STANDARDIZED FIELD SAMPLING METHOD FOR MONITORING THE DISTRIBUTION AND RELATIVE ABUNDANCE OF THE PLAINS MINNOW (*HYBOGNATHUS PLACITUS*) POPULATION IN CANADA

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ABSTRACT

Macnaughton, C.J., Rudolfsen, T., Watkinson, D.A., and Enders, E.C. 2019. Standardized field sampling method for monitoring the distribution and relative abundance of the Plains Minnow *(Hybognathus placitus)* population in Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3317: vii + 24 p.

The Species at Risk Program's objective for Plains Minnow (*Hybognathus placitus*) is to quantify and maintain current population levels throughout its Canadian range. In an effort to provide science information to meet the Species at Risk Program objective, this report aims to provide a consistent sampling method and survey design that may accurately inform on changes in the distribution and relative abundance of the Plains Minnow in Saskatchewan, where it is listed as *Threatened*. This report details (1) the sampling gear, (2) recommended sampling effort and timing, and (3) sampling sites for Plains Minnow distribution and relative abundance. This standardized sampling protocol is intended to improve the monitoring of the species throughout its Canadian range, the assessment of population trends, and consequently allow for a better informed management of the species over time.

RÉSUMÉ

Macnaughton, C.J., Rudolfsen, T., Watkinson, D.A., and Enders, E.C. 2019. Standardized field sampling method for monitoring the distribution and relative abundance of the Plains Minnow *(Hybognathus placitus)* population in Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3317: vii + 24 p.

Une des mesures de gestion provenant de la Loi sur les Espèces en Péril (LEP) pour la conservation du méné des plaines consiste à élaborer un plan de surveillance suffisamment solide afin de quantifier l'abondance, la distribution et l'habitat du poisson utilisé par l'espèce. Dans le cadre d'établir des cibles quantitatives pour le méné des plaines en vue d'assurer sa protection et son rétablissement, ce rapport sert à définir un protocole et un design d'échantillonnage qui serviront à faire l'inventaire de la population de méné des plaines dans les rivières Rock et Morgan en Saskatchewan, où elle est menacée. Ce rapport vise à décrire (1) l'engin de pêche recommandé, (2) l'effort et le moment de l'année idéal pour l'échantillonnage, et (3) la localisation des sites d'échantillonnage qui se retrouvent dans l'ensemble de l'aire de répartition de l'espèce, ainsi qu'à l'extérieur de cette zone pour faire le suivi de l'abondance à long-terme. Ce rapport contribue directement à la conservation de l'espèce en mettant en œuvre un plan de surveillance dans les cours d'eau canadiennes pour assurer la viabilité à long-terme de l'espèce.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The purpose of the *Species at Risk Act* (SARA) is to protect wildlife species at risk from becoming extinct or extirpated in Canada, help with the recovery of extirpated, endangered, and threatened species, and ensure that species of special concern do not become extirpated or threatened as a result of human activity (*Species at Risk Act S.C. 2002, c.29*). Under provisions in the *Act*, wildlife species, designatable units (DUs) thereof, and the critical habitats of populations listed under the SARA as threatened or endangered receive protection. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is an independent body of experts tasked with identifying and assessing the status of wildlife species at risk. Once a species' outcome (i.e., designation) has been decided by COSEWIC and subsequent listing pursuant to SARA, assessments on the distribution and relative abundance of the species concerned are necessary for determining population trends and whether recovery strategies are effective or not. COSEWIC assessments determine the status of a species on a ten year cycle, setting the timeline for when the information is required to update a species' status and to ensure the species' recovery is on the anticipated trajectory. The challenge in this process lies in achieving consistent and current population trend updates by establishing a frequency of sampling events that potentially aligns with COSEWIC status review timelines and surveying methods for a given species.

Various field sampling methods for quantifying the distribution and relative abundance of small-bodied freshwater fishes in wadeable streams are currently in use. However, different field methods (e.g., beach seining vs. electrofishing) often yield different information, leading to conflicting, complementary and/or incomplete data records for any given species. Inconsistent or different sampling effort and survey designs may, therefore, preclude pooling data from different sources for obtaining reliable estimates (e.g., distribution and relative abundance) of target species. In fact, relatively few and scattered data records exist for the Canadian distribution of Plains Minnow (*Hybognathus placitus*, Girard 1856), making the task of estimating their current relative abundance and true distribution very difficult.

In an effort to provide science information to meet the Species at Risk Program's objective of monitoring population trends within the ten year cycle, this report aims to provide a consistent sampling method and survey design that may accurately inform on changes in the distribution and relative abundance of the Plains Minnow Saskatchewan population, particularly for the Milk River populations (DU2), where the species was assessed as *Threatened* (COSEWIC 2012). Properly designed sampling programs should include knowledge of the biology of the species and the deployment of the appropriate gear under the direction of experienced personnel. This report details which sampling gear to use and how much effort is required, where to sample Plains Minnow populations, and where range extension sampling should be planned as part of a long-term monitoring for the species. This Plains Minnow sampling protocol uses elements of an existing fish surveying protocol for first-time surveys of small streams (Fish and Wildlife Alberta 2008) as a template, which applies to wadeable streams (<1 m in water depth) in Alberta and Saskatchewan. Using the latest seining field sampling data records for the species, this technical report offers a sampling approach, which can provide advice to the Species at Risk program on baseline Plains Minnow Catch per Unit Effort (CPUE) for the Rock Creek watershed including Morgan and Rock creeks in Saskatchewan. Since the latest data available is nearly a decade old and the species has yet to be listed under the SARA, a standardized sampling protocol for monitoring Plains Minnow population and distribution targets that includes the frequency of sampling events over time should lead to improved and better informed management of the species (i.e., Plains Minnow Recovery Strategy).

2.0 PLAINS MINNOW

2.1 TAXONOMY

The genus *Hybognathus* contains four species in Canada: the Plains Minnow, the Western Silvery Minnow (*H. argyritis*), the Eastern Silvery Minnow (*H. regius*), and the Brassy Minnow (*H. hankinsoni*) (Schmidt 1994; Nelson *et al.* 2004). Plains Minnow was originally grouped with Mississippi Silvery Minnow (*H. nuchalis*), but was subsequently recognized as a separate species. Discrimination within the silvery minnow group is difficult and definitive identification often requires laboratory dissection of the posterior process of the basioccipital bone, a key character for separating the species (Niazi and Moore 1962; Bailey and Allum 1962; Al-Rawi and Cross 1964; Pflieger 1971). Plains Minnow co-occur with the Brassy Minnow and although none have been collected to date, they may co-occur with Western Silvery Minnow in the Rock Creek watershed. Another reliable method to identify Plains Minnow from other *Hybognathus* is by measuring the orbit diameter, standard length (SL), and eye position (Scheurer *et al.* 2003).

