Report to the 2022 Montana Water Policy Interim Committee on Stream Gaging in Montana

Prepared for: **Montana Water Policy Interim Committee**

Prepared by: **Stream Gage Oversight Work Group, Drought and Water Supply Advisory Committee**

September 12, 2022

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Terms and Acronyms

- BIA: Bureau of Indian Affairs
- CMF: Cooperative Matching Funds
- CSKT: Confederated Salish & Kootenai Tribes
- DNRC: Montana Department of Natural Resources and Conservation
- FERC: Federal Energy Regulatory Commission
- FIIP: Flathead Indian Irrigation Project
- FPS: Federal Priority Stream Gage Network
- FWP: Montana Department of Fish, Wildlife and Parks
- GOES Satellite: Geostationary Operational Environmental Satellite, operated by the U.S. National Oceanic and Atmospheric Administration
- MDT: Montana Department of Transportation
- NSN: National Streamflow Network
- O&M: Operation and maintenance
- Rating Curve: Relationship between water stage (elevation) and water discharge in a channel
- Stage: Height of water above a surveyed local datum point
- USGS: United States Geological Survey

Preface

Information on costs, sources of operation and maintenance funding, and number of stream gages operating in Montana, are accurate based on the best information available to the Stream Gage Oversight Work Group in Fiscal Year 2022.

Summary

The Stream Gage Oversight Work Group (Work Group) was created in 2019 by the 66th Montana Legislature in response to stakeholders' concerns over the loss of 10 U.S. Geological Survey (USGS) stream gages in 2018. State budget reductions in 2018 forced Montana to cut back support to the USGS for ongoing operation and maintenance (O&M) costs. Without funding to cover O&M costs, the USGS was compelled to shut down 10 gages. The loss of these gages came with little warning to the water user communities who depended on them for monitoring and cooperatively managing local water resource plans. The event revealed that, as demand for water continues to grow, the continuity of Montana's stream gaging network is threatened by declining state and federal funding for ongoing O&M.

Montana's real-time stream gage network is composed of stream gages operated and maintained by the following entities:

1. The USGS currently operates a network of 218 real-time gages across Montana. These gages are located primarily on Montana's mainstem rivers and their large tributaries. Streamflow information collected by these gages serves multiple federal, state, tribal, and local objectives. The USGS network is discussed in Section 3.1.
2. Montana Department of Natural Resources and Conservation (DNRC) operates a network of real-time stream gages on smaller streams and tributaries not monitored by the USGS. Streamflow information collected by DNRC serves state-specific water administration, distribution, and management objectives. DNRC's network is further discussed in Section 3.2.
3. Several tribal nations in Montana operate stream gage networks to support the administration and distribution of water under tribal jurisdiction. An example of one of these tribal networks is discussed in Section 3.3.

These federal, state, and tribal networks collectively serve a diverse array of water managers and water users across Montana. The common theme linking these networks is the need for reliable, secure O&M funding to keep them operating and funding to expand the networks to meet future demands.

The Work Group collaborated with the USGS and several stakeholder groups to collect user stories and conduct surveys to shed light on the priorities and needs of local water users and the entities that provide O&M funding. Several consistent and common themes emerged from the users' stories and survey results.

- Stream gage data are used by many public and private users, including government agencies responsible for water management and emergency response, utilities, environmental agencies, universities, colleges, consulting firms, and recreational interests.
- Users access the data for a wide variety of purposes, including decision-making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, environmental and watershed management, research, and water-based recreation.
- Stream gage funders support the stream gages deemed most critical to meeting their own natural resource management objectives and/or statutory responsibilities.

- Stream gage funders, particularly federal and state government agencies, often rely on information generated from a wider array of gages other than the ones they fund, demonstrating the importance of the network as a whole and the benefits it provides.
- As demand for water continues to increase, both water users and water managers cite the need for additional stream gages.

As demand for water grows, effective water right administration will increasingly depend on accurate real-time measurements of streamflow. In addition, as Montana transitions to a post-adjudication future, the number of rivers and streams from which water is distributed by court-appointed water commissioners will expand. In the post-adjudication future, Montana will face the challenge of maintaining the stream gages we already have and expanding the number of stream gages to meet future needs.

The Work Group acknowledges that operating and maintaining a network of real-time stream gages carries a substantial cost and represents a long-term commitment to funding. Equipment to collect, transmit and manage the data must be purchased, operated, maintained, repaired, and replaced. Highly skilled personnel including hydrologists, engineers, and technicians must be employed for these tasks and for the task of applying knowledge to convert the collected data into information that is useful to the broad user community.

The cost of this investment must be weighed against the value of the information provided. If water is Montana's most precious resource, then access to accurate information to manage the resource is close to priceless. The Work Group concludes that for Montana to meet the demands of today, and plan for our future, the state and its citizens will need to make a long-term commitment to supporting and expanding real-time stream gaging in Montana. Real-time stream gages offer the best, most cost-effective method to collect streamflow information used by the broadest range of stakeholders. Therefore, the Stream Gage Oversight Work Group recommends:

1. Montana advocate for a significant and sustained federal investment in the USGS stream gage network. Montana's ability to incorporate USGS streamflow information into its water management, administration, and planning decisions is threatened by congressional inaction to adequately fund the USGS stream gage infrastructure. Section 7.1
2. Montana increase state funding to maintain or expand the state's level of support to the USGS network in Montana, which is comprised of gages on Montana's mainstem rivers and their large tributaries. Section 7.2
3. Montana appropriate funding to complete the build-out of the DNRC state-based stream gage network recommended in the 2015 State Water Plan. The DNRC stream gage program measures flows on smaller streams and tributaries not monitored by the USGS. Streamflow information collected by DNRC serves state-specific water administration, distribution, and management objectives. Section 7.3

1.0 Introduction

Water is an essential ingredient to Montana's way of life and our economy. Water supply across Montana is controlled by variability in seasonal temperature and precipitation, as well as long-term climatic trends. While demand for water continues to grow, physical water availability varies from year to year and can often change dramatically between seasons in any given year. As a result, coping with supply and demand imbalances is a constant feature of water management in Montana.[1] The continuous streamflow measurements recorded by stream gages in near real-time provide Montanans with the critical information they need to manage our water supplies today and plan for future demands.

Why "gage' instead of "gauge"
When water measurement methods were first developed by the USGS in the late-1800's, the Chief Hydrologist, Frederick H. Newell adopted that spelling which was also being used in the Standard Dictionary of the time.
Source: USGS

Montana's real-time stream gage network is composed of stream gages operated and maintained by the following entities:

1. U.S. Geological Survey (USGS) currently operates a network of 218 real-time gages across Montana. These gages are located primarily on Montana's mainstem rivers and their large tributaries. Streamflow information collected by these gages serve multiple federal, state, tribal and local objectives. The USGS network is discussed in Section 3.1.
2. Montana Department of Natural Resources and Conservation (DNRC) currently operates a network of 36 real-time stream gages on smaller streams and tributaries not monitored by the USGS. Streamflow information collected by DNRC serves state-specific water administration, distribution, and management objectives. DNRC's network is further discussed in Section 3.2.
3. Several tribal nations in Montana operate stream gage networks to support the administration and distribution of water under tribal jurisdiction. An example of one of these tribal networks is discussed in Section 3.3.

These federal, state, and tribal networks collectively serve a diverse array of water managers and water users across Montana. The common theme linking these networks together is the need for reliable, secure O&M funding to keep them operating and funding to expand them to meet future demands.

The value of streamflow information is derived from its use in decision making. Direct users of stream gage data include a local, state, tribal, and federal agencies; private companies; irrigated agricultural; and recreationists. Data from stream gages inform real-time decision making and long-term planning on water issues, such as water management, economic development, energy development, infrastructure design, water compacts, municipal growth, flood forecasting, water quality, aquatic ecosystem management, and recreational safety. Specific uses of the stream gage data include the following:

- Planning, forecasting, and warning about floods and droughts.
    - On June 11, 2022, streamflow data recorded by stream gages on the Yellowstone River at Corwin Springs and on the West Fork of Rock Creek provided the towns of

[1] 2015 Montana State Water Plan.

Livingston and Red Lodge, respectively, with early warning of approaching flood conditions, allowing city managers and residents to begin emergency preparations.
    - The US Army Corps of Engineers relies on streamflow data for flood control planning and operations at Fort Peck, Garrison, Canyon Ferry, Clark Canyon, Tiber, and Yellowtail, and Hungry Horse dams.
    - The Governor's Drought and Water Supply Advisory Committee – Monitoring Subcommittee reviews statewide streamflow data on a weekly basis to help inform its recommendations to the U.S. Drought Monitor.

- Managing water rights and transboundary water issues.
    - Stream gage data supports the local enforcement of decrees and the distribution of water by court-appointed water commissioners.
    - The USGS relies on 36 stream gages located in the U.S., Alberta, and Saskatchewan to calculate and monitor the international apportionment of water between the U.S. and Canada in the St. Mary and Milk River basins.[2]

- Operating waterways for power production and navigation.
    - Hydropower producers, like Northwestern Energy, Avista Corp., and Energy Keepers, monitor stream gages above their facilities to predict reservoir inflows, and below their facilities to monitor compliance with downstream flow objectives for aquatic resources, such as fisheries.

- Monitoring environmental conditions to protect aquatic habitats.
    - Montana Fish, Wildlife & Parks (FWP) relies on stream gage data to manage the state's fishery resources and aquatic ecosystems to meet the public's demand for recreational opportunities and stewardship of aquatic wildlife. FWP supports the Big Hole Watershed Committee, Jefferson River Watershed Council, and Blackfoot Challenge in activating their drought management plans either by making call on water users who are junior to FWP's instream flow water rights or implementing temporary fishing restrictions or closures when high stream temperatures and/or low flow conditions are present.

- Describing impacts to streamflow from changing land and water uses.
    - Montana DNRC uses stream gage data to determine the physical availability of water for new water use permits.

- Assessing water quality and regulating pollutant discharges.
    - DEQ relies on stream gage data to assess long-term changes in water quality, ensure pollution discharge permits are protective of Montana's water quality, and monitor water quality agreements with surrounding states.

- Determining if rivers and streams are safe for recreational activities.
    - Montanans are savvy about outdoor recreation and know the importance of checking both the weather report and the stream gage report before leaving home. Spring runoff and early summer rains can dramatically change the character of Montana's

[2] Personal communication from John Kilpatrick, Director, USGS Wyoming and Montana Science Center. September 2, 2022

rivers and streams. Debris and fast flowing currents can pose a significant danger for floaters, swimmers, and fishermen. High flows can also cause banks to become unstable and subject to collapse.

- Designing reservoirs, roads, bridges, drinking water, and wastewater facilities.[3]

Most stream gages have value for more than one application. The same gage may provide useful information for water commissioners, flood forecasting, water rights administration, local drought plan implementation, water quality monitoring, and protection of the Montana's aquatic resources.

The Stream Gage Oversight Work Group (Work Group) was created in 2019 by the 66th Montana Legislature in response to stakeholders' concerns over the loss of 10 USGS stream gages in 2018. State budget reductions in 2018 forced Montana to cut back support to the USGS for ongoing operation and maintenance (O&M) costs. Without funding to cover O&M costs, the USGS was forced to shut down 10 gages. The loss of these gages came with little warning to the water user communities who depended on them for monitoring and cooperatively managing local water resource plans. The event revealed that, as demand for water continues to grow, the continuity of Montana's stream gaging network is threatened by declining state and federal funding for ongoing O&M.

The Legislature established the Work Group as a subcommittee of the Drought and Water Supply Advisory Committee. Section 2-15-3308, MCA defines the scope of the Work Group activities (Appendix A). Work Group members represent the seven state agencies that are voting members of the Drought and Water Supply Advisory Committee (Table 1).

The purpose of the Work Group is to engage stakeholders in a review of the USGS stream gage network in Montana and develop recommendations to improve network resilience and continuity in light of funding challenges.

