COSEWIC
Assessment and Status Report

on the

Western Silvery Minnow
Hybognathus argyritis

in Canada

THREATENED
2017

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2008. COSEWIC assessment and update status report on the western silvery minnow *Hybognathus argyritis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 38 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2001. COSEWIC assessment and update status report on the western silvery minnow *Hybognathus argyritis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 14 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

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COSEWIC
Assessment Summary

Assessment Summary – November 2017

Common name
Western Silvery Minnow

Scientific name
Hybognathus argyritis

Status
Threatened

Reason for designation
This is a small-bodied minnow species that is restricted in Canada to the Milk River of southern Alberta. It is a habitat specialist found in shallow zones of turbid prairie waters with high seasonal flow variability and unstable fine sediments. It is threatened by flow management resulting from water diversions in the US and a warming and drying climate with negative impacts on habitat quantity and quality. Despite meeting criteria for Endangered, the severity of the threats is uncertain and there is no evidence of a decline in abundance since the previous assessment.

Occurrence
Alberta

Status history
Designated Special Concern in April 1997. Status re-examined and designated Threatened in November 2001. Status re-examined and designated Endangered in April 2008. Status re-examined and designated Threatened in November 2017.

COSEWIC
Executive Summary

Western Silvery Minnow
Hybognathus argyritis

Wildlife Species Description and Significance

The Western Silvery Minnow (*Hybognathus argyritis*) is a small fish belonging to the Cyprinidae family. It has an elongated body, triangular head, and small subterminal mouth. Its sides are bright silver, fading to brownish yellow dorsally and white ventrally. This species averages 80-85 mm in fork length (FL) and grows to a maximum of ~150 mm FL. A single population of Western Silvery Minnow exists in Canada. The species is native to Alberta and was first sampled in the province in 1961.

Distribution

The Western Silvery Minnow is present in medium and large prairie rivers in the Missouri River drainage and portions of the middle Mississippi River drainage. The Ohio River represents the southern extent of its range, while its northern extent is the Milk River in southern Alberta. To date it has not been found in any of the tributaries of the Milk River in Alberta. While range contractions have been noted in some states, the distribution of the Western Silvery Minnow in Canada has remained similar since sampling began in 1961.

Habitat

Western Silvery Minnows live exclusively in prairie streams, preferring relatively shallow, slow moving sections with sand or silt substrates. It is well adapted to live in highly turbid rivers that experience large fluctuations in flow and temperature. In Alberta they have been captured in waters with temperatures of up to 29.4 °C. Spawning and rearing habitats are largely unknown. Overwintering most likely takes place in deeper pools and runs where flow is maintained under the ice all winter. An inter-basin diversion transfers water from the St. Mary River into the Milk River annually from April to October. The increase in flow from this augmentation has been shown to decrease the amount of suitable habitat for Western Silvery Minnows for much of the year.

Biology

Western Silvery Minnows live up to 4 years and can attain lengths of ~150 mm FL. Individuals are typically ~ 50 mm FL by their first winter, 80-90 mm FL by their second and > 100 mm FL by their third. Females reach maturity at age 2 and can produce up to 19573 eggs annually. The average annual fecundity of a 4 year old female is estimated at 9214 eggs. Generation time is 2.6 years for the species. They spawn from late May to early July, and while their reproductive strategy is unknown, they are suspected to be pelagic broadcast spawners with semi-buoyant eggs. They have a mostly herbivorous diet of diatoms, algae and detritus. Western Silvery Minnows are tolerant of a wide range of environmental conditions and can tolerate high water temperatures and conductivities. They are strong swimmers and have been observed to travel relatively long distances, though it is unknown if this is a regular occurrence. They often form schools with Flathead Chub, Longnose Dace, Fathead Minnow and juvenile suckers. Predators such as Northern Pike, Sauger, Burbot and Walleye likely feed on the Western Silvery Minnow in the Milk River.

Population Sizes and Trends

There have been no estimates of Western Silvery Minnow abundance completed in the Milk River of Alberta. Previous studies speculated that there were no more than several thousand individuals in the population; however, recent surveys have captured thousands of individuals, with almost 4000 captured at a single site in 2013. This indicates that the current population is likely much higher than previously thought. It is unclear if this is the result of a population increase or changes in the sampling methodologies. There is no conclusive evidence of either a population increase or decrease since sampling began in the 1960s.

Threats and Limiting Factors

Since 1917 the St. Mary Canal has annually diverted water from the St. Mary River into the Milk River via the North Milk River in Montana, augmenting summer flow by roughly 10-fold and altering fish habitat in the Milk River. Discussions are ongoing regarding how to address the aging diversion infrastructure and what impact that will have on the diversion and fish habitat in the Milk River. Habitat alterations stemming from the diversion, water withdrawals for agricultural, municipal, and industrial use, and a potential dam site on the Milk River are the greatest threats to Western Silvery Minnow in Alberta.

The creation of a dam on the Milk River in Alberta would likely result in the introduction and/or proliferation of fish species that could compete with or feed on Western Silvery Minnow and reduce the suitability of feeding and spawning habitat. Agriculture and forestry effluents and utility and service lines also pose some risks to the species. Their restricted range and lack of refuge areas outside the Milk River increases their susceptibility to these threats.

Protection, Status and Ranks

The Western Silvery Minnow was assessed by COSEWIC as “Special Concern” in 1997, reassessed as “Threatened” in 2001, and “Endangered” in 2008. It is currently listed as “Threatened” under the federal *Species at Risk Act*. Provincially, it is listed as “Threatened” under Alberta’s *Wildlife Act*. Globally, the IUCN Red List ranks Western Silvery Minnow as “Near Threatened”, while NatureServe ranks it as “Apparently Secure”. NatureServe ranks the species as “Critically Imperilled”, both nationally in Canada and provincially in Alberta. The most recent Wild Species general status ranking was “Critically Imperilled” to “Imperilled” from the 2015 assessment.

TECHNICAL SUMMARY

Hybognathus argyritis

Western Silvery Minnow

Méné d'argent de l'Ouest

Range of occurrence in Canada: Alberta

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2016) is being used)	2.6 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	N/A
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. N/A b. N/A c. N/A
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	1194 km^2.
Index of area of occupancy (IAO) (Always report 2x2 grid value).	260 km^2 (discrete – based on 2km x 2km grid over each observation) 412 km^2 (continuous – based on continuous stretch of the Milk River between all observations)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No. b. No.

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	One.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, projected from Threats.
Are there extreme fluctuations in number of subpopulations?	NA.
Are there extreme fluctuations in number of "locations"∗?	No.
Are there extreme fluctuations in extent of occurrence?	No.
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Milk River	Unknown. No population estimates have been completed for the Milk River population. See Abundance in the Population Sizes and Trends section.
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Unknown. This analysis has not been completed.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species?

Yes, draft completed by Kenton Neufeld in October 2016. Threats conference call scheduled 13 January 2017.

i. Dams and water management/use (High-Low)
ii. Invasive non-native/alien species (Low)
iii. Problematic native species (Low)
iv. Agriculture and forestry effluents (Low)
v. Utility and service lines (Low)

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

What additional limiting factors are relevant? Restricted range.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Apparently Secure (S4) The population in the Milk River of Montana upstream of the Fresno Dam is most likely to provide immigrants to Canada. NatureServe currently ranks Western Silvery Minnow as 'Apparently Secure' in Montana and nationally in the United States.
Is immigration known or possible?	Yes (possible). There are no barriers to movement between the Canadian and US population above Fresno Dam in the Milk River. No direct observations of movement across the border have been made; however, it is assumed to occur.
Would immigrants be adapted to survive in Canada?	Yes. Conditions in the Milk River above Fresno Dam in Montana are similar to the lower Milk River in Canada and immigrants would be well adapted to survive.
Is there sufficient habitat for immigrants in Canada?	Yes.
Are conditions deteriorating in Canada?[+]	Unknown.
Are conditions for the source population deteriorating?[+]	Unknown.
Is the Canadian population considered to be a sink?[+]	No.
Is rescue from outside populations likely?	Possible

Data Sensitive Species

Is this a data sensitive species? No.

Status History

COSEWIC Status History: Designated Special Concern in April 1997. Status re-examined and designated Threatened in November 2001. Status re-examined and designated Endangered in April 2008. Status re-examined and designated Threatened in November 2017.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** Meets Endangered, B1ab(iii)+2ab(iii), but designated Threatened, B1ab(iii)+2ab(iii), because the species is not at risk of imminent extirpation.
Reasons for designation: This is a small-bodied minnow species that is restricted in Canada to the Milk River of southern Alberta. It is a habitat specialist found in shallow zones of turbid prairie waters with high seasonal flow variability and unstable fine sediments. It is threatened by flow management resulting from water diversions in the US and a warming and drying climate with negative impacts on habitat quantity and quality. Despite meeting criteria for Endangered, the severity of the threats is uncertain and there is no evidence of a decline in abundance since the previous assessment.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(iii)+2ab(iii), since the EOO and IAO are below the threshold, there are less than 5 locations, and there is a projected decline in quantity and quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable
Criterion D (Very Small or Restricted Population): Not applicable
Criterion E (Quantitative Analysis): Not applicable

PREFACE

Since the last COSEWIC Status Report (2008), new knowledge has contributed to a better understanding of habitat requirements and trends, biology, and threats to the Canadian population of Western Silvery Minnow. Habitat suitability has been more clearly defined and the impact of increased flows from the St. Mary diversion on habitat availability has been investigated. Recovery potential for the species has been modelled, with growth, fecundity, survival, and generation time quantified. Empirical data from laboratory swim studies have shown that Western Silvery Minnows are strong swimmers and a mark recapture study has shown that individuals are able to move long distances in the Milk River (up to 14 km).

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2017)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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2017

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Cypriniformes

Family: Cyprinidae

Genus: *Hybognathus*

Species: *argyritis*

Scientific name: *Hybognathus argyritis*

Common names:
English: Western Silvery Minnow
French: Méné d'argent de l'Ouest

Western Silvery Minnow belongs to the genus *Hybognathus*, a North American monophyly supported by both morphometric (Schmidt 1994) and genetic (Moyer *et al.* 2009) investigations. Seven *Hybognathus* species are currently recognized, with four occurring within Canada: Western Silvery Minnow, Plains Minnow (*H. placitus*), Brassy Minnow (*H. hankinsoni*), and Eastern Silvery Minnow (*H. regius*). There has been considerable confusion over species taxonomy within the genus *Hybognathus*. Western Silvery Minnow was originally described as *H. argyritis* (Girard 1856), before being lumped with the Eastern and Central Silvery minnows as *H. nuchalis* (Scott and Crossman 1973). Pflieger (1971) proposed that *H. argyritis* and *H. regius* be considered separate species from *H. nuchalis* based on the shape of the basioccipital process. Schmidt (1994) found that *H. argyritis*, *H. nuchalis*, *H. hayi* and *H. amarus* formed a clade within the *Hybognathus* monophyly and that distinction between *H. argyritis* and *H. nuchalis* was inconsistent when based on morphological characteristics alone. A genetics study completed by Moyer *et al.* (2009) has since provided evidence supporting *H. argyritis* as a distinct species within the *Hybognathus* genus and the Western Silvery Minnow is currently recognized as a species by the American Fisheries Society (Page *et al.* 2013). Mitochondrial DNA sequences available on the Barcode of Life Data System on March 6, 2017 (Ratnasingham and Hebert 2007, Hubert *et al.* 2008, April *et al.* 2011), including five *H. argyritis* specimens from the province of Alberta, seven *H. argyritis* specimens from the state of Missouri as well as all the other Canadian species of this genus, also support the conclusion that *H. argyritis* represents a distinct species.