2.2 MORPHOLOGY

Plains Minnow are a small-bodied and silvery minnow species, similar to other minnows in their range (Figure 1). They have a short triangular head with a blunt snout and relatively small eyes (4.4–5.5 times into the head length) positioned just above the midline of the head (Robison and Buchanan 1988; Scheurer *et al.* 2003). On average, adults range from 50–90 mm in total length, with a maximum length of about 125–130 mm (Scheurer *et al.* 2003). A sample of seven Plains Minnow collected from Morgan Creek in Saskatchewan, indicated a range in fork lengths (FL) from 44–84 mm, with a corresponding range in weights of 0.7–5.8 g (Sylvester *et al.* 2005). A larger sample of 133 fish collected from the same watershed had a range FL of 45–93 mm and weight of 1.0–11.0 g (unpublished data, Watkinson). Generally, males have larger heads and thicker caudal peduncles than females, who have deeper and more elongated bodies (Ostrand *et al.* 2001). During the spawning season, males develop nuptial tubercles on the head, dorsal surface, and pectoral fins (Sublette *et al.* 1990). Plains Minnow fins are pointed while those of Brassy Minnow are rounded (Scheurer *et al.* 2003).

Figure 1. Plains Minnow *Hybognathus placitus* collected from Rock Creek, Saskatchewan. D.A. Watkinson photo (COSEWIC 2012).

2.3 BIOLOGY

There is limited information on the Canadian population of Plains Minnow because it was only first identified in Canada in 2003 (Sylvester *et al.* 2005). Information about the species' biology originates principally from research conducted in the southwestern United States. No comprehensive study on age and growth of Plains Minnows was found in the scientific literature, but directed surveys on Plains Minnow in 2006 and 2007 in Saskatchewan observed that males and females obtained similar weight at fork length and age ranges from 1–2 years (45–72 mm age 1, 70–92 mm age 2; unpublished data, Watkinson). Plains Minnow are a herbivorous and benthivorous species, potentially transferring energy and nutrients up the food chain (Moyer *et al.* 2005).

<u>Life Cycle and Reproduction</u>

Plains Minnow are a schooling species, commonly co-occurring with other cyprinids near the bottom of streams including: Western Silvery Minnow, Silver Chub (*Macrhybopsis storerieana*), Sand Shiner (*Notropis stramineus*), Flathead Chub (*Platygobio gracilis*) (Pflieger 1971, 1997) and more recently, Lake Chub (*Couesius plumbeus*), Brassy Minnow, Northern Redbelly Dace (*Chrosomus eos*), Longnose Dace (*Rhinichthys cataractae*) among others. Plains Minnow have a short life cycle, with high mortality occurring post-spawning (Taylor and Miller 1990). They do not typically live more than two years and are sexually mature after one (Lehtinen and Layzer 1988). During the spawning season (May to June), females release semi-buoyant, non-adhesive eggs that drift downstream before hatching (Pflieger 1971, 1997; Lehtinen and Layzer 1988; Platania and Altenbach 1998). Preferred spawning streams are turbid with sufficient flow to carry eggs downstream. Mean fecundity of females ranging in standard length from 51–87 mm is estimated to be 817 eggs (Taylor and Miller 1990). Eggs are approximately 1 mm in diameter immediately upon release, but they quickly expand to about 3 mm 10–30 minutes later following fertilization (Platania and Altenbach 1998).

Physiology and Adaptability

Plains Minnow tolerate a broad range of water quality, exhibiting tolerance for high temperatures and low oxygen as determined by loss of equilibrium at dissolved oxygen levels of 2.08 +/- 0.14 $mg \cdot l^{-1}$ (Mathews and Maness 1979; Bryan *et al.* 1984; Ostrand and Wilde 2001). Plains Minnow abundance declined as turbidity fluctuated and pool volume declined (Ostrand and Wilde 2004). Gradual changes in environmental factors that structure headwater fish communities may stem from intermittency in water supply and subsequently, increase the potential for pool evaporation (Ostrand and Wilde 2004). The security of water supply is, thus, an important feature of Plains Minnow fish habitat, despite the species' ability to tolerate degraded water quality conditions compared to many other co-occurring species.

2.4 KNOWN DISTRIBUTION IN CANADA

Saskatchewan Population - Threatened (COSEWIC 2012)

The Canadian population of Plains Minnow have been collected only in Rock and Morgan creeks that pass through the East Block of Grasslands National Park (Sylvester 2004) (Figure 2). There are no human-made barriers to movement within the Canadian range and at present, the degree of movement in or out of the Canadian Rock Creek watershed to the United States remains unknown, but transboundary movements are thought to occur. The Canadian population represents the northern extent of the larger Plains Minnow population that exists in the United States portion of the Rock Creek watershed and in the Milk River, further downstream [Montana Fisheries Information System (MFISH 2010)]. The distribution of the Plains Minnow in the Milk River watershed occurs in tributaries downstream of the Dodson Diversion Dam in Montana to the confluence of the Missouri River (Bramblett 2008).

Plains Minnow was assessed by COSEWIC as *Threatened* in May 2012 (COSEWIC 2012) and is currently under consideration for listing under the *Species at Risk Act*. It is, however, listed as S1 (Critically Imperiled) in Saskatchewan and the species is afforded the protection of the Canadian *National Parks Act* within the Grasslands National Park, Saskatchewan.

