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 PROJECT: Bradley Lake Expansion Project
 SUBJECT: 2025 Dixon Operations Model Update

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DOWL again collected discharge measurements on the Martin River and its major tributaries. This memorandum describes the updates to the Dixon Diversion operations model with 2025 streamflow measurements.

STREAMFLOW MEASUREMENTS

DOWL has collected streamflow measurements on the Martin River for the past three consecutive years (i.e., 2023-2025). The Martin River Streamgaging Data Acquisition and Analysis Report (Attachment 1) describes the methodology, details of the discharge measurements, development of the rating curves, and rating shifts. Figure 1 presents locations and drainages of the streamgaging stations. Streamflow was measured at the following locations:

- Martin River at the Constriction
- Red Lake Basin Outlet
- OCH2.8R
- Trib 1.070
- East Fork Martin River at the Mouth (not continuous)

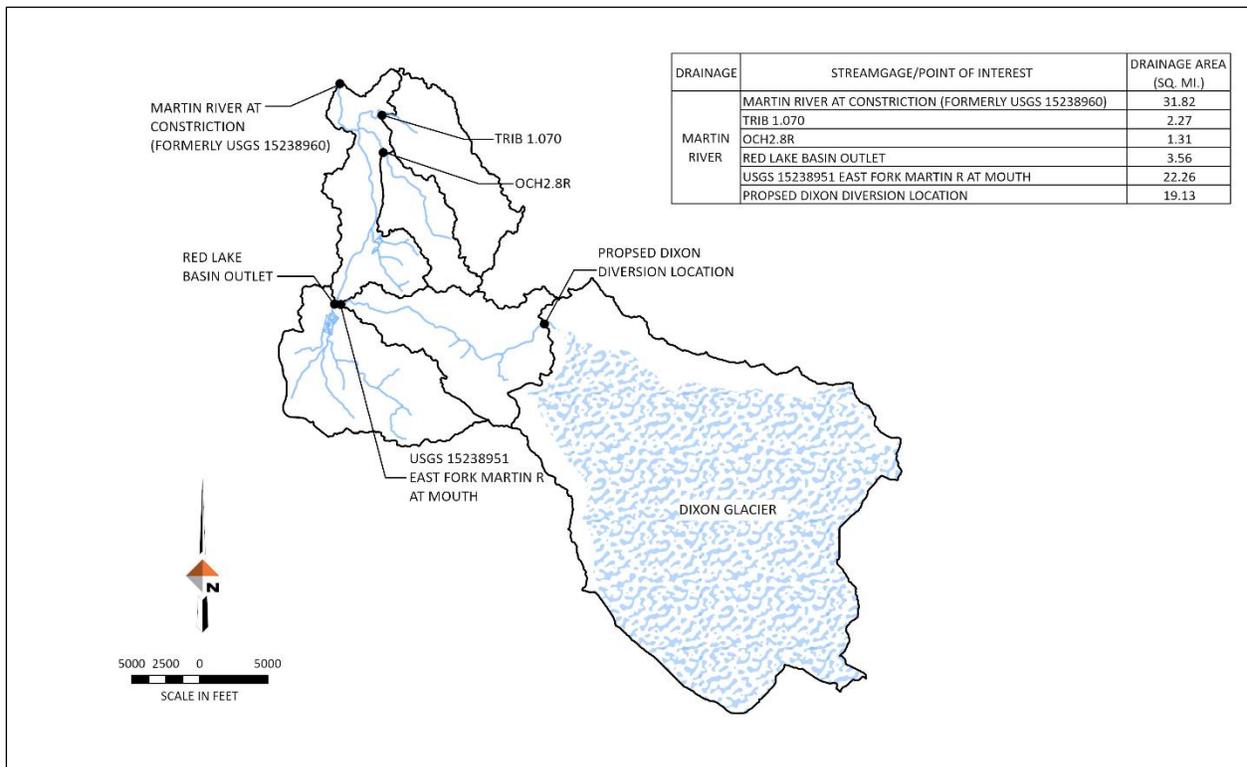


Figure 1: Streamgages along the Martin River Watercourse

Continuous streamflow measurements are not available at the East Fork Martin River at the Mouth (USGS 15238951), although discharge is occasionally measured by the USGS and DOWL; therefore, DOWL created an approximate discharge hydrograph for the Dixon Basin. The discharge at the East Fork Martin River was calculated by subtracting the discharge at Red Lake, OCH2.8R, and Trib 1.070 from the discharge of the Martin River at the Constriction. The calculated discharge at the Mouth was validated using point discharge measurements by DOWL and the USGS (USGS 15238951). Note that there is an unaccounted-for area between the proposed diversion and the Mouth, which is about 3.13 mi² (~16% of the drainage area to the Dixon Diversion), but is believed to not significantly affect the discharge estimates at the diversion because the runoff would only be from early season snowmelt (as opposed to glacier melt throughout the summer) and precipitation. Figure 2 presents the 2025 average daily East Fork Martin River Hydrograph at the Mouth and Attachment 2 summarizes the discharge calculations.

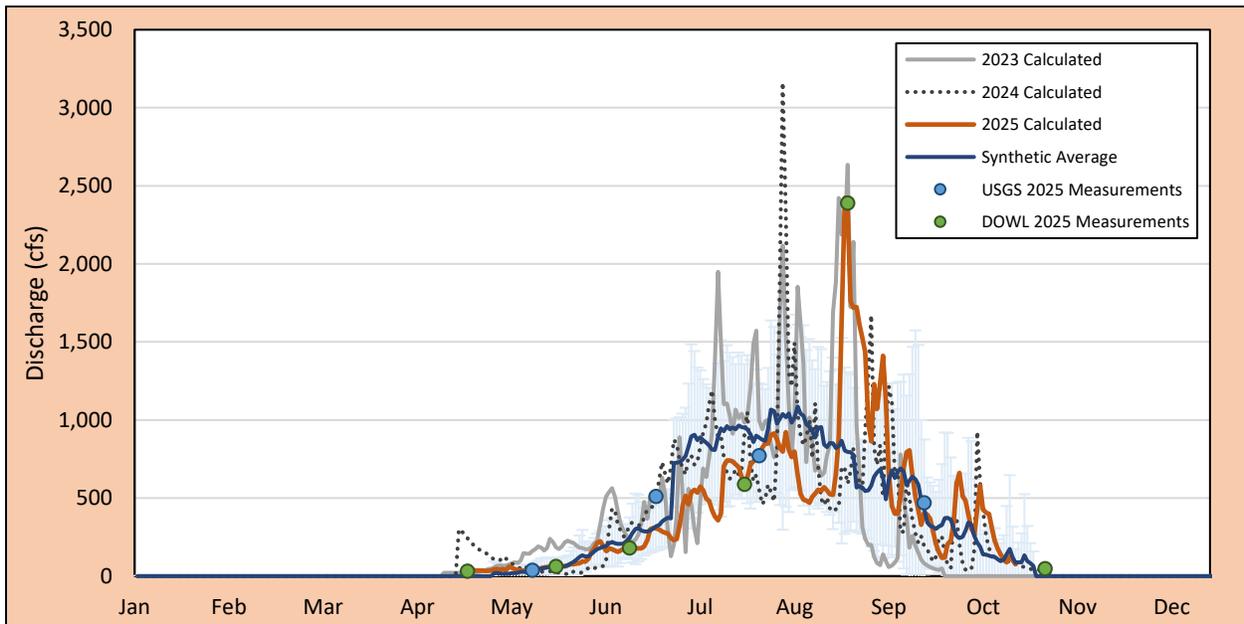


Figure 2: East Fork Martin River Discharge at the Mouth

A significant flood in August 2024 washed out the streamgage near Nuka Glacier (USGS 15238990). As a result, the rating relationship is still being developed, and continuous discharge measurements are not available. No updates were made to the synthetic hydrograph, flood-frequency, or flood-exceedance relationships.

DIVERSION OPERATIONS MODEL UPDATE

DOWL updated the Dixon Diversion Operations model using two different records: 1) the 2025 East Fork Martin River discharge at the Mouth (Measured Record) and 2) the Synthetic and Measured Record. The 20-year Synthetic and Measured Record includes the combination of the three years of measured discharges (2023-2025) with the synthetic record (2006-2022), which is documented in the *Update to the 2023 Hydrology Report with 2024 Data* memorandum. The full synthetic record spans from 1980 to 2022.

Since the 2024 Dixon operations model update, the design and layout of the diversion have undergone significant refinement. Most notable is the diversion tunnel size and capacity, which is set at 1,650 cfs. Hence, the 2025 operations model update uses a tunnel capacity of 1,650 cfs. Attachment 3 presents the updated model results.

Attachment 1: Martin River Streamgaging Data Acquisition and Analysis Report

MARTIN RIVER STREAMGAGING DATA ACQUISITION AND ANALYSIS REPORT

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APPENDICES

Appendix A: Photo Log

ACRONYMS AND ABBREVIATIONS

ADCP	Acoustic Doppler Current Profiler
ADV	Acoustic Doppler Velocimeter
AEA	Alaska Energy Authority
cfs	cubic feet per second
EFMR	East Fork Martin River (gage)
GNSS	Global Navigation Satellite System
HOBO MX2001	water-level and temperature logger manufactured by Onset
iGage	Radar-based water-level gage (Iridium-telemetry enabled)
QC	quality control
QRev	USGS software for ADCP discharge review and analysis
RM	River Mile
RLS	Radar Level Sensor
RTK	Real-Time Kinematic
SNR	Signal-to-Noise Ratio
S/N	Serial number
Trib	Tributary
USGS	United States Geological Survey
WFMR	West Fork Martin River (gage)
WSE	Water Surface Elevation

EXECUTIVE SUMMARY

This report outlines the methods and analysis used in a multi-year hydrologic monitoring program conducted by DOWL Alaska for Alaska Energy Authority to characterize streamflow in the Martin River basin. The primary objective of this analysis is to develop continuous discharge records at multiple locations in the basin to support hydrologic characterization and subsequent project evaluations.

From 2023 through 2025, water-level monitoring equipment was deployed at five sites to document hydrologic conditions across a range of seasonal, geomorphic, and hydraulic regimes. All sensors were surveyed to a common project datum using Global Navigation Satellite System-enabled Real-Time Kinematic methods. Routine level checks and reference monument surveys were conducted to confirm vertical stability and detect sensor drift or movement. Continuous stage records were paired with discrete discharge measurements collected using Acoustic Doppler Current Profilers and current meters in accordance with U.S. Geological Survey techniques and methods, ensuring the resulting rating curves and continuous discharge records are consistent with established hydrometric standards.

Across the monitoring network, water level and discharge data show clear seasonal patterns driven by glacial melt, snowmelt, summer groundwater recession, and fall rainfall. Multiple gaging locations maintained stable hydraulic controls and well-constrained rating curves, resulting in defensible continuous discharge records supported by repeated measurements over a range of flow conditions.

At three sites, hydraulic conditions were periodically affected by overbank flooding from the East Fork and mainstem Martin River. These events temporarily elevated stage at the gages and produced discharge values that are not representative of flows generated within the tributary basins. Flood-impacted periods were identified using a combination of visual inspections, time-lapse imagery, geomorphic observations, and comparison to unaffected seasonal recession patterns. Data from these intervals were flagged and excluded from interpretation.

The monitoring program generated robust hydrologic datasets that characterize the natural behavior of the Martin River watershed. Data collection, processing and quality control procedures followed established U.S. Geological Survey techniques and methods, ensuring the integrity and defensibility of the hydrologic results for subsequent hydrologic, environmental and project-level analysis.

1.0 INTRODUCTION

This report outlines the methodology, data collection, and analysis for a multi-year hydrologic monitoring program conducted by DOWL Alaska for Alaska Energy Authority to characterize streamflow in the Martin River basin. The primary objective of this analysis is to develop continuous discharge records at multiple locations in the basin to support hydrologic characterization and subsequent project evaluations.

Field measurements were collected during the open-water seasons of 2023 through 2025 to document water-surface elevations and discharge under a range of seasonal hydrologic conditions. The resulting dataset provides the foundation for characterizing hydrologic processes within the Martin River basin and supports subsequent evaluations conducted for project feasibility and environmental assessment.

The Martin River is within the Kachemak Bay basin in Southcentral Alaska (Figure 1). The river hydrology is dominated by meltwater contributions from Dixon Glacier and several smaller tributary sub-basins. Five monitoring locations distributed throughout the Martin River system were established for the study (Figure 2). These sites were selected to differentiate the hydrologic contributions from the East Fork Martin River, primarily influenced by Dixon Glacier, from those of the smaller tributaries that also supply flow to the mainstem.

Instrumentation was deployed in the tributary basins to quantify individual flow contributions and to support concurrent fish habitat investigations conducted by Kleinschmidt. The resulting discharge and water-level datasets will inform assessments of minimum instream flow (MIF) requirements for aquatic habitat suitability and provided critical context for evaluating water availability to support hydropower development. For these reasons, both the East Fork Martin River and the smaller tributaries were monitored throughout the study period.



Figure 1: Martin River Watershed

2.0 SURFACE WATER ELEVATION

2.1 METHODOLOGY

To develop a high-resolution dataset with water surface elevation (WSE) measurements tied to the project datum, using consistent sampling rates and timestamps, DOWL installed water level loggers at five locations on the Martin River. Installation of the equipment was guided by United States Geological Survey (USGS) Techniques and Methods 3-A7, *Stage Measurement at Gaging Stations* [1].

The collected data is used to characterize flow from the Martin River and its tributaries. Stage was recorded at 15-minute intervals with a pressure transducer or radar sensor operating on a vertical local datum. The DOWL water level logger’s local datum and corresponding water surface elevation was surveyed to the Bradey Lake Vertical Datum using Global Navigation Satellite System (GNSS)-enabled real-time kinematic (RTK) equipment.

2.2 LOCATION

Figure 2 depicts the approximate locations of the water level loggers.



Figure 2: Locations of Water Level Loggers

USGS Sensor Locations:

East Fork Martin River Gage (EFMR) Station 15238951: Located at the canyon outlet of the East Fork Martin River.

DOWL Sensor locations:

Constriction Gage: Located furthest downstream at a narrow point on the Martin River.

Tributary (Trib) 1.070 Gage: Located on a tributary to the Martin River.

OCH2.8R Gage: Located on a tributary to the Martin River. (This gage was permanently removed after the 2024 open water season due to flooding affecting the majority of the discharge record and the recorded flows accounting for less than 1% of the Martin River watershed.)