Morphological Description

This morphological description has been compiled from Scott and Crossman (1973), Pflieger *et al.* (1975), Nelson and Paetz (1992), and a collection of 20 fish examined by Doug Watkinson. Fork length (FL) data were obtained from surveys completed in 2007 by Watkinson (unpublished data) and in 2013 by Neufeld (unpublished data). Western Silvery Minnows average approximately 80-85 mm FL in the Milk River, with a maximum observed length of 147 mm FL. Their body is elongate and moderately compressed, with a narrow isthmus. The head is triangular, with a small, subterminal and slightly oblique mouth. The distance between the eyes is twice the eye diameter. The dorsal fin is inserted in front of the insertion of the pelvic fins, the tips of the dorsal and pectoral fins are pointed, the caudal fin is forked, and there are usually eight rays in both the dorsal and anal fins, seldom 7. Scales are cycloid, with 5-12 distinct radii on the posterior margin. There are between 37-41 scales along the complete lateral line (average: 38-39), ~5-6 above the lateral line and 13-14 around the caudal peduncle. The intestine is long and coiled. There are between 38-40 vertebrae, 0,4-4,0 pharyngeal teeth, and 9-11 long gillrakers, usually present on the first gill arch. The basioccipital process is a helpful feature for distinguishing *Hybognathus* species, and that of Western Silvery Minnow is broad and blade-like, with a straight or slightly concave back margin. Its greatest length is 1.2-1.8 times its greatest width.

Western Silvery Minnows are bright silver on their sides, fading to a brownish yellow on the back, with a white underbelly (Nelson and Paetz 1992). Orange and blue highlights and dusky spots are sometimes present above the lateral line. Fins are generally transparent and mostly colourless, and the peritoneum is black. There are no coloration differences between males and females, though males may have small tubercles on the head, fins and forward part of the body during breeding season (Pflieger *et al.* 1975).

Western Silvery Minnows can be distinguished from sympatric Brassy Minnows by the pointed tip of the dorsal fin: Brassy Minnow have a rounded dorsal fin tip (Pflieger *et al.* 1975). Brassy Minnows also have ~20 radii on their scales as opposed to an average of ten on Western Silvery Minnows (Pflieger *et al.* 1975). While Plains Minnows and Western Silvery Minnows have not been observed in sympatry in Canada, the possibility of range overlap exists in tributaries of the Milk River in southern Saskatchewan and overlap occurs within their range in the United States. These species closely resemble one another, though Loomis (1997) was able to consistently distinguish between the species based on the larger eye and pupil diameter, and less numerous and larger scales across the belly of Western Silvery Minnow. Accurate identification can also be made by examining the basioccipital process of the specimen, which is narrow and peg-like in Plains Minnow (Pflieger *et al.* 1975).

Population Spatial Structure and Variability

The Canadian population of Western Silvery Minnow exists in a single river, with no permanent physical barriers to movement within their range. During drought, sections of the Milk River can become completely dry except for isolated pools, which would present a barrier to movement (RL&L 2002a). These barriers are temporary and do not prevent frequent mixing of the Canadian Milk River population. A tagging study in the Milk River in 2013 (Neufeld unpublished data) observed an adult Western Silvery Minnow move upstream ~14 km in 16 days. Long range dispersal has been observed in other *Hybognathus* species (Platania *et al.* 2003; Wilde 2016), and similar movement patterns by Western Silvery Minnow in the Milk River would suggest a single mixed population rather than spatially distinct subpopulations.

Designatable Units

The Canadian distribution of Western Silvery Minnow is within the Missouri National Freshwater Biogeographic Zone and considered a single population; therefore, one designatable unit is recognized for Western Silvery Minnow in Canada.

Special Significance

Western Silvery Minnow is native to the Milk River in Canada, with the earliest collections taken in the lower Milk River in 1961 by Grant Campbell (Nelson and Paetz 1992). It was first collected from the Milk River in Montana by Dr. George Suckley in 1853 (Girard 1856; Smithsonian National Museum of Natural History 2016) and there is no indication it was introduced into the Alberta portion of the Milk River. Willock (1969) suggested that the species may have only moved into the Alberta portion of the Milk River after 1917, after the St. Mary diversion was constructed; however, habitat was likely suitable for Western Silvery Minnow in this reach prior to the diversion (see Habitat Trends) and the species was probably already present in that section of the Milk River.

DISTRIBUTION

Global Range

Western Silvery Minnow is present in large and medium prairie rivers in the Missouri River drainage and portions of the middle Mississippi River drainage (Figure 1; Pflieger 1980). Populations are present in many of the tributaries to the Missouri River in addition to the mainstem Missouri River itself from Fort Benton, Montana to the confluence with the Mississippi River (Montana Field Guide 2016). The Des Moines River in Iowa is the only known tributary of the Mississippi where this species occurs, other than the Missouri River (Parks *et al.* 2014). Within the mainstem Mississippi River, Western Silvery Minnows are found from the Des Moines River downstream to the Ohio River; this represents the southern extent of the known distribution (Pflieger 1980). The northern extent of the range is the Milk River in southern Alberta (Nelson and Paetz 1992). While distribution within this range is continuous, dams fragment many rivers and localized extirpations could result in a disjointed distribution (Perkin and Gido 2011).

Range contractions have been noted in South Dakota (Dieterman and Berry 1999; Harland 2003; Hoagstrom *et al.* 2006a), Kansas (Eitzmann and Paukert 2010; Gido *et al.* 2010), and Wyoming (Hoagstrom *et al.* 2006b). Recent observations of Western Silvery Minnows in the Des Moines River, Iowa (Parks *et al.* 2014) and the possible capture of a single individual in the White River, Arkansas (Etnier and Robison 2004) may indicate slight range expansions, or the discovery of previously undetected subpopulations.

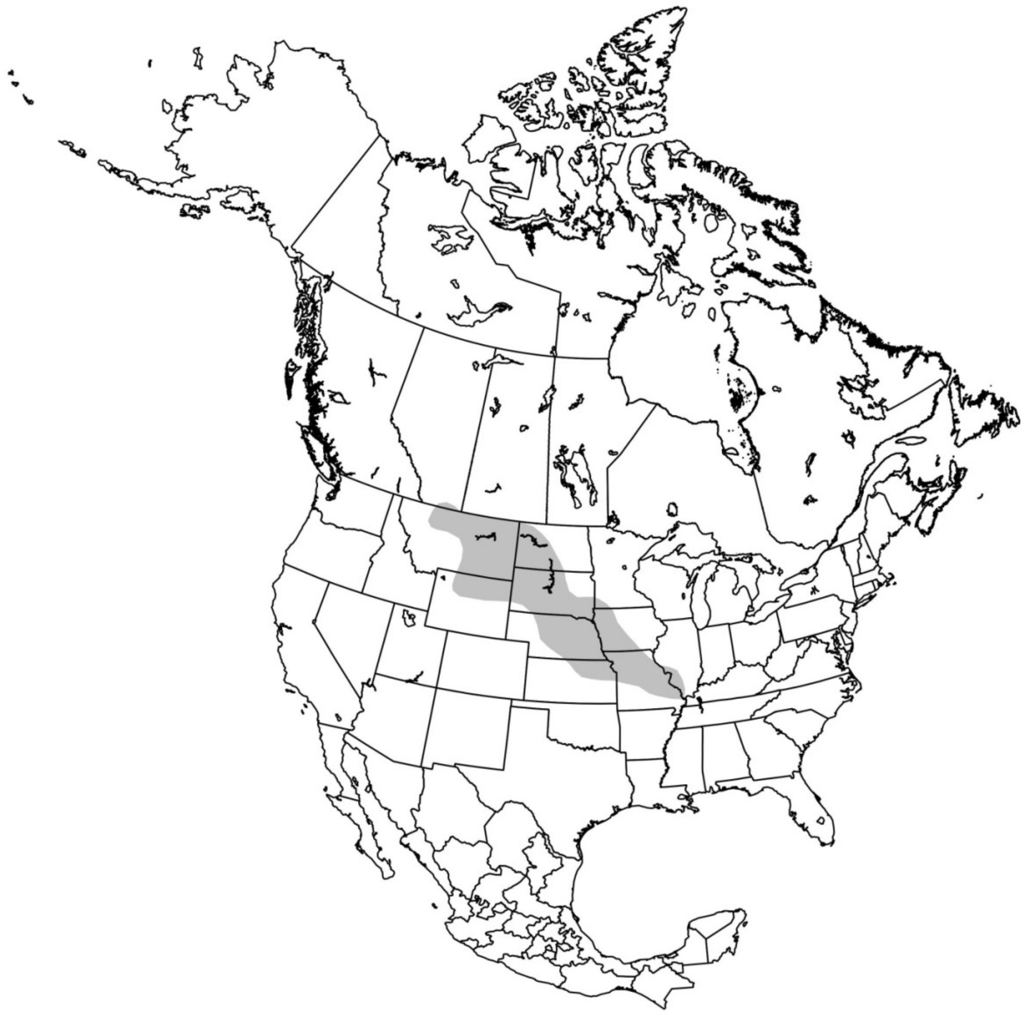

Figure 1. The distribution of Western Silvery Minnow in North America. From Pflieger (1980), NatureServe (2016), and Watkinson (unpublished data).

Canadian Range

Within Canada, Western Silvery Minnow populations have only been confirmed in the Milk River of southern Alberta (Figure 2). A single specimen was reported from the South Saskatchewan River in Medicine Hat, Alberta, by Henderson and Peter (1969). It is thought that this individual was introduced from adjacent populations in the Milk River and does not represent an established population (Willock 1969). No further specimens have been reported from the South Saskatchewan River and it is not likely that Western Silvery Minnows are currently present in the system. Twelve juvenile *Hybognathus* spp. collected from Tobin Lake, Saskatchewan, in 1966 and stored at the Royal Ontario Museum were initially identified as *Hybognathus nuchalis* and subsequently as Western Silvery Minnow (Holm, pers. comm. 2016). These specimens are likely actually Brassy Minnow, but were reclassified as *Hybognathus* spp. upon re-examination in 2016 as a positive identification could not be made (Holm, pers. comm. 2016). Several streams in southern Saskatchewan are part of the Missouri River drainage (e.g., the Frenchman River), and while no Western Silvery Minnows have been captured in these systems to date (McCulloch *et al.* 1993; Sylvester *et al.* 2005; Watkinson unpublished data), they may be detected with increased monitoring.

Western Silvery Minnows are distributed in the Milk River in Canada from the eastern crossing of the international border upstream to approximately 15 km downstream of the North Milk River and Milk River confluence. Distribution within this range is continuous and there is no evidence for the existence of subpopulations. Earlier surveys reported Western Silvery Minnows from the vicinity of Writing-on-Stone Provincial Park and downstream (Willock 1969; RL&L 1980, 1987a), a stream length of approximately 140 km. More recent surveys completed in 2007 (Watkinson unpublished data) have confirmed the continuous distribution of the species upstream of the town of Milk River, a total stream length of approximately 223 km. While concentrations of Western Silvery Minnows have been noted at the mouths of tributary rivers and coulees (Willock 1969; RL&L 2002b), they have not been observed occupying any tributaries of the Milk River in Alberta (Clayton 2003a; Clayton and Downey 2005).

