# BEAVERLODGE RIVER WEIR MONITORING PROGRAM - 2019 SUMMARY REPORT

BEAVERLODGE RIVER
SE ½ 34-071-10 W6M

Prepared for:
**MIGHTY PEACE WATERSHED ALLIANCE**

Prepared by:
**MATRIX SOLUTIONS INC.**

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March 2020
Calgary, Alberta

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Prepared for Mighty Peace Watershed Alliance, March 2020


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# 1 INTRODUCTION

The Mighty Peace Watershed Alliance (MPWA) conducted works to improve fish passage at the Beaverlodge River weir, located southwest of the Town of Beaverlodge, Alberta (Figure 1-1). Natural riffle features and channel enhancements were built at the weir and immediately downstream; the purpose of the fish passage structures was to create conditions suitable for fish to migrate/pass the weir situated on the Beaverlodge River, with the design species being Arctic Grayling (*Thymallus arcticus*). In order to assess the ongoing performance of the fish passage structures, including structural integrity of the riffles and flow suitability for fish passage through these structures, the MPWA prepared a monitoring plan which was approved by Alberta Environment and Parks (AEP) under the *Alberta Water Act* (Approval No. 00372572-00-00).

The fish passage improvement project (the Project) was supported by Alberta Transportation to meet offset conditions in their *Fisheries Act* Authorization to twin the Peace River Bridge, near Peace River, Alberta. In addition to the parameters detailed in the monitoring plan submitted to AEP, Fisheries and Oceans Canada (DFO) requested monitoring of fish movement through the fish passage structure over a 5-year period, beginning the first-year post-construction (i.e., 2019); a summary of the first-year of monitoring results prepared for DFO is presented in Section 3.4. Results of the AEP 2019 monitoring program are presented herein.

## 1.1 Background

The Beaverlodge River weir is situated approximately 12 km upstream from the confluence of the Beaverlodge and the Wapiti rivers (Figure 1-1). The weir was constructed in the early-1980s to provide a drinking water source for the town of Beaverlodge. Fish movement past the weir has been extremely limited to periods of higher discharge such as during spring freshet. Due to the shape of the weir, summer flows have been insufficient to maintain fish passage over the weir in either direction. Consequently, fish populations are low, and some historically abundant populations, such as Arctic Grayling, are now absent and considered functionally extirpated (CharettePellPoscente Environmental Corp. 2012). A fish ladder has been present at the Beaverlodge River weir since 1981; however, the weir has been in disrepair and was unlikely to be providing upstream or downstream fish passage.

As part of the MPWA's larger plans for watershed restoration and water quality improvement in the Beaverlodge River, fish passage improvement structures, comprising of two rock riffles, were installed at the weir, and immediately downstream in the fall of 2018. The intent of the Project was to create the conditions needed to facilitate fish access to the upstream spawning and rearing habitat in the spring and just as importantly, to downstream habitat later in the summer and fall (i.e., overwintering in the Wapiti River). Historical activities in the watershed, including agriculture and logging, the installation of the weir for water supply, and wetland modifications, among other elements, have altered streamflow, water quality, and fish habitat. The MPWA is still working with stakeholders in the watershed to restore watershed conditions facilitating a return of natural environmental processes.

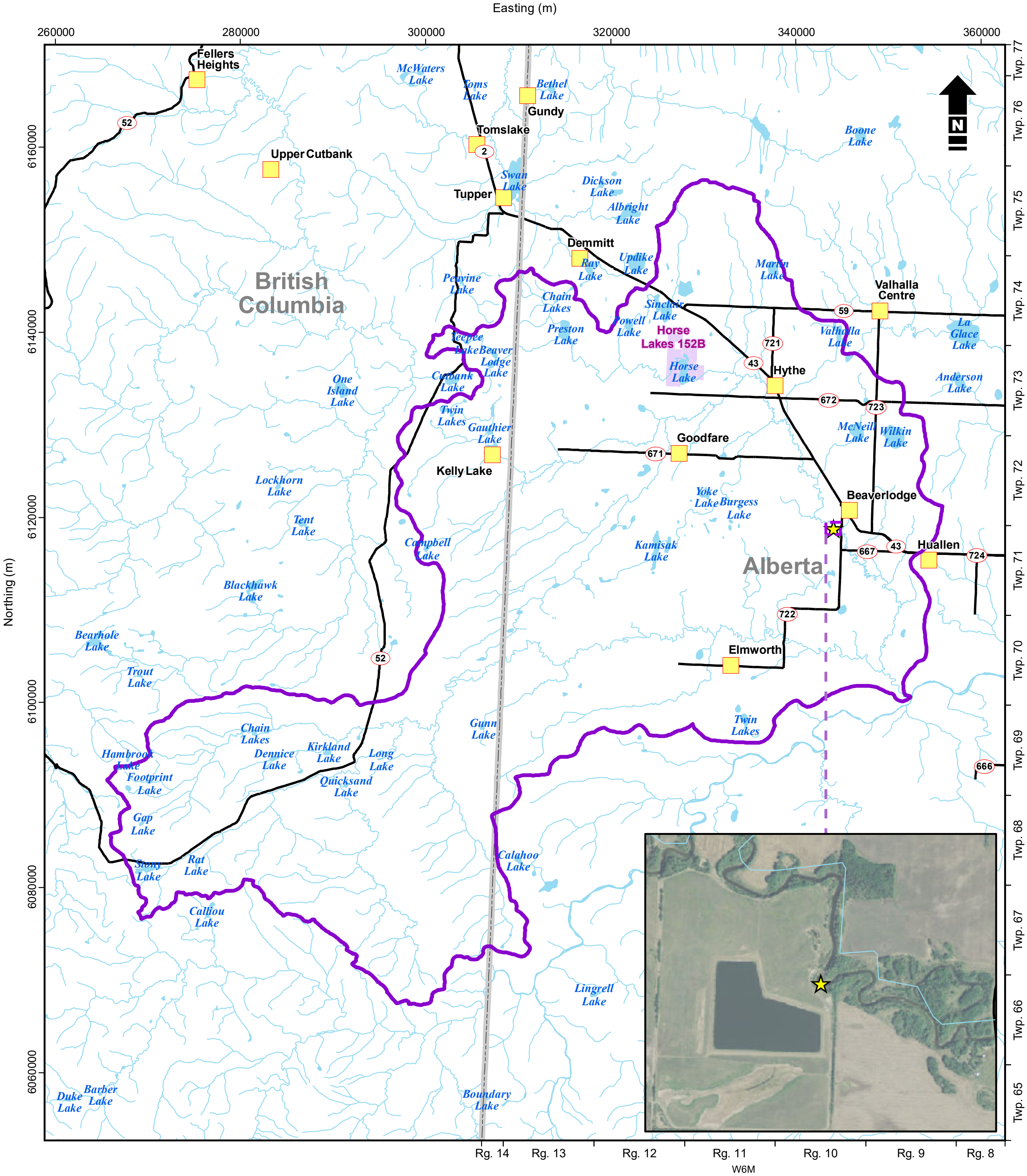
The specific objective of the Project was to create conditions suitable for fish to migrate/pass the weir situated on the Beaverlodge River in a manner that complements the need to keep the existing weir. The objective considered the following:

- maintaining weir (water level) for water supply for the town of Beaverlodge
- allowing passage of Arctic Grayling, among other resident large-bodied fish, including Northern Pike (*Esox lucius*), Bull Trout (*Salvelinus confluentus*), Burbot (*Lota lota)*, Longnose Sucker (*Catostomus catostomus),* White Sucker (*Catostomus commersonii*), and small-bodied fish during spring freshet, but also as importantly, during summer as the hydrograph declines
- minimizing maintenance (e.g., the movement of woody debris, sediment accumulation, and bank erosion) to maximize its capacity to function without attention

The fish passage design considered the extent of different flows to facilitate the passage of fish upstream and downstream past the weir, particularly during the decreasing portion of the hydrograph. The design maximizes available discharge by concentrating river flow into the centre of the structure to permit swimming during low flow periods, but not so much that fish cannot swim and pass. Larger boulders were left exposed along the centre of the structure to provide shelter or rest locations and stimulate fish passage.

Arctic Grayling were an important design consideration; however, the design also considered other resident fish including Northern Pike, Longnose Sucker, and Burbot. The fish passage design considered maximum flow velocities that resident fish can negotiate (i.e., fish burst speed or maximum speed for 10 seconds). This accounts for short sections between resting locations within the fish passage structure (i.e., <1 m step between pools). Flow velocities to accommodate burst speeds for various sized fish are outlined below (Katapodis 1992); these velocities consider both anguilliform and subcarangiform swimming forms:

- 20 cm long fish – burst speed/maximum flow velocity is 1.20 m/s
- 25 cm long fish – burst speed/maximum flow velocity is 1.50 m/s
- 30 cm long fish – burst speed/maximum flow velocity is 1.85 m/s
- 40 cm long fish – burst speed/maximum flow velocity is 2.45 m/s




- Redwillow Watershed Boundary
- Community
- Indian Reserve
- Water Body
- Watercourse
- Provincial Boundary
- Highway
- Existing Weir Location

1:600,000 metres
5,900 0 5,900 11,800
NAD 1983 UTM Zone 11N

Reference: Data obtained from AltaLIS © Government of Alberta, GeoBase® and GeoGratis © Department of Natural Resources Canada (all rights reserved) used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license.

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Mighty Peace Watershed Alliance
MPWA / Beaverlodge Fish Passage

# Site Location

| Date: | Project: | Submitter: | Reviewer: |
|---|---|---|---|
| November 2019 | 2199 | K. Lowes | S. Christidis |

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Figure 1-1

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## 1.2 Monitoring Program Parameters

The monitoring program is structured to assess conditions necessary for fish passage during the early and late portions of the hydrograph (i.e., seasonal streamflow measurements including velocity and depth at important points on the structure). However, fish use of the structures is dependent on the success of the MPWA to achieve recovery in watershed conditions that lead to improved hydrology and water quality in the Beaverlodge River to support and restore fish populations. Monitoring parameters were developed based on available information on hydrology and potential fish species use and were approved by AEP. Parameters include:

- Visual inspection of the fish passage structure by a qualified engineer to assess erosion and redistribution of sediments (i.e., degradation and aggradation) caused by altered hydraulic dynamics and assess the ongoing structural integrity of the structure.
  - Rationale: ensure that the structures are stable and work with a fisheries biologist to provide recommendations for improvement, if needed.
- Assessment of the passage structure channel shape – channel depth and width, stream discharge, and water depth.
  - Rationale: the channel has been constructed with an inverted parabolic shape concentrating stream flows through the middle of the fish passage structure and these parameters will be used to determine if the channel shape changes over time.
- Monitoring of water depth and velocity over each of the passage structure steps, and water depth in each associated downstream pool.
  - Rationale: the fish passage structure was designed with the intent that flow velocities over each step will be less than burst speeds for anguilliform and subcarangiform fish 20 cm or larger, which is 1.2 m/s (Katapodis 1992).
- Monitoring of water temperature and dissolved oxygen (DO) above and immediately below the fish passage structure.
  - Rationale: concentrating the flows through the central portion of the fish passage structure will decrease the width of the flow, increase depth, and allow water to move through this section of the river more quickly. Thus, water temperatures and DO levels should be maintained.
- Visual inspection by a fish biologist to identify potential conditions that may prevent fish using the fish passage structure.
  - Rationale: changes to site conditions from variable stream flows and hydraulic forces may result in subtle changes to the structure and adjacent habitat that discourage fish from passing.

# 2 METHODS

The following subsections describe the methods used to assess the parameters identified in Section 1.2. The upstream (weir) and downstream riffle structures are herein referred to as Riffle 1 and Riffle 2, respectively.

## 2.1 Spatial Monitoring Extent

Site inspections, hydrology, and fish use monitoring were focussed on a 400 m reach of the Beaverlodge River: 100 m upstream of Riffle 1, within the large scour pool downstream of Riffle 1, and 100 m downstream of Riffle 2 (Table 2-1; Figure 2-1):

- Six monitoring locations were established for annual site inspections, photographic documentation and water quality monitoring; site included four locations upstream and downstream of Riffle 1 and Riffle 2, and two locations within the scour pool between Riffle 1 and Riffle 2.
- A pressure transducer was installed and stream discharge measurements taken immediately upstream of Riffle 1.

