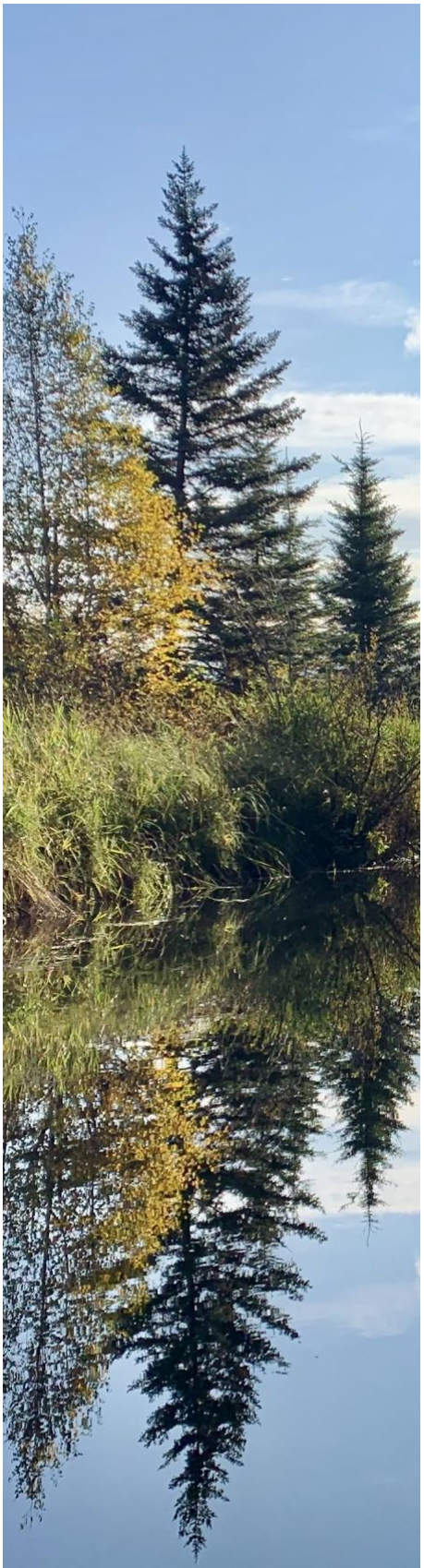

Upper McLeod River Native Trout Inventory, 2021–2022

Alberta Conservation Association

wildlife | fish | habitat

ACA PROJECT REPORT

Upper McLeod River Native Trout Inventory, 2021–2022

Zachary Spence, Chad Judd, and Mike Rodtka
Alberta Conservation Association
#101, 9 Chippewa Road
Sherwood Park, Alberta, Canada T8A 6J7

Alberta Conservation Association

Report Editors

PETER AKU
Alberta Conservation Association
#101, 9 Chippewa Rd.
Sherwood Park, AB T8A 6J7

SUE PETERS
Alberta Conservation Association
#101, 9 Chippewa Rd.
Sherwood Park, AB T8A 6J7

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Alberta Conservation Association
#101, 9 Chippewa Rd.
Sherwood Park, AB T8A 6J7
Toll Free: 1-877-969-9091
Tel: 780-410-1999
Email: info@ab-conservation.com
Website: www.ab-conservation.com

EXECUTIVE SUMMARY

Athabasca rainbow trout (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*) abundance and distribution have decreased from historical levels in Alberta. These species are listed under the federal *Species at Risk Act,* which identifies many anthropogenic threats to native trout in the province. Alberta's Native Trout Recovery Program is a collaboration of government and non-government organizations tasked with assessing native trout populations and recovering at-risk populations. The upper McLeod River watershed was identified through the Native Trout Recovery Program as a priority for inventory to provide current fisheries information on at-risk Athabasca rainbow trout and bull trout populations. The Alberta Fish Sustainability Index (FSI) is a standardized process of assessment that provides the framework within which fishery inventories must occur for greatest relevance to government managers and planners. Our objective was to describe fish distribution, abundance, and habitat in the upper McLeod River watershed of Alberta, with emphasis on native Athabasca rainbow trout and bull trout to address data deficiencies for these FSI priority species.

From July 13 to August 13, 2021, and July 12 to August 25, 2022, we sampled fish with backpack electrofishing gear and collected habitat data at 76 sites randomly distributed throughout eight watersheds classed as Hydrologic Unit Code (HUC) 10: Beaverdam Creek, Gregg River, Upper McLeod above Beaverdam Creek, Upper McLeod above Gregg River, Upper McLeod above Sundance Creek, Upper McLeod below Gregg River, Sundance Creek, and Whitehorse Creek. These HUC 10 sub-watersheds make up the greater Upper McLeod River HUC 8 watershed. We sampled an additional 15 sites in the Upper McLeod above Beaverdam Creek HUC 10 that were initially sampled by the Government of Alberta (GOA) in 2017 and will be used by GOA to assess the effectiveness of recovery actions in the Mackenzie Creek drainage. From 2020 to 2022, we measured stream temperature (hourly) at stations distributed throughout the HUC 10 sub-watersheds.

We captured 2,055 fish, including 368 rainbow trout ranging in size from 34 to 248 mm fork length (FL). Rainbow trout was the most widely distributed species we captured. We detected them in each HUC 10 sub-watershed and at 28 of the 76 sites sampled. The Upper McLeod above Sundance Creek HUC 10 had the highest mean relative abundance (fish per 300 m) of immature (<142 mm FL) and non-immature rainbow trout at 20.7 (Confidence Limits [CL] = 0.0–48.6) and 3.7 (CL = 0.0–9.4), respectively. We captured 82 bull trout (39–583 mm FL) in four of the HUC 10 sub-watersheds and at 6 of the 76 sites. The Upper McLeod above Beaverdam Creek HUC 10 had the highest mean relative abundance (fish per 300 m) of immature (<150 mm FL) and non-immature bull trout at 6.9 (CL = 0.0–17.3) and 0.4 (CL = 0.0–0.9), respectively. Of the 82 bull trout we captured, 73 were from two sites in the Upper McLeod above Beaverdam Creek HUC 10 on Mackenzie Creek, a stream known to be used by bull trout

for spawning. Thirty-three sites spread across all watersheds had zero fish captures (of any species).

Stream substrate composition in the headwaters of the Upper McLeod River HUC 8 watershed was dominated by cobble and large gravels, a habitat quality preferred by bull trout, while lower reaches were characterized by finer sediments. Suitable thermal habitat for rainbow trout was found throughout all HUC 10 sub-watersheds, while highly suitable summer temperatures for bull trout were limited to a few locations in the Upper McLeod above Beaverdam Creek, Upper McLeod above Gregg River, and Whitehorse Creek HUC 10 sub-watersheds.

Our study provides current information on stream habitats, and the abundance and distribution of Athabasca rainbow trout and bull trout, FSI priority species, within the Upper McLeod River HUC 8 watershed. This information is useful to land managers who must balance the diverse values of the land base and is critical for the conservation of native fish species that are particularly sensitive to habitat degradation.

Key words: Alberta, McLeod River, FSI, Athabasca rainbow trout, bull trout, distribution, abundance.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

Native trout species along the Eastern Slopes of the Rocky Mountains have intrinsic economic and ecologic value yet have seen a decrease in population size and distribution compared to historical levels (Sinnatamby et al. 2019). Athabasca River populations of rainbow trout (*Oncorhynchus mykiss*) are listed as *Endangered* under the federal *Species at Risk Act*, while Western Arctic populations of bull trout (*Salvelinus confluentus*) are listed as a species of *Special Concern* (Government of Canada 2023). Provincially, both species are listed as *Threatened* under Alberta's *Wildlife Act* (Alberta King's Printer 2023). Anthropogenic threats are leading causes of the decline of both populations, including habitat alteration and fragmentation, sediment introductions, non-native fish stocking, hybridization, and angling mortality (COSEWIC 2012, 2014; DFO 2020).

The Canadian Nature Fund for Aquatic Species at Risk (CNFASR) is a federal funding source to help slow the decline of at-risk aquatic species by supporting recovery activities that address key threats to the populations. The CNFASR has identified the Eastern Slopes as a priority area for funding recovery initiatives including population assessments and monitoring, habitat rehabilitation, and communication and outreach. The Native Trout Recovery Program, a collaboration between government and non-government organizations, has received funding through the CNFASR to carry out these initiatives with the goal of restoring fish habitat and increasing sustainable native trout populations.

The success of recovery actions is assessed using the Alberta Fish Sustainability Index (FSI). The FSI is a standardized process of assessment that provides a landscape-level overview of fish sustainability within the province and enables broad-scale evaluation of management actions and land-use planning. The FSI evaluates fish species on four groups of metrics: population integrity, population productivity, threats, and data reliability (MacPherson et al. 2014). Fishery inventory data are particularly suited to evaluation of the population integrity (adult and immature density) and productive potential (geographic extent) metrics. When conducting fishery inventories in Alberta, watersheds are scaled using a Hydrological Unit Code (HUC), appropriate for the focal fish species, with HUC 2 being the coarsest level and HUC 10 being the finest level.

The Upper McLeod River HUC 8 watershed was identified through the Native Trout Recovery Program as a priority for inventory work to provide current fisheries information on at-risk Athabasca rainbow trout and bull trout. While non-native rainbow trout stocking occurred in the watershed, genetic testing has shown that most rainbow trout populations are native (COSEWIC 2014). Angling restrictions in the watershed have led to some protection for Athabasca rainbow trout and bull trout; however, habitat degradation and fragmentation, and poaching still contribute to the stresses on these populations.

We had two objectives for this study:

- Provide up-to-date information on population abundance and distribution of native Athabasca rainbow trout and bull trout in the upper McLeod River watershed.
- Describe fish inventory and stream habitat in the Upper McLeod River HUC 8 watershed by assessing several HUC 10 sub-watersheds.

2.0 STUDY AREA

The McLeod River originates on the north side of the Cardinal Divide in Whitehorse Wildland Provincial Park south of Hinton, Alberta. It flows approximately 371 km northeast to its confluence with the Athabasca River at Whitecourt, Alberta. The Upper McLeod River HUC 8 watershed is approximately 3,062 km^2 and major tributaries within the watershed include Andersen Creek, Beaverdam Creek, Drinnan Creek, Gregg River, Mackenzie Creek, Teepee Creek, the Tri-Creeks (Deerlick, Eunice, and Wampus creeks), Sundance Creek, and Whitehorse Creek. Land-use activities within this watershed include forestry, mining, oil and gas exploration, and recreation. Historical fish stocking in the watershed has included Arctic grayling (*Thymallus arcticus*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), cutthroat trout (*Onchorhynchus clarkii*), rainbow trout (*Oncorhynchus mykiss*), tiger trout (*Salmo trutta* x *Salvelinus fontinalis*), walleye (*Sander vitreus*), and yellow perch (*Perca flavescens*) (Government of Alberta 2023). Our study area consists of the Upper McLeod River watershed (HUC 8) and includes the following HUC 10 sub-watersheds: Beaverdam Creek, Gregg River, Upper McLeod above Beaverdam Creek, Upper McLeod above Gregg River, Upper McLeod above Sundance Creek, Upper McLeod below Gregg River, Sundance Creek, and Whitehorse Creek (Figure 1).