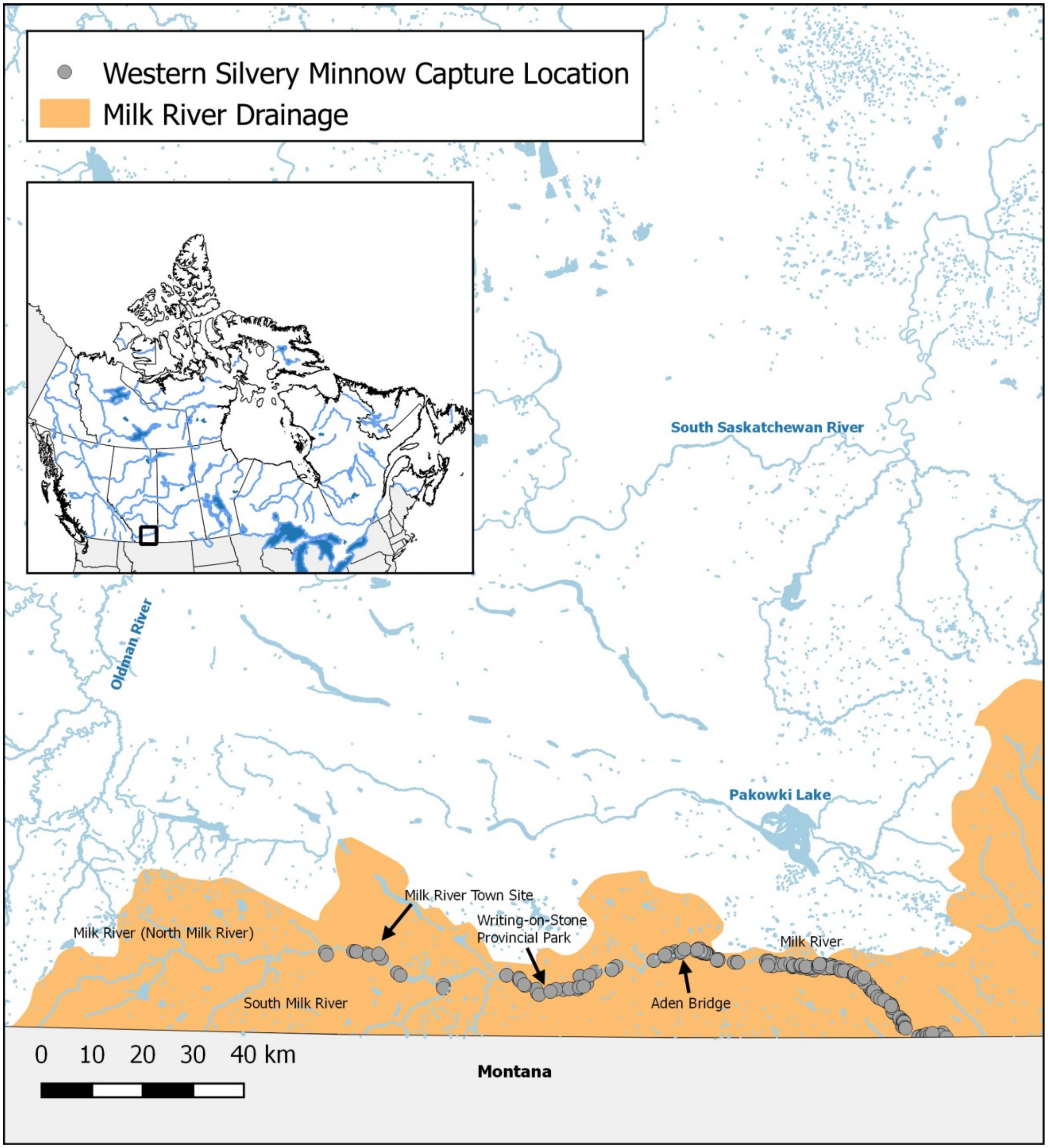

Figure 2. Canadian distribution of the Western Silvery Minnow within the Milk River drainage, Alberta. All documented Western Silvery Minnow capture sites are indicated. See Acknowledgements and Authorities Contacted for full list of data sources.

Extent of Occurrence and Area of Occupancy

The extent of occurrence is estimated to be 1194 km^2, which is based on a minimum convex polygon encompassing all known observations of occurrence. The discrete index of area of occupancy is 260 km^2 and is calculated as the surface area of 2 km x 2 km grid cells that intersect with observations of occurrence. The continuous index of area occupancy (the surface area of 2 km x 2 km grid cells intersecting a continuous stretch of the Milk River between observations of occurrence) is 412 km^2. This is excluding the observation of a single Western Silvery Minnow in the South Saskatchewan River, as it was likely an isolated introduction (Henderson and Peter 1969).

Search Effort

Early fish sampling efforts in the Milk River drainage occurred in 1966/67 (Willock 1969), 1979/80 (RL&L 1980), and 1986 (RL&L 1987a) (Table 1). Since 2000, extensive fisheries surveys have been completed on the Milk River as well as the North Milk River and other tributaries. Sampling efforts have utilized electrofishers (boat and backpack) and seine nets most commonly, though other sampling techniques have also been used (Table 1). While continued sampling may extend the range of Western Silvery Minnow further upstream as occasional vagrants are captured, the current data likely accurately represents the range of the species in the Milk River, Alberta.

In Saskatchewan, extensive sampling in Frenchman River found no Western Silvery Minnow (COSEWIC 2012).

Table 1. Major fisheries surveys completed in the Milk River drainage. Upper Milk River = upstream US border crossing to the town of Milk River, Middle Milk River = the town of Milk River to Aden bridge, Lower Milk River = Aden bridge to downstream US border crossing.

Sampling Organization	Year	Number of Sites Sampled					Capture Methods Utilized
		Upper Milk River	Middle Milk River	Lower Milk River	North Milk River	Other Tributaries	
Willock, Thomas (Carleton University)	1966/1967	5	12	8	4	23	Seine net, set line, electrofisher
RL&L Environmental Services Ltd.	1979/1980	11	4	1	9	1	Electrofisher, minnow trap, hoop net
RL&L Environmental Services Ltd.	1986	5	3	2	5	2	Electrofisher, seine net, angling, gill net
RL&L Environmental Services Ltd.	2000 (August)	2	2	2	4	1	Electrofisher, seine net
RL&L Environmental Services Ltd.	2000 (October)	1	10	3	4	0	Electrofisher, seine net
RL&L Environmental Services Ltd.	2001 (summer)	0	0	10	0	0	Electrofisher, seine net
RL&L Environmental Services Ltd.	2001 (fall)	1	5	13	1	0	Electrofisher, seine net
P&E Environmental Consultants Ltd.	2002	1	0	29	5	0	Seine net, electrofisher

Sampling Organization	Year	Number of Sites Sampled					Capture Methods Utilized
		Upper Milk River	Middle Milk River	Lower Milk River	North Milk River	Other Tributaries	
Alberta Sustainable Resource Development	2002 (fall)	0	0	0	0	21	Electrofisher, minnow trap, dip net
Alberta Sustainable Resource Development	2004	0	0	0	0	5	Dip net
Alberta Sustainable Resource Development	2005	0	6	8	0	0	Seine net, minnow trap, drift net, dip net, setline, electrofisher
Fisheries and Oceans Canada	2005-2007	15	24	53	0	0	Electrofisher, seine net
Neufeld, Kenton (University of Alberta)	2013	0	0	102	0	0	Seine net
Alberta Conservation Association	2014	1	2	0	0	0	Electrofisher

HABITAT

Habitat Requirements

Western Silvery Minnows inhabit large to medium-sized prairie streams, and have not been collected in lentic habitats. They have been found much more frequently and in higher abundance in the lower sections of the Milk River in Alberta than the upper sections (Clayton 2003b). The portion of river from the eastern crossing of the US border upstream approximately 141 km is characterized by a low gradient, a high proportion of run habitat type, a low proportion of riffles and pools, and dominated by sand/silt substrate (RL&L 1987b). Upstream of this section, the gradient increases, the proportion of riffle habitat increases, and coarse sediment becomes more abundant. No Western Silvery Minnows have been observed inhabiting tributaries of the Milk River; however, they are present at confluences of some tributaries (Willock 1969). Although aquatic vegetation and overwintering refugia are present in some tributaries, these habitats are apparently not utilized by Western Silvery Minnows. It should be noted that studies investigating habitat associations of Western Silvery Minnow in Alberta have focused on adults and juveniles and there are few data on the habitat requirements of the larval stage.

The Western Silvery Minnow is a habitat specialist that is only found in prairie streams characterized by turbid waters, large seasonal fluctuations in flow and unstable sand/silt dominated substrate (Pflieger *et al.* 1975; Hoagstrom *et al.* 2007). Western Silvery Minnows have a strong preference for relatively shallow areas (Watkinson and Riemersma 2011; Neufeld unpublished data). Water depth averaged 0.38 m at sites where Watkinson captured Western Silvery Minnows (unpublished data), and Welker and Scarnecchia (2004) found individuals were most often at depths less than 1 m. The species also prefers low water velocities, with an average velocity of 0.24 m/s at sites where Watkinson (unpublished data) captured individuals, while Welker and Scarnecchia (2004) captured individuals most often at sites with velocities below 1 m/s. Western Silvery Minnows are often associated with sandy and silty substrates. On average Watkinson (unpublished data) found 96% of the substrate was composed of sand and silt at sites where Western Silvery Minnows were captured, and Sikina and Clayton (2006) and Quist *et al.* (2004) observed similar relationships. The association of this species with slow moving, sandy areas of large prairie rivers has been observed by multiple additional authors, including Pflieger (1971, 1980), Duehr (2004), the Wyoming Game and Fish Department (2010), and Mounts (2015).

Western Silvery Minnows are often found in turbid streams that experience high temperatures during the summer. Watkinson (unpublished data) captured individuals at sites with Secchi depths ranging from 0.13 – 0.63 m, and the presence of Western Silvery Minnows is positively associated with increased turbidity (Barfoot 1993). They also appear tolerant of high water temperatures, with Neufeld (unpublished data) capturing individuals in the Milk River at water temperatures of up to 29.4 °C and Watkinson (unpublished data) capturing individuals in water up to 27.2 °C. Water temperatures are as low as 0 °C in the winter in the Milk River, suggesting that Western Silvery Minnows are tolerant of a wide range of water temperatures.