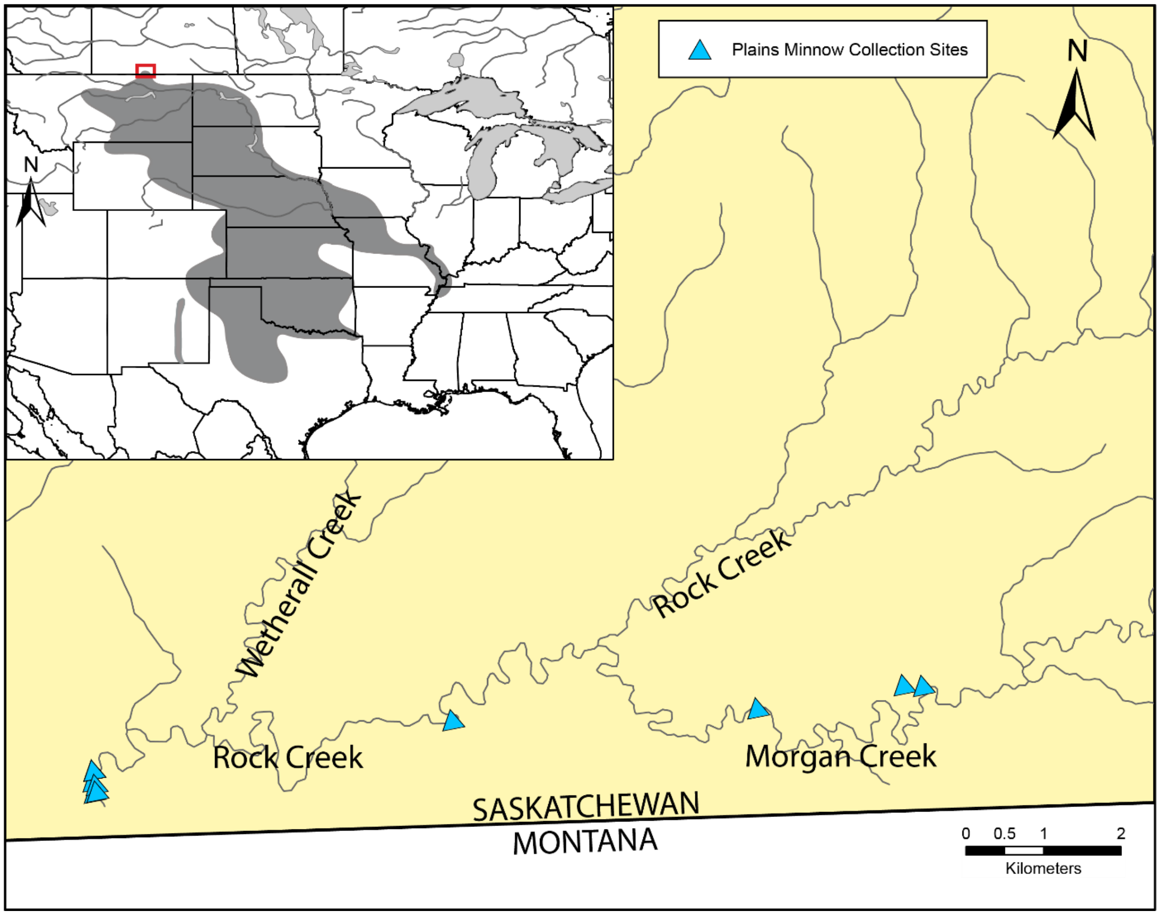

Figure 2. Plains Minnow occurrence (triangles) in the Rock Creek watershed in Saskatchewan for sampling conducted in 2006 and 2007 (unpublished data, Watkinson). Inset map represents the global distribution modified from Page and Burr (2011).

2.5 HABITAT

Habitat Features

Plains Minnow prefer a wide range of streams with fine sediment such as sand and silt (COSEWIC 2012). The streams range from clear to turbid, and possess constant to intermittent flows (Smith 2002; Sublette *et al.* 1990), but they are most commonly found in backwaters and slow moving habitats, where silt and sand accumulate (Robison and Buchanan 1988; Cross and Collins 1995; Pflieger 1997). High flow environments are typically avoided (Mathews and Hill 1980). Small to medium rivers that Plains Minnow inhabit are prone to drying into intermittent pools during dry summers or cold winter, but also experience flash floods of turbid water in precipitation events. Despite being an obligate riverine species, Plains Minnow are adapted to naturally fluctuating environments, including flow intermittency, water quality degradation, and low oxygen concentrations (see section Physiology and Adaptability, section 2.3).

Field surveys conducted in Rock and Morgan creeks in 2006 and 2007 provided general site descriptors of the habitat where Plains Minnow occurred. Overall, habitat characteristics for Rock and Morgan creek surveys align with previous accounts of the species habitat preferences for narrower streams (1–9 m in wetted width), with slow moving (<0.12 $m \cdot s^{-1}$), turbid water (15–30 cm in visibility), and soft, uniform substrate types (silt and sand) (Figure 3). Due to inconsistent reporting of wetted widths among sites in 2006, wetted width at upstream and downstream portions for those sites (11–15; Table 1) were estimated based on site photos. Habitat use in the systems broadened as flows increased and narrowed during the period of low water flows, causing fish to converge to fewer habitats when flow conditions were adverse.

Figure 3. Site 9 in Morgan Creek in Saskatchewan sampled in 2007 (D.A. Watkinson photo).

Table 1. Habitat descriptors for Plains Minnow including wetted width, water depth, velocity, turbidity, temperature, conductivity, and substrate complexity for Morgan and Rock creeks based on field surveys conducted in 2006 and 2007 (unpublished data, Watkinson). NA refers to non-available data.

Waterbody	Site	Width (m)	Depth (m)	Velocity ($m \cdot s^{-1}$)	Turbidity (cm)	Temperature (°C)	Conductivity ($\mu S \cdot cm^{-1}$)	Silt (%)	Sand (%)	Gravel (%)
Morgan Creek	6	3.25	0.86	NA	17	16.6	1266	100	0	0
	7	1.15	0.52	NA	17	16.6	1266	50	50	0
	8	1.4	0.17	NA	22	14.8	1230	50	50	0
	9	1.375	0.28	NA	16	14.2	1271	50	50	0
	10	1.55	0.45	NA	16	14.2	1271	50	50	0
	15	2.5	0.4	0.11	12	12.4	1082	100	0	0
Rock Creek	1	8.55	0.6	NA	19	15.8	2030	60	0	40
	2	8.95	0.65	NA	30	17.1	2010	80	0	20
	3	6.1	0.45	NA	30	19.3	1916	30	0	70
	4	7.65	0.58	NA	30	15.7	2370	60	0	40
	5	6.3	0.43	NA	32	15.4	1622	100	0	0
	11	8	0.6	0.03	15	11.5	1331	0	100	0
	12	9	0.66	0	NA	11.3	1334	50	50	0
	13	5.5	0.34	0.02	NA	11.4	1334	0	10	90
	14	1.5	0.42	0.12	10	10.8	1050	100	0	0

Habitat Trends and Threats

The naturally fluctuating hydrograph of plains streams is important to the long-term sustainability of robust populations of Plains Minnow (Winston *et al.* 1991; Bonner and Wilde 2000). Rock Creek is a typical prairie intermittent stream with a highly variable hydrograph, where 37 monthly mean flows of 0 m^3 s^{-1} occurred between 1979–2009 (COSEWC 2012). Plains Minnow distribution is reduced due to human alterations such as dam construction, water withdrawal for irrigation pollution, and introduction of non-native species (Anderson *et al.* 1983; Cross and Moss 1987; Pflieger and Grace 1987; Winston *et al.* 1991; Bonner and Wilde 2000; Quist *et al.* 2004; Haslouer *et al.* 2005; Jelks *et al.* 2008). Impoundments are the primary threat to Plains Minnow habitat (COSEWIC 2012). Dams not only stagnate flow which is required for the incubation and hatching of Plains Minnow eggs, they also typically reduce sediment, providing clear, rocky habitat that may be preferred by non-native predators. There are currently no native or exotic piscivores known from the Canadian portions of Rock Creek.