**TABLE 2-1 Monitoring Locations**

| Site ID | Location (UTM Location NAD 83 11 U ) | |
|---|---|---|
| | Easting | Northing |
| **Riffle Structures** | | |
| Riffle 1 (weir, upstream) | 344044 | 6118864 |
| Riffle 2 (downstream) | 344093 | 6118823 |
| **Monitoring Locations** | | |
| BL1 | 344049 | 6118870 |
| BL2 | 344039 | 6118857 |
| BL3 | 344019 | 6118815 |
| BL4 | 344038 | 6118833 |
| BL5 | 344086 | 6118811 |
| BL6 | 344105 | 6118827 |
| **Hydrology** | | |
| Manual Flow Measurement Location | 344056 | 6118871 |
| Pressure Transducer Location | 344050 | 6118876 |

Notes:
UTM = Universal Transverse Mercator Coordinate system
NAD = North American Datum
U = UTM Zone


Fish Fence Location
Level Logger Location
Monitoring Location

1:800 metres
10 0 10 20
NAD 1983 UTM Zone 11N

Reference: Imagery (2018) Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User

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Beaverlodge River

# Site Plan

| Date: | Project: | Submitter: | Reviewer: |
|---|---|---|---|
| February 2020 | 2199 | K. Lowes | S. Christidis |

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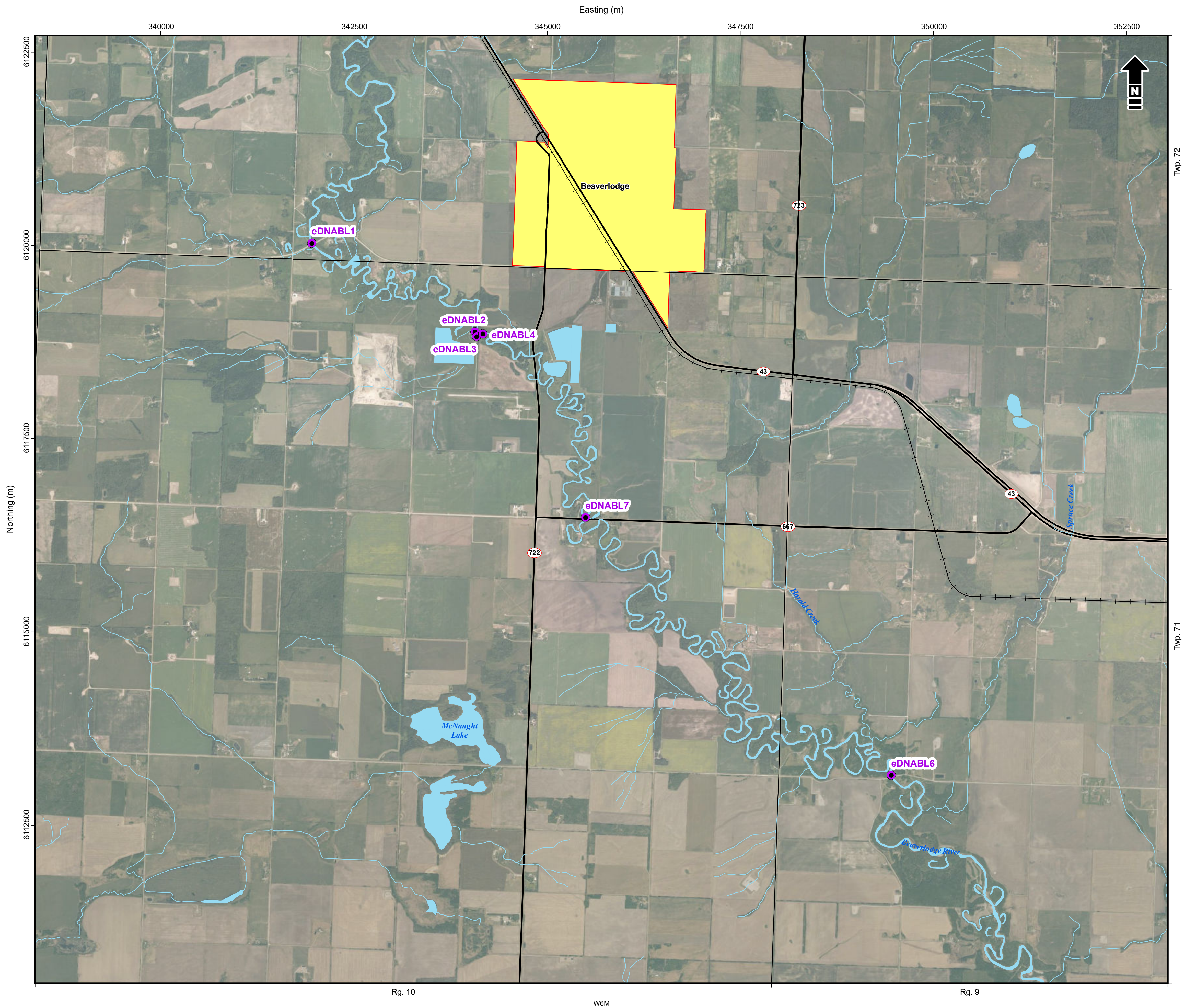
Figure 2-1




Reference: Data obtained from AltaLIS © Government of Alberta used under license. GDM transportation infrastructure data provided by IHS © 2019 used under license.Imagery (2018) Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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# eDNA Sampling Location

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Figure 2-1

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## 2.2 Habitat Site Inspections

Habitat structure inspections were completed during each site visit to determine if conditions deviated from the engineered design or have changed since the construction completion (based on as-built drawings) in a manner that degrades fish habitat and/or prevents fish using the passage structure. Sites included BL1 to BL6 (Table 2-1; Figure 2-1).

Velocity and water depth measurements were completed to ensure potential fish passage through the structure. In addition, in-situ water quality (water temperature, DO, pH, specific conductance, and turbidity) were measured upstream and downstream of the fish passage structures to determine if these parameters are affected by the structure. In situ water quality was collected using a calibrated multimeter (YSI 550 or YSI Pro Plus).

## 2.3 Hydrology

Streamflow was monitored 1.5 km upstream of the Water Survey of Canada hydrometric gauge 07GFD001 from May 31 to October 1 to estimate the percentage of time that sufficient flow is present within the Beaverlodge River at the Weir location to allow fish passage (Q-fish$_{min}$).

A self-vented Ott Ecolog 500 pressure transducer (0 to 4 m range; 0.05% Full Scale accuracy) was installed upstream of Riffle 1 to record water levels at 15-minute intervals. The transducer was encased inside a stilling well (10 cm diameter PVC pipe) and weighted to the bottom of the stream bed. Four flow measurements and corresponding water level surveys were completed at the same location to develop a stage-discharge rating which was used to convert stage to continuous streamflow. Flow measurements were completed using a Sontek Flowtracker Acoustic Doppler Velocimeter.

All hydrometric data was entered into the Matrix AQUARIUS™ database. The software was used throughout the hydrometric data production process including corrections, stage-discharge rating curve development, and streamflow calculations. The British Columbia Resources Information Standards Committee Hydrometric Standards were followed throughout the processing of hydrometric data (B.C. MoE 2009), moving forward versions 2 (2018) standards will be applied.

