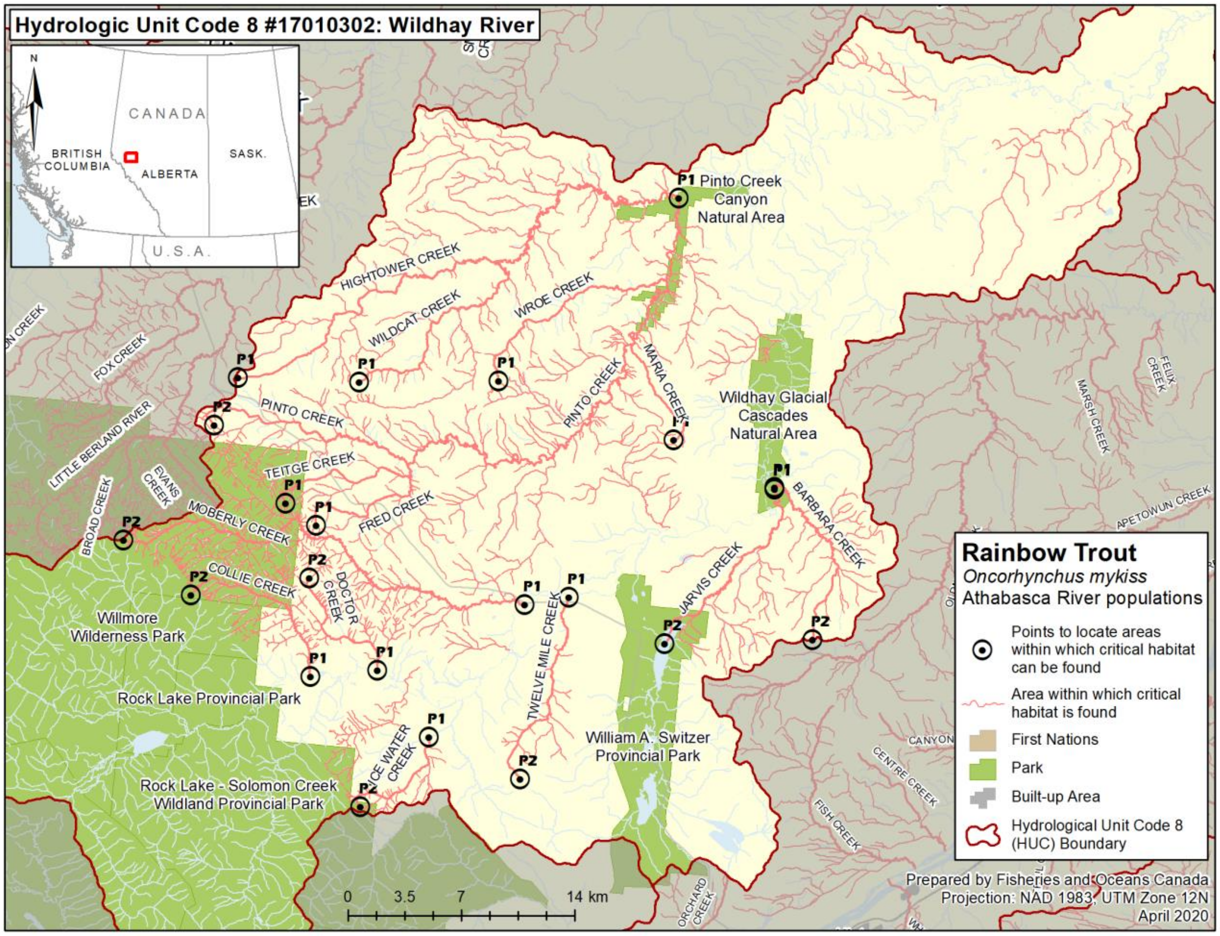

Figure A2. Athabasca Rainbow Trout critical habitat within HUC 8 17010302 (Wildhay River).

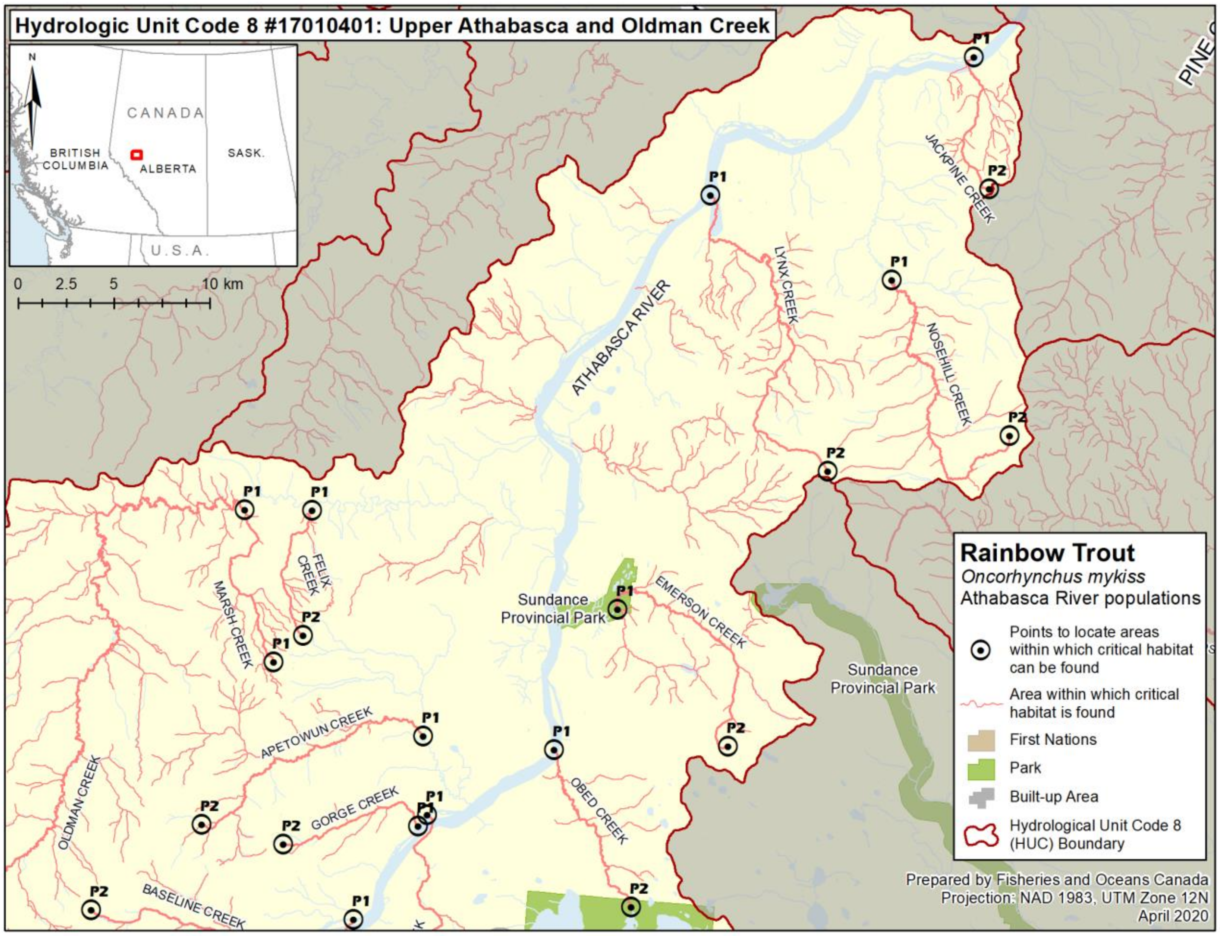

Figure A3. Athabasca Rainbow Trout critical habitat within HUC 8 17010401 (Upper Athabasca and Oldman Creek; northern portion).