Table 1: Representation on the Stream Gage Oversight Work Group

Representing	Name
Dept. of Natural Resources and Conservation	Paul Azevedo – Co-Chair
Dept. of Fish Wildlife & Parks	Stephen Begley – Co-Chair
Dept. of Livestock	Mike Honeycutt
Dept. of Agriculture	Jon Peterson
Dept. of Emergency Services/Military Affairs	Andrew Long
Dept. of Commerce	Cody Ferguson
Dept. of Environmental Quality	Darin Kron

1.1. Work Group Achievements

1) Improved Communications. The events of 2018 exposed the need to improve both the timeliness of notifications and the distribution of the information to interested stakeholders. To address this need, the Work Group and USGS Wyoming-Montana Office developed a Stream Gage Notification Plan (Appendix B). The plan lays out the steps and processes the local USGS office and the State of

[3] https://www.usgs.gov/mission-areas/water-resources/science/federal-priority-streamgages

Montana will take to ensure the timely exchange of information regarding funding or program changes that could potentially impact the ongoing operation of the USGS stream gage network in Montana. The end goal is to minimize network disruptions by exchanging information far enough in advance that it can be acted on before the USGS shuts down a gage.

As of August 31, 2022, the USGS has notified Montana about the potential loss of gages on seven occasions (Table 2). Of the 17 gages included in the notifications, seven have been discontinued and ten have had their funding restored. While it is not possible to definitively say the notification plan "saved" any of these gages, stakeholders have expressed support and appreciation for receiving timely notifications and being given an opportunity to affect the outcome.

2) Recommendations. The Work Group developed recommendations that, if implemented, will provide the state and people of Montana with the information necessary to meet the complex challenges for managing our water resources to meet current uses and the needs of future generations.

Table 2: USGS Notifications to the Montana Regarding Potential Loss of USGS Stream Gages

Date of Notice	Gage # Location Period of Record	Funding	Current Status
5.8.20	#12323600. Silver Bow Creek at Opportunity. 31 yrs.	Federal - EPA	Funding renewed by EPA
	#12323750. Silver Bow Creek at Warm Springs. 35 yrs.	Federal - EPA	Funding renewed by EPA
	#06088500. Muddy Creek near Vaughn. 82 yrs.	USGS-CMP and local	Rescued by Green Fields Irrigation District, DNRC and USGS-CMP
2.17.21	#06077500. Smith River near Eden MT. 33 yrs.	USGS-CMP and DEQ	DEQ will fund through 2023.
3.22.21	#06062500. Tenmile Creek near Rimini, MT. 80 yrs.	USGS-CMP, DNRC & L&C Water Quality District	Rescued by L&C County Public Works, DNRC & USGS
8.19.21	#12362000. Hungry Horse Reservoir near Hungry Horse MT. 70 yrs.	Federal - USBR	Rescued by Energy Keepers Inc., DNRC and USGS-CMP
	#06132000. Missouri River below Fort Peck Dam MT. 5 yrs.	Federal - USACE	Discontinued on 9.30.21
	#06214500. Yellowstone River at Billings MT (water temp only). 20 yrs.	USGS	Rescued by Montana Trout Unlimited, FWP and USGS-CMP
	#12340000. Blackfoot River near Bonner MT (water temp only). 13 yrs.	USGS	Rescued by Montana Trout Unlimited, DNRC, FWP and USGS-CMP
2.7.22	#05014300.Swiftcurrent Creek above Swiftcurrent Lake at Many Glacier, MT. 19 yrs.	USGS	Discontinued on 3.31.22

Date of Notice	Gage # Location Period of Record	Funding	Current Status
	#06050000. Hyalite Creek at Hyalite R S nr Bozeman MT. 28 yrs.	USGS	Rescued by Gallatin Water Quality District, DNRC, & USGS-CMP
	#06090000. Missouri River at Great Falls MT (Gage height only). 8 yrs.	USGS	Discontinued on 3.31.22
	#12324590. Little Blackfoot River near Garrison MT. 31 yrs.	USGS	Funding renewed by USGS-FPS
7.19.22	#12357800. Snyder Creek nr mouth, nr West Glacier, MT. 5 yrs.	Federal - NPS	Discontinued on 7.20.22
7.25.22	#06192900. Dugout Creek at mouth, nr Wilsall MT. 3 yrs.	USGS	Discontinued 9.30.22 Short-term study
	#12355342. Hallowat Creek above Kletomus Creek, near Olney MT. 3 yrs.	USGS	Discontinued 9.30.22 Short-term study
	#12355347. Big Creek below Lookout Creek, near Apgar MT. 3 yrs.	USGS	Discontinued 9.30.22 Short-term study

1.2. Operation of Work Group

Since August 2019, the Work Group met nine times, both in-person and virtually. The Work Group developed and adopted Terms of Reference to guide their work (Appendix C). The meeting agendas, presentations, and meeting summaries are available on the Work Group website.[4]

1.3. Outreach and Public Participation

Montana's legislature created the Work Group in response to stakeholders who use and depend on the availability of streamflow data. All Work Group meetings were open to the public and attended by multiple watershed representatives and other interested parties. Meeting notices and draft agendas were posted on the Work Group website and emailed to interested stakeholders. Engaged groups also promoted the meetings via newsletters to their constituents.

Representatives from the following stakeholder groups participated in Work Group meetings either in person or virtually:

- Soil and Water Conservation Districts of Montana
- Big Hole Watershed Committee
- Musselshell Watershed Coalition
- Sun River Watershed Group
- Blackfoot Challenge
- Montana Watershed Coordination Council
- Montana Trout Unlimited

[4] http://dnrc.mt.gov/divisions/water/drought-management/drought-committee/stream-gage-oversight-work-group

- Confederated Salish and Kootenai Tribes
- Montana Water Resources Association
- Montana Bureau of Mines and Geology
- Office of U.S. Senator Daines
- U.S. Forest Service

Stakeholders attending the Work Group meetings had a vested interest in finding a solution for keeping stream gages operating in Montana. The ability to monitor streamflows and water temperature in real time is critical for making day-to-day decisions on the implementation of local water management plans and drought plans. While their interest is focused on local needs, they understand the critical role stream gages play in the overall management of Montana's water resources. Stakeholders want to know that state government has a plan to keep stream gages operating in Montana.

In addition to the Work Group meetings, the USGS Helena office hosted two meetings for interested stakeholders. These meetings opened additional dialogue on funding and coordination of information. Multiple representatives from the Work Group and stakeholders attended each meeting.

Representatives of the Work Group also gave presentations at the Montana Association of Conservation Districts Spring 2020 Board Meeting, and the 2020 Montana Water Resources Association Annual Conference.

The Work Group collaborated with several stakeholder groups to collect user stories and conduct a survey to understand the priorities and needs of local water users and communities (Section 5 describes the results of these efforts). Several consistent and common themes emerged from the stories and survey results.

- Stream gage data are used by a large number of public and private users, government agencies responsible for water management, aquatic resources, and emergency response, utilities, universities, consulting firms, municipalities, irrigated agriculture, and recreational interests.
- Users access the data for a wide variety of purposes, including decision making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, environmental and watershed management, research, and water-based recreation.
- As demands for water continue to grow, both water users and water managers cite the need for additional stream gages.

2.0 Introduction to Stream Gages – What they do and how they work

The science of collecting streamflow information has evolved since the USGS first began conducting hydrologic surveys of the arid West in the 1880's. Today, trained hydrologists may employ various methods to collect streamflow data. This report focuses on stream gages that provide a continuous record of streamflow (discharge), which is a measure of water volume (in cubic feet per second) passing a specific location over a period of time. The gages automatically take measurements at a preset schedule and relay the data via satellite to a central datacenter for processing. The data are used to generate hydrographs, which show discharge over time at a specific location (Figure 1). Stream gages may also be outfitted with sensors to monitor water temperature and a variety of water quality parameters. Advances

in stream gaging technology now provide end-users with accurate information on streamflow and water temperature in near "real time."

In Montana, access to real-time streamflow information supports decision-making by water managers, water users, recreationists, and the public as they adjust to changes in seasonal water supply and demand. Local governments, and state, tribal, and federal agencies also rely on streamflow information for emergency planning and notification, as well as longer-term water supply planning.

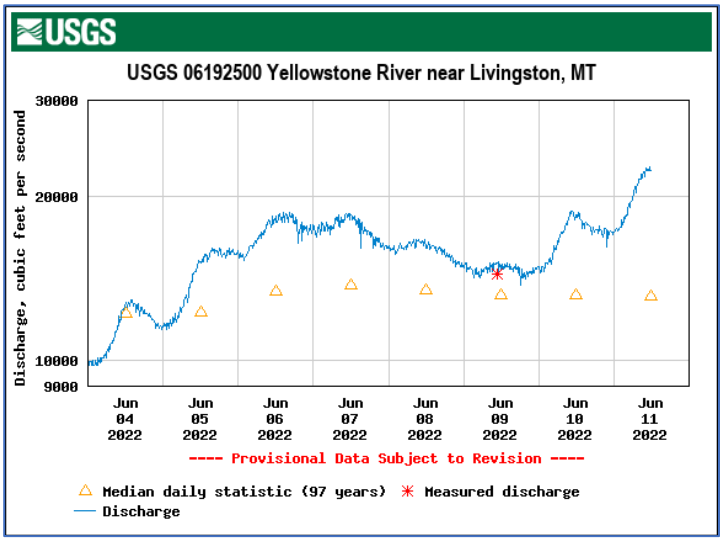

Figure 1: Hydrograph showing discharge over time on the Yellowstone River near Livingston, MT. Source: USGS

Streamflow records collected over a long period of time are particularly valuable because they enable users to understand extreme events, hydrologic variability, long-term climatic trends, and the effects of land use changes and project operations on streamflows.[5] Many stream gages have data records that are at least 50 years long, and Montana has a few with 100-year records.

2.1. Measuring Streamflow

The objective of a stream gage is to provide a continuous record of streamflow or discharge. However, stream gages do not actually measure discharge. Stream gages only measure stream stage (the height of water above a known surveyed point). Stage is also referred to as gage height. Most streamflow gages in Montana use a pressure sensing device to determine the river stage (Figure 2). Pressure readings increase as the river stage gets higher and decrease as the water level drops. Pressure reading measurements are taken every 15 minutes, which provides a near continuous record of stream stage. These data are transmitted to a GOES satellite (Geostationary Operational Environmental Satellite) at a preset schedule once every hour.

Developing and maintaining the ongoing validity of the rating curve is the foundation of accurate stream gaging.

To convert the stage (measured by the gage) to discharge requires knowing the mathematical relationship between stage and discharge. The stage-discharge relationship depends on the shape, size, slope, and roughness (uneven or irregular surface) of the channel at each gage site and is different for every stream gage. The stage-discharge rating curve (rating curve) is developed by taking numerous physical stream discharge measurements over time and over a range of stages (from low flow to flood stage). Each point on the stage-discharge graph represents one physical discharge measurement - or data gathering visit - to a gage. Connecting each point with a smooth line allows one to

[5] National Hydrologic Warning Council. Benefits of USGS Streamgaging Program. March 7, 2006

estimate the discharge at any given stage (Figure 3). Developing and maintaining the ongoing validity of the rating curve is the foundation of accurate stream gaging.

Figure 2: Diagram of typical stream gage installation with equipment used to measure stage and take physical discharge measurements to maintain the validity of the rating curve. *Source: USGS*

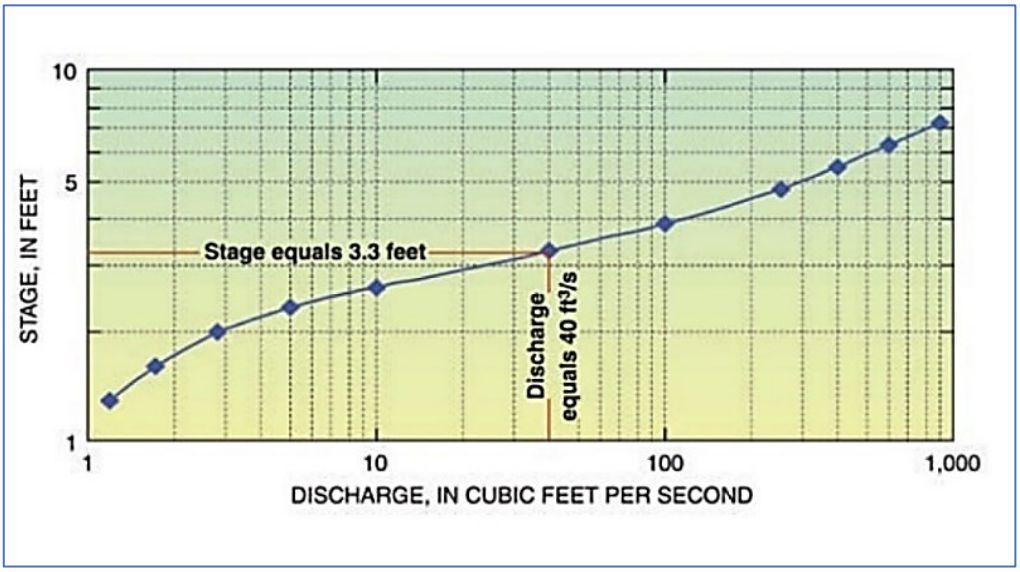

Figure 3: Example of a typical stage-discharge relation or rating curve. In this example, a stage of 3.3 feet gives a discharge of 40 cubic feet per second.
Source: USGS Fact Sheet 2007-3043

Since rivers and streams are dynamic environments, the rating curve for almost every stream gage will vary over time due to changes in the stream channel resulting from sedimentation, scour, bank erosion, ice, and the collection of debris (Figure 4). For example, aquatic vegetation growth in late summer when flows are low can raise the measured stream stage enough to create an error, or drift, in the rating curve. To keep rating curves accurate and up to date, hydrologists visit each stream gage eight to ten times per year over the life of the gage to verify gage height and make a physical discharge measurement. This requires time, travel, field work in all conditions, special equipment, and a specially trained workforce. Hydrologists will also visit a site after an extreme weather event, or if they notice unexpected variations in the data transmitted from the gage. Unanticipated variations in the data may indicate faulty equipment, or that a change in local conditions, such as a collapsed bank or collection of debris, has altered streamflow in the vicinity of the gage.

