NCHRP 20-68A
"US Domestic Scan Program"

Domestic Scan 15-02
Bridge Scour Risk Management

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Domestic Scan 15-02
“Bridge Scour Risk Management”

- This scan is being conducted as a part of NCHRP Project 20-68A, the U.S. Domestic Scan program
- The program was requested by the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP)

NCHRP 20-68A
U. S. Domestic Scan Program

- The Program is a multi year project conducting 3-4 scans per year.
- Each scan is selected by AASHTO and the NCHRP 20-68A Project Panel.
- Each scan addresses a single technical topic of broad interest to many state departments of transportation and other agencies.
- The purpose of each scan and of Project 20-68A as a whole is to accelerate beneficial innovation by:
  - facilitating information sharing and technology exchange among the states and other transportation agencies;
  - identifying actionable items of common interest .

Scan Team

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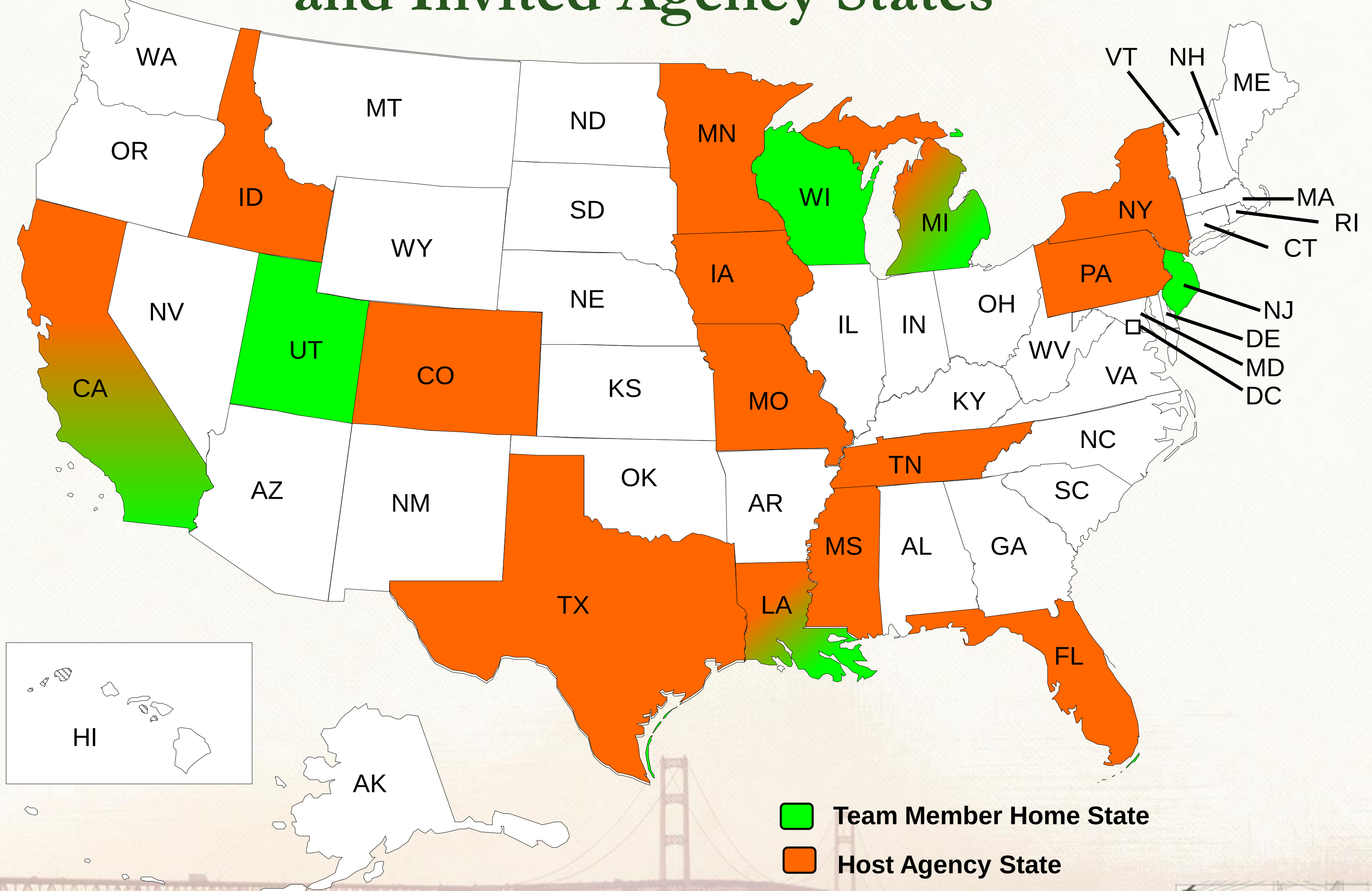
Scan 15-02 Team Members Home State and Invited Agency States