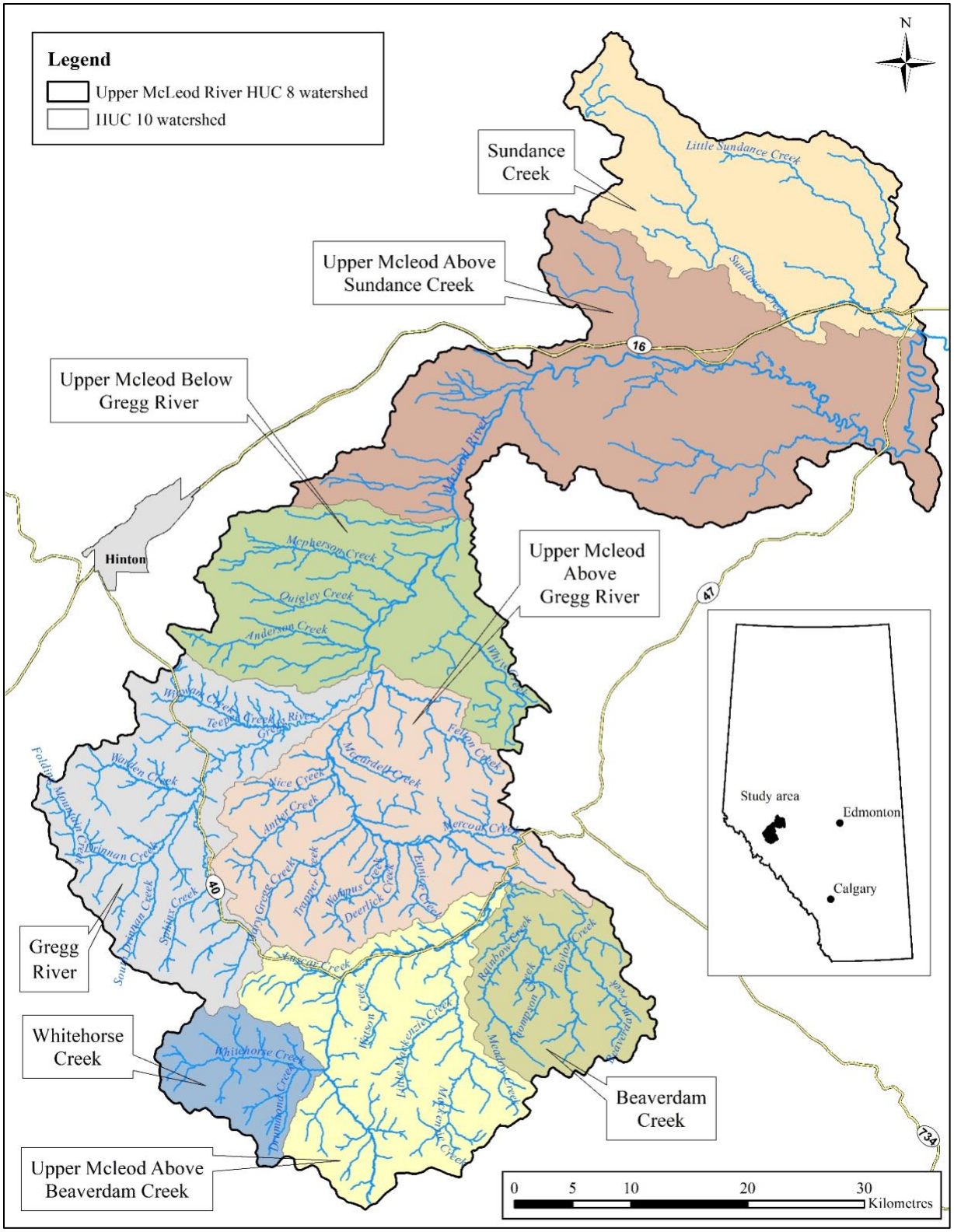

Figure 1. The Upper McLeod River Hydrological Unit Code (HUC) 8 watershed and HUC 10 sub-watersheds. Inset map shows the location of the study area within the province of Alberta.

3.0 MATERIALS AND METHODS

3.1 Fish distribution and abundance

From July 13 to August 13, 2021, and July 12 to August 25, 2022, we sampled 76 randomly distributed sites to describe the distribution and relative abundance of Athabasca rainbow trout, bull trout, and other fish species in the Upper McLeod River HUC 10 sub-watersheds (Figure 2). We distributed prospective sample sites at 800 m intervals in an upstream progression along the length of second- to fifth-order streams (>400 m; 1:20,000 scale) (Strahler 1952) within each HUC 10 sub-watershed using a geographical information system (GIS) (ArcGIS version 10.6) and the Government of Alberta (GOA) Resource Management Information Branch hydro line data layer. Sample sites were randomly selected without replacement using a generalized random tessellation stratified (GRTS) design (Stevens and Olsen 2004). We used a conservative target of ten sample sites per HUC 10 sub-watershed based on past evaluations of our power to detect immature bull trout (Rodtka and Judd 2015, Rodtka et al. 2015). Sites were assessed in the order in which they were drawn. To accommodate non-response sites, we drew a total of 13 sites per sample frame. Non-response sites (n = 23) included dry sites, inaccessible sites (i.e., sites > 1 km from the nearest access), and sites that could not be safely sampled. Alternate sites were sampled if a non-response site was identified (Figure 2). The GRTS sampling design allowed us to adjust our sample size to accommodate non-response sites while maintaining a spatially balanced sample (Stevens and Olsen 2004).

The previous watershed-scale assessment was completed in 2006 and reaffirmed the importance of Mackenzie Creek, a McLeod River tributary, for bull trout spawning (Fitzsimmons 2010). In 2017, the GOA completed a 19-site electrofishing inventory in the Mackenzie Creek drainage prior to initiating trail system restoration and upgrades to lessen the impact on native fish populations. In August 2022, we completed an additional 15 sites in the Upper McLeod above Beaverdam Creek HUC 10 (MAB), repeating sites initially sampled by the GOA in 2017. The other four GOA sites were either near sites we had already sampled as part of the project (MAB2 and MAB3), or the trails used to access them were reclaimed and the sites are no longer accessible. These repeated sites will be used by the GOA to assess effectiveness of recovery actions in in the Mackenzie Creek drainage. Repeated sites were not a part of our random sample and consequently are excluded from our analysis. Summary data from these sites are contained in Appendix 1.

A handheld Global Positioning System (GPS) was used to locate sample sites. All site sampling commenced at the head of riffle habitat. Our sample protocol for backpack electrofishing required sample sites be 300 m long (measured with a hip chain). Some sites were less than 300 m due to insufficient flow. Sites were sampled using a Smith-Root LR-20B backpack electrofisher with pulsed DC (voltage 150–300 V, frequency 30–50 Hz, and duration

6.7–10.0 ms). Electrofishing effort (seconds) was recorded at 50 m intervals. Fish were identified to species, enumerated, and measured (fork length [FL], mm). Bull trout were visually inspected upon capture for morphological features of hybridization with brook trout based on criteria in Popowich et al. (2011). We report native salmonid relative abundance by maturity classification to align with FSI convention. Immature bull trout, rainbow trout, and mountain whitefish (*Prosopium williamsoni*) are defined as having a fork length less than 150, 142, and 221 mm, respectively (L. MacPherson pers. comm.).

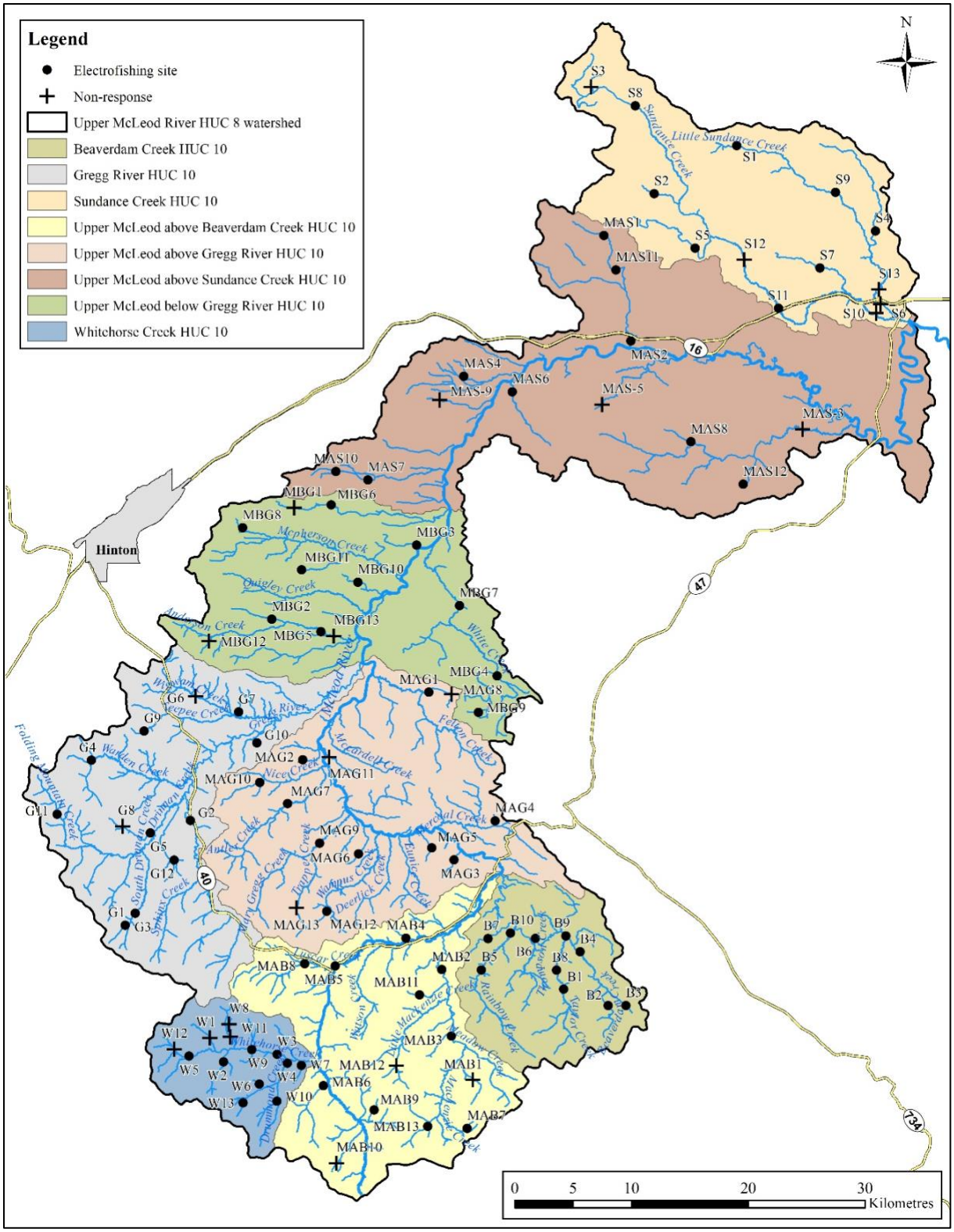

Figure 2. Electrofishing sites within the HUC 10 sub-watersheds of the Upper McLeod River watershed in Alberta, 2021 and 2022.

3.2 Stream habitat measurement

At all sample sites, we measured stream temperature (1°C) and ambient stream conductivity (1 µS/cm) prior to electrofishing. Ambient stream conductivity has been demonstrated to significantly impact detection of immature bull trout using electrofishing gear (Rodtka et al. 2015). We measured stream depth (0.01 m), wetted width (0.1 m), and rooted width (0.1 m) at transects spaced at 50 m intervals. Habitat type and dominant substrate type were assessed between transects. We visually estimated the percentage (nearest 5%) of pool habitat (reduced current velocity, little surface turbulence, water deeper than surrounding areas), riffle habitat (swift flow of water over bed materials producing surface turbulence), and run habitat (uniform but swift flow of water without surface waves). Dominant substrate type was scored based on a modified Wentworth (1922) scale: fines (< 2 mm; score 0), small gravel (2–16 mm; score 1), large gravel (17–64 mm; score 2), cobble (65–256 mm; score 3), boulder (>256 mm; score 4), and bedrock (score 5).

In 2020, we installed temperature loggers (HOBO UA-001-64) to measure summer (July 1–August 31) stream temperature (1°C) every hour at eight stations located throughout the Upper McLeod River HUC 8 watershed to describe the thermal habitats available. In 2021 and 2022, we replicated the 2020 stream temperature monitoring and added more stations throughout the watershed, for a total of 13 and 16 stations, respectively (Figure 3). We did not include temperature data from loggers not expected to be in water (n = 3 in 2020), loggers that were not recovered (n = 1 in 2020), and loggers that malfunctioned (n = 1 in 2022).

All fish and habitat sampling followed the GOA's *Standard for Sampling of Small Streams in Alberta* (AESRD 2013). Information acquired in the field was submitted for inclusion into the GOA Fisheries and Wildlife Management Information System (FWMIS) database and to Fisheries and Oceans Canada as a condition of *Species at Risk Act* permit requirements.

