Peak Flow Regression Equations for Small Drainage Basins in Central and Eastern Montana

U.S. Geological Survey

Wyoming-Montana Water Science Center

Prepared for Montana Department of Transportation

Prepared by Seth Siefken and Olivia Drukker

September 9, 2025

Flow over roadway near Tampico, Montana, April 2023. Photo by Seth Siefken.

Peak Flow Regression Equations for Small Drainage Basins in Central and Eastern Montana

U.S. Geological Survey

Wyoming-Montana Water Science Center

Prepared for Montana Department of Transportation

Prepared by Seth Siefken and Olivia Drukker

September 9, 2025

Introduction

Accurate peak-flow rates are needed by the Montana Department of Transportation (MDT) to properly size culverts and bridges on highway stream crossings. For stream crossings with drainage areas less than one square mile, one of the current methods available for estimating peak-flow rates is the set of Nallick peak-flow regression equations in the MDT hydraulics manual (MDT, 2022).

The Nallick regression equations as presented in MDT (2022) use drainage area, average annual precipitation, and 25-year 1-hour rainfall intensity to estimate peak streamflow for 2, 5, 10, 25, 50, and 100-year return intervals and are applicable to small drainage basins (less than 1 square mile) in the plains east of the Continental Divide. The equations were developed using data collected through 1988. Since 1988, more advanced methodologies have emerged for determining the three explanatory variables (drainage area, average annual precipitation, and 25-year 1-hour rainfall intensity) used in the equations. Furthermore, additional peak-flow data collected on small drainage basins and improved methods of peak-flow frequency analysis offer opportunities to improve the streamgage peak-flow frequency estimates used to develop the regression equations. Generalized least-squares (GLS) analysis and machine learning methods offer further potential to improve the mathematical development of the equations.

Records in the Transportation Research Board (TRB) database have emphasized the need for accurate peak-flow information to use in hydrologic modeling and infrastructure design. MDT and the U.S. Geological Survey (USGS) have been addressing this deficiency in peak-flow information by maintaining a crest-stage gage (CSG) network in Montana that has been collecting peak-flow data since 1955 (Sando, 2021). CSGs are simple streamgages that only record the peak stage between visits to the gage. This CSG system is especially important for collecting data in small drainage basins that are often overlooked by continuous streamflow gages. Part of the goal of the CSG network is to collect data for developing peak-flow regression equations at ungaged sites. Peak-flow variability in Montana generally increases as drainage area decreases (Sando, 2021). This variability emphasizes the need for updated regression equations that can effectively predict peak-flow rates in smaller drainage basins.

The work proposed in this project will produce updated regression equations to replace the Nallick peak-flow equations. Project tasks include camera monitoring on small streamgages, Lidar-derived basin delineations, calculation of basin characteristics, and peak-flow frequency analysis to supply the inputs needed for updated regression equations. The updated equations will be derived using generalized or weighted least squares methods and informed by exploratory machine learning analysis. By integrating advanced methods for estimating the explanatory variables and utilizing the extensive peak-flow data collected through the CSG network, this project has the potential to enhance the accuracy and reliability of peak-flow predictions for small drainage basins. Ultimately, this project aims to provide MDT with improved tools for infrastructure design, ensuring that stream crossings are appropriately sized to accommodate the peak-flows occurring in small drainage basins.

Problem

Accurate estimation of peak-flow frequency at ungaged locations is critical for MDT to appropriately size culverts and bridges at stream crossings. The existing Nallick peak-flow regression equations outlined in MDT's hydraulics manual provide a basic method for estimating these flows in drainage basins less than one square mile in the plains east of the Continental Divide. However, since their development circa 1988, there have been numerous advancements in data observation and hydrologic methods that can better account for variable peak-flows. The current regression equations rely on drainage area, average annual precipitation, and 25-year 1-hour rainfall intensity. Lidar has become a more accessible remote sensing tool to model drainage area with much finer spatial resolution. NOAA Atlas 14 provides updated precipitation frequency data. Additionally, other updated datasets for landcover and soil properties should allow for development of more accurate peak-flow models. By integrating these modern data sources, this project aims to improve the accuracy and reliability of peak-flow estimates.