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NCHRP Panel's General Guidance to the Scan Team

"This scan will examine practices of states, counties, metropolitan areas, municipalities and other transportation agencies, to identify and document successful approaches to reducing bridge flooding and scour risk through appropriate use of countermeasures. The scan will also consider how innovative bridge owners assess structural vulnerability or bridge scour susceptibility."

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NCHRP Panel's General Guidance to the Scan Team (cont.)

"The scan team would examine innovative approaches such as

- *Risk-based decision analysis. for*
  - *selection and installation of countermeasures*
  - *selection, installation, and management of monitoring systems*
  - *bridge replacement rather than use of countermeasures or monitoring systems*
- *Inspection procedures for scour countermeasures*
- *Alert systems to trigger inspections during flood events*
- *Road-closing and -reopening decision process*
- *Bridge inspection and documentation procedures during and after a flood event, including updating bridge inspection reports and the agencies' Scour Plan of Action."*

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NCHRP Panel’s General Guidance to the Scan Team (cont.)

“The scan team will focus on practices for inspection, monitoring, countermeasure selection and placement, and risk management for scour-critical and scour-susceptible bridges individually and in networks of varying sizes. ”

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NCHRP Panel's Anticipated Outcomes

"By documenting and sharing successful practices the scan team will produce a valuable resource for use by bridge owners, state and local bridge inspectors, bridge designers and bridge management staff in reducing the risk to the travelling public due to flooding and scour."

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Team's Approach

- Perform Desk Scan and Literature review
- Identify Topics that are related to Scour Risk Management
- Produce Amplifying Questions/Survey for Participating States based on Identified Topics
- Compile Responses to Amplifying Questions
- Hold Workshop of Invited States
- Establish Findings and Recommendations

Team's Approach(Continued)

- the Scan Team identified topics that are essential for the understanding of Scour Risk Management as follows:
  - General Procedures and Risk Analysis
  - Scour Modeling and Analysis
  - Monitoring and Field Inspection of Scour Critical Bridges
  - Design, Construction, and Sustainability of Countermeasures
  - Plan of Action (POA)

Topic 1: General Procedures and Risk Analysis

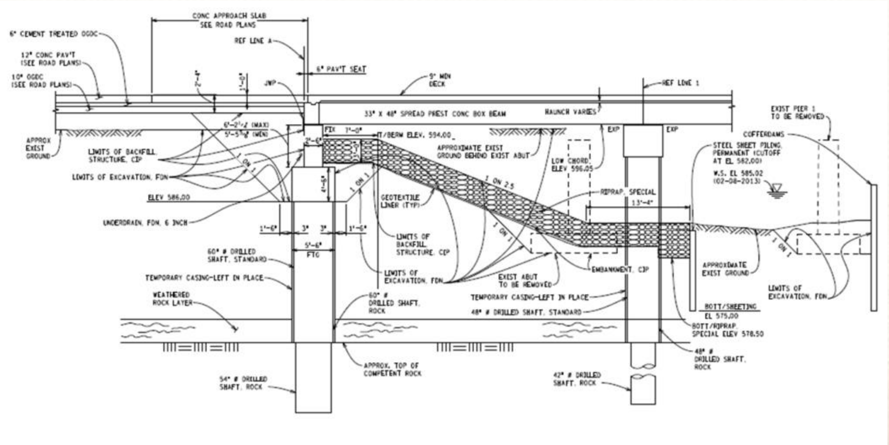
Findings:

- Most states used criticality and others used Probabilistic Approaches to help perform Risk Analysis.
- A number of States perform Vulnerability analysis and table scoring to help mitigate scour
- Many states have strong Teams of Structural, Hydraulic, and Geotechnical Engineers
- Definition of risk and minimizing Uncertainty using various methods

Criteria	Rehabilitation	Replacement
Construction Cost	Lower Initial Cost = $18,790,000	Higher Initial Cost = $ 43,392,000
Life Cycle Costs	Net Present Value = $ 27,266,671 Equiv. Uniform Annual Cost = $ 1,123,598	Net Present Value = $ 47,616,837 Equiv. Uniform Annual Cost = $ 1,962,183
Functionality	Remains the same	Wider roadway deck promotes safety & accommodates center channelization lane for left turns
Long Term Reliability	Substructures would be 130 years old before bridge is replaced Additional future scour countermeasures likely required	New bridge built to current codes and requirements Scour resistant Substructure
Risk	Greater potential for unforeseen issues with major structural repairs Higher likelihood for possible issues with 80-year old substructures	Fewer unknowns with all-new construction Ability to fully considerer potential issues in new design
Constructability	Specialized & complex repairs for track and tread replacements Jacking and shoring leaves Major work during winter	Typical Movable Bridge Construction
Construction Disruption	9-Month Roadway Closure	21-Month Roadway Closure

Topic 1: General Procedures and Risk Analysis

- <u>Conclusions:</u>
  - Scour Risk Management is a complex process and requires input and open communication from multiple disciplines.
  - Due to limited resources, states need to prioritize risk assessment including advanced design, monitoring, and design of countermeasures.
  - Prioritization appears to be based on criticality alone with limited consideration to vulnerability



ABUTMENT A & PIER 1 SECTION

Topic 1: General Procedures and Risk Analysis

- Recommendations:
  - States need to form scour committees with interdisciplinary capabilities (i.e., Engineers from Geotechnical, Structural, and Hydraulics areas)
  - scour is a nation-wide threat - AASHTO should create a multidisciplinary task force that would develop guidelines and specifications for scour mitigation design and to serve as a clearing house for new innovations.
  - Due to limited resources, States should consider using Risk Analysis to prioritize how to best apply their limited resources rather than using vulnerability analysis to identify scour critical bridges.

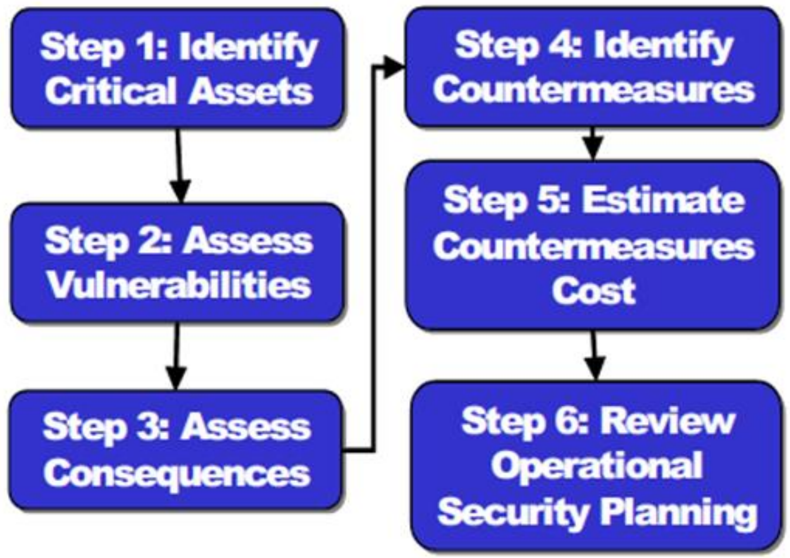
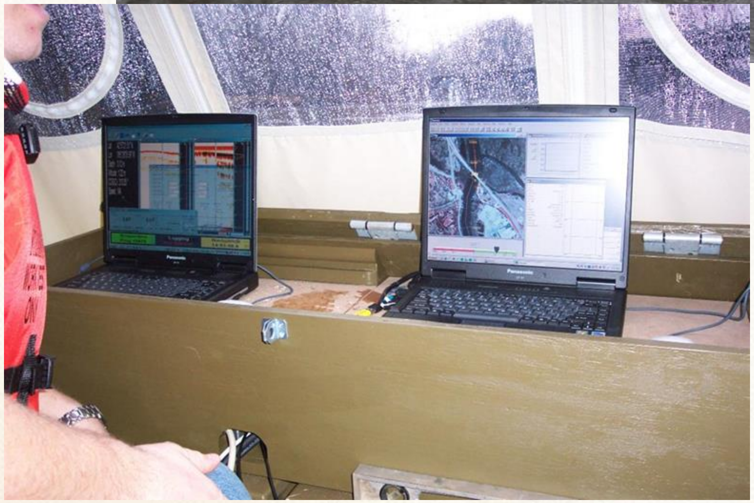