The spawning habitat of Western Silvery Minnow has not been determined. Their spawning strategy was previously assumed to be similar to that of the related Eastern Silvery Minnow (*H. regius*), a spring spawner that lays non-adhesive eggs in shallow vegetated backwater areas with little current (Raney 1939). Aquatic vegetation is largely absent from the mainstem Milk River in Alberta (RL&L 1987a) and Western Silvery Minnows have not been observed in tributaries that contain greater amounts of vegetation (Willock 1969; Clayton 2003a). Both the Plains Minnow (*H. placitus*) and the Rio Grande Silvery Minnow (*H. amarus*) produce semi-buoyant eggs and are thought to be pelagic broadcast spawners (Platania and Altenbach 1998). Their eggs are broadcast into the main flow of the stream and are carried downstream as they develop. These species occupy systems similar to Western Silvery Minnow and it is more likely that Western Silvery Minnows follow this reproductive strategy. Pelagic broadcast spawners in prairie streams require adequate flow and unfragmented lengths of streams to allow the eggs enough time to develop and hatch. The spawning success of pelagic broadcast spawners has been linked to increased flow during the spawning period (Durham and Wilde 2008), and reductions or alterations in flow could have negative impacts on Western Silvery Minnow spawning success. Perkin and Gido (2011) estimated that a minimum unfragmented stream length of 115 km is required for the persistence of the Plains Minnow, with similar values estimated for other species in the pelagic broadcast spawning guild. Western Silvery Minnow likely requires a similar length of unfragmented stream to successfully reproduce.

Species-specific overwintering habitat requirements for Western Silvery Minnow are unknown, though they are able to persist despite some winters when sections of the Milk River are reduced to a series of isolated pools (RL&L 2002a). Dissolved oxygen concentrations appear to be adequate to support fish overwintering, even in these isolated pools (RL&L 1986, 2002a); however, increased dewatering could extirpate Western Silvery Minnow from some sections of the Milk River in dry years.

There is little information on the habitat area required for the home range of Western Silvery Minnow. The species is not territorial and has been observed in large schools of several thousand individuals in the Milk River (Neufeld unpublished data). A single adult individual has been observed travelling ~14 km over 16 days in the Milk River, suggesting potentially large home ranges (Neufeld unpublished data). The Plains Minnow has been observed to travel up to 213 km (Wilde 2016) and Rio Grande Silvery Minnows have been observed to travel up to 25 km (Platania *et al.* 2003). These two closely related species occupy similar stream habitats and support the notion of a relatively large home range for Western Silvery Minnow.

Habitat Trends

Currently, habitat suitable for Western Silvery Minnow is most abundant in the lower sections of the Milk River (RL&L 2002b). This largely consists of slow-moving shallow areas, often associated with sandbars, backwaters and the margins of the river. The proportion of wetted area that is suitable habitat for Western Silvery Minnow varies between sections. Golder Associates (2010) found that at discharge levels typical of the April-October period, 35 – 40% of the wetted area was suitable for Western Silvery Minnows at a site in the lower reach of the Milk River, while 40 – 50% was usable at a site near the town of Milk River. Suitable habitat increased as discharge decreased at both sites. Neufeld (2016) estimated that during augmented flows, only 9.5% and 3.9% of the wetted areas at two sites in the lower Milk River were suitable. During lower natural flows (1-2 m^3/s), 40.2% and 28.3% of the wetted areas were suitable. While the absolute estimates of suitable habitat vary between these studies, they both found reduced habitat suitability during discharge levels typical of augmented flow (15-20 m^3/s).

The main driver of habitat changes in the Milk River in Canada has historically been the St. Mary diversion, which transfers water from the St. Mary River to the Milk River in Montana before the Milk River enters Canada in southwestern Alberta. This inter-basin water transfer commenced in 1917 and serves the primary function of providing water for irrigation use in Montana once the Milk River enters the USA again. The diversion is typically operational from April to October of each year and augments the natural flow of the North Milk River and the Milk River downstream of the North Milk River confluence to 10 – 20 times its natural flow (International St. Mary – Milk Rivers Administrative Measures Task Force 2006). The diversion has impacted aquatic habitat in the Milk River at two temporal scales, first by changing channel and bed morphology and rates of erosion compared to pre-diversion conditions (McLean and Beckstead 1980), and secondly by causing intra-annual variation in habitat availability (Neufeld 2016).

Prior to the diversion, the North Milk River was a small meandering prairie stream with mostly gravel substrate, riffle-pool morphology, and an average bankfull width of 19.3 m (McLean and Beckstead 1980). The Milk River from the North Milk River confluence to Writing-on-Stone Provincial Park had an average bankfull width of 52 m, more sinuous meanders than the North Milk River, mostly gravel substrate, and silty or sandy loam banks, except when confined by valley walls. Downstream of Writing-on-Stone Provincial Park, substrate shifted abruptly to predominantly sand and the meandering channel contained mid-channel sand bars, waves and shoals. Bankfull width averaged 73 m. The estimated bankfull discharge of the pre-diversion channel in all sections was exceeded by natural floods several times since diversion began, indicating that natural flood events likely exceeded bankfull discharge of the channel regularly prior to diversion. Evidence of lateral channel movement and cutoff activity was present in all sections.

Since the commencement of the diversion, channel morphology has changed most drastically in the North Milk River, while the channel characteristics of the Milk River have changed less (Table 2; McLean and Beckstead 1980). The North Milk River has widened, deepened and bankfull discharge has increased. A similar pattern was found in the Milk River; however, the changes were less drastic. Sediment yield in the lower Milk River increased post-diversion as a result of increased erosion in upstream sections. Willock (1969) has suggested that the increased flow from the diversion may have allowed Western Silvery Minnow to populate previously unoccupied portions of the Milk River in Canada. Based on the channel characteristics described by McLean and Beckstead (1980), most of the Milk River downstream of Writing-on-Stone Provincial Park likely provided suitable habitat for Western Silvery Minnow prior to the diversion. While no data exists to confirm their presence, a population was likely historically present in this reach of the Milk River.

Table 2. Comparison of bankfull channel properties along the Milk River in 1915 (pre-diversion) and 1979 (post-diversion) (from McLean and Beckstead 1980). This study defined the upper Milk River as the section between Writing-on-Stone Provincial Park and the confluence with the North Milk River, and the lower Milk River as the section downstream of Writing-on-Stone Provincial Park.

Reach	Year	Channel Area (m^2)	Top Width (m)	Mean Depth (m)	Bankfull discharge (m^3/s)	Slope
North Milk River	1915	21.5	19.3	1.1	33.4	0.0030
	1979	43.8	30.2	1.45	83.0	0.0035
upper Milk River	1915	72.3	51.5	1.4	87.0	0.0013
	1979	83.0	56.0	1.48	104.0	0.0013
lower Milk River	1915	133.0	73.0	1.82	225.0	0.00070
	1979	165.0	85.4	1.93	260.0	0.00055

The St. Mary diversion has altered the annual flow regime of the Milk River, increasing average flows and maintaining elevated flows throughout the April - October period (International St. Mary – Milk Rivers Administrative Measures Task Force 2006). Changes in discharge have short term effects on the amount of suitable habitat available for Western Silvery Minnows (Golder Associates 2010; Neufeld 2016). An instream flow needs study completed by Golder Associates (2010) found that weighted usable area (WUA) for

Western Silvery Minnow was lowest between 15 and 20 m^3/s in the lower section of the Milk River. WUA increased to ~100% as discharge decreased to 0.4 m^3/s, and increased as discharge increased over 20 m^3/s to ~70% WUA at 40 m^3/s. The Golder (2010) study was based on preliminary habitat suitability curves; however, subsequent investigations have developed suitability curves similar to those used here (Watkinson and Riemersma 2011; Neufeld 2016). Neufeld (2016) found that suitable habitat was 4 – 7 times more common at low, natural discharge levels than during high augmented discharge. These results suggest that the quantity of suitable habitat for Western Silvery Minnows was higher in the lower Milk River prior to the diversion. Overwintering habitat is sparse in the Milk River and may be a limiting factor for Western Silvery Minnow (Mainstream Aquatics Ltd. 2005). The increased channel depth associated with the diversion (McLean and Beckstead 1980) may slightly increase overwintering success.

Changes to the operation of the St. Mary diversion will eventually be required as a result of aging infrastructure and changing climate (US Department of the Interior 2012). While the exact nature of these changes is not known, it is possible that they may drastically alter habitat availability for Western Silvery Minnow. Maintaining adequate winter flow is key for the persistence of species, as it will not likely utilize refugia in tributaries and would be unable to recolonize from downstream of the Fresno Dam in Montana.

Natural variability in flow in the Milk River occurs as a result of climatic and local weather processes. Drought is a regular occurrence in the Milk River watershed and during some winters, low water levels and dissolved oxygen may limit winter survival of fish, including Western Silvery Minnow (Leigh Noton Chemical and Geological Laboratories Ltd. 1980; RL&L 1987a, 2002a). Drought has been implicated in a range contraction of Western Silvery Minnow in the upper Cheyenne River in South Dakota (Hoagstrom *et al.* 2006b). With changing climate conditions, rivers in the western prairie provinces of Canada will experience additional demands and stresses on their water supplies (International Joint Commission 2002; Schindler and Donahue 2006). Increased human demand, shrinking glaciers and declining snowpacks, and natural drought cycles may combine to increase the frequency and severity of drought events in the Milk River. While Western Silvery Minnow is well adapted to fluctuating flows in prairie streams, extended drought could extirpate it in the Milk River, with the Fresno Dam preventing recolonization from downstream populations. There is no apparent threat from rising temperatures to the species.

BIOLOGY

Given the large intraspecific variation in life history characteristics across the geographic range, this section attempts to rely on data that have been collected in the Milk River of Alberta. Relatively little biological data has been collected from the Canadian population of Western Silvery Minnows; however, surveys in 2005-2006 (Watkinson unpublished data) and 2013 (Neufeld unpublished data) comprise the two major data sources. Most of these data pertain to the adult life stage of Western Silvery Minnow. In instances where there are no biological data from the Milk River, data from other populations/surveys are referenced with appropriate caveats.

Life Cycle and Reproduction

In the Milk River, Western Silvery Minnows grow to a maximum of ~150 mm fork length and live to an age of 4+ years. Western Silvery Minnows are typically ~ 50 mm (FL) by the end of their first year, and reach 80-90 mm (FL) by the end of their second year. In their third year fish exceed 100 mm (FL) and the asymptotic length for the species in Canada has been estimated at 120.5 mm (FL). Young and Koops (2013) estimated the von Bertalanffy growth curve for Western Silvery Minnow growth as $L_t = 120.5(1 - e^{-0.574(t+0.04)})$ (Figure 3). This growth curve was based on age data obtained from Watkinson (unpublished data), and is corroborated by length frequency data from Neufeld (unpublished data). Young and Koops (2013) used catch curve analysis to estimate mean survival to age 1 at 1.1%, survival from age 1 to 2 at 20.7%, from age 2 to 3 at 30.2 % and from age 3 to 4 at 34.7 %. The maximum observed age of Western Silvery Minnow in Canada is 4 years old (Watkinson unpublished data).