Trib RM4.2 Gage: Located on a tributary to the Martin River.

West Fork Martin River Gage (WFMR): Located on a tributary to the Martin River near the outlet of Red Lake.

Table 1 lists the sensor locations and period of deployment to present day.

Table 1: DOWL Logger Location and Active Time Period

Gage Description	Sensor Type	Active Time Period	River Mile	Northing ¹	Easting ¹	Gage Datum ²
Constriction	RLS, iGage & HOBO MX2001 S/N: 21386603 S/N: 21762509 (Replaced 24')	2023-2025	1.9	2098618.241	1455532.387	67.96
Trib 1.070	HOBO MX2001 S/N: 22283910	2025	2.8	2096296.425	1458686.166	110.34
OCH2.8R	HOBO MX2001 S/N: 22283890	2025	3.1	2093577.394	1458723.814	122.78
Trib RM4.2	HOBO MX2001 S/N:21264492 S/N:21386622 (Replaced 24')	2023-2024	4.2	2087662.249	1457952.625	190.21
WRMR	HOBO MX2001 S/N: 21386621 S/N: 22283909 (Replaced 24') S/N: 22260256 (Replaced 25')	2023-2025	5.3	2082416.928	1455123.905	274.84
USGS Gage 15238951 EFMR	Radar Sensor (make and model unknown)	2023-2025	5.3	2082416.928	1455123.90	N/A

¹ Alaska State Plane Coordinates Zone 4, NAD83(2011) in U.S. Survey Feet

² Bradley Lake Vertical Datum

2.3 EQUIPMENT AND INSTALLATION

Initial monitoring conducted in 2022 informed the design and implementation of the study period from 2023 through 2025. Although the 2022 observations guided site selection, instrumentation choices, and deployment strategies, the data collected during 2022 were not incorporated into the formal analysis due to differences in methods, locations, and data quality objectives established for subsequent years.

During the open-water season (April to November), water-level and temperature sensors were deployed at multiple locations along the Martin River as part of a multi-year program. Site visits were conducted periodically to download data and inspect the instruments and anchor systems, ensuring they remained secure and undamaged. All sensors were retrieved before the onset of freezing conditions, with deployments repeated annually throughout the 2023 to 2025 study period. Because monitoring locations varied from year to year, sensor types, deployment methods, and logging durations were selected to best suit each site. The following sections describe the specific instrumentation and deployment methods.

2.3.1.1 HOBO MX2001

All gage sites are equipped with a HOBO MX2001 water-level logger. The HOBO MX2001 is a Bluetooth-enabled water level and temperature data logger designed by Onset to monitor groundwater or surface water. It consists of a top-end unit with a wireless interface and replaceable batteries, connected to a pressure and temperature sensor via a direct-read cable. Data can be wirelessly configured and downloaded, eliminating the need for manual retrieval in the field. The HOBO MX2001 provides high-accuracy water level measurements ($\pm 0.05\%$). The small sensor housing, various cable lengths, and accuracy make it a reliable and efficient tool for water-level monitoring applications.

Each HOBO MX2001 water-level logger was mounted within a protective casing, either a 1.25-inch stainless steel pipe or a 2-inch aluminum stilling well, depending on site conditions. In low-velocity environments, the sensor was installed in a 1.25-inch stainless-steel pipe and attached to a 2-foot dowel, which was then driven into the channel bed. In high-velocity environments, the sensor was placed in a 2-inch aluminum stilling well and secured directly to bedrock using self-tapping rock bolts. Loggers were configured to sample at 15-minute intervals, and the tethered data logger assembly was positioned at least 3 feet above the high-water line to allow safe retrieval during elevated flows. Anchoring was reinforced using bedrock or nearby trees to protect the data logger from debris impact. The elevation of each sensor and the corresponding water-surface elevation were surveyed to the project datum.

2.3.1.2 OTT Radar Level Sensor

The Constriction at River Mile (RM) 1.9 was equipped with an OTT Radar Level Sensor (RLS) in 2024. Submerged water loggers at the Constriction were avoided due to sensor damage incurred by debris and sediment loads in 2023. The OTT RLS is a non-contact, pulse-radar water level instrument designed for precise monitoring of surface water applications, including rivers, lakes, tidal zones, and flood-prone channels. It emits radar pulses toward the water surface and calculates the distance based on the return time, delivering reliable level data unaffected by factors such as temperature gradients, floating debris, or sediment loads. With a typical measurement range of up to 35 meters, the sensor supports integration into remote or solar-powered measurement stations. Its low power consumption, compact design, and rugged housing make it suitable for long-term deployment with minimal maintenance in challenging field environments.

The OTT RLS was mounted to an 8-foot steel Unistrut and positioned approximately 4 feet out from the bank and 10 feet above the typical low water surface elevation within the gage pool. The Unistrut was secured to the streambank using three 2-foot dowels embedded into the ground. To provide additional lateral stability, two steel guide cables were attached to the Unistrut and anchored to the bank with 2-foot metal L-brackets. Power for the system was supplied by a 220-ampere-hour battery bank housed in a gage box on the bank, supported by a 20-watt solar panel and a cellular antenna. The OTT RLS recorded water level at 15-minute intervals using a 30-second averaging period. Data were logged by a Starlink 500 unit and transmitted to a Hydromet cloud server every three hours via Verizon cellular telemetry.

2.3.1.3 iGage Sensor

The Constriction gage (RM 1.9) is also equipped with a backup iGage sensor. The iGage is a compact, radar-based water-level gage designed for easy deployment on bridges or other fixed structures for hydrological monitoring. It measures the distance from the sensor to the water surface over a range of 0 to 10 meters, with a distance accuracy of approximately 1% and a resolution of ± 1 millimeter. Its satellite-based Iridium communication allows for real-time water-level reporting, and its low power consumption enables long-term autonomous deployments.

The iGage sensor was mounted on the steel Unistrut next to the OTT RLS. The iGage recorded the water level at 1-hour intervals. Data were transmitted to a Stillwater cloud server every hour with Iridium telemetry.

2.4 WATER LEVEL DATA HANDLING AND QUALITY CONTROL

Water surface elevations at each sensor location were surveyed using GNSS-enabled RTK equipment to reference water depth measurements to the Bradley Lake Vertical Datum. A differential level survey was completed twice per season, typically at deployment and removal, to verify vertical control. During each site visit, gage heights were collected by measuring water surface elevation relative to two or three surveyed reference monuments. These field surveys were used to evaluate sensor stability throughout the monitoring period. Sensor drift was identified only at the WFMR gage (HOBO MX2001, S/N: 22283909), which was subsequently replaced. Sensor movement was also documented in the iGage and RLS sensors at the Constriction, the HOBO MX2001 (S/N: 22283909) at WFMR, and the HOBO MX2001 (S/N: 21386622) at Trib RM4.2; these movements were confirmed through fall surveys. Flooding events caused by the Martin River overtopping its banks were confirmed using time-lapse cameras aimed at the section/channel controls, and were observed to affect Trib RM4.2, WFMR, and OCH2.8R.

Time series datasets were inspected to identify anomalies and periods of questionable data quality. Outliers exceeding three standard deviations from the mean were removed; these were primarily associated with sensor installation and removal. Sudden increases in water surface elevation corresponding to documented Martin River flooding were also detected during outlier review. Flooding events introduced periods where hydraulic control was lost or substantially altered, resulting in water surface elevations and inferred discharges that were not representative of typical tributary behavior. No corrections were applied to compensate for these flood-related effects, and data collected during confirmed flooding periods were excluded from subsequent analysis.

Logger-based water-level time series were compared with gage height measurements and level survey results to identify and quantify sensor drift or movement. These comparisons informed decisions regarding data acceptance and removal in the final processed dataset, ensuring that the remaining records reflected periods of stable hydraulic and sensor conditions.

3.0 DISCHARGE

3.1 METHODOLOGY

Depending on the flow conditions, DOWL used either a Sontek RS5 Acoustic Doppler Current Profiler (ADCP), a Teledyne RiverPro ADCP, or a FlowTracker2 Acoustic Doppler Velocimeter (ADV) to measure discharge. Discharge measurements were performed as close as possible to the water level data logger. Discharge measurements were attempted at every site visit, but not all were successfully measured during each trip due to safety concerns, time constraints, and longer discharge measurement times during high water. These measurements were collected to capture seasonal variations in discharge of the watershed,

develop a stage-discharge relationship, and validate continuous discharge records. Discharge measurements performed by DOWL used guidance from the following USGS methodologies:

- Techniques and Methods 3-A8: *Discharge Measurements at Gaging Stations* [2]
- Techniques and Methods 3-A22: *Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat* [3]

3.1.1 Location

Discharge measurements were collected at all gaging sites, with measurement locations selected in accordance with USGS recommendations for identifying cross-sections that provide uniform, steady, and representative hydraulic conditions. At each site, a measurement cross-section was chosen to ensure adequate depth, uniform banks, minimal turbulence, and a smooth, unobstructed bed, while also allowing safe deployment of an ADCP or current meter. Measurement locations were kept as consistent as possible throughout the study period, and no missing or additional inflows were present between the measurement cross-section and the gage, ensuring that measured discharge directly corresponded to the recorded stage.

A photo log of the gage locations at varying measured or estimated discharges is included in Appendix A.

3.1.1.1 OCH2.8R Measurement Location

Discharge measurements were collected 15 feet downstream of the OCH2.8R gage at a stable riffle control (Figure 3). It was selected based on USGS recommendations for its uniform flow, with consistent depth and velocity distribution, and suitable hydraulic conditions for accurate discharge measurements.



Figure 3: OCH2.8R Discharge Measurement Location

3.1.1.2 Constriction Measurement Location

At the Constriction gage (RM 1.9), discharge measurements were collected at two downstream cross-sections selected in accordance with USGS recommendations for identifying sites with uniform, steady, and representative hydraulic conditions. For flows between approximately 20 and 1,000 cubic feet per second (cfs), measurements were taken about 200 feet downstream of the gage at a straight, well-defined cross-section (Discharge Measurement Location 1 in Figure 4) that provided adequate depth, minimal turbulence, and stable banks for ADCP and current meter measurements. Under high-flow conditions

exceeding 1,000 cfs, measurements were conducted approximately 40 feet downstream at Discharge Measurement Location 2, where a steel cable could be deployed to allowed secure attachment of the trimaran and provided a safer, more controlled environment for operating equipment during elevated, high-velocity conditions. Together, these locations offered hydraulically appropriate and safe measurement conditions across the full range of observed discharges.



Figure 4: Constriction Discharge Measurement Location

3.1.1.3 Trib 1.070 Measurement Location

Discharge measurements at Trib 1.070 were collected within a reach extending approximately 5 to 150 feet downstream of the gage (Figure 5). The measurement location varied seasonally and was selected in accordance with USGS recommendations. Within this short, low-gradient channel, the optimal measurement location shifted with water levels and vegetation growth. Cross-sections were chosen where the channel exhibited a well-defined shape, consistent depth and velocity distribution, minimal bankside vegetation interference, and stable bed conditions suitable for wading measurements.



Figure 5: Trib 1.070 Discharge Measurement Location

3.1.1.4 Trib RM4.2 Measurement Location

At Trib RM 4.2, discharge measurements were typically collected approximately 15 feet upstream of the gage at a straight, well defined section of the tributary channel (Figure 6). This location provides a stable hydraulic section where flow is confined between vegetated banks and passes over a shallow sandy gravel bed, producing uniform depth and velocity profiles suitable for wading measurements. The upstream cross-section was selected in accordance with USGS recommendations.



Figure 6: Trib RM4.2 Discharge Measurement Location

3.1.1.5 WRMR Measurement Location

At the WFMR gage, discharge measurements were typically collected approximately 10 to 15 feet downstream of the gage at a straight, confined section of the channel, upstream of the confluence with the EFMR (Figure 7). This location provides a well-defined measurement cross-section with uniform flow, moderate depths suitable for wading or low-flow ADCP deployment, and a relatively stable sandy cobble bed that minimizes lateral variability in velocity. The proximity to the gage ensures that no tributary inflows, channel bifurcations, or backwater influences occur between the gage and the measurement site. The cross-section was selected in accordance with USGS recommendations.



Figure 7: EFMR and WFMR Discharge Measurement Location

3.1.1.6 EFMR Measurement Location

Discharge measurements at the East Fork Martin River were typically collected 150 to 250 feet upstream of the USGS gage at a straight, hydraulically suitable section of the channel. All viable measurement locations in this reach contain numerous large boulders embedded in the channel bed, producing irregular velocity fields and making it difficult to obtain fully uniform discharge measurements. The selected upstream cross-section represented the most uniform location available, offering comparatively consistent depths and fewer flow obstructions than nearby alternatives. Beginning in August 2024, the formation of a secondary channel approximately 70 feet upstream of the USGS gage diverted part of the flow away from the primary channel, resulting in the USGS gage receiving only an estimated 85% to 95% of the total discharge through November 2025. Conducting measurements upstream of the bifurcation ensured that both channels were captured during discharge measurements. Discharge measurements and gage heights collected at the EFMR were provided to the USGS for review in their independent gage analysis.

3.1.2 Equipment

ADCPs and a current meter were used to measure discharge at all locations.

3.1.2.1 Teledyne RDI RiverPro ADCP

A Teledyne RDI RiverPro ADCP, operating with WinRiver II software, was used to measure discharge during high summer flows. The RiverPro 1200 kilohertz beams enable accurate discharge profiling in water depths up to 80 feet, with adaptive sampling to maintain high-quality velocity and depth data despite variations in turbidity, bed formation, and flow conditions.

ADCP measurements were conducted using either a remote-controlled HR Wallingford ARCboat, a 4-foot trimaran platform or Sontek Hydroboard, attached to a tethered rope. When using the Hydroboard or trimaran, the ADCP was guided across the channel along controlled transects to collect velocity, depth, and boat-track data. The operator maintained consistent cross-section coverage by manually pulling the rope attached to the trimaran while monitoring real-time quality indicators to ensure valid bottom tracking and signal performance. Figure 8 shows ADCP measurements conducted at the Constriction and EFMR.



Figure 8: RiverPro ADCP on Trimaran, Right Photo - 8/29/25 | Constriction | 2,490 cfs Left Photo - 7/23/24 EFMR | 614 cfs

3.1.2.2 Sontek RS5 ADCP

A SonTek RS5 ADCP was used to measure discharge at the Constriction, EFMR, and WFMR during low to medium flows. The RS5 five-beam, 5-megahertz acoustic system enables high-resolution measurements in shallow and dynamic flow conditions, with precise bottom tracking and adaptive sampling to maintain data quality across varying depths, turbulence levels, and channel conditions.