Figure 1 – Six Steps for Conducting a Vulnerability Assessment

Topic 2: Scour Modeling and Analysis



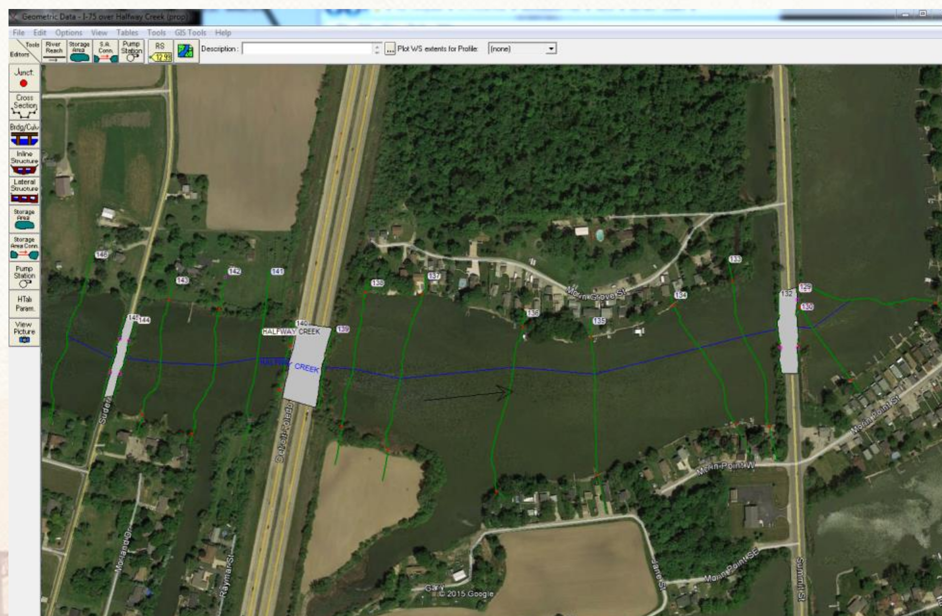
<u>Findings:</u>

- Better testing methods of soil and rock is needed. (i.e. Erosion test for site-specific type of soils, Rock Erosion/Texas Cohesive soil methods /Predictive Models)
- Use of 2D/3D hydraulic modeling to simulate stream flow
- Texas velocity chart for verifying modeling. Texas Data management for quality control/assurance. Data checks, such as in Texas case, can help provide quality control for scour predictions.
- Agencies are using Google earth to study historic stream migration patterns
- HEC-18 provides a scour methodology for cohesive soils but requires getting shear stress bytesting.

Topic 2: Scour Modeling and Analysis

Conclusions:

- Advanced methods for modeling and material testing can be used to enhance scour predictions.
- Using external data sources can enhance the quality control of scour predictions.



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Topic 2: Scour Modeling and Analysis

Recommendations:

- Materials testing for cohesive soils or rocks can performed using new techniques such as those developed by Florida DOT or FHWA
- States are recommended to use 2D/3D models that are shown to be very useful in advanced cases. There is a need to identify the conditions or parameters when the 2D models can be applied.
- Encourage States and other agencies, involved with 2D modeling, to participate in NHI courses and other training workshops.