2.6 POPULATION SIZE AND CPUE TRENDS IN CANADA

Data on the abundance of Plains Minnow in the Milk River in the United States are limited, but it is not considered to be a species of concern in either Montana or North Dakota, the two states adjacent to Saskatchewan (NatureServe 2010). There is only one known population of Plains Minnow in Canada, in the Rock Creek watershed of Saskatchewan.

There have been two directed surveys in the Rock Creek watershed conducted since the first description of Plains Minnow in Canada in 2003. A population estimate from 2007 suggested that there may be ~ 41,751 mature fish in Rock Creek (unpublished data, Watkinson). Average CPUE across sites in Rock Creek watershed was found to be below 0.5 fish·m^{-2}, except for Site 7, where a beaver dam created a barrier for upstream movement and resulted in an abundance of 44 fish over a small area ~ 16 m^2 (CPUE of ~ 3 fish·m^{-2}; Table 2). CPUE estimates calculated for each seine pass were calculated for the eight sites sampled in 2007, where up to five seine passes were conducted per site (Figure 4). Results indicated that no more than a single seine pass per site was required to obtain mean site CPUE, as CPUE estimates and variance were close to zero for seine passes two to five. Current Plains Minnow population trends in Canada are unknown as there has not been an assessment since 2007.

Table 2. Average survey effort, Plains Minnow abundance and CPUE per site surveyed in Morgan and Rock creeks, in 2006 and 2007 (unpublished data, Watkinson).

Waterbody	Site	Date	Latitude	Longitude	Mean Effort (area m^2)	Mean Site Abundance (# fish)	Mean Site CPUE (fish·m^{-2})
Morgan Creek	6	6-Sep-07	49.00933	-106.6636	65	0	0
	7	6-Sep-07	49.00933	-106.6636	16.1	44	2.73
	8	7-Sep-07	49.01148	-106.6364	28	0	0
	9	7-Sep-07	49.01152	-106.6377	27.5	0	0
	10	7-Sep-07	49.01152	-106.6377	21.7	9	0.41
	15	26-Sep-06	49.01132	-106.6343	100	4	0.04
Rock Creek	1	5-Sep-07	49.00178	-106.7808	171	0.2	0.001
	2	5-Sep-07	49.00223	-106.7803	179	0	0
	3	5-Sep-07	49.003	-106.7807	122	0	0
	4	6-Sep-07	49.00435	-106.7808	153	11.6	0.08
	5	6-Sep-07	49.00897	-106.7173	126	0.2	0.00
	11	26-Sep-06	49.00189	-106.7803	400	2	0.01
	12	26-Sep-06	49.00269	-106.7805	360	49	0.14
	13	26-Sep-06	49.00308	-106.781	110	34	0.31
	14	26-Sep-06	49.00308	-106.781	30	0	0

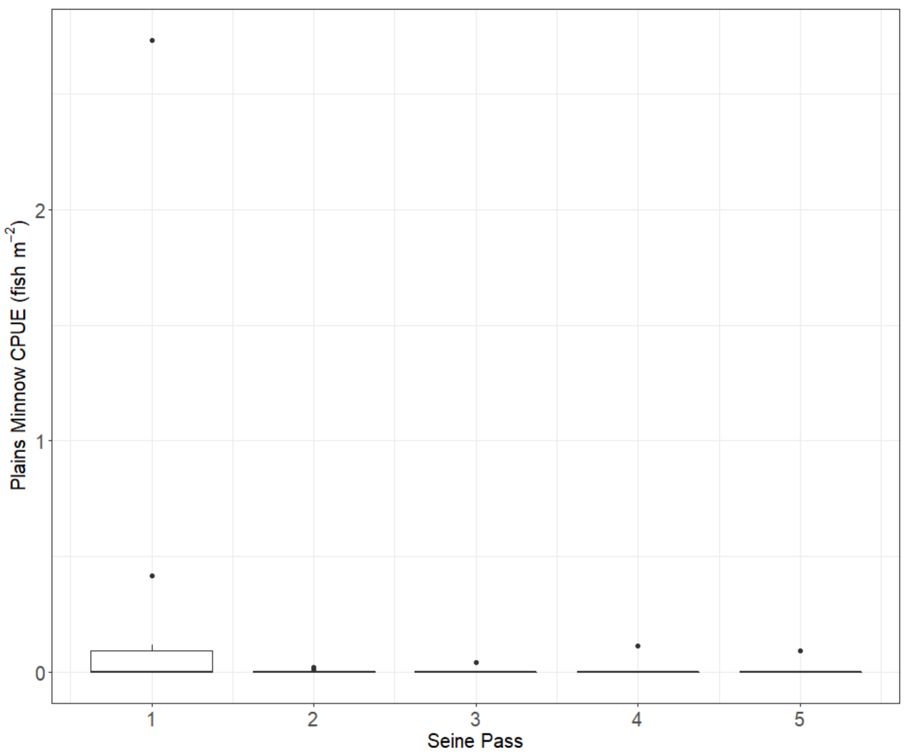

Figure 4. Boxplot of Plains Minnow CPUE (fish·m^{-2}) sampled per seine pass (1–5 passes) for sites where more than one pass was conducted in Morgan and Rock creeks in Saskatchewan. Points and boxplot represent outliers and median CPUE, respectively.

3.0 SAMPLING PROTOCOL

To obtain consistent fish survey data and ensure that monitoring is effective, a standard sampling protocol using beach seining has been developed to monitor occurrence and abundance of Plains Minnow. The sampling protocol describes a standardized approach for fish and habitat collection throughout the species' distribution in the Rock Creek watershed, Saskatchewan. Due to the intermittency of stream habitats, sampling should take place in stream habitats with a minimum wetted area of ~100 m^2.

Access points

Four access points have been identified for sampling Morgan and Rock creeks within the known distribution of the Plains Minnow (Figure 5). The access points presented below (see Appendix 1 for the full list of access points and associated coordinates) are recommended for accessing locations in the watershed for sampling and monitoring population trends over time. Sampling proposed range extension locations may provide information on whether the species' distribution could be expanding. They have been chosen based on their position in the Canadian portion of the watershed, the lowest reaches that have road access, upstream of the United States border.