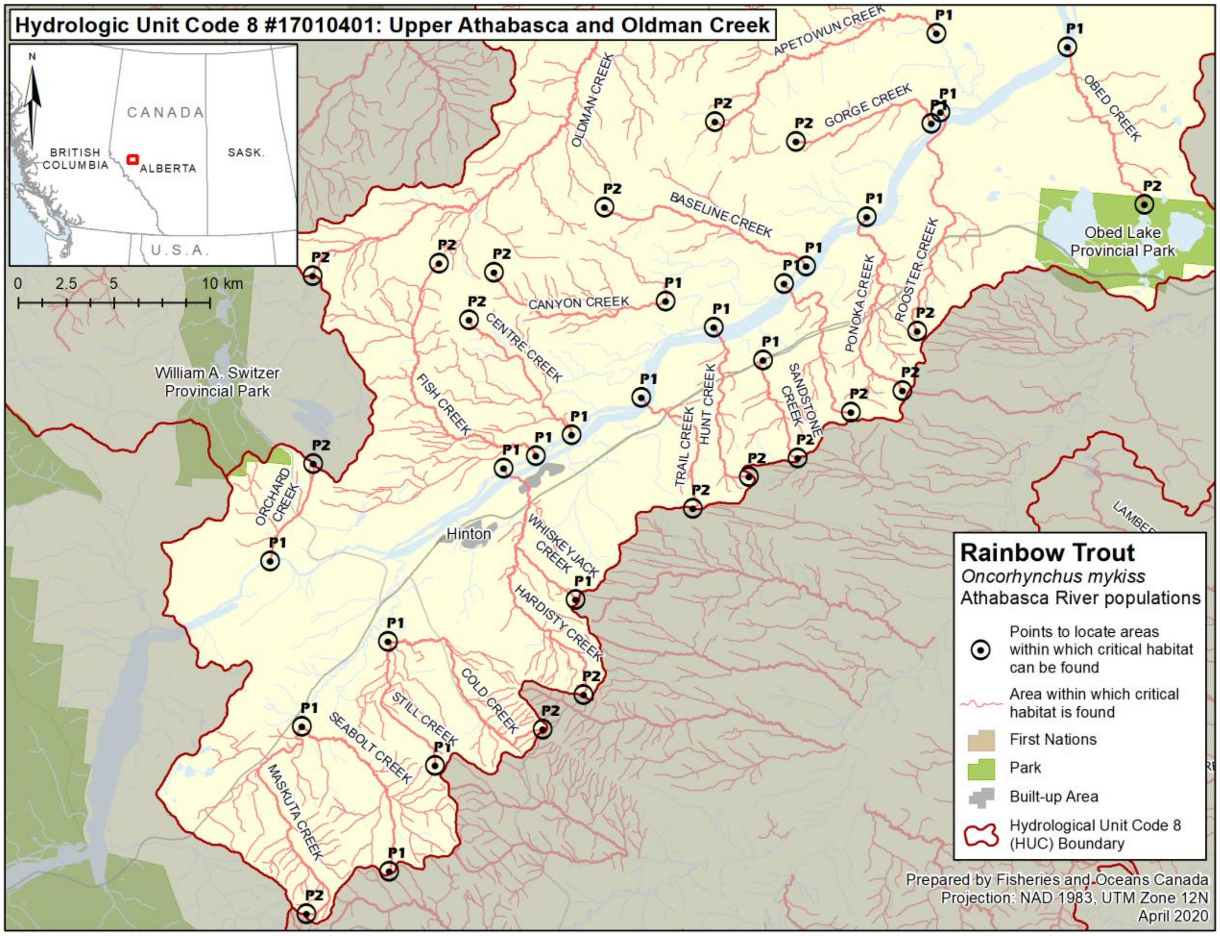

Figure A4. Athabasca Rainbow Trout critical habitat within HUC 8 17010401 (Upper Athabasca and Oldman Creek; southern portion).

