

Vulnerability to Increases in Flood Flows Throughout Wisconsin Based on Classification of Landtype Associations in Wisconsin

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About the Authors

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Map Description

Areas with landform characteristics that lead to more rapid runoff may be more vulnerable to increases in flood flows from more intense rainfall in the future. Those characteristics include fine-grained soils, low storage in lakes and wetlands, steep slopes, and high drainage densities. Landform characteristics that attenuate runoff include coarse-grained soils, high storage, gentle terrain, and low drainage densities. Groundwater recharge tends to be a dominant hydrologic process in such areas. Landtype associations (LTAs) are ecological units that relate closely with characteristics affecting runoff. A case study from the July 2016 northwest Wisconsin flood regarding the design of flood resilient road-stream crossings used LTAs to classify the vulnerability of landforms in Wisconsin to increases in flood flows (Figure 10 in Higgins and Donner 2025). LTAs were classified as either vulnerable, moderately vulnerable, moderately resilient, or resilient based on characteristics and results from the study. The classification relied on professional judgement guided by drainage density and storage for each LTA and data from flood flows observed at nearby U.S. Geological Survey (USGS) gaging stations with drainage areas less than 75 square miles. Identifying more vulnerable or resilient areas will help planners and project designers improve the resilience of road-stream crossings.

Drainage density (miles of stream per square mile) was found using streams derived from the WI 24k hydro line/arc shapefile (WDNR 2007) including single line streams, the centerline of rivers mapped as polygons, and ditches or canals. Both perennial and intermittent duration were used. Centerlines through lakes, ponds, and reservoirs were excluded. Drainage densities for each LTA were determined by intersecting stream and LTA layers in a geographic information system (GIS).

Storage (%) was determined by combining lake and pond area with wetland area. Lake and pond area was derived from the WI 24k hydro SHAID shapefile including lake or pond and backwater areas (WDNR 2007). Reservoir or flowage areas were not included in the storage determination because the objective was to characterize the general vulnerability of LTAs to flood flow increases during culvert design. Reservoirs on main rivers are often too large for culverts or bridges, and therefore not relevant. When computing percent storage, the reservoir area was removed from the LTA. Wetland area was determined from the Wisconsin Wetland Inventory Geodatabase. The wetland area included all wetland polygons except those coded with a special modifier description of red clay complex. These units primarily occurred on an old lake plain adjacent to Lake Superior where wet and dry clay soils are intermingled (WDNR 1992). These wetland units are more likely to contribute to rapid runoff so were removed from the layer prior to calculating storage. Lake and pond areas that overlapped wetlands were removed to avoid overcounting of storage.

Wisconsin

National forest boundary

Vulnerability to increased flood flows

Resilient

Moderately resilient

Moderately vulnerable

Vulnerable

USGS gage 1% AEP flows (cfsm)*

3.0 - 20.0

20.0 - 50.0

50.0 - 100.0

100.0 - 300.0

300.0 - 1741.0

*AEP = annual exceedance probability for gages with drainage areas <75 square miles;

cfsm = cubic feet/second/square mile.

Suggested Citation

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Data Sources

Data used in this analysis are available through the Wisconsin Department of Natural Resources GIS Open Data Portal (WDNR 2021). The Wisconsin LTA GIS data layer is available at [Land Type Associations | Wisconsin DNR Open Data Portal](#). The most recent version of the Wisconsin [24k GIS hydrography data is available at 24k Hydro Full File Geodatabase | Wisconsin DNR Open Data Portal](#). The most recent version of the wetland layer used in the storage determinations is available at [Wisconsin Wetland Inventory Geodatabase - new | Wisconsin DNR Open Data Portal](#).

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Higgins, Dale; Donner, Deahn M. 2025. **Designing flood resilient road-stream crossings: a case study from the July 2016 northwest Wisconsin flood**. Gen. Tech. Rep. NRS-231. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 69 p. <https://doi.org/10.2737/NRS-GTR-231>.

Higgins, Dale A.; Donner, Deahn M.; Fowler, Jessica R. 2025. **Research map showing vulnerability of Wisconsin landtype associations to increased flood flows**. Fort Collins, CO: Forest Service Research Data Archive. <https://doi.org/10.2737/RDS-2025-0026>.

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