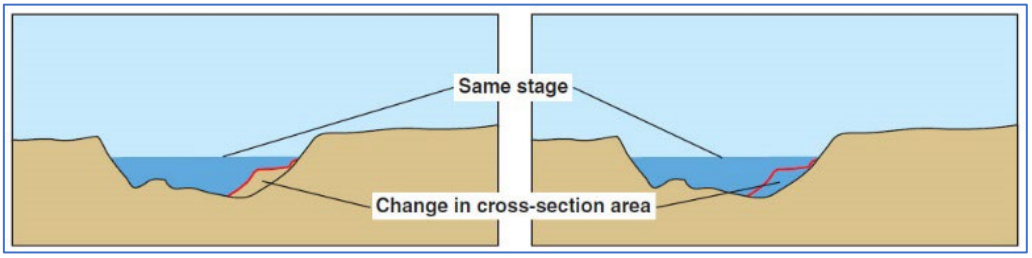

Figure 4: Because stream channels change with time, additional manual measurements must be made to maintain the accuracy of the rating curve.
Source: USGS Fact Sheet 2007-3043

Site visits to collect stage and discharge measurements generally involve several steps. These include inspecting equipment for damage, running system checks on electronic equipment, downloading a copy of all data collected since the previous site visit, taking a physical stage and discharge measurement, and documentation of all actions taken, and observations made. Each site visit will generally take one to four hours depending on the width and stage of the river. Weather conditions, along with the need to replace or repair broken/damaged equipment add time to each site visit.

To make a discharge measurement, hydrologists use a current velocity meter to measure both the velocity and depth of water at 25-30 evenly spaced points across the river or stream channel (Figure 5). These velocity and depth measurements are used to compute the total volume of water flowing past the gage. The results of these physical measurements are used to apply adjustments or "shifts" to the rating curve as stream channel conditions change.

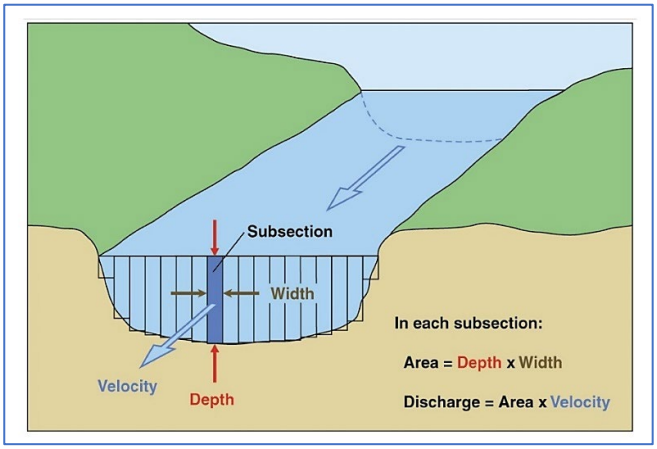

Figure 5: Diagram of channel cross section with subsections. Source: USGS Fact Sheet 2011-3001

Each site visit requires several additional hours in an office running quality assurance/quality

control checks on all the streamflow data collected. This includes comparing the record of streamflow data transmitted by the satellite to the backup copy downloaded from the gage. On occasion, atmospheric conditions will interrupt data transmissions to and from the satellite, resulting in an incomplete discharge record. Data discrepancies are then corrected and documented.

3.0 Stream Gaging in Montana

The USGS operates the largest stream gage network Montana. This network is complemented by smaller, state, and tribal networks that, in combination, provide the information Montana needs to manage its water resources. The common theme linking these networks together is the need for reliable, secure O&M funding to keep the current networks operating and funding to expand them to meet future demands. These networks are discussed in the following sections.

3.1. USGS Stream Gage Network

The first recorded measurement of streamflow in Montana by the USGS occurred in 1890 on the Yellowstone River at Corwin Springs. Montana currently hosts 218 USGS stream gages, measuring discharge, water temperature, or a combination of both (Figure 6). As discussed in Section 3.1.3, funding for USGS network in Montana comes from a variety of federal, state, tribal, local, and private sources. However, all streamflow information generated by the network is freely available to every citizen with access to the internet. As a result, the financial burden for supporting the network is carried by relatively few entities, while the benefits accrue directly or indirectly to every citizen in Montana.

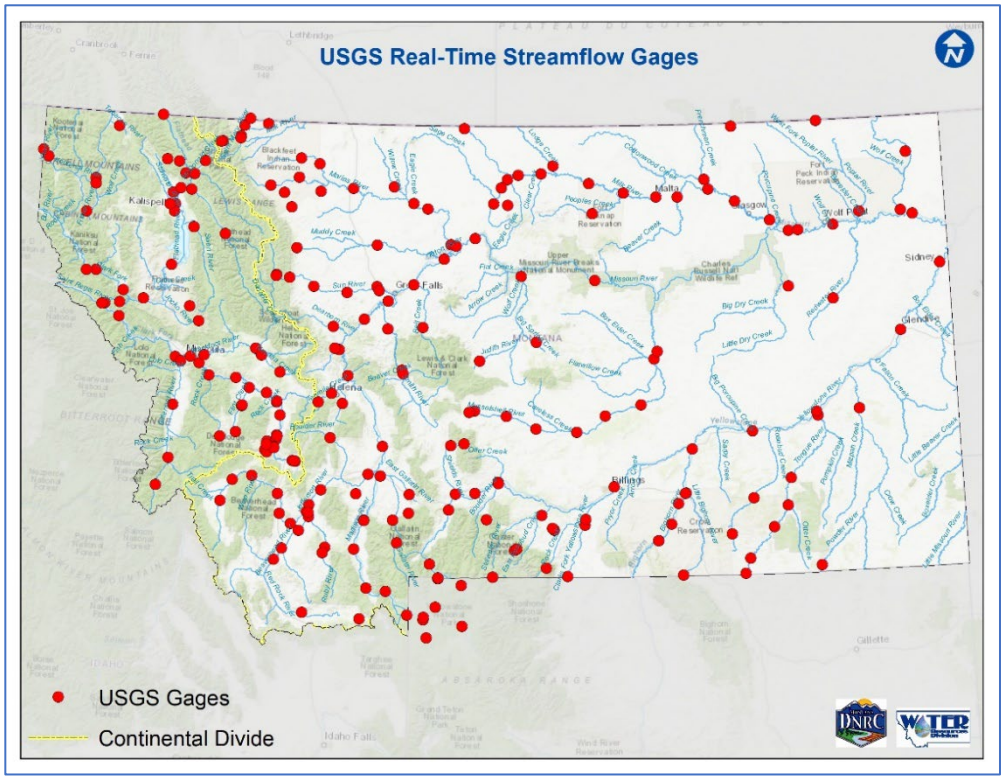

Figure 6: Locations of USGS real-time streamflow gages in Montana.

3.1.1. USGS Network Cost

USGS activities to collect, manage, disseminate, and analyze streamflow data is an expensive undertaking. Equipment to collect, transmit and manage the data must be purchased, operated, maintained, repaired, and replaced. Highly skilled personnel, including scientists, engineers, and technicians, must be employed for these tasks and for the task of applying knowledge to convert the collected data into information that is useful to the broad user community.

Stream gaging costs are divided into two categories: installation and O&M. The installation costs vary widely depending on location and site conditions. Three recent installations in Montana at sites with easy access on wadable streams averaged about $7,800 each.[6] In comparison, recent replacement of cableway across the Clark Fork River near Missoula cost over $100,000.[7] These costs do not include the stream gage equipment itself which runs approximately $15,000 per site.

Installation is considered a one-time expense that includes:

- Site reconnaissance and selection,
- Site elevation surveying,
- Site preparation and construction,
- Database configuration, and
- If necessary, cableway installation or other means for measuring streamflow at sites that are too wide and/or swift to wade.

O&M costs include everything that goes into collecting and publishing publicly accessible streamflow data. This is often referred to as "Gage to Page." O&M costs include:

- Continuous year-round collection of gage-height and streamflow data at 15-minute intervals,
- Establishment and maintenance of stage-discharge relation (i.e., rating curve),
- USGS personnel collecting eight to ten discharge measurements per year,
- Satellite telemetry,
- Quality assurance measures, including field validation of stream gage datum; analysis and approval of all measurements and records,
- Repair and/or replacement of equipment and instrumentation,
- Database maintenance and permanent archival of all data and records, and
- Support, which includes:
    - USGS National Streamflow Information Program – access to technical specialists, periodic audits, and database enhancements, and
    - Local USGS Science Center – management, administrative functions, IT infrastructure, facilities, vehicles.

For the purposes of allocating O&M costs, the USGS manages the network as a complete system. Total O&M cost is equally allocated to each gage in the network. The annual O&M cost in FY22 was $17,300 for a year-round stream gage, $13,500 for an eight-month seasonal gage and $12,150 for a seven-month seasonal gage.

[6] August 12, 2020, presentation by the USGS to the Stream Gage Oversight Work Group.
[7] August 12, 2020, presentation by the USGS to the Stream Gage Oversight Work Group.

3.1.2. Why Does it Cost So Much?

According to USGS, salary is the largest driver of cost, accounting for 44% of annual O&M cost.[8] Although the gages are fully automated, each one must be visited eight to ten times per year to maintain the validity of the stage-discharge rating curve and data accuracy. This requires time, travel, field work in all conditions, special equipment, and a skilled workforce. The second largest cost driver is System Support (39%), which includes management, administrative functions, IT infrastructure, and facilities. Vehicles, travel, equipment, and supplies account for approximately 18% of annual O&M costs.

Although the gages are fully automated, each one must be visited eight to ten times per year to maintain the validity of the stage-discharge rating curve and data accuracy.

3.1.3. Who Funds the USGS Network in Montana?

Funding for the 218 USGS stream gages in Montana comes from a variety of federal, state, tribal, local, and private sources (Figure 7). Sharing the cost over multiple funding sources results in the operation of far more stream gages than would be possible if funded solely by USGS. Current USGS appropriations from Congress are enough to cover approximately 39% of the stream gage network cost in Montana. There are 160 gages supported by a single source of O&M funding. Other gages may receive O&M funding from as many as five different sources.

3.1.4. Federal Funding

The largest share of federal funding is directly through the USGS (Figure 7). Congress appropriates funds to the USGS stream gaging program via two sources:

1. Cooperative Matching Funds (CMF). These funds support studies and data collection serving both partner and USGS objectives. Cooperative Matching Funds can be used to cost share with partners up to 50% of costs on stream gages. However, congressional appropriations have not kept pace with cost increases and partner demands. To make up for lack of federal funding partners now shoulder up to 60% of the cost. Cooperative Matching Funds are only available to partner entities that have taxing authority, i.e., state and local governments. Federal Cooperative Matching Funds support 77 gages in Montana.
2. Federal Priority Stream Gage (FPS) Funds. These funds can be used to cover 100% of the costs for gages in the Federal Priority Network. Gages within the FPS network must meet one or more of five congressionally authorized strategic Federal priorities or responsibilities.[9] Montana has 158 sites eligible for FPS funds. However, the USGS office for Montana and Wyoming is only able to fully fund 47 eligible gages with FPS dollars. As with Cooperative Matching Funds, congressional appropriations for the Federal Priority Network have not kept pace with rising costs, which forces the USGS to either deactivate an FPS-eligible gage or secure other sources of funding. Currently, 71 sites in Montana that could be 100% supported with FPS funds must rely on other sources of

[8] August 12, 2020, presentation by the USGS to the Stream Gage Oversight Work Group.

