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Bridge Scour Technology Transfer

Final Report, No. SPR-1673

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16. Abstract
Scour and flooding are the leading causes of bridge failures in the United States and therefore should be monitored. New applications of tools and technologies are being developed, tested, and implemented to reduce bridge scour risk. The National Cooperative Highway Research Program's Domestic Scan 15-02, on Bridge Scour Risk Management, had its active scan period completed during the summer of 2016, where it was recommended that the findings be disseminated among American Association of State Highway and Transportation Officials member and the engineering community. MDOT initiated this project focused on planning, organizing, and executing the Bridge Scour Technology Transfer Event, which was held on October 5, 2017 at the Horatio Earle Learning Center in Dimondale, Michigan. The event invited scour experts and bridge engineers from MDOT and companies to attend and discuss current topics and trends in scour analyses, modeling, and monitoring. Presentations, which were given by both MDOT and national experts, were grouped in and focused on the five key topics identified by Domestic Scan 15-02. After the event, questionnaires indicated that participants gained a better understanding about scour issues and technologies used to reduce its risks.

17. Key Words Bridge scour, technology transfer workshop		**18. Distribution Statement** No restrictions. This document is available to the public through the Michigan Department of Transportation.	
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Research Report Disclaimer

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1. Executive Summary

New applications of technologies and systems are being developed, tested, and implemented that can reduce bridge scour risk. With scour and flooding being the lead cause of bridge failures in the U.S. (Deng and Cai 2010, Landers and Mueller 1996), technology transfer of bridge scour risk management advancements is critical to getting these results implemented at the state level. The National Cooperative Highway Research Program (NCHRP), administered by the Transportation Research Board (TRB) (a unit of the National Academy of Sciences, Engineering and Medicine), has been actively engaged in domestic scans to help expand the rate of information exchange among transportation practitioners. Scan 15-02, on "Bridge Scour Risk Management", had its active scan period completed during the summer of 2016, and is due to be published in February of 2018. The final recommendations of Scan 15-02 included disseminating the findings among American Association of State Highway and Transportation Officials (AASHTO) members and the engineering community.

Research staff from the Michigan Tech Research Institute (MTRI) of Ann Arbor, MI, a research center of Michigan Technological University (Michigan Tech), planned, organized, and executed the Bridge Scour Technology Transfer Eevent. The event, which was held on October 5, 2017 at the Horatio Earle Learning Center in Dimondale, Michigan, invited scour experts and bridge engineers from MDOT, local agencies, and engineering firms to attend and discuss current topics and trends in scour analyses, modeling, and monitoring (Figure 1). Presentations, which were given by MDOT, companies, and federal and local agency personnel, were grouped and focused on the five key topics identified by Scan 15-02, including 1. General Procedures and Risk Analysis, 2. Scour Modeling and Analysis, 3. Monitoring and Field Inspection of Scour Critical Bridges, 4. Design, Construction, and Sustainability of Countermeasures, and 5. Plan of Action. After the event, participants were asked to complete a survey, which indicated that prior to the event, the general understanding of scour issues was rated 3.17/5 - Moderate and that after the event, it was higher at 3.67/5 - Moderate. Lastly, Michigan Tech provided an overview of the event as well as access to each presentation on a project website: http://mtri.org/mdot_scour_workshop.html.

Figure 1: Scour experts and bridge engineers attending the workshop.

This document overviews the planning, organization, execution, and findings of the Bridge Scour Technology Transfer Event. First, a summary of the NCHRP 20-68A US Domestic Scan Program's Domestic Scan 15-02 "Bridge Scour Risk Management" report by Capers (2016) is provided (Section 2.2 and Appendix A.4). Next, in Section 3, planning and organization efforts are briefly described. Afterwards, each presentation is briefly overviewed in Section 4, with a link for each provided for viewing purposes. Lastly, survey results (Section 4.16) and conclusions (Section 5) from the project can be reviewed.

2. Introduction

2.1. Background and Objective

As noted by Capers (2016) and others, flooding and scour are the leading cause of bridge failure in the United States requiring transportation agencies to implement effective programs to reduce threats to the structures. This Domestic Scanwas comprised of a group of bridge engineers from various departments of transportation throughout the country who travelled to multiple states to discuss current scour minimizing practices and addressed topics of interest such as improving scour identification and quantification technologies as well as sharing information through face-to-face interviews and hands-on learning events. The information gained from these discussions is being combined and eventually distributed as the domestic scan to national transportation groups and the AASHTO.

Scan 15-02 had its active scan period completed during the summer of 2016, with the draft report due to be delivereted to NCHRP in October of 2016 and the final report delivered to NCHRP in March of 2017, with it due to be published in February of 2018. Once Domestic Scan 15-02 is released, there will be a large amount of information for transportation agency personnel to absorb and implement into day-to-day operations.

Through planning and executing a technology transfer workshop for both MDOT and Michigan-based agencies to learn about advancements in scour monitoring and modeling, advanced and practical methods to manage scour will be better understood. Therefore, Michigan Tech and MDOT held the Bridge Scour Technology Transfer Event, which invited both groups to discuss sensing technologies, countermeasures, and plans of action. The objective of this project was to invite national experts and peer agencies to a technology transfer event to enable the more thorough and faster dissemination of the 15-02 scan findings to MDOT.

2.2. Literature Review

As part of Task 1 of this project, Michigan Tech reviewed the findings of the NCHRP 20-68A US Domestic Scan Program's Domestic Scan 15-02 "Bridge Scour Risk Management" report (Capers, 2016). The scan team was comprised of bridge engineers from various state transportation agencies, who met with various departments of transportation that focus on bridge scour risk management. The scanning method allows effective face-to-face conversation, promoting the exchange of information that is hard to match through other methods such as emails and telephone conversations. Discussions between the scan team and DOTs consisted of reviews of how scour is managed at the state-, county-, metropolitan area- and municipal-level as well as how scour is assessed using innovative approaches. Examples of these approaches included risk-based decision making for selection of countermeasures and monitoring systems, inspections of countermeasures, and alerting systems and bridge inspections during flooding events.

