

Extreme Weather Vulnerability Studies - Designing for Resilience

Update on PennDOT Efforts

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Agenda

- **Phase 1:**

- PennDOT's Extreme Weather Vulnerability Study
- FHWA Pilot Project

- **Phase 2:**

- Designing for Resilience

- **Questions:**

Impetus for Resiliency Efforts

PennDOT Concern
with Number and
Intensity of Storms
and Damage

FHWA Order
5520 and Pilot
Studies

Emphasis from DEP
/ Climate Change
Advisory
Committee

Asset Management
Requirements

FAST Act

CEQ Final
Guidance
(Rescinded)

Federal Flood Risk
Management
Standard

AASHTO

Emergency Funds
Obligated:
**\$140 million spent on
Federal Aid System
since 2006**



Climate and Weather-Related Hazards

Flooding Considered a Primary Issue in Pennsylvania

Flooding

Sea-Level
Rise

Fires

Landslides

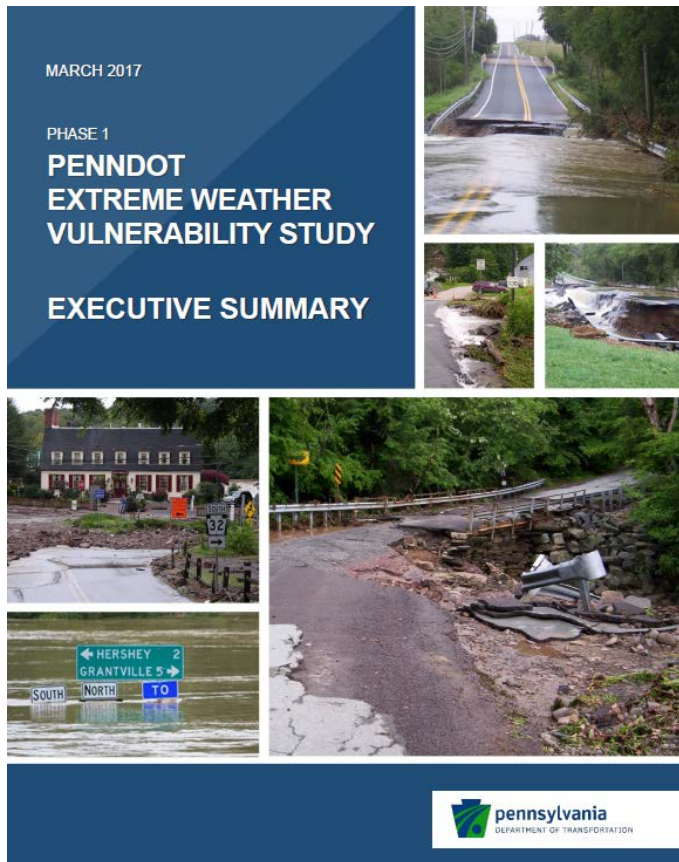
Earthquakes

High Winds

High
Temperature
Days

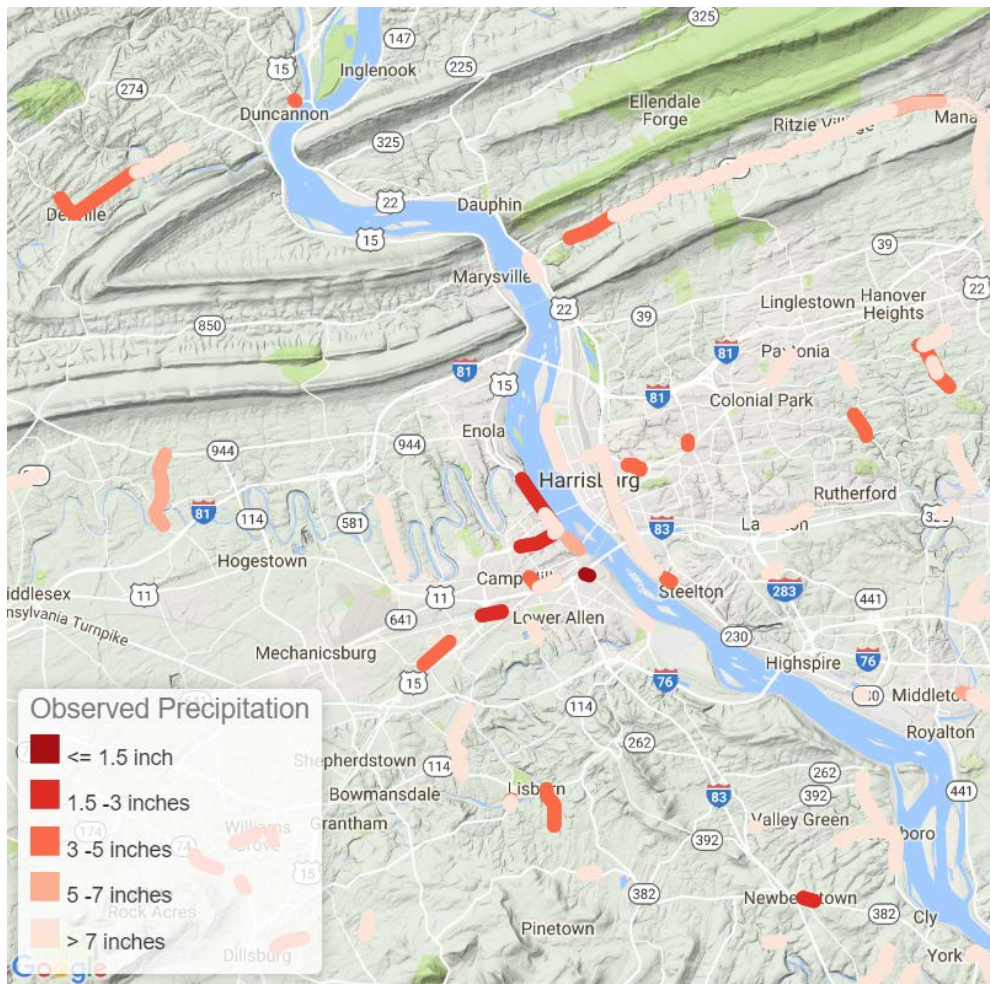
Extreme Weather Vulnerability Study

Status of Vulnerability Study



- Initial study completed in March 2017
- Distributed to Districts, MPOs, other state agencies for planning purposes
- Updated in Fall 2017
- Additional updates underway