[9] 1) Forecasting floods, droughts, etc., 2) Support water quality assessments of major rivers, 3) Support interstate and international compacts and agreements, 4) Track streamflow in major rivers and contributions from key basins to the next downstream basin, or 5) Describe long-term trends in streamflow at sentinel watershed sites that typify major ecoregions and river basins.

federal, state, tribal, or other funds for O&M costs. Another 40 FPS eligible gages are currently inactive due to lack of funding.

Additional federal funding support is provided by seven different federal agencies listed below and shown in Figure 7.

1. US Bureau of Reclamation
2. US Army Corps of Engineers
3. US Environmental Protection Agency
4. US State Department – International Joint Commission
5. US Department of Energy - Bonneville Power Authority
6. US Fish and Wildlife Service
7. US National Park Service – Yellowstone National Park.

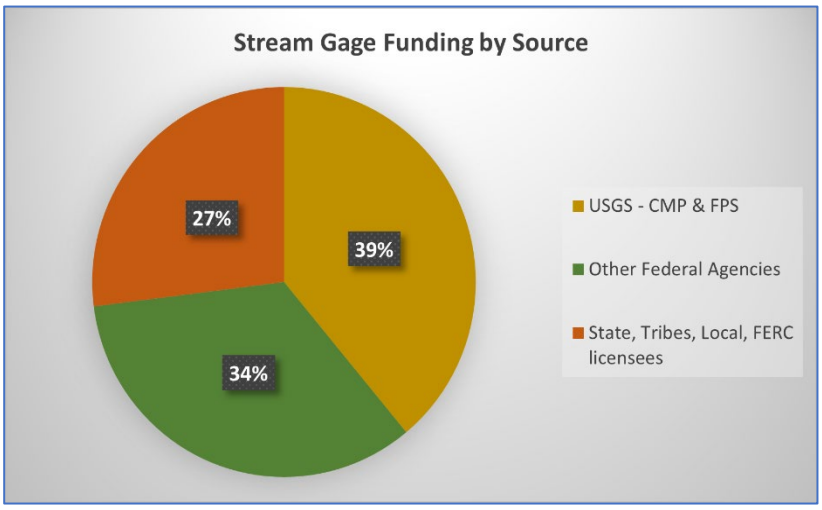

Figure 7: Sources of O&M funding for USGS stream gages in Montana. Source: USGS

3.1.5. State Funding

The State of Montana provides annual O&M funding support to 98 of Montana's 218 USGS stream gages. Ninety-four of these gages are supported by DNRC and FWP. In FY22, DNRC spent $384,759 in general funds to support 47 USGS stream gages (Figure 8). USGS provides cost share support on 40 of these 47 gages.

FWP supports streamflow and/or water temperature monitoring on 47 individual gages. FWP's stream gage funding is provided through general license dollars. In FY22, FWP provided $214,226. All 47 gages supported by FWP are cost-shared with USGS.

In FY22, DNRC and FWP provided $598,985 to support ongoing O&M for 94 of Montana's 218 USGS real-time stream gages.

Although FWP and DNRC financially contribute to a portion of the overall network, the ability of both agencies to meet their natural resource management objectives and statutory responsibilities is dependent upon streamflow information generated by all 218 stream gages in the network.

In addition, Montana water users often turn to DNRC and FWP for assistance when a USGS stream gage is in danger of being lost due to lack of funding. Both agencies report that new funding partners are more willing to participate if they see state government is willing to contribute too. As a result, both DNRC and FWP will often assume additional funding obligations in support of local stewardship of Montana's water resources. Absent an available source of funds to bridge over, or cover funding gaps, both DNRC and FWP must divert funds from other programs within their departments.

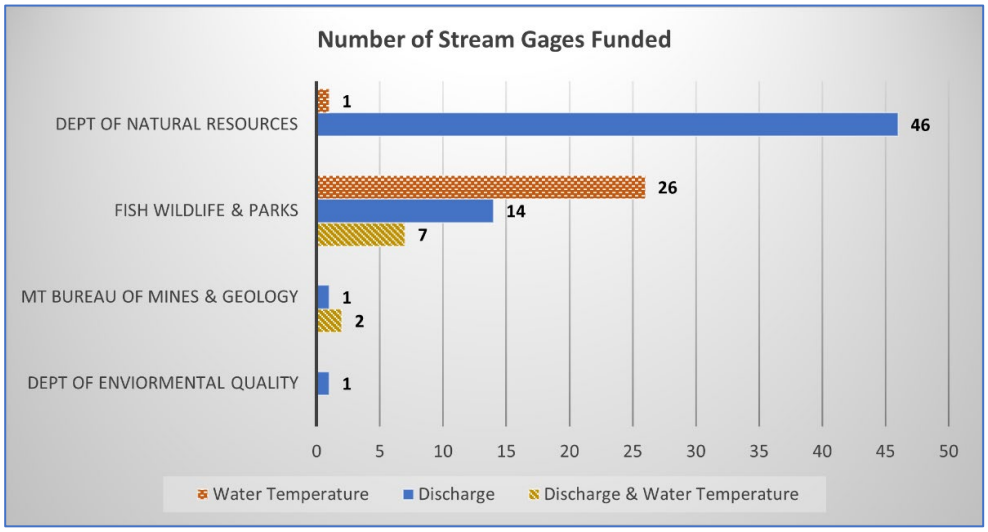

Figure 8: USGS stream gages receiving State funding for O&M support.

3.1.6. Tribal Nation Funding

Five of the seven Tribal Nations in Montana provide funding support to 15 USGS gages. Nine of these gages also receive USGS cooperative matching funds (Figure 9).

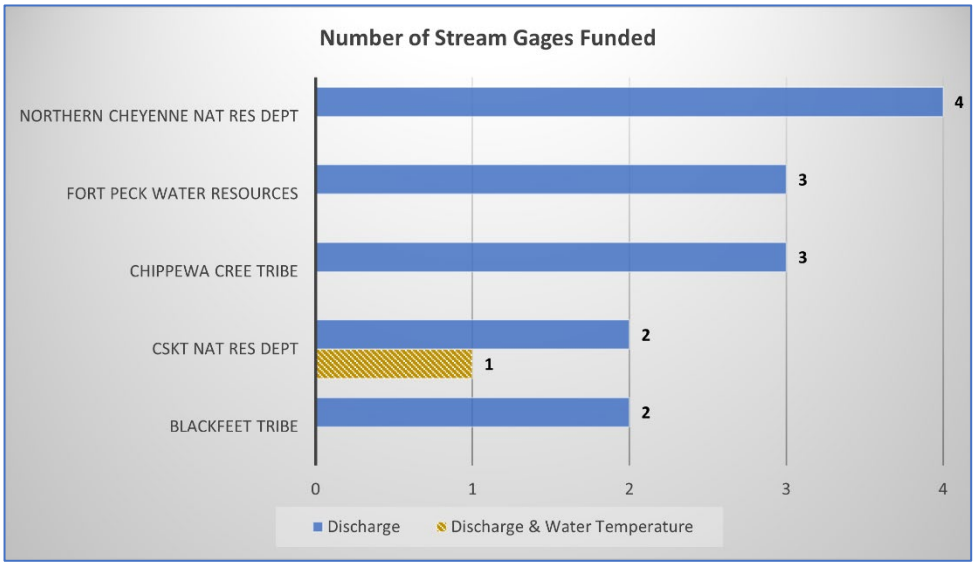

Figure 9: Stream gages receiving O&M funding from Tribal Nations.

3.1.7. Local, and Other Funding

Forty-three USGS gages are supported by a variety of local and other sources of funding (Figure 10).

1. Eighteen gages receive 100% of their funding from entities licensed by the Federal Energy Regulatory Commission (FERC) to generate hydroelectric power in Montana. Northwestern Energy supports 11 gages and is the largest single funder in this category. Stream gages funded by FERC licensees are not eligible for USGS cooperative matching funds.
2. The Wyoming State Engineers Office provides funding to seven gages directly tied to the interstate administration of water under the 1951 Yellowstone River Compact. These funds are combined with funding provided by DNRC and USGS.
3. Funding provided by Talen Energy and Sibanye-Stillwater mining is tied to conditions in their operating permits.
4. Sixteen gages are partially supported by the following 14 local entities:[10]
    - Big Hole Watershed Committee
    - Clark Fork Coalition
    - Montana Trout Unlimited
    - Madison River Foundation[11]
    - Madison Conservation District
    - Teton Conservation District
    - Petroleum County Conservation District
    - East Bench Irrigation District
    - Greenfields Irrigation District
    - Tongue River Water Users Association
    - Big Sky Water and Sewer District
    - City of Bozeman
    - Granite County
    - Lewis & Clark County

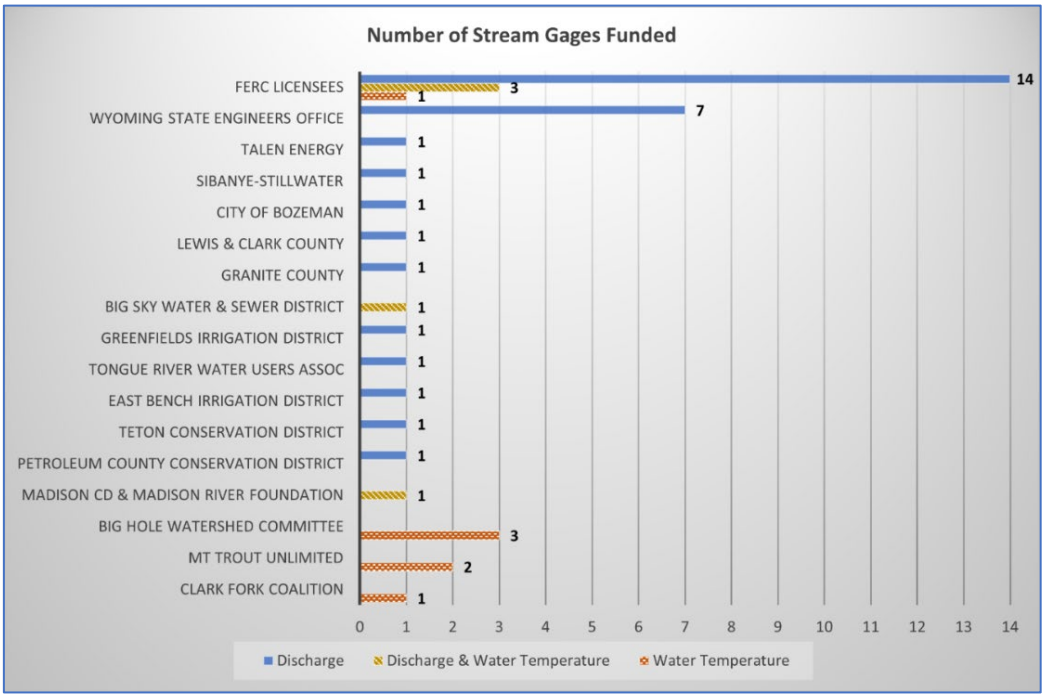

Figure 10: Stream gages receiving O&M funding from local or other sources.

[10] The Flathead Conservation District provides O&M funding support to a stage-only gage on the Flathead River at Foys Bend near Kalispell. The Foys Bend gage is not included in the list of 16 gages because the gage is not used to compute discharge measurements.

[11] The Madison River Foundation and Madison Conservation District jointly cost share on a single gage.

These 16 gages are the only examples the Work Group is aware of where local Montana citizens are contributing financially to the annual O&M of USGS stream gages. Each of these organizations raise funds directly from their members to support stream gages in their local watersheds. For many, their contributions place an additional burden on already strained budgets.

Stakeholders who contributed to discussions with the Work Group feel that stream gages are a fundamental tool in the toolbox of local water management. The USGS network provides them the best information available to quantify water supplies and availability, which they use to develop and implement local water management and drought plans in real time. While stakeholders acknowledge the importance of having "skin in the game," they also struggle with raising funds to support their local stream gage. It is difficult for even the most dedicated local organizations to raise adequate cost-share funds on an annual basis.

3.2. DNRC Stream Gage Program[12]

The 2015 State Water Plan identified the need to improve Montana's water supply and distribution monitoring network to support planning, policy development and decision making at local, state, and federal levels.