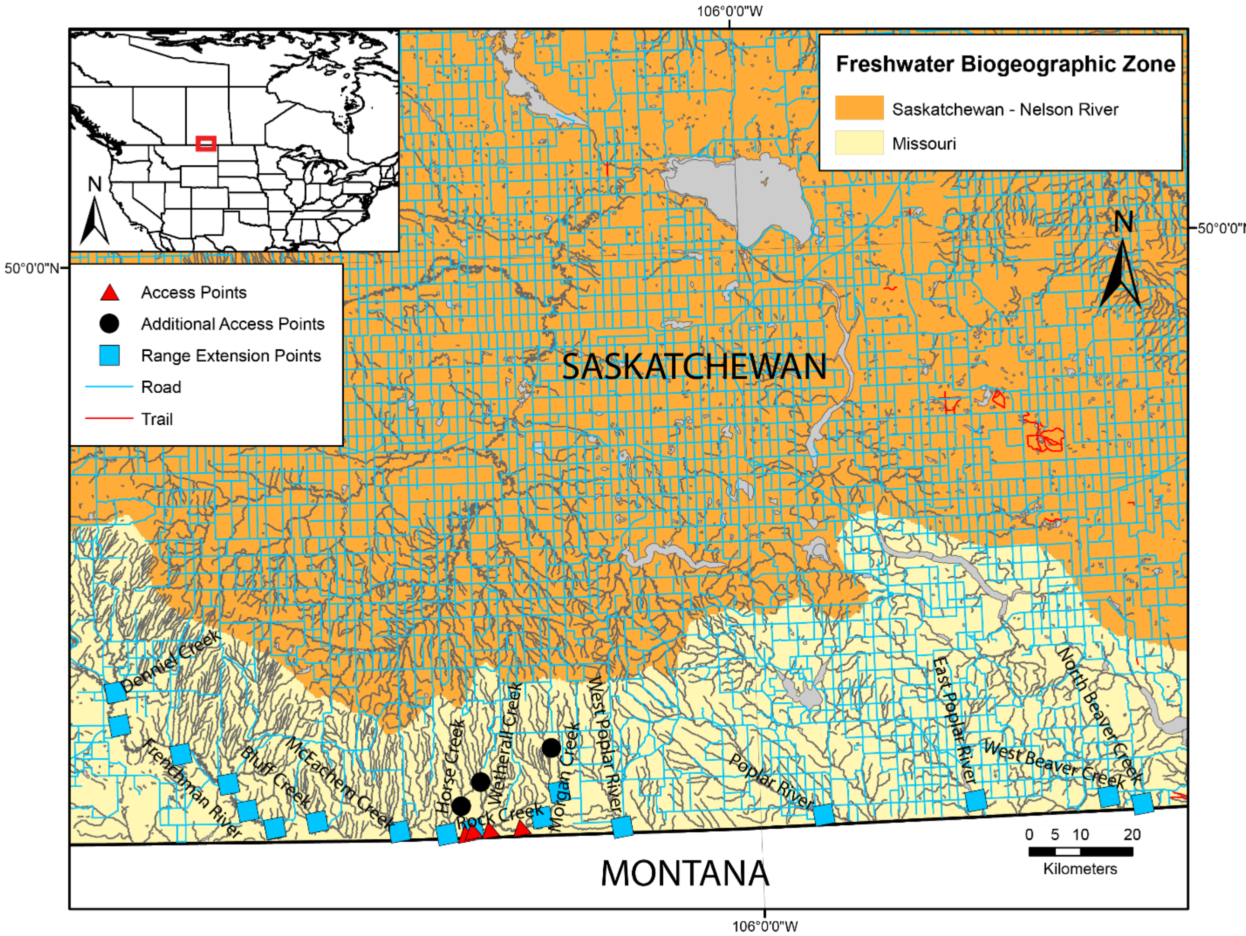

Figure 5. Map of access points (triangles) and potential range extension sampling sites for Rock and Morgan creeks in Saskatchewan and the Frenchman River in Alberta.

Sites

Rock Creek merges with Morgan Creek (the confluence ~ 1 km north of the Canada-USA border) and extends northward, in Grasslands National Park, Saskatchewan. Upstream portions of Morgan Creek are spring-fed whereas downstream portions of the creek are intermittently dry, leaving isolated pools where fish may be sampled. Upstream and downstream portions of Morgan Creek are quite variable, which make consistent sampling based on the length of a site in Morgan Creek nearly impossible. Sites represent the sampling unit for which CPUE is calculated. If the availability of stream habitat is not limited, sites should be consistent and measure ~100 m^2 (for example: 5 m wide by 20 m seine pull). Irrespective of the length of a site, upstream and downstream boundaries of the site should be blocked off using block nets and the area surveyed will correspond to the product of the length of the seine haul by the average creek wetted width. Sample sites should be evenly distributed among recommended access points along each river (i.e., three sites per access point), maximizing the spatial extent of the surveying effort (~12 sites throughout the known distribution of the species). In order to balance the spatial distribution of sampling sites with the effort of moving between these sites, we recommend that sites are spaced out from 50–100 m apart from one another. To avoid disturbing fish habitats during surveys, sampling should commence at the most downstream site at any given access point, moving upstream with each new site. Furthermore, habitat and environmental descriptors that specifically measure water quality (i.e., water turbidity and conductivity) should be obtained prior to entering the stream for sampling.

3.1 TIMING OF SAMPLING

Seasonality

It is important that sampling be timed to match the most appropriate conditions every year to reduce environmental variation. The sampling sites should therefore be georeferenced and photographed in the field to ensure that the same approximate locations are used repeatedly across years. The timing of sampling events should also be relatively consistent across years with the caveat that creeks should be sampled when they are flowing, rather than when much of the system is dry with isolated pools or stagnant.

Sampling feasibility in the Rock Creek watershed is contingent on seasonal water levels and water temperatures that allow sampling to consistently occur. Rather than aiming to sample particular calendar dates each year, annual studies should be conducted for targeted stream flows within a particular calendar period or under a similar flow stage. Real-time hydrometric data for the systems are available from the Water Survey of Canada and United States Geological Survey (USGS) to inform on seasonal flow and water level variability in Rock Creek (Sources: Water Survey of Canada 2019; USGS 2019; Table 3) and should be checked prior to field surveying. The Rock Creek watershed becomes intermittent in late-summer and winter, limiting the movement of fishes throughout the watershed. However, Plains Minnow should be able to immigrate and emigrate from the downstream portion of the watershed in Montana during most spring freshet conditions (April–May; Days 91–121). Rock Creek has a highly variable hydrograph, dipping to seasonal lows of 0 $m^3 \cdot s^{-1}$ from July 1st to mid-October (Figure 6). Upstream portions of Morgan Creek are spring-fed with greater flows than downstream portions of the creek. The lower Frenchman River has been surveyed for range extension of Plains Minnow, but low flows (0 $m^3 \cdot s^{-1}$) for ~2 months of the year (end of August to mid-October) may restrict survey area to isolated pools (Figure 6).