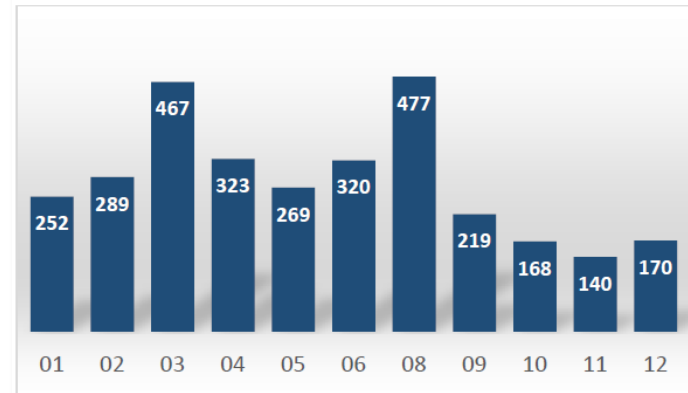
Historic Flooding Vulnerabilities



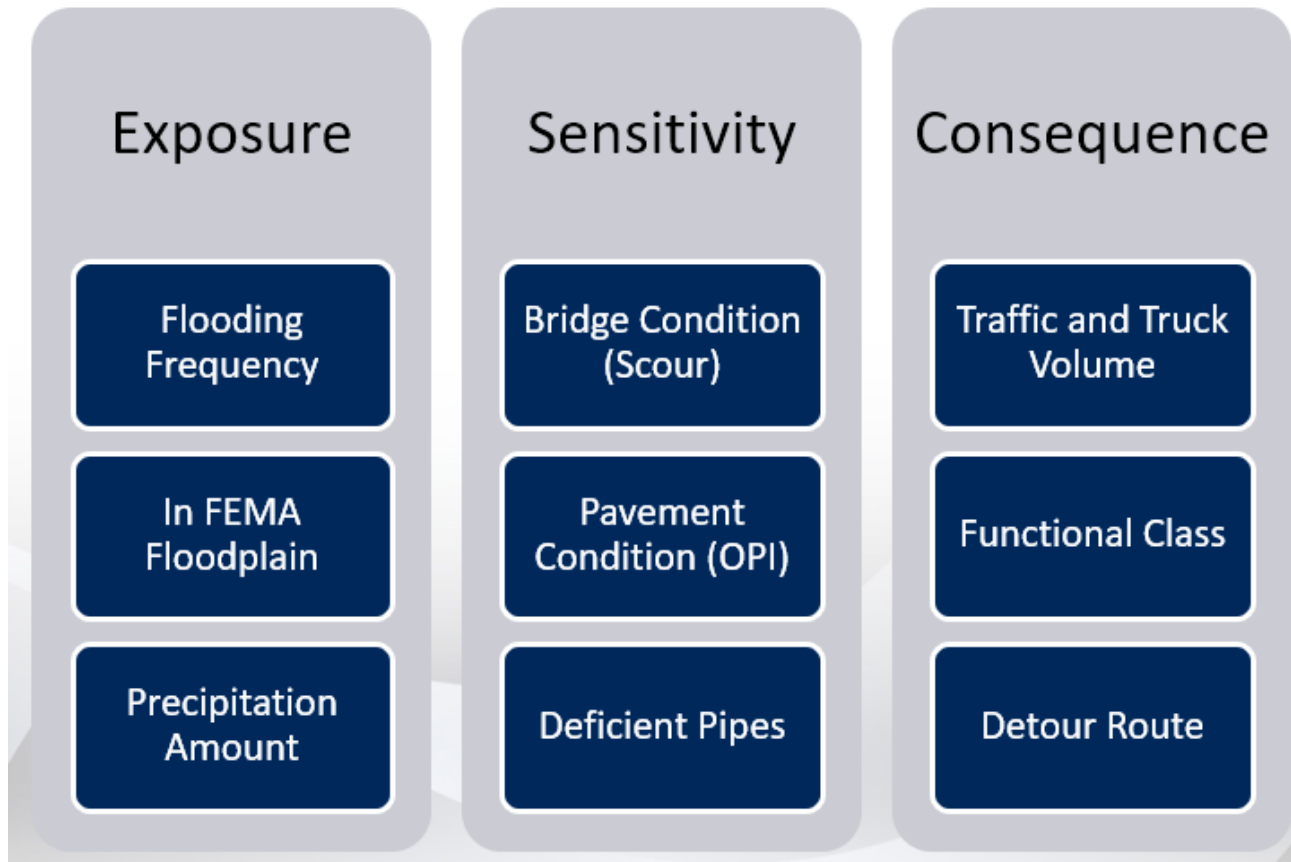
Sources:

- ❑ Road Condition Reporting System (RCRS)
- ❑ FEMA Floodplain Maps
- ❑ NOAA Weather Data