The importance of ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed by the four Basin Advisory Councils who assisted DNRC in developing Montana's 2015 State Water Plan. The 2015 State Water Plan identified the need to improve Montana's water supply and distribution monitoring network to support planning, policy development, and decision making at local, state, and federal levels. To meet this need, the 2015 State Water Plan recommends Montana develop a network of 100 state-operated, permanent, year-round stream gages to gather and distribute real-time streamflow information on smaller streams and tributaries not monitored by the USGS. In 2015, DNRC started a Stream Gage Program (DNRC Program) within the Water Resources Division to implement this recommendation.

The DNRC Program focuses on state-specific water management issues by providing critical real-time streamflow data to water commissioners, watershed groups, water resource professionals, fisheries managers, and other stakeholders to aid them in day-to-day water management decisions. To date, the DNRC Program operates 36 real-time stream gages.

Montana DNRC's Stream Gage Program Goals:

- Collect, analyze, and present accurate, high quality, real-time streamflow data on Montana's rivers, streams, and other critical surface water locations not monitored by the national USGS network.
- Install and maintain up to 100 permanent real-time stream gages by 2025.
- Provide real-time streamflow information to the public via a user-friendly website.
- Support individual, local, and regional water resource allocation, distribution, and management goals.

[12] In addition to the DNRC stream gage program discussed in this report, DNRC operates a network of 21 gages specifically for the operation and management of state-owned dams and canals.

Montana DNRC's Stream Gage Program Benefits:

- Enable water users and managers to make water use and distribution decisions based on real-time information.
- Collect and provide essential information on the amount of water physically available for new appropriations.
- Expand the capability for both short and long-term water resource planning, such as developing basin water budgets, evaluating local and regional water supplies, and evaluating opportunities for increased storage.
- Support the local enforcement of decrees and the distribution of water by water commissioners, ditch riders, and reservoir and canal operators.
- Support the efforts of Montana citizens to develop and implement local drought management plans.
- Promote public awareness of Montana's water resources.
- Support work carried out by other state agencies, such as FWP, Montana Bureau of Mines & Geology, the departments of Environmental Quality, Agriculture, and Transportation.

To date, existing resources have allowed the DNRC Program's two full-time hydrologist to install, operate, and maintain 36 real-time gages (Figure 11). Data collection, processing, management, review, and QA/QC procedures follow USGS protocols.

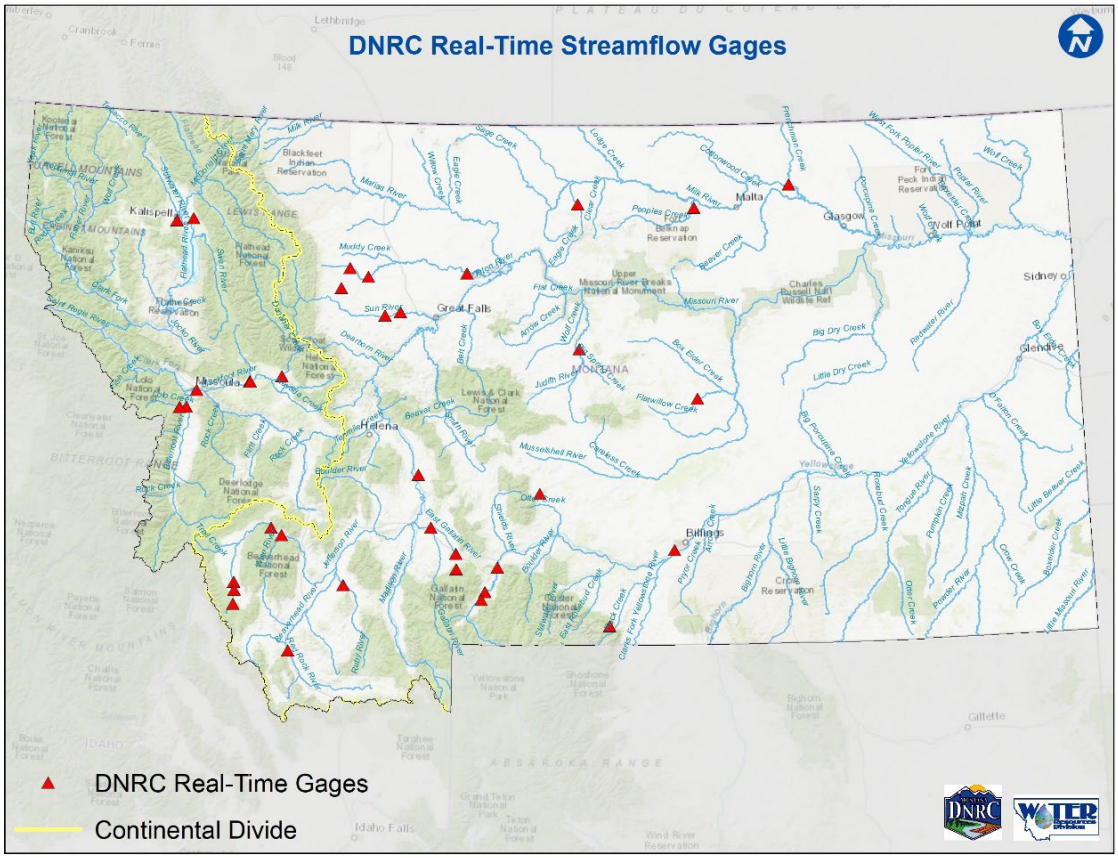

Figure 11: Location of stream gages operated by DNRC's Stream Gage Program.

DNRC Program hydrologists work with managers in DNRC's regional offices, water commissioners, and/or local stakeholders to identify locations where access to streamflow information would support the administration of water rights, contribute to the resolution of local water resource conflicts, and/or support the development of local water management and drought plans.

All streamflow information generated by the DNRC Program is publicly available on DNRC's Stream And Gage Explorer (StAGE) website.[13] StAGE is designed to quickly get streamflow information into the hands of water users whether they are using a desktop computer, tablet, or mobile device. StAGE also allows users to view streamflow information collected by other agencies, including FWP and USGS (Figure 12).

Features of StAGE include a user-friendly map interface, the ability to query the gages by name or location, and a data downloader that allows users to download stream gage data and statistics as needed (Figure 13). StAGE also provides the public one-stop access to historical and seasonal streamflow data collected by DNRC hydrologists, water measurement sites at state-owned dams and canals, and ground water elevations at selected sites.

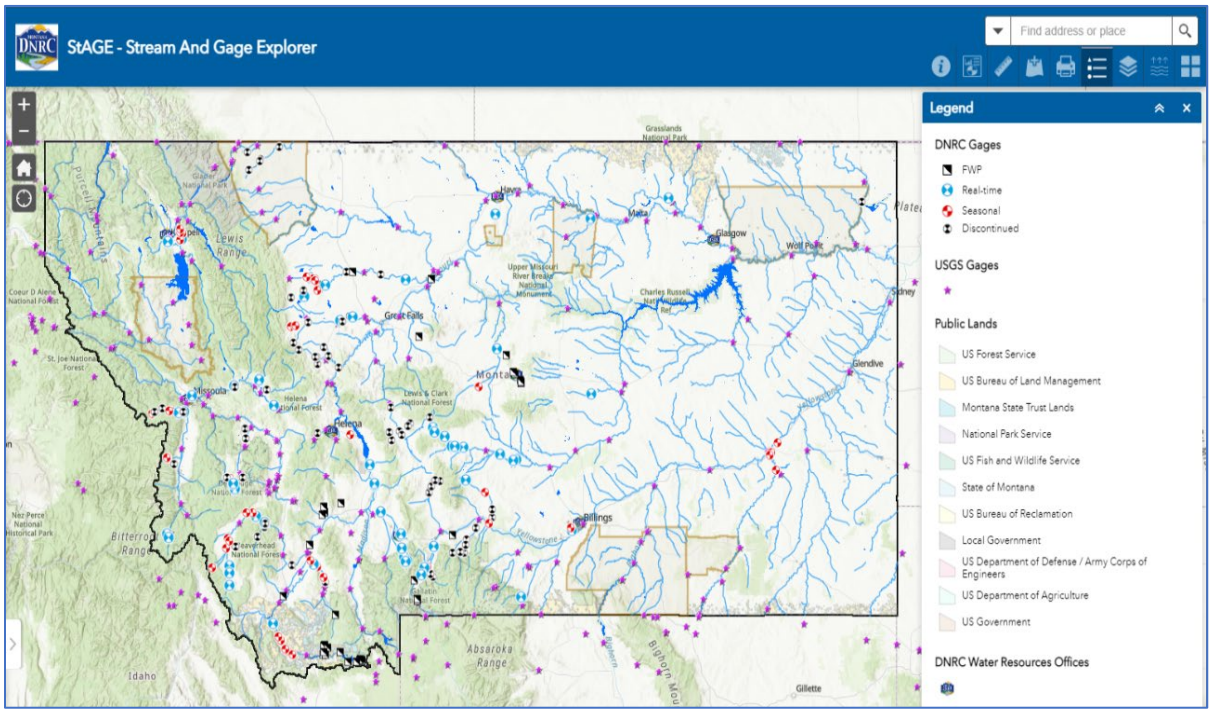

Figure 12: StAGE provides users with access to streamflow information collected by DNRC, FWP and the USGS.

Annual O&M costs of approximately $7,200 per gage are covered by the existing DNRC Program budget. This cost does not include start-up costs or support provided by personnel in the Water Resources Division's regional offices, who assist with O&M activities as time permits.

[13] https://gis.dnrc.mt.gov/apps/StAGE/

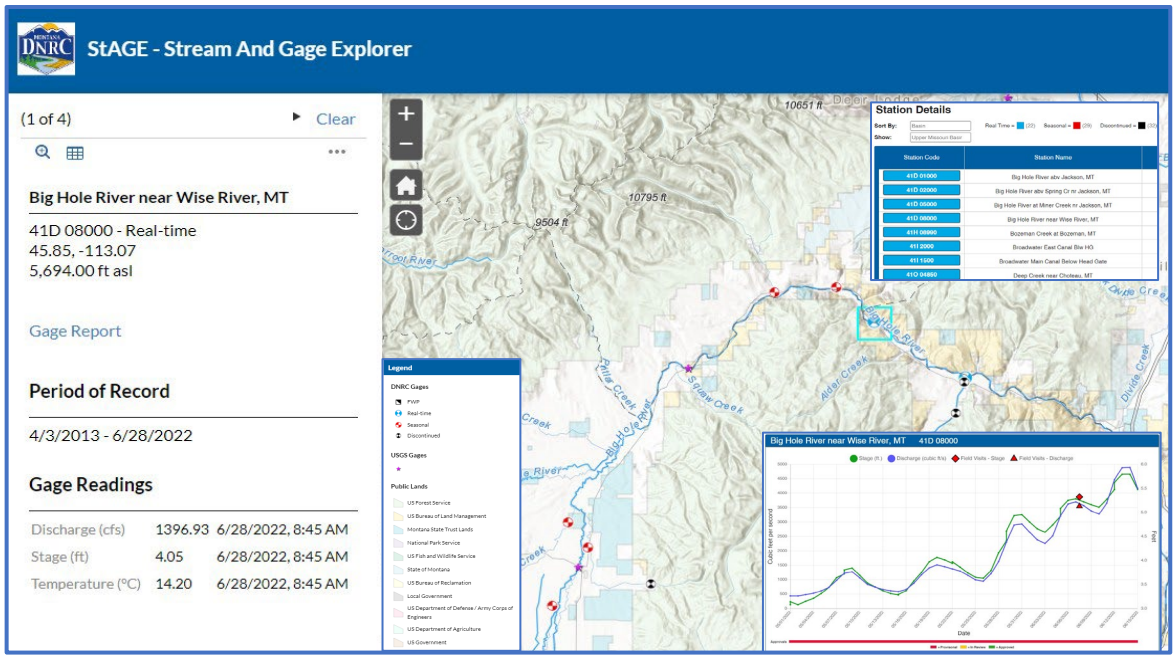

Figure 13: StAGE allows users to explore stream gage data in its spatial context, query gage by name or location, and see the latest discharge readings with a single click.

Salary is the largest driver of DNRC O&M cost similar to USGS. Support for DNRC's Program comes from the Water Resources Division budget, with no special appropriation from the legislature. Current annual DNRC Program costs are approximately $259,200, in addition to the $384,759 used to support the USGS as a cooperative funder.