3.1.2.3 Sontek Flowtracker2 ADV

A SonTek FlowTracker2 ADV was used to obtain discharge measurements during shallow wading conditions. The FlowTracker2 is a current meter that utilizes acoustic doppler technology to measure two-dimensional water velocity with high precision, making it well-suited for shallow, low-velocity, or complex flow environments where larger instruments cannot be deployed. The system features built-in quality assurance checks, real-time signal diagnostics, and onboard data processing to support consistent, defensible velocity measurements in accordance with standard hydrometric practices. Figure 9 shows the ADV measurements being conducted at Trib RM4.2 and WFMR.



**Figure 9: FlowTracker2 Measurements: Left Photo - 11/17/23 | Trib RM4.2 | 0.5 cfs
Right Photo - 5/22/25 | WFMR | 16.0 cfs**

3.1.3 Data Handling and Quality Control

A comprehensive set of automated and visual quality control (QC) checks was conducted on ADCP and current meter measurements to ensure the accuracy, consistency, and adherence of discharge data to USGS hydrologic standards. [1]

3.1.3.1 ADCP Data Handling and QC

Before each measurement, the ADCP underwent standard USGS-recommended field operational checks, including verification of system time, internal firmware diagnostics, compass calibration, and moving-bed tests to confirm the suitability of bottom tracking. Discharge data were collected using multiple transects, following the USGS mid-section and equal-transit-rate principles, which ensured complete coverage of the channel cross-section and minimized flow-direction bias. During data collection, vessel speed, transect alignment, depth returns, and real-time quality indicators were monitored to detect signal interference, poor beam performance, or anomalous velocity profiles. Transects were repeated as necessary to meet USGS measurement standards.

Post-processing quality control was completed using QRev, a USGS software for evaluating and documenting ADCP discharge measurements. Each measurement was assessed for transect path consistency, proper edge discharge estimation, moving-bed corrections, and extrapolation methods. Additional diagnostics included a review of ensemble validity, beam correlation and amplitude, velocity profile shape, depth consistency, discharge variability between transects, and calculation of measurement uncertainty. Final discharge values were accepted only after all QRev checks were satisfied and the measurement met USGS criteria. Figure 10 depicts the Qrev output of a discharge transect, in terms of velocity and depth, for a measurement at the constriction. The white areas at the water surface, channel bed, and along the banks represent zones where direct velocity data could not be collected. QRev automatically estimates velocities in these unmeasured regions using USGS-approved extrapolation methods.

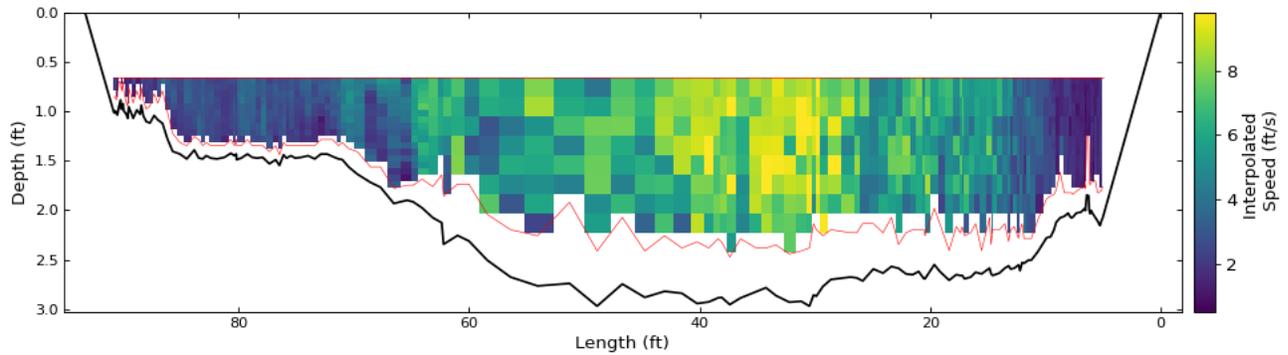


Figure 10: QRev ADCP Discharge Profile, Constriction, 7/3/24 at 15:30, 722 cfs

3.1.3.2 Sontek Flowtracker2 Data Handling and QC

SonTek FlowTracker2 ADV measurements were conducted in accordance with standard USGS current-meter measurement procedures to ensure accuracy and defensibility. In the field, velocity data were collected using the mid-section method, with careful selection of cross-section geometry, sufficient verticals to capture hydraulic variability, and proper positioning of the sensor at a depth of 0.6 (or the 0.2/0.8 or 0.2/0.6/0.8 method, where appropriate). Discharge measurements, following the mid-section method, collected at least 20 discrete measurements at sampling stations along a transect. During each measurement, the FlowTracker2 real-time diagnostics were monitored, including signal-to-noise ratio (SNR), beam correlation, and turbulence indicators. Verticals failing the instrument or USGS quality criteria were repeated. Additional field checks included verification of stable stage conditions, consistent wading rod orientation, and repeat velocity readings if abnormal variability was observed.

Post-processing QC included exporting and reviewing measurement results in Flowtracker2 software, ensuring that subsection widths, mean velocities, and discharge calculations were consistent and free of anomalous values. The final discharge result was accepted only after a comprehensive review of both field diagnostics and processed data confirmed compliance with USGS current-meter measurement standards. Figure 11 depicts the velocity profile from an ADV measurement at the WFMR. Within the FlowTracker2 software, velocity data can be examined for both magnitude and direction at each vertical where measurements were collected, allowing detailed assessment of flow structure across the cross-section.

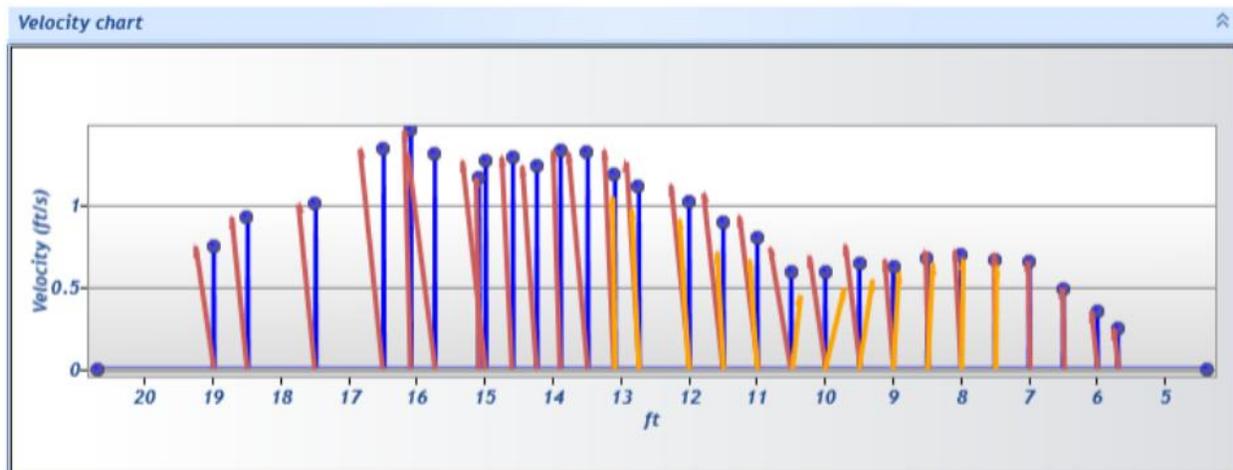


Figure 11:Flowtracker2 Velocity Profile, WFMR 5/22/25 at 9:30, 17.0 cfs

4.0 DATA ANALYSIS

An analysis was completed for all DOWL-operated gage locations. The USGS-operated gage at the ERM R was not included, as the USGS will conduct its own independent evaluation

4.1 STAGE-DISCHARGE METHODOLOGY AND QUALITY CONTROL

Discharge measurements collected from ADCP, and current-meter methods were paired with corresponding gage height readings and plotted to form the basis of a stage-discharge rating following USGS standards. Each point was examined for consistency with expected hydraulic behavior, including assessment of measurement uncertainty, stability of channel control, and potential influences such as backwater, hysteresis, or temporary obstructions. Scatter within the plotted data was evaluated by comparing point clusters to typical flow-regime transitions, reviewing repeat measurements collected under similar stage conditions, and examining residuals relative to preliminary rating estimates. Outliers were investigated for possible causes such as poor edge estimates, moving-bed effects, unstable velocity measurements, or rapidly changing stage before determining whether they should be included.

A rating curve was then developed by fitting a standard USGS power function, Equation 1, where e is the rating shift or control elevation, and a and b are empirically derived coefficients. [4]

$$Y = a + b(X - e)^c$$

Y = discharge
X = gage height
a = equation constant
b = multiplier
e = scale offset
c = exponent

Equation 1: USGS power-function equation

Initial parameters were estimated using log-transformed linear regression and then refined through iterative adjustments to minimize residuals while maintaining realistic hydraulics across the full flow range. Additional segmentation was reviewed when distinct low-, mid-, or high-flow controls were evident. The resulting rating was reviewed for agreement with expected channel hydraulics and long-term stability. It was validated against supplemental measurements and continuous gage records before being accepted as the operational stage-discharge relationship.

4.1.1 Constriction Stage-Discharge Relationship

Figure 12 illustrates the Constriction stage-discharge relationship, based on 27 recorded measurements, compared to the computed rating curve equation.

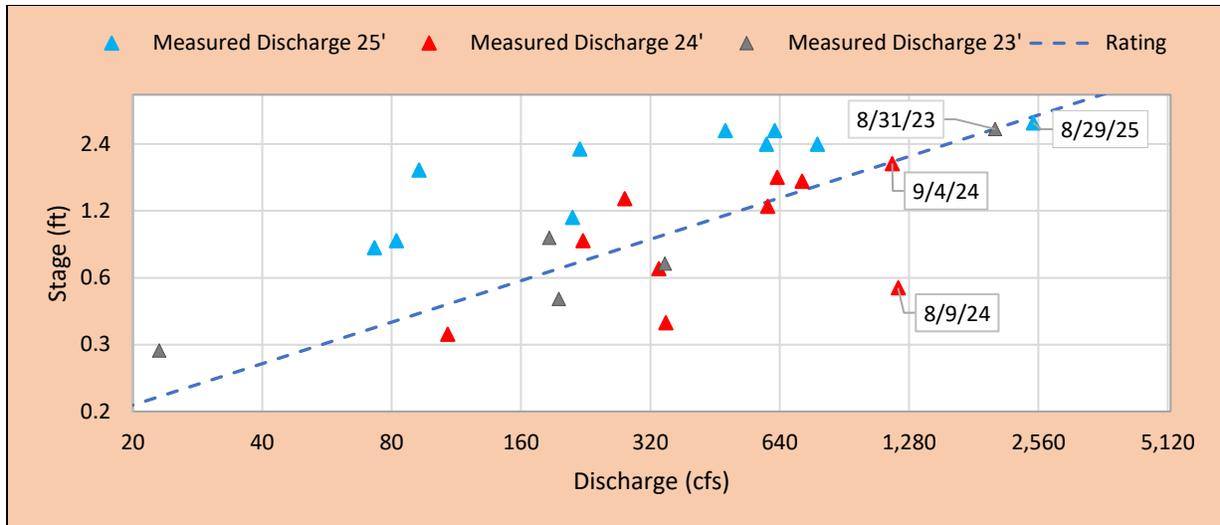


Figure 12: Constriction Rating Curve

The Constriction gage on the Martin River is situated within a braided gravel-bed system at an abrupt narrow reach, where the channel transitions from a broad 550- to 950-foot active width to a confined section approximately 120 feet wide between 15-foot-tall, vertically stable banks. The constriction as a gage location exhibits highly unstable hydraulic controls, with repeated cycles of scour, deposition, and hydraulic-forcing conditions that elevate the water surface, and low water channel migration, typical of wide gravel-bed channels. Summer measurements (July to August) display the most significant variability, forming both scour clusters tied to mid-summer storm events that mobilize bed material and aggradational clusters reflecting deposition during receding flows.

Rating stability is poor, with shifts ranging from +1.49 to -1.61 (Figure 13), far exceeding the typically acceptable range for a stable USGS rating. Several large shifts in 2025 indicate a significant change in bed elevation or channel migration toward the river's left gage location. The magnitude and variability suggest that a single rating curve is inappropriate, and that frequently updated shifts to the rating curve, along with gage height-based control switching, may be necessary.



Figure 13: Constriction Shift Diagram

4.1.2 WFMR Stage-Discharge Relationship

Figure 14 illustrates the WFMR stage-discharge relationship, based on 25 recorded measurements, in comparison to the computed rating curve equation.

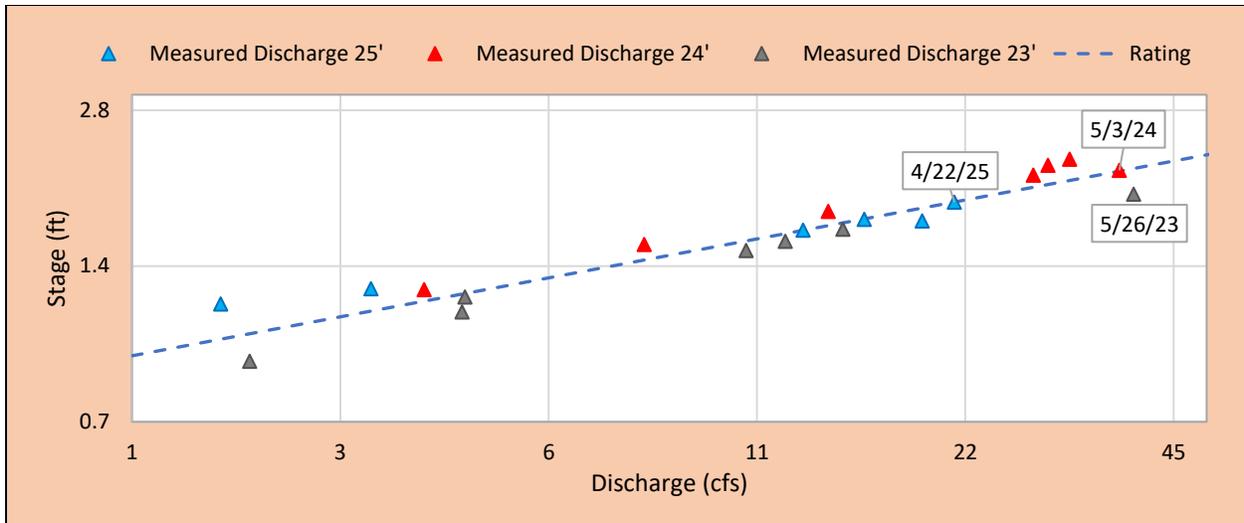


Figure 14: WFMR Rating Curve

The rating-curve data for this gravel/cobble stream with a boulder-dominated section control exhibits relatively small and stable shifts throughout the 2023 to 2025 period, indicating a largely stable hydraulic control. Most shifts fall within a narrow range of approximately -0.20 to +0.23 (Figure 15), suggesting minimal bed elevation changes or channel morphology adjustments affecting the stage-discharge relationship.