The USGS has long provided equations for estimation of peak-flow frequency statistics at ungaged locations. The Montana StreamStats project (McCarthy and others, 2016) implemented regional regression equations for peak flows applicable to most streams in Montana unaffected by artificial streamflow regulation. However, Montana StreamStats did not implement the Nallick regression equations for small streams as part of that project. The opportunity to develop more accurate versions of the Nallick peak-flow regression equations and implementing them in StreamStats will enhance the StreamStats implementation for Montana by providing a set of equations specifically intended for use on small drainage basins. This has the potential to provide benefits for MDT as well as other agencies and private entities that use peak-flow frequency data.

The proposed work ties in closely with the long-standing Montana CSG project. Since its inception in 1955 (Sando, 2021) the CSG project has been a simple and cost-effective means of collecting peak-flow data in small drainage basins that are not represented by the USGS continuous streamgage network. This project will make use of the extensive CSG dataset to develop the new regression equations and will enhance the CSG network with camera monitoring at selected streamgages.

USGS has been involved in recent projects addressing gaps in peak-flow information in other states as well. For example, in Idaho, the USGS collaborated with the Idaho Transportation Department to revise regional regression equations that estimate peak-flow statistics at ungaged sites (Wood et al., 2016). The work used recent streamflow data and modern statistical techniques, resulting in improved accuracy for predicting peak flows for the varied hydrologic settings in Idaho.

Objectives and Scope

The overall objective of this project is to develop regression equations to estimate peak-flow frequency on small drainage basins less than two square miles. These updated equations aim to help MDT to create data-driven infrastructure designs for culverts and small bridges.

Specific objectives include:

1. **Enhance Small Drainage Basin Peak Flow Data Collection**: Install cameras at selected CSGs on small drainage basins to improve the quality of peak flow data collection.
2. **Modernizing small drainage basin peak flow equations**: Update the Nallick peak flow regression equations with modern methodology by incorporating updated datasets and new hydrologic modeling techniques, such as machine learning.
3. **Make updated equations available in StreamStats**: Update Montana StreamStats to incorporate the new regression equations for small basins in eastern Montana.

The geographic scope of this project is focused on drainage basins of less than two square miles located on the plains east of the Continental Divide in Montana. An initial set of 82 streamgages with 10 or more years of peak flow data meeting the drainage area criteria that could be used to develop regression equations is shown in figure 1. Data availability and analysis results will determine the final range of hydrologic settings for which the equations are applicable, which will be documented in the final report. It is anticipated the equations will not be applicable for mountainous or urbanized drainage basins.