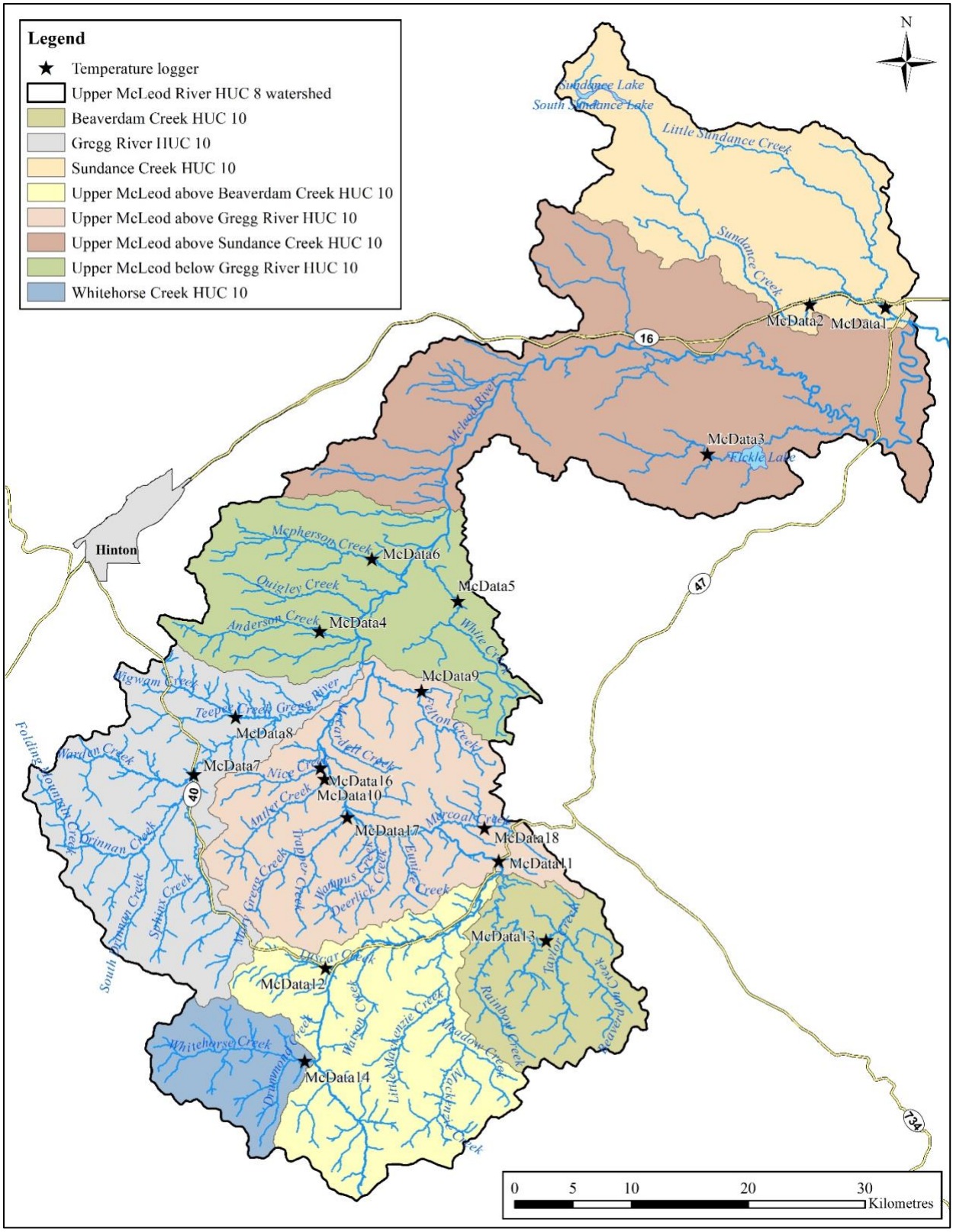

Figure 3. Locations of stream temperature stations within the Upper McLeod River HUC 8 watershed in Alberta, 2021 and 2022.

4.0 RESULTS

4.1 Fish distribution and abundance

We sampled 76 sites with backpack electrofishing gear resulting in a total sampling effort of more than 68,500 seconds over 22.4 km of stream. Site-specific location information and effort data are provided in Appendix 2. In total, we captured 2,055 fish (Table 1). Our catch included several species in addition to rainbow trout and bull trout: brook trout, brook stickleback (*Culaea inconstans*), burbot (*Lota lota*), finescale dace (*Phoxinus neogaeus*), lake chub (*Couesius plumbeus*), longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mountain whitefish, northern redbelly dace (*Chrosomus eos*), northern pike (*Esox lucius*), pearl dace (*Margariscusn nachtriebi*), spoonhead sculpin (*Cottus ricei*), and white sucker (*Catostomus commersonii*).

Rainbow trout were the most abundant salmonid species we captured, composing 18% of our total catch (Table 1). Rainbow trout were also the most widely distributed fish species, detected in each of the HUC 10 sub-watersheds and at 28 of the 76 sites sampled. We captured a single rainbow trout at site W3 on Whitehorse Creek, the only fish caught in the Whitehorse Creek HUC 10 sub-watershed (Table 1, Figure 4). There is a waterfall barrier immediately upstream of the endpoint of site W3.

Bull trout were less abundant and captured in only four of the HUC 10 sub-watersheds and at 6 of the 76 sites (Table 1). Most of the bull trout we captured electrofishing were from two sites in the Upper McLeod above Beaverdam Creek HUC 10 sub-watershed on Mackenzie Creek, a stream known to be used by spawning bull trout (Appendix 2). None of the bull trout we captured showed evidence of hybridization with brook trout. Brook trout were abundant in the Beaverdam Creek HUC 10 sub-watershed and were detected at 8 of the 10 sites (Table 1). We captured mountain whitefish at only four sites located in two of the HUC 10 sub-watersheds (Table 1). Thirty-three sites, occurring across all sub-watersheds, had zero fish captures (of any species) (Figure 4). Site-specific catch data are provided in Appendix 3.

We repeated an additional 15 sites in the Mackenzie Creek drainage in the Upper McLeod above Beaverdam Creek HUC 10 sub-watershed that were initially sampled by GOA in 2017. We caught 650 bull trout, 15 rainbow trout, and one mountain whitefish. Site-specific location and catch data are provided in Appendix 1.

Table 1. Number of sites where fish were detected and total catch of each fish species using backpack electrofishing gear in eight HUC 10 sub-watersheds of Alberta, sampled from July 13 to August 13, 2021, and July 12 to August 25, 2022.

Species[1]	Site detections (n) per HUC 10 sub-watershed								Total catch (%)
	Beaverdam Creek	Gregg River	McLeod above Beaverdam	McLeod above Gregg	McLeod above Sundance	McLeod below Gregg	Sundance Creek	Whitehorse Creek	
BKTR	8	1	2	2	0	1	4	0	266 (13)
BLTR	0	1	3	1	0	1	0	0	82 (4)
BRST	0	0	0	0	2	0	3	0	54 (3)
BURB	5	0	0	1	1	0	0	0	19 (1)
FNDC	0	0	0	0	1	0	3	0	832 (40)
LKCH	0	0	0	0	0	0	2	0	13 (1)
LNDC	2	0	0	0	2	1	0	0	16 (1)
LNSC	0	0	0	0	0	1	6	0	64 (3)
MNWH	3	0	0	1	0	0	0	0	34 (2)
NRDC	0	0	0	0	0	0	2	0	17 (1)
NRPK	0	0	0	0	0	0	1	0	2 (<1)
PRDC	0	0	0	0	5	2	4	0	141 (7)
RNTR	8	3	2	5	3	2	4	1	368 (18)
SPSC	7	0	0	0	0	0	0	0	35 (2)
WHSC	0	0	0	0	1	1	3	0	112 (5)

[1] Species codes: BKTR = brook trout, BLTR = bull trout, BRST = brook stickleback, BURB = burbot, FNDC = finescale dace, LKCH = lake chub, LNDC = longnose dace, LNSC = longnose sucker, MNWH = mountain whitefish, NRDC = northern redbelly dace, NRPK = northern pike, PRDC = pearl dace, RNTR = rainbow trout, SPSC = spoonhead sculpin, WHSC = white sucker.

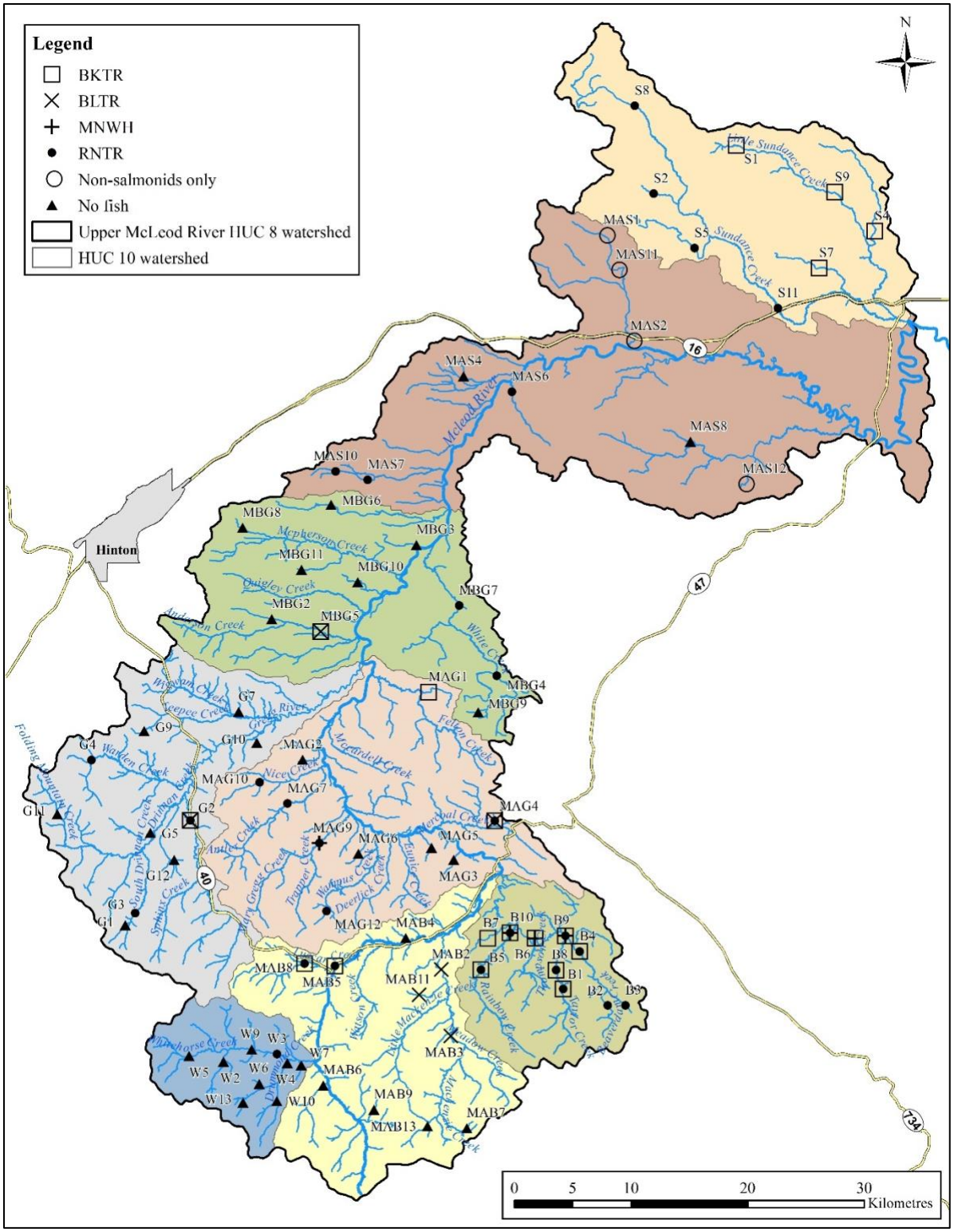

Figure 4. The distribution of salmonid and non-salmonid species captured using backpack electrofishing gear within each HUC 10 sub-watershed of the Upper McLeod River watershed in Alberta, July 13 to August 13, 2021, and July 12 to August 25, 2022. Species codes: BKTR = brook trout, BLTR = bull trout, MNWH = mountain whitefish, and RNTR = rainbow trout.