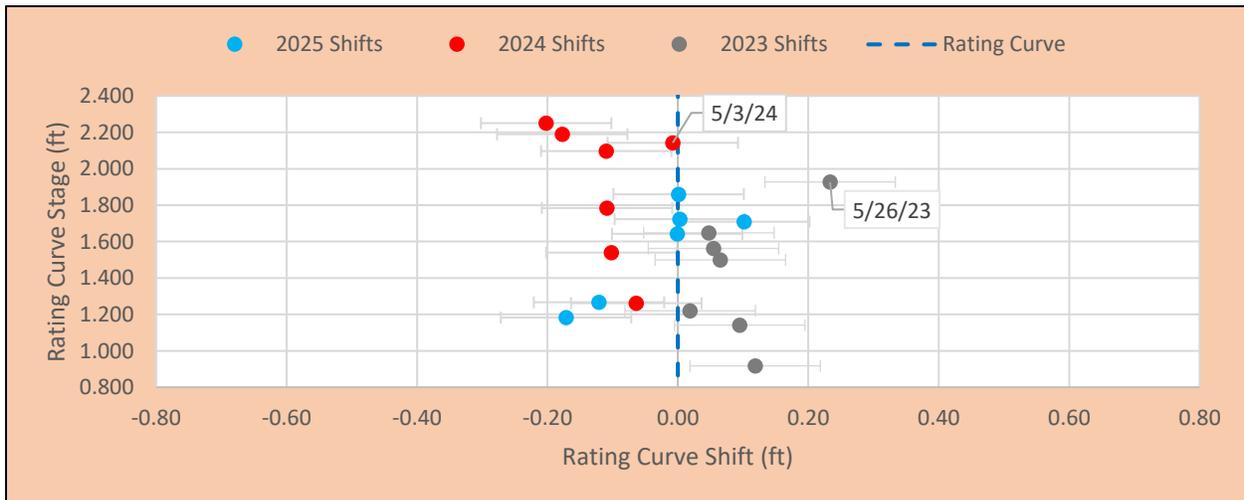


Figure 15: WFMR Shift Diagram

Early data from spring to fall 2023 show small shifts (0.02 to 0.23), which likely reflect minor adjustments in bed material around the boulder control. In 2024, a moderate shift of -0.20 was observed in April, possibly indicating minor aggradation; however, this shift quickly returned toward zero after the spring high flows in subsequent measurements. Most 2024 and 2025 measurements cluster close to zero shift, with only minor changes (up to -0.18) observed during summer and fall months, indicating generally stable control conditions with occasional minor scour and aggradation events. Martin River overbank flooding conditions in late summer and early fall 2024 do not indicate significant changes in control. The small magnitude and limited variability of rating-curve shifts suggest the boulder control provides a relatively stable hydraulic reference, reducing the need for frequent rating adjustments or major re-surveys.

4.1.3 Trib RM4.2 Stage-Discharge Relationship

Figure 16 illustrates the Trib RM4.2 stage-discharge relationship, based on 14 recorded measurements, compared to the computed rating curve equation.

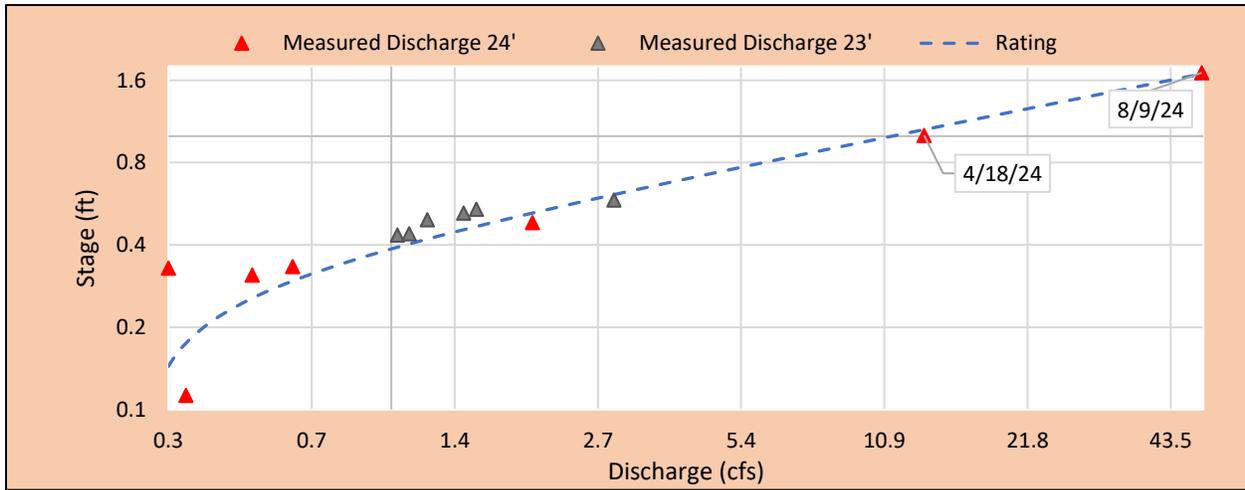


Figure 16: Trib RM4.2 Rating Curve

This small, 5-foot-wide stream with a boulder section control appears stable over the 2023 to 2024 monitoring period, with shifts mostly between -0.04 and +0.07 (Figure 17), indicating a relatively stable hydraulic control and minimal bed elevation changes under typical flow conditions. The small magnitude of shifts through spring to mid-summer 2024 suggests consistent channel geometry and control integrity, with the boulder section providing a reliable reference for discharge estimation. Discharge values for the small stream range mostly between 0.3 and 2.9 cfs, reflecting low-flow conditions.

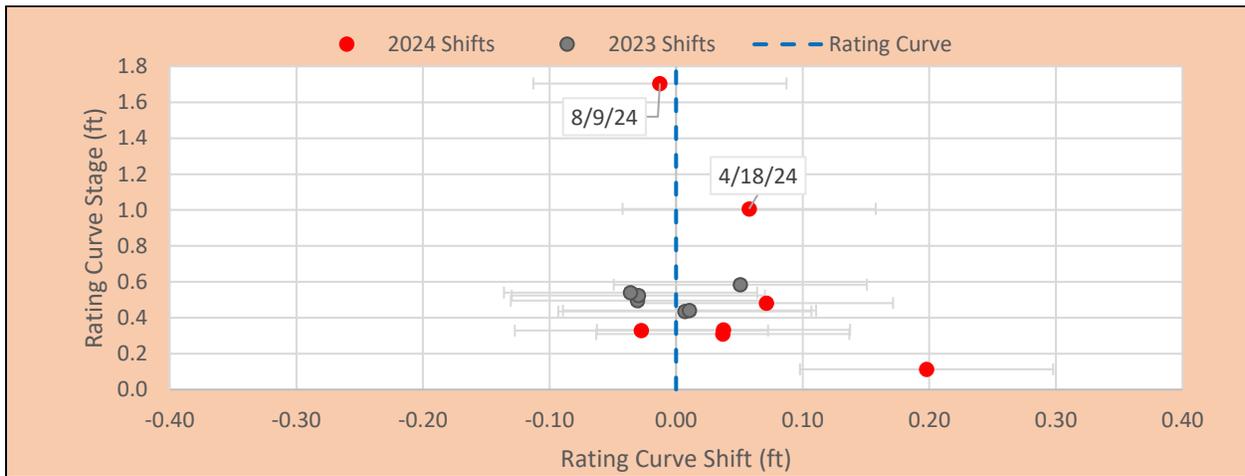


Figure 17: Trib RM4.2 Shift Diagram

A notable outlier is on 8/9/24, when a significant flooding event from Martin River caused a sudden spike in discharge to over 50 cfs. This gage location was lost during the event, and the sensor was removed. Overall, the stable, low-amplitude rating-curve shifts suggest a resilient section control through the monitoring period. The boulder control and sandy gravel substrate likely contribute to limited channel mobility under typical flows. This stability supports reliable use of the established rating curve for continuous discharge estimation outside of extreme events.

4.1.4 Martin River Tributary 1.070 Stage-Discharge Relationship

Figure 18 illustrates the Martin River Tributary 1.070 stage-discharge relationship, based on six recorded measurements, compared to the computed rating curve equation.

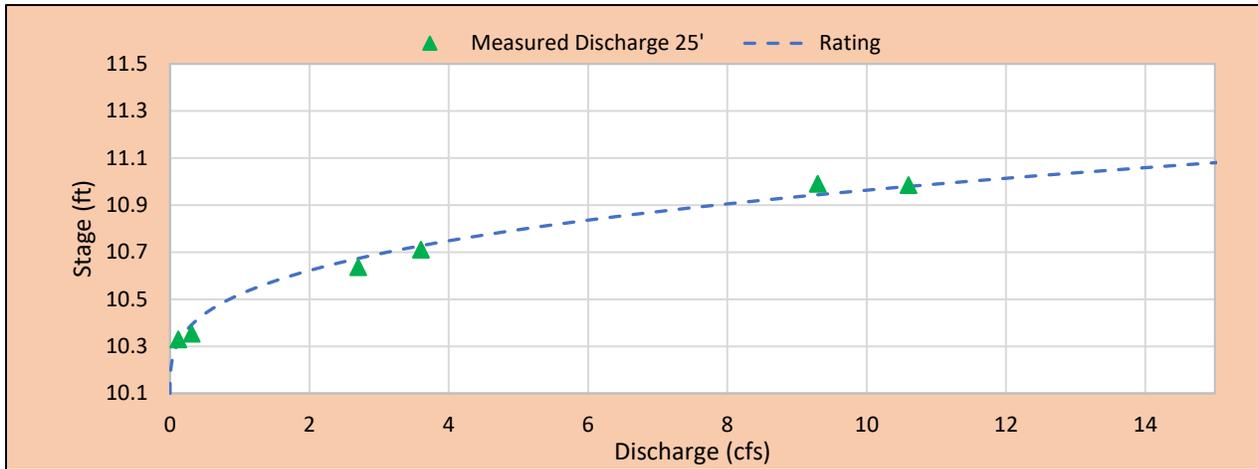


Figure 18: MR Tributary 1.070 Rating Curve

This approximately 10-foot-wide sandy gravel bed stream with a gravel riffle section control appears stable over the 2025 monitoring period. The dataset includes six discrete discharge measurements, ranging from 0.12 to 10.6 cfs, with associated rating-curve shifts between -0.05 and $+0.04$ (Figure 19).

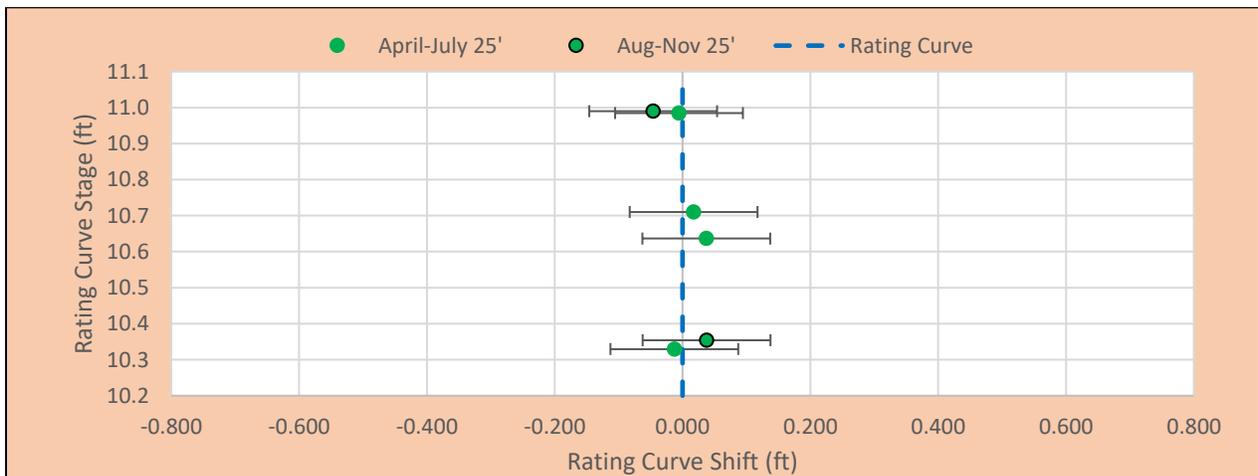


Figure 19: Martin River Tributary 1.070 Shift Diagram

Compared to USGS best practices, the number of measurements collected is substantially lower than the typical 12 or more readings used to establish or validate an initial rating curve. With only six points available, the resulting rating curve will have elevated uncertainty, reduced ability to capture rating curvature, and limited capacity to confirm or diagnose rating shifts. As a result, the curve derived from this dataset should be considered preliminary and less reliable than one developed under standard USGS data-collection protocols. [5]

4.1.5 OCH2.8R Stage-Discharge Relationship

Figure 20 depicts the Martin River tributary OCH2.8R stage-discharge relationship, with seven recorded measurements, relative to the computed rating curve equation.

