FHWA-HEP-16-074

U.S. Department of Transportation
Federal Highway Administration

FHWA Climate Resilience Pilot Program:

Michigan Department of Transportation

The Federal Highway Administration's (FHWA)'s Climate Resilience Pilot Program seeks to assist state Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Federal Land Management Agencies (FLMAs) in enhancing resilience of transportation systems to extreme weather events and climate change. In 2013-2015, nineteen pilot teams from across the country partnered with FHWA to assess transportation vulnerability to extreme weather events and climate change and evaluated options for improving resilience. For more information about the pilot programs, visit: **http://www.fhwa.dot.gov/environment/climate_change/adaptation/**.

MDOT
Michigan Department of Transportation

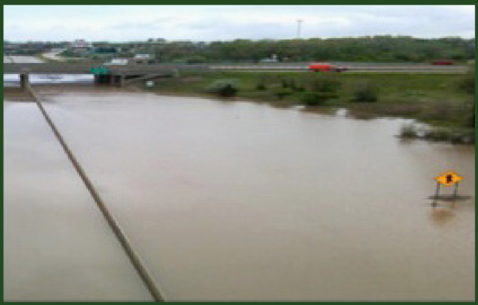
Michigan Department of Transportation (MDOT) conducted a climate-based vulnerability assessment of primarily MDOT-owned and operated transportation infrastructure. The assessment overlaid projected climate data onto MDOT's existing asset management database to help identify locations and infrastructure that may be at risk. The assessment found that the most at-risk transportation assets were situated in the southern third of the state, where the state's larger urban areas are located. The assessment was a first step to help the department protect the transportation infrastructure investments in Michigan.

Scope

For this study, MDOT selected the highway system it owns and operates, including pavement, bridges, culverts, and drainage infrastructure (pumps and storm sewers) across the state.

Objectives

- Assess the state-owned transportation network's vulnerability to climate-related risks, particularly precipitation and extreme heat.
- Continue to develop and improve MDOT's asset management database.
- Identify data gaps.



Flooding impacts to a highway in Michigan. Photo credit: MDOT

Road collapse in Michigan. Photo credit: MDOT

Flooded parking lot in Michigan. Photo credit: MDOT

Approach

Form a Technical Advisory Committee (TAC) and internal working group. In order to provide insight into the process and help share data resources appropriately, the study team identified and convened a TAC. Members included representatives from different state agencies, advocacy groups, academic institutions, and local planning partners (see box). The TAC met three times throughout the course of the study to: provide insight into the project work plan; reflect on the gap analysis and refine the risk analysis approach; and discuss findings from the vulnerability assessment and opportunities to integrate the approach into MDOT's asset management decision-making processes.

Technical Advisory Committee:

- Michigan Department of Community Health
- Michigan Environmental Council
- Michigan Department of Natural Resources
- Great Lakes Integrated Sciences + Assessments Center
- State Climatologist, Michigan State University
- Michigan Infrastructure Transportation Association
- Southwest Michigan Planning Commission
- Wexford County Road Commission
- MDOT Transportation Asset Management Council
- Michigan State Police Emergency Management and Homeland Security Division
- Federal Highway Administration, Michigan Division

MDOT Working Group:

- Bureau of Planning
- Bureau of Highway Development
- Bureau of Field Services

Assemble information on key climate stressors. The study team identified climate variables of interest based on the impact of recent extreme weather events on the transportation system, including erosion from intense precipitation, seasonal precipitation changes, bridge scour, freeze/thaw cycles, Great Lakes ice cover, road buckling, and wildfire. Based on these concerns, the study team identified temperature and extreme precipitation as key climate stressors for evaluation in the study. The study team used output from five climate models selected to represent the range of models (drier and cooler to warmer and wetter projections for Michigan) and medium and high emissions pathways from the Intergovernmental Panel on Climate Change's 5th Assessment over two timeframes (twenty-year periods surrounding 2050 and 2100) to obtain average annual, seasonal, and extreme event projections for temperature and precipitation. The team generated data for ten climate regions in Michigan (as defined by the Great Lakes Integrated Sciences + Assessments Center at the University of Michigan) and summarized them into three broader regions (Northern, Middle, and Southern) to keep the study more focused and manageable. The study team conducted a literature review on recent trends and potential future conditions of lake levels and wildfire conditions, which were not readily captured with the climate models.