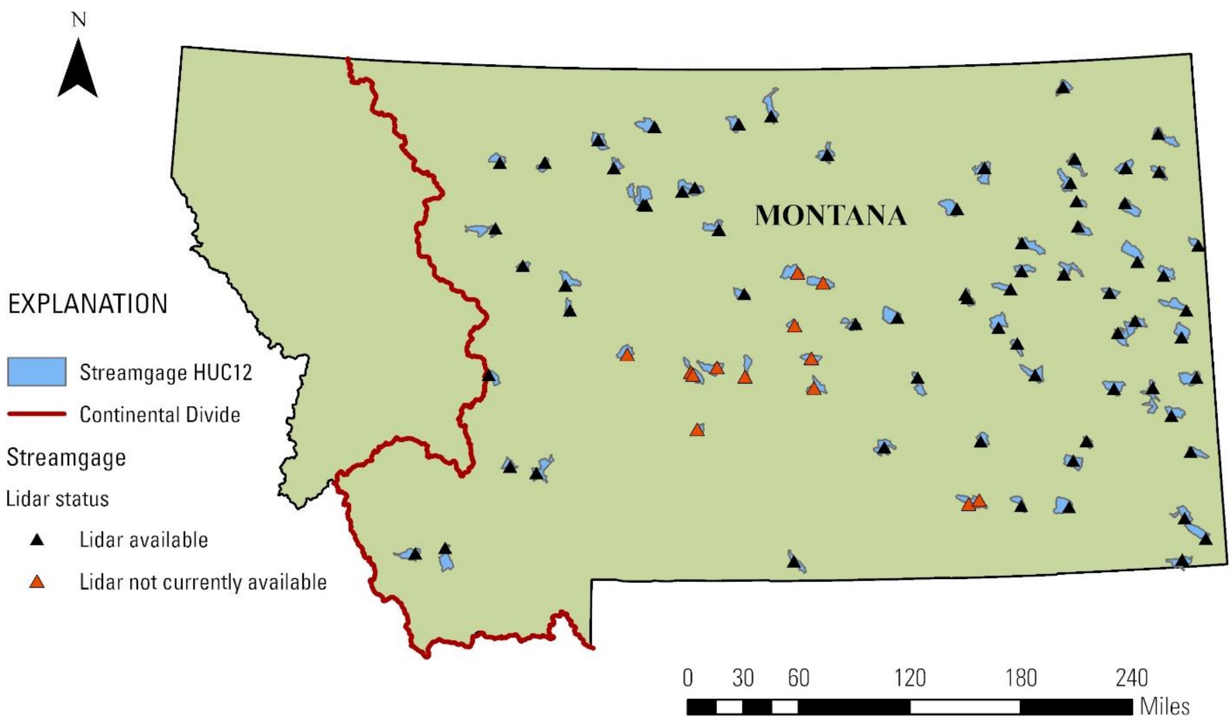

Figure 1. Locations of streamgages on drainage areas less than 2 square miles east of the Continental Divide in Montana.

Relevance and Benefits

The proposed project addresses an ongoing need for accurate peak-flow frequency statistics for small drainage basins in eastern Montana. Accurate peak-flow statistics are critical for MDT to design safe and cost-efficient infrastructure. By modernizing the Nallick regression equations using current datasets and methods, the project directly benefits MDT by reducing the risk of infrastructure failure due to undersized designs. This is especially important with regards to the safety of Montana residents living in rural areas where road networks are sparse and detours can be extremely long. Modern regression equations will also help ensure stream crossings are not over-designed and excessively expense.

The USGS will benefit from this project by improving its capabilities in hydrologic modeling and contributing to the agency's mission of providing reliable scientific information. This project aligns with several of the USGS Strategic Science Directions (USGS, 2012), particularly:

1. **Improve integrated science planning for water**: Developing updated regression equations will improve understanding of hydrologic processes in small basins, leading to better management of water resources.
2. **Expand and enhance water-resource monitoring networks**: The installation of cameras at streamgages and adding this data to the USGS Hydrologic Imagery Visualization and Information System (HIVIS; https://apps.usgs.gov/hivis/) will strengthen the monitoring network and lead to more data-driven analyses.
3. **Provide flood-inundation science and information**: Accurate peak-flow predictions are important for flood risk assessment, enabling better preparedness and response for flood events.
4. **Conduct integrated watershed assessment, research, and modeling**: This project will incorporate modern datasets and hydrologic modeling techniques, advancing the understanding of peak-flows in small drainage basins.
5. **Deliver water data and analyses to the Nation**: The updated regression equations will be incorporated into Montana StreamStats, providing the public with accessible tools for hydrologic analyses.

This project also addresses the Future Water Priorities for the Nation (National Academies of Sciences, Engineering, and Medicine; 2018) objective of identifying how long-term water-related risk management can be improved. Accurate peak-flow predictions for small basins are important to anticipate and mitigate flood impacts. Improved hydrological understanding of peak-flows will further the USGS's commitment to providing objective science and lead to more resilient infrastructure planning, ensuring a safer transportation system.

MDT's mission is to plan, build, operate, and maintain a safe and resilient transportation system to move Montana forward (MDT, 2025). By equipping MDT with improved tools for infrastructure design, this project supports MDT's vision of setting "the gold standard for a highly effective, innovative, and people-centric department of transportation" (MDT, 2025). The modernized regression equations will allow MDT to make data-driven decisions that prioritize safety and resilience in transportation infrastructure, especially in rural areas.

Approach

Work will be carried out in six tasks, as summarized in Table 1. All tasks, except the machine learning component of Task 5, rely on established methods that have been previously used in USGS studies.

Task 1 is a data collection task to install cameras on at least 10 streamgages with small drainage areas to enhance data collection for the existing Montana crest-stage gage project. These cameras will be deployed by the end of April 2026 and operated as part of the existing CSG program. Imagery from the cameras will be published in the USGS Hydrologic Imagery Visualization and Information System (HIVIS; https://apps.usgs.gov/hivis/). After the initial 2026 deployment, it is anticipated that cameras will be operated seasonally in future years as part of the ongoing crest-stage gage project.