Seven bridge scour experts were selected to serve on the scan team, which interviewed 14 state DOTs about five general topic areas:

1. General Procedures and Risk Analysis
2. Scour Modeling and Analysis
3. Monitoring and Field Inspection of Scour Critical Bridges
4. Design, Construction, and Sustainability of Countermeasures
5. Plan of Action

Findings, conclusions, and recommendations from each of the topic areas are presented in the Capers (2016) review. Generally, it was agreed upon that scour is a critical, complex process that needs to be closely monitored using current and advancing technologies and overseen by collaborative partnerships and a national committee. This domestic scan review document served as the basis for the development of the Bridge Scour Technology Transfer Event.

3. Methodology

3.1. Executing Scour Technology Transfer Event

The event was held on October 5th, 2017 at MDOT's Horatio S. Earle Learning Center. Event registration opened at 8:00 AM and remained open throughout the day. Prior to the event starting, all handout material (presentation and speaker information) for each topic's moderator were handed out. Towards the end of the day, a question and answer discussion was provided to allow participants to ask questions that time did not allow for and to allow further in-depth discussion into topics covered throughout the day. The total number of participants was 78 with a breakdown of 44 MDOT personnel and 34 Non-MDOT personnel.

4. Review of Presentations and Results

Each of the presentations are briefly reviewed in the following section, with links to the presentation as given at the event.

4.1. Scour Technology Transfer – General Procedures

Rebecca Curtis, MDOT, CurtisR4@michigan.gov, (517) 449-5243
Ryan Snook, MDOT, snookr@michigan.gov, (517) 322-574
Erik Carlson - MDOT, CarlsonE2@michigan.gov, (517) 335-7281
(Figures 2 and 3)
Link to presentation:
http://mtri.org/mdot_scour_workshop/1_Curtis_ScourWorkshop_MDOT_opening%20presentation.pdf

- Welcome by **Matt Chynoweth (MDOT)**
  - Cannot always put in a new bridge
  - Need to be strategic - use monitoring and other technologies
- MDOT has been reducing the number of scour critical bridges, more challenging ones are coming
- MDOT Scour Committee taking the lead, focused on reducing the risk of scour
- Bridges are being designed for 100-year flood, 500-year check flood

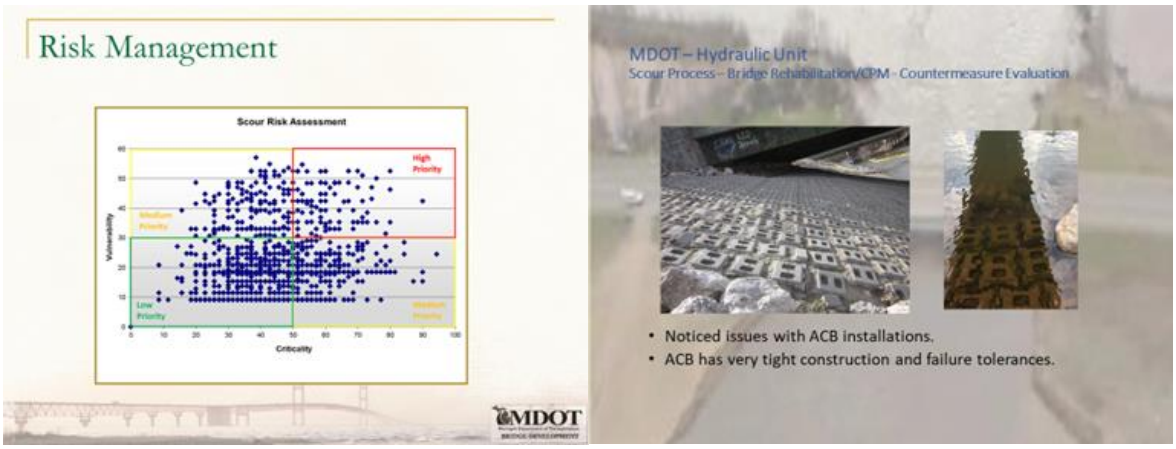


Figure 2: Slides from the "Scour Technology Transfer - General Procedures" presentation.

Figure 3: Presenters Beckie Curtis, Ryan Snook, and Eric Carlson.

4.2. Scour Risk Management

Jerry Richardson, Ph.D., University of Missouri - Kansas City (UMKC),
richardsonj@umkc.edu, (816) 235-1282

(Figures 4 and 5)

Link to presentation:
http://mtri.org/mdot_scour_workshop/2_Richardson_Scour%20risk%20management.pdf

- Risk Management is a hard topic
- Need to be better about observing the real world, including using physical models
- Need to improve understanding of level of hydraulic uncertainty
- Understanding the meaning of real risk – what is the risk of a 100-year flood after 25 years? (22.2%) – there is risk every year
- Primary options have been increasing level of conservatism or finding an expert to invoke; newer strategies are using risk-based approach & utilizing more experts with more "level 3" tools
- Results in higher engineering costs, but reduced structure & construction costs
- Hydraulic engineers need to be involved earlier in the bridge design process. Don't spend $10,000 on designing countermeasures on a $100 million bridge.
- "We need chefs, not just cookbooks"

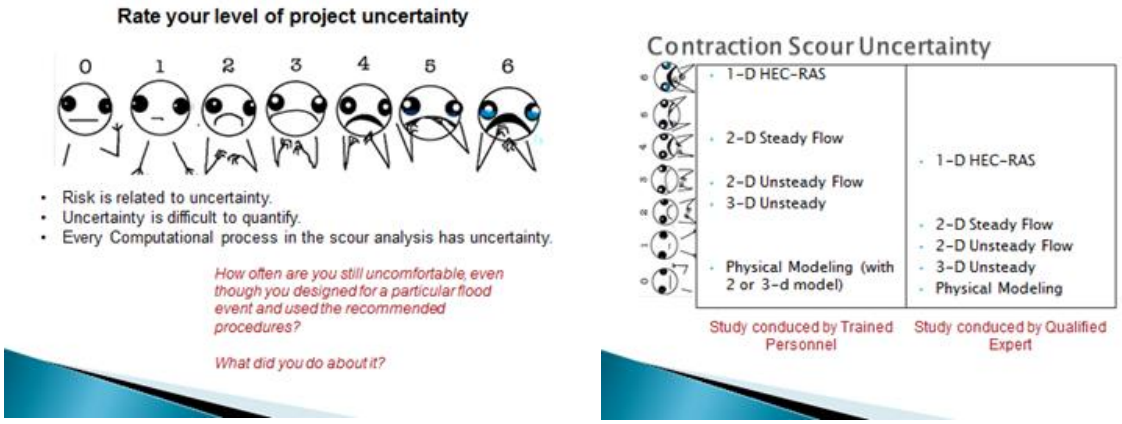


Figure 4: Slides from the "Scour Risk Management" presentation.