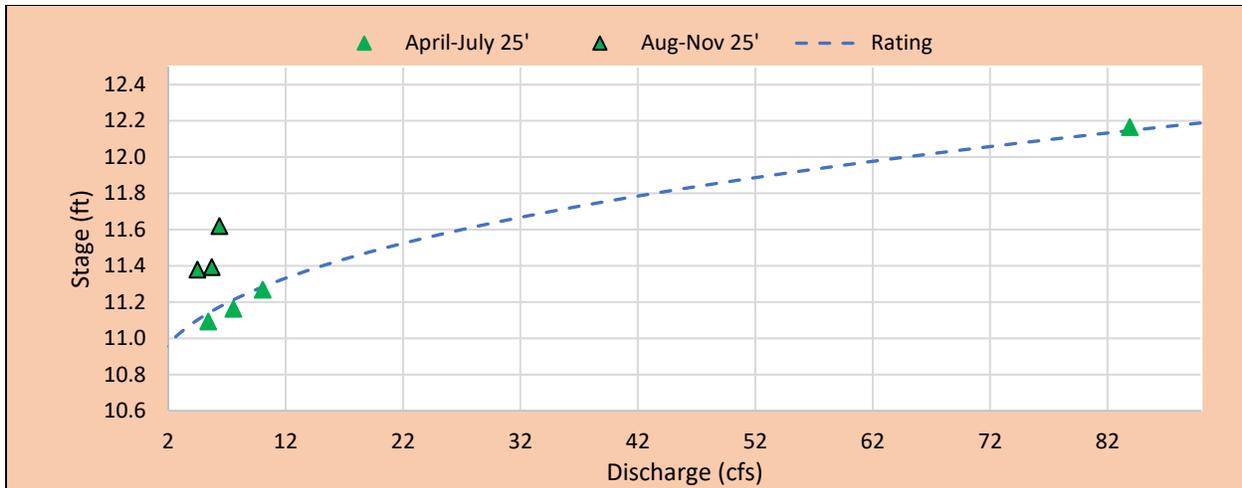


Figure 20: OCH2.8R Rating Curve

This approximately 20-foot-wide tributary, characterized by a sandy-gravel bed with stable 3-foot banks and a well-defined cobble riffle control, displayed stable hydraulic behavior early in the 2025 season. Rating curve shifts before mid-June were minor (+0.01 to +0.05 ft) (Figure 21), indicating that the riffle control and reach maintained a relatively stable bed configuration. During this period, the channel retained its typical coarse controlling roughness, and the stage-discharge relationship showed minimal deviation across low to moderate flows. The largest discharge measurement recorded on July 25 (83.9 cfs) exhibited a negligible shift (-0.02 ft), without evidence of immediate geomorphic alteration at the control.

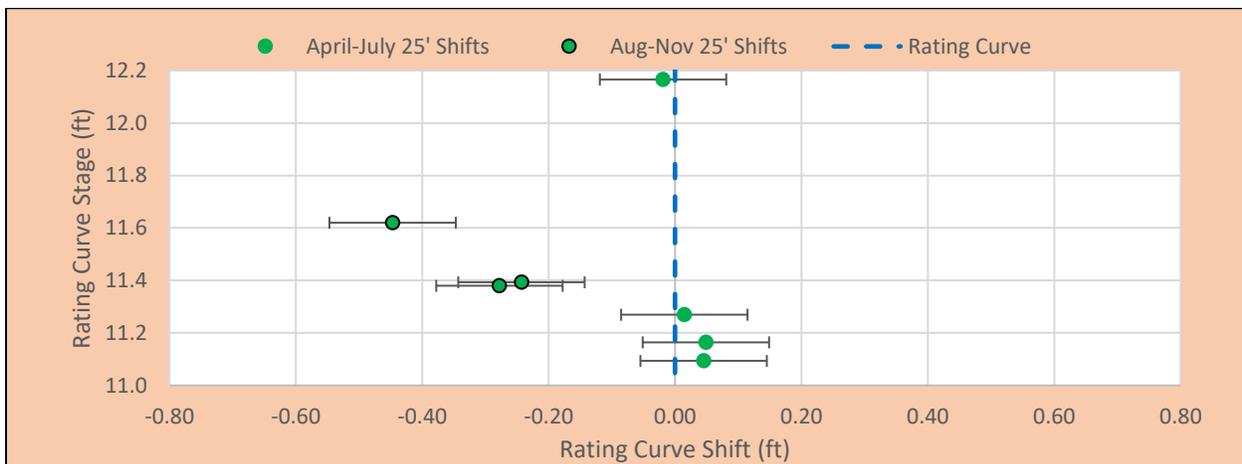


Figure 21: OCH2.8R Shift Diagram

Conditions changed sharply following the prolonged overbank input upstream from Martin River between June and September. The flood introduced sand and fine sediment into the tributary, and post-flood measurements show progressively larger rating-curve shifts (from -0.24 to -0.45 ft) from September to November. These increasing offsets are consistent with net aggradation noted at the gage, where burial of the channel bed surface reduced hydraulic conveyance and increased stage for a given discharge. The trend indicates that deposition continued into the fall, altering the control geometry. As a result, the stream should be considered in a transitional, sediment-impacted state; the pre-flood rating is no longer valid without adjustments to the rating curve for fall flows.

The number of measurements collected is substantially lower than the typical 12 or more readings used to establish or validate an initial rating curve. USGS guidance also emphasizes the need for multiple measurements across each part of the hydrograph and routine re-measurement following potential channel-altering events. With only six points available, the resulting rating curve will have elevated uncertainty, reduced ability to capture rating curvature, and limited capacity to confirm or diagnose rating shifts. As a result, the curve derived from this dataset should be considered preliminary and less reliable than one developed under standard USGS data-collection protocols.

4.2 CONTINUOUS DISCHARGE RECORD

Continuous discharge records were developed by applying USGS-approved procedures that integrate continuous stage data, a stage-discharge rating, and routine field verification with discharge measurements and time-lapse cameras to ensure accuracy through time.

4.2.1 Data Handling and Quality Control

A continuous discharge record was computed by applying the best-fit rating curve to the reviewed and validated stage data. Each discharge measurement was evaluated for hydraulic validity and used to confirm, refine, or shift the rating as needed in accordance with USGS Techniques and Methods Book 3 guidelines [6]. Rating curve shifts were introduced only when supported by field evidence such as control scour, aggradation, channel migration, or woody debris. The final continuous discharge record is defensible because it reflects a traceable chain of hydrologic evidence, including verified sensor performance, repeated cross-section and control inspections, a sufficient number of discharge measurements to constrain the rating, and a systematic review of hydrographs and residuals. These quality assurance steps demonstrate that the computed discharge record represents the most reliable interpretation of streamflow conditions given the physical state of the gaging site and the available hydrologic data.

4.2.2 Constriction Continuous Discharge Record

The three-year hydrograph illustrates a coherent, continuous-discharge record with consistent measurement coverage and identifiable hydrologic patterns that align with seasonal drivers (Figure 22). Across the record, discharge measurements align well with the computed continuous discharge record, indicating that rating-curve shifts were appropriately applied. These adjustments, applied between measurements, effectively maintain continuity without introducing artificial bias in the hydrograph. Measurement density is appropriate, particularly around rising and falling limbs, providing multiple independent checks for rating stability during highly dynamic hydraulic conditions. High-flow measurements collected during peaks confirm the upper-end performance of the rating, while low-flow measurements collected during spring and late autumn constrain the lower limb.

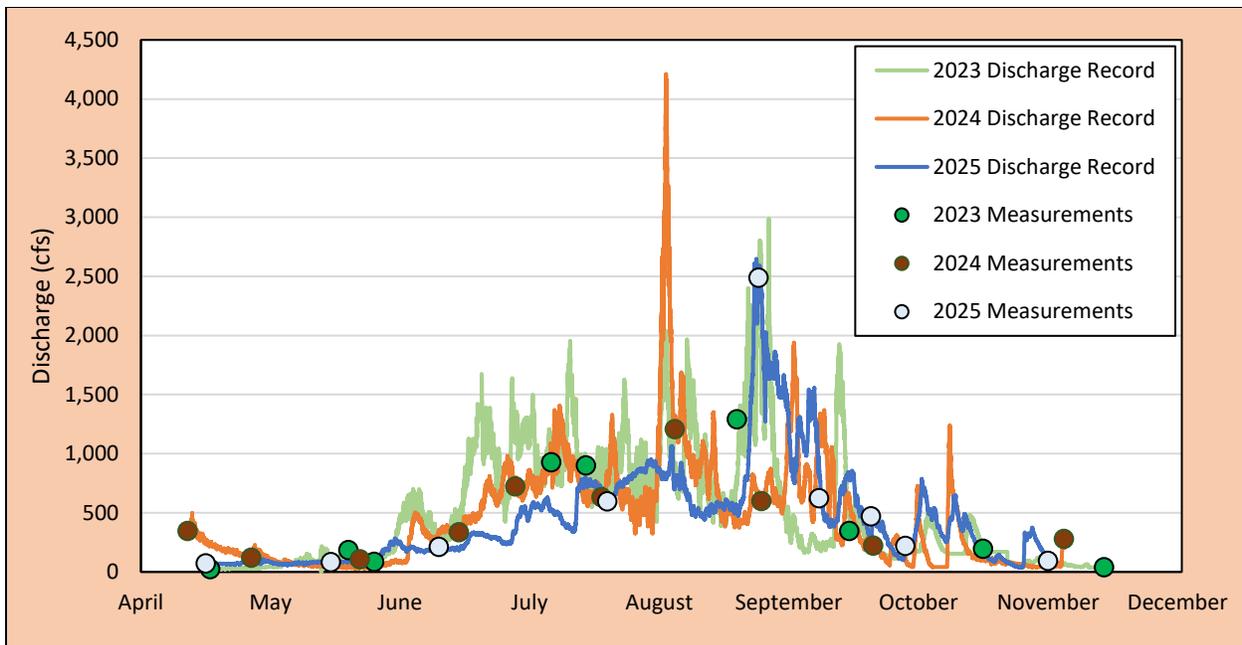


Figure 22: Constriction Discharge Record

All three years exhibit the expected seasonal pattern for a glacially influenced system: low baseflows during early spring, rapid snowmelt-driven increases through late spring and early summer, and the highest flow variability from July through September when glacier melt and episodic rainfall combine to produce high-discharge events with short-lag runoff responses. Despite year-to-year variability, the overall hydrograph shape is consistent with regional glacial melt-dominated hydrology.

Annual Differences

- **2023:** Multiple midsummer events exceeded 1,500 cfs.
- **2024:** Produced the highest flow of the three years, with an early August peak surpassing 3,500 cfs.
- **2025:** Generated its largest event in late August, reaching over 2,500 cfs.

The continuous discharge record is quantitatively validated by discrete measurements, transparent in its interannual differences, and consistent with expected hydrologic processes affecting the site. Together, these data support a defensible and internally consistent continuous record for each year.

4.2.3 West Fork Martin River Discharge Record

The computed three-year hydrograph of the West Fork Martin River, shown in Figure 23, exhibits a consistent snowmelt-dominated regime with some annual variability in peak magnitude and summer baseflow. Spring runoff in 2023 and 2024 produced high flows (over 50 cfs) followed by a smooth recession to late summer baseflows generally between <1 and 3 cfs. The 2025 season experienced higher summer baseflows, and the spring peak likely occurred before sensor deployment. Overall, the hydrographs exhibit a characteristic transition from snowmelt to groundwater-dominated baseflow, with some responses to fall storms.

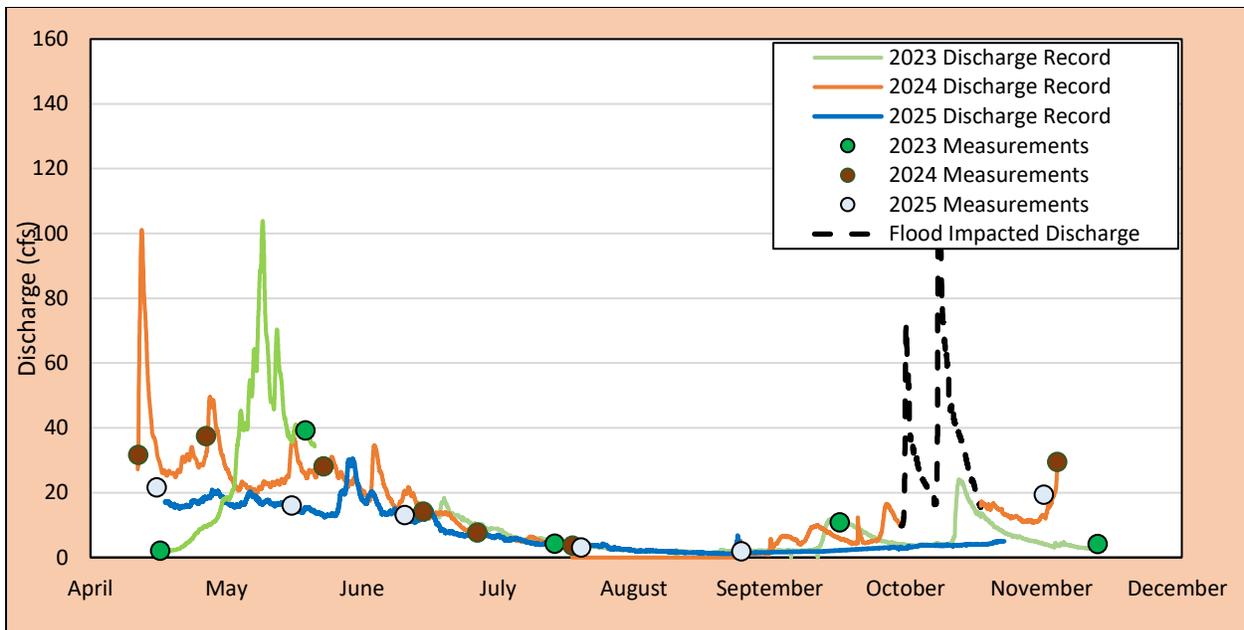


Figure 23: West Fork Martin River Discharge Record

Beginning in late August 2024, the record was periodically affected by overflows from the East Fork Martin River, indicated by a black dashed line, after its channel migrated and began flooding the WFMR gage reach. These events caused abrupt and unrepresentative increases in stage and computed discharge, and the affected data were flagged and excluded from hydrologic analysis. In 2025, woody debris accumulated at the downstream control, periodically raising the local water surface, invalidating the standard rating. Daily discharges were estimated during periods of debris-impacted stage data. Periods of flood-impacted discharge and debris-related control changes in 2024 and 2025 were validated using time-lapse camera data.

The discharge measurements exhibit strong agreement with the applied rating curves, and the scatter of points demonstrates that stage-discharge remained consistent during periods of valid hydraulic control. The discharge measurements provide strong evidence that the computed continuous discharge record is reliable and reflective of the actual hydrologic behavior of the West Fork Martin River during periods unaffected by external flooding or debris-related control changes.