# 3 RESULTS

## 3.1 Habitat Structure Habitat Structure Site Inspections

### 3.1.1 Riffle Structures

Both riffle structures appeared to be performing as intended. Flow was being directed through the centre of each riffle and a high level of flow variability was observed; numerous step pools, back water eddies, cascades and chutes, were present. Wetted depths in the riffle structures ranged from less than 0.1 m up to 0.4 m. Flow was observed to be moving over the riffles, with no subterranean flow observed; smaller material consisting of fines and gravel had settled within the interstices of the larger cobble and boulder material.

Riffle structures appeared stable, with no erosion observed at the downstream or upstream ends or along the river edges. Some movement of cobble and boulder material may have occurred; however, any movement was likely insignificant. The large pool at the downstream end of Riffle 1 (weir Riffle) was still present, and wetted depths at the time of assessment were up to 3 m (similar depths to what was recorded pre-construction). Wetted depths downstream of Riffle 2 ranged from 0.4 to 2.0 m. Wetted depths upstream of Riffle 1, within 100 m, were up to 2.0 m.

Installation of root balls was abandoned during construction due to bank stability concerns from the contractor and onsite engineer (Matrix 2019). Attempts at the root ball installation did not achieve the desired results; excavation of the already unstable, high banks presented a safety risk to construction crews; attempts to push the root balls into the banks was attempted but the root balls were destroyed in the process. Alternative installation methods such as by excavation were discussed but were deemed too invasive.

Although the additional cover intended by the root balls was not achieved, woody debris from the eroding banks and from upstream have accumulated along the banks (Appendix A, Photographs 3, 6, 12, 16. Additional scrub material has also accumulated along the banks (Appendix A, Photographs 7, 18, 19). The naturally occurring woody debris and scrub material has provided suitable cover and provided some bank protection.

The MPWA conducted willow planting in the summer of 2019. Plantings occurred along the south bank from Riffle 2 for a distance of 30 m upstream; planting could not be conducted further upstream as the high, unstable bank presented overhead safety concerns (Appendix A, Photographs 1, 16, 19).

## 3.2 Hydrology

### 3.2.1 Precipitation

Precipitation from the Environment Canada Climate Data Archive (CDA) for the Beaverlodge Climate Station (Climate ID: 3070560) for 2019, including a comparison to the 1981-2010 normal precipitation (30-year mean precipitation) is shown on Figure 3-1. The monthly variation in precipitation for 2019 from the 1981-2010 normal precipitation are shown as percent differences indicating the dominant wet or dry runoff conditions over the course of the year (Table 3-1).

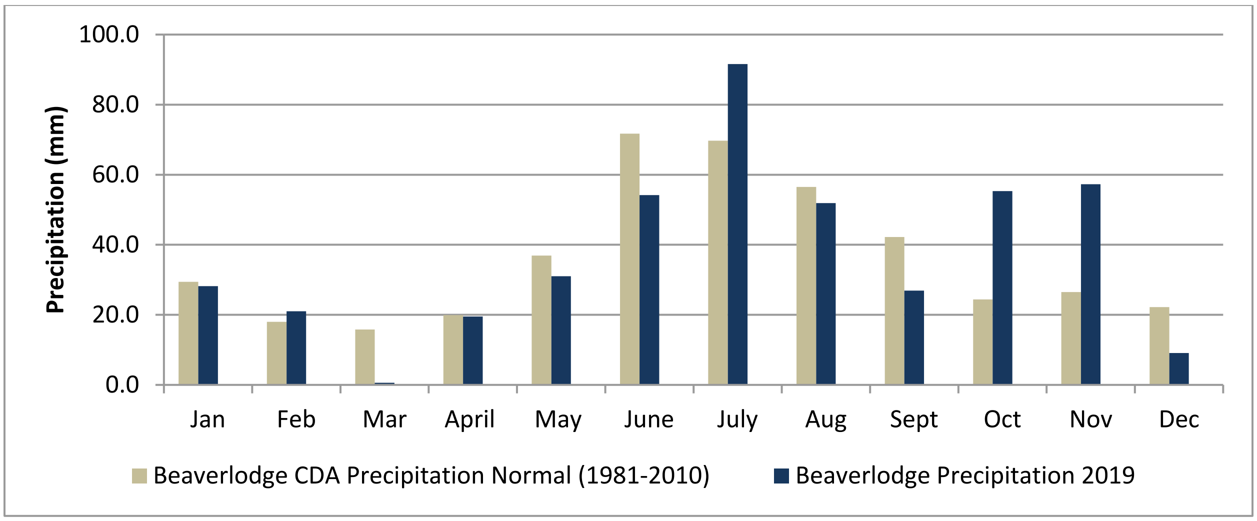


**FIGURE 3-1 Beaverlodge Precipitation for 2019 Compared to 30-year Normal Precipitation**

Annual precipitation was within 1% of normal but varied throughout the year. Winter precipitation was near normal in January, February, April, and May, while precipitation in March was nearly 100% below normal. Summer precipitation was variable with slightly below normal precipitation in June, August, and September. Greater than normal precipitation was recorded for the months of July, October, and November, contributing to greater low flows in the late-summer and fall.

**TABLE 3-1 Beaverlodge Precipitation for 2019 and departures from the 1981-2010 Normal**

| Year | Site | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 - 2010 | Beaverlodge CDA 1981-2010 Normal (mm) | 29.4 | 18.0 | 15.8 | 19.9 | 36.9 | 71.7 | 69.7 | 56.5 | 42.2 | 24.4 | 26.5 | 22.2 | 433.1 |
| 2019 | Beaverlodge Precipitation (mm) | 28.2 | 21 | 0.6 | 19.5 | 31 | 54.2 | 91.6 | 51.9 | 26.9 | 55.3 | 57.3 | -9.1 | 446.6 |
| | Departure from Normal | **-4%** | **17%** | **-96%** | **-2%** | **-16%** | **-24%** | **31%** | **-8%** | **-36%** | **127%** | **116%** | **-59%** | **1%** |

### 3.2.2 Water Survey of Canada Gauge 07GD001

Over the period of available record (1968 to 2018), discharge on the Beaverlodge River at the WSC gauge 07GD001 is dominated by snowmelt runoff with maximum annual flows occurring toward the end of April. Streamflow for the remainder of the year is highly dependent on the magnitude and frequency of rainfall runoff events. Base flows decrease throughout the open season with minimum flows frequently approaching zero from August to March (Table 3-2).