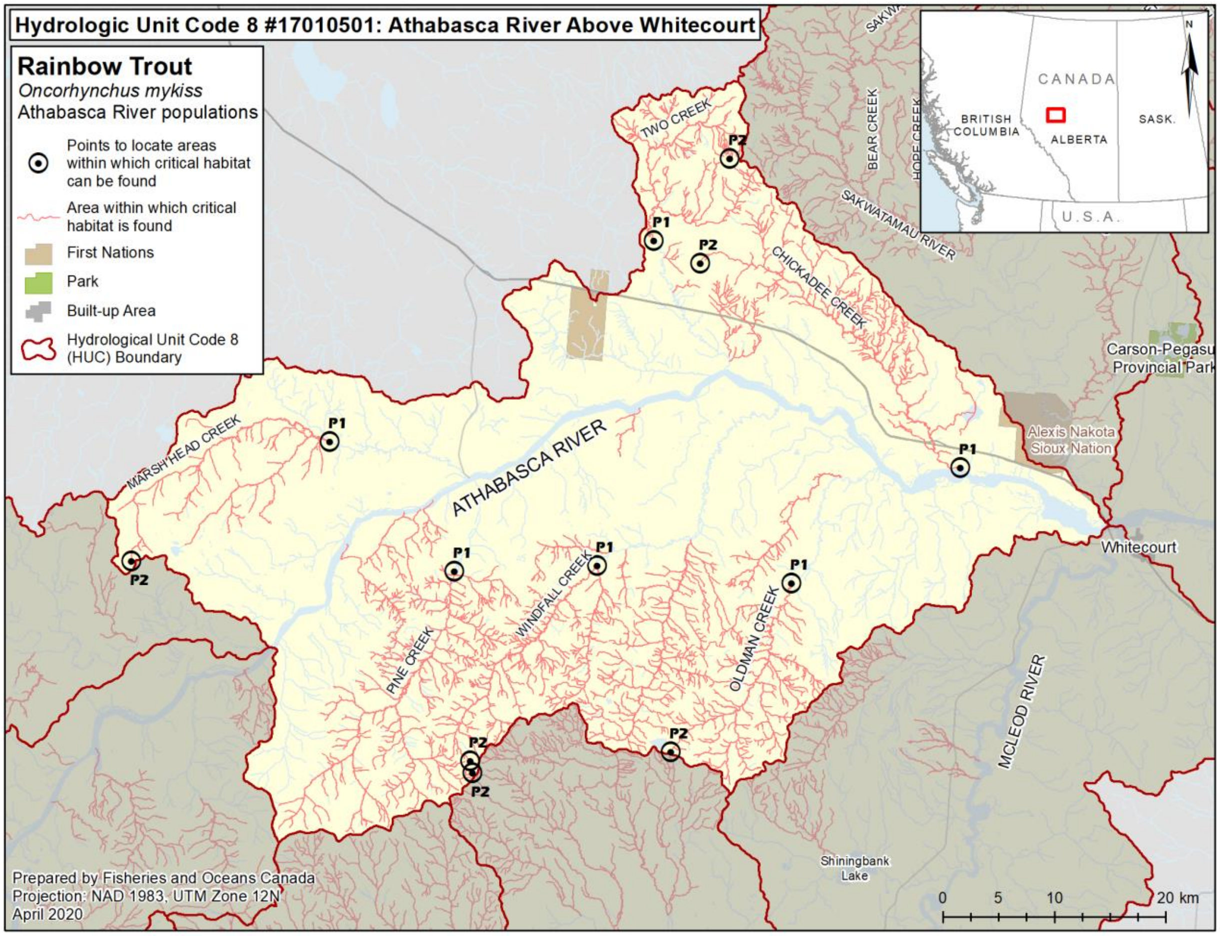

Figure A5. Athabasca Rainbow Trout critical habitat within HUC 8 17010501 (Athabasca River above Whitecourt).

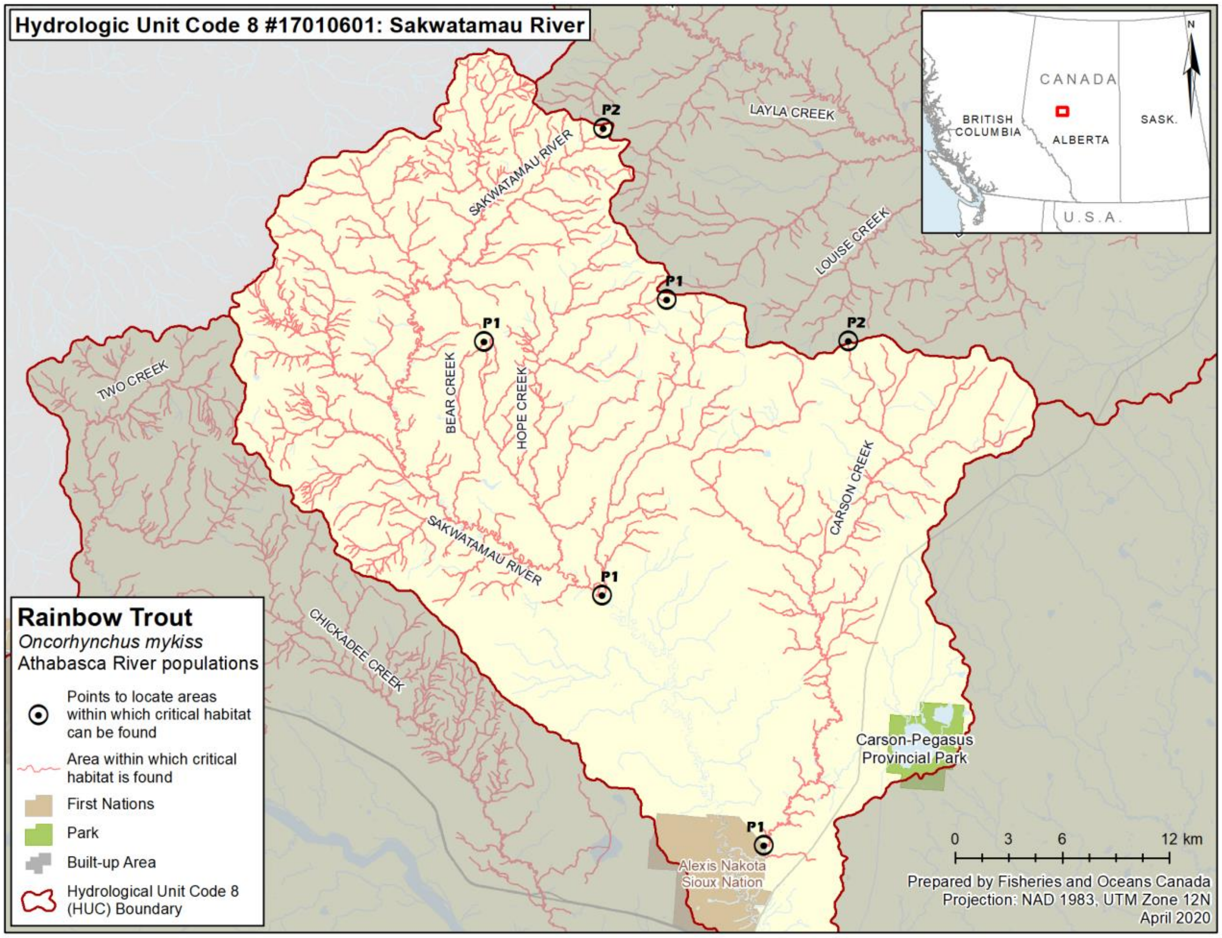

Figure A6. Athabasca Rainbow Trout critical habitat within HUC 8 17010601 (Sakwatamau River).

