

MARCH 2017

PHASE 1

PENNDOT EXTREME WEATHER VULNERABILITY STUDY

EXECUTIVE SUMMARY



The Pennsylvania Department of Transportation (PennDOT) has initiated a multi-phase effort aimed to better anticipate the consequences and impacts of extreme weather events and to identify funding priorities and strategies to improve transportation system resiliency.

This *Phase 1 Extreme Weather Vulnerability Study* focuses on the evaluation of historic vulnerabilities, development of a framework for addressing climate change impacts, and an initial assessment of risks and priorities related to the identified vulnerabilities. The study's analyses and mapping products are focused primarily on the flooding impacts on state-owned roads and bridges.

Phase 1 Study Tasks



Stakeholder Engagement

Stakeholder engagement was an important component of the study. Specific outreach efforts included a March 2016 webinar with more than 120 participants, including staff from PennDOT's Central Office and 11 district offices and other federal and state planning partners. Between May and June of 2016, separate outreach meetings were held at each PennDOT district office.

The district outreach effort highlighted weather events that were of most concern to design and maintenance personnel within PennDOT. Snow and ice continue to be of most concern, but processes and procedures are in place to deal with these events. Flooding was also identified as an important weather issue for the department. Currently, the districts are primarily reactive to flooding events. As a result, most of the participants stressed that more data, procedures, and

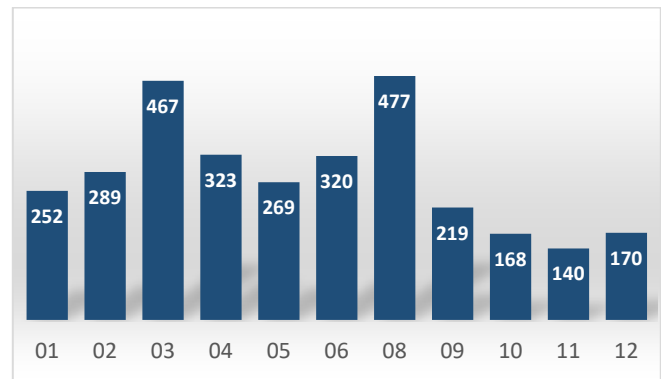
strategies for planning, maintenance, and design are needed to better address flooding. Through the district meetings and supporting web-based mapping tools, more than 450 vulnerable locations were identified within the state.

Historic Flooding Assessment

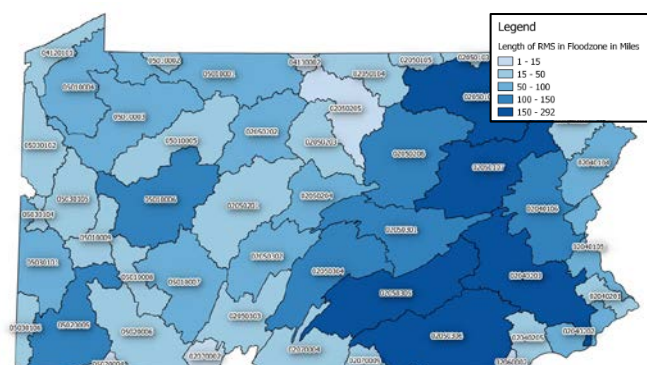
The historic flooding assessment in this study makes use of two primary data sources: PennDOT's Road Conditions Reporting System (RCRS) and the collected stakeholder comments.

RCRS historical database records were combined with the stakeholder comments on flooding locations. This combined data source, representing more than 3,000 miles of roadway, is used to identify the locations of flooding vulnerabilities within the state. The data was combined with other information sources, including National Oceanic and Atmospheric Administration (NOAA) historical precipitation data, and integrated into maps and tables.

State Roadway Mileage Vulnerable To Flooding (By PennDOT District Number)



State Roadway Mileage Vulnerable to Flooding (By HUC-8 Watershed Designations)

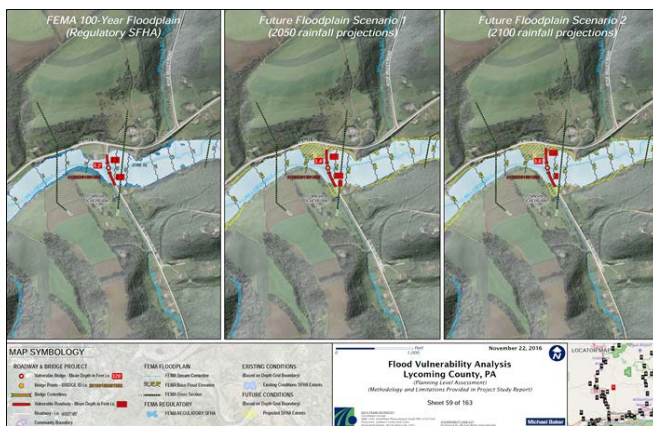


Forecast Flooding Assessment

This study included a planning-level analysis to evaluate flooding inundation of state-owned roadways and bridges based on existing Federal Emergency Management Agency (FEMA) one percent-chance flood zone maps and climate model projections for Pennsylvania. The analysis is intended to provide general insights on potential transportation vulnerabilities within the state as a result of climate change and increased extreme weather events. The analyses may be supplemented in the future by more detailed hydraulic modeling at specific site locations.