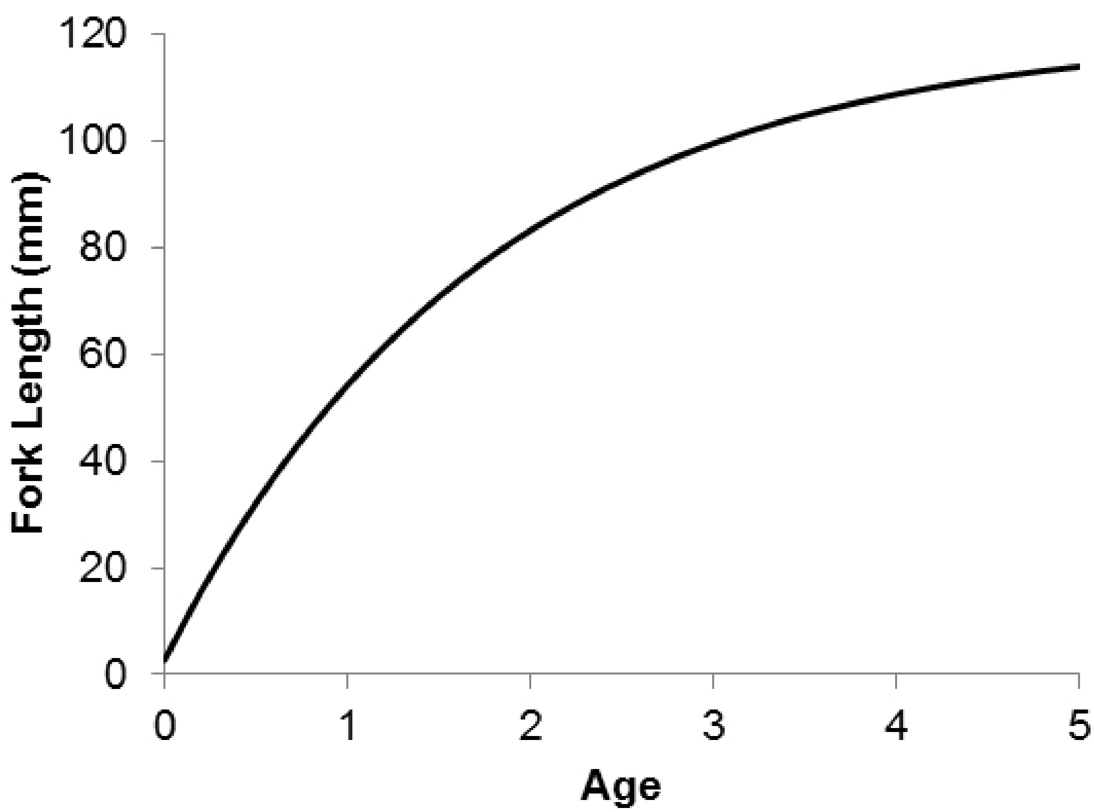

Figure 3. Von Bertalanffy growth curve for the Western Silvery Minnow in the Milk River of Alberta (Young and Koops 2013).

Little information is currently available on the population structure of Western Silvery Minnow in Canada. Catches were dominated by 1+ aged fish, with fewer individuals in the 2+ age category in 2013 (Neufeld unpublished data). Watkinson (unpublished data), however, found strong representation of both the 1+ and 2+ age classes. It is likely that yearly variation in survival produces strong and weak year classes based on reproductive and overwintering success. A sample of sixty 80 – 140 mm Western Silvery Minnows retained for a tag retention study revealed a female-skewed sex ratio (32 females to 9 males), though there was a high proportion of individuals of unknown sex (n=19) (Neufeld *et al.* 2015).

Watkinson (unpublished data) collected mature female Western Silvery Minnows in the Milk River as small as 81 mm, and mature females ranged in size from 81 to 127 mm. Maturity was reached in females at an age of 2, though it is unknown at what age males mature. The fecundity of eleven mature females was determined, with egg counts ranging from 2924 eggs in the 81 mm female to 19573 eggs in the 127 mm female. Young and Koops (2013) used a log-linear regression and Watkinson's data to create a fecundity curve. At age 2, average female fecundity was estimated at 3630 eggs, 6766 eggs at age 3, and 9214 eggs at age 4. Females caught in the Milk River near the Bear Creek confluence, on 22 June 2005, had much lower egg counts, ranging from 1006 to 20126 eggs for females of 91 to 115mm, respectively (Sikina and Clayton 2006). It is unknown whether these females had already released some of their eggs prior to capture or if differences in egg counts are the result of natural variation. Based on Watkinson's data, Young and Koops (2013) estimated a generation time of 2.6 years for Western Silvery Minnow in the Milk River.

The reproductive strategy of Western Silvery Minnow is poorly understood and largely relies on accounts from other closely related species. Scott and Crossman (1973), and Alberta Sustainable Resource Development (2003) relied on an account of Eastern Silvery Minnow spawning habits provided by Raney (1939) and suggested that the species lays non-adhesive eggs in heavily vegetated, slow moving, backwater areas. Common characteristics of streams inhabited by Western Silvery Minnow are constantly shifting sand substrate, high turbidity, notable lack of aquatic vegetation, and extreme variations in flow. These environmental conditions suggest that Western Silvery Minnow may exhibit a spawning strategy more similar to the Plains Minnow and Rio Grande Silvery Minnow, two closely related species that live in similar environments. These species are pelagic broadcast spawners and produce semi-buoyant eggs that remain suspended in the water column when current is present (Platania and Altenbach 1998). The eggs travel downstream until the hatched fry are able to find suitable habitat and hold their position out of the main current. This reproductive strategy is well suited to naturally flowing prairie streams and is likely utilized by Western Silvery Minnows.

Western Silvery Minnows likely spawn from late May to early July in the Milk River. Watkinson (unpublished data) captured females with maturing eggs in May and females with only limited numbers of bound eggs in July. Water temperatures during this period ranged from 13.6 °C to 26.8 °C.

Hybridization is known to occur within the *Hybognathus* genus (Moyer *et al.* 2009), though no direct references to Western Silvery Minnow hybridization with other species was found. Given the close phylogenetic relationship between *Hybognathus* species (Moyer *et al.* 2009), it is possible that Western Silvery Minnows may hybridize with closely related species in areas of range overlap. Within Canada, Brassy Minnows are the only *Hybognathus* species to coexist with Western Silvery Minnows.

All *Hybognathus* species have enlarged pharyngeal arches, long pharyngeal teeth, and pharyngeal papillae which suggest an adaptation for filtering and feeding on small food items (Hlohowskyj *et al.* 1989). These characteristics along with a long coiled intestine suggest a primarily herbivorous diet. Nelson and Paetz (1992) and Scott and Crossman (1973) describe Western Silvery Minnow's diet as algae and organic material filtered from the substrate. A more detailed study by Watkinson (unpublished data) found that stomach contents of Western Silvery Minnows in the Milk River in May were composed of diatoms (35%), green algae (26%), plant remains (23%), blue-green algae (10%) along with smaller quantities of carbon, fungi, chrysophytes, pollen, zooplankton, and heterocysts. The species is believed to filter mud and silt substrates, ingesting available organic matter.

Physiology and Adaptability

Western Silvery Minnows live in prairie streams that experience large seasonal fluctuations in temperature, turbidity, and flow. Sections of the Milk River have dried, leaving only a series of isolated pools in some recent winters. The persistence of Western Silvery Minnows in these systems suggests some level of adaptation to harsh conditions, though their physiological tolerances have not been measured in laboratory conditions. In the Milk River, Western Silvery Minnows have been captured at locations with water temperatures ranging up to 29.4 °C and conductivity ranging from 90 to 725 μS/cm (P&E Environmental Consultants Ltd. 2002; Watkinson unpublished data; Neufeld unpublished data). Brassy Minnows are capable of tolerating dissolved oxygen levels as low as 0.03 mg/L and water temperatures as high as 35.5 °C (Scheurer *et al.* 2003). Plains Minnows are able to tolerate dissolved oxygen concentrations of 2.08 mg/L, and water temperatures up to 39.7 °C (Ostrand and Wilde 2001). The high level of physiological tolerance in these closely related species and the harsh environments inhabited by Western Silvery Minnows suggest that they are well adapted to live in streams with seasonally high water temperatures and low dissolved oxygen.

Neufeld (2016) measured the swimming performance of Western Silvery Minnows in a laboratory setting and found that they were able to swim for sustained lengths of time (>200 min) at water velocities of 0.42 m/s and less. On average they were able to swim for longer than 1 minute at water velocities of 0.68 m/s and less. The length of time they were able to swim decreased exponentially with increased water velocity, following the equation: $Time = e^{18.01-20.53(Water\ Velocity)}$. Individuals were successfully held in 120L aerated tanks at 17 °C for up to 104 days with minimal mortality. We are unaware of any aquaculture production of Western Silvery Minnows, though Rio Grande Silvery Minnows have been successfully reared in captivity as part of conservation efforts (Hutson *et al.* 2012).

Dispersal and Migration

A mark-recapture study found that two individuals had travelled ~14 km upstream in the lower Milk River, Alberta, one of which travelled that distance in ~ 16 days (Neufeld unpublished data). There has been little other work done on Western Silvery Minnow movement patterns, though research on closely related species also suggests that they may undertake relatively long distance migrations. Plains Minnows have been observed to travel up to 213 km upstream in the Canadian River of New Mexico and Texas (Wilde 2016). Rio Grande Silvery Minnows are capable of travelling at least 25 km (Platania *et al.* 2003). Periodic drying of sections of the Milk River and subsequent re-colonization by Western Silvery Minnows indicates an ability to actively disperse, as has been observed for the Brassy Minnow (Scheurer *et al.* 2003). If the species is a pelagic broadcast spawner with a downstream passive dispersal stage associated with egg and larval drift, then it stands to reason that there would be upstream active dispersal associated with a portion of their life cycle.

Natural dispersal to waterbodies adjacent to the Milk River drainage is highly improbable, as individuals would have to ascend the Milk and North Milk rivers and move upstream through the diversion structure between the St. Mary and North Milk rivers. The Canadian Western Silvery Minnow population is able to disperse downstream to portions of the Milk River in Montana; however, the Fresno Dam prevents upstream dispersal of downstream populations. Human-aided dispersal to other waterbodies is possible, though a current prohibition on collecting Western Silvery Minnow for baitfish in Alberta minimizes this risk.

Interspecific Interactions

Western Silvery Minnows in the Milk River are commonly found in mixed schools with Flathead Chubs (*Platygobio gracilis*), Longnose Dace (*Rhinichthys cataractae*), Fathead Minnow (*Pimephales promelas*), and juvenile suckers (Neufeld unpublished data). Aggregation size seems to increase in the fall as flows decrease, with one school of 8-9000 fish (approximately half Flathead Chubs, half Western Silvery Minnows) observed on the Pinhorn Ranch on October 21, 2013 (Neufeld unpublished data). Western Silvery Minnow likely provides forage for predatory fish species in the Milk River, including Northern Pike (*Esox lucius*), Sauger (*Sander canadensis*), Burbot (*Lota lota*), and Walleye (*Sander vitreus*). Predatory fish densities are relatively low due to fluctuating flow and high turbidity (RL&L 1987b), which suggests that predation may not be a major factor impacting the Western Silvery Minnow population in the Milk River. Parasites of Western Silvery Minnows in the Milk River are unknown, though Hoffman (1967) lists trematode, protozoan, and cestode parasites as being associated with silvery minnows in North America.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Relatively few fisheries surveys have been completed in the Milk River of Alberta, with the most extensive surveys occurring in the last 15 years. The number of sites sampled in each survey and their distribution is presented in Table 1. Willock (1969) surveyed much of the Milk River drainage in 1966/67 using seine nets, set lines, and electrofishers. In the late 1970s and 1980s, RL&L Environmental Services Ltd. completed fisheries surveys in the Milk River as part of investigations into potential dam sites on the Milk River (RL&L 1980, 1986, 1987a, b). Since 2000, fisheries surveys in the Milk River have increased in frequency and have focused on gathering information about species at risk, including Western Silvery Minnow. RL&L Environmental Services Ltd. conducted fisheries surveys from 2000 to 2002 (RL&L 2002a, b) using seine nets and electrofishers, P&E Environmental Consultants Ltd. surveyed the Milk River in 2002 using the same types of gear (P&E Environmental Consultants Ltd. 2002), and the Government of Alberta conducted surveys in 2002, 2004, and 2005 (Clayton 2003a, b; Downey 2004; Clayton and Downey 2005; Sikina and Clayton 2006). The Government of Alberta surveys in 2002 and 2004 took place exclusively in the tributaries to the Milk River and did not encounter any Western Silvery Minnow. The most intensive fisheries surveys of the Milk River were completed in 2005-2007 by Watkinson (unpublished data), and in 2013 by Neufeld (unpublished data). These surveys focused on the lower Milk River within the range of Western Silvery Minnow and utilized seine nets (electrofishers were also used by Watkinson). An additional survey of the Milk River using only electrofishers was completed by the Alberta Conservation Association in 2014 (ACA 2014).