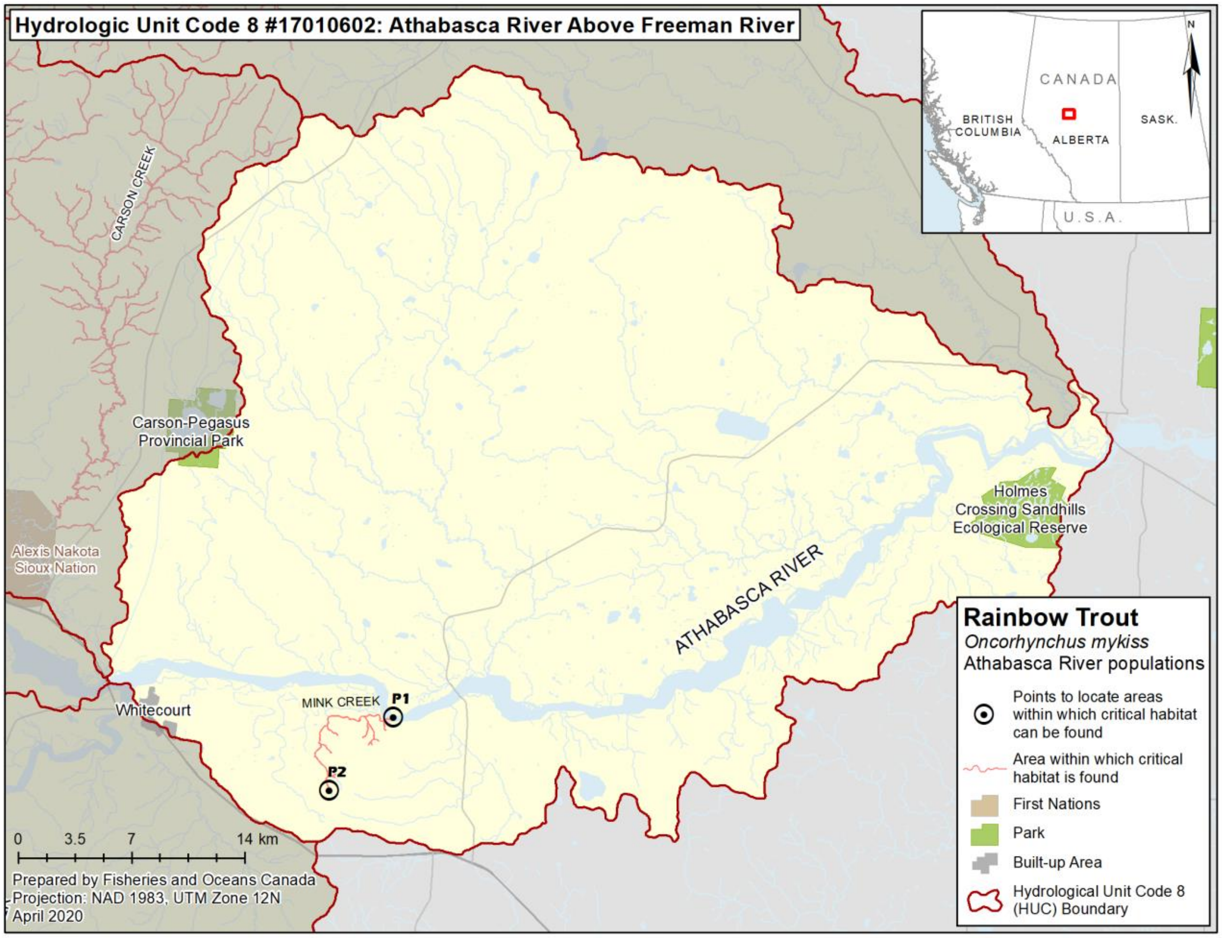

Figure A7. Athabasca Rainbow Trout critical habitat within HUC 8 17010602 (Athabasca River above Freeman River).

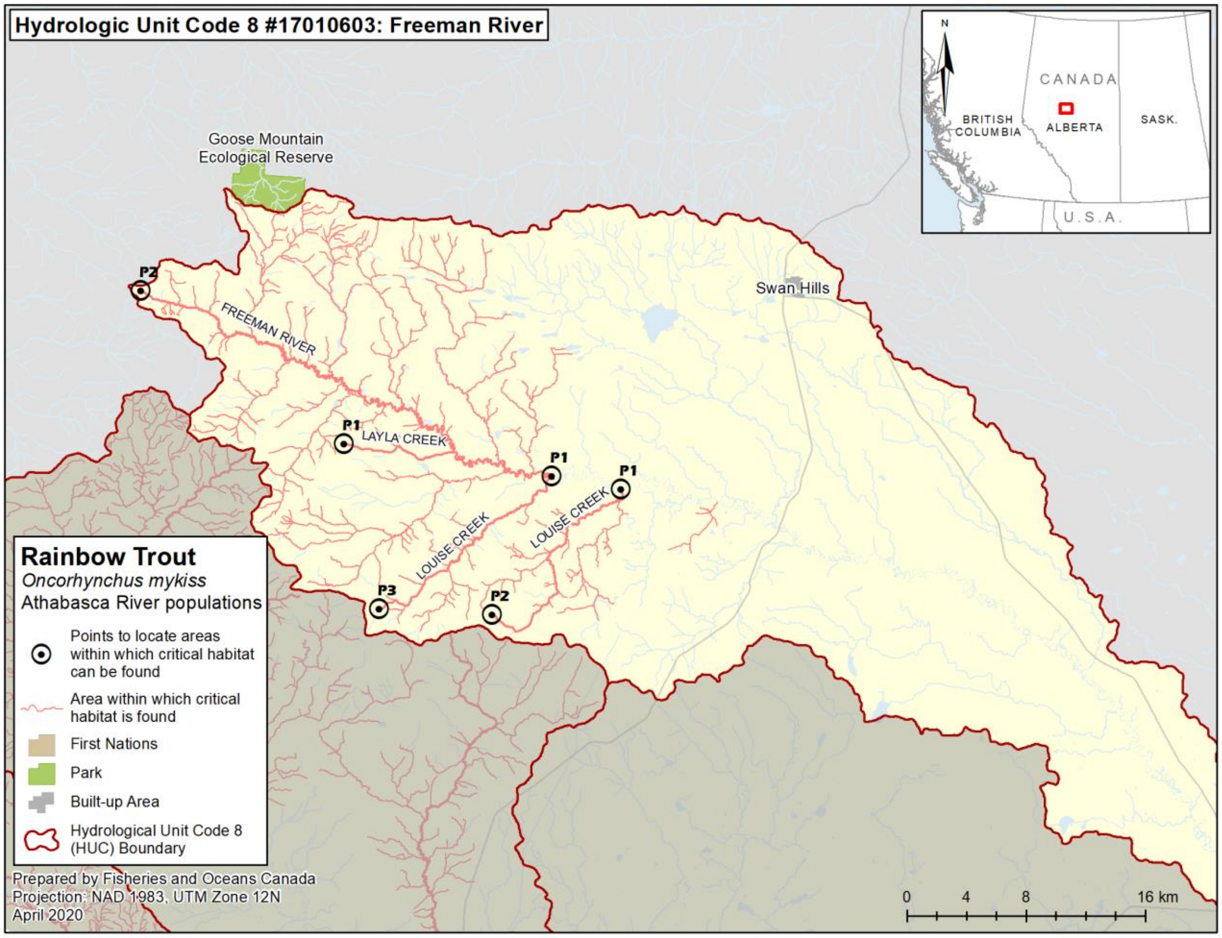

Figure A8. Athabasca Rainbow Trout critical habitat within HUC 8 17010603 (Freeman River).