Assess vulnerability. Following the FHWA Climate Change and Extreme Weather Vulnerability Assessment Framework, the study team used a Geographic Information Systems (GIS) platform to perform a vulnerability assessment of MDOT transportation assets to extreme precipitation and extreme heat. Due to the statewide scale of the study and data limitations, the analysis focused primarily on exposure to future climate risks, with elements of historical sensitivity and adaptive capacity carried throughout. Using GIS software, the study team then overlaid MDOT transportation asset data with projected changes in extreme precipitation and extreme heat to generate exposure scores for each asset under different climate scenarios. The team normalized these scores across all scenarios and assigned final exposure scores to each asset.

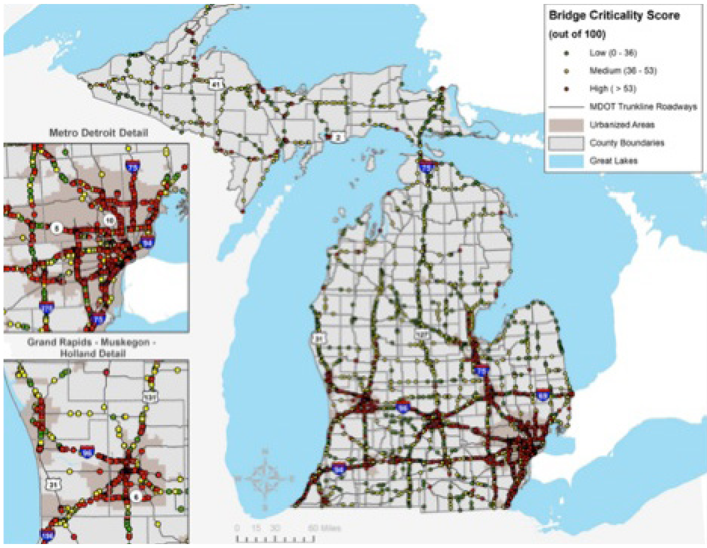


Figure 1. Results from criticality assessment for bridges. Green dots indicate low criticality; yellow dots medium; and red dots high.

Assess criticality. The study team assessed asset criticality by studying the consequences of removing an asset from service and assigning criticality scores based on the asset's relative importance to the transportation system as a whole. The assessment built on a previous criticality assessment and included a score for criticality based on the traffic volume, functional classification, detour length (only for bridges), cost of replacement, and economic impact. Final criticality scores were recalculated on a scale from 0 to 100 and grouped into three tiers of criticality: "low," "medium," and "high" (see Figure 1).

Statewide risk analysis. Finally, the study team multiplied each asset's vulnerability score and criticality score together in order to focus on the most at-risk and critical assets. The team normalized final scores to a 0 to 100 scale and produced them for each model year and emissions scenario, resulting in four risk scores each for extreme precipitation and extreme heat for all MDOT-owned bridges, trunk line roadways, pumps, and culverts for which MDOT geodata were available.

Focused risk analysis. The team performed a focused risk analysis for five areas across the state to illustrate the exposure of specific assets and to better capture the sensitivity of those assets to climate stressors and adaptive capacity of the system. The study team facilitated an interactive exercise with the TAC that included a presentation of findings from the risk analysis overlaid spatially with MDOT asset data at a refined scale. Participants then discussed the results of the risk findings for asset management purposes and identified any data that would be necessary to conduct a more detailed analysis for the highest risk assets.

Key Results & Findings

High-risk assets. Most of the assets categorized as the highest-risk were located in the southern portions of Michigan, in part due to the greater volume of travel on these assets. For extreme precipitation, the major metropolitan areas in the southern third of the state contained the highest risk roadways (see Figure 2). The extreme heat risk assessment yielded similar results. The Detroit area contained roadways with the highest risk scores for extreme heat—a function of both the relatively high vulnerability scores in this area (due to urban heat island effects) as well as the high criticality of these roadways.