Abundance

No estimates of population size have been completed for Western Silvery Minnow in the Milk River. Abundance has historically been considered low for the species, as it typically comprised only a small portion of the catch in fisheries surveys (RL&L 1987a, b; Alberta Sustainable Resource Development 2003). Previous authors suggested that the population likely did not exceed a few thousand individuals (Alberta Sustainable Resource Development 2003). While it is impossible to know the past abundance of the species, it is now clear that Western Silvery Minnow are considerably more abundant than previously thought. A mark-recapture study conducted in the Milk River, from June to August 2013 captured 2111 individuals, marked 1884, and only recaptured five fish. Sampling in October 2013 resulted in a single catch of Flathead Chub and Western Silvery Minnow, where 3882 Western Silvery Minnows were counted (Neufeld unpublished data). While this was likely an overwintering aggregation of fish and fish from several kilometres of river may have been concentrated in this one school, it is very unlikely that it contained the entire Milk River population. Similarly, surveys by Fisheries and Oceans Canada in 2005 and 2006 captured 528 and 1610 Western Silvery Minnow, respectively (Watkinson unpublished data). These more recent data suggest the population is substantially larger than a few thousand individuals and likely in the tens of thousands. However, with poor data on population fluctuations, it is unknown if the population has remained at this level, increased, or decreased.

Fluctuations and Trends

There is no conclusive evidence of a change in Western Silvery Minnow abundance since fisheries surveys began in the Milk River. The two main measures available for temporal comparisons of Western Silvery Minnow in the Milk River are seine net catch rate and relative abundance, both of which are reported in most of the fisheries studies to date on the Milk River. While these data are not a replacement for quantitative abundance estimates and have a greater degree of uncertainty associated with them, they can reveal large shifts in abundance or community composition. As sampling progressed through the years, there has been an increased focus on species at risk in the Milk River, including Western Silvery Minnow. This shift in focus may have created a bias towards more effective sampling for Western Silvery Minnows in recent years and higher catch rates.

Prior to 2002, percent composition of Western Silvery Minnows in fisheries surveys was consistently less than 1% of the overall catch (Table 3). In more recent surveys by P&E Environmental Consultants Ltd. (P&E Environmental Consultants Ltd. 2002), Alberta Sustainable Resource Development (Sikina and Clayton 2006), Fisheries and Oceans Canada (Watkinson 2005-2007 unpublished data), and the University of Alberta (Neufeld 2013 unpublished data), percent composition has increased substantially, with a maximum of 43.7% in 2002. Habitat preference knowledge gained in earlier Fisheries and Oceans Canada surveys was used towards designing surveys that specifically targeted Western Silvery Minnows (Neufeld 2013 unpublished data), yielding a percent composition of 11.3%. This was lower than three previous surveys and suggests that Western Silvery Minnow population in the Milk River can experience rapid and drastic fluctuations in relative abundance, or that other species' populations experience fluctuations.

Western Silvery Minnow seine net catch rates are historically low, similar to percent composition; however, they do not increase substantially until surveys by Fisheries and Oceans Canada (Watkinson unpublished data) and the University of Alberta (Neufeld unpublished data) (Table 3). These surveys had catch rates many times higher than previous surveys. While Neufeld's survey was targeting Western Silvery Minnows and likely had an unrepresentatively high catch rate, Watkinson was sampling whole fish communities.

In the absence of quantitative abundance estimates, standardized sampling needs to be repeated on multiple occasions in order to obtain informative data on trends in Western Silvery Minnow abundance. While such surveys have been completed (e.g., Watkinson unpublished data), they have not been repeated and no conclusions can yet be made about trends in abundance. Highly variable environmental conditions, such as drought, likely cause considerable mortality in years that experience low flows. This mortality would cause a drastic decline in abundance and suggests that large fluctuations in the population occur regularly.

Table 3. Western Silvery Minnow catch rate and percent composition from fisheries surveys conducted with a beach seine.

Sampling Organization	Year	Catch Rate (#/100m^2)	Percent Composition*	Source
Willock, Thomas (Carleton University)	1966/1967	-	<0.1	RL&L 1980
RL&L Environmental Services Ltd.	1986	0.001	0.001	RL&L 1987a
RL&L Environmental Services Ltd.	2000	0.03	0.1	RL&L 2002b
RL&L Environmental Services Ltd.	2001 (summer)	0.1	0.4	RL&L 2002b
RL&L Environmental Services Ltd.	2001 (fall)	3.0	0.5	RL&L 2002b
P&E Environmental Consultants Ltd.	2002	0.62	43.7	P&E Environmental Consultants Ltd. 2002
Alberta Sustainable Resource Development	2005	0.6	2.9*	Sikina and Clayton 2006
Fisheries and Oceans Canada**	2005	25.3	15.5	Watkinson unpublished data
Fisheries and Oceans Canada	2006	-	36.6	Watkinson unpublished data
Kenton Neufeld (University of Alberta)	2013	14.46	11.3	Neufeld unpublished data

* Species composition (# of Western Silvery Minnows captured /total fish captured * 100) for this survey was calculated based on fish captured with all methods.

** Catch rate was estimated based on an effective seining width of ½ of the width of the seine net (9.14 m).

Rescue Effect

The Canadian population of Western Silvery Minnow in the Milk River is connected to the Milk River in Montana above the Fresno Reservoir, and exchange of individuals likely occurs regularly between these two reaches of river across the international border. There are no permanent barriers to movement above the Fresno Dam, though seasonal dewatering may restrict movement in this reach of river during periods of drought. Western Silvery Minnow population above Fresno Reservoir, both in the USA and Canada, experiences similar threats and environmental conditions. Any event or factor that would cause extirpation of the Canadian population would likely affect the USA population above Fresno Reservoir, making rescue from that population less likely. An advantage of the reservoir is it is unlikely to dry up during an extreme drought, providing temporary refuge habitat. The Fresno Dam itself is an effective barrier to upstream movement and recolonization from populations downstream of the dam is not likely.

THREATS AND LIMITING FACTORS

Threats

Dams and Water Management/Use

The largest threats to Western Silvery Minnows in Canada are from flow modification and water management projects in the Milk River. In 1917 the St. Mary Canal was built in Montana to divert water from the St. Mary River to the North Milk River, which flows into the Milk River in southern Alberta. Water management in the St. Mary and Milk rivers is governed by the Boundary Waters Treaty of 1909 between Canada and the United States. This diversion increases flow in the Milk River in Canada to levels of approximately 10-15 times its natural rate during the April – October period (International St. Mary – Milk Rivers Administrative Measures Task Force 2006). On the Milk River in Montana, the Fresno Dam and reservoir act as water storage and is a barrier to upstream movement of fish.

McLean and Beckstead (1980) discuss the long term effects of the diversion on the Milk River morphology, and found some important impacts. While the channel morphology in the lower sections of the river has remained largely the same, there has been increased sediment yield and channel aggradation since the diversion began. Pre-diversion floods exceeded the current diverted flow and maintained channel structure and bed shape in a similar condition to its present state. The increase in absolute amount of water flowing through the system has increased wetted area; however, suitable habitat has likely not increased considerably (Neufeld 2016). The current rate of diversion is likely maintaining erosion rates and sediment transport, which creates a highly turbid environment favoured by Western Silvery Minnow.

Due to the age of the diversion structure, recent discussions have been held to discuss options for repairing, replacing, or otherwise altering the diversion structure that would result in changes to the flow regime in the Milk River (International St. Mary – Milk Rivers Administrative Measures Task Force 2006; US Department of the Interior 2012). The impacts of any changes are difficult to predict without details of the resulting flow regime; however, any changes would alter Western Silvery Minnow habitat to some degree, potentially drastically. Increases in flow would be accompanied by increases in water velocity reducing the amount of suitable habitat present (Neufeld 2016). Decreases in flow may result in more suitable habitat; however, decreased erosion, sediment transport, and turbidity could benefit species less tolerant of high turbidity or increase the effectiveness of visual predators (e.g. Northern Pike and Walleye). The cessation of augmentation in the Milk River would significantly increase the risk of dewatering in the Milk River in times of drought. While Western Silvery Minnow is generally well adapted to drought in prairie streams, if extirpation were to occur above Fresno Dam, there would not be any opportunity for the species to naturally recolonize as the structure is a barrier to movement. Yet, in a period of extreme drought, the reservoir could provide rescue to the upstream river population. But it should be noted that reservoir habitat is poor for Western Silvery Minnow. Changes in flow and water velocity may also impact the reproductive success of Western Silvery Minnow, which is thought to be a pelagic broadcast spawner (Perkin and Gido

2011). Low velocity water allows the eggs to sink and risk being smothered by sediment, while high velocity water may carry eggs downstream into reservoirs where the eggs may also sink and be smothered by sediment.

There have been discussions about the potential for constructing a dam at various locations on the Milk River in Alberta (RL&L 1986, 1987b; Cornish 1988; Alberta Environment 2003). To date, the river remains unimpounded in Alberta; however, concerns about water security in a drought prone area may prompt construction of a dam in the future. The impacts of a dam would depend upon its location and operation. Fragmentation of stream habitat by dams has been linked to declines of pelagic broadcast spawning fish in prairie streams (Dudley and Platania 2007; Perkin and Gido 2011). This spawning guild of fishes, likely including Western Silvery Minnow, requires unimpounded lengths of streams in order to successfully reproduce. The reservoirs that form upstream of dams also create suitable habitat for the introduction of non-native species that could threaten Western Silvery Minnow (Johnson *et al.* 2008). Walleye, Northern Pike, and Burbot would colonize any reservoir on the Milk River and would likely increase the predation pressure on Western Silvery Minnow in adjacent stretches of river. The altered flow downstream of a reservoir would likely decrease habitat suitability for Western Silvery Minnow. Stabilized flows would decrease erosion and favour the establishment of aquatic vegetation. Depending on the type of dam, water release from the hypolimnion of the reservoir decreases water temperature downstream of the dam. These changes would benefit species that prefer cooler, less turbid systems, such as the Spottail Shiner (*Notropis hudsonius*). This thermal trend is reversed in the winter season when warmer water (4°C) would be released from the hypolimnion.

Surface water extraction for municipal, agricultural, and commercial use poses a seasonal threat to Western Silvery Minnow. During augmented flow, water extraction from the Milk River and its tributaries is mainly used for agriculture and irrigation (Milk River Watershed Council 2013). Other water uses include commercial, municipal and conservation project users. While regulation of surface water extraction would partially mitigate this threat, any water extraction during the non-augmented period could pose a serious threat to Western Silvery Minnow population if water levels in the Milk River are already low. Reducing flow in the Milk River during winter would likely reduce overwintering success of the species.