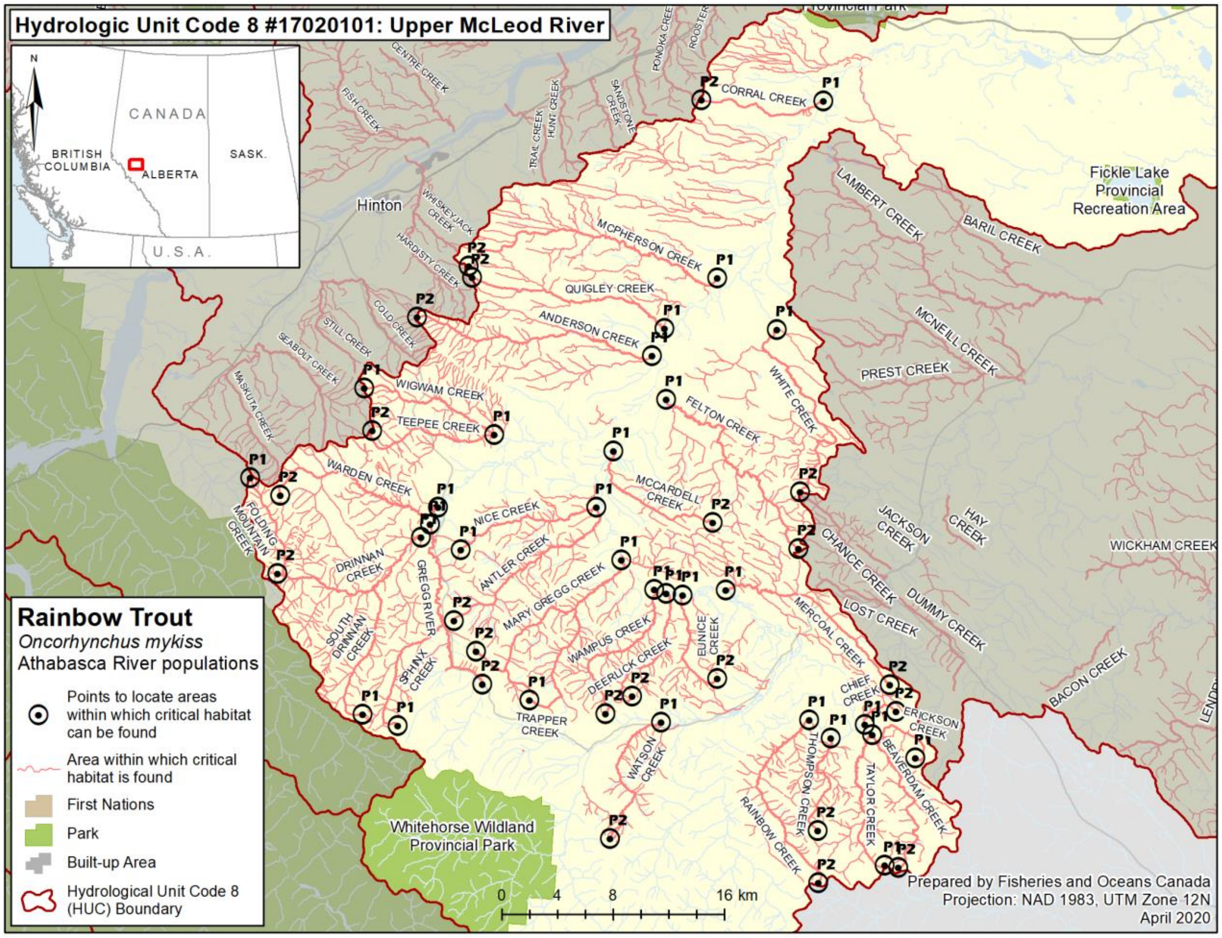

Figure A9. Athabasca Rainbow Trout critical habitat within HUC 8 17020101 (Upper McLeod River).

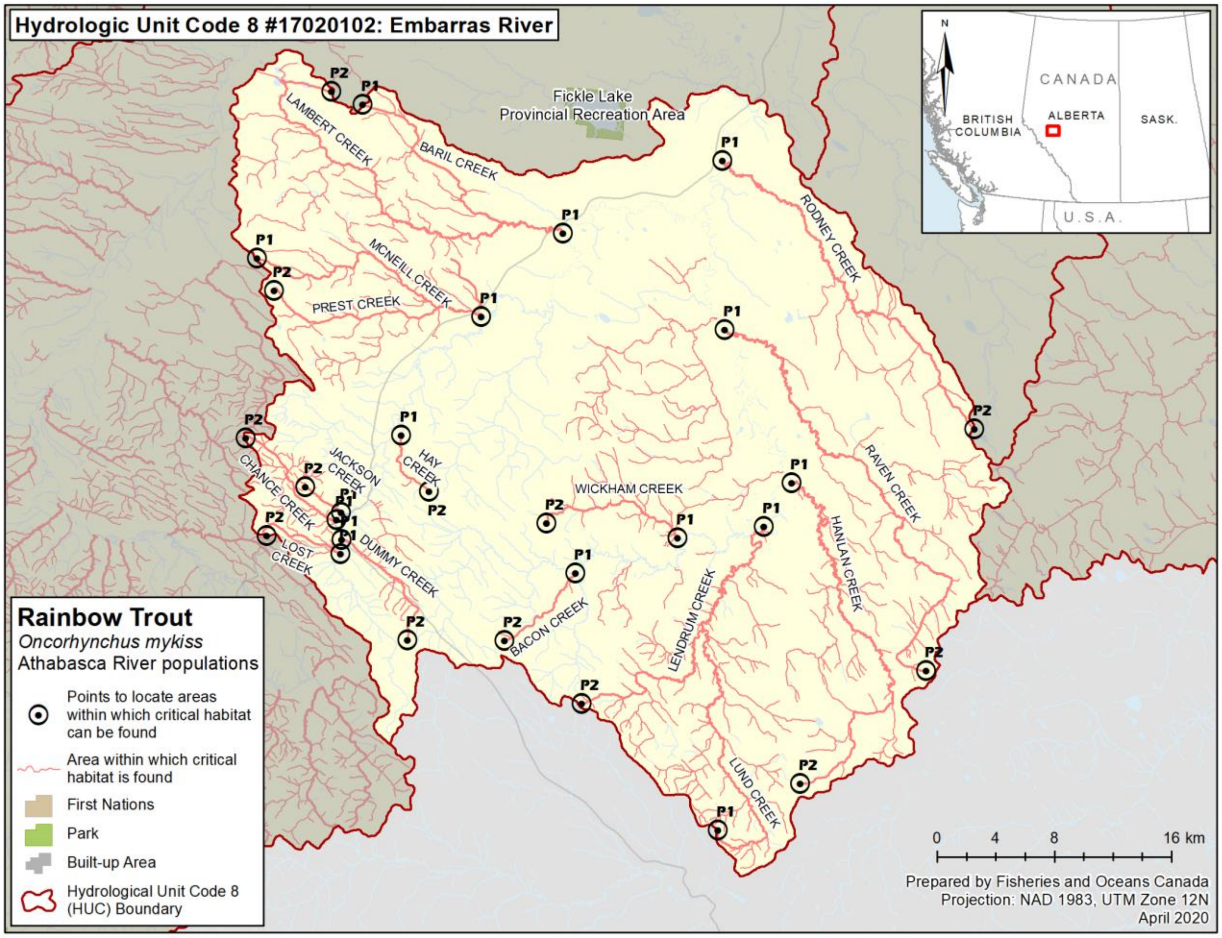

Figure A10. Athabasca Rainbow Trout critical habitat within HUC 8 17020102 (Embarras River).