DNRC Program staff receive five to ten unsolicited inquiries per year from stakeholders working on local water issues that would benefit from the information a real-time stream gage can provide. These inquires demonstrate the unmet need for additional stream gages. However, the DNRC Program has reached the limit of its current resources and cannot expand beyond 36 gages. Without additional funding for personnel, operating expenses, and equipment, the DNRC Program cannot fulfill requests by stakeholders for additional stream gages.

3.3. Confederated Salish & Kootenai Tribes Water Measurement Program

Several Tribal Nations in Montana also operate stream gage networks to support the administration of water under tribal jurisdiction. The Confederated Salish & Kootenai Tribes (CSKT) Stream Measurement Program is an example of one of these tribal operated networks. The information below was provided to the Work Group by Seth Makepeace, Water Management Program Manager for the CSKT.[14]

The Flathead Reservation of the CSKT covers 1.3 million acres in western Montana. Contained within the Reservation boundaries is the 130,000-acre Flathead Indian Irrigation Project (FIIP), the largest Bureau of Indian Affairs (BIA) project in the nation. In 1906, the USGS began measuring streamflow on the Reservation to characterize water availability for developing the FIIP. In the 1940's – 1960's, water

[14] February 17, 2021, Presentation to Work Group by Seth Makepeace, Water Management Program Manager for the Confederated Salish & Kootenai Tribes.

measurement was conducted by the BIA for water supply forecasting, reservoir management, canal operations, and on-farm water allocation. The CSKT Water Measurement Program (CSKT Program) was started in 1982 and now manages the water measurement activities previously conducted by the USGS and BIA.

Today, the CSKT Program operates and maintains a network of 82 real-time gaging stations within the boundaries of the Reservation. The focus of the CSKT Program is to support implementation of the Tribe's Federal Reserved Water Rights Compact by measuring natural streamflows, regulated streamflows, canal diversions, return flows, and reservoir levels. Approximately 50% of these gages are in the large canals of the FIIP.

CSKT Program staff include one lead Hydrologist, a Data Management Hydrologist, a Chief of Field Operations and four Hydrographers. All data collection, processing, management, review, and QA/QC procedures follow USGS protocols. All streamflow information generated by the CSKT Program is publicly available on the CSKT Hydrology Data WebPortal (Figure 14).[15]

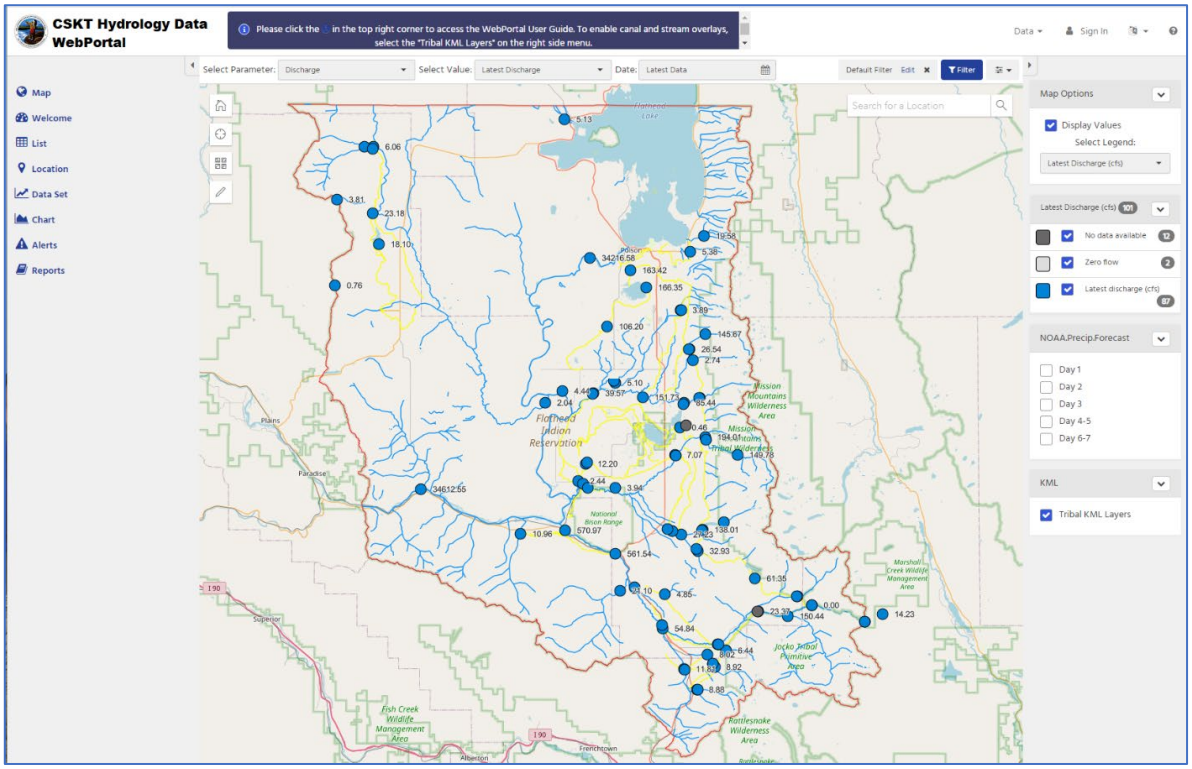

Figure 14: CSKT Hydrology Data WebPortal provides users with access to streamflow information collected by the CSKT Water Measurement Program.

[15] https://cskt.aquaticinformatics.net/AQWebPortal

The CSKT Program's current annual budget of approximately $500,000 is funded by a combination of tribal funds and Compact Settlement Funds. The annual O&M costs for gages in the CSKT Program is approximately $6,000 - $6,500/yr. Mr. Makepeace attributed the lower O&M costs to the following factors:

- Staff costs are lower because most of the field work is conducted by hydrographers rather than hydrologists;
- Lower travel costs, because all the gages are within the boundaries of the Reservation; and
- The O&M cost of operating a gage on a canal is lower than a natural stream channel. Canals operate seasonally and the stage-discharge rating curves on large canals are generally stable over a season. Thus, gages on large canals require fewer site visits to conduct discharge measurements to maintain the validity of the stage-discharge rating curve.

In addition, DNRC's Compact Implementation Program partners with Blackfeet, Chippewa Cree, and Northern Cheyenne Tribes on gages tied to the administration of those Tribes' Federal Reserved Water Rights. DNRC's Compact Implementation Program is committed to working with and supporting Tribal governments' efforts to build internal capacity to measure and monitor streamflows on tribal lands.

4.0 Cost Effective and Reasonable Alternatives to USGS Stream Gages

Section 2-15-3308, MCA instructed the Work Group to investigate "cost effective and reasonable alternatives to stream gages, including gages that are not part of the USGS stream gage network."

4.1. Alternative Stream Gage Networks

As discussed in Sections 3.2 and 3.3, DNRC and several Tribal Nations in Montana operate and maintain real-time stream gage networks. DNRC's network focuses on smaller streams and tributaries not monitored by the USGS. Networks operated by Tribal governments support the administration and distribution of water under tribal jurisdiction. The Work Group believes these state and tribal networks are complementary to, and not a replacement for, Montana's USGS network. The USGS, DNRC and tribal networks combined provide the information Montanans needs to manage their water resources.

4.2. Alternative Methods to Monitor Streamflow

Stream gages that provide continuous real-time information on discharge and gage height are the most familiar method for monitoring streamflow conditions. This type of gage is used when you need to know the discharge and gage height at any given time throughout the season or year. Continuous discharge gages are the most appropriate for managing and administering water real-time in rapidly changing conditions.

However, there are other "traditional" methods and "alternative" methods for deriving streamflow information. Mr. Kirk Miller with the USGS Wyoming and Montana Science Center gave a presentation to the Work Group on a variety of methods that can be used to derive information on streamflow.[16] Some

[16] November 4, 2020 – presentation to Work Group by Kirk Miller with the USGS Wyoming and Montana Science Center

methods provide a near-continuous record of measurements while others collect and record measurements on a periodic basis. Recorded data may be transmitted via satellite to a central location or stored locally at the measurement site for later retrieval. Other methods require trained personnel to be on site to read the measuring device and record the results in a notebook. Mr. Miller stressed that the choice of method should be determined by the end user's data needs and monitoring objectives.

A summary of five "traditional" monitoring methods along with information they provide, infrastructure requirements, and associated O&M costs and four "alternative" methods the USGS currently uses or are testing and evaluating for future use are found in Appendix D. Examples of both are given below.

Examples of "traditional" monitoring methods

1. Continuous Stage Monitoring – aka stage-only site. Continuous stage-only monitoring sites provide the end user with a continuous record of gage height. These stations do not compute stream discharge. Data collected from these sites is primarily used in flood forecasting. Stage-only sites use the same equipment and telemetry as the real-time stream gages discussed in this report. However, the annual O&M cost of $5,000 - $6,000 is less because there is no need to develop and maintain a stage-discharge rating curve. The USGS maintains five stage-only sites in Montana.
2. Annual Maximum Monitoring – aka Crest-stage site. Crest-stage monitoring is a good choice if all the end user needs to know is how high the water got and the related maximum discharge at a single point in time during any given year. A crest-stage gage may be as simple as a 2" galvanized pipe filled with cork. As the water rises in the pipe, the cork marks the maximum water level (Figure 15). O&M costs for these sites is typically $1,500 - $2,000 per site per year. The cost is related to the need to make periodic site visits to survey the cork line and take discharge measurements which are used to compute the annual maximum discharge value.

Figure 15: The cork line marks the maximum water level in a crest stage gage. Source: USGS

The USGS Wyoming and Montana Science Center in partnership with the Montana Department of Transportation (MDT) operate a network of 61 crest-stage gages in Montana. MDT contributes $50,000 annually to USGS to support O&M of the crest-stage network. The purpose of this network is to inventory and monitor peak discharges throughout the state of Montana, with special emphasis on streams that may damage transportation infrastructure. Recorded data documenting peak streamflow at various sites within the state are used by MDT to support assessments of culvert size, bridge construction, and road grade. Additionally, the crest-stage gage network provides peak flow data that can be used to evaluate protocols for estimating flood frequency.

Discharge Only Monitoring – aka Staff gage. A staff gage site is good alternative if the end user only needs to monitor streamflow on a periodic basis. The annual O&M cost of approximately $1,500 - $2,000 per year is related to the need to make periodic site visits to read the staff gage and take a discharge measurement, which are used to develop a stage-discharge rating curve (Figure 16).

Figure16: Staff gage coupled with a crest-stage gage (left side of photo).
Source: USGS

Examples of "alternative" monitoring methods

1. Large -Scale Particle-Image Velocimetry (LSPIV) – LSPIV uses video to capture particles on the surface of the water passing beneath the instrument (Figure 17). Surface water velocity is calculated based on the time it takes for particles to flow pass 4 known points in the video frame. Discharge (volume/time) can be estimated if you know the relationship between channel discharge and surface velocity; i.e., Velocity-Discharge curve.

   According to Mr. Miller, the method appears to provide a reliable estimate of discharge. The accuracy LSPIV is dependent on maintaining the viability of Velocity-Discharge curve by taking periodic discharge measurements as discussed in Section 2.1. Current drawbacks to using LIPIV include the method does not work at night, and surface velocity cannot be monitored on a continuous basis because the video files are too large to transmit in real-time. Mr. Miller informed the Work Group that it is difficult to estimate the cost of using LSPIV because the technology is still being developed and method is not widely used.

Figure 17: Large -Scale Particle-Image Velocimetry (LSPIV) uses video to capture particles on the surface of the water passing beneath the instrument.
Source: USGS

   The USGS Wyoming and Montana Science Center, in partnership with MDT, is currently testing this method at four sites to determine if LSPIV can increase the accuracy of current bridge scour prediction methods.

2. Pulsed Radar – Pulsed radar uses a bridge mounted device very similar to a radar speed gun to measure the velocity of the water passing beneath the instrument. As with LSPIV, discharge can be estimated if you know the relationship between channel discharge and surface velocity; i.e.,

Velocity-Discharge curve. Pulsed radar can provide continuous monitoring because the method works at night and the data files are small enough to transmit in real-time. According to Mr. Miller the USGS Wyoming and Montana Science Center has not tested pulsed radar and the cost is difficult to estimate because the technology is still under development.