Figure 5: Presenter Jerry Richardson discussing scour risk management and project uncertainty.

4.3. USGS Streamflow Data in Michigan – Using the USGS National Water Information System (NWIS) Database

Thomas Weaver, U.S. Geological Survey (USGS), tlweaver@usgs.gov, (517) 887-8923

(Figures 6 and 7)

Link to presentation: http://mtri.org/mdot_scour_workshop/3_Weaver_Scour%20meeting.9-27-2017.tlw%20edits10-23-2017.pdf

- 192 surface water sites, 166 stream gages
- Historical stage vs. discharge data available
- https://mi.water.usgs.gov/ as starting point
- Users can create email & text "water alerts" – know if a gaged river goes above a certain discharge (cfs) or stage height (ft).
- Stream gages cost $18k - $25k per installation, but federal funding trend has been downward

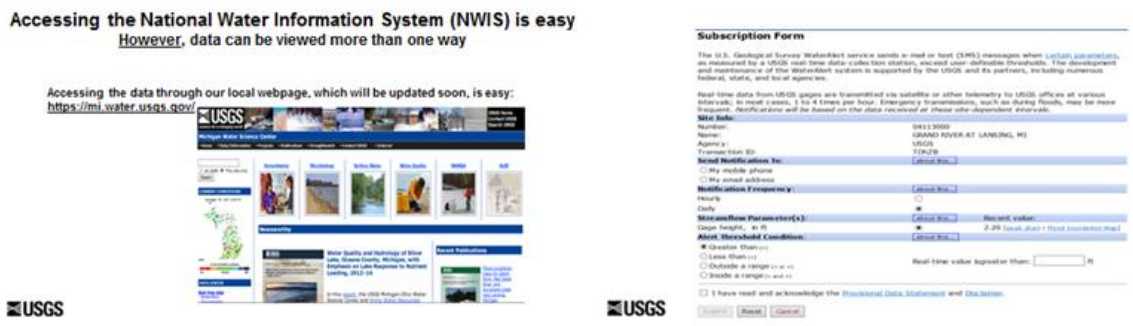


Figure 6: Slides from the "USS Streamflow data in Michigan - Using the USGS NWIS Database" presentation.

Figure 7: Presenter Thomas Weaver discussing the USGS National Water Information System database.

4.4. Observation Method: A New Tool for the Bridge Scour Engineer

Jean-Louis Briaud, Ph.D., Texas A&M, briaud@tamu.edu, (979) 845-3795

(Figures 8 and 9)

Link to presentation: http://mtri.org/mdot_scour_workshop/4_Briaud-Observation%20Method-5Oct2017.pdf

- Scour is the #1 reason for bridge failure
- Bridge failures (due to scour) has greatly decreased in the past 50 years due to research
- Erosion rates differ based on the type of sand, clay, gravel, or rock and the mean grain size
- Observation method developed due to calculated scour depths being larger than depths observed – OMS tool
    - Observe maximum scour depth
    - Use gage data to determine maximum flood bridge has experienced
    - Predict future scour depth based on field measurements
    - Compare further scour depth to foundation depth
- Pros:
    - Use for bridge repair prioritization
    - Input to FHWA risk approach
    - Actual soils, flow, and geometry
    - Can reduce conservatism over HEC-18 analysis
- Limits:
    - Requires network of gages
    - Cannot be used for new bridges

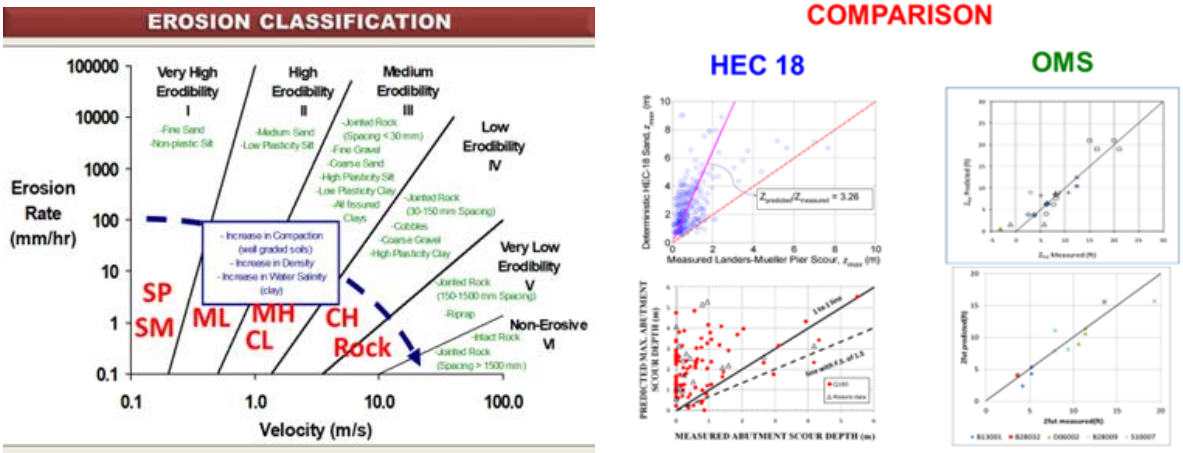


Figure 8: Slides from the "Observation Method: A New Tools for the Bridge Scour Engineer" presentation.

Figure 9: Presenter Jean-Louis Briaud discussing the Observation Method.