Our rainbow trout catch ranged in size from 34 to 238 mm FL and mainly consisted of immature fish (<142 mm FL) across all HUC 10 sub-watersheds. Our bull trout catch ranged in size from 39 to 583 mm FL and mainly consisted of immature fish (<150 mm FL) from the Upper McLeod above Beaverdam Creek HUC 10 (Table 2). Length frequency histograms of our brook trout, bull trout, mountain whitefish, and rainbow trout catch are contained in Appendix 4.

The mean relative abundance (catch per 300 m) of rainbow trout and bull trout was highest in the Upper McLeod above Sundance Creek and Upper McLeod above Beaverdam Creek HUC 10s, respectively (Table 3).

Table 2. Size distribution of brook trout, bull trout, rainbow trout, and mountain whitefish captured in each HUC 10 sub-watershed of Alberta's Upper McLeod River watershed using backpack electrofishing gear, July 13 to August 13, 2021, and July 12 to August 25, 2022.

HUC 10 sub-watershed	Fork length (mm)											
	BKTR			BLTR			RNTR			MNWH		
	Mean ± SD	Range	n	Mean ± SD	Range	n	Mean ± SD	Range	n	Mean ± SD	Range	n
Beaverdam Creek	100 ± 42	30–230	76	-	65–199	35	117 ± 35	65–199	35	93 ± 35	46–131	33
Gregg River	157 ± 35	63–192	13	149 ± 32	116–181	6	158 ± 39	95–238	20	-	-	-
McLeod above Beaverdam	112 ± 37	42–205	120	110 ± 61	39–583	74	102 ± 40	65–205	35	-	-	-
McLeod above Gregg	141 ± 32	93–175	7	170 ± 0	-	1	93 ± 32	50–169	32	275 ± 0	-	1
McLeod above Sundance	-	-	-	-	-	-	109 ± 31	34–193	220	-	-	-
McLeod below Gregg	115 ± 49	71–190	5	208 ± 0	-	1	138 ± 39	76–226	15	-	-	-
Sundance Creek	117 ± 53	53–270	45	-	-	-	108 ± 29	77–159	10	-	-	-
Whitehorse Creek	-	-	-	-	-	-	231 ± 0	-	-	-	-	-

[1]Species codes: BKTR = brook trout, BLTR = bull trout, RNTR = rainbow trout, and MNWH = mountain whitefish.

Table 3. Bootstrapped mean relative abundance (10,000 replicates) of brook trout, bull trout, rainbow trout, and mountain whitefish captured in each HUC 10 sub-watershed of Alberta's Upper McLeod River watershed using backpack electrofishing gear, July 13 to August 13, 2021, and July 12 to August 25, 2022.

HUC 10 sub-watershed	Mean catch/300 m (95% CL[1]) by species[2] and maturity						
	BKTR	BLTR		RNTR		MNWH	
	All fish	Immature <150mm FL[3]	Non-immature	Immature <142mm FL	Non-immature	Immature <221mm FL	Non-immature
Beaverdam Creek	7.6 (3.7–11.6)	0	0	2.7 (0.4–6.9)	0.8 (0.3–1.4)	3.3 (0.0–7.7)	0
Gregg River	1.3 (0.0–3.9)	0.3 (0.0–0.9)	0.3 (0.0–0.9)	0.5 (0.0–1.5)	1.5 (0.0–3.1)	0	0
McLeod above Beaverdam	12.8 (0.0–38.4)	6.9 (0.0–17.3)	0.4 (0.0–0.9)	2.9 (0.0–8.7)	0.6 (0.0–1.6)	0	0
McLeod above Gregg	0.7 (0.0–1.9)	0	0.1 (0.0–0.3)	2.9 (0.2–7.7)	0.3 (0.1–0.6)	0	0.1 (0.0–0.3)
McLeod above Sundance	0	0	0	20.7 (0.0–48.6)	3.7 (0.0–9.4)	0	0
McLeod below Gregg	0.5 (0.0–1.5)	0	0.1 (0.0–0.3)	0.8 (0.0–2.0)	0.7 (0.0–1.9)	0	0
Sundance Creek	5.6 (0.5–13.4)	0	0	0.9 (0.1–2.0)	0.4 (0.0–0.9)	0	0
Whitehorse Creek	0	0	0	0	0.1 (0.0–0.3)	0	0

[1]CL = confidence limits
[2]Species codes: BKTR = brook trout, BLTR = bull trout, RNTR = rainbow trout, MNWH = mountain whitefish
[3]FL = fork length

4.2 Stream habitat measurement

Stream substrate composition was dominated primarily by cobble and large gravels from the headwaters of the HUC 8 watershed downstream to the Upper McLeod above Gregg River HUC 10 (Tables 4a, 4b). Large gravel and cobble substrate are habitat qualities preferred by bull trout (ASRD and ACA 2009). Stream substrate composition in HUC 10 sub-watersheds downstream from the Upper McLeod above Gregg River was dominated primarily by finer sediments (Tables 4a, 4b). See Appendix 5 for site-specific habitat measurements.

All stations across the Upper McLeod River HUC 8 watershed from 2020, 2021, and 2022 had mean summer stream temperatures ranging from 6 to 16°C, with temperatures generally highest in 2021 and lowest in 2020 (Table 5). Highly suitable thermal habitat for bull trout (i.e., mean summer stream temperature ≤ 10°C; Isaak et al. 2009) was present in the Upper McLeod River HUC 8 watershed in Anderson Creek (McData4), Whitehorse Creek (McData14), and Nice Creek (McData16) (Table 5). In 2020, loggers were installed during high stream flows and several of the locations went dry shortly after installation. High stream temperatures in early July 2021 were influenced by a record-breaking heatwave that occurred across western North America in late June 2021. Logger McData14 was close to Whitehorse Creek Campground, and we suspect was pulled out of the water before the end of each season; therefore, data for this logger was trimmed (see Table 5 footnote). A two-day moving average of stream temperatures recorded at each station during each year is presented in Appendix 6.

Table 4a. Summary of stream habitat measurements (temperature, ambient conductivity, mean wetted width) in each HUC 10 sub-watershed of Alberta's Upper McLeod River watershed collected while backpack electrofishing, July 13 to August 13, 2021, and July 12 to August 25, 2022.

	Stream temperature (˚C)		**Ambient conductivity (µS/cm)**		**Mean wetted width (m)**	
HUC 10 sub-watershed	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**
Beaverdam Creek	14 ± 4	6–19	95 ± 18	71–124	4.3 ± 3.0	0.2–12.3
Gregg River	9 ± 2	7–13	250 ± 152	104–599	2.5 ± 2.3	0.2–11.5
McLeod above Beaverdam	9 ± 2	6–11	278 ± 235	67–796	3.8 ± 4.0	0.5–16.1
McLeod above Gregg	9 ± 4	6–16	178 ± 218	61–783	1.8 ± 2.1	0.3–8.4
McLeod above Sundance	13 ± 4	6–18	311 ± 47	257–416	1.8 ± 1.2	0.2–6.4
McLeod below Gregg	11 ± 4	8–22	193 ± 91	74–369	1.7 ± 1.6	0.2–6.8
Sundance Creek	16 ± 3	10–19	318 ± 45	251–386	3.3 ± 1.7	0.8–7.7
Whitehorse Creek	9 ± 3	4–15	240 ± 96	88–353	3.6 ± 2.4	0.3–12.1

[1]Substrate codes: B = boulder, C = cobble, F = fines, LG = large gravel, SG = small gravel.

Table 4b. Summary of stream habitat measurements (mean rooted width, mean maximum depth, modal stream stage, modal substrate) in each HUC 10 sub-watershed of Alberta's Upper McLeod River watershed collected while backpack electrofishing, July 13 to August 13, 2021, and July 12 to August 25, 2022.

	Mean rooted width (m)		Mean maximum depth (m)		Modal stream stage	Modal substrate[1]	
HUC 10 sub-watershed	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**		**Primary**	**Secondary**
Beaverdam Creek	6.5 ± 3.8	0.2–14.2	0.36 ± 0.26	0.04–1.64	Moderate	LG	SG
Gregg River	4.2 ± 3.9	0.2–18.7	0.24 ± 0.13	0.03–0.72	Low	C	LG
McLeod above Beaverdam	5.0 ± 4.6	0.5–16.9	0.25 ± 0.16	0.07–1.05	Low	C	LG
McLeod above Gregg	2.8 ± 3.4	0.2–12.4	0.30 ± 0.21	0.06–1.21	Moderate	LG	SG
McLeod above Sundance	3.9 ± 2.2	0.6–10.9	0.26 ± 0.22	0.02–1.18	Low	F	SG
McLeod below Gregg	2.1 ± 2.2	0.2–8.4	0.30 ± 0.18	0.02–0.91	Moderate	F	LG
Sundance Creek	4.1 ± 1.9	1.1–8.0	0.53 ± 0.27	0.14–1.18	Moderate	F	SG
Whitehorse Creek	8.1 ± 5.1	0.5–23.4	0.30 ± 0.16	0.05–0.88	Moderate	C	LG

[1]Substrate codes: B = boulder, C = cobble, F = fines, LG = large gravel, SG = small gravel.

Table 5. Summary of stream temperature measurements in Alberta's Upper McLeod River watershed, 2020–2022.

Station	UTM Location NAD 83 Zone 11		2020[1]		2021[2]		2022[3]	
	Easting	Northing	Mean ± SD temperature (°C)	Temperature range (°C)	Mean ± SD temperature (°C)	Temperature range (°C)	Mean ± SD temperature (°C)	Temperature range (°C)
McData1	526121	5935100	-	-	15 ± 3	9–25	15 ± 2	11–21
McData2	519644	5935349	14 ± 2	9–19	16 ± 3	9–24	16 ± 2	11–20
McData3	510881	5922534	13 ± 2	7–20	16 ± 3	8–26	16 ± 3	9–25
McData4	477689	5907367	8 ± 2	5–12	10 ± 2	6–15	10 ± 2	6–14
McData5	489510	5909939	13 ± 3	7–20	16 ± 3	8–23	-	-
McData6	482167	5913577	-	-	-	-	15 ± 2	11–21
McData7	466892	5895093	-	-	12 ± 2	7–17	11 ± 2	6–16
McData8	470486	5900022	-	-	13 ± 2	6–19	11 ± 2	6–16
McData9	486410	5902244	9 ± 2	5–14	11 ± 2	6–17	11 ± 2	6–15
McData10	478106	5894704	-	-	13 ± 2	7–20	12 ± 2	7–16
McData11	493015	5887692	-	-	13 ± 3	7–19	13 ± 3	6–19
McData12	478168	5878535	10 ± 2	5–17	12 ± 3	6–19	11 ± 2	6–17
McData13	497070	5880891	12 ± 3	6–21	15 ± 3	7–23	14 ± 3	7–21
McData14[4]	476411	5870569	6 ± 2	3–15	9 ± 2	5–15	8 ± 3	3–15
McData16	477744	5895669	-	-	-	-	10 ± 2	6–14
McData17	480049	5891437	-	-	-	-	12 ± 3	6–19
McData18	491793	5890520	-	-	-	-	15 ± 2	9–20

[1] eight stations, July 1 to August 31, 2020

[2] 13 stations, July 1 to August 31, 2021

[3] 16 stations July 1 to August 31, 2022

[4] July 1 – Aug. 6, 2020, July 1 – Aug. 6, 2021, and July 1 – Aug. 26, 2022

5.0 SUMMARY

Alberta Conservation Association staff sampled 76 sites located throughout eight HUC 10 sub-watersheds within the Upper McLeod River HUC 8 watershed in 2021 and 2022 using backpack electrofishing gear. We detected rainbow trout in each of the HUC 10 sub-watersheds, with the Upper McLeod above Sundance Creek HUC 10 having the highest relative abundance. Rainbow trout were the most widely distributed fish species we captured and the most abundant salmonid species. We detected bull trout in four of the HUC 10 sub-watersheds, with the Upper McLeod above Beaverdam Creek having the highest relative abundance. We captured 650 bull trout at 15 sites in the Mackenzie Creek drainage that repeated sites originally sampled by GOA in 2017. Use of Mackenzie Creek by spawning and rearing bull trout is well documented and it appears to be the only tributary of its kind in the upper Mcleod River watershed.