Forecast analyses have been conducted for three sample counties, Lycoming, Allegheny, and Delaware, with a focus on procedures and tools that can be cost-effectively applied in other counties. The results from the analyses are to be evaluated against local stakeholder knowledge and other historic flooding information, including PennDOT's RCRS.

Forecast Analysis Mapping Products (Map Book)



Risk Assessment

An initial risk assessment framework has been developed to evaluate historic and future flooding vulnerabilities within Pennsylvania. The primary goals of developing a risk assessment process include:

- Understanding potential consequences and costs of extreme weather impacts on specific locations
- Helping PennDOT determine priority locations for more detailed further study
- Providing information to support planning and programming of projects.

The risk assessment process may also provide other information in support of district maintenance planning, emergency management activities, and the evaluation of project design alternatives.

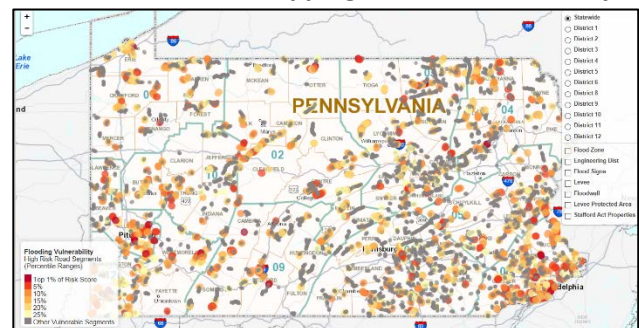
The risk assessment integrated information from PennDOT's Roadway Management System (RMS), Bridge Management System, and RMS Pipe databases. The criteria were scored and weighted, providing an overall score for each vulnerable location.

Examples of Risk Assessment Criteria

NOAA Precipitation Data	Average Depth of Inundation from Analyses	Location in a FEMA Flood Zone	Overall Pavement Index
Bridge Scour Rating	Pipe Deficiency Rating	Traffic and Truck Volume	Functional Class

The risk assessment mapping is the primary mapping product of this study. PennDOT will be working to integrate similar information into its GIS-IQ and Maintenance-IQ systems to support direct linkages to other PennDOT data systems and sharing with planning partners.

Risk Assessment Mapping Products from Study



Mapping of Historic
Flooding Locations

<http://s3.amazonaws.com/tmp-map/climate/historic-flooding-risk-assessment.html>

Mapping of Future
Flooding Locations

<http://s3.amazonaws.com/tmp-map/climate/historic-flooding-risk-score.html>

<http://s3.amazonaws.com/tmp-map/climate/future-flooding-risk-assessment.html>

PennDOT is seeking input on the content of these interactive maps in an effort to further improve data quality and prioritization methods. The online maps provide features for users to provide feedback on individual vulnerable segment locations.

Strategies

Improving the resiliency of Pennsylvania's transportation system ultimately requires the application and integration of cost-effective adaptation strategies. For this study, example strategies are highlighted from stakeholder outreach comments, current practices within Pennsylvania, and a national literature review. These strategies and the associated toolbox are intended to be a starting point for future discussions and activities in determining the strategies that may be most viable for PennDOT and its planning partners.

Next Steps and Integration

This study and the associated data and methodologies should be considered to be an evolving process. Comments and insights from PennDOT district offices and other planning partners will be used to refine and improve the vulnerability locations and risk assessment methods.

Through the outreach process and the project steering committee, an initial set of recommendations has been prepared to assist PennDOT in applying the results of this study and further enhancing the department's efforts to identify and implement adaptation strategies. Further action on any of these implementation steps will most likely require a more detailed assessment of the scope of each action; identification of lead parties and supporting staff; and further assessments of data, research, and procedures at the local and national levels.

Comments on the Study

Any comments regarding the study, vulnerabilities, recommendations for risk criteria or weighting, and adaptation of best practices can be directed to:

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Future PennDOT Implementation Steps

Historical Vulnerabilities

- Share RCRS vulnerability mapping for review and evaluation
- Evaluate historic risk assessment process
- Develop PennDOT vulnerability mapping and data report products for department and planning partner use
- Identify methods to better monitor costs associated with extreme weather
- Identify and develop other data and mapping reports that assist in identifying needs or monitoring resiliency progress
- Develop methods to share best practices

Impacts of Climate Change

- Share forecast scenario vulnerability analyses for further assessment and review
- Explore options for application of forecasting methodology beyond the three pilot counties
- Continue to track Department of Environmental Protection and Penn State University climate assessments and adaptation efforts
- Evaluate new data sources and agency activities related to flood zones

Assessing Adaptation Strategies

- Establish strategy working groups to evaluate strategies in more detail.
- Conduct more detailed focus studies to evaluate vulnerabilities and strategies for specific locations

Integration of Resiliency Concepts

- Support integration of study results to address other Department requirements and initiatives
- Support districts and metropolitan planning organizations in conducting resiliency planning
- Provide local technical assistance to support resiliency planning.
- Determine other improvements in capabilities and funding necessary for successful implementation.