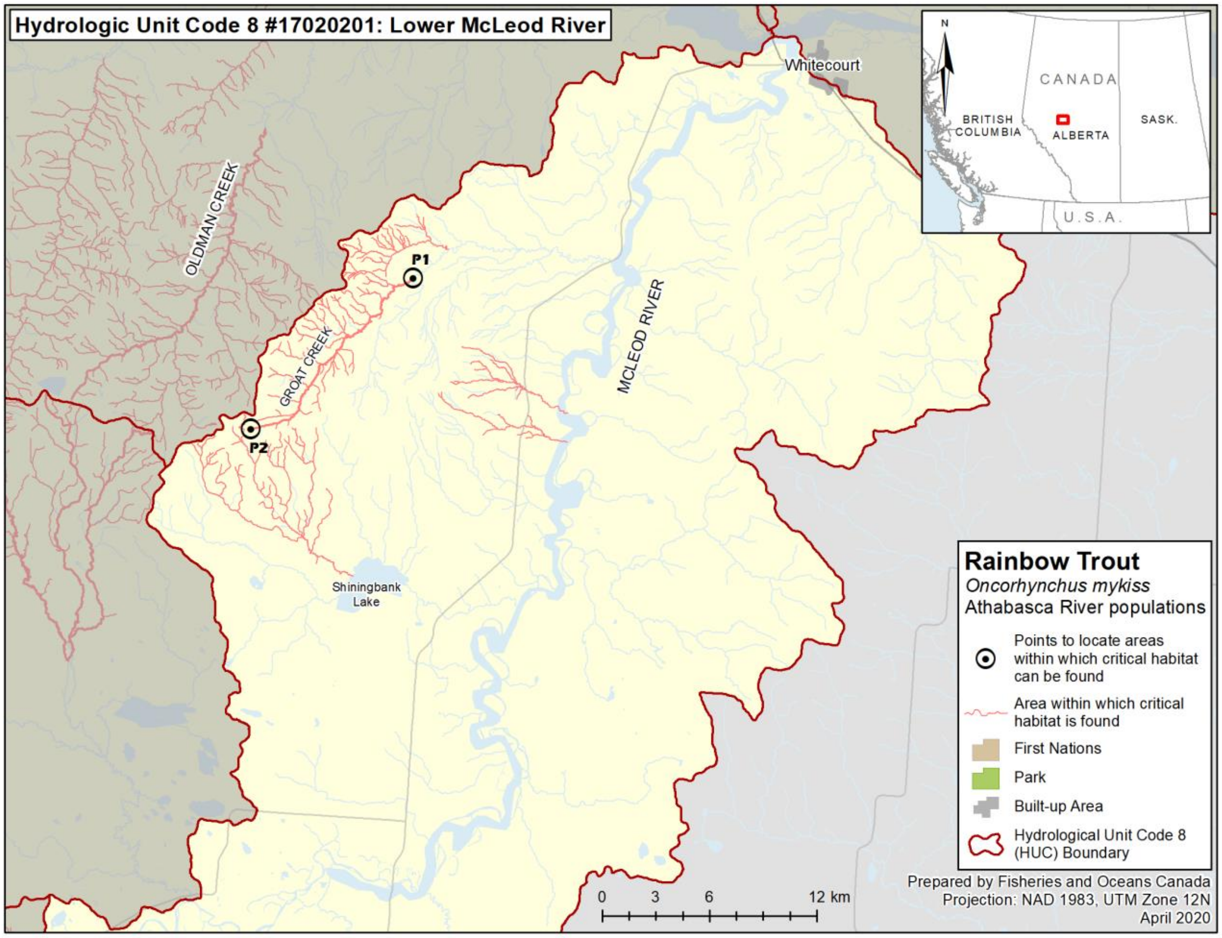

Figure A11. Athabasca Rainbow Trout critical habitat within HUC 8 17020201 (Lower McLeod River).