**TABLE 3-2 Minimum, Mean, and Maximum Average Monthly Discharge ($m^3/s$) in the Beaverlodge River at 07GD001 (1968 to 2018)**

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | 0 | 0 | 0 | 0.251 | 0.011 | 0.031 | 0.006 | 0 | 0 | 0 | 0 | 0 |
| Mean | 0.06 | 0.13 | 1.34 | 10.48 | 7.29 | 3.72 | 2.49 | 1.11 | 0.56 | 0.50 | 0.15 | 0.22 |
| Maximum | 0.196 | 0.217 | 11.50 | 38.60 | 39.60 | 26.100 | 27.00 | 15.20 | 10.20 | 3.70 | 0.57 | 1.22 |

### 3.2.3 Beaverlodge River at the Weir

Streamflow measurements completed in 2019 ranged from 1.743 to 3.681 $m^3/s$ and are limited to the lower third of the stage-discharge rating curve. Additional flow measurements are expected to further define the low and high ranges and stability of the stage-discharge rating curve (Appendix B).

Snowmelt runoff occurred before the installation of the hydrometric gauge and distinct rainfall-induced peak flows were recorded in mid-June, late-July, and late-September. A maximum instantaneous flow of 17.358 $m^3/s$ occurred on July 25, corresponding to greater than normal precipitation in July. A minimum instantaneous flow of 0.245$m^3/s$ occurred on June 25. Mean streamflow in September, typically the beginning of the low flow season was elevated at 1.945 $m^3/s$.

Monthly streamflow statistics for the Beaverlodge River at the Weir for the monitored season (June to October) are summarized in Table 3-3 while the streamflow hydrograph and mean daily streamflow summary for 2019 is included in Appendix B. Compared to the 1968 to 2018 average at the WSC gauge 07GD001, minimum monthly flows at the weir were above average from June to September and with the exception of June, mean monthly flows were also greater. Maximum monthly flows measured at the weir were less from June to September compared to the WSC gauge 07GD001.

**TABLE 3-3 Minimum, Mean, and Maximum Average Monthly Discharge ($m^3/s$) for the Beaverlodge River at the Weir - 2019**

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum | | | | | | 0.245 | 0.732 | 2.479 | 1.027 | | | |
| Mean | | | | | | 2.045 | 3.617 | 5.220 | 1.945 | | | |
| Maximum | | | | | | 6.913 | 17.358 | 10.460 | 3.901 | | | |

### 3.2.4 Point Velocity Monitoring

Point velocity measurements were collected randomly throughout each riffle feature. Flow through the riffles was highly variable. Measures were taken within a variety of flow conditions within the channel, including against the channel banks, within step pools, and backwater eddies where velocities were lower, and with the centre channel thalweg, cascades, and chutes where velocities were higher.

Point velocities ranged from 0.10 m/s along the banks (0 m/s in pools and back water eddies) to 8.19 m/s within the thalweg mid-channel (recorded during high flow events). Velocities were typically lower against the channel banks when compared to the thalweg at centre channel.

## 3.3 Water Quality

Water temperatures ranged from 15.9 to 17.7°C in July and August, dropping to below 6°C in October (Table 3-4). DO concentrations were consistently above 7 mg/L at all sampling locations during the summer and increased above 11 mg/L in October. pH was slightly alkaline and stayed relatively constant at all sampling locations and during each sampling event. The EC ranged from 345 to 433 µS/cm in July and decreased between 194.2 to 246.2 µS/cm in August and October.

**TABLE 3-4 Water Quality Summary**

| Date | Water Quality Parameter | BL1 | BL2 | BL5 | BL6 |
|---|---|---|---|---|---|
| 03-Jul-19 | pH | 8.0 | 8.0 | 8.1 | 8.9 |
| | Temperature (°C) | 17.6 | 17.3 | 17.7 | 17.7 |
| | EC (µS/cm) | 369.0 | 363.0 | 359.0 | 433.0 |
| | DO (mg/L) | 7.9 | 7.3 | 8.2 | 7.9 |
| | Turbidity (NTU) | 18.6 | 17.0 | 13.3 | 16.9 |
| | | | | | |
| 04-Jul-19 | pH | 8.4 | 8.0 | 8.1 | 8.2 |
| | Temperature (°C) | 17.7 | 17.3 | 17.7 | 17.7 |
| | EC (µS/cm) | 345.0 | 363.0 | 359.0 | 433.0 |
| | DO (mg/L) | 7.1 | 7.3 | 8.2 | 7.9 |
| | Turbidity (NTU) | n/a | 17.0 | 13.3 | 17.0 |
| 08-Aug-19 | pH | 7.9 | 7.5 | 7.7 | 7.9 |
| | Temperature (°C) | 16.4 | 15.9 | 16.9 | 15.9 |
| | EC (µS/cm) | 209.3 | 263.7 | 227.7 | 229.2 |
| | DO (mg/L) | 8.7 | 8.8 | 8.1 | 8.15 |
| | Turbidity (NTU) | 17.0 | 21.6 | 19.1 | 19.0 |
| 01-Oct-19 | pH | 7.6 | 7.9 | 8.1 | 8.1 |
| | Temperature (°C) | 5.0 | 4.7 | 5.2 | 5.2 |
| | EC (µS/cm) | 243.8 | 194.2 | 245.6 | 246.2 |
| | DO (mg/L) | 11.4 | 11.0 | 12.2 | 11.4 |
| | Turbidity (NTU) | 11.0 | 17.6 | 9.8 | 12.3 |

## 3.4 2019 DFO Weir Monitoring Summary

Additional sampling conducted under the monitoring plan submitted to DFO was conducted in 2019. A summary of these results is presented below, and detailed results are available upon request by AEP.

The requirements of the DFO approval for the Project required fish sampling be completed to confirm habitat use by resident fish populations and determine if fish are staging and passing upstream of the fish passage structures. Methods to observe fish presence and movement included eDNA sampling and analysis, sonar videography, fish fence and trap (fyke net) system, electrofishing and angling; fish sampling was conducted under Fish Research Licence (FRL) RL19-1009. All sport fish over 200 mm fork length had floy tags applied as per conditions in the FRL and released at their capture location.

Fish sampling within the Project area resulted in the capture of Lake Chub (*Couesius plumbeus*), Longnose Dace (*Rhinichthys cataractae*), Northern Pike, Redshide Shiner (*Richardsonius balteatus*), and White Sucker. 58 fish were captured of which 43 were tagged for mark-recapture effort. Two Longnose Sucker and one White Sucker were captured in the fish fence and fyke net trap located upstream of Riffle 1. None of these fish had floy tags attached. It was unclear whether these fish had moved upstream through the riffle or were resident in this area before the fish fence was installed and were not captured during clearing of this area.