4.2.4 Trib RM4.2 Outlet Discharge Record

The two-year hydrograph for Trib RM4.2 (Figure 24), exhibits a consistent pattern of spring snowmelt peaks, followed by smooth seasonal recessions to low summer baseflows. In both 2023 and 2024, tributary discharge remains predominantly below 3 to 5 cfs after early May, with only brief melt-driven pulses. This low and stable hydrograph shape is characteristic of a short, groundwater-moderated drainage with limited storage. During periods of valid hydraulic control, the continuous record aligns well with expected watershed behavior, indicating that the rating curve application was appropriate.

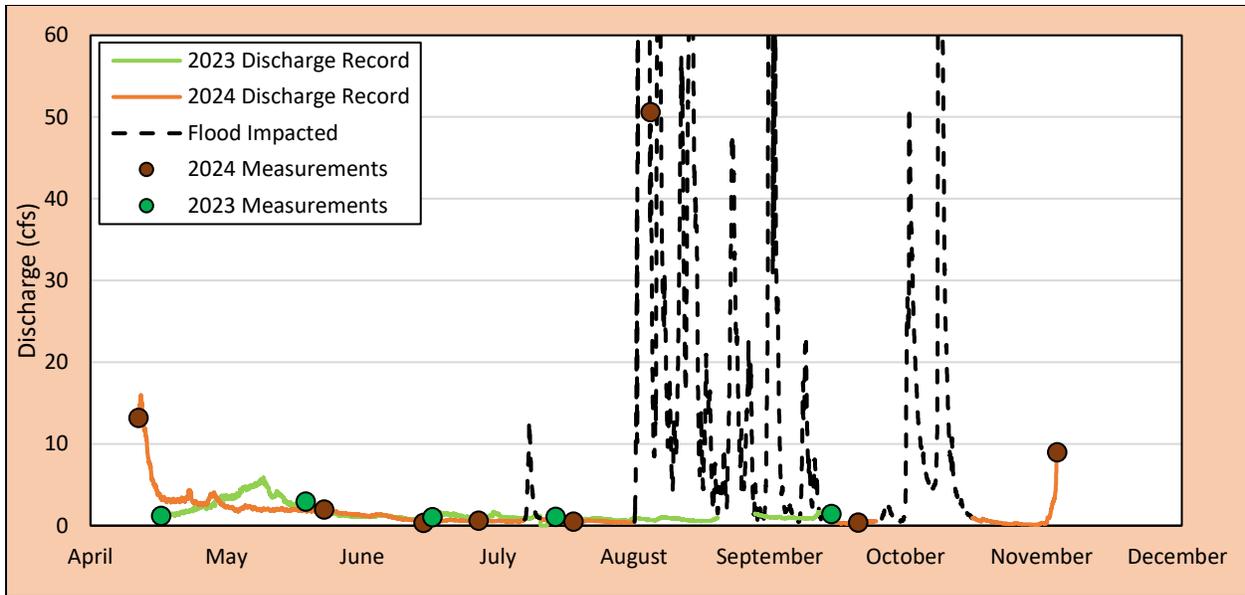


Figure 24: Trib RM4.2 Discharge Record

The periods of extreme variability beginning in mid-August 2024 and late August 2025, shown as black dashed lines, "Flood Impacted" discharge values, do not represent actual Trib RM4.2 flows. These abrupt and repeated spikes coincide with overbank flooding from the Martin River, which inundated or backwatered the Trib RM4.2 channel. The overbank peaks are not shown on Figure 24 for clarity. The Trib RM4.2 basin is too small to generate flows of this magnitude or frequency; the elevated stage recorded and associated discharge during these intervals cannot be interpreted as natural flow from the Trib RM4.2 watershed. Periods of 2024 flood-impacted discharge were validated with time-lapse camera data. The discharge record with overbank flooding removed is shown on Figure 25.

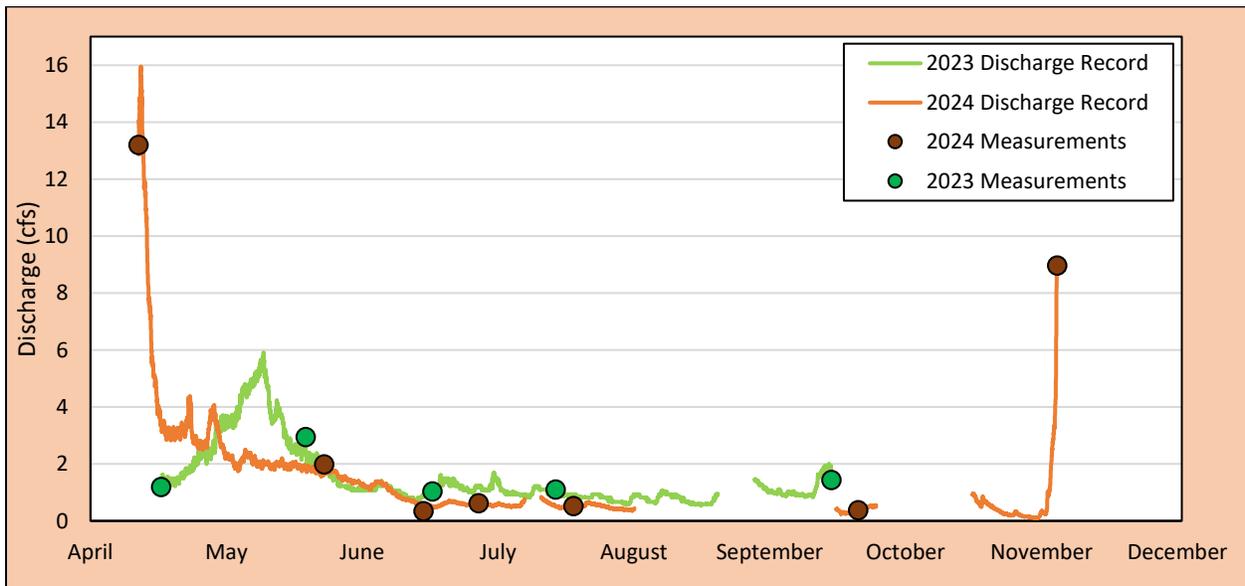


Figure 25: Trib RM4.2 Discharge Record (Overbank Flooding Removed)

Discharge measurements collected during 2023 and 2024 plot well along their respective hydrographs, closely matching the computed discharge at the time of measurement. Measurements match computed discharge during spring runoff, early-summer recession, and late-season baseflow, demonstrating that the underlying rating curve is stable and that the continuous discharge values are defensible during

periods not affected by Martin River flooding. No rating curve shifts were applied because the discharge measurements do not indicate bias or a persistent deviation from the existing rating. The tight clustering of measurements around the computed record further supports confidence in the continuous dataset outside of the flood impacted periods.

4.2.5 MR Tributary 1.070 Discharge Record

The 2025 hydrograph for Trib 1.070, shown in Figure 26, exhibits a clear early-season snowmelt pulse followed by a long, smooth summer recession and a late-season rise expected with rainfall. Discharge increases rapidly in April to early May, peaking around 10 to 11 cfs before declining steadily through June as snowmelt contributions diminish. By July and August, flows stabilize at very low baseflow conditions (<0.1 cfs), reflecting minimal remaining snowmelt and a predominantly groundwater-controlled hydrologic regime. Beginning in September and continuing into October, discharge begins to rise again, responding to periodic fall storm events with small but distinct peaks.

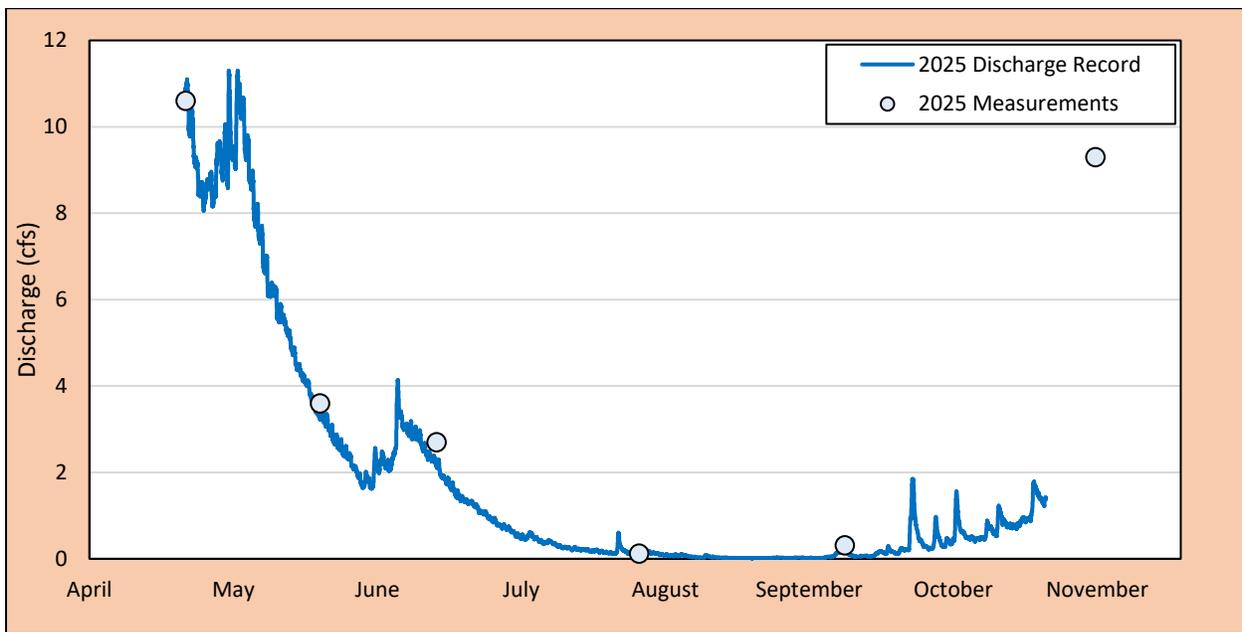


Figure 26: MR Trib 1.070 Discharge Record

The discrete discharge measurements show strong agreement with the computed continuous discharge record, indicating a stable rating curve with no evidence of significant shifts. The early season April measurement aligns well with the stage-derived peak flows, while the May and June measurements fall along the seasonal recession, following the transition into summer baseflow conditions. No measurements suggest bias or deviation, and the continuous record behaves as expected for the watershed's hydrologic regime.

4.2.6 OCH2.8R Discharge Record

The 2025 continuous discharge record for OCH2.8R (Figure 27), reflects a small tributary system characterized by typically low flows driven by snowmelt and rainfall. Throughout spring and early summer, discharge remains generally below 12 cfs with brief increases associated with early-season rainfall. Beginning on June 19, the hydrograph exhibits abrupt and extreme stage and discharge increases that far exceed the hydrologic capacity of the OCH2.8R watershed. These spikes, ranging from tens to over an estimated 200 cfs, correspond to overbank flow from the Martin River, which overtopped a bank and flowed into the OCH2.8R channel and gage pool. The peaks in overbank flooding is not shown on Figure

27 for clarity. These periods are not representative of the tributary discharge but instead reflect the flooding effects of the much larger Martin River.

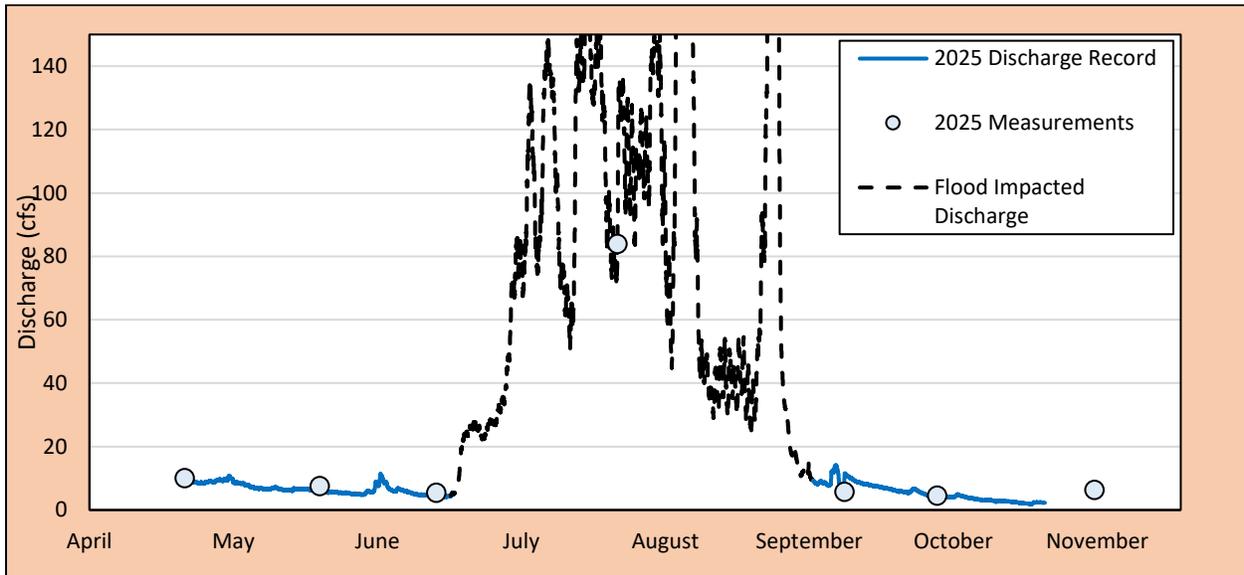


Figure 27: OCH2.8R Discharge Record

During these overflow periods, computed discharge above 85 cfs is a rough estimate based on Manning's calculations and the recorded stage. Calculated values from June 19 to September 4 correspond to flooding from the Martin River and should be excluded from hydrologic interpretation. This period of flood-impacted discharge was validated with time-lapse camera and water temperature data. The discharge record with overbank flooding removed is shown on Figure 28.