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

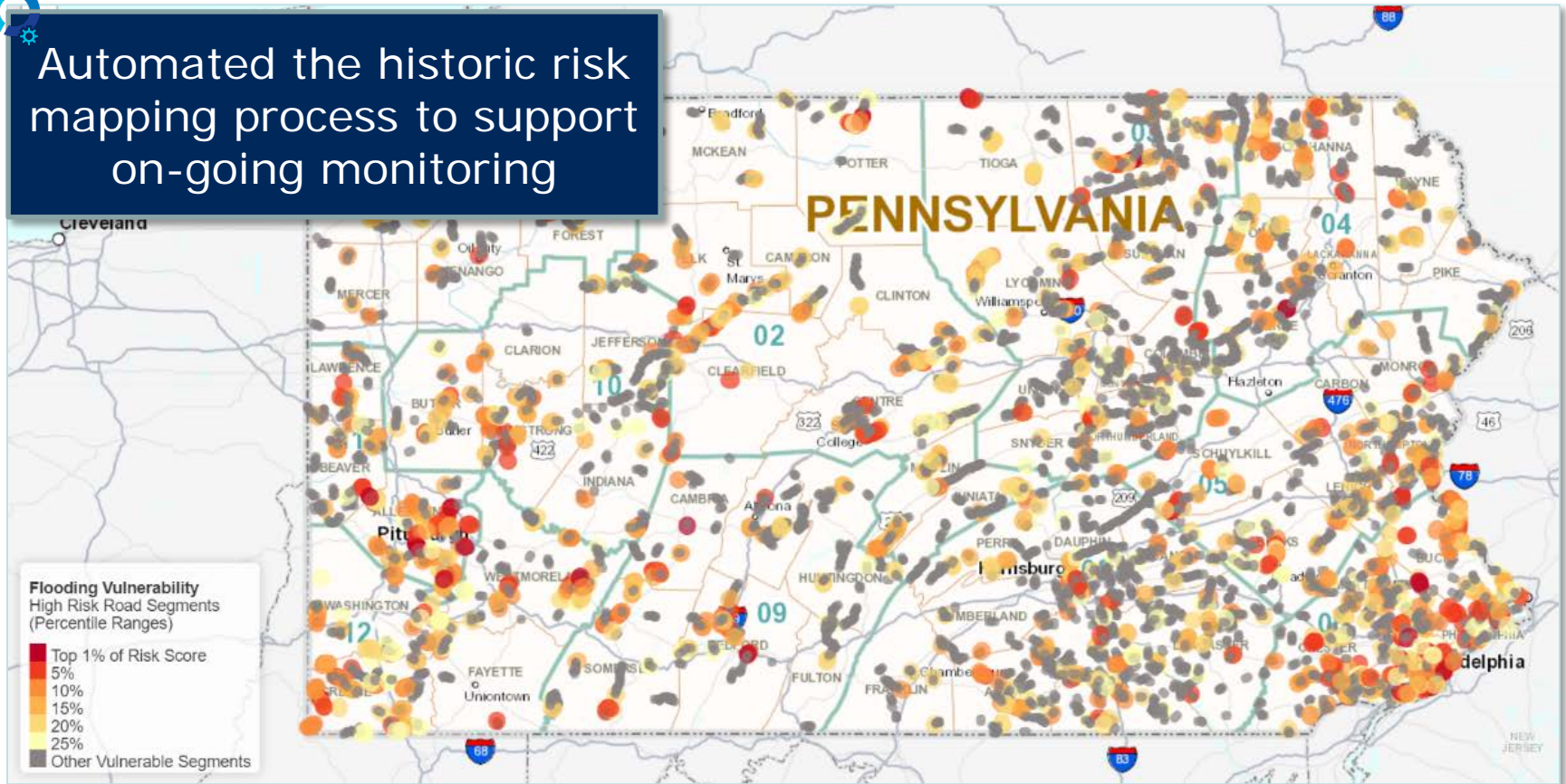


Risk Assessment Criteria



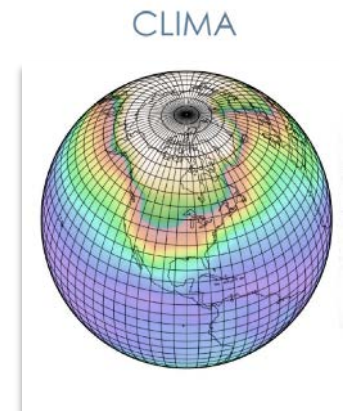
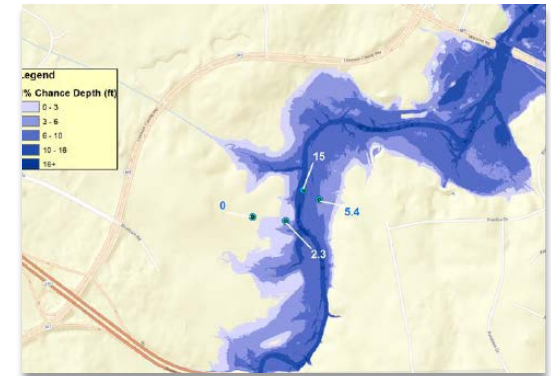
Flood Risk Mapping

Automated the historic risk mapping process to support on-going monitoring



Forecast Climate Impact on Flooding

- **Planning level analyses to assess changes to FEMA 1% floodplain maps** based on increased rainfall scenarios
- Assessment of **global climate model outputs**
- Utilized stream gauge, forecast impervious area, and digital elevation data.
- Assessed **inundation of PennDOT roads and bridges** based on increased stream depths and sea-level rise
- **Compare to historic data**