Task 2 consists of delineating drainage areas for 82 streamgages east of the continental divide in Montana with drainage areas of 2 square miles or less where published Lidar data are publicly available (figure 1). Lidar is currently available for 70 of these streamgages. Based on the early 2026 schedule for completion of statewide Lidar coverage from the Montana State Library, Lidar should be available for all 82 streamgages in time for inclusion in this project. The delineations will be performed using published software packages and will follow a similar process to that used by USGS to develop a Lidar-derived update to the StreamStats application for Florida. If time permits, the flow direction grid for the drainage basins, as well as any surrounding areas processed along with the drainage basins, will be published as a beta grid in the StreamStats application.

Task 3 consists of preparing basin characteristics to develop and implement the new regression equations. Characteristics will include NOAA Atlas 14 precipitation frequency, mean annual precipitation, one evapotranspiration (ET) statistic, basin shape parameters, minimum and maximum elevation, longest flow path, soil parameters, landcover parameters, and curve numbers. Landcover parameters will include the portion of the basin in agricultural land or forest cover and possibly additional parameters. All characteristics will be computed for the drainage basins of the streamgages used to develop the regression equations and published in a USGS data release. Characteristics will be computed from published datasets using commercial GIS software. Statewide grids for precipitation, evapotranspiration, landcover parameters, soil parameters, curve numbers, and any other parameters needed to implement the new regression equations will be published in StreamStats. Curve numbers will be computed using an automated method from soil and landcover data. The curve number computation will be based on the tables in TR-55 (USDA, 1986) or another applicable method and documented with the released data. Urban areas will be excluded from the statewide grids for parameters that cannot be accurately estimated for urban areas. If time permits, Lidar-derived depression storage may be computed and published for the streamgages used in the regression equations.

Task 4 will compute and publish peak-flow frequency analyses for the streamgages used to develop the regression equations. The analyses will follow the methods described in Bulletin 17C (England and others, 2018) and Siefken and others (2025).

Task 5 will develop regression equations using either generalized least squares (GLS) or weighted least squares (WLS) methods. The regression analysis will be performed using the WREG software package (Farmer, 2021). Machine learning methods will be explored to improve the regional regression equations. A literature review will examine applicable machine learning methods that can be used with the GLS and WLS regression methods, for example the cluster analysis method used by Levin and Sanocki (2023). The equations and supporting documentation on their development will be published in a USGS series report.

Task 6 will implement the regression equations in the StreamStats application. The equations will be implemented using the current 30-meter flow direction grid for Montana. Exclusion polygons will be applied in StreamStats for any areas where the equations are known to be non-applicable (for example, Montana west of the Continental Divide). If a beta flow direction grid derived from Lidar is published as part of Task 2, the equations will also be implemented on the beta grid, although spatial coverage of the beta grid would be limited. The peak-flow frequency analyses computed in task 4 will also be published in StreamStats as part of task 6.

Table 1. Project task summary

Task	Name	Description
1	Camera Monitoring on Small Streamgages	Installation of cameras for at least 10 streamgages with small drainage areas to enhance collection of peak streamflow data.
2	Lidar Basin Delineation	Delineation of drainage areas from Lidar data for 82 streamgages east of the continental divide in Montana with drainage areas of 2 square miles or less where published Lidar data are publicly available. If time permits, the flow direction grid for the drainage basins, as well as any surrounding areas processed along with the drainage basins, will be published as a beta grid in the StreamStats application.
3	Basin Characteristics	Computation of basin characteristics for the streamgages used in the regression equations. Basin characteristics for the streamgages used in the regression equations will be published as a USGS data release. Statewide grids for the precipitation, ET, landcover parameters, soil parameters, and curve numbers will be published in StreamStats. If time permits, Lidar-derived depression storage may be computed and published for the streamgages used in the regression equations.
4	Peak-flow Frequency Analysis	Peak-flow frequency analysis of streamgages used to develop the regression equations using the methods of Bulletin 17C. Results will be published in a USGS data release.
5	Regressions	Development of GLS or WLS regression equations using WREG. Machine learning techniques will be investigated to improve traditional linear regression techniques. Work will be documented in USGS series report.
6	Publication of Equations and peak-flow frequency analyses in StreamStats	The new regression equations will be implemented om StreamStats using the existing 30-meter flow direction grid for Montana. Results of the peak-flow frequency analyses used to develop the regression equations will also be published in StreamStats.