Ground water extraction has led to the decline of water levels in some areas of the Milk River watershed (Milk River Watershed Council 2013). Municipalities are allocated the greatest volume of groundwater (53% in 2013), followed by agriculture (36%) and commercial (5%) users. There is only one groundwater licence related to oil and gas activity. The impact of groundwater withdrawals on Western Silvery Minnow is unknown.

Invasive Non-Native/Alien Species

Northern Pike, Walleye, Yellow Perch (*Perca flavescens*) and Spottail Shiner are non-native species that have been found within Western Silvery Minnow habitat in the Milk River of Alberta to date. These species have been stocked in Fresno Reservoir, Montana and Shanks Lake, Alberta, both within the Milk River watershed. Northern Pike appears to be the most widespread of these species and is a potential predator of Western Silvery Minnow. They require well-vegetated areas to successfully spawn (Nelson and Paetz 1992), which may limit their numbers throughout much of the Milk River mainstem. They are also sight feeders, and the high turbidity of the Milk River most of the year likely reduces their impact on native forage species, including Western Silvery Minnows. Walleyes are also potential predators, though their numbers are low in the Milk River at present. Walleyes are less tolerant of high turbidity than the native Saugers, which may currently limit their expansion. Yellow Perch are potential predators as adults and competitors as juveniles, when their diet consists of plankton and invertebrates (Nelson and Paetz 1992). They are relatively intolerant of both fast current and high turbidity (Stewart and Watkinson 2004), which limits their distribution within the Milk River and their impact on Western Silvery Minnows. Spottail Shiner have been found in the lower reaches of the Milk River (Neufeld unpublished data), and are likely expanding upstream from introduced populations in Fresno Reservoir, Montana. They feed on plankton and invertebrates (Nelson and Paetz 1992) and would likely compete with Western Silvery Minnows for habitat and food.

Additionally, Black Crappie (*Pomoxis nigromaculatus*), found in Fresno Reservoir, would be a potential predator of Western Silvery Minnow should they expand upstream into the Canadian portion of the Milk River. Black Crappie are not particularly tolerant of high turbidity and would not likely colonize the Milk River in Canada at high densities under the current flow regime.

Zebra Mussel (*Dreissena polymorpha*) has been found in the Missouri River drainage in Montana, with suspected occurrences in the Milk River downstream of the Fresno Dam (Schmidt and McLane 2017). It is unclear how successful the species would be in the Milk River due to its largely sand substrate; however, as an effective filter feeder, it has the potential to alter food web structure in systems in which it becomes established (Ludyanskiy *et al.* 1993).

Problematic Native Species

Saugers are native to the Milk River and feed on Western Silvery Minnow. Augmented flow has likely increased Sauger overwintering and spawning success, resulting in higher abundances of the species. This elevated abundance could have detrimental impacts on Western Silvery Minnow, though this threat needs further research.

Agricultural and Forestry Effluents

Ranching and farming are important economic activities in the Milk River watershed, with native rangeland covering 65% of the watershed and 17% used for growing annual crops (Milk River Watershed Council 2013). Crops may cause limited amounts of increased erosion and nutrient and pesticide input into the Milk River, though much of the Milk River is located in a steep valley which prevents cropland from encroaching on the banks. Nitrogen and phosphorus occasionally exceed water quality guidelines (A. A. Aquatic Research Limited 1986) and fecal coliform counts are high, though whether the source of the bacteria is agricultural inputs is currently unknown (Milk River Watershed Council 2013). Increased sediment is not likely detrimental to Western Silvery Minnow but chemical and nutrient inputs could impact the species either directly or by altering the food web structure.

Utility and Service Lines

Eleven pipeline crossings of the Milk River or its tributaries exist in Alberta (Milk River Watershed Council Canada 2013), and an accidental spill or release could negatively impact Western Silvery Minnow. No significant spills have been documented in the Milk River to date, and the impact of a future spill would depend on the timing, location and substance released. During flow augmentation the increased flow would dilute any liquid released into the river, though the impacts could still be significant depending on the substance. Increased flow could also transport the spilled substance further distances, increasing the impacted area. Overall, negative impacts would likely be more serious in winter or late fall when flows are low and spills would be difficult to respond to and clean up.

Cumulative Effects

Water use and withdrawal from the Milk River would compound any effects of natural drought on fish in the Milk River by further lowering water levels. This increases the risk of low dissolved oxygen levels and dewatering, both of which could severely impact Western Silvery Minnow. Increased water withdrawal associated with irrigation would also increase the potential impacts of agricultural effluents.

Dams and the associated impoundments are conduits for the introduction of invasive species (Johnson *et al.* 2008), and the construction of an impoundment on the Milk River in Alberta would likely be accompanied by an increased abundance of predators such as Walleye and Northern Pike. Potential stabilization of flow downstream of a dam would also likely benefit non-native predators as well as competitors that are better adapted to stable flows. The creation of a reservoir would draw additional tourism to the area, and potentially residential and commercial development. This could result in an increased risk of water pollution and ecosystem modifications such as bridge construction and diking.

Limiting Factors

Restricted Range

Western Silvery Minnows are native only to the Mississippi River watershed and the Milk River in southern Alberta. There are no natural connections between the Milk River in Alberta and other watersheds and as a result, the species has a very restricted range with little potential for range expansion. A number of tributaries to the Milk River support fish populations; however, the habitat available in them is not generally suitable for Western Silvery Minnows (Clayton 2003a). This reduces the species' resiliency in Canada and makes it more susceptible to threats such as flow alterations.

Number of Locations

Based on the extent of the most likely threats, flow management and drought, Western Silvery Minnows occur in one location in Canada. Western Silvery Minnows have not been observed utilizing any tributaries and any threat that impacts the entire length of the Milk River would affect all individuals in the population. For example, a closure of the St. Mary diversion canal for maintenance or replacement during an extreme drought would affect all Western Silvery Minnow individuals in Canada.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Western Silvery Minnows were first assessed by COSEWIC as "Special Concern" in 1997, and later reassessed as "Threatened" in 2001, and "Endangered" in 2008. They are currently listed as "Threatened" under the *Species at Risk Act* (SARA). A recovery strategy for the species was published by Fisheries and Oceans Canada in 2008 (Milk River Fish Species at Risk Recovery Team 2007), and amended in 2017 (Fisheries and Oceans Canada 2017) to include the identification of critical habitat in the Milk River. This strategy outlines research, monitoring, management and education actions that can be taken to meet the goal of maintaining a Western Silvery Minnow population in the Milk River. Recovery efforts have included research focused on clarifying life history characteristics (Watkinson unpublished data) and habitat requirements (Watkinson unpublished data; Neufeld 2016), providing public education at access points (such as Writing-on-Stone Provincial Park), regulatory control of Western Silvery Minnow use and research by both the Alberta government and Fisheries and Oceans Canada, ongoing water quality monitoring in the Milk River, and the creation of various local, national and international partnerships to conserve Western Silvery Minnow (DFO 2016). The amended 2016 recovery strategy identified the lower 140 km of the mainstem Milk River in Canada as critical habitat for the Western Silvery Minnow.

Western Silvery Minnow is also listed as 'Threatened' provincially under Alberta's *Wildlife Act*. In 2008 the province published a recovery plan for the species (Milk River Fish Species at Risk Recovery Team 2008), laying out an approach to meeting the goal of "to protect and maintain a self-sustaining population of Western Silvery Minnow within its current range in the Milk River". The recovery plan's objectives were similar to those outlined in the Fisheries and Oceans Recovery Strategy: to maintain population levels, protect habitat, and identify and mitigate threats.

Non-Legal Status and Ranks

The IUCN Red List ranks Western Silvery Minnow as 'Near Threatened' due to declines in abundance and distribution, though the species is still widespread and has a large population size globally (IUCN Red List 2016). NatureServe ranks Western Silvery Minnow globally as 'Apparently Secure' (G4) based on their moderately widespread distribution, along with observed declines in abundance in some states (NatureServe 2016). The apparently secure designation is applied for organisms that are uncommon but not rare and have some concerns about long term viability due to observed declines or other factors. They rank the species as 'Critically Imperilled' nationally in Canada (N1) and provincially in Alberta (S1). This is due to their restricted distribution, the high frequency of drought in the area, and the uncertainty around future water management scenarios in the Milk River. Western Silvery Minnow is ranked as 'Apparently Secure' (N4) in the United States, 'Secure' (S5) in South Dakota and Nebraska, 'Apparently Secure' (S4) in Montana, 'Imperilled' (S2) in Wyoming, Kansas, Illinois, and Missouri, and 'Critically Imperilled' (S1) in Iowa. The species has not yet been ranked by NatureServe in North Dakota. The most recent Wild Species general status ranking was 'Critically Imperilled' to 'Imperilled' from the 2015 assessment (CESCC 2016). This ranking was based on information presented in the 2008 COSEWIC assessment, which ranked the species as 'Endangered' due to its limited distribution and the potential negative consequences of future flow modifications in the Milk River.

Habitat Protection and Ownership

The *Public Lands Act* stipulates that the title of the bed and shores of the Milk River are owned by the province of Alberta, as is the case for most naturally occurring waterbodies in the province. Habitat in the Milk River would also be protected from permanent alteration or destruction under Section 35 of the federal *Fisheries Act*. Twelve percent of the land in the Milk River watershed in Alberta is set aside for protection in provincial parks, natural areas, ecological reserves, heritage rangelands, and through ownership by private conservation agencies such as the Nature Conservancy of Canada (Milk River Watershed Council Canada 2013). The Milk River flows through Twin River Heritage Rangeland Natural Area, Writing-on-Stone Provincial Park, and the Milk River Natural Area. The Pinhorn Grazing Reserve which is owned by the Province of Alberta also encompasses a portion of the Milk River. In 2011 Writing-on-Stone purchased an additional 1,000 ha of land along the Milk River, and conservation agencies such as the Nature Conservancy of Canada continue to purchase and protect land in the watershed. As of 2008, 56% of the land bordering the Milk River and North Milk River mainstems was publicly owned (COSEWIC 2008).

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Kenton Neufeld is a Professional Biologist and Fisheries Technician with Alberta Environment and Parks in Cochrane, AB. He obtained his B.Sc. (2009) from the University of Calgary and M.Sc. (2016) from the University of Alberta. His Masters research focused on the impacts of hydrologic alteration on Western Silvery Minnow in the Milk River and he spent two years working extensively with species in both the field and laboratory. His current work focuses on species at risk in Alberta, including Bull Trout (*Salvelinus confluentus*), Athabasca Rainbow Trout (*Oncorhynchus mykiss*) and Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*).

Doug Watkinson is a Research Biologist with Fisheries and Oceans Canada in Winnipeg. He has sampled fish in many of the major river systems of the Hudson Bay drainage from northwestern Ontario west to the Rockies, including sampling for Western Silvery Minnow. His current research focuses on species at risk, habitat impacts, and aquatic invasive species. He has co-authored six COSEWIC reports and the field guide The Freshwater Fishes of Manitoba.