4.5. Scour Modeling and Analysis

Jerry Richardson, Ph.D., University of Missouri - Kansas City, richardsonj@umkc.edu, (816) 235-1282

(Figures 10 and 11)

Link to presentation:
http://mtri.org/mdot_scour_workshop/5_Richarson_Scour%20modeling%20and%20analysis.pdf

- Advanced scour modeling (Level 3A) should be implemented into analyses
  - 2-D hydraulic models – become easier
  - Physical models
  - 3-D and Sediment Transport models
- Physical first models reduce costs, are observable, and produce unanticipated findings.
- Integrating physical and numerical models yields cost savings
  - Example of saving 60% for client by building N. Platte River model
- Vigorous analysis decreases cost by minimizing uncertainty

Figure 10: Slides from the "Scour Modeling and Analysis" presentation.

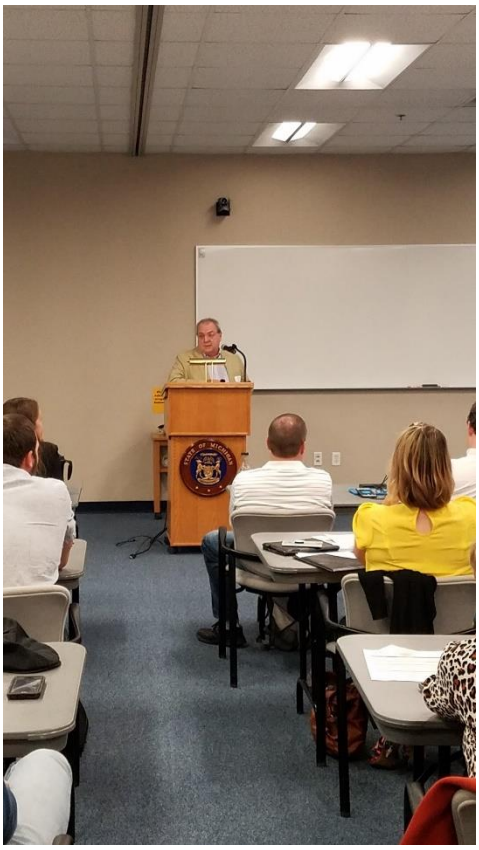


Figure 11: Presenter Jerry Richardson discussing advanced scour modeling.

4.6. High Flow Monitoring

Rich Kathrens, MDOT, kathrensr@michigan.gov, (517) 322-5715
Mike Halloran, MDOT, halloranm@michigan.gov, (269) 327-4499
(Figures 12 and 13)

Link to presentation:
http://mtri.org/mdot_scour_workshop/6_Halloran_Scour%20Tech%20Transfer%20Presentation_Final.pdf

- Ch.6 Scour updated in MiSIM
- MiBRIDGE High Flow Event Reports
    - Inspector can monitor past events to determine level of confidence and predict with scour will be a concern
    - Inspector can record observations from the site during scour event
- Monitoring guidelines:
    - Begin monitoring when flood warning issued
    - Follow Plan of Action
    - (Re)visit bridge during flooding until post-event inspection
    - Update Plan of Action as necessary
- Additional tools for monitoring scour:
    - Deeper Smart Sonar PRO+ Fish Finder – build depth maps, cast from shore, $250

- ArcGIS High-Flow Monitoring Tool

Figure 12: Slides from the "High Flow Monitoring" presentation.

Figure 13: Presenters Rich Kathrens (left) and Mike Halloran (right).

4.7. MDOT Bathymetric Boat Survey Research Project

Brian Schroeder - Ayers Associates, SchroederB@ayresassociates.com, (970) 223-5556
(Figures 14 and 15)
Link to presentation:
http://mtri.org/mdot_scour_workshop/7_Schroeder_MDOT%20Scour%20Summit%20171005%20-%20Bathymetric%20Boat%20Survey%20Presentation%20w-o%20notes.pdf

- MDOT selecting a bathymetric survey boat based on a number of criteria and ratings
  - Quick deployment
  - Efficient measurements
  - Long-term support
  - Hull shape, speed, battery, weight, etc.
  - Be able to handle strong current, high water
- Selected boat will be able to record measurements above and below the surface
  - Sonar underneath, camera on top

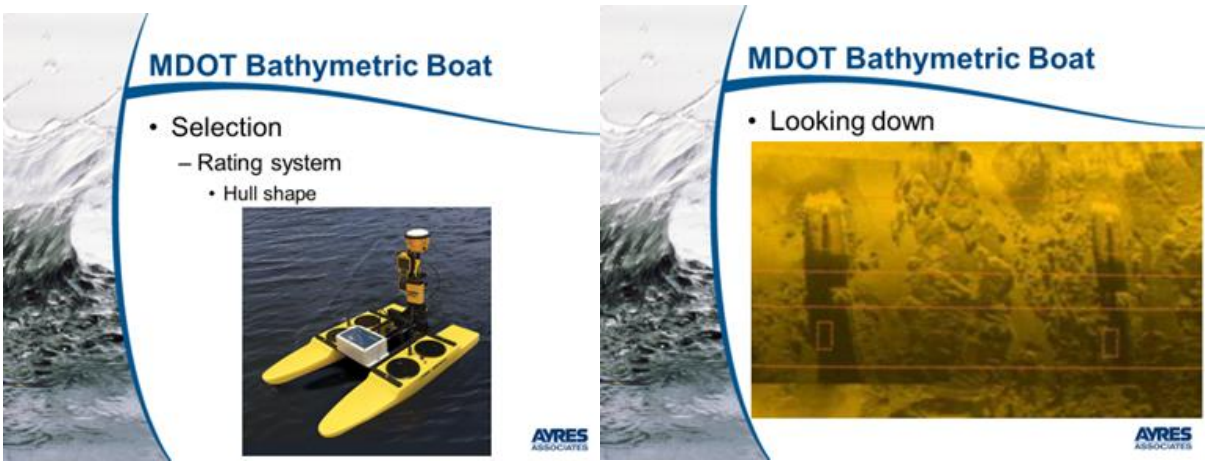


Figure 14: Slides from the "MDOT Bathymetric Boat Survey Research Project" presentation.