Focused risk analysis. The focused risk analysis revealed that additional data on elevation, flood plains, and land use would be helpful to provide a more robust assessment of asset vulnerability. Addressing identified vulnerabilities also may not be straightforward. For example, MDOT's low-lying pumps in Detroit are vulnerable to increased precipitation. Increasing the pump capacity to address this vulnerability would require an increase in floodwater storage capacity that is not easily found in Detroit and presents engineering challenges.

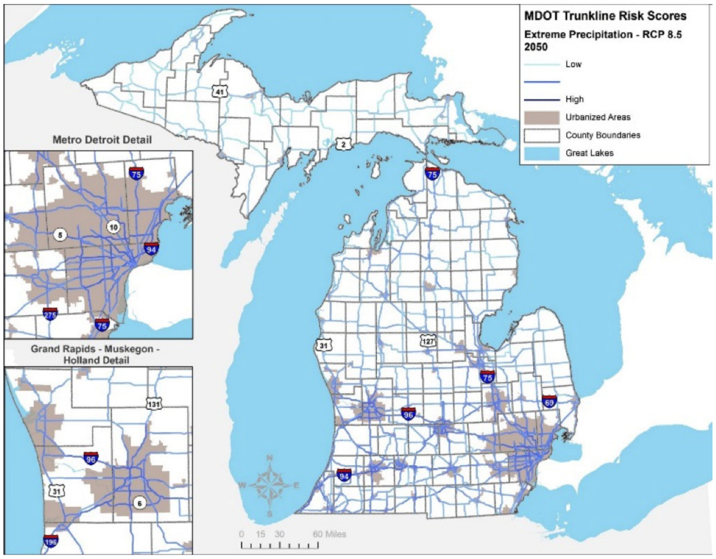


Figure 2. Extreme precipitation risk for MDOT trunk line roadways under a high-emissions scenario in 2050. Darker blue shading indicates roadways with higher risk scores.

Lessons Learned

Select clear thresholds. While this study used a continuous range of exposure to climate risks, it considered thresholds to better capture the significance of the risks. Determining thresholds for these risks proved challenging for the study team; additional work on understanding these thresholds is needed.

Use multiple models to address uncertainty. This study used five climate models to capture the range of future climate impacts. For some climate scenarios, changes in precipitation ranged from very little to over a 60 percent increase. If a single model was used, it might have conveyed a false precision to these projections.

Downscaling data may not be necessary. Climate variables did not vary much across the state, so the process of downscaling data to much smaller regions added little value to project findings. When assessing high level impacts to transportation assets statewide, it may be sufficient to use data available through the National Climate Assessment. For monitoring purposes, it may be sufficient to consider the scale from the climate models and consider using more models to better understand the certainty of estimates.

Obtain robust elevation and floodplain data. This data is needed to inform the sensitivity and adaptive capacity elements of the vulnerability analysis. It was challenging to complete a full vulnerability assessment at a statewide scale without this information; instead, this analysis focused more on exposure.

Leverage existing data and information. The study team made use of MDOT's scour critical bridge inventory and analysis framework for determining criticality, which in turn informed the overall risk score. This approach was consistent with existing practices, allowing MDOT to more readily integrate findings into other planning and investment analysis efforts.

Next Steps

The study team identified suggestions for integrating the study's findings into MDOT's asset management program, which ranged from planning and additional analyses to project development, to construction, to operations and maintenance of the system. The team is drafting a work plan to identify which actions to proceed with to ensure that the study findings are integrated into existing activities and address the most critical needs.

MDOT is verifying the accuracy of the findings through discussions with regional staff and plans to continue to develop this data as resources become available.

"We have a lot of existing resources such as culvert studies and scour critical bridge reports, thus we were able to fold in a lot of this existing research and data to save a considerable amount of effort."

– Niles Annelin, MDOT Project Team

For More Information

Final report available at:
www.fhwa.dot.gov/environment/climate/adaptation/2015pilots/

Contacts:

Niles Annelin
Environmental Policy
Michigan DOT
annelinn@michigan.gov, 517-335-2893

Becky Lupes
Sustainable Transport & Climate Change Team
Federal Highway Administration
Rebecca.Lupes@dot.gov, 202-366-7808