Stream substrate composition in the headwaters of the Upper McLeod River HUC 8 watershed was dominated primarily by cobble and large gravels, a habitat quality preferred by bull trout. Stream temperature also plays an important role in aquatic community processes and has been correlated to fish species distribution and abundance (Rieman et al. 2007, Isaak et al. 2012). Athabasca rainbow trout and bull trout are adapted to living in cold-water habitats, which limits their distribution to cold headwater streams within their preferred temperature range. Preferred temperatures for rainbow trout range from 7 to 18°C, while temperatures from 22 to 24°C are considered life threatening (Alberta Athabasca Rainbow Trout Recovery Team 2014). Stream temperature measurements recorded during this study indicate that summer stream temperatures were suitable for rainbow trout throughout the Upper McLeod River HUC 8 watershed, whereas temperatures highly suitable for bull trout were limited to a few locations in the Upper McLeod above Beaverdam Creek, Upper McLeod above Gregg River, and Whitehorse Creek HUC 10 sub-watersheds.

Our study provides current information on stream habitats, and the abundance and distribution of at-risk Athabasca rainbow trout and bull trout, FSI priority species, within the Upper McLeod River HUC 8 watershed. This information is useful to land managers who must balance the diverse values of the land base upon which they operate and is critical for the conservation of native fish species that are particularly sensitive to habitat degradation.

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7.0 APPENDICES

Appendix 1. Backpack electrofishing site locations and fish catch in the Mackenzie Creek drainage in the Upper McLeod above Beaverdam Creek HUC 10 that repeated Government of Alberta sites sampled in 2017.

Site ID	Date (dd/mm/yyyy)	UTM Location NAD 83 Zone 11		Distance (m)	Effort (s)	Species[1]			
						BLTR		MNWH	RNTR
		Easting	Northing			Immature < 150 mm FL	Non-immature	All fish	All fish
MC1	06/08/2022	487749	5878768	300	1,619	34	2	0	2
MC2	06/08/2022	490265	5871738	300	1,444	32	0	0	0
MC4	25/08/2022	487946	5866838	300	1,817	170	3	0	3
MC5	24/08/2022	492324	5869292	300	584	0	5	0	0
MC6	05/08/2022	488646	5877014	300	1,236	34	1	0	0
MC7	25/08/2022	488638	5869768	300	1,364	34	10	0	0
MC9	03/08/2022	487979	5875696	300	996	47	0	0	5
MC10	03/08/2022	487246	5875038	300	1,196	38	2	0	4
MC11	25/08/2022	488946	5872700	300	1,441	65	14	0	0
MC13	05/08/2022	488779	5875120	300	1,544	89	2	1	0
MC15	25/08/2022	485411	5873556	300	954	20	3	0	1
MC16	03/08/2022	488309	5877173	300	829	6	2	0	0
MC17	24/08/2022	493914	5869203	300	675	0	0	0	0
MC18	24/08/2022	492075	5870632	300	1,143	8	0	0	0
MC19	06/08/2022	488979	5873040	300	931	29	0	0	0

[1] Species codes: BLTR = bull trout, MNWH = mountain whitefish, RNTR = rainbow trout. FL = fork length.

Appendix 2. Backpack electrofishing site locations and effort in the Beaverdam Creek (B), Gregg River (G), Upper McLeod above Beaverdam Creek (MAB), Upper McLeod above Gregg River (MAG), Upper McLeod above Sundance Creek (MAS), Upper McLeod below Gregg River (MBG), Sundance Creek (S), and Whitehorse Creek (WH) HUC 10 sub-watersheds in Alberta, 2021 and 2022

Site ID	Date (dd/mm/yyyy)	UTM Location NAD 83 Zone 11		Distance (m)	Effort (s)
		Easting	Northing		
B1	13/07/2021	498547	5876699	300	1,140
B2	14/07/2021	502369	5875317	300	889
B3	13/07/2021	503894	5875303	300	688
B4	14/07/2021	499957	5879941	300	1,087
B5	15/07/2021	491513	5878364	300	967
B6	15/07/2021	495980	5880897	300	1,483
B7	15/07/2021	492088	5881061	300	665
B8	13/07/2021	497961	5878348	300	1,265
B9	14/07/2021	498784	5881282	300	1,348
B10	15/07/2021	494235	5881705	300	1,094
G1	28/07/2021	461012	5882189	300	802
G2	04/08/2021	466589	5891167	300	1,895
G3	29/07/2021	461862	5883221	300	1,087
G4	17/07/2021	458109	5896318	300	956
G5	18/07/2021	463182	5890101	300	859
G7	16/07/2021	470715	5900456	300	433
G9	16/07/2021	462639	5898822	300	626
G10	16/07/2021	472283	5897814	300	668
G11	29/07/2021	455195	5891697	300	906
G12	19/07/2021	465206	5887775	300	728
MAB2	05/08/2022	488129	5878394	300	1,141
MAB3	06/08/2022	488946	5872700	300	1,530
MAB4	04/08/2022	485059	5881081	300	623
MAB5	04/08/2022	479001	5878709	278	1,111
MAB6	04/08/2022	477983	5868466	300	799
MAB7	24/08/2022	490291	5864808	300	679
MAB8	04/08/2022	476378	5878889	300	1,090
MAB9	06/08/2022	482335	5866386	300	764
MAB11	06/08/2022	486221	5876221	300	651
MAB13	25/08/2022	486920	5864978	300	647

Appendix 2 continued:

Site ID	Date (dd/mm/yyyy)	UTM Location NAD 83 Zone 11		Distance (m)	Effort (s)
		Easting	Northing		
MAG1	14/07/2022	487017	5902149	300	550
MAG2	20/07/2022	476214	5896370	300	664
MAG3	22/07/2022	489177	5887793	300	919
MAG4	14/07/2022	492700	5891133	300	1,170
MAG5	22/07/2022	487269	5888826	300	669
MAG6	21/07/2022	480995	5888304	300	758
MAG7	20/07/2022	474913	5892615	300	894
MAG9	21/07/2022	477663	5889216	300	1,344
MAG10	20/07/2022	472531	5894425	300	749
MAG12	21/07/2022	478277	5883392	300	652
MAS1	07/08/2021	501997	5941259	160	627
MAS2	07/08/2021	504316	5932211	300	1,246
MAS4	05/08/2021	490003	5929229	243	430
MAS6	06/08/2021	494172	5927885	300	1,209
MAS7	05/08/2021	481815	5920322	300	1,485
MAS8	06/08/2021	509468	5923599	300	660
MAS10	05/08/2021	479055	5921052	300	1,633
MAS11	07/08/2021	503001	5938326	300	1,300
MAS12	07/08/2021	513946	5919964	300	603
MBG2	12/07/2022	473573	5908400	300	1,109
MBG3	12/07/2022	485967	5914757	300	661
MBG4	13/07/2022	492874	5903550	300	738
MBG5	13/07/2022	477778	5907347	300	1,200
MBG6	12/07/2022	478645	5918202	300	502
MBG7	13/07/2022	489653	5909559	300	1,503
MBG8	12/07/2022	471071	5916226	300	825
MBG9	13/07/2022	491263	5900416	300	506
MBG10	12/07/2022	480936	5911576	300	749
MBG11	12/07/2022	476115	5912638	150	197
S1	24/07/2022	513387	5948966	300	964
S2	23/07/2022	506322	5944842	300	860
S4	25/07/2022	525273	5941651	300	1,032
S5	23/07/2022	509819	5940178	300	823
S7	24/07/2022	520498	5938480	300	1,094
S8	23/07/2022	504701	5952367	300	1,013
S9	25/07/2022	521842	5944964	300	867
S11	24/07/2022	516968	5935038	300	728

Appendix 2 continued:

Site ID	Date (dd/mm/yyyy)	UTM Location NAD 83 Zone 11		Distance (m)	Effort (s)
		Easting	Northing		
W2	28/07/2021	469439	5870502	300	696
W3	28/07/2021	474033	5871141	300	924
W4	28/07/2021	474900	5870385	300	939
W5	28/07/2021	466474	5870973	300	772
W6	28/07/2021	472488	5868594	300	710
W7	04/08/2021	476100	5870183	300	692
W9	28/07/2021	471849	5871557	300	1,085
W10	28/07/2021	474005	5867136	300	684
W13	28/07/2021	471019	5866822	300	611

Appendix 3. Backpack electrofishing fish catch in the Beaverdam Creek (B), Gregg River (G), Upper McLeod above Beaverdam Creek (MAB), Upper McLeod above Gregg River (MAG), Upper McLeod above Sundance Creek (MAS), Upper McLeod below Gregg River (MBG), Sundance Creek (S), and Whitehorse Creek (WH) HUC 10 sub-watersheds in Alberta, 2021 and 2022.

Site ID	Species[1]														
	BKTR	BLTR	BRST	BURB	FNDC	LKCH	LNDC	LNSC	MNWH	NRDC	NRPK	PRDC	RNTR	SPSC	WHSC
B1	5	0	0	6	0	0	0	0	0	0	0	0	1	3	0
B2	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0
B3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B4	3	0	0	2	0	0	0	0	0	0	0	0	1	7	0
B5	6	0	0	2	0	0	0	0	0	0	0	0	2	2	0
B6	13	0	0	2	0	0	1	0	21	0	0	0	0	7	0
B7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B8	17	0	0	3	0	0	0	0	0	0	0	0	4	9	0
B9	17	0	0	0	0	0	1	0	2	0	0	0	1	6	0
B10	13	0	0	0	0	0	0	0	10	0	0	0	1	1	0
G1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G2	13	6	0	0	0	0	0	0	0	0	0	0	9	0	0
G3	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
G4	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
G5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB2	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB3	0	53	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3 continued:

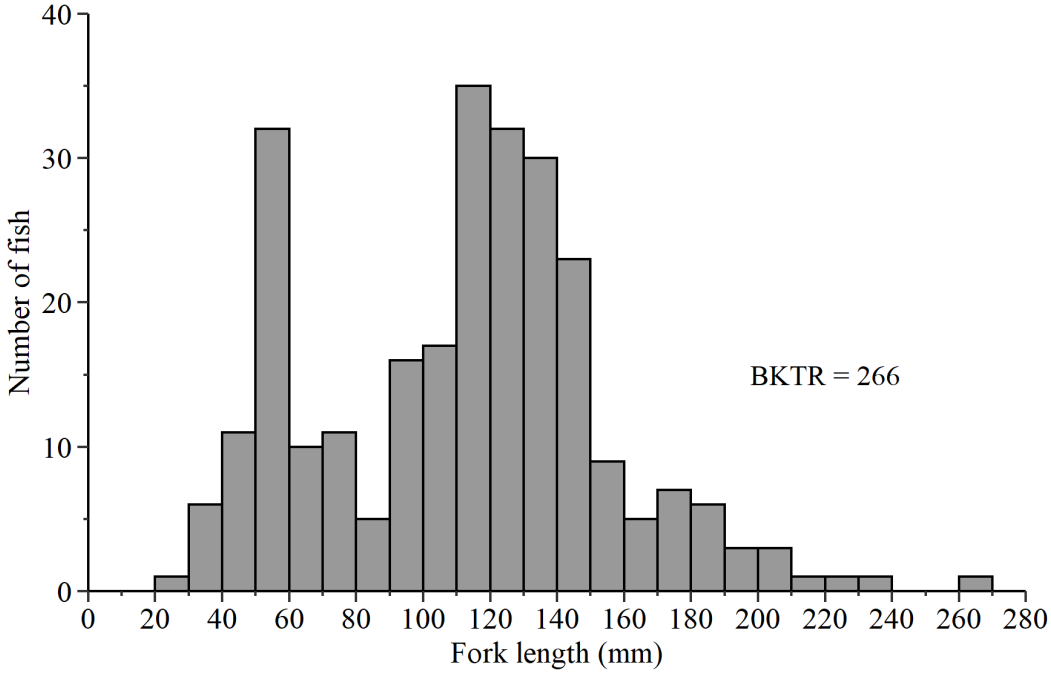
Site ID	Species[1]														
	BKTR	**BLTR**	**BRST**	**BURB**	**FNDC**	**LKCH**	**LNDC**	**LNSC**	**MNWH**	**NRDC**	**NRPK**	**PRDC**	**RNTR**	**SPSC**	**WHSC**
MAB5	118	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MAB6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB8	2	0	0	0	0	0	0	0	0	0	0	0	34	0	0
MAB9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB11	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MAB13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG4	6	1	0	0	0	0	0	0	0	0	0	0	1	0	0
MAG5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAG7	0	0	0	1	0	0	0	0	0	0	0	0	5	0	0
MAG9	0	0	0	0	0	0	0	0	1	0	0	0	23	0	0
MAG10	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
MAG12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MAS1	0	0	3	0	0	0	0	0	0	0	0	10	0	0	0
MAS2	0	0	0	3	5	0	12	0	0	0	0	49	0	0	50
MAS4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAS6	0	0	0	0	0	0	1	0	0	0	0	3	46	0	0
MAS7	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0
MAS8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAS10	0	0	0	0	0	0	0	0	0	0	0	0	144	0	0
MAS11	0	0	5	0	0	0	0	0	0	0	0	22	0	0	0
MAS12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MBG2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG4	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1