Table 3. List of real-time hydrometric stations and recommended sampling time in the Frenchman River and Rock Creek where Plains Minnow occur.

Waterbody	Hydrometric station	Location of hydrometric station	Suggested sampling time	Station source
Frenchman River	11AC041	At international boundary	June 30 to mid-October	Water Survey of Canada
Rock Creek	6169500	Below the confluence of Horse Creek (Montana)	June 30 to mid-October	USGS

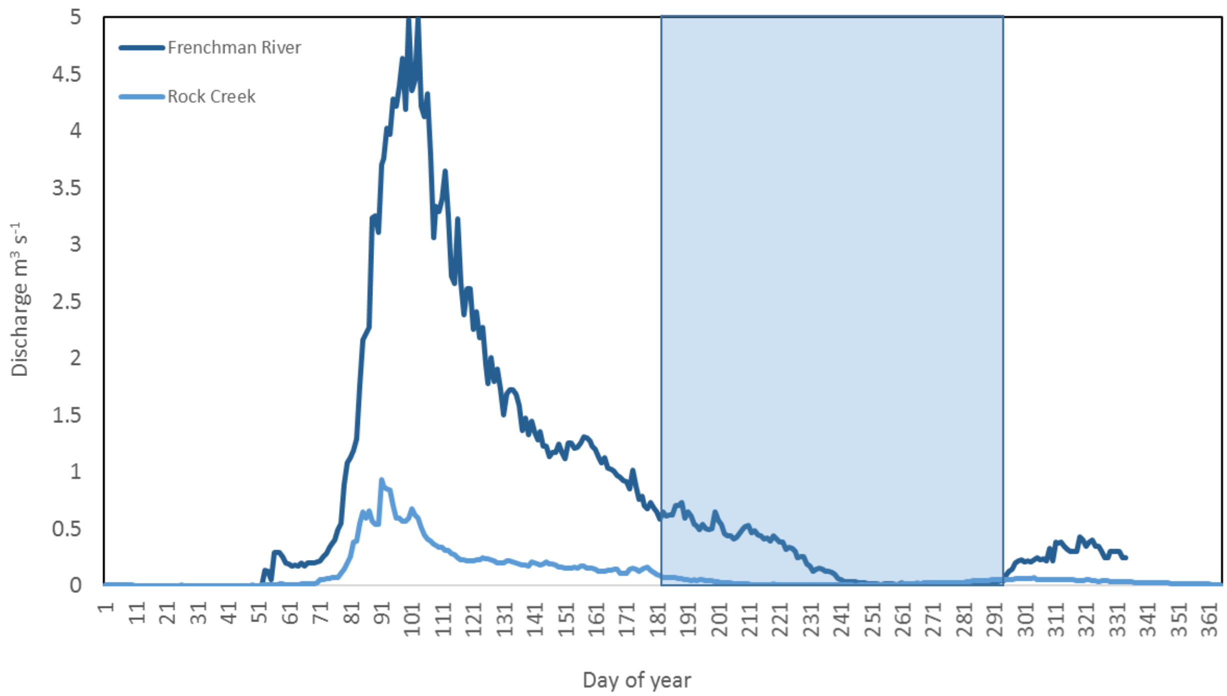

Figure 6. Hydrographs illustrating the median discharge ($m^3 s^{-1}$) over the days of a year (Day 1= January 1). Data for Rock Creek sourced for years 1979–2017 (continuous, 365 day a year record) and 1918–2015 for the Frenchman River (no data for winter months). Data collected by Water Survey of Canada for the Frenchman River and United States Geological Survey for Rock Creek. Window of time for surveying Plains Minnow for both systems depicted by the blue box boxes from Day 181–291 (July 1st–mid-October).

<u>**Surveying Frequency**</u>

Baseline CPUE data is available for Rock Creek watershed, however, the last population assessment was conducted in 2007. To determine whether Plains Minnow populations are expanding or contracting, population trend assessments require more frequent surveying of the same sites and should include range extension sampling. COSEWIC assessments determine the status of a species on a ten year cycle, setting the timeline for when the information is required to update a species' status. To maximize the temporal extent of surveys and to provide a minimum of two estimates of the distribution and relative abundance of the species, sampling should be conducted twice in the ten year cycle. Ideally, sites should be sampled at least every five years, once baseline data has informed the survey effort necessary to achieve reliable population trends. Two to three years of consecutive annual sampling should be sufficient to provide baseline data.

3.2 SAMPLING GEAR AND METHOD

A minimum crew size of two people is required to pull a seine net (length = 9.14 m by width = 1.82 m, mesh size = 4.76 mm, and 1.82 m^3 center pocket) over ~20 m distance within a site. To reduce fish escaping from sites, block nets should be placed at the upstream and downstream portions of a site. To efficiently sample fish within a site where water turbidity limits visibility, it is advisable to stretch the seine net across the creek and for crew members to move slowly downstream toward the block net. Once at the downstream block net, crew members quickly grab the seine's lead line and pull up the net, parallel to the block net (Figure 7). For ease of sampling around snags and backwaters, the direction of the seine pull is opposite to what is prescribed above (i.e., upstream direction to the upstream block net), preventing the seine from bunching as water pushes it in the opposite direction.

Sampling effort corresponds to the average wetted width taken from the upstream and downstream portions of a site (i.e., at the locations where block nets are installed) multiplied by the distance over which the seine is pulled. Since sites and sampling area are variable throughout the watershed on account of seasonal water level changes, it is essential that sampling effort is measured consistently for each site, ensuring that fish density and biomass estimates may be compared across sites and between years. With block nets in place, fish depletion estimates can be measured within the site by immediately placing fish in buckets after each pass of the seine and releasing fish back into the site once the sampling is complete.

Figure 7. Image of crew lifting seine at block net at Site 5 in Morgan Creek in 2007 (D.A. Watkinson photo).