Quality Assurance and Quality Control

Quality assurance for all products will be provided in accordance with USGS standards for fundamental science practices. All products published as data releases or USGS series reports will receive two peer reviews, as required by Wyoming-Montana water science center policy. Peer reviews will provide thorough evaluations of the technical quality of the research as required by USGS policy (U.S. Geological Survey, 2016). Imagery data published from task 1 will follow the quality control requirements for the USGS HIVIS system. Data releases and reports will be sent to MDT for courtesy review prior to publication.

Data Management

Imagery data from Task 1 will be published and stored in the USGS HIVIS system. Other data produced by the project will be published on Science Base (www.sciencebase.gov) as USGS data releases. A data management plan will be developed for the project which will document storage of interim data and computer code used to develop the published products.

Products

Table 2. Product summary

Product	Type	Description
Imagery Data	HIVIS imagery	Imagery data from the Task 1 camera monitoring will be published to the USGS HIVIS data base.
Lidar Basin Delineations and Basin Characteristics	USGS data release	Lidar-derived basin delineations will be published as a USGS data release with the associated basin characteristics computed for each drainage basin.
Basin Characteristics Grids	USGS data release or direct publication in StreamStats	Statewide grids for the precipitation, ET, landcover, soil, and curve number parameters computed in Task 3 will be published as a USGS data release and made available in the StreamStats application. If any grids can be published in the StreamStats application without being included in the data release, those grids will be excluded from the data release.
Peak Flow Frequency Analysis	USGS data release	Peak-flow frequency analyses for the streamgages used to develop the updated regression equations will be published in a USGS data release and made available through the StreamStats application.
Regression Equations report	USGS series report	The updated regression equations and the methodology used to develop them will be published in a USGS series report. Any supporting information not included in the data releases described above will be published in an accompanying USGS data release. The regression equations will be made available in the StreamStats application and solved on the existing 30 m flow direction grid for Montana.

In addition to the products described in Table 2, USGS will provide MDT with quarterly progress reports following MDT's template available at:
https://www.mdt.mt.gov/other/webdata/external/research/forms/MDT-RES-003.pdf

Timeline

		2025			2026												2027												2028											
Task	**Task Completion Dates**	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Kick-off Meeting	**October 2025**																																							
Task 1 - Camera-based monitoring on small basin crest-stage gages																																								
1.a. Purchase and prepare camera monitoring equipment																																								
1.b. Deploy camera monitoring equipment and collect images																																								
1.c. Publish water year 2026 camera images on HIVIS	**December 31, 2026**																																							
Task 2 - Lidar basin delineations																																								
2.a. Download and review Lidar Data																																								
2.b. Process basin delineations																																								
2.c. Data release preparation and USGS review (published with Task 3 data release)																																								
2.d. MDT review panel review																																								
2.e. Data release publication	**September 30, 2027**																																							
Task 3 - Basin Characteristics																																								
3.a. Identify and download source datasets																																								
3.b. Clip and reproject source datasets as needed																																								
3.c. Compute state-wide curve number grid																																								
3.d. Compute basin characteristics for streamgages used in regression equations																																								
3.e. Data release preparation and review																																								
3.e. MDT review panel review																																								
3.g. Data release publication	**September 30, 2027**																																							
Task 4 - Peak-flow Frequency Analysis																																								
4.a. Download peak flow data																																								
4.b. Perform peak-flow frequency analysis																																								
4.c. Data release preparation and review																																								
4.d. MDT review panel review																																								
4.e. Data release publication	**December 31, 2027**																																							
Task 5 - Regression Equation Development																																								
5.a. Exploratory analysis with machine learning methods																																								
5.b. Develop GLS or WLS equations																																								
5.c. Report preparation and review																																								
5.d. MDT review panel review																																								
5.e. Report layout																																								
5.f. Report publication	**November 30, 2028**																																							
Task 6 - Publishing to StreamStats																																								
6.a. Publish basin characteristic grids to StreamStats	**December 31, 2028**																																							
6.b. Publish regression equations to StreamStats	**December 31, 2028**																																							
6.c. Publish peak-flow frequency analyses to StreamStats	**December 31, 2028**																																							