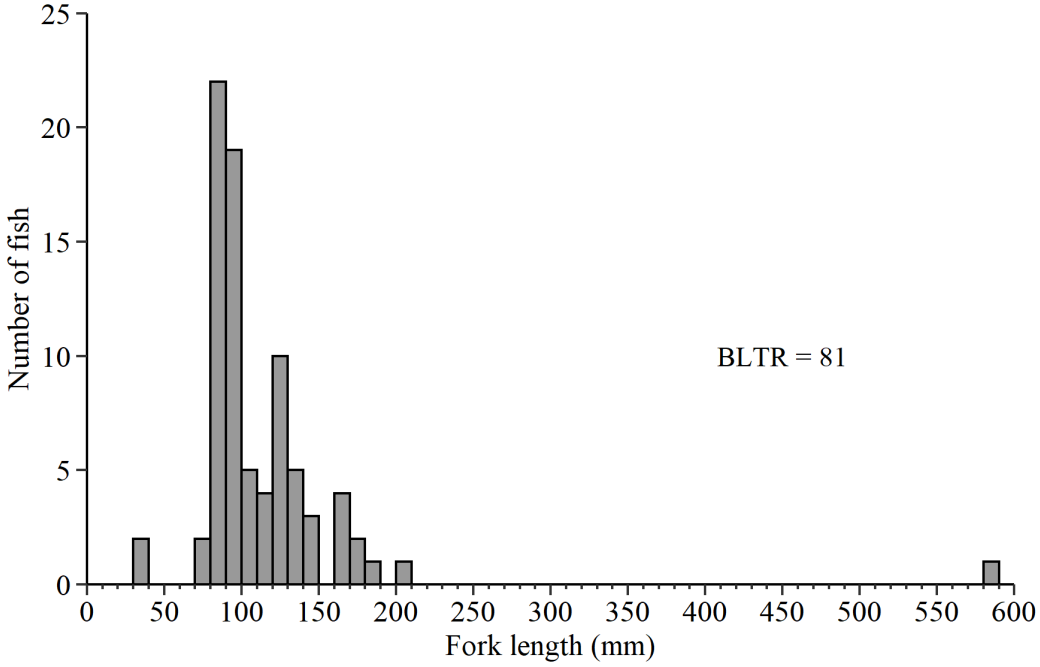
Appendix 3 continued:

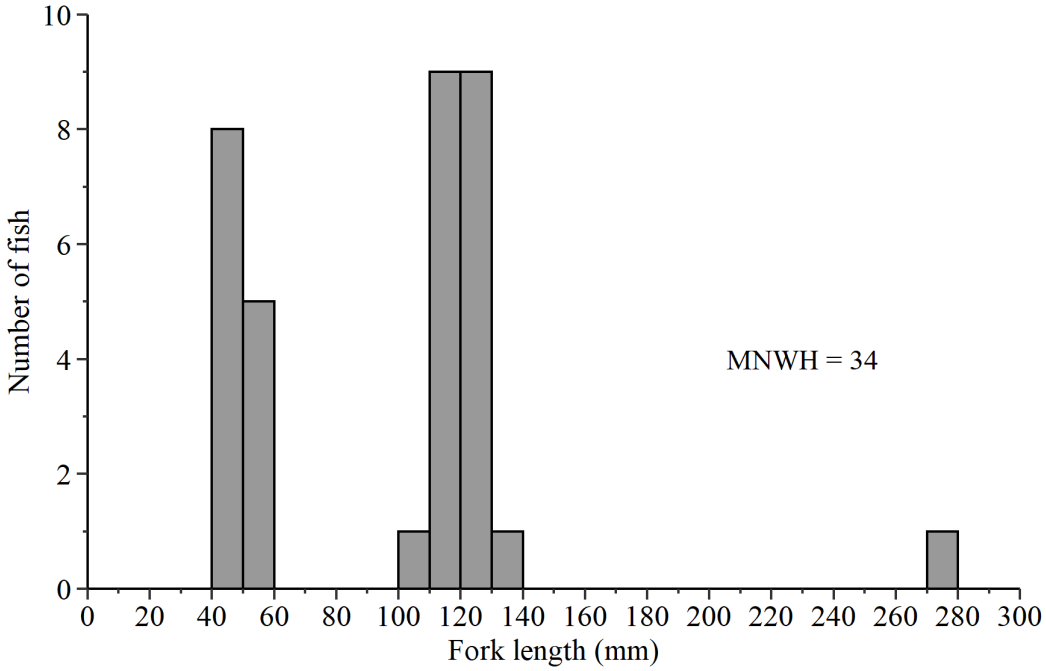
Site ID	Species[1]														
	BKTR	**BLTR**	**BRST**	**BURB**	**FNDC**	**LKCH**	**LNDC**	**LNSC**	**MNWH**	**NRDC**	**NRPK**	**PRDC**	**RNTR**	**SPSC**	**WHSC**
MBG5	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG7	0	0	0	0	0	0	1	3	0	0	0	6	12	0	0
MBG8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MBG11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1	8	0	0	0	0	0	0	0	0	0	0	1	0	0	3
S2	0	0	0	0	0	0	0	13	0	0	0	0	4	0	0
S4	4	0	1	0	785	0	0	3	0	2	0	0	0	0	0
S5	0	0	28	0	0	1	0	0	0	0	0	11	4	0	44
S7	2	0	17	0	35	0	0	27	0	15	0	28	0	0	14
S8	0	0	0	0	0	12	0	12	0	0	2	0	1	0	0
S9	31	0	0	0	7	0	0	4	0	0	0	9	0	0	0
S11	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0
W2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
W4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

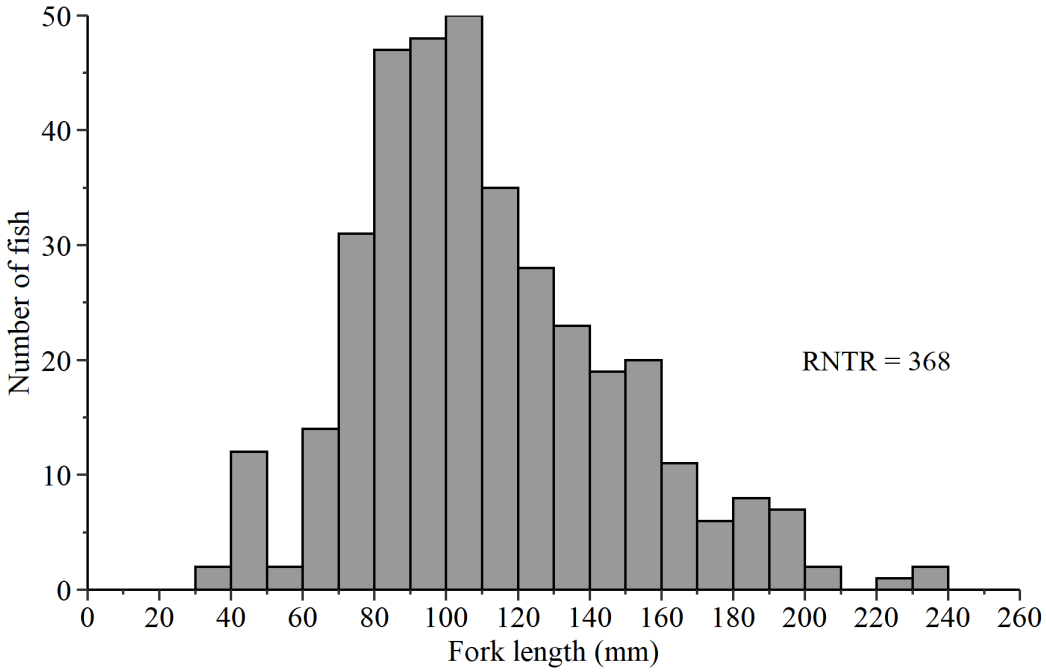
[1]Species codes: BKTR = brook trout, BLTR = bull trout, BRST = brook stickleback, BURB = burbot, FNDC = finescale dace, LKCH = lake chub, LNDC = longnose dace, LNSC = longnose sucker, MNWH = mountain whitefish, NRDC = northern redbelly dace, NRPK = northern pike, PRDC = pearl dace, RNTR = rainbow trout, SPSC = spoonhead sculpin, WHSC = white sucker.

Appendix 4. Length frequency histograms of brook trout, bull trout, rainbow trout, and mountain whitefish, captured using backpack electrofishing gear in the upper McLeod River HUC 10 sub-watersheds, 2021 and 2022. Species codes: BKTR = brook trout, BLTR = bull trout, RNTR = rainbow trout, MNWH = mountain whitefish.






Number of fish
Fork length (mm)
MNWH = 34


Number of fish
Fork length (mm)
RNTR = 368

Appendix 5. Habitat measurements at electrofishing sites in Beaverdam Creek (B), Gregg River (G), Upper McLeod above Beaverdam Creek (MAB), Upper McLeod above Gregg River (MAG), Upper McLeod above Sundance Creek (MAS), Upper McLeod below Gregg River (MBG), Sundance Creek (S), and Whitehorse Creek (WH) HUC 10 sub-watersheds in Alberta, 2021 and 2022.

Site ID	Temp (°C)	Ambient cond. (µS/cm)	Mean wetted width ± SD (m)	Mean rooted width ± SD (m)	Mean depth ± SD (m)	Dominant/ secondary substrate[1]	Mean % pool (min - max)	Mean % riffle (min - max)	Mean % run (min - max)
B1	15.8	73	4.1 ± 2.1	6.1 ± 3.1	0.55 ± 0.35	F/SG	5 (0–15)	12 (0–30)	83 (60–100)
B2	12.0	90	2.4 ± 0.7	4.4 ± 0.6	0.33 ± 0.19	LG/C	7 (5–10)	29 (20–40)	64 (55–75)
B3	9.3	103	0.6 ± 0.3	0.6 ± 0.3	0.16 ± 0.23	SG/C, F	11 (0–50)	28 (0–60)	62 (35–100)
B4	19.0	124	4.0 ± 1.1	6.2 ± 1.1	0.33 ± 0.18	LG/SG	2 (0–10)	28 (10–50)	69 (50–90)
B5	14.5	71	4.0 ± 0.5	7.8 ± 1.3	0.35 ± 0.17	LG/SG	20 (0–30)	19 (10–30)	61 (55–75)
B6	15.6	113	9.2 ± 1.8	11.1 ± 1.2	0.37 ± 0.10	C/LG	1 (0–5)	30 (10–60)	69 (35–90)
B7	6.2	99	1.0 ± 0.4	1.2 ± 0.6	0.19 ± 0.08	SG/F	6 (0–15)	57 (40–75)	38 (25–50)
B8	13.6	79	4.0 ± 1.5	7.7 ± 2.3	0.35 ± 0.20	SG/LG	11 (0–20)	20 (5–30)	69 (55–90)
B9	16.9	107	9.0 ± 1.3	12.0 ± 2.0	0.67 ± 0.44	LG, SG/LG	0 (0–0)	14 (0–40)	86 (60–100)
B10	15.5	87	4.9 ± 2.2	7.9 ± 1.5	0.27 ± 0.09	LG/SG	11 (0–20)	32 (15–60)	58 (30–85)
G1	7.9	347	2.1 ± 0.5	4.3 ± 0.9	0.25 ± 0.06	C/B	7 (5–10)	79 (75–85)	14 (10–20)
G2	12.9	599	7.1 ± 3.0	12.9 ± 3.3	0.38 ± 0.08	LG/C	2 (0–5)	28 (0–50)	69 (45–100)
G3	8.9	315	4.4 ± 0.9	7.6 ± 1.6	0.27 ± 0.03	C/LG	8 (0–15)	75 (65–85)	18 (10–25)
G4	8.8	160	3.9 ± 0.8	5.9 ± 1.3	0.38 ± 0.20	C, LG/C, LG	5 (0–10)	60 (40–75)	35 (20–50)
G5	8.6	172	2.1 ± 0.9	2.6 ± 1.2	0.23 ± 0.06	LG/C	2 (0–10)	64 (55–80)	33 (20–40)
G7	7.3	289	0.6 ± 0.3	0.7 ± 0.3	0.13 ± 0.06	C/F, LG	20 (5–30)	60 (30–80)	20 (0–40)
G9	7.2	104	0.9 ± 0.3	1.6 ± 0.4	0.10 ± 0.04	C/C, F, LG	3 (0–10)	58 (50–60)	39 (30–50)
G10	7.4	122	0.6 ± 0.2	0.5 ± 0.2	0.10 ± 0.05	C/F	2 (0–5)	89 (65–100)	8 (0–30)
G11	8.6	115	2.8 ± 0.8	4.8 ± 0.8	0.25 ± 0.05	C/LG	5 (0–10)	48 (25–85)	48 (15–65)
G12	9.8	275	0.7 ± 0.3	1.3 ± 0.8	0.30 ± 0.14	F/C	12 (5–20)	6 (0–15)	82 (75–90)