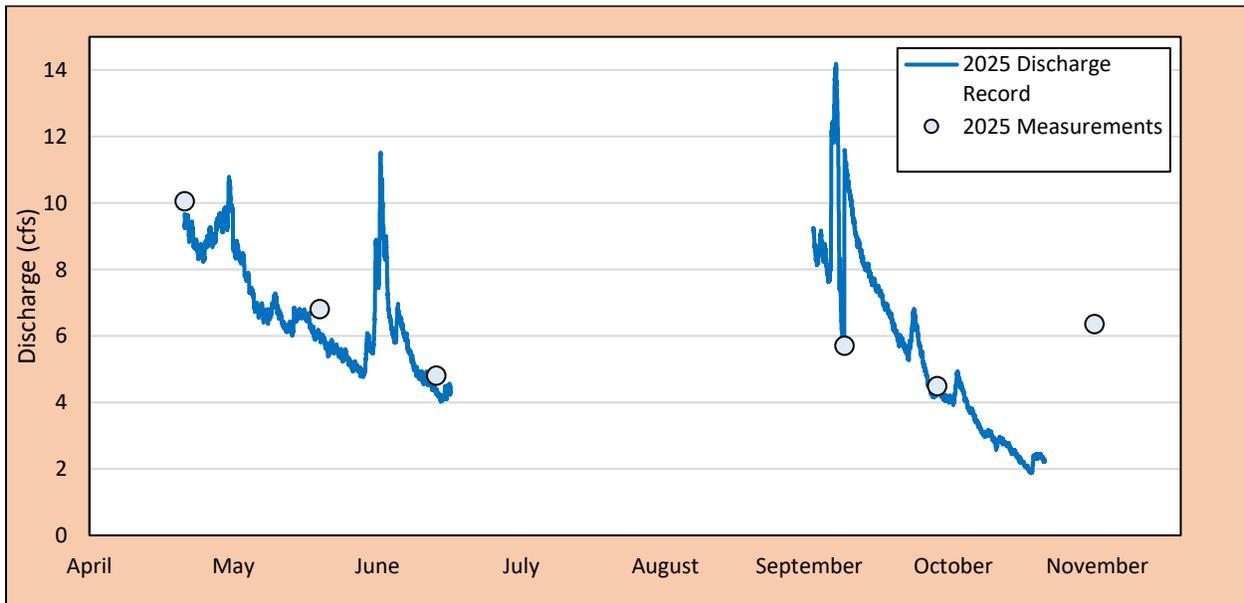


Figure 28: OCH2.8R Discharge Record (Overbank Flooding Removed)

Field measurements match the modeled hydrograph during periods of stable hydraulic control, confirming that the continuous discharge record is reliable and representative of natural tributary behavior. The recession from May into late June further supports a consistent rating relationship and undisturbed basin hydrology during this part of the season.

5.0 ASSUMPTIONS AND LIMITATIONS

Instrumentation and Measurement Assumptions

- All water-level sensors (HOBO MX2001, OTT RLS, iGage) are assumed to have performed within their manufacturer-specified accuracy ranges except where drift or movement was identified through field checks or level surveys.
- ADCPs and velocimeters are assumed to produce accurate discharge values when operated under appropriate field conditions and when passing all USGS QRev or FlowTracker2 quality-control checks.

Rating Curve and Discharge Computation Assumptions

- Stage-discharge ratings are assumed to be valid only during periods of stable hydraulic control, free from debris accumulation, control scour, or aggradation, or backwater effects.
- Rating shifts are based on measured evidence and assumed to be applicable between measurement dates unless field or hydrograph indications suggest otherwise.
- For tributaries with limited measurements (Trib 1.070, OCH2.8R), rating curves are considered preliminary and subject to elevated uncertainty due to sparse data coverage.
- Estimated discharges applied during flooding, debris influence, or sensor disturbance are assumed to reasonably reflect expected patterns based on comparable periods of valid data.

Data Quality and Interpretation Limitations

- Overbank flooding from the Martin River in 2024 and 2025 produced extended periods of elevated stage at multiple tributary sites (Trib RM4.2, West Fork Martin River, OCH2.8R). Continuous discharge during these periods does not represent tributary-generated flow and is excluded from interpretation.
- Channel instability at the Constriction gage location, including rapid scour, deposition, channel migration, and channel-forcing hydraulics, introduces significant uncertainty to the rating curve and requires frequent adjustments that may not capture all short-term geomorphic changes.
- Measurement frequency varied among sites due to access limitations, safety constraints, and high-flow conditions, causing uneven temporal coverage that may reduce confidence in specific rating segments.
- Sensor drift, movement, and sedimentation, although corrected when detected, may introduce short-duration uncertainties that are not fully captured by scheduled checks.

Analytical and Methodological Limitations

- Manning's calculation-based estimates for flood-influenced flows at OCH2.8R (>100 cfs), WFMR (>80 cfs), and Trib RM4.2 (> 60 cfs) are coarse approximations and should not be used for design-level analysis.
- The dataset covers only the spring-fall open-water seasons; winter flows, ice effects, and freeze-up/break-up dynamics were not measured and remain uncharacterized.

6.0 REFERENCES

- [1] United States Geological Survey, *USGS Techniques and Methods*, vol. A22, no. Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat.
- [2] United States Geological Survey, *USGS Techniques and Methods*, vol. A7, no. Stage Measurement at Gaging Stations.
- [3] United States Geological Survey, *USGS Techniques and Methods*, vol. A8, no. Discharge Measurements at Gaging Stations.
- [4] V. Sauer, "Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods," *United States Geological Survey*, vol. Water Resources Investigations, no. 01-4044, 2002.
- [5] United States Geological Survey, *USGS Techniques and Methods*, vol. A10, no. Discharge Ratings at Gaging Stations.
- [6] United States Geological Survey, *USGS Techniques and Methods*, vol. A13, no. Computation of Continuous Records of Streamflow.

Appendix A: Photo Log

PROJECT NAME: Bradley Lake Expansion Project

PROJECT #: 1162.90200.01 REPORT: Martin River Streamgaging DATE: 12/5/2025

NOTES: Martin River Gage Site Photos



FIGURE: Constriction, 4/24/2025, 75 cfs

Photo collected by camera installed on river left bank, approximately 40 feet downstream of gage, facing upstream



FIGURE: Constriction, 5/22/2025, 85 cfs

Photo taken from approximately 300 feet downstream of gage facing upstream



FIGURE: Constriction, 6/16/2025, 210 cfs
Photo taken from approximately 400 feet downstream of gage, facing upstream



FIGURE: Constriction, 7/19/2025, 770 cfs
Photo collected by camera installed on river right bank, approximately 50 feet upstream of gage, facing downstream



FIGURE: Constriction, 8/29/2025, 2490 cfs
Photo taken from helicopter, approximately 300 feet upstream of gage, facing downstream



FIGURE: Constriction, 8/29/2025, 2490 cfs
Photo taken approximately 400 feet downstream of gage, facing upstream



FIGURE: Trib 1.070, 4/23/2025, 11 cfs
Photo taken approximately 5 feet upstream of gage from river left bank, facing downstream



FIGURE: Trib 1.070, 5/22/2025, 3.6 cfs
Photo taken approximately 200 feet downstream of gage, facing upstream



FIGURE: Trib 1.070, 9/12/2025, 0.3 cfs
Photo taken approximately at gage location, facing downstream



FIGURE: OCH 2.8, 4/23/2025, 10 cfs
Photo taken approximately 30 feet downstream of gage, facing upstream



FIGURE: OCH 2.8, 5/22/2025, 7.6 cfs
Photo taken approximately 30 ft downstream of gage, facing upstream



FIGURE: OCH 2.8, 7/18/2025, 160 cfs estimated
Photo collected by camera installed on river left bank, approximately at gage location, facing downstream



FIGURE: OCH 2.8, 7/25/2025, 85 cfs
Photo taken approximately at gage location, from river right bank, facing downstream



FIGURE: OCH 2.8, 7/25/2025, 75 cfs
Photo collected by camera installed on river left bank, approximately at gage location, facing downstream



FIGURE: Trib RM 4.2, 5/26/2023, 2.9 cfs
Photo taken approximately 20 ft downstream of gage, facing upstream



FIGURE: Trib RM 4.2, 6/26/2023, 1.0 cfs
Photo taken Photo taken approximately 10 ft downstream of gage, facing upstream



FIGURE: Trib RM 4.2, 4/18/2024, 13 cfs
Photo taken approximately 20 ft downstream of gage, facing upstream

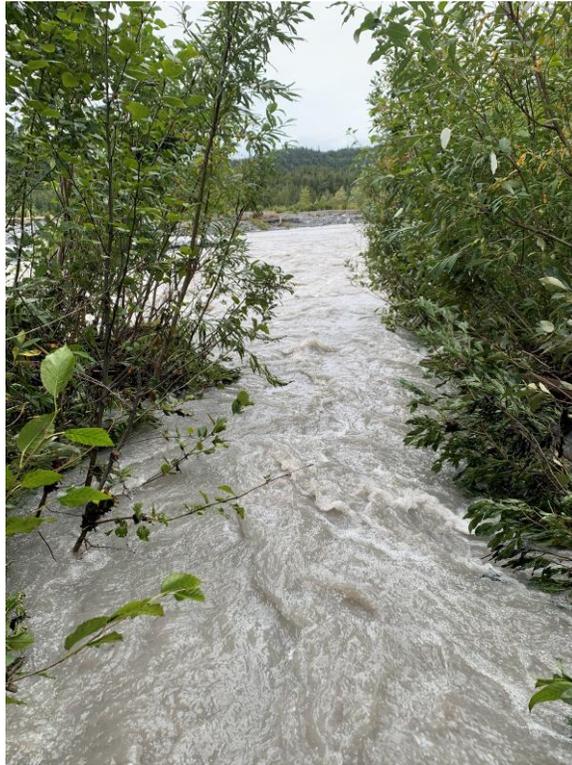


FIGURE: Trib RM 4.2, 8/9/2024, 50 cfs
Photo taken approximately 15 ft upstream of gage facing downstream



FIGURE: WRMR, 4/22/2025, 22 cfs
Photo taken from helicopter, above Red Lake, facing downstream



FIGURE: WRMR, 4/22/2025, 22 cfs
Photo taken approximately 15 ft downstream of gage, from river right bank, facing upstream



FIGURE: WRMR, 5/22/2025, 16 cfs
Photo taken approximately 30 ft downstream of gage, facing upstream



FIGURE: WRMR, 7/25/2025, 3.6 cfs
Photo taken approximately 10 ft upstream of gage, facing downstream



FIGURE: WRMR, 8/25/2025, 1.2 cfs
Photo taken by camera installed approximately 60 ft downstream of gage, facing upstream



FIGURE: USGS gage 15238951 EFMR, 5/22/2025, 62 cfs
Photo taken approximately 450 ft upstream of gage, facing upstream



FIGURE: USGS gage 15238951 EFMR, 6/16/2025, 180 cfs
Photo taken approximately 350 ft upstream of gage, facing upstream



FIGURE: USGS gage 15238951 EFMR, 6/16/2025, 588 cfs
Photo taken approximately 300 ft upstream of gage, facing downstream



FIGURE: USGS gage 15238951 EFMR, 8/29/2025, 2390 cfs
Photo taken approximately 400 ft upstream of gage, facing upstream



FIGURE: USGS gage 15238951 EFMR, 8/29/2025, 2390 cfs
Photo taken from helicopter, approximately 500 ft downstream of gage, facing upstream

Attachment 2: 2025 EFMR Hydrograph Calculation

Date	Discharge (cfs)				
	Martin River at the Constriction	Red Lake Basin Outlet	OCH2.8R	Trib 1.070	East Fork Martin River at the Mouth
4/23/2025	75.7	18.9	9.4	10.9	36.5
4/24/2025	76.6	17.0	9.3	10.3	40.0
4/25/2025	70.8	16.7	8.9	9.6	35.6
4/26/2025	69.2	15.9	8.6	8.7	36.0
4/27/2025	67.3	15.6	8.5	8.4	34.9
4/28/2025	66.5	15.7	8.9	8.7	33.3
4/29/2025	67.0	15.9	9.0	8.5	33.7
4/30/2025	70.2	17.0	9.3	9.1	34.8
5/1/2025	79.7	17.0	9.4	9.2	44.2
5/2/2025	81.8	17.4	9.7	9.4	45.3
5/3/2025	78.0	18.5	10.0	10.0	39.6
5/4/2025	84.4	19.1	8.6	9.9	46.7
5/5/2025	76.4	20.0	8.4	10.6	37.4
5/6/2025	96.7	19.6	8.0	9.8	59.3
5/7/2025	88.7	17.8	7.5	9.0	54.3
5/8/2025	77.4	16.6	7.0	8.2	45.5
5/9/2025	70.8	15.9	6.8	7.6	40.5
5/10/2025	67.4	16.0	6.7	7.0	37.8
5/11/2025	65.4	16.5	6.6	6.4	35.8
5/12/2025	66.0	18.2	6.9	6.2	34.7
5/13/2025	74.0	19.6	6.9	5.8	41.8
5/14/2025	77.0	18.4	6.5	5.6	46.5
5/15/2025	74.2	17.1	6.2	5.3	45.6
5/16/2025	73.8	17.1	6.2	4.9	45.5
5/17/2025	79.9	17.2	6.6	4.6	51.5
5/18/2025	82.4	16.3	6.7	4.3	55.1
5/19/2025	84.7	16.5	6.6	4.1	57.4
5/20/2025	86.1	16.5	6.4	3.9	59.3
5/21/2025	84.1	15.5	6.0	3.5	59.0
5/22/2025	80.7	15.0	6.0	3.3	56.3
5/23/2025	85.0	14.7	5.9	3.3	61.2
5/24/2025	86.0	14.1	5.6	3.1	63.2
5/25/2025	86.0	15.2	5.7	2.8	62.3
5/26/2025	92.2	14.9	5.5	2.7	69.2
5/27/2025	98.0	14.1	5.4	2.5	76.0
5/28/2025	97.4	13.7	5.4	2.4	76.0
5/29/2025	99.9	12.9	5.1	2.2	79.6
5/30/2025	102.7	13.0	5.1	2.0	82.6
5/31/2025	113.6	13.2	4.9	1.8	93.7
6/1/2025	115.0	14.3	5.4	1.8	93.4
6/2/2025	137.8	19.9	5.7	1.7	110.5
6/3/2025	186.5	23.3	7.2	2.2	153.7
6/4/2025	217.4	29.3	9.3	2.1	176.7
6/5/2025	251.3	26.5	9.0	2.3	213.5
6/6/2025	252.5	20.0	6.9	2.1	223.4
6/7/2025	219.0	17.2	6.0	2.4	193.5
6/8/2025	190.8	18.8	6.5	3.5	161.9
6/9/2025	206.7	19.4	6.2	3.2	177.9
6/10/2025	196.5	16.4	5.8	3.0	171.3
6/11/2025	186.5	13.9	5.3	2.9	164.4