Figure 15: Presenter Brian Schroeder presenting on the bathymetric boat research project.

4.8. Multibeam Sonar Case Study

Lucas Hanson - Spicer Group, lucash@spicergroup.com, (989) 754-4717
(Figures 16 and 17)

- Multibeam sonar is beneficial as it increases:
  - Accuracy
  - Level of detail
  - Coverage area
- Integrating with GPS increases positional accuracy (DGPS/RTK/PPK)
- Bridges throughout Michigan have been assessed
  - Lafayette Bascule Bridge in Bay City, MI: Two large scour holes found near piers
  - Fort Street Bridge in Detroit, MI: Established baseline for future scour analysis
  - M-35 over Cedar River in Menominee County, MI: Pier footing exposed

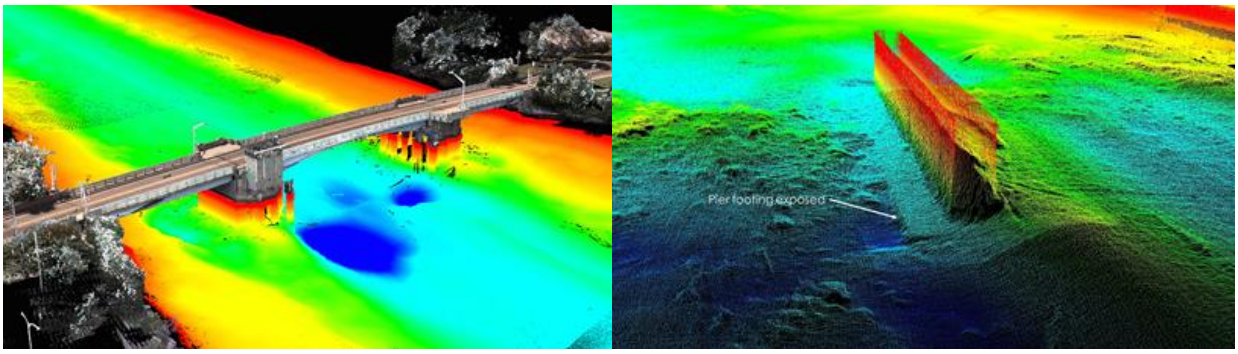


Figure 16: Slides from the "Multibeam Sonar Case Study" presentation.

Figure 17: Presenter Lucas Hanson presenting on multibeam sonar.

4.9. Bathymetric Survey Boat – Case Studies

Phil Case - Gourdie Frasier, phil@gfa.tc, (231) 946-5874
Jon Arleth - Gourdie Frasier, Jon@gfa.tc, (231) 946-5874
(Figures 18 and 19)
Link to presentation:
http://www.gfa.tc/mdot_hydraulic/

- Bathymetric Survey Boat allows for improved accessibility and quick / easy launch and retrieve
    - Using Seafloor EchoBoat
    - Seeing data in real-time
    - 3 case studies
- Data is immediately analyzed in on-site trailer
- In addition to the survey boat, terrestrial LiDAR is used to collect above water data

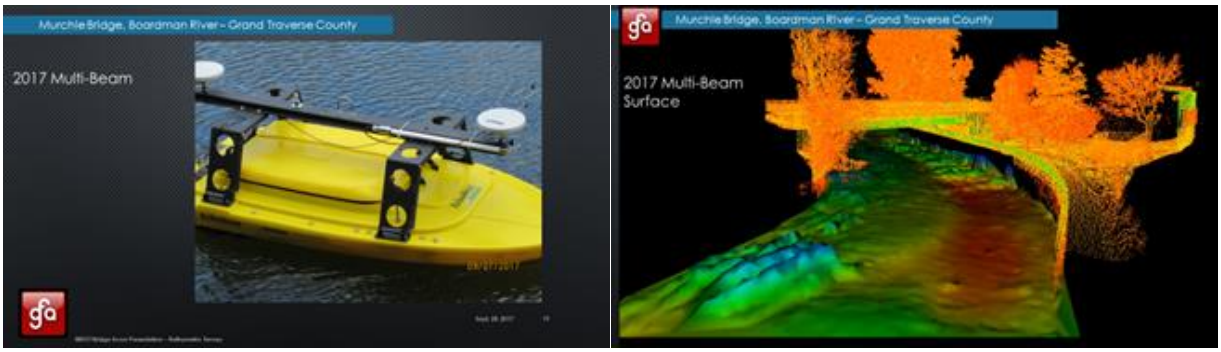


Figure 18: Slides from the "Bathymetric Survey Boat - Case Studies" presentation.

Figure 19: Presenters Jon Arleth and Phil Case discussing their bathymetric survey boat applications.

4.10. Field Inspection and Monitoring of Scour of Bridge Width Culverts

Therese Kline - MDOT, KlineT@michigan.gov, (517) 420-7942`
(Figures 20 and 21)

- Culvert inspection can be compared to zombies
    - Slow zombies - road way is not yet impacted;
        - Soil movement at in/outlets
        - Curtainwall beginning to be exposed
        - Debris
        - Minor slope loss
        - Can still be dealt with with cheaper solutions sooner, before road/shoulder impacts
    - Fast zombies – road surface is reflecting condition of culvert;
        - Slope failure
        - Shoulders/roadway impacted
        - (mis-)alignment
        - loss of backfill material
        - footing breakage

Figure 20: Slides from the "Field inspection and Monitoring of Scour of Bridge Width Culverts" presentation.

Figure 21: Presenter Therese Kline discussing culvert inspection.