A total of 18 hours of sonar camera videography was reviewed for presence of fish and fish movement. Results from the camera work was inconclusive; bed substrates and occasional debris were visible in the video; however, images on the sonar were not clearly presented. Fish presence or movement was not observed.

Arctic Grayling DNA was not detected in any of the eDNA samples collected in the river (samples were analyzed by the Hebling Laboratory, Victoria, British Columbia). Laboratory QA/QC performed using chloroplast DNA amplification was conducted and all samples performed well when tested for chloroplast DNA with the IntegritE-DNA test, meaning that there was ample intact DNA present in the samples, and inhibitory chemicals did not significantly interfere with the qPCR amplifications. Therefore, if Arctic Grayling DNA was present in the samples, it would likely have been identified.

# 4 DISCUSSION

Overall, the fish passage improvement area appeared stable and functional. Movement of the riffle materials (cobble and boulders) and erosion and scouring were not observed. Water was observed to be flowing over each riffle during all sampling events, and was concentrated through the centre of the channel, achieving one of the design objectives. Finer materials had settled out within the interstices of the cobble and boulders; flow is remaining on the surface of the riffles; however, all observations of flow over the riffles were observed during high water conditions, so it was not clear if water flowing over the riffles was a function of the fines filling interstices or simply the high water conditions. Fine materials should continue to settle out and ensure that water flow remains on the surface of the structures, particularly during low flow periods.

Erosion of the steep, unstable south bank has continued to occur. High flows were observed more continuously in 2019 compared to previous years; the pool formed between the two riffle structures is partially intended to slow water velocities and reduce the erosion potential; however, with the longer duration of high flows and already unstable banks, erosion potential was increased in 2019. Woody debris and shrubs have deposited in this area and may provide some erosion protection; however, these materials may continue to shift. The willow plantings that occurred further downstream on the south bank may provide some erosion protection if they are able to establish before further erosion occurs.

In situ water quality data indicated no variation of water quality throughout the sample stations downstream are comparable to monitoring stations upstream. In addition, water quality results at the time of each sampling event were within Alberta surface water guidelines for the protection of aquatic life (CCME 2020). Water quality may change throughout the open water period due to various environmental variables such as changing nutrient and solar input combining with varying water discharge. Higher water velocities and increased water volumes contributed to improved water quality in the Beaverlodge River throughout the open water season.

July, August, and September 2019 mean monthly flows were above the historical mean. August and September mean monthly flows for 2019 were more than triple the historical mean (Section 3.2). Monitoring during this portion of the hydrograph was of particular interest to determine the success of the design objective of being able to pass fish during flow periods. As flows were higher than average throughout the late summer and fall, downstream migration and movement through the rock riffles was unimpeded. 2019 flow conditions did not allow for observations of fish passage potential during low flows.

Upstream migration potential was assessed based on habitat structure within each riffle and measurement of point velocities. Point velocities within both riffle structures were within flow velocity requirements to accommodate the burst speeds for various sized anguilliform and subcarangiform swimming forms; although higher velocities were observed in the centre of each riffle, velocities decreased from centre to the edge of the wetted channel. Additionally, the structure of habitat within each riffle was providing suitable holding and resting areas for fish to move upstream. Back water eddies and small pools were present throughout the riffles.

Instream and overhead cover elements were present throughout the assessment reach. Deep water within the runs and pools, along with turbid water, provided the majority of cover. However, woody debris were abundant, particularly along the right downstream bank (south bank), where debris has accumulated and slumping banks have contributed shrub material instream; the majority of fish were captured within these areas. The riffles themselves were providing suitable cover that may be utilized by a range of species, particularly Longnose Sucker and Burbot (Burbot were captured during the 2018 construction fish rescue).

# 5 RECOMMENDATIONS

Monitoring activities will continue to follow the Beaverlodge River monitoring plan (Matrix 2017) with the following recommended changes and additions:

- Aerial imagery will be taken to document yearly changes in river morphology and fish habitat.
  - Rationale: Aerial photographs will provide up-to-date fish habitat conditions and documentations of channel morphology throughout the 5-year monitoring period.
- Complete bathymetric survey within the Project area.
  - Rationale: more detailed monitoring of channel morphology within the Project area.
- Increased monitoring of the erosion along the high, unstable south bank, downstream of Riffle 1.
  - Rationale: more detailed erosional monitoring of this bank should be conducted, as further erosion may pose integrity issues of Riffle 2. This could be achieved through a combination of survey stakes and aerial imagery using an Unmanned Aerial Vehicle.
- Monitoring water temperature at the confluence of the Beaverlodge and Redwillow rivers to better understand the movement of Arctic Grayling within the watercourse. Movement of Arctic Grayling is expected to reach peak movement when water temperatures reach 10°C (Hvenegaard 2001). Monitoring of flow velocities would be dependent on suitable access and location within the Redwillow River.
- Continuous water quality monitoring throughout the open water period.
  - Rationale: monitoring water quality, particularly temperature and DO, throughout the open water period will provide additional data on habitat suitability throughout the summer. Poor water quality conditions may deter species such as Arctic Grayling migrating upstream and residing in the Beaverlodge River. Fish passage of the weir riffle structures may not occur during particular years as a result of fish being excluded due to poor water quality conditions, rather than the riffle features not being passable.
  - Installation of continuous water quality monitoring loggers will only occur if they can be accounted within the current and approved monitoring budget.

Changes to the monitoring program as described above should be approved by AEP before being executed in 2020.

# 6 REFERENCES


British Columbia Ministry of Environment (B.C. MoE). 2009. *Manual of British Columbia Hydrometric Standards*. Version 1.0. Resources Information Standards Committee Report. March 12, 2009.

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Matrix Solutions Inc. (Matrix). 2017. *Monitoring Plan for the Natural Channel Design and Fish Passage Project on the Beaverlodge River at S ½ 34-071-10 W6M*. Prepared for Mighty Peace Watershed Alliance Submitted to Alberta Transportation. Calgary, Alberta. August 2017.