Personnel

The project will be co-led by Seth Siefken and Olivia Drukker. Seth is a hydrologist with 7 years of experience with USGS and is a licensed professional engineer in Montana. He has previously worked on projects processing large terrain datasets for hydrologic studies in Montana and Wyoming (Barnhart et. al, 2020) and numerous peak-flow frequency studies (Siefken and others, 2025; Siefken and others, 2023). Olivia Drukker is a physical scientist with a master's degree in geographic information systems. She has experience developing network models using ArcGIS Pro, as well as expertise in Lidar processing.

The camera data collection in Task 1 will be led by a USGS hydrologic technician with experience in real-time surface water data collection. Other hydrology and physical science staff will assist as needed with data analysis, review, and publication.

Budget Summary

The project will be funded cooperatively by USGS and MDT, with USGS providing $150,000 of cooperative matching funds for the project. The following tables provide details of the budget.

Table 3. State fiscal year cost breakdown

Item	SFY26	SFY27	SFY28	SFY29	Total
Salaries	$37,315	$75,792	$64,146	$25,718	$202,970
Benefits	$9,329	$18,948	$16,036	$6,429	$50,743
Travel	$2,676	$1,759	$-	$-	$4,435
Supplies and Equipment	$10,710	$-	$-	$-	$10,710
Reports	$-	$-	$-	$10,612	$10,612
Total Direct Costs	$60,029	$96,499	$80,182	$42,759	$279,470
Indirect Cost	$41,999	$67,516	$56,099	$29,916	$195,530
Total Project Cost	**$102,028**	**$164,015**	**$136,281**	**$72,675**	**$475,000**
USGS Cooperative Matching	$32,219	$51,794	$43,036	$22,950	$150,000
MDT Cost	**$69,809**	**$112,221**	**$93,245**	**$49,725**	**$325,000**

Table 4. Cost breakdown by task

Labor Expenses

Person	Role	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Total Hours	Hourly Wage	Total Wages	Hourly Benefits	Total Benefits	Total Cost
Seth Siefken	Co-principal Investigator	60	120	150	428	800	150	1708	$72.93	$124,561	$18.23	$31,140	$155,702
Olivia Drukker	Co-principal Investigator	0	393	400	0	250	0	1043	$47.50	$49,561	$11.88	$12,390	$61,951
Technician	Camera Installation Lead	120	0	0	0	0	0	120	$64.31	$7,717	$16.08	$1,929	$9,646
Technician	Camera Installation	120	0	0	0	0	0	120	$35.47	$4,257	$8.87	$1,064	$5,321
Physical Scientist	Reviewer	0	0	80	80	0	0	160	$65.94	$10,550	$16.49	$2,638	$13,188
Hydrologist	Reviewer	0	0	0	0	80	0	80	$79.04	$6,324	$19.76	$1,581	$7,904
Totals		300	513	630	508	1130	150	3231		$202,970		$50,743	$253,713

Direct Expenses

Equipment	$10,710
Travel	$4,435
Report publishing	$10,612
Indirect Cost	$195,530
Total Project Cost	**$475,000**
USGS Matching Funds	$150,000
Cost to MDT	**$325,000**

Table 5. Travel costs

Item	Number	Unit Cost	Total
Hotel	20	$110.00	$2,200
Vehicle, cost per mile	1800	$ 0.49	$ 875
Per Diem			$1,360
Total			**$4,435**

Table 6. Federal fiscal year cost breakdown

	Federal Fiscal Year				
Component	**FY26**	**FY27**	**FY28**	**FY29**	**Total**
USGS Cooperative Matching	$ 50,000	$ 50,000	$ 50,000	$ -	$ 150,000
MDT Contribution	$ 79,535	$ 131,086	$ 90,433	$ 23,946	$ 325,000
Total Cost	$ 129,535	$ 181,086	$ 140,433	$ 23,946	$ 475,000

References

Barnhart, T.B., Sando, R., Siefken, S.A., McCarthy, P.M., and Rea, A.H., 2020, Flow-Conditioned Parameter Grid Tools: U.S. Geological Survey Software Release, DOI: https://doi.org/10.5066/P9W8UZ47.