Appendix 5 continued:

Site ID	Temp (°C)	Ambient cond. (µS/cm)	Mean wetted width ± SD (m)	Mean rooted width ± SD (m)	Mean depth ± SD (m)	Dominant/ secondary substrate[1]	Mean % pool (min - max)	Mean % riffle (min - max)	Mean % run (min - max)
MAB2	8.6	176	12.5 ± 2.6	14.5 ± 1.8	0.43 ± 0.09	C/LG	3 (0–20)	84 (40–100)	12 (0–40)
MAB3	6.4	180	9.4 ± 1.6	11.6 ± 1.4	0.50 ± 0.26	C/LG	14 (0–30)	42 (20–70)	44 (25–80)
MAB4	8.6	74	1.1 ± 0.4	1.7 ± 0.4	0.18 ± 0.05	C/LG	1 (0–5)	88 (80–100)	11 (0–20)
MAB5	11.3	796	4.4 ± 1.5	6.9 ± 2.2	0.34 ± 0.07	LG/SG	6 (0–15)	70 (40–100)	24 (0–50)
MAB6	7.6	408	3.4 ± 0.5	4.4 ± 1.0	0.31 ± 0.04	C/LG	3 (0–10)	90 (70–100)	7 (0–20)
MAB7	9.2	163	0.8 ± 0.1	1.4 ± 0.3	0.09 ± 0.01	LG/SG	3 (0–5)	72 (60–80)	25 (20–35)
MAB8	10.6	545	3.1 ± 0.5	4.6 ± 0.7	0.29 ± 0.07	C/LG	5 (0–10)	80 (65–90)	15 (5–25)
MAB9	6.8	228	1.2 ± 0.6	2.0 ± 0.7	0.12 ± 0.04	C, LG/LG	8 (5–15)	61 (40–75)	31 (20–45)
MAB11	7.4	67	1.1 ± 0.4	1.1 ± 0.5	0.15 ± 0.05	LG/SG	1 (0–5)	72 (60–90)	27 (10–40)
MAB13	11.3	147	1.0 ± 0.2	1.8 ± 0.6	0.10 ± 0.02	LG/C	1 (0–5)	60 (50–70)	39 (25–50)
MAG1	6.2	123	0.4 ± 0.1	0.9 ± 0.3	0.47 ± 0.25	F/SG	18 (0–40)	3 (0–5)	79 (55–100)
MAG2	5.8	108	0.9 ± 0.3	1.0 ± 0.3	0.32 ± 0.40	LG, SG	4 (0–5)	50 (40–65)	46 (30–60)
MAG3	5.5	77	1.0 ± 0.3	1.3 ± 0.4	0.20 ± 0.12	LG, SG	1 (0–5)	85 (80–90)	14 (10–20)
MAG4	16.4	783	1.0 ± 0.4	3.7 ± 2.8	0.23 ± 0.13	SG, LG	6 (0–20)	64 (10–90)	30 (10–80)
MAG5	5.5	107	0.5 ± 0.2	0.5 ± 0.3	0.19 ± 0.05	LG/C	2 (0–5)	31 (25–40)	67 (60–70)
MAG6	6.1	61	0.9 ± 0.3	0.9 ± 0.3	0.13 ± 0.03	LG/C	2 (0–5)	42 (35–55)	56 (40–60)
MAG7	12.3	118	5.5 ± 1.5	8.0 ± 1.8	0.34 ± 0.12	LG/SG	3 (0–10)	82 (65–100)	14 (0–35)
MAG9	12.9	238	5.6 ± 1.6	9.8 ± 1.3	0.41 ± 0.12	LG, SG/C, LG	4 (0–5)	41 (30–50)	55 (45–65)
MAG10	7.5	94	1.2 ± 1.5	0.8 ± 0.4	0.48 ± 0.11	F/LG	4 (0–15)	66 (55–75)	30 (20–45)
MAG12	6.9	76	0.7 ± 0.3	0.7 ± 0.4	0.22 ± 0.23	LG/F	5 (0–15)	75 (50–90)	20 (10–35)
MAS1	13.7	277	1.2 ± 0.4	2.7 ± 0.9	0.16 ± 0.06	F/SG	2 (0–5)	38 (0–85)	60 (10–100)
MAS2	14.4	316	3.2 ± 1.2	6.6 ± 0.9	0.16 ± 0.08	LG/C, SG	7 (0–15)	37 (25–50)	57 (40–75)
MAS4	6.4	337	0.7 ± 0.4	1.9 ± 0.4	0.15 ± 0.04	F/C	2 (0–5)	12 (10–20)	86 (80–90)
MAS6	14.3	301	2.5 ± 0.6	3.4 ± 0.8	0.23 ± 0.11	C/LG	2 (0–10)	63 (35–80)	35 (20–65)
MAS7	7.4	297	3.3 ± 1.6	5.3 ± 1.7	0.21 ± 0.06	LG/SG	4 (0–10)	59 (45–75)	37 (25–45)
MAS8	15.8	416	1.3 ± 0.3	5.1 ± 1.0	0.76 ± 0.30	F/	2 (0–10)	0 (0–0)	98 (90–100)

Appendix 5 continued:

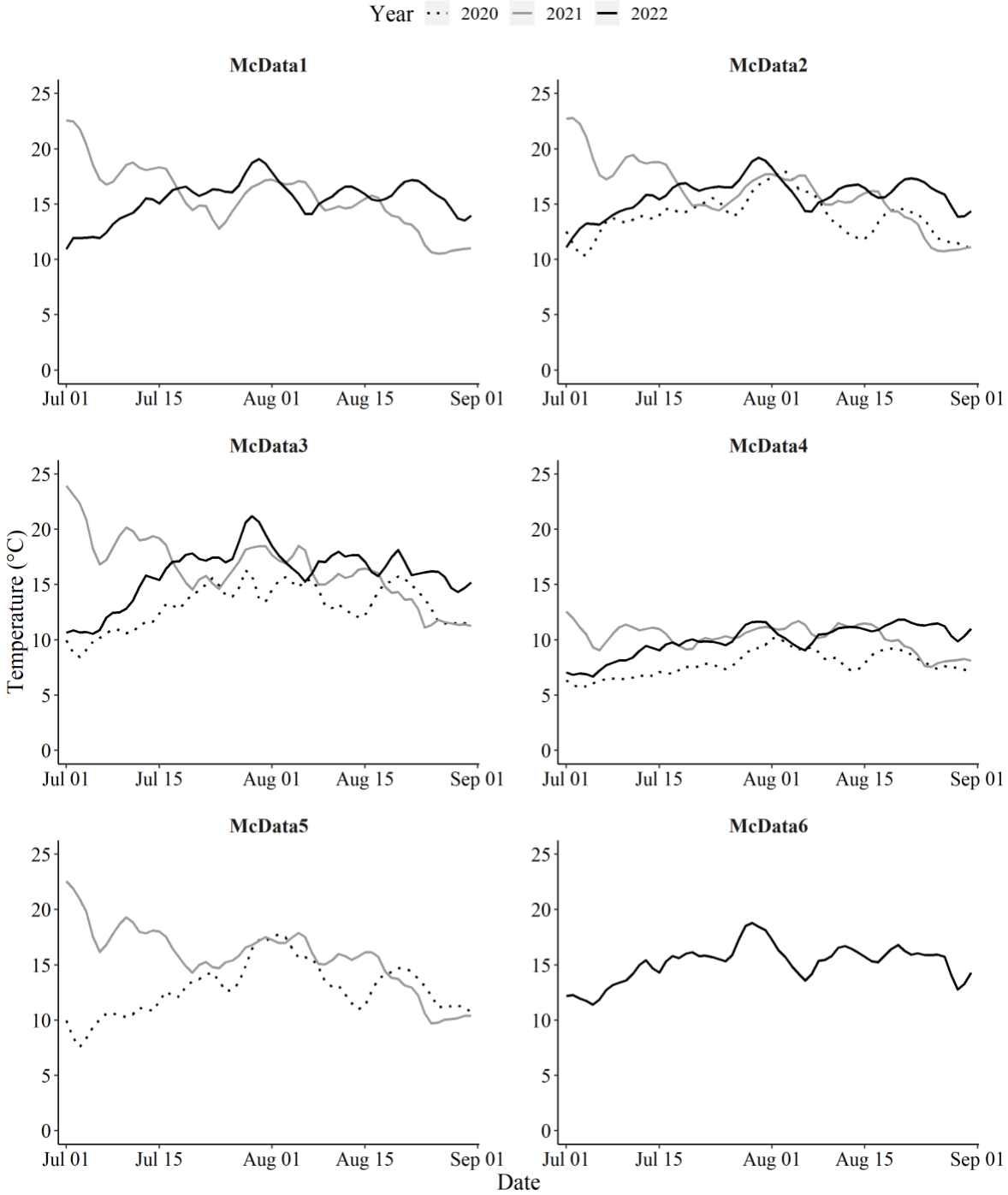
Site ID	Temp (°C)	Ambient cond. (µS/cm)	Mean wetted width ± SD (m)	Mean rooted width ± SD (m)	Mean depth ± SD (m)	Dominant/ secondary substrate[1]	Mean % pool (min - max)	Mean % riffle (min - max)	Mean % run (min - max)
MAS10	12.9	324	1.4 ± 0.6	2.3 ± 1.0	0.16 ± 0.07	C/F	1 (0–5)	26 (15–40)	73 (60–80)
MAS11	15.6	257	2.1 ± 0.9	5.6 ± 2.7	0.21 ± 0.06	F/LG, SG	2 (0–10)	10 (0–20)	88 (70–100)
MAS12	17.9	275	0.5 ± 0.2	1.6 ± 1.0	0.29 ± 0.15	F/	0 (0–0)	2 (0–10)	98 (90–100)
MBG2	9.6	209	1.5 ± 0.6	1.3 ± 0.3	0.21 ± 0.08	F/F, LG	0 (0–0)	55 (30–80)	45 (20–70)
MBG3	9.7	233	0.7 ± 0.4	0.8 ± 0.5	0.25 ± 0.18	LG/F	12 (0–25)	34 (0–70)	53 (20–75)
MBG4	10.3	91	1.2 ± 0.2	1.6 ± 0.4	0.50 ± 0.15	F/SG	0 (0–0)	5 (0–10)	95 (90–100)
MBG5	8.1	183	4.2 ± 1.0	5.7 ± 1.4	0.35 ± 0.06	C/LG	2 (0–5)	68 (55–80)	30 (20–40)
MBG6	11.1	369	0.6 ± 0.1	0.8 ± 0.2	0.11 ± 0.05	F/SG	5 (0–10)	72 (65–80)	23 (15–30)
MBG7	15.4	107	4.9 ± 1.1	6.4 ± 1.7	0.57 ± 0.21	C/LG	12 (0–25)	32 (10–60)	56 (35–70)
MBG8	7.7	285	1.3 ± 0.3	0.9 ± 0.4	0.19 ± 0.07	C/F	1 (0–5)	88 (85–90)	11 (10–15)
MBG9	9.2	74	0.6 ± 0.2	1.3 ± 1.2	0.33 ± 0.10	F/	32 (0–65)	16 (0–30)	52 (30–70)
MBG10	21.7	206	0.9 ± 0.3	0.9 ± 0.3	0.31 ± 0.08	LG/C, F, LG	5 (0–15)	57 (20–80)	38 (20–65)
MBG11	9.5	174	0.6 ± 0.2	0.5 ± 0.4	0.05 ± 0.04	F/C	0 (0–0)	32 (20–50)	68 (50–80)
S1	9.9	330	2.8 ± 0.2	3.7 ± 1.2	0.38 ± 0.13	F/LG	2 (0–5)	38 (25–50)	59 (45–75)
S2	17.0	318	2.3 ± 0.7	4.1 ± 0.8	0.32 ± 0.10	F/SG	1 (0–5)	8 (5–10)	92 (85–95)
S4	16.0	325	1.7 ± 0.3	1.8 ± 0.1	0.31 ± 0.14	F/SG	2 (0–5)	10 (10–10)	88 (85–90)
S5	18.4	251	1.6 ± 0.9	2.0 ± 1.0	0.32 ± 0.19	F/LG	6 (0–20)	10 (0–25)	84 (70–100)
S7	17.2	386	3.5 ± 1.0	4.2 ± 1.6	0.58 ± 0.20	F/SG	98 (90–100)	0 (0–0)	2 (0–10)
S8	18.6	269	3.8 ± 1.0	4.9 ± 1.3	0.68 ± 0.25	F/SG	9 (0–20)	12 (0–30)	79 (65–100)
S9	13.4	364	3.7 ± 0.4	4.6 ± 1.1	0.69 ± 0.15	F/-	2 (0–5)	10 (0–25)	88 (75–100)
S11	16.1	303	6.7 ± 0.7	7.3 ± 0.8	0.91 ± 0.17	F/SG	0 (0–0)	0 (0–0)	100 (100–100)
W2	8.5	181	3.0 ± 0.7	6.0 ± 1.5	0.27 ± 0.09	C/LG	3 (0–10)	85 (70–100)	12 (0–20)
W3	11.5	175	6.6 ± 2.8	13.0 ± 2.3	0.49 ± 0.07	C/ B, BR	8 (0–20)	50 (20–75)	42 (15–80)
W4	10.3	347	4.6 ± 0.9	6.4 ± 0.9	0.36 ± 0.10	C/LG	5 (0–10)	83 (70–90)	12 (5–20)
W5	6.7	238	4.2 ± 1.1	9.0 ± 3.1	0.34 ± 0.16	B, C/LG	9 (5–20)	68 (60–75)	22 (10–30)
W6	3.8	88	1.1 ± 0.4	1.4 ± 0.5	0.14 ± 0.04	C/LG	0 (0–0)	90 (80–100)	10 (0–20)