Date	Discharge (cfs)				
	Martin River at the Constriction	Red Lake Basin Outlet	OCH2.8R	Trib 1.070	East Fork Martin River at the Mouth
6/12/2025	176.9	13.5	4.9	2.8	155.6
6/13/2025	184.3	13.9	4.7	2.7	163.0
6/14/2025	197.0	14.1	4.7	2.5	175.7
6/15/2025	213.3	13.6	4.5	2.3	192.8
6/16/2025	215.6	12.8	4.4	2.2	196.2
6/17/2025	195.3	11.5	4.2	2.0	177.5
6/18/2025	194.2	11.1	4.2	1.8	177.1
6/19/2025	195.9	11.7	4.4	1.7	178.1
6/20/2025	196.9	12.2	4.5	1.6	178.7
6/21/2025	210.2	12.9	4.5	1.4	191.3
6/22/2025	251.4	13.5	4.6	1.4	231.9
6/23/2025	316.8	10.8	4.6	1.3	300.1
6/24/2025	323.9	8.8	4.7	1.3	309.2
6/25/2025	320.7	7.9	4.8	1.2	306.9
6/26/2025	311.7	7.8	4.8	1.1	298.0
6/27/2025	299.2	7.4	4.9	1.0	285.9
6/28/2025	290.1	7.0	5.0	0.9	277.2
6/29/2025	285.9	6.8	5.0	0.9	273.2
6/30/2025	257.2	7.0	5.1	0.8	244.3
7/1/2025	243.6	7.0	5.1	0.7	230.6
7/2/2025	250.8	7.2	5.2	0.7	237.6
7/3/2025	336.7	7.4	5.3	0.6	323.5
7/4/2025	465.2	6.9	5.3	0.5	452.4
7/5/2025	525.9	6.5	5.4	0.5	513.5
7/6/2025	472.5	6.5	5.5	0.5	460.0
7/7/2025	550.1	6.5	5.5	0.5	537.6
7/8/2025	564.5	5.6	5.6	0.5	552.8
7/9/2025	545.7	5.4	5.6	0.4	534.3
7/10/2025	585.7	5.7	5.7	0.4	574.0
7/11/2025	563.0	5.7	5.8	0.4	551.2
7/12/2025	507.4	5.2	5.8	0.3	496.0
7/13/2025	493.3	4.7	5.9	0.3	482.4
7/14/2025	432.4	4.4	6.0	0.3	421.8
7/15/2025	391.6	4.2	6.0	0.2	381.2
7/16/2025	367.3	4.0	6.1	0.2	356.9
7/17/2025	411.9	4.5	6.1	0.2	401.0
7/18/2025	715.0	4.6	6.2	0.2	703.9
7/19/2025	751.6	4.3	6.3	0.2	740.9
7/20/2025	751.5	3.9	6.3	0.2	741.0
7/21/2025	745.7	3.7	6.4	0.2	735.4
7/22/2025	727.1	3.5	6.4	0.2	717.0
7/23/2025	707.1	3.6	6.5	0.1	696.9
7/24/2025	645.1	3.4	6.6	0.1	635.0
7/25/2025	618.4	3.3	6.6	0.2	608.2
7/26/2025	644.1	3.5	6.7	0.3	633.6
7/27/2025	726.2	3.7	6.8	0.2	715.5
7/28/2025	745.1	3.6	6.8	0.1	734.5
7/29/2025	773.6	3.5	6.9	0.1	763.0
7/30/2025	798.5	3.9	6.9	0.2	787.5
7/31/2025	831.3	3.0	7.0	0.2	821.1

Date	Discharge (cfs)				
	Martin River at the Constriction	Red Lake Basin Outlet	OCH2.8R	Trib 1.070	East Fork Martin River at the Mouth
8/1/2025	859.8	2.8	7.1	0.2	849.8
8/2/2025	858.9	2.7	7.1	0.1	849.0
8/3/2025	913.8	2.5	7.2	0.1	903.9
8/4/2025	923.2	2.4	7.3	0.1	913.4
8/5/2025	884.0	2.3	7.3	0.1	874.3
8/6/2025	831.9	2.0	7.4	0.1	822.5
8/7/2025	808.0	2.0	7.4	0.1	798.5
8/8/2025	931.8	2.0	7.5	0.1	922.2
8/9/2025	819.3	2.1	7.6	0.1	809.6
8/10/2025	771.9	2.0	7.6	0.1	762.2
8/11/2025	807.4	1.9	7.7	0.0	797.8
8/12/2025	657.9	1.9	7.7	0.0	648.2
8/13/2025	535.9	1.8	7.8	0.1	526.3
8/14/2025	499.2	1.7	7.9	0.1	489.5
8/15/2025	493.1	1.7	7.9	0.0	483.4
8/16/2025	478.4	1.6	8.0	0.0	468.8
8/17/2025	517.8	1.5	8.1	0.0	508.2
8/18/2025	537.3	1.5	8.1	0.0	527.7
8/19/2025	562.1	1.5	8.2	0.0	552.5
8/20/2025	556.6	1.4	8.2	0.0	546.9
8/21/2025	578.7	1.4	8.3	0.0	569.0
8/22/2025	559.4	1.3	8.4	0.0	549.7
8/23/2025	534.7	1.3	8.4	0.0	524.9
8/24/2025	530.1	1.2	8.5	0.0	520.4
8/25/2025	662.8	1.2	8.6	0.0	653.1
8/26/2025	901.9	1.2	8.6	0.0	892.1
8/27/2025	1641.8	1.1	8.7	0.0	1631.9
8/28/2025	2434.4	3.0	8.7	0.0	2422.6
8/29/2025	2350.9	2.3	8.8	0.0	2339.8
8/30/2025	1770.6	1.4	8.9	0.0	1760.3
8/31/2025	1728.3	1.4	8.9	0.0	1717.9
9/1/2025	1733.4	1.5	9.0	0.0	1722.9
9/2/2025	1621.8	1.5	9.1	0.0	1611.2
9/3/2025	1537.2	1.5	9.1	0.0	1526.5
9/4/2025	1445.9	1.6	9.2	0.0	1435.2
9/5/2025	992.5	1.6	9.2	0.0	981.6
9/6/2025	872.0	1.6	8.4	0.0	861.9
9/7/2025	1240.0	1.7	8.7	0.0	1229.6
9/8/2025	1079.8	1.7	8.3	0.0	1069.8
9/9/2025	1249.5	1.7	9.0	0.0	1238.7
9/10/2025	1425.9	1.8	13.2	0.1	1410.9
9/11/2025	1132.3	1.8	9.1	0.3	1121.2
9/12/2025	670.7	1.8	8.1	0.2	660.6
9/13/2025	459.9	1.8	10.5	0.1	447.4
9/14/2025	411.4	1.8	9.5	0.1	400.0
9/15/2025	411.5	1.8	8.8	0.1	400.8
9/16/2025	523.2	1.9	8.3	0.1	513.0
9/17/2025	704.8	1.9	8.0	0.1	694.8
9/18/2025	803.5	2.0	7.7	0.1	793.7
9/19/2025	815.5	2.1	7.5	0.1	805.8

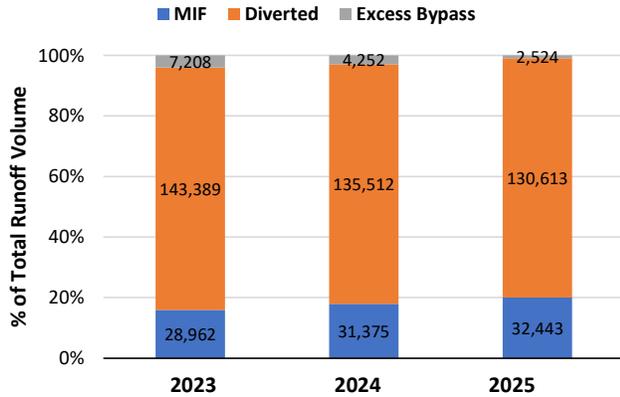
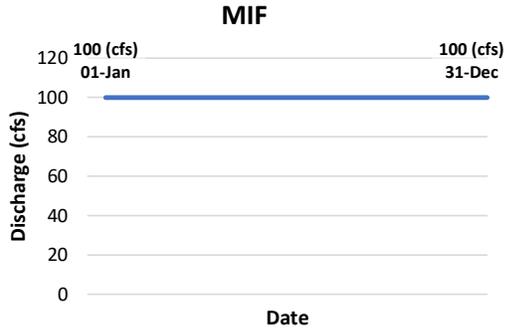
Date	Discharge (cfs)				
	Martin River at the Constriction	Red Lake Basin Outlet	OCH2.8R	Trib 1.070	East Fork Martin River at the Mouth
9/20/2025	660.7	2.2	7.2	0.2	651.1
9/21/2025	516.3	2.3	6.9	0.2	507.0
9/22/2025	431.3	2.4	6.6	0.2	422.1
9/23/2025	336.8	2.4	6.2	0.1	328.0
9/24/2025	412.1	2.5	5.9	0.2	403.5
9/25/2025	403.6	2.6	5.7	0.2	395.1
9/26/2025	377.1	2.7	5.6	0.5	368.4
9/27/2025	298.7	2.8	6.5	1.4	288.0
9/28/2025	216.3	2.8	5.9	0.5	207.0
9/29/2025	160.2	2.9	5.2	0.3	151.6
9/30/2025	124.4	3.0	4.7	0.3	116.4
10/1/2025	126.2	3.0	4.3	0.3	118.7
10/2/2025	214.8	3.1	4.3	0.7	206.7
10/3/2025	233.7	2.9	4.2	0.3	226.1
10/4/2025	356.7	2.9	4.1	0.4	349.3
10/5/2025	603.2	3.1	4.1	0.4	595.6
10/6/2025	670.6	3.2	4.4	1.0	662.0
10/7/2025	521.9	3.5	4.6	0.8	513.1
10/8/2025	493.1	3.7	4.2	0.6	484.6
10/9/2025	405.1	3.8	3.8	0.5	397.1
10/10/2025	312.7	3.7	3.6	0.5	305.0
10/11/2025	275.6	3.7	3.3	0.5	268.2
10/12/2025	438.3	3.6	3.1	0.5	431.1
10/13/2025	586.1	3.6	3.1	0.7	578.7
10/14/2025	434.4	3.8	2.9	0.7	427.1
10/15/2025	414.4	3.7	2.8	0.8	407.1
10/16/2025	405.1	3.7	2.9	0.9	397.6
10/17/2025	313.6	3.9	2.7	0.8	306.2
10/18/2025	232.1	4.0	2.6	0.8	224.8
10/19/2025	178.3	4.0	2.4	0.8	171.1
10/20/2025	144.6	4.0	2.3	0.8	137.4
10/21/2025	111.7	4.0	2.1	0.9	104.6
10/22/2025	95.5	4.0	1.9	0.9	88.6
10/23/2025	133.5	4.2	2.3	1.6	125.4
10/24/2025	109.9	4.6	2.4	1.5	101.5
10/25/2025	84.4	4.9	2.3	1.3	75.9

Attachment 3: Operational Model Results

DIXON DIVERSION OPERATIONAL MODEL

USING MEASURED RECORDS

INPUT



Note: Tunnel capacity of 1,650 cfs

OUTPUT

2023 Measurements							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	9,267	5,654	3,613	0	61%	39%	0%
June	21,514	5,949	15,565	0	28%	72%	0%
July	54,416	6,147	47,874	395	11%	88%	1%
August	81,807	6,147	68,846	6,814	8%	84%	8%
September	12,556	5,065	7,492	0	40%	60%	0%
October	0	0	0	0	0%	0%	0%
Total	179,559	28,962	143,389	7,208	16%	80%	4%

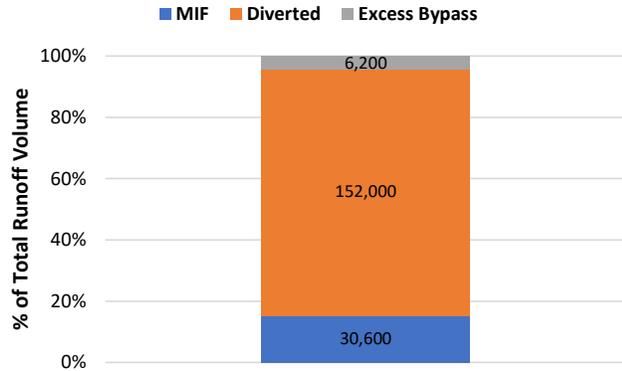
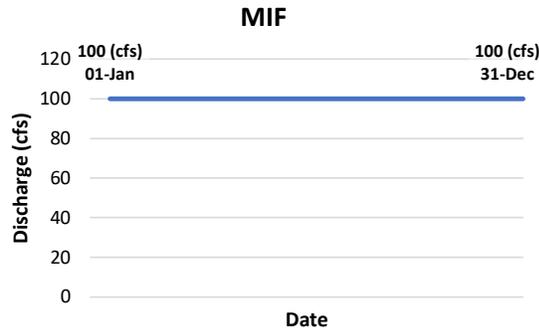
2024 Measurements							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,030	2,939	91	0	97%	3%	0%
June	19,620	5,275	14,345	0	27%	73%	0%
July	48,086	6,147	41,938	0	13%	87%	0%
August	55,899	6,147	45,500	4,252	11%	81%	8%
September	34,147	5,935	28,212	0	17%	83%	0%
October	10,357	4,932	5,425	0	48%	52%	0%
Total	171,139	31,375	135,512	4,252	18%	79%	3%

2025 Measurements							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	3,377	3,377	0	0	100%	0%	0%
June	12,201	5,936	6,265	0	49%	51%	0%
July	34,783	6,147	28,636	0	18%	82%	0%
August	54,803	6,147	46,132	2,524	11%	84%	5%
September	45,141	5,949	39,192	0	13%	87%	0%
October	15,276	4,887	10,389	0	32%	68%	0%
Total	165,580	32,443	130,613	2,524	20%	79%	1%

DIXON DIVERSION OPERATIONAL MODEL

USING SYNTHETIC & MEASURED RECORD

INPUT



Statistical Range

Start Year: 2006
End Year: 2025

All Data 30-yr Record 20-yr Record 10-yr Record

OUTPUT

1,650 cfs Tunnel Capacity							
Month	Volume (acre-ft)				Percentage		
	Total Runoff	MIF	Diverted	Bypass in Excess of MIF	MIF	Diverted	Bypass in Excess of MIF
May	4,000	2,800	1,200	0	70%	30%	0%
June	17,300	5,700	11,600	0	33%	67%	0%
July	58,200	6,100	50,800	1,300	10%	87%	3%
August	62,500	6,100	52,700	3,700	10%	84%	6%
September	33,500	5,800	26,800	1,000	17%	80%	3%
October	13,500	4,100	8,900	200	30%	66%	4%
Total	189,000	30,600	152,000	6,200	16%	80%	4%