England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2018, Guidelines for determining flood flow frequency — Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., https://doi.org/10.3133/tm4B5.

Farmer, W.H., 2021, WREG: Weighted Least Squares Regression for Streamflow Frequency Statistics: U.S. Geological Survey software release, R package, Reston, Va., https://doi.org/10.5066/P9ZCGLI1.

Levin, S.B., and Sanocki, C.A., 2023, Estimating flood magnitude and frequency for unregulated streams in Wisconsin: U.S. Geological Survey Scientific Investigations Report 2022–5118, 25 p., https://doi.org/10.3133/sir20225118.

McCarthy, P.M., Dutton, D.M., Sando, S.K., and Sando, Roy, 2016, Montana StreamStats—A method for retrieving basin and streamflow characteristics in Montana: U.S. Geological Survey Scientific Investigations Report 2015– 5019–A, 16 p., http://dx.doi.org/10.3133/sir20155019A.

Montana Department of Transportation, 2025, About MDT, accessed June 27, 2025, at https://www.mdt.mt.gov/about.aspx.

Montana Department of Transportation, 2022, Hydraulics Manual, Chapter 9, accessed June 27, 2025, at https://www.mdt.mt.gov/other/webdata/external/hydraulics/manuals/Chapter-09-Hydrology.pdf.

Montana State Library, 2025, Montana Lidar Inventory, accessed June 27, 2025, at https://montana.maps.arcgis.com/apps/MapSeries/index.html?appid=55cc886ec7d2416d85beca68d05686f4.

National Academies of Sciences, Engineering, and Medicine. 2018. Future Water Priorities for the Nation: Directions for the U.S. Geological Survey Water Mission Area. Washington, DC: The National Academies Press, accessed June 27, 2025 at https://doi.org/10.17226/25134.

Sando, S.K., 2021, Peak-flow variability, peak-flow informational needs, and consideration of regional regression analyses in managing the crest-stage gage network in Montana: U.S. Geological Survey Scientific Investigations Report 2021–5063, 124 p., https://doi.org/10.3133/sir20215063.

Siefken, S.A., Taylor, N.J., and Hamilton, W.B., 2023, Peak-flow frequency analyses for selected streamgages in the Upper Yellowstone River Basin, based on data through water year 2022: U.S. Geological Survey data release, https://doi.org/10.5066/P9J1U1GB.

Siefken, S.A., Williams-Sether, T., Barth, N.A., Chase, K.J., and Cedar Face, M.A., 2025, Methods for peak-flow frequency analysis for streamgages in or near Montana, North Dakota, South Dakota, and Wyoming: U.S. Geological Survey Scientific Investigations Report 2025–5019, 19 p., https://doi.org/10.3133/sir20255019.

U.S. Department of Agriculture (USDA), 1986, Urban Hydrology for Small Watersheds: TR-55, accessed June 18, 2025, at https://www.hydrocad.net/pdf/TR-55%20Manual.pdf.

U.S. Geological Survey, 2016, Fundamental Science Practices: Peer Review: U.S. Geological Survey Manual section 502.3, accessed June 18, 2025, at https://www.usgs.gov/survey-manual/5023-fundamental-science-practices-peer-review.

U.S. Geological Survey, 2019, National Hydrography Dataset (NHD), accessed January 16, 2025, at https://www.usgs.gov/national-hydrography/access-national-hydrography-products.

U.S. Geological Survey, 2019, The StreamStats program, accessed June 17, 2025, at https://streamstats.usgs.gov/ss/.

U.S. Geological Survey, 2025, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed January 16, 2025, at https://doi.org/10.5066/F7P55KJN.

Wood, M.S., Fosness, R.L., Skinner, K.D., and Veilleux, A.G., 2016, Estimating peak-flow frequency statistics for selected gaged and ungaged sites in naturally flowing streams and rivers in Idaho: U.S. Geological Survey Scientific Investigations Report 2016–5083, 56 p., https://doi.org/10.3133/sir20165083.