Pilot Forecast Analyses [Climate Change Scenarios]



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

Addressing Sea-Level Rise

- Literature review of available climate science on sea-level rise

IPCC

NOAA

FHWA

USACE

Historical
Tide gage
records

- IPCC and NOAA chosen for scenario analyses
- Adjusted for local tide data

Scenario	Sea Level Rise by 2050 (m)	Sea level rise by 2100 (m)
NOAA Highest	0.7	2.1
IPCC 2013 Upper Estimate	0.4	1.1

Current Home for Resiliency Data

- PennDOT PennShare Site

<http://pennshare.maps.arcgis.com/apps/MapSeries/index.html?appid=29bf9f06045f47feb9888193674f8a95>

Extreme Weather Vulnerability Study



Future Revisions
Needed To Support
Implementation

1 Introduction



[View the Original Study Executive Summary](#)

[View the Original Study Full Report](#)

This study is for planning purposes only

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.

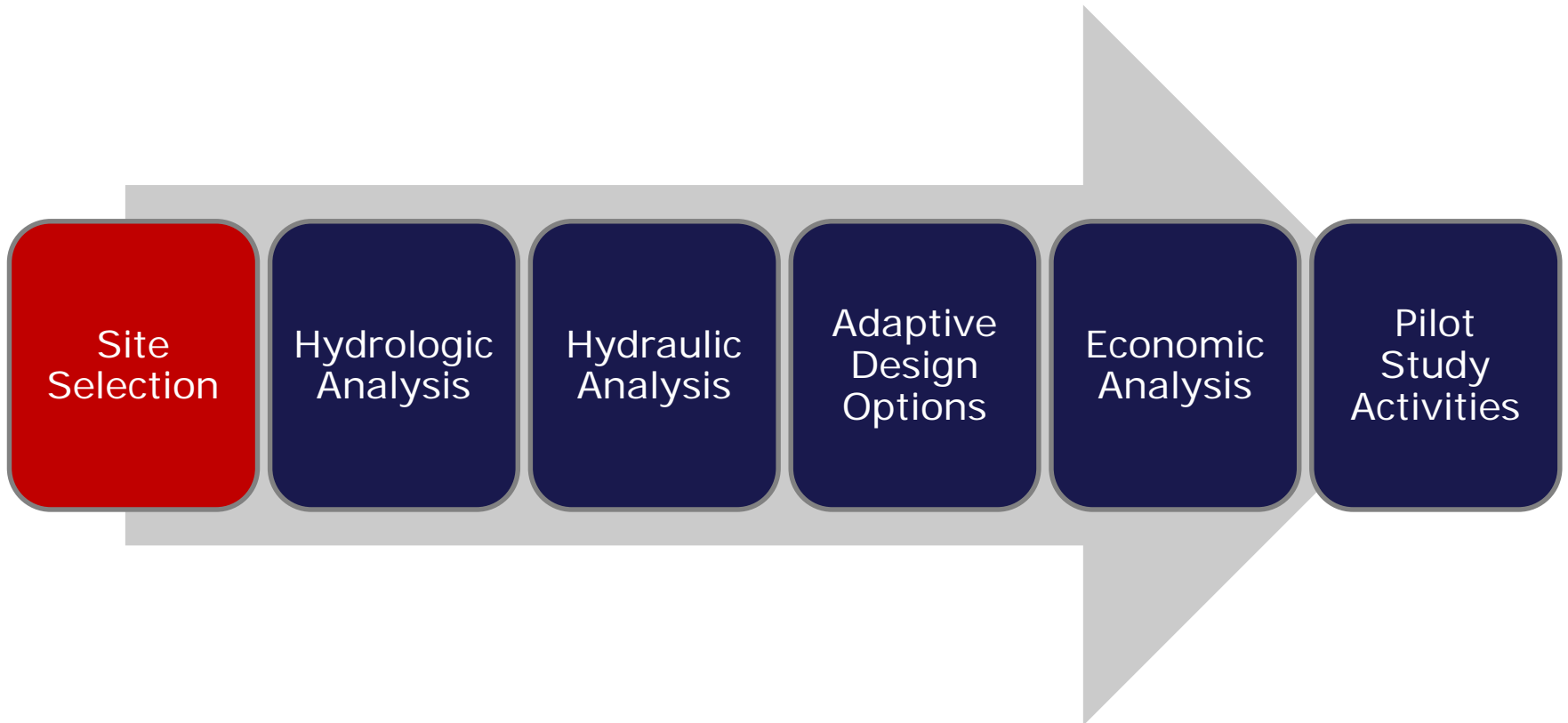
2 Historic Vulnerability Locations and Risk Assessment