At each sampling site, habitat data (described in following section) should be collected to complement fish data and to quantify habitat. Water temperature trends (i.e., among and within streams) are thought to drive species' distribution via their cumulative impacts with water flow, dissolved oxygen concentration, and other habitat variables. Along with the habitat descriptors collected for each site, temperature loggers programmed for long-term monitoring of thermal trends at each access point should be considered to better understand population trends over time. Not included in the report is an approach for quantifying thermal trends in rivers, however, details on launching temperature loggers and their placement in streams may be found in Chu *et al.* (2009) and Mandrak and Bouvier (2014).

Many factors affect the success of seining in small stream habitats, namely water turbidity, substrate complexity, and the presence of woody debris that can snag the lead line and allow fish to escape under the net. Other variables, including water depth and velocity, may also affect seining efficiency, which is why habitat variables must be recorded to complement fish data and to quantify usability at each sampling site. The Plains Minnow protocol described here uses elements of the existing fish surveying protocol for first-time surveys of small streams in Alberta (FMSC 2008) as a template. This protocol applies to wadeable streams (<1 m in water depth) in Alberta and Saskatchewan, where the distribution of Plains Minnow is currently being monitored. Refer to Appendix 2 for the database template.

Collecting Habitat Data

Collecting habitat data from sampling locations is an important activity as changes to habitat through time may help explain future presence/absence or changes in the abundance of Plains Minnow at any given location. Habitat data collected while sampling for Plains Minnow should include; water velocity, depth, substrate complexity, and plant cover (see items 12, 13, 15 & 16 in list below environmental/habitat descriptors). There are inherent biases to sampling habitat conditions and what one perceives as similar or different may not be so if sites are not selected randomly for collecting habitat data. In an attempt to capture the variability within a site and to aid in the random sampling of habitat variables/conditions/features at each site, it is recommended to overlay an imaginary grid over the sampled creek/river area, dividing the site into 2 m long sections with the width of the creek/river divided into halves. As an example, this results in 20 potential quadrat locations that could be sampled within a 20 m long site. To select the placement of the five quadrats per site, randomly select five numbers from a number generator or a table of numbers. These randomly selected numbers can be used to correspond to five of the 20 potential sampling quadrat locations from the example given above. The habitat data collected from the five quadrats are then entered on the database template shown below (Appendix 2). Habitat data must be collected from each sampled stretch of creek/river regardless of whether Plains Minnow are captured.

Environmental/Habitat Descriptors

1. Waterbody name – List the name of the river surveyed (e.g., Morgan Creek).
2. Date of surveying – Use the format (dd/mm/yyyy). Do not abbreviate.
3. Crew – List the names of crew members so that appropriate persons may be contacted to verify data.
4. Latitude and longitude coordinates – Units should be in decimal degrees (WGS84). Provide geographic reference locations of each sample site.
5. Site location notes – Give concise description of the geographic location of the reach or site surveyed using map and site observations (e.g., 10 m upstream from confluence with tributary X).
6. Site number – Give a unique number to the site surveyed.
7. Water temperature – Measure the water temperature (ºC) mid-water depth, using an appropriately calibrated thermometer. Temperature influences the distribution of biota and the catchability of certain species. Avoid taking measurements in stream margins, outflows from tributaries or stagnant pools (unless the site is located in these habitats). Record the time of day (24 h).
8. Conductivity – Measure the conductivity, the capacity of transmitting electricity, mid-water depth within the site using a portable conductivity meter ($\mu S\ cm^{-1}$, standardized to 25 ºC). Conductivity influences catchability and may provide the means to stratify data.

9. Turbidity – Measure the turbidity within the site using a portable turbidity meter (NTU) and Secchi disk (cm). Turbidity influences catchability and may provide the means to stratify data.
10. Wetted and rooted width of the cross section – Measure the channel wetted and rooted widths (m) using a tape measure at the downstream and upstream locations of the river reach surveyed and where block nets are anchored. Wetted width corresponds to the width of the channel at the surface of the water at the time of survey. Wetted width influences seining effort and efficiency, affecting catchability and CPUE. Rooted or bank-full width corresponds to the channel width at the base of permanently rooted vegetation. For braided channels, the measurement should include any islands not covered by permanent vegetation.
11. Maximum depth – Measure the depth of the water at the deepest point between the wetted banks using a meter stick.
12. Water depth – Measure the depth of the water (m) at five randomly distributed points within a site using a meter stick, making sure to obtain measurements from the center of the randomly selected quadrats.
13. Water velocity – Measure the water velocity of the water (m s^{-1}) at five randomly distributed quadrats within a site using a flow meter metre and wading rod (Marsh-McBirney Flo-Mate), making sure to obtain measurements from the center of the randomly selected quadrats.
14. Site discharge – Measure the water velocity (m s^{-1}) and depth (m) at three points along the upstream-most cross-section of the site, using a flowmeter and wading rod (Marsh-McBirney Flo-Mate). Divide the creek/river width into thirds and measure water depth and velocity at each point.
15. Substrate complexity – Calculate the proportion of the substrate within a ~1 m^2 quadrat (visual and tactile assessment) that are: bedrock, boulder, cobble, large gravel, small gravel, sand, silt, and clay (modified Wentworth scale). Repeat substrate complexity estimates at five randomly distributed quadrats within a site.
16. Plant cover – Calculate the proportion of plant cover within a ~1 m^2 quadrat (visual assessment), at five randomly distributed points within a site.
17. Site characterization – Characterize the site surveyed based on the pool/riffle/run categories observed to provide a broad idea of productivity and a mechanism for stratifying data.
18. Photo number – Take at least one picture and record the number of the photographs taken during the stream survey.
19. Photo description – Briefly describe the picture taken for later reference. Indicate whether you are facing upstream or downstream.
20. Comments – Briefly describe any details relating to surveying, location, and sources of error (e.g., outflow from tributary) or change (e.g., seepage or barrier).

Beach Seining Descriptors

21. Distance/effort – Record the distance (m) over which the seine net is pulled within a site. Seining effort corresponds to the product of the distance covered by the average wetted width of the site.
22. Pass – Record the number of the pass or seine haul. It is not necessary to conduct more than a single seine pass per site, but in the case that multiple passes are done, indicate the pass number.

Fishing Descriptors

23. Capture method – Since the recommended capture method for Plains Minnow is beach seining, note the specifications of the beach seine (i.e., 9.14 m length x 1.82 m width, mesh size 4.76 mm).
24. Sample Number – Sequentially number fish, an entry per fish sampled.
25. Species – Enter the name code for the Plains Minnow sampled (PLMW).
26. Fork length/total length – Record the fork (tip of the snout to the natural fork of the tail) and total (tip of the snout to the end of the tail) lengths (mm) for each fish sampled. Ensure that fish are placed on a flat measuring board.
27. Injuries/ comments – Note body condition and injury observations (e.g., lesions or parasite burden).
28. Sample picture – Place the fish on a flat, non-reflective surface and take a photograph of the fish on its left side, next to a ruler. Identify the picture number- (PLMW-number-date-river).
29. Sample specimen – retain a voucher specimen at each access point, indicating the location, time and date where the specimen was taken.
30. Refer to specimen collections for archives and life history (Macnaughton *et al.* in revision; Appendix 3).
31. Refer to eDNA sampling protocol (Macnaughton *et al.* in revision; Appendix 4).

