

RESEARCH SPOTLIGHT

Project Information

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Modernizing flood discharge estimates for Michigan watersheds

Intense rainfall and flooding that have occurred in recent years led the Michigan Department of Transportation (MDOT) and the Department of Environment, Great Lakes and Energy (EGLE) to evaluate updating the procedures and input data used to estimate flood discharges in ungaged watersheds. This research provided MDOT and EGLE with updated rainfall data, source data for land use delineation and modern geographic information system (GIS) tools to help MDOT engineers produce consistent and more accurate flood estimates.

PROBLEM

To estimate flood discharge, MDOT and EGLE had relied on hydrologic calculation procedures that include a rainfall-runoff method for smaller watersheds and regression equations for larger watersheds. Both methods used outdated data sources, including rainfall and land use.

However, simply replacing older rainfall data with newer data was not enough for reliable estimates. In recent years, MDOT and EGLE have increasingly used digital workflows and advanced technologies such as LiDAR-derived digital elevation models (DEMs), land use mapping and GIS. These tools now allow watershed characteristics to be defined more accurately than in the past, but only if procedures are updated to take advantage of the tools. Existing methods needed to be recalibrated and compared



Updated flood discharge estimates will help MDOT design structures that reflect current rainfall patterns and watershed conditions.

against a statistical analysis at stream gages using newer datasets to ensure that updated flood discharge estimates are reliable.

RESEARCH

The rainfall frequency and storm distribution data (*Midwestern Climate Center Bulletin 71*) currently used to model flood discharges was replaced with NOAA Atlas 14, a national

"Having solid research behind the methods used to estimate extreme events really matters. It moves us away from opinion and toward decisions that are more data-driven."

Erik Carlson,
Project Manager

dataset developed by the National Oceanic and Atmospheric Administration (NOAA) that provides location-specific estimates of how much rain is likely to fall during storms of various intensities and durations. The research team then analyzed the two calculation approaches MDOT and EGLE currently use based on watershed size: a rainfall-runoff method for smaller watersheds and regional regression equations for larger basins.

For smaller watersheds with drainage areas less than 20 square miles, team members recalibrated the rainfall-runoff model parameters using observed rainfall and streamflow data from 66 storm events in 21 watersheds across Michigan. They also developed automated GIS-based tools for watershed delineation and runoff parameter estimation, and evaluated opportunities to automate calculations related to runoff travel time through a watershed.

For larger watersheds, the team compiled peak discharge observations and basin and climate characteristics for 240 watersheds and applied advanced statistical methods to update the regression equations used to calculate peak flood discharge at ungaged sites. As part of the geospatial analysis, an updated land use and land cover dataset for the state was developed and recommended for use. The team also investigated alternative hydrologic techniques and provided recommendations for future research.

RESULTS

The study resulted in a modernized set of hydrologic calculation tools and procedures that better reflect Michigan's current rainfall patterns, land conditions and data capabilities. All required GIS layers and calculation procedures were provided, allowing both the rainfall-runoff method and regression equations to be easily implemented using spreadsheet-based tools.

The research team members developed new recommendations for defining rainfall zones based on how precipitation amounts and storm timing vary across the state. For smaller watersheds, they updated the parameter values and equations used in the rainfall-runoff model to better reflect regional differences in watershed behavior. For larger watersheds, they updated the regional regression equations using longer streamflow records, readily available geospatial datasets and improved statistical techniques.

A comparison of the two approaches found that the regression equations more closely matched observed flood data at gaged sites across a range of watershed sizes. This finding suggests that the regression method may be appropriate for watersheds as small as 10 square miles, expanding its usefulness beyond traditionally larger basins.

One of the most practical outcomes of the research is a set of new GIS-based tools that make flood discharge analysis faster and easier to perform. Tasks that once involved considerable manual work, such as delineating watershed boundaries and ensuring drainage paths are connected across roads, bridges and culverts, can now be completed using updated, high-resolution spatial data. Of particular importance is a new land use and land cover dataset that combines national data with a Michigan-specific wetlands layer, giving engineers a better representation of how water moves across the landscape.

IMPLEMENTATION

MDOT is incorporating the revised hydrologic calculation procedures in its *Drainage Manual*, and EGLE has begun implementing portions of the research. The updated datasets and GIS-based tools support more efficient, consistent flood discharge analyses across agencies. Future updates are recommended as new data sources become available.

Research Administration

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The final report is available online at

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