www.dot.state.pa.us

FHWA Pilot Study

Project Goals



Study Locations and Coordination

1 site location in:

- ❑ Allegheny County
- ❑ Delaware County
- ❑ York County

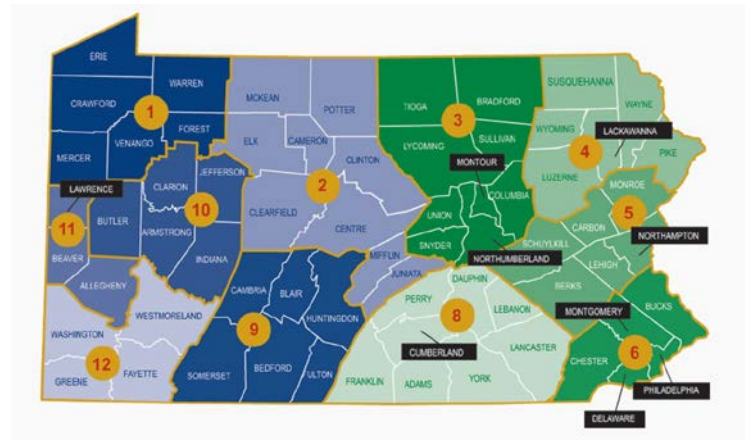
Metropolitan Planning Organizations (MPOs)



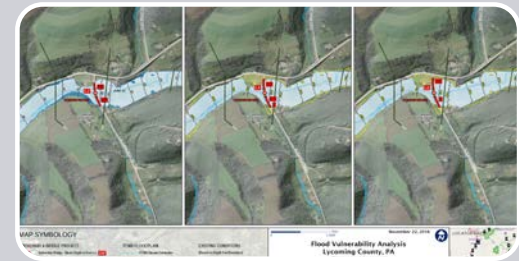
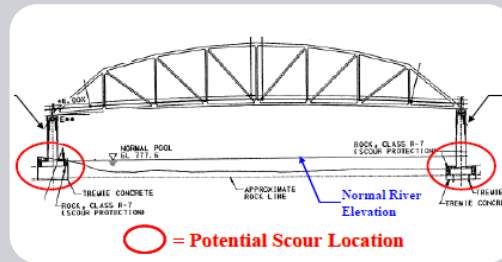
PennDOT Central Office:

- ❑ PennDOT Bureau of Planning & Research
- ❑ Planning and Programming
- ❑ Highway Design
- ❑ Bridge Design

PennDOT District Offices



Project Goals



Provide a detailed template for conducting H&H studies that include climate change impacts

Case study in evaluation of adaptation strategies and cost-effectiveness

Evaluating planning-level climate flooding forecasts from PennDOT's Extreme Weather Vulnerability Study

Pilot Study Next Steps

- Finalize site locations
- Initiate download of projected precipitation data
- Conduct detailed H&H studies incorporating climate projections
- Field visit 3 locations

Designing for Resilience



Workgroup Focus Areas

- Internal Workgroup
 - Focusing on design, construction and maintenance aspects.
 - Traffic Operations separate workgroup
- Multiyear initiative
 - Some items implemented in 6-12 months; others will take longer.
- Short term items
 - Use of geotextiles to prevent loss of approach embankments and to encapsulate pipe backfill.
- Update H & H Manual
 - Incorporate revised USGS regression equations, as well as updates to stream stats database.