Mark Poesch is an Assistant Professor at the University of Alberta. He completed his Ph.D. (2010) from the University of Toronto, his MSc (2005) from the University of Guelph and BSc (Hons; 2002) from the University of Western Ontario. His research focuses on: 1) threats to freshwater fish species at risk (e.g. invasive species, climate change, landuse change), 2) developing novel tools to assess aquatic ecosystems, and 3) restoration and reclamation of impacted sites. He has conducted research on over 20 fish species at risk throughout Canada.

COLLECTIONS EXAMINED

Twenty Western Silvery Minnows collected in the Milk River Alberta in 2007 were examined for meristic counts (Watkinson unpublished data).

Twelve *Hybognathus* sp. juveniles from the Royal Ontario Museum were examined by Erling Holm (Holm pers. comm. 2016). These individuals were collected from Tobin Lake, Saskatchewan, in the Saskatchewan River basin and were previously identified as Western Silvery Minnows. Re-examination revealed characteristics indicative of Brassy Minnows, though a positive identification could not be made. The individuals were reclassified as *Hybognathus* sp.

Appendix 1. IUCN Threats calculator for Western Silvery Minnow.

Species or Ecosystem Scientific Name	*Hybognathus argyritis* - Western Silvery Minnow		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	13/01/2017		
Assessor(s):	Dwayne Lepitzki (moderator), John Post (co-chair), Kenton Neufeld (writer), Doug Watkinson (co-writer and SSC Member), Bill Tonn, Pete Cott and Julien April (SSC members), Shane Petry (AB gov), Angele Cyr (Secretariat)		
References:	draft calculator and draft report provided by report writers, telecon 13 Jan 2017		

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	1	0
C	Medium	0	0
D	Low	3	4
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	generation time 2.6yrs = 10yrs into the future for score, severity and timing. 10-70% or 3-30% population decline over the next 10 years or 3-70%? High range is from uncertainty. Medium to high (3-70%) concluded as overall threat impact.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						<1% of watershed is developed. No population growth in recent years. No development on top of watershed.
1.2	Commercial & industrial areas						<1% of watershed is developed. No population growth in recent years. No development on top of watershed.
1.3	Tourism & recreation areas						12% of Milk river watershed in Albertaparks and protected areas. No known plans of future boat launches.
2	Agriculture & aquaculture		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops						17% of Milk watershed is cropland. Demand for irrigation water falls under dams and water management, and agricultural runoff falls under agricultural and forestry effluents. Probably not applicable since aquatic. Pollution accounted for under 9. Storage on the Milk will be accounted for under dams and water management (7.2).
2.2	Wood & pulp plantations						Forest cover 1% of Milk watershed in Alberta. Not applicable to aquatic in this case.
2.3	Livestock farming & ranching		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Native rangeland 65% of watershed in alberta. But erosion and runoff of nutrients should be considered under Agriculture and Forestry Effluents. Cattle have access to Milk River so trampoling is plausible. Pollution and siltation associated with livestock accounted for under pollution and ecosystem modification. not sure where the eggs are deposited so impact from trampoling is unknown. Turbidity accounted for elsewhere. trampoling of prey habitat could accounted for under this threat category however impact is neglible.
2.4	Marine & freshwater aquaculture						Not aware of any aquaculture facilities in watershed. Goldspring park has stocked pond (RNTR). Not applicanble.
3	Energy production & mining		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	The major concerns associated with oil and gas drilling are water use (which falls under section 7.2 Dams and Water Management) and pipeline leaks (which falls under section 4.2 Utility and service lines). Significant number of abandonned oil and gas wells that may be affecting the watersheds. some actively drilled on the flood plane. Footprint from drilling directly in the minnow habitat is unlikely since no drilling in watershed. orphin wells that are affected by flood plane levels.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.2	Mining & quarrying		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	No known mines in Alberta porton of Milk River watershed. Sand and quarrying. Agregate mining. No new proposals to occur in the channel. New agregate plans in the flood plane. No sand mining in the channel. Some unlicences gravel removal occuring.
3.3	Renewable energy						no known wind farms exist in Milk Watershed. Solar energy and hookin transmission lines accounted for under 4.2.
4	Transportation & service corridors	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads						2426km of roads in watershed. Only a handful of bridges. Miminal impact on WSM.
4.2	Utility & service lines	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	While utility and service lines do cross the MilkRiver, the exact number is unknown and impact is likely small. Risk of breakage or release into the Milk River is the major concern. No new line expected and those installed would not impact unless the capacity is increased (digging up existing line). Threat impact of crossing and maintenance is unknown over the next 10 years. Spill is accounted for under pollution.
4.3	Shipping lanes						No commercial shipping lanes in Milk River. Recreational boaters (canoe, kayak, inner tube) accounted for under different category. No dredging.
4.4	Flight paths						Flight path density not known. Local airstrips in area. No direct impacts on WSM.
5	Biological resource use		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Hunting is common along Milk River, but no impacts on WSMN. No direct collection from game fishing.
5.2	Gathering terrestrial plants						Unknown how common this activity is, but it would have minimal impact on WSM.
5.3	Logging & wood harvesting						little wood harvesting in watershed

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Recreational fishing and baitfish collection allowed in the Milk River. Fishing and bait collection is probably restricted to accessible sections of the river and is not likely a popular activity. Prohibition on collecting WSM, though misidentification can occur. bait fishing for WSM is prohibited but it is permissible for other fish species in the Milk therefore bycatch is applicable.
6	Human intrusions & disturbance		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Recreational activities occur, however they are mostly low impact on WSM (ie. hiking, birdwatching, camping, etc.). No power boating. Maybe some jet boating during discharge throughout river potentially but unknown. No boat launches but possible with outboard engine. mostly unmotorized so negligible or small.
6.2	War, civil unrest & military exercises						No war, civil unrest or military excercises.
6.3	Work & other activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Scientific research of WSM, Sauger, Stonecat, Rocky Mountain Sculpin is likely to continue in the Milk River. Necessity of obtaining a SARA permit and Fish Research Licence reduces chances of negatively impacting population. Some lethal sampling from targetted and nontargetted research. Some presence absence sampling which is nonlethal. area sampled is small.
7	Natural system modifications	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	
7.1	Fire & fire suppression						Active fire suppresion in watershed. Impacts on erosion into streams and nutrient input is unknown accounted for under ecosystem modification. Grass fire possible but impact negligible. Aerial spraying for fire suppression is accounted for under pollution.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High (Continuing)	Entire length of WSM habitat affected. Summer flow increased by >100%. Diversion ongoing and has been present for almost 100 years. The construction of a dam has been considered for many years, and while not being actively pursued right now, there is the potential in the future. Groundwater extraction by municipalities. Species persists despite this ongoing threat. Threat impact is mostly during augmentation but severity is unknown. a new dam development would be detrimental but none currently planned.
7.3	Other ecosystem modifications		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Some small scale habitat alterations (eg rip rap, beach building) may be present, but for the most part, few habitat alterations are present. Negligible.
8	Invasive & other problematic species & genes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Several non-native fish species have been found in the Milk River in recent years that could impact WSM populations. Walleye, Northern Pike and Yellow Perch may predate on WSM, while Spottail Shiner could compete for resources. Lake Whitefish and Black Crappie are also present in Fresno Reservoir and could expand into the Alberta portion of the Milk River. While the impacts of these species are currently likely minimal, stabilization of the flow regime (from the construction of a dam, say) may favour these species over WSM and exaccerabte the effects. Overall impact from Pike predation is significant though WSM has persisted despite Pike presence. Pike present throughout WSM range though in low numbers. Zebra Mussels present in the Milk below Fresno. Likely will be a threat in the near future. unsure whether ZM will establish well in the Milk River due to moving sand dunes and turbidity (though low turbidity for most of the year). Fresno Dam currently separates the Alberta WSM population from those downstream of the dam in the Milk River, however in the past they would have been connected. Movement of this genetic material into the Milk likely does not pose a problem. Introcution of other Hybognathus species (Plains Minnow) into the Milk River above Fresno could pose hybridization challenges, though these introductions are unlikely.
8.2	Problematic native species	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Predatory native species such as Burbot and Sauger may negatively impact WSM populations is flow conditions are altered to improve their feeding and reproductive success. May be more of a limiting factor rather than a threat. Augmentation supports Sauger populations so likely a threat. More abundant due to the diversion and the most populated predator to WSM. Abundance is relative though. more research needed to determine threat impact by Saugers.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material						not applicable. No stocking of this species.
9	Pollution	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
9.1	Household sewage & urban waste water		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	I don't believe Milk River wastewater enters the Milk River, however I'm not entirely sure. Dischjarge unlikely but annual warnings to avoid entering river due to high bacterial count. Cattle waste is present. Human assumed. Outhouse waste are trucked out. urban waste impact is likely small. this threat accounts for town effluent pumping out or septic leakage which is rare. dillution down stream though flow does not change. road salt also accounted for under this threat but minimal since roads are minimal in species' range. definitely some human effluent spilling into the river.
9.2	Industrial & military effluents		Unknown	Unknown	Unknown	High (Continuing)	There is little industrial or military activity in the watershed and minimal rsik of effluent entering the Milk River. Oil spills also accounted for under this threat category. Mining extraction as well. Potential for frack outs but drilling is mostly gas (small 4-6 inch) so frack out is unlikely. Orphin pipes and wells as more of a threat to this species. unknown scope. will be looked into.
9.3	Agricultural & forestry effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Likely some agricultural runoff and nutrient input from cattle in riparian area. The exact extent of this input is unknown but thought to be low, and the impacts on WSM is also thought to be low. Cattle feces. Hogs as well. Classification as feed lots is unknown but present. Ponds with high bacterial counts spilling into the river.
9.4	Garbage & solid waste						Minimal solid waste in the Milk River and likely no impact on WSM population
9.5	Air-borne pollutants						Unknown amount of airborne pollutants, but likely low given lack of industrial activity in the area. Possibly smoke from grassfires. Impact on species unknown but likely minimal. Aerial fire suppression unlikely a threat to this range.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.6	Excess energy						Some excess noise and light from road crossing and residences along river, but minimal impact.
10	Geological events						
10.1	Volcanoes						No nearby volcanoes
10.2	Earthquakes/tsunamis						Earthquakes not common in area. None from fracking either.
10.3	Avalanches/landslides						Avalanches not present in area. Maybe occasional mudslide in Milk River valley, but minimal impact. Erosion from landslides might be an issue but not common.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Scored 11.2 and 11.4 together as an overall threat impact for climate change and severe weather (both applicable). Evidence of winter kills during dry winters. In the absence of historical water diversion, this prairie river would have been subject to natural variations in water lever after several years of drought. The threat impact of climate change is unknown.
11.1	Habitat shifting & alteration						Habitat shifting due to changing climate is generally unknown. Changes in timing of runoff could affect reproduction success, but mostly speculatory.
11.2	Droughts						Drought is historically common in the area and could cause dewatering of stream, especially in winter months when augmentation has ceased. This could result in decreased overwintering potential. Climatic trends indicate that drought may increase due to decreased snowpack and increased irrigation demand.
11.3	Temperature extremes						Extreme heat and cold waves are possible and not uncommon. WSMN on northern edge of range and increased temperatures not likely to pose a negative impact on the species. Extreme cold in winter could increase ice extent and reduce overwintering survival, though no indication that these events will increase in severity.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms & flooding						Thunder storms and blizzards relatively common. Dust storms possible in dry times. Hail, snow, rain, and dust probably present no real negative impacts on WSMN.