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# APPENDIX A

## Site Photographs

1. BL1, viewing downstream (May 2019)

2. BL5, viewing downstream (May 2019)

3. BL6, viewing upstream (May 2019)


4. BL1, viewing downstream (July 2019)

5. BL2, viewing upstream (July 2019)

6. BL3, viewing downstream (July 2019)

7. BL4, viewing upstream (July 2019)

8. BL5, viewing downstream (July 2019)


9. BL6, viewing upstream (July 2019)

10. BL1, viewing downstream (August 2019)

11. BL2, viewing upstream (August 2019)

12. BL3, viewing downstream (August 2019)

13. BL4, viewing upstream (August 2019)

14. BL5, viewing downstream (August 2019)

15. BL6, viewing upstream (August 2019)

16. BL1, viewing downstream (October 2019)


17. BL2, viewing upstream (October 2019)


18. BL4, viewing upstream (October 2019)


19. BL3, viewing downstream (October 2019)


20. BL5, viewing downstream (October 2019)

21. BL6, viewing upstream (October 2019)

# APPENDIX B

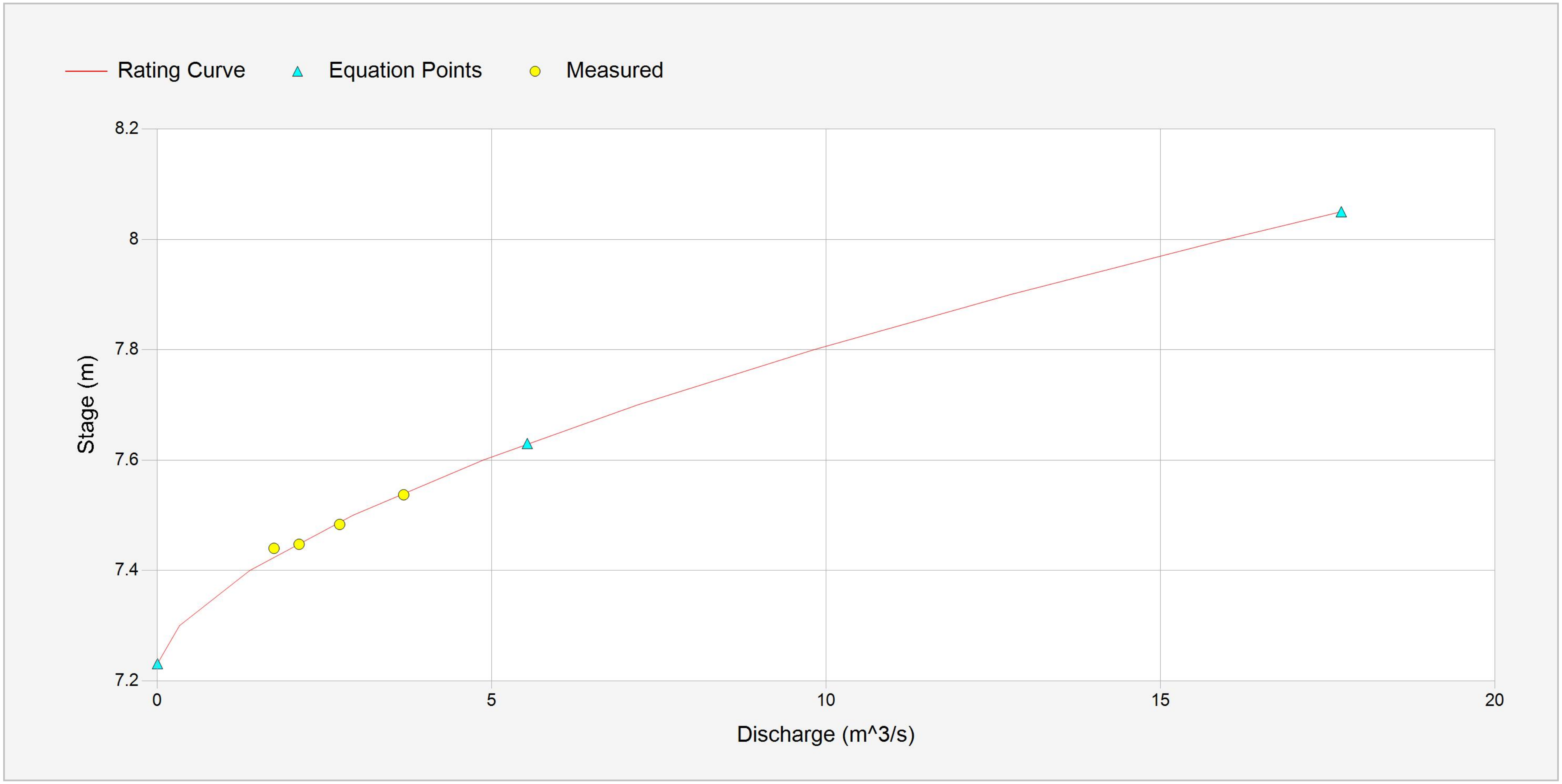
## Hydrology

# Rating Curve

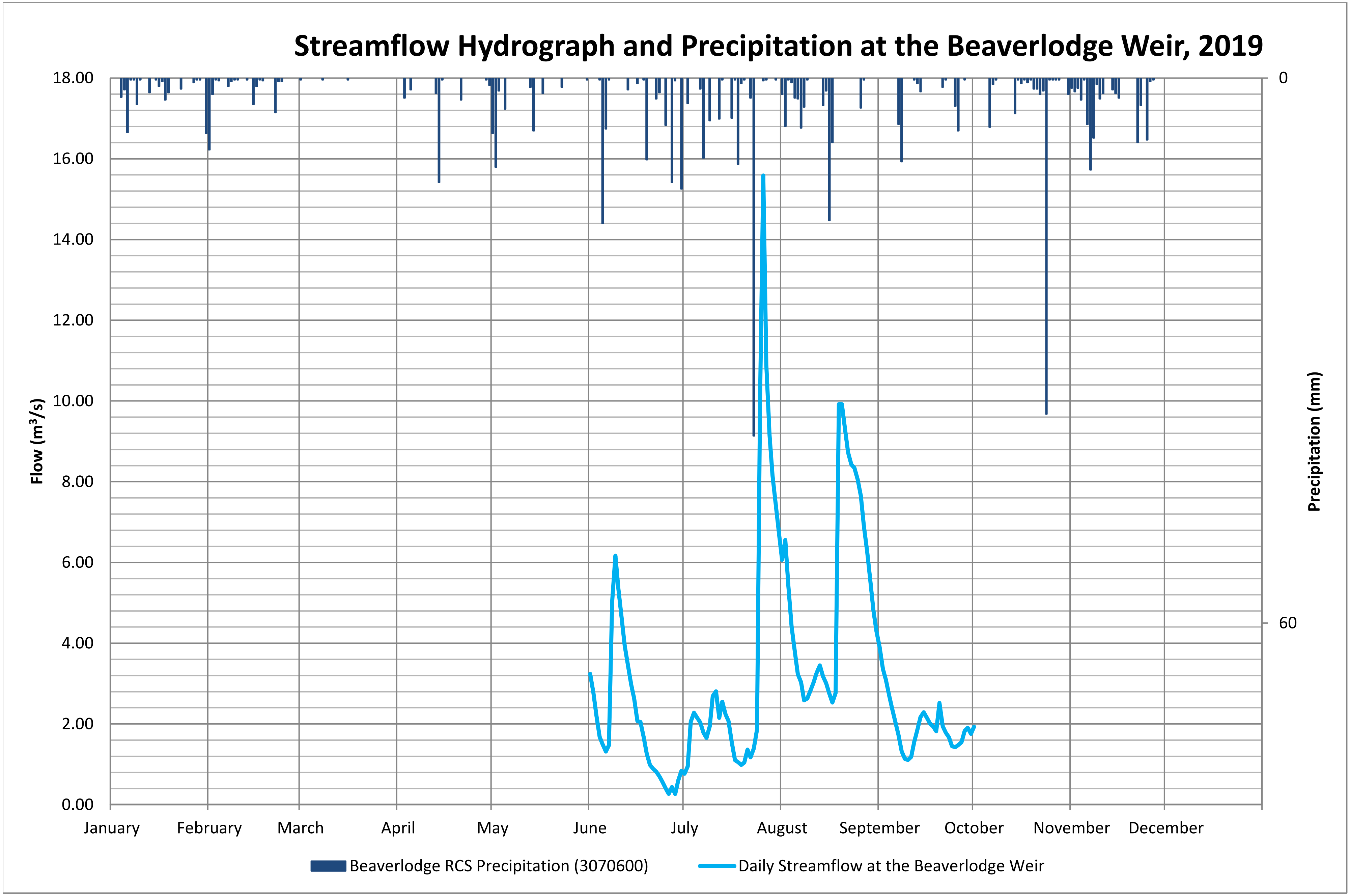
[Untitled Report]