5.0 Stream Gaging Priorities and Needs

Streamflow data are used by a variety of public and private users, including government agencies, researchers, agricultural interests, and recreational interests. The 2019 Legislature instructed the Work Group to review the priorities, needs, and expectations of both the entities that provide O&M funding to the USGS network and those who use the data collected by the network. To better understand the priorities and needs of both sides, Work Group members collaborated with the USGS and stakeholders to develop and conduct a survey of stream gage funders and a separate survey of stream gage data users.

5.1. Stream Gage Funders

Governmental agencies and other entities providing O&M funding support to the USGS stream gage network play an important role in keeping the network operational across our state. The Work Group collaborated with the USGS WY-MT Science Center to conduct a survey of federal agencies contributing O&M funding to the USGS network in Montana to understand their priorities and needs. The Work Group also conducted a survey of the four state agencies who contribute funding for O&M. In addition, Work Group reached out to the five Tribal governments providing O&M support. (Appendix E).

All respondents reported that they fund the stream gages deemed most critical to meeting their own natural resource management objectives and/or statutory responsibilities (Table 3). In addition, funders also reported that they rely on information generated from a wider array of gages from the ones they fund, which demonstrates the importance of the network as a whole and the benefits it provides. Finally, several funders identified data gaps that could be filled if additional USGS gages were installed.

In addition, funders also reported that they rely on information generated from a wider array of gages from the ones they fund, demonstrating the importance of the network as a whole and the benefits it provides.

5.2. Stream Gage Users

The Work Group collaborated with several stakeholder groups to collect user stories and conduct a survey to understand the priorities and needs of local water users and communities.

5.2.1. Stream Gage Users Survey

The Gage User Survey (survey) was a collaborative effort between the Work Group and stakeholders to get a better understanding of the priorities and needs of individuals who use streamflow data. The survey was open between mid-April through early-October 2020. It was promoted and distributed via newsletters, emails, meetings, social media, listservs and flyers posted in communities. Organizations that assisted in publicizing the survey included federal, state, city, and county agencies; watershed groups;

Table 3: Summary of Responses to Funders Survey

Entity	USGS Gages funded	Management objectives	Other USGS gages relied on	Additional gages needed
Federal Agencies				
Fish and Wildlife Service	2	Adhere to conditions of 2 Federal Reserved Water Right Compacts	7	2
Bureau of Reclamation – Pacific NW Region	2	Reservoir operations, water supply forecasting	16	---
Bureau of Reclamation – MT Area Office	19	Reservoir operations, irrigation water deliveries, support of flood control planning	34	---
Army Corps – Seattle Office	5	Reservoir regulation, flood control operations at Albeni Falls and Libby dams	---	---
Army Corps – Omaha District	12	Flood control operation of Fort Peck, Garrison, Canyon Ferry, Tiber, and Yellowtail dams	110	2
Environmental Protection Agency	17	Monitoring post-mining water quality in the Clark Fork Basin	---	---
National Park Service – Yellowstone Nat Park	4	No response	No response	No response
Dept of Energy - Bonneville Power Administration	3	No response	No response	No response
State Dept – International Joint Commission	3	No response	No response	No response
State Agencies				
Department of Natural Resources and Conservation	46	Physical and legal availability, reservoir operations, interstate appropriation of water, support of Tribal Water Right Compacts, and support of water commissioners.	172	65
Montana Fish, Wildlife & Parks	47	Administration of instream flow water rights and drought monitoring (fishing restrictions and closures).	35	--
Montana Bureau of Mines and Geology	3	Monitoring contract obligations of Superfund Program and compliance with Consent Decree requirements	Variable*	6
Montana Department of Environmental Quality (DEQ)	1	Protect and restore water quality and administration of water quality standards.	217	1

Entity	USGS Gages funded	Management objectives	Other USGS gages relied on	Additional gages needed
Tribal Governments				
Confederated Salish and Kootenai	3	Mission Creek and SF Jocko gages are used for hydrologic analysis that includes determining wet/normal/dry year hydrologic conditions which determine Minimum Enforcement Flows and River Diversion Allowances as called for by the CSKT-Montana Water Compact. Flathead gage is critical for the operation of the Séliš Qlispé Ksanka Dam	Energy Keepers Inc. Relies heavily on multiple USGS gages upstream on the Flathead River System.	2
Fort Peck	3	Monitor instream flows in relation to Fort Peck-Montana Water Compact and Tribal Water Code; monitor instream flow compliance with a water rights legal settlement.	None currently	None currently
Northern Cheyenne	4	Assure tribal administration and management of Tribe's compact water rights.	1	None currently
Blackfeet	2	Assure tribal administration and management of Tribe's compact water rights.	--	--
Chippewa Cree	3	Assure tribal administration and management of Tribe's compact water rights.	--	--

* Varies based on streamflow and groundwater studies being conducted by MBMG Scientists

conservation districts; and water related nonprofits. Below is summary of the survey results. Full results are found in Appendix F.

- There were 576 individual respondents.
- Responses came from 122 zip codes from 30 counties in Montana and nine other states.
- A majority of the respondents accessed stream gage data either daily or weekly and had been doing this for over seven years.
- Personal/recreation, emergency management, and drought information were the top reasons cited for accessing streamflow information.
- Streamflow data was accessed the most between March and August.
- The primary source for the data was the USGS website.

5.2.2. Montana Stream Gage Story Map

The Montana Stream Gage Story Map was a collaborative effort between the Work Group and stakeholders to highlight the role stream gages play in managing Montana's water resources. Below are three examples of users' stories showcasing how access to streamflow data benefits local water users and communities. Additional stories along with interactive maps that allow users to explore the source of O&M funding for each gage can be found on the Montana Stream Gage Story Map.

Gage # 06088500 Muddy Creek at Vaughn

The USGS stream gage on Muddy Creek has been collecting data for over 82 years and is one of the longest data sets among USGS gages in Montana. According to the Sun River Watershed Group, the stream gage on Muddy Creek is essential for understanding how much irrigation water is coming off the Fairfield bench, between the towns of Power and Vaughn, and returning to the Sun River. Data from this gage was key for the Sun River Watershed Group and Montana's Department of Environmental Quality to complete the Sun River Watershed Restoration Plan in 2012.

Gage #06115200 – Missouri River Near Landusky

One of the most basic services stream gages provide is giving local authorities real-time information from areas at risk for flood danger. The Missouri River Near Landusky gage has been recording water discharge data for over 38 years. The gage is operated to monitor water going into the Fort Peck Reservoir and partially for the Fergus County Emergency Management. Hydrologists and meteorologists at the National Weather Service (NWS) monitor river conditions around the clock, watching for potential flooding conditions. This is crucial during times of high water particularly for the James Kipp Campground and surrounding recreation area. This area is popular among fisherman and rafters on the Missouri River, and during flood season, there is a lot of camping occurring in the area. Because of the elevation drop from the prairie to the river, there is no cell service, and it doesn't take much high water for the campground to flood, making it impossible for people to evacuate if they wait too long. If the NWS hydrologists see potential for flooding to occur, the Fergus County Sherriff's office is called and a deputy is sent out to the campground to knock on the doors of campers and tents, evacuating the campground. These events can be fast moving and unexpected. The campground has been evacuated at 3 a.m. Historically this occurs about every other year, with the evacuations saving lives and property. This

gage is operated by the USGS Wyoming-Montana Science Center in cooperation with the U.S. Army Corps of Engineers.

Gage # 76F 03500 – North Fork of the Blackfoot at Ryan Bridge

The North Fork of the Blackfoot River is a major bull trout spawning tributary, and home to the North Fork of the Blackfoot at Ryan Bridge gage. This gage tracks important flow and temperature data and allows the Blackfoot Challenge, along with FWP to watch for potential fish passage issues in late summer during low water years.

This gage provides critical information for irrigators and managers concerned with bull trout migration and spawning. Jennifer Schoonen, Water Steward for the Blackfoot Challenge, reports that, "Although there are no specific flow-related drought plan restrictions for this tributary, we do ask for voluntary water conservation from North Fork irrigators in years when there may be fish passage concerns for spawning bull trout. Our landowners in this area are very cooperative with voluntarily reducing water use to ensure the bull trout can move in and out of the North Fork in August and September."

In addition, the North Fork has a temperature trigger, which is followed for the Blackfoot Drought Response Plan. If the water rises above 65 degrees Fahrenheit for more than three consecutive days, FWP may enact partial or all-day fishing restrictions. This gage is operated by the DNRC Stream Gage Program.

The Work Group received additional input on the importance of stream gaging from stakeholders who attended Work Group meetings. The importance of stream gaging to water users and communities is summed up best by Bill Milton, a dryland rancher and facilitator for the Musselshell Watershed Committee.

> "Gaging stations are essential and essentially public infrastructure. These water measuring stations area a fundamental tool to support water managers (often court-appointed water commissioners) to best optimize and leverage local understanding and decision-making to respond to daily changes of water availability in real-time particularly for irrigation water delivery and flood risk mitigation. The improved predictive skillfulness of these managers who rely on these stations, have immeasurable economic implications for river dependent rural communities. For state water planners and their respective agencies, gages provide the historic record and trend line that will influence and inform state water policy overtime."

From the survey results and users' stories of both gage funders and data users, consistent and common themes emerged.

- Stream gage data are used by a large number of public and private users, government agencies responsible for water management, aquatic resources, and emergency response, utilities, universities, consulting firms, municipalities, irrigated agriculture, and recreational interests.
- Users access the data for a wide variety of uses, including decision making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, environmental and watershed management, research, and water-based recreation.

- Stream gage funders support the stream gages deemed most critical to meeting their own natural resource management objectives and/or statutory responsibilities.
- Stream gage funders, particularly federal and state government agencies, often rely on information generated from a wider array of gages from the ones they fund, demonstrating the importance of the network as a whole and the benefits it provides.
- As demands for water continue to grow, both water users and water managers cite the need for additional stream gages.

6.0 Future Challenges

Water supply across Montana is controlled by variability in seasonal temperature and precipitation, as well as long-term climatic trends. While the demand for water continues to grow, physical water availability varies from year-to-year and can often change dramatically between seasons in any given year. As a result, coping with supply and demand imbalances is constant struggle for both water managers and water users.

The importance of ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed throughout the 2015 Montana State Water Plan.

The importance of ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed throughout the 2015 Montana State Water Plan. As demand rises, so will the need for accurate, real-time measurement of the amount of water physically available to satisfy demands at the local, basin and regional scales.

6.1. New Water Use Permits

An applicant for a new water use permit must provide DNRC with evidence that water is both physically and legally available at the point of diversion during the requested period of use. They must also demonstrate that their proposed new use will not harm other users on the source of supply.

In basins with high demand, DNRC may issue a new water use permit with the condition that the new user can only divert water when the streamflow measured by an identified stream gage exceeds a specific "trigger" flow. As of 2020, the DNRC water rights database listed at least 135 water rights conditioned on trigger flows measured at one or more of 36 stream gages in the USGS network. Owners of these rights cannot legally divert water when the flow as measured by the identified gage falls below the trigger flow threshold identified on their water right.

By cross referencing water right information from DNRC's database with information provided by the USGS, the Work Group determined that O&M funding for these 36 gages is provided by 10 different sources, including US Army Corp of Engineers, US EPA, Northwestern Energy (FERC licensee), FWP and DNRC. Eighty-eight (65%) of these water rights are conditioned on flows measured at just nine gages (Table 4).

As mentioned in Section 5.1, governmental agencies and other entities providing O&M support to the USGS stream gage network fund the gage(s) deemed most critical to meeting their natural resource

management objectives and/or statutory responsibilities. The fact that a water user has a water right conditioned on flows measured at a particular gage(s) is immaterial to providers of O&M funds for that gage.

If providers of O&M funding decide to scale back their level of support, the ongoing operation of the gage(s) they fund will be at risk. If the USGS is unable to find a new funding partner(s), the gage(s) will cease operation. When this happens, affected water right holders may find themselves in violation of the conditions of their water use permit.

Table 4: USGS stream gages associated with 5 or more water right/water use permits

Basin	Gage Number	Site Name	Number of Water Rights/ Permits	O&M Funding
Upper Missouri	06078200	Missouri River near Ulm	14	US Army Corps
Clark Fork	12324680	Clark Fork at Gold Creek	14	MT FWP
Upper Missouri	06089000	Sun River near Vaughn	13	NW Energy
Yellowstone	06192500	Yellowstone River near Livingston	12	USGS-FPS
Yellowstone	06309000	Yellowstone River at Miles City	9	US Army Corps
Yellowstone	06214500	Yellowstone River at Billings	8	US Army Corps
Musselshell	06126500	Musselshell River near Roundup	7	USGS-FPS
Musselshell	06130500	Musselshell River at Mosby	6	USGS-FPS
Clark Fork	12340500	Clark Fork above Missoula	5	US EPA

Given the federal government's current method for funding the USGS stream gage network, water managers and water users must consider a potential future scenario – one where funding decisions made by 3rd parties will directly impact the ability of Montana water users to legally exercise their water rights.