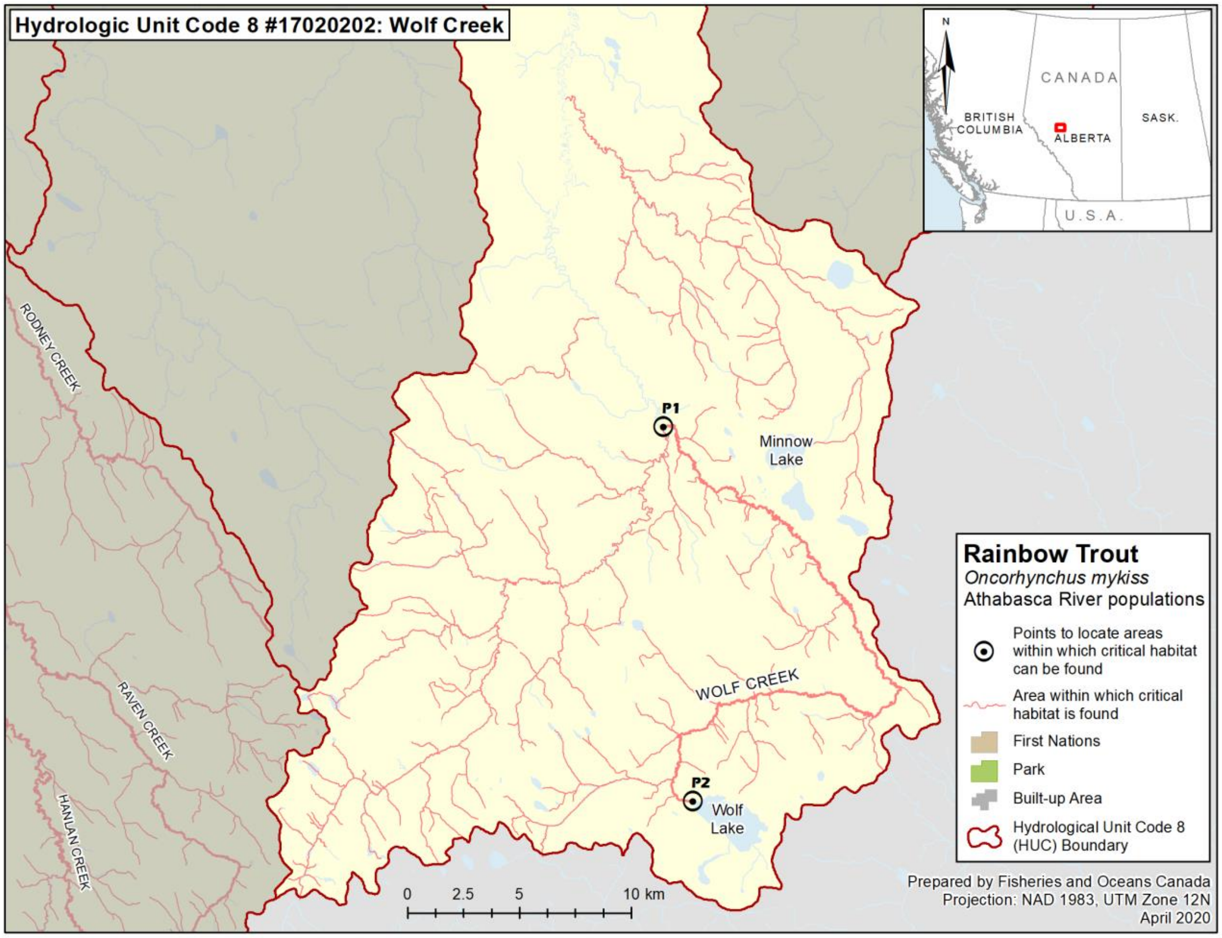

Figure A12. Athabasca Rainbow Trout critical habitat within HUC 8 17020202 (Wolf Creek).

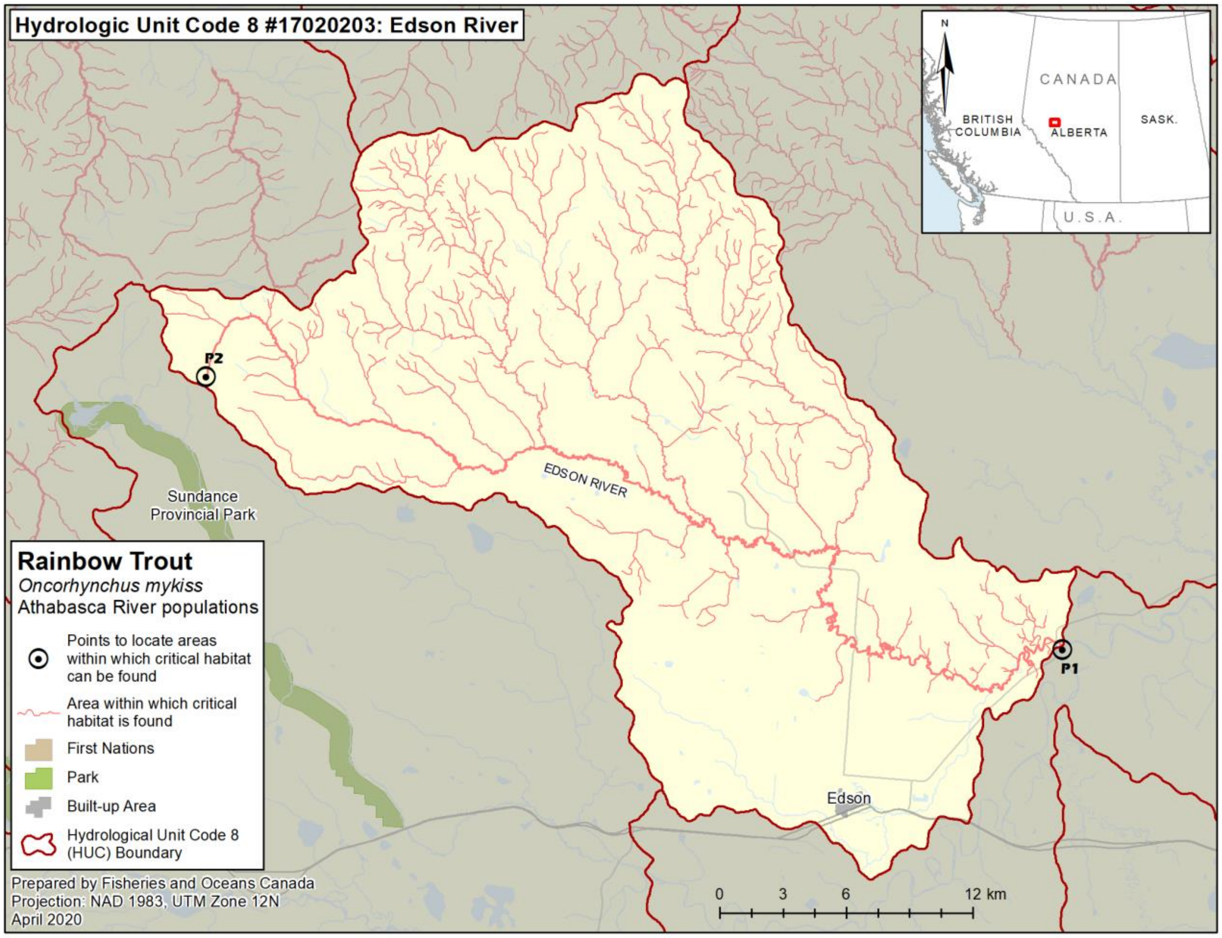

Figure A13. Athabasca Rainbow Trout critical habitat within HUC 8 17020203 (Edson River).