Label: Rating Curve
Description: Site ID-2199-01

Curve on: November 29, 2019 Curve Start Date: May 30, 2019 Location: Beaverlodge River




Date Processed: November 29, 2019 15:27



Streamflow Hydrograph and Precipitation at the Beaverlodge Weir, 2019
Flow (m³/s)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Precipitation (mm)
0
60
January
February
March
April
May
June
July
August
September
October
November
December
Beaverlodge RCS Precipitation (3070600)
Daily Streamflow at the Beaverlodge Weir

| | |
|---|---|
| **Identifier:** | Discharge@2199-01 |
| **Location:** | Beaverlodge River |
| **Units:** | m^3/s |

## Mean Daily Stream Flow

**Year:** 2019

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | 3.051 B | 0.947 B | 6.342 E | 3.656 B | | | |
| 2 | | | | | | 2.477 B | 1.67 B | 6.025 E | 3.274 B | | | |
| 3 | | | | | | 1.953 B | 2.319 B | 4.913 B | 2.922 B | | | |
| 4 | | | | | | 1.587 B | 2.383 B | 4.06 B | 2.6 B | | | |
| 5 | | | | | | 1.471 B | 2.057 B | 3.544 B | 2.215 B | | | |
| 6 | | | | | | 1.389 B | 1.953 B | 3.301 B | 2.088 B | | | |
| 7 | | | | | | 3.052 B | 1.677 B | 2.768 B | 1.527 B | | | |
| 8 | | | | | | 6.363 E | 1.653 B | 2.604 B | 1.205 B | | | |
| 9 | | | | | | 5.738 E | 2.608 B | 2.739 B | 1.138 B | | | |
| 10 | | | | | | 5.048 B | 2.565 B | 2.903 B | 1.109 B | | | |
| 11 | | | | | | 4.245 B | 2.433 B | 3.192 B | 1.381 B | | | |
| 12 | | | | | | 3.694 B | 2.234 B | 3.424 B | 1.691 B | | | |
| 13 | | | | | | 3.217 B | 2.322 B | 3.5 B | 2.098 B | | | |
| 14 | | | | | | 2.655 B | 2.176 B | 3.085 B | 2.29 B | | | |
| 15 | | | | | | 2.45 B | 1.761 B | 2.873 B | 2.214 B | | | |
| 16 | | | | | | 2.056 B | 1.297 B | 2.721 B | 2.093 B | | | |
| 17 | | | | | | 1.876 B | 1.011 B | 2.579 B | 2.004 B | | | |
| 18 | | | | | | 1.529 B | 1.023 B | 5.913 E | 1.898 B | | | |
| 19 | | | | | | 1.135 B | 0.89 B | 10.256 E | 1.994 B | | | |
| 20 | | | | | | 0.957 B | 0.922 B | 9.512 E | 2.192 B | | | |
| 21 | | | | | | 0.835 B | 1.303 B | 8.975 E | 1.851 B | | | |
| 22 | | | | | | 0.746 B | 1.171 B | 8.539 E | 1.736 B | | | |
| 23 | | | | | | 0.636 B | 1.642 B | 8.343 E | 1.525 B | | | |
| 24 | | | | | | 0.451 B | 3.641 B | 8.204 E | 1.406 B | | | |
| 25 | | | | | | 0.305 B | 15.75 E | 7.812 E | 1.463 B | | | |
| 26 | | | | | | 0.402 B | 12.823 E | 7.27 E | 1.5 B | | | |
| 27 | | | | | | 0.317 B | 9.937 E | 6.615 E | 1.749 B | | | |
| 28 | | | | | | 0.543 B | 8.662 E | 5.928 E | 1.833 B | | | |
| 29 | | | | | | 0.658 B | 7.777 E | 5.195 B | 1.868 B | | | |
| 30 | | | | | | 0.771 B | 7.074 E | 4.554 B | 1.818 B | | | |
| 31 | | | | | | | 6.446 E | 4.119 B | | | | |
| **Mean** | | | | | | 2.054 | 3.617 | 5.22 | 1.945 | | | |
| **Min** | | | | | | 0.245 | 0.732 | 2.479 | 1.027 | | | |
| **Max** | | | | | | 6.913 | 17.358 | 10.46 | 3.901 | | | |
| **Total** | | | | | | 5323 | 9688 | 13980 | 5040 | | | |

Note: Calculated flows are provisional and graded B until the rating is verified further with flow measurements across the full range of high and low flow conditions. For quality grades, see Hydrometric Grading Criteria.

Instantaneous Minimum Flow: 0.245 m3/s on June 25, 2019 at 19:45

Instantaneous Maximum Flow: 17.358 m3/s on July 25, 2019 at 13:30