4.11. Countermeasure Design, Implementations, and Monitoring

Nicole Bartelt - Minnesota Department of Transportation (MnDOT), nicole.bartelt@state.mn.us, (651) 366-4474

(Figures 22 and 23)

Link to presentation:
http://mtri.org/mdot_scour_workshop/11_Bartelt_Bridge%20Scour%20Tech%20Transfer%20Workshop_Oct2017.pdf

- MnDOT has assessed and evaluated all scour critical bridges; each assigned a scour code and plan of action
- Countermeasures – riprap (most common), guidebanks/spurdikes, bendway weirs, and articulated concrete blocks (least common)
- New countermeasures – matrix riprap (partially grouted), geobags (geotextile bags filled with aggregate)
- Countermeasures are inspected during and after flooding to ensure proper performance
    - Visual observations, 3D sonar, tilt sensors, underwater diving

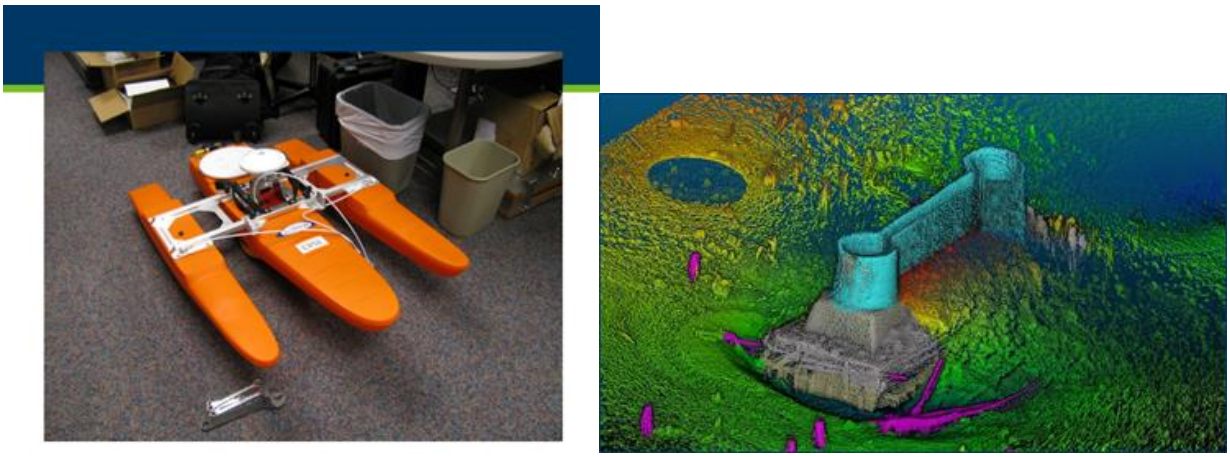


Figure 22: Slides from the "Countermeasure Design, Implementations, and Monitoring" presentation.

Figure 23: Presenter Nicole Bartelt discussing MnDOT's scour countermeasures.

4.12. FHWA's Future Scour Design Approach

Kornel Kerenyi - Federal Highway Administration (FHWA), Kornel.Kerenyi@dot.gov, (202) 493-3142

(Figures 24 and 25)

Link to presentation:
http://mtri.org/mdot_scour_workshop/12_Kerenyi_Scour%20Workshop%20-%20FHWA%2010-05-2017.pdf

- FHWA Hydraulic Engineering Lab – future vision
- New version of HEC-18 in 2018
- Scour modeling goals
    - 2017: Physical (40%), Numerical (60%)
    - 2018: Physical (35%), Numerical (65%)
    - 2020: Physical (30%), Numerical (70%)
    - 2030: Physical (20%), Numerical (80%)

- Critical soil erosion resistance is being testing using in-situ devices and ex-situ experiments (erosion rate curve)
- Vision for more automated systems
    - Ex: by 2030, drones will pick up & deliver soil samples from field to lab for faster, more automated processing
    -

Figure 24: Slides from the "FHWA's Future Scour Design Approach" presentation.

Figure 25: Presenter Kornel Kerenyi presenting on FHWA's scour design approach.

4.13. Countermeasures to Protect Abutments from Scour

R. Andrew Swartz - Michigan Technological University, raswartz@mtu.edu, (906) 487.2439
(Figures 26 and 27)
Link to presentation:
http://mtri.org/mdot_scour_workshop/13_Swartz_ScourCountermeasures_2017.pdf

- Overview of NCHRP 587 (Brian Barkdoll, MTU)
- "Scour countermeasures are good protection when applied correctly!"
- Countermeasures considered:
    - Approach-channel control
    - Downstream channel control
    - Armoring of bridge opening
    - Bridge modification

    - Drainage control
- Recommended steps for countermeasure design:
    - Identify process causing scour
    - Select countermeasure
    - Select construction method
    - Design countermeasure
    - Review
- Countermeasures & construction options described to meet scour concerns

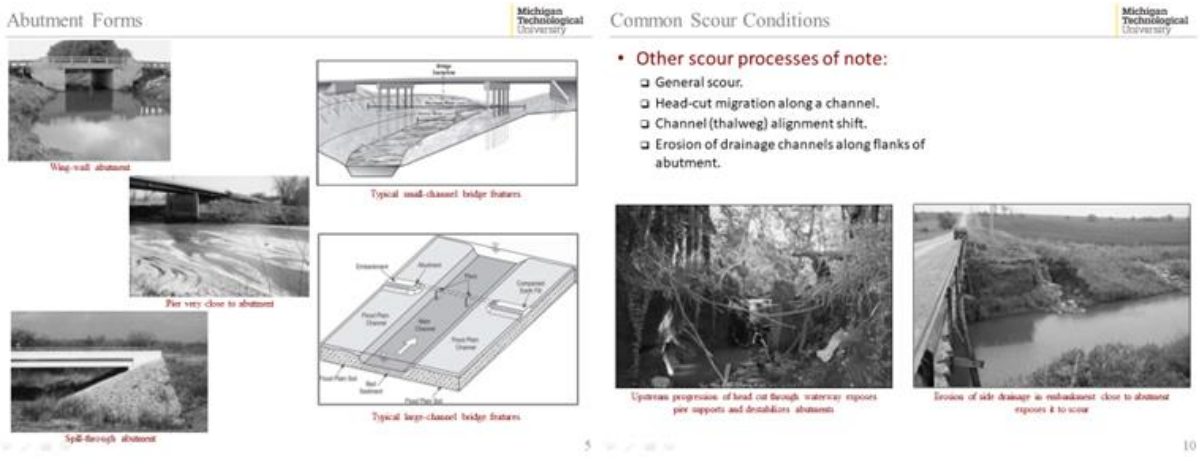


Figure 26: Slides from the "Countermeasures to Protect Abutments from Scour" presentation.