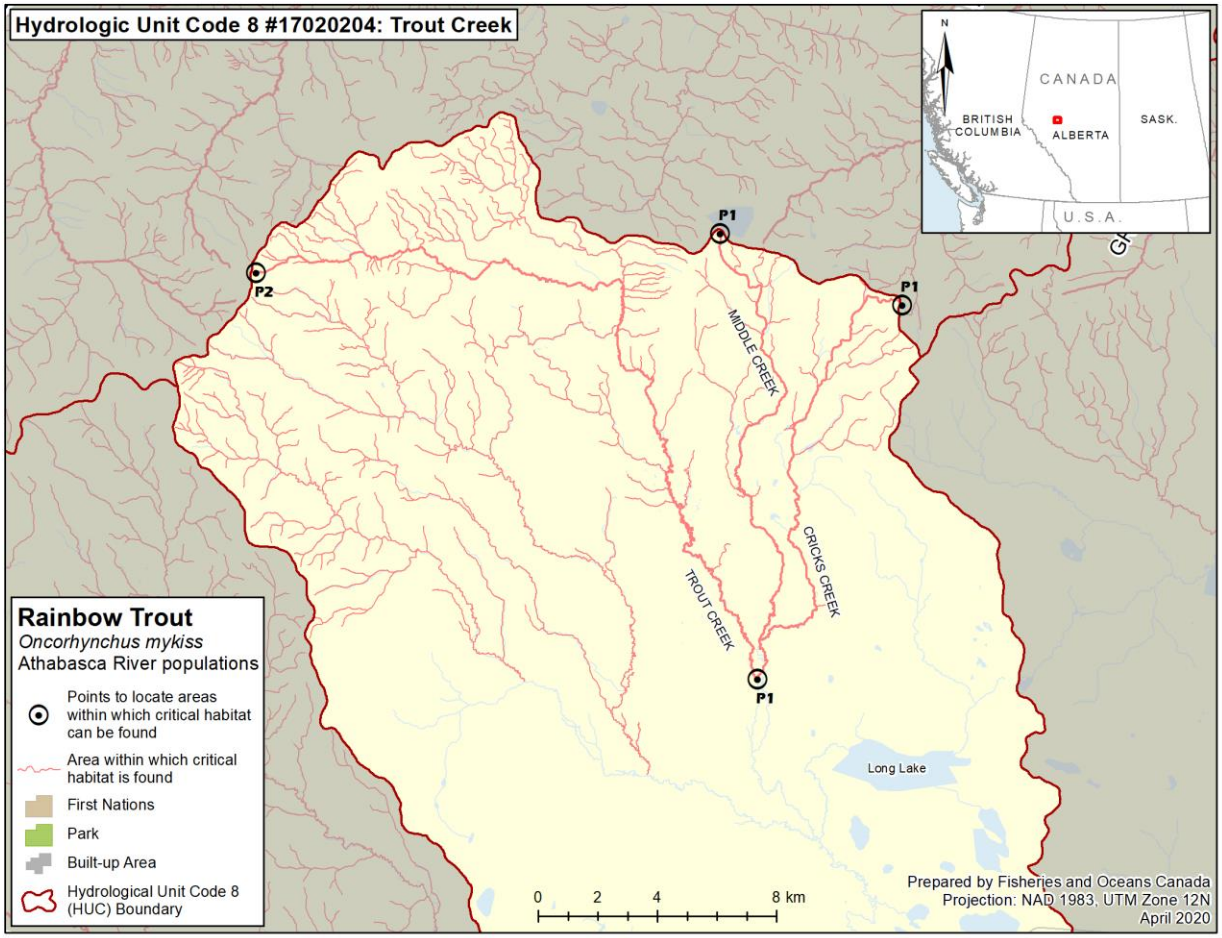

Figure A14. Athabasca Rainbow Trout critical habitat within HUC 8 17020204 (Trout Creek).

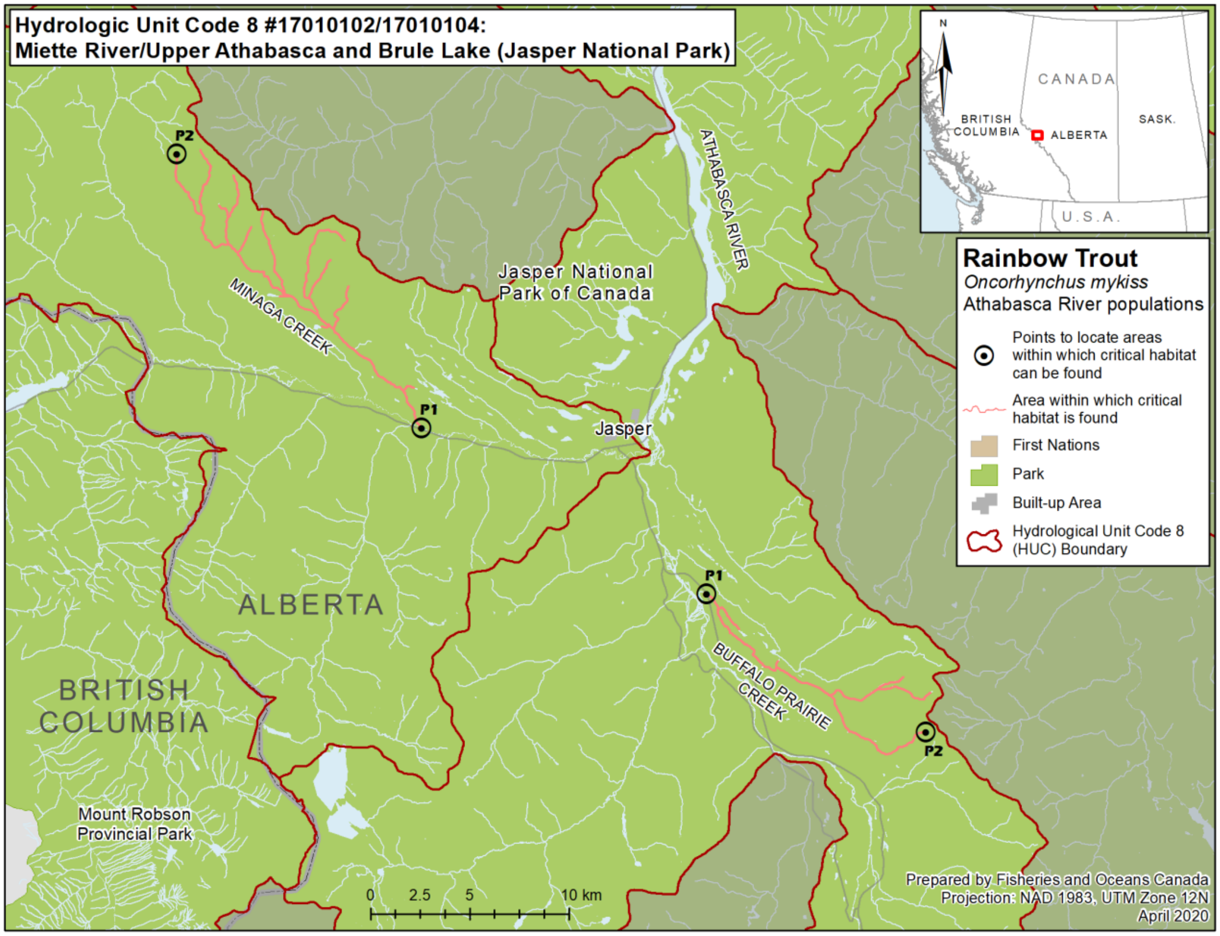

Figure A15. Athabasca Rainbow Trout critical habitat within HUC 8s 17010102/17010104 (Miette River/Upper Athabasca and Brule Lake; Jasper National Park).