Nebraska Department of Transportation
Funded Research
Project Completed May 2025

Executive Summary, Research Readiness Level Assessment, and Technology Transfer

Drainage Area Limitations for NDOT Hydrologic Computations

Research Objectives

- Compare estimates of peak discharge using SCS curve number methods to those from smaller gaged watersheds to determine a logical lower and upper limit for drainage area applicability.
- Apply recently developed hydrologic methods that provide long-term simulations for gaged and ungaged areas and apply flood frequency estimates derived therefrom to those from gage records and curve number results.

Research Benefits

- Provide designers better guidance on the application of available hydrologic methods for calculating peak discharge, which will provide additional consistency and uniformity when sizing hydraulic structures.
- Increase skill levels using more sophisticated computational approaches such as the Watershed Modeling System (WMS).
- Allow designers to consider new methods for predicting peak discharge.
- Share results at Transportation Research Board and/or National Hydraulic Engineering Conference
- Lead the way in considering the power of recent and ongoing hydrologic research

Principal Investigator

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NDOT Lead TAC Member

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Background

The NDOT Roadway Design Division and Bridge Division commonly use three traditional methods to predict peak discharge for the design of storm drains, culverts, and bridges: the Rational Method, Soil Conservation Service (SCS) methods based on curve numbers, and statistical regression equations. Which method is most appropriate depends on, besides other factors, the size of the contributing watershed (drainage area). Designers are not confident about the drainage area limitations associated with each method. There is a lack of performance-based guidance on drainage area-based use of hydrologic methods to predict peak discharge. Specifically, a lack of guidance when using SCS curve number-based methods leaves designers with less confidence about the applicability decisions. While such guidelines are needed, state-of-the-art applications in hydrology suggest there may also be new approaches and tools available to designers.

Conclusion

Most state Department of Transportation roadway design sections predict peak flow for culvert design using, amongst other approaches, Natural Resources Conservation Service (NRCS) TR-20 technology. Even though this technology is more than 50 years old, there are no clear guidelines for how large a single watershed drainage area may be while remaining appropriate for predicting peak discharge with this method. Our objective was to identify the drainage area where TR-20 peak flow predictions significantly deviate from flow frequency predictions. We developed flow frequency estimates for 130 small-area stream gage sites in rural Nebraska and compared the calculated return period discharges with those from TR-20 using both the segmental and lag equation approaches for estimating the time of concentration. Additionally, we compared available regression predictions to both flow frequency and TR-20 estimates.

We found that there are no significant differences between peak discharges calculated using the TR-20 lag method and segmental method for estimating the time of concentration. If TR-20 continues to be used in the future, we recommend using the segmental approach to be more consistent with commonly accepted practice. Results did show, however, that predictions are consistently higher than those from stream gage estimates and become worse for drainage areas larger than fifteen square miles. The regression equations developed for small drainage areas (perhaps uniquely available for Nebraska) perform better than the TR20 estimates. As a first step to further investigate the performance of the TR-20 equations, we made peak flow estimates assuming drier soil conditions that effectively reduce the runoff curve number for each watershed. Results again showed poor agreement, but instead of being consistently high, were consistently low. We therefore discourage using an uncalibrated TR-20 model to calculate peak flow for culvert design for any size drainage area in Nebraska. If peak discharge estimates are required for changing land use conditions, we recommend a TR-20 model be calibrated to the regression model results for present conditions, thus allowing the simulation of changed land use conditions easily done with TR-20.

Next generation hydrologic approaches such as the National Water Model and GEOGloWS currently lack the resolution required to simulate peak flows from smaller watersheds. Tests showed universally low estimates compared to gage estimates of return period discharges.

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Final report is available:
[HERE]

NDOT Recommendations Based Off Research Project – 2025 – RRL4

Recent research indicates that regression equations for small watersheds offer more reliable predictions of peak flows than the TR-20 technology. Before these finds can be formally adopted, the Hydraulics Section must conduct internal discussions to assess their validity and determine their suitability for implementation. If accepted, the results will be incorporated into updates to both the Drainage Design and Erosion Control Manual and the Hydraulics Manual. Because revisions to the Design and Erosion Control Manual require approval from the Federal Highway Administration (FHWA), the finds may be included as an appendix to streamline the approval and upload process.

- *As provided by Julie Ramirez, Lead TAC Member*

Research Readiness Level (RRL) Assessment

Level 4: Implementation

Technology refined and adopted. This project will have a follow-up in 1 year.

RRL 4

Technology Transfer

Webinars/Presentations

- Hotchkiss, Rollin H. and Timothy Maughan. 2024. "Drainage area limitations for NRCS methods." 2024 National Hydraulic Engineering Conference, Aug 27-30, Biloxi, MS.
- Maughan, Timothy A., Rollin H. Hotchkiss, Kenneth T. Quintana, Mark K. Payne, Madelin E. Pollei, Allison J. Kunz. 2024. "Drainage area limitations of single watershed, peak flow estimates with NRCS methods." Proceedings, World Environmental & Water Resources Congress, May 19-22, Milwaukee, WI.
- Maughan, Timothy A., Rollin H. Hotchkiss, Kenneth T. Quintana, Mark K. Payne, Madelin E. Pollei, and Allison J. Kunz. 2025. TR-20 Segmental and Lag Time Approaches for Peak Flow: Comparison to Stream Gage Flow Frequency. Proceedings, World Environmental & Water Resources Congress, May 18-21, Anchorage, Alaska.

This brief summarizes Project SPR-FY24(033)
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Nebraska Department of Transportation Research Program