Designing for Resilience - *preliminary*

- Bridge Design
- Opening sized so that design flood/storm to satisfy limitations on backwater increase:
 - Detailed FEMA flood Zone – 0.00" increase in backwater
 - Approximate FEMA flood Zone -1.00' increase in backwater
- Scour design – evaluates 100yr and 500yr storm events and uses storm with highest velocity (typically the 100yr event)
- Foundation design – 100 year storm event, but check stability of 500 year storm event

Designing for Resilience - *preliminary*

- Culvert Design

- Basic design similar to bridge, size opening for design flood per DM2 Table 10.6.1.

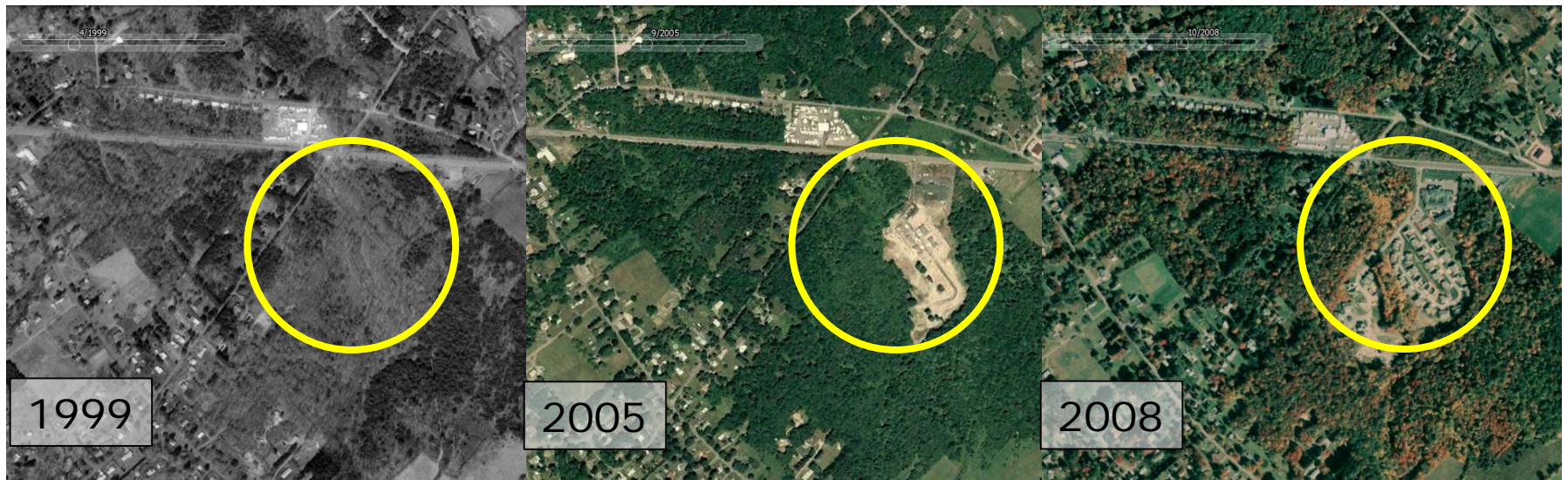
- Mitigation measures

- Check opening for 100 year event
- Increase opening by 20%?
- Downstream impacts must be considered
- Rock the embankment slope, interlocking block (DEP coordination required)
- Proper construction procedures, flowable fill at inlet

Designing for Resilience

o H&H Design Flood Considerations

- Changing drainage area characteristics
- Stream stats is being updated in conjunction with regression equations
- Other hydrologic methods can evaluate land use changes



Questions

Designing for Resilience – H&H- Current Return Periods

**TABLE 10.6.1
DESIGN FLOOD SELECTION GUIDELINES**

FUNCTIONAL CLASSIFICATION	MAXIMUM EXCEEDANCE PROBABILITY (%)	MINIMUM RETURN PERIOD (YEARS)
Interstate and Limited Access Highways	2	50
Principal Arterial System	2	50
Minor Arterial System	4	25
Rural Collector System, Major	4	25
Other Collector Systems	10	10
Local Road and Street Systems	10	10

Note: Federal Policy states that the design flood for encroachments by through lanes of Interstate highways shall not be less than the flood with a 2 percent chance of being exceeded in any given year. Interstate highways should be designed to accommodate the 2% (50-year) flood event.