4.0 SUMMARY AND RECOMMENDATIONS FOR FUTURE SAMPLING INVESTIGATIONS

The basis of any effective monitoring program is reliable baseline data against which to monitor and compare future conditions. Generally, a couple of years of data should be collected to establish baseline trends for targeted species and monitoring should continue for several years with the same methods, sites and timing of sampling. Adopting monitoring programs that include integrated and consistent surveying protocols should provide more efficient, comparable, and powerful assessments of population trends over time.

The appropriate method for a particular project, or combination of methods for fish sampling, will require consideration of the capture probability of the species/life stages of interest, as well as the physical conditions of the site (Lewis *et al.* 2013). Although this report describes a protocol for sampling a minimum area (~ 100 m^2) based on a seining techniques, the timing of surveys will dictate whether seining can take place and the minimum area can be achieved. Specifically, stream intermittency in the Rock Creek watershed will drive the distribution of fishes throughout the system, converging fishes into isolated pools. As such, the timing of surveys should consider annual flow conditions as well as inter-annual flow trends, to ensure that surveys are conducted for similar flow stages.

Plains Minnow are thought to be moderately abundant in the Rock Creek watershed, according to surveys conducted in 2006 and 2007. However, the absence of consistent survey estimates since 2007 precluded the assessment of population trends over the last decade and contributed to the uncertainty in population estimates for Plains Minnow in Canada. The greatest threats to the survival and persistence of the species are related to the cumulative effects of landscape changes causing habitat loss and degradation, especially as a result of flow alteration. Although the species is known to withstand drought and anoxic conditions, flow intermittency may exacerbate population survivability. In the face of uncertain changes to suitable fish habitat and scarcity of data to derive population trends for Plains Minnow in Rock and Morgan creeks in Saskatchewan, the need has never been more critical for consistent sampling protocols, frequent assessments, and reporting of fish and fish habitat data collections.

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APPENDICES

APPENDIX 1. Access point information for all current Plains Minnow sampling locations in Saskatchewan. Information for possible Saskatchewan and Alberta range extension locations are also provided.

Waterbody	Location of Access	Access Type	Latitude	Longitude	Notes
Rock Creek	Grasslands National Park	Main Access Point	49.00269	-106.78045	Trail crossing near US border
Rock Creek	At the confluence with Wetherall Creek	Main Access Point	49.00797	-106.76197	Foot access ~1 km hike
Rock Creek	Grasslands National Park	Main Access Point	49.00897	-106.71734	Trail crossing
Morgan Creek	Grasslands National Park	Main Access Point	49.01132	-106.63426	Trail crossing
Morgan Creek	South of trail in Grasslands National Park	Range Extension	49.02747	-106.57884	Foot access
Morgan Creek	McGowan's in Grasslands National Park	Range Extension	49.07151	-106.5299	End of road access
Denniel Creek	HWY 18 Crossing	Range Extension	49.26192	-107.69942	Roadside access
Frenchman River	Grasslands National Park	Range Extension	49.02046	-107.28407	Trail crossing, furthest downstream site
Frenchman River	Grasslands National Park	Range Extension	49.05161	-107.35500	Roadside access
Frenchman River	Grasslands National Park	Range Extension	49.09898	-107.40431	Roadside access
Frenchman River	Grasslands National Park, Near Breed and Little Breed creeks	Range Extension	49.15228	-107.52845	Roadside access
Frenchman River	Road Crossing in Grasslands National Park	Range Extension	49.20365	-107.69005	Roadside access
Horse Creek	Grasslands National Park	Range Extension	49.00300	-106.83077	Trail crossing near US border
Wetherall Creek	At the confluence with Rock Creek	Range Extension	49.00959	-106.76133	Foot access ~1 km hike
Bluff Creek	Private Land	Range Extension	49.02992	-107.17178	Trail crossing
McEachem Creek	Private Land	Range Extension	49.00997	-106.95607	Trail crossing
West Poplar River	HWY 2 Crossing	Range Extension	49.00649	-106.36653	Roadside access
Poplar River	Ford Crossing on grid road	Range Extension	49.01418	-105.83438	Roadside access
East Poplar River	HWY 18 Crossing	Range Extension	49.02704	-105.43058	Roadside access
West Beaver Creek	Private Land	Range Extension	49.02249	-105.08011	Roadside access
North Beaver Creek	Road Access, Private Land	Range Extension	49.00659	-104.99167	Foot access
Horse Creek	Grasslands National Park	Additional Access Point	49.05093	-106.79129	Trail crossing
Wetherall Creek	Grasslands National Park	Additional Access Point	49.09234	-106.73767	Trail crossing
Morgan Creek	Just north of Grasslands	Additional Access Point	49.14786	-106.54741	Trail crossing

APPENDIX 2. Database template developed for the standardized sampling protocol of Plains Minnow in wadeable rivers in Saskatchewan.

Waterbody Body		Activity Date (day/month/year)	
Access Point		Time of Day	
Description of access		Crew	

Upstream Latitude (decimal degrees)	Upstream Longitude (decimal degrees)	Site #	Wetted Width (m)	US Rooted Width (m)
Downstream Latitude (decimal degrees)	Downstream Longitude (decimal degrees)	Site #	Wetted Width (m)	DS Rooted Width (m)

Discharge (velocity/ depth) at upstream site	1	2	3

Water Temperature (°C)	Turbidity (NTU)	Max. Depth (m)	Secchi (cm)	Conductivity (µS · cm^{-1})

SEINING

Seine dimensions	Distance fished (m)	Pass number

QUADRAT	1	2	3	4	5
Water Depth (m)					
Water Velocity (m s^{-1})					
Bedrock (>1024 mm)					
Boulder (256–1024 mm)					
Cobble (64–256 mm)					
Large Gravel (34–64 mm)					
Small Gravel (2–34 mm)					
Sand (0.062–2 mm)					
Silt (0.004–0.062 mm)					
Clay (<0.004 mm)					
Plant Cover					

Photo Number:	Description:

Fish #	Species ID	Fork Length (mm)	Picture	Specimen Collected (Y/N)	Comments