Figure 27: Presenter R. Andrew Swartz presenting on NCHRP Report 587.

4.14. Implementing Plans of Action

Rich Kathrens – formerly MDOT
Chad Skrocki - MDOT, skrockic@michigan.gov, (989) 220-9633
(Figures 28 and 29)
Link to presentation:
http://mtri.org/mdot_scour_workshop/14_Skrocki_Kathrens_Implementing%20Plans%20of%20Action.pdf

- All bridges over water must be scour evaluated as indicated by National Bridge Inventory (NBI) coding; with scour critical bridges having a plan of action
    - FHWA performing field evaluations
- After major flooding event, all scour critical bridges are evaluated first
- New technology and methods are assisting in scour readings
    - Deeper Pro+ sonar bobber
    - Painted elevation markers

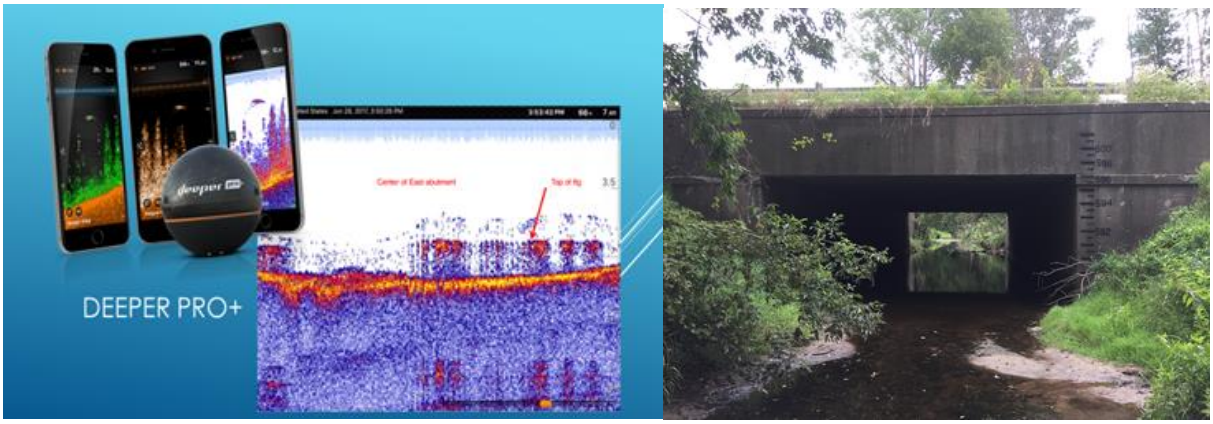


Figure 28: Slides from the "Implementing Plans of Action" presentation.

Figure 29: Presenter Chad Skrocki discussing scour plans of actions.

4.15. Questions and Answers Session

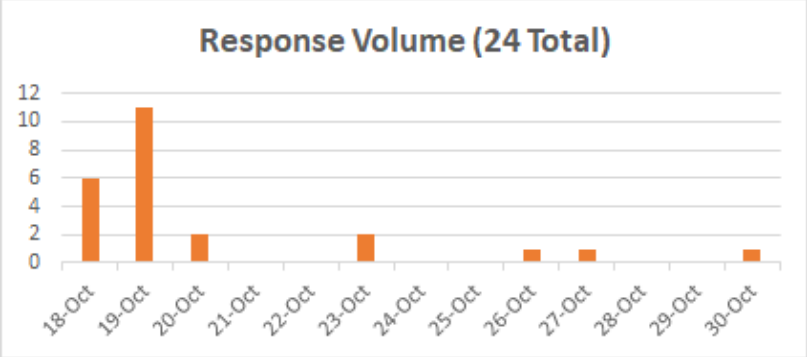
- There was an active questions and answer session, with discussion on:
    - Critical shear strength of cohesive soils
    - Known techniques for arresting slaking
    - Requirement for scour analysis on bridges over 20' (Federal)
    - Understanding vulnerability vs. criticality
    - Flood probabilities are not the same as bridge failure risk
    - 14% change of 500-year flood in 75 years
    - Are we using the right design flood for our bridges? Should it be longer?
    - EFA (Erosion Function Apparatus – push-up) from Texas A&M – not useful for bedrock

    - Discussion of how scour problem is more for older bridges
    - What fails? It's often the approach embankment, the bridge may be fine
    - Is there a need for a certification program for countermeasure analysis?
- Beckie Curtis – conclusion session
    - Very dedicated group keeping people safe
    - MI can learn from other efforts
    - Making presentations available (with permission of presenters)

4.16. Survey Results

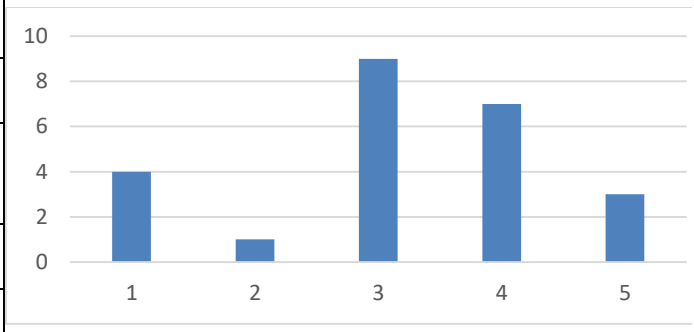
An online survey was made available to attendees on Oct. 18, 2017 using the web tool Survey Monkey (www.surveymonkey.com). The survey received 24 responses. We started receiving responses on Oct. 18 and the last response was received on Oct. 30 (Figure 30).

Figure 30: Survey response volume over the two-week period of responses.