As demand for water grows, effective water right administration will increasingly depend on accurate real-time measurements of streamflow. As this happens, Montana and its water users will have an increasingly vested interest in maintaining a stable network of stream gages.

As demand for water grows, effective water right administration will increasingly depend on accurate real-time measurements of streamflow. As this happens, Montana and its water users will have an increasingly vested interest in maintaining a stable network of stream gages.

6.2. Distribution of Water by Decree

As Montana nears completion of the adjudication of pre-1973 water rights, stream gages, whether they are part of the USGS network, DNRC Program network, or tribal network, will play an increasingly important role in the distribution of water by decree. Currently, 47 gages in the USGS network and 10 gages in the DNRC Program network are essential to water commissioners for distributing water by decree on 20 water distribution projects. O&M funding for these "decree gages" is provided by a combination of federal, state, tribal, and other sources. As mentioned previously, entities providing O&M support to the USGS stream gage network

fund the gage(s) deemed most critical to meeting their natural resource management objectives and/or statutory responsibilities. The fact that a particular gage(s) is critical to a water commissioner is immaterial to O&M funders.

As Montana transitions to a post-adjudication future, the number of rivers and streams from which water is distributed by court-appointed water commissioners will grow. In the post-adjudication future, Montana will face the challenge of maintaining the stream gages we already have, and potentially expanding the number of stream gages to meet future needs.

7.0 Options and Recommendations for Funding of Streamflow Information

The value of streamflow information derives from its use in decision making. It is clear to this Work Group and through the numerous surveys, comments, and input from water users and managers statewide, that access to accurate, reliable, real-time streamflow information is foundational for the management and distribution of Montana's water resources.

Direct users of stream gage data include a local, state, tribal, and federal agencies; private companies; irrigated agricultural; and recreationists. Data from stream gages inform real-time decision making and long-term planning on water issues, such as water management, economic development, energy development, infrastructure design, water compacts, municipal growth, flood forecasting, water quality, aquatic ecosystem management, and recreational safety.

The Work Group acknowledges that operating and maintaining a network of real-time stream gages carries a substantial cost and represents a long-term commitment to funding. Equipment to collect, transmit and manage the data must be purchased, operated, maintained, repaired, and replaced. Highly skilled personnel including hydrologists, engineers, and technicians must be employed for these tasks and for the task of applying knowledge to convert the collected data into information that is useful to the broad user community.

The cost of this investment must be weighed against the value of the information provided. If water is Montana's most precious resource, then access to accurate information to manage the resource is close to priceless. The Work Group concludes that for Montana to meet the demands of today, and plan for our future, the state and its citizens will need to make a long-term commitment to support real-time stream gaging. Real-time stream gages offer the best most cost-effective method to collect streamflow information used by the broadest range of stakeholders.

The recommendations of the Stream Gage Oversight Working Group fall into the following broad categories:

1. Advocate for a significant and sustained federal investment in the USGS stream gage network.
2. Increase state funding to maintain or increase Montana's current level of support to the USGS network in Montana.
3. Appropriate funding to complete the build-out of the DNRC state-based stream gage network called for in the 2015 State Water Plan.

7.1. Encourage Federal Investment in the USGS Stream Gage Network

Congress appropriates funding to the USGS for stream gaging through two programs: the Cooperative Matching Funds (CMF) and Federal Priority Stream Gage Network Funds (FPS). As discussed in Section 3.1.4, federal appropriations for these programs have not kept pace with cost increases. Therefore, USGS pushes the responsibility to cover cost increases onto state and local partners. For the state of Montana, the burden falls almost entirely on DNRC and FWP.

Increasing federal funding for the CMF and FPS programs will have the greatest impact on stream gaging in Montana. Absent a significant and sustained federal investment in the USGS stream gage network, Montana's ability to absorb continuous cost increases is not sustainable. Therefore:

1. The Work Group recommends that Montana's Executive and Legislative branches collectively work with Montana's congressional delegation to increase federal appropriations for USGS CMF program. Congress should fund the CMF program at a level that will allow the USGS to provide at least 50% of the annual O&M costs for USGS operated gages. Congressional funding must also factor in the costs associated with upgrading equipment and increases due to inflation.
2. The Work Group recommends that Montana's Executive and Legislative branches collectively work with Montana's Congressional delegation to increase federal appropriations for the USGS FPS program. These funds can be used to cover 100% of the cost of gages in Federal Priority Network. Currently 71 sites in Montana that could be 100% supported with FPS funds must rely on other sources of federal, state, tribal, or local funding. DNRC and FWP currently provide O&M funding to 22 of these 71 gages. Full congressional funding of the FPS Program could allow both agencies to direct state funding towards other stream gaging priorities.
3. The Work Group recommends that Montana's Executive and Legislative branches collectively work with and support the efforts of national organizations such as the Interstate Council on Water Policy, Western States Water Council, and Western Governors' Association, to create a unified western voice for USGS stream gages.

7.2. Increase in State Funding to Maintain Montana's Current Level of Support to the USGS Network in Montana

The State of Montana provides annual O&M funding support to 98 of Montana's 218 USGS stream gages. Ninety-four of these gages are supported by the DNRC and FWP. In FY22, DNRC spent $384,759 in general funds to support 46 USGS stream gages. In FY22, FWP provided $214,226 to support streamflow and/or water temperature monitoring on 47 individual gages. Although FWP and DNRC financially contribute to a portion of the overall network, the ability of both agencies to meet their natural resource management objectives and statutory responsibilities is dependent upon streamflow information generated by all 218 stream gages in the network.

As previously mentioned, congressional appropriations to the USGS for operation of the nation's stream gage network have not kept pace with increased demand and rising costs. As a result, the USGS is forced to pass cost increases on to other funding partners. For state government, the burden falls almost entirely on DNRC and FWP. Cost has gone up 7% over the last 5 years, which places an ever-increasing strain on both agency's budgets.

Montana stakeholders often turn to DNRC and FWP for assistance when a USGS stream gage is in danger of being lost due to lack of O&M funding. Both agencies will then work with local stakeholders to identify partners with the ability and willingness to provide funding. Both agencies report that new funding partners are more willing to participate if they see state government is also willing to contribute too. As a result, DNRC and FWP will often assume additional funding obligations in support of local stewardship of Montana's water resources. Absent an available source of funds to bridge over, or cover funding gaps, both DNRC and FWP must divert funds from other programs within their departments.

There are 12 USGS stream gages that are partially supported by voluntary contributions from local entities such as conservation districts, watershed groups, and non-governmental organizations. Stakeholders who contributed to discussions with the Work Group feel that stream gages are a fundamental tool in the toolbox of local water management. While stakeholders acknowledge the importance of having "skin in the game," they also struggle with raising funds to support their local stream gage. Even the most dedicated local organizations have a difficult time raising adequate cost-share funds on an annual basis.

The State of Montana does not have jurisdiction over funding decisions made by the federal agencies or other partners supporting USGS gages in Montana. However, Montana can stay abreast of information that may signal a change in these agencies' participation. Therefore, the Stream Gage Oversight Work Group should continue their partnership with the USGS, to ensure the timely exchange of information regarding funding or program changes that have the potential to impact the ongoing operation of the USGS stream gage network in Montana. Therefore:

1. The Work Group recommends that the Montana Legislature consider providing adequate state funding to maintain Montana's current level of support to the existing USGS network in Montana.
2. The Work Group recommends that the Montana Legislature consider appropriating funds to be used in cases where a USGS stream gage is in danger of being lost due to lack of O&M funding. These funds would serve to bridge any funding gaps until other funding partners can be found.
3. The Work Group recommends that the Montana Legislature consider appropriating funds to DNRC for the purpose of transitioning the cost-share burden from local entities to DNRC. This will allow the affected conservation districts, watershed groups, and non-governmental organizations to stay focused on working with landowners and other stakeholders to support local stewardship of Montana's water resources.
4. The Work Group recommends the Montana Legislature amend §2-15-3308, MCA, to assign the Drought and Water Supply Advisory Committee with the responsibility of working with the USGS to maintain and implement the Stream Gage Notification Plan. The Legislature may also consider requiring the Drought and Water Supply Advisory Committee to receive an annual report from the USGS on funding or program changes with the potential to impact the ongoing operation of the USGS stream gage network in Montana.

7.3. Complete the Build-out of the DNRC Stream Gage Program

In 2015, DNRC initiated a Stream Gage Program within the Water Resources Division. The purpose of the Program is to implement the 2015 State Water Plan recommendation to develop a network of 100 state-

operated, permanent, year-round stream gages that can gather and distribute real-time streamflow information from smaller streams and tributaries not monitored by the USGS.
Streamflow information collected by DNRC serves state-specific water administration, distribution, and management objectives. To date, existing resources have allowed the DNRC Program to install, operate, and maintain 36 real-time gages. All streamflow information collected through the network is available to the public on the Department's StAGE website. DNRC needs additional funding for 4.50 FTEs, operating expenses, and equipment, to install, operate, and maintain the remaining 64 gages. Therefore:

1. The Work Group recommends that the State Legislature consider appropriating sufficient funds to complete full build out of the DNRC Stream Gage Program. This will require funding for 4.50 FTEs, operating expenses, and equipment, to install, operate, and maintain the remaining 64 gages.

8.0 Conclusions

Water is an essential ingredient to Montana's way of life and our economy. While the demand for water continues to grow, physical water availability varies from year-to-year and can often change dramatically between seasons in any given year. As a result, coping with supply and demand imbalances is a constant struggle for both water managers and water users. Stakeholders and representatives of both state and federal natural resource agencies who participated in surveys or contributed to discussions with the Work Group feel that stream gages are a fundamental tool in the toolbox of water management.

Consistent and common themes emerged from the survey results and users' stories.

- Stream gage data are used by a large number of public and private users, government agencies responsible for water management, aquatic resources, and emergency response, utilities, universities, consulting firms, municipalities, irrigated agriculture, and recreational interests.
- Users access the data for a wide variety of uses, including decision-making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, municipal growth, environmental and watershed management, research, and water-based recreation.
- Stream gage funders support the stream gages deemed most critical to meeting their own natural resource management objectives and/or statutory responsibilities. Their funding decisions align with their own priorities.
- Stream gage funders, particularly federal and state government agencies, often rely on information generated from a wider array of gages in addition to the ones they fund, demonstrating the importance of the network as a whole and the benefits it provides.
- As demands for water continue to grow, both water users and water managers cite the need for additional stream gages.

The value of streamflow information is derived from its use in decision making. It is clear to this Work Group and from the numerous surveys, comments, and input from water users and managers statewide, that access to accurate, reliable, real-time streamflow information is foundational for the management and distribution of Montana's water resources.

The Work Group acknowledges that operating and maintaining a network of real-time stream gages carries a substantial cost and represents a long-term commitment to funding. In FY22, the annual O&M

cost of a single gage operating 12 months/year was $17,300. In FY22, DNRC and FWP provided $598,985 to support ongoing O&M costs for 98 of Montana's 218 USGS real-time stream gages.

The cost of this investment must be weighed against the value of the information provided. If water is Montana's most precious resource, then access to accurate information to manage the resource is close to priceless. The Work Group concludes that for Montana to meet the demands of today, and plan for our future, the state and its citizens will need to make a long-term commitment to support and expand real-time stream gaging in Montana. Real-time stream gages offer the best most cost-effective method to collect streamflow information used by the broadest range of stakeholders Therefore, the Stream Gage Oversight Work Group recommends:

1. Montana advocate for a significant and sustained federal investment in the USGS stream gage network. Section 7.1
2. Montana increase state funding to maintain or expand the state's level of support to the USGS network in Montana, which is comprised of gages on Montana's mainstem rivers and their large tributaries. Section 7.2
3. Montana appropriate funding to complete the build-out of the DNRC state-based stream gage network recommended in the 2015 State Water Plan. Section 7.3

Appendices

A. Section 2-15-3308 MCA
B. Stream Gage Notification Plan
C. Terms of Reference
D. Traditional and Alternative Methods to Monitor Streamflows
E. Results of Stream Gage Funders Survey
F. Results of Stream Gage User Survey
G. Compiled Public Comments