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Topic 3: Monitoring and Field Inspection of Scour Critical Bridges

Findings:

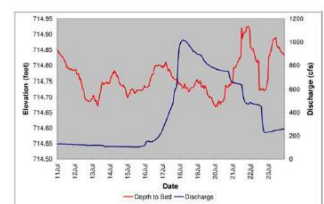
- Improved methods to predict scour depth (i.e., 2D modeling to include better parameters for the HEC18 equations).
- Improved and safer inspection methods (i.e. Sonar versus diving). Use of 3-D Sonar in lieu of Under Water Inspection (UWI).
- A number of states have had successful relationship with USGS through contracts and partnership.
- Smart Phone Point Cloud

Michigan Bridge Element Inspection Manual

SCOUR MONITORING (ea.)

Description: This element defines scour monitoring systems applied to substructure elements.			
No.	Name	CS Table	Description
838	Scour Monitoring	12	Scour monitoring systems.
Quantity Calculation: The quantity for this element is measured per bridge and includes all devices attached to the bridge for monitoring velocity or scour depths.			

Scour Monitoring Device



Sour Data

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Topic 3: Monitoring and Field Inspection of Scour Critical Bridges

<u>Conclusions:</u>

- Advanced technology such sonar can be applied effectively to enhance data collection efficiency and inspector safety.
- External data sources, such as USGS generated data, are essential for the successful implementation and management of scour programs in the USA

Michigan Bridge Element Inspection Manual

CS TABLE 10 – SCOUR PROTECTION

Defects	Condition State 1 GOOD	Condition State 2 FAIR	Condition State 3 POOR	Condition State 4 SEVERE
Scour or Erosion	None.	Countermeasure is substantially effective. Scour or Erosion exists without undermining.	Countermeasure device has limited effectiveness Erosion may be evident with undermining of countermeasure.	The channel protection device or scour countermeasure are unstable, missing or no longer effective.
Material Defect (scaling, abrasion, spalling, corrosion, cracking, splitting and decay)	Insignificant or minor defects.	Countermeasure device is substantially effective. Extensive minor to isolated advanced defects.	Scour countermeasures have limited effectiveness. Extensive advanced to major defects.	
Damage (unraveling, displacement, separation, and sagging)	Insignificant or minor damage.	Countermeasure device is substantially effective. Extensive minor to isolated advanced damage.	Scour countermeasures have limited effectiveness. Extensive advanced to major damage.	

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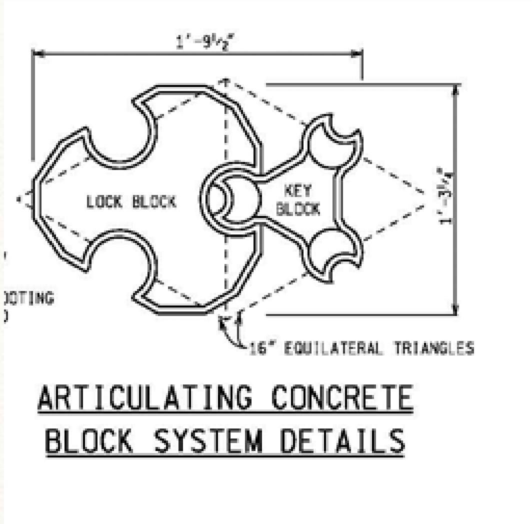
Topic 3: Monitoring and Field Inspection of Scour Critical Bridges

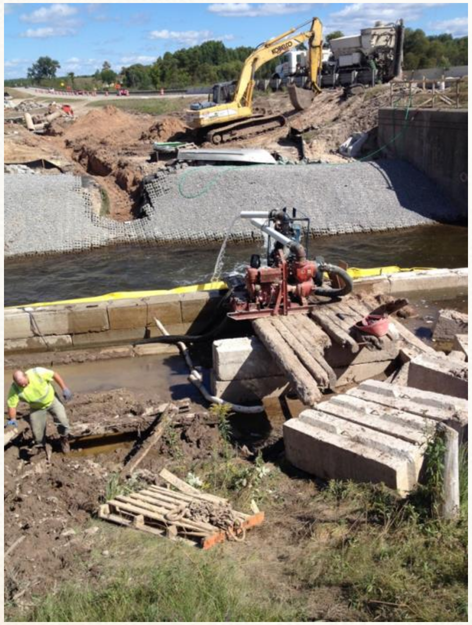
Recommendations:

- States should establish collaborative partnerships with USGS and other agencies to facilitate sustainable data collection for scour predictions.
- AASHTO and FHWA should establish partnerships with USGS and other agencies for innovative applications to advance the State-of-Art of flooding on highway infrastructure.
- States should work proactively with FHWA for use and acceptance of advanced technologies for under water inspection (e.g., sonar) to improve data collection and divers' safety.
- Continued and future research is needed to enhance the capabilities of various systems to measure real-time scour. Moreover, communication and dissemination of various research projects is needed to raise awareness of accomplishments.

Topic 4: Design, Construction, and Sustainability of Countermeasures

Findings - A number of States have had good experience with various countermeasure designs.





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Topic 4: Design, Construction, and Sustainability of Countermeasures

Conclusions:

- States had varying levels of success in implementing the same countermeasures.
- The design and installation of countermeasures needs to be appropriate given all parameters
- States had success in Innovative techniques in applying countermeasures such as Articulated Mattresses, GeoBags, Caged Blocks, AJAX, rock riffle.
- Countermeasures have a shorter lifespan compared to the design and service life of the bridge.

Topic 4: Design, Construction, and Sustainability of Countermeasures

Recommendations:

- States are encouraged to share lessons learned based on their specific experience with countermeasure design and application (e.g., Ski, etc .)
- States should pay more attention to inspecting countermeasures during construction and routine inspections.
- Establishment of a body to help disseminate the information related to the performance of various types of countermeasures is needed.

Topic 5: Plan of Action (POA)

Findings:

- Implementing inspection during significant flood events can be a strain on departmental resources.

SCOUR EVALUATION

Item 113	**Scour Criticality**	3 SC - Unstable	**Source of Item 113**	Assessed
Item 71	**Waterway Adequacy**	7 Above Minimum		
Level I Assessment		Yes		
Level II Analysis		Yes		

Document Date	Document Name	Document Type
03/07/2016	MDOT Level Two Example.pdf	Level II
03/07/2016	MDOT Level One Example.pdf	Level I

Calculated Values

Scour Analysis Frequency	25 Year	50 Year	100 Year	500 Year	Comments
Anticipated Surface Elevation (ft)	581.75	585.63	600.21	602.3	
Distance Below Bottom Chord (ft)	5.0	4.5	0.0	0.0	Pressure Flow at the 100 Year
Anticipated Flow (cubic ft/sec)	150.0	180.0	200.5	225.24	
Anticipated Pressure Flow (Y/N)	N	N	Y	Y	

Topic 5: Plan of Action (POA)

Conclusions:

- Only few states included information useful to the stakeholders of the POA rather than purely meeting the FHWA mandate.
- Some States are using innovative methods (e.g., BridgeWatch or ArcGIS Online) to implement POA's
- It has been observed that during extremely large flood events, bridges that are not scour critical were also impacted.

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Topic 5: Plan of Action (POA)

Recommendations:

- It is recommended that States consider additional information (e.g., cross section, whether the bridges on the detour route are scour critical, etc.) to enhance their POA which could be useful to the stakeholders.
- States are recommended to develop emergency protocols for widespread flood events. (POA are bridge-specific)
- States should create risk-based prioritization for implementing POA during flood events, which could be based on specific trigger for specific bridges. .

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Next Steps

- Scan Team will develop a Scan Report:
  - Document “Findings” and “Conclusions”.
  - Include a Dissemination Plan.
  - Provide recommended next steps.
  - Invited states will review and approve their state’s info prior to finalizing and publishing.

Final Report and other material will be made available on the web at

www.domesticscan.org

Early 2017

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