Appendix 5 continued:

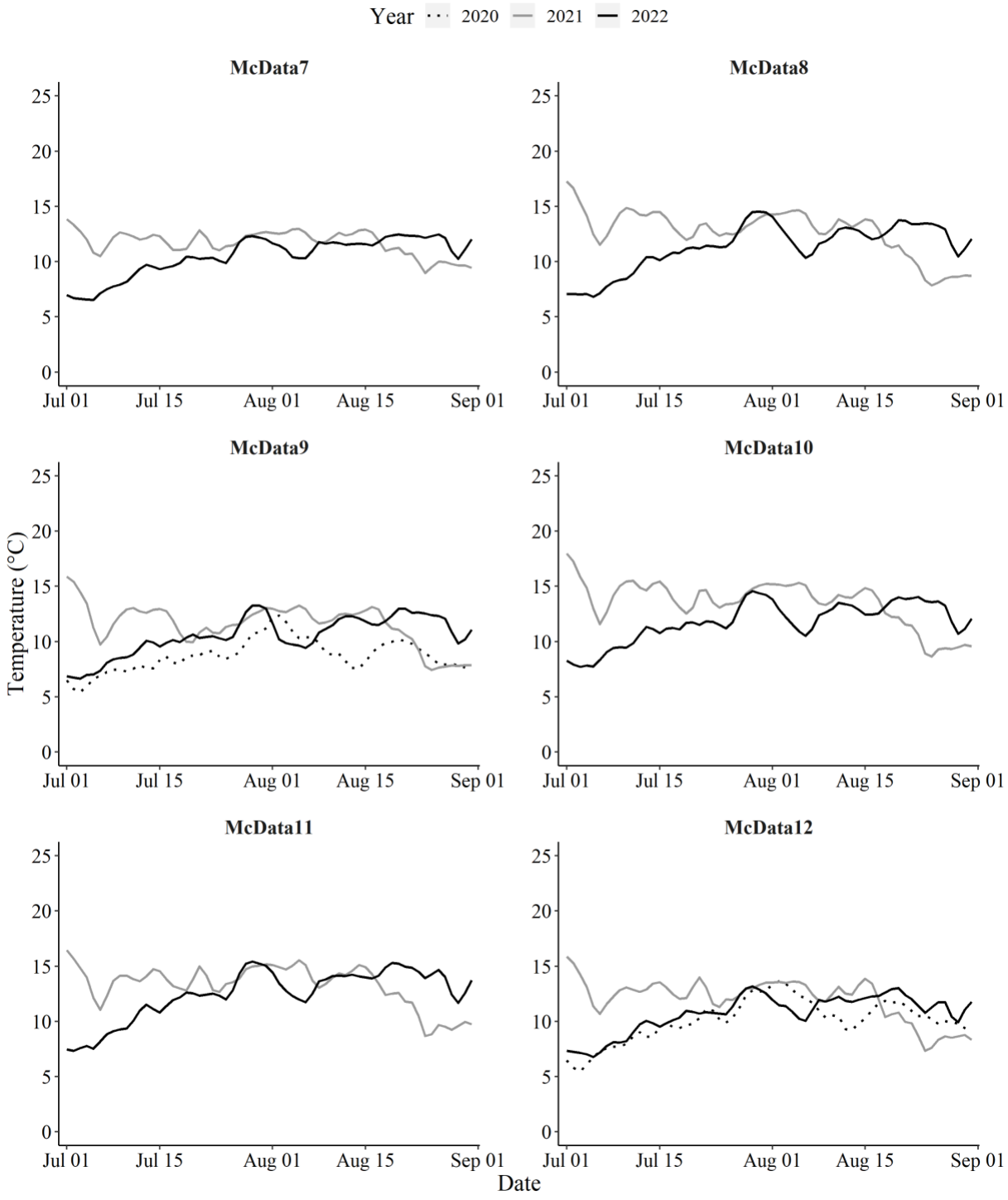
Site ID	Temp (°C)	Ambient cond. (µS/cm)	Mean wetted width ± SD (m)	Mean rooted width ± SD (m)	Mean depth ± SD (m)	Dominant/ secondary substrate[1]	Mean % pool (min - max)	Mean % riffle (min - max)	Mean % run (min - max)
W7	9.9	307	1.2 ± 0.5	2.6 ± 1.1	0.16 ± 0.07	C/B	8 (0–30)	83 (70–100)	8 (0–20)
W9	9.5	155	6.9 ± 0.9	10.8 ± 0.9	0.47 ± 0.18	C/B	3 (0–15)	79 (65–100)	18 (0–35)
W10	4.8	319	3.1 ± 0.5	6.1 ± 0.9	0.30 ± 0.06	C, LG/C	11 (5–15)	74 (60–90)	15 (5–25)
W13	15.0	353	1.5 ± 0.8	17.1 ± 3.5	0.15 ± 0.05	C/SG	2 (0–5)	88 (85–90)	11 (5–15)

[1] Substrate codes: B = boulder, BR = bedrock, C = cobble, F = fines, LG = large gravel, SG = small gravel.

Appendix 6. Two-day moving average stream temperature at eight stations in the Upper McLeod River HUC 8 watershed, 2020, 13 stations in the Upper McLeod River HUC 8 watershed, 2021, and 16 stations in the Upper McLeod River HUC 8 watershed, 2022.



Appendix 6 continued:



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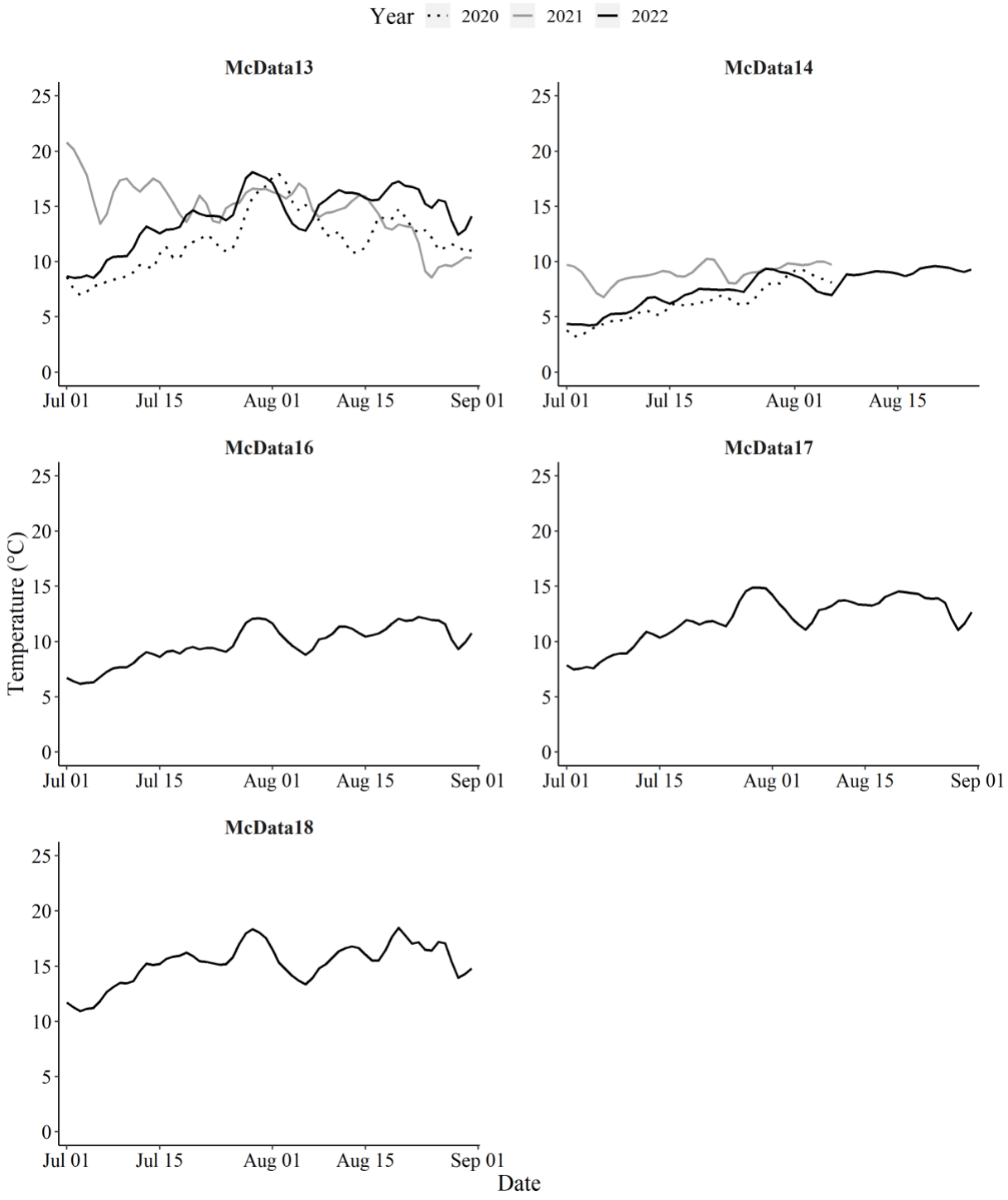

wildlife | fish | habitat