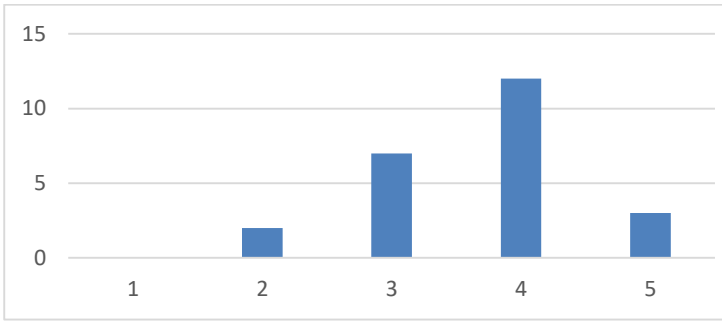
Question 1: How would you rate your understanding of scour issues before attending the class?
Answer 1: 3.17 (weighted average from 24 responses)

Level of Understanding	Responses
1 – Introductory	4
2 – Introductory to Moderate	1
3 – Moderate	9
4 – Moderate to Expert	7
5 – Expert	3



Question 2: How would you rate your understanding of scour issues after the transfer?
Answer 2: 3.67 (weighted average from 24 responses)

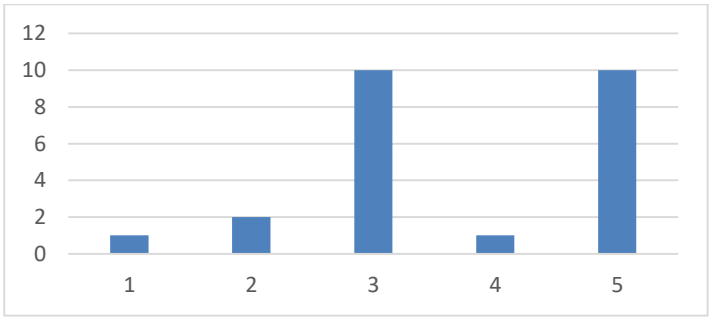
Level of Understanding	Responses
1 – Introductory	0
2 – Introductory to Moderate	2
3 – Moderate	7
4 – Moderate to Expert	12
5 – Expert	3



Question 3: How likely are you to further investigate the analysis, mitigation or inspection techniques discussed in the transfer?

Answer 3: 3.71 (weighted average from 24 responses)

Level of Understanding	Responses
1 – Not Very Likely	0
2 – Not Likely/Likely	2
3 – Likely	7
4 – Likely/Very Likely	12
5 – Very Likely	3



Question 4: What worked best at the workshop?
Answer 4: 6 people skipped this question. The individual answers are:

- The presentations by different disciplines.
- The variety of scour related topics
- A varied group of presenters.
- Networking!
- Results of modelling
- All good
- The local coordination was superior.

- Very well organized agenda and all presentations were on schedule. This is very unusual.
- Hearing from other agencies and representatives outside of the Michigan area.
- I liked that there were multiple disciplines represented that could offer different insights to the issue of scour as a whole. I think everybody probably learned some great info.
- Presentations and interaction with other attendees.
- trying to get microphone to audience members
- I think bringing in experts from around the nation was what helped make this workshop worthwhile.
- Professors presentations and the modeling
- The moderators did a very good job of keeping the presentations on schedule.
- Information
- The many speakers with varied backgrounds & approaches.
- The workshop stayed on schedule very well

Question 5: What could have been improved?
Answers 5: 10 people skipped this question. The individual answers are:

- Some handouts
- More time for Q&A, networking
- Too fast - more time on topics NOT the boat
- Gluten Free Option at Breakfast
- A little more time to catch up with the speakers, but I did have to leave right after
- Cannot think of anything
- Add another day to allow more discussion.
- I really liked the whole thing.
- the screen is hard to see if not in first few rows (in my opinion). it would be nice to have handouts of every presentation prior to the class so that one could follow along on the handouts if they could not see the screen.
- Having a wireless microphone would have been nice for the speakers.
- Nothing
- Use a bigger space so more people can attend.
- Nothing
- Could have been more technical

Question 6: What other topics would you like more information on?
Answers 6: 10 people skipped this question. The individual answers are:

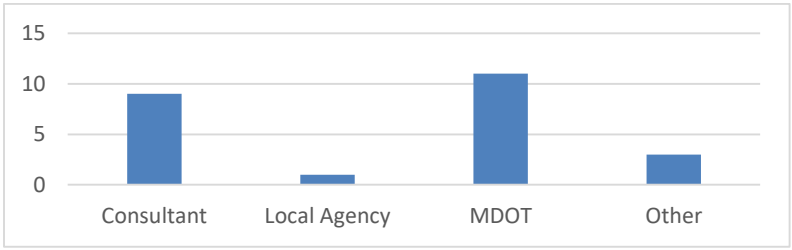
- Health monitoring
- Bridge maintenance
- Scour mitigation: rip rap, how to stop what's happening
- None
- Physical process modeling
- If possible, share more case studies
- I'm personally interested in anything that I can learn. Maybe have a construction-specific course on the ins and outs of the different scour countermeasures. I also think a preventive maintenance course would be beneficial.

- Alternate mitigation measures for SC bridges that have piers in the river.
- NA
- Anything related to bridge hydraulics
- Mitigations done on specific projects and how they held up after major storm events.
- Load rating culverts, especially CMP. The worksheets provided by MDOT do not seem to provide realistic results.
- Integrating high-resolution bathymetric & 3D LiDAR data into scour modeling.
- Additional details on how the physics work

Question 7: What agency are you affiliated with?

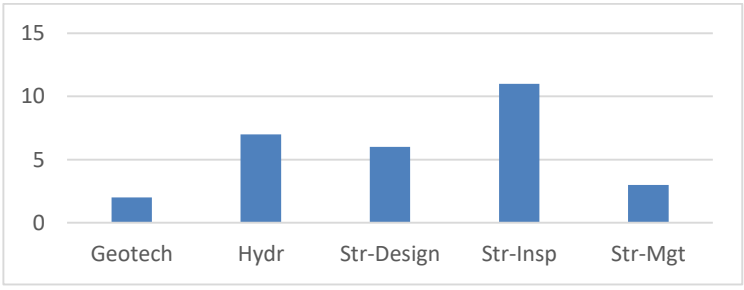
Answer 7: 23 people responded

Agency	**Response**	**%**
Consultant	9	39.13
Local Agency	1	4.35
MDOT	11	43.48
Other - FHWA, MTRI	3	13.04



Question 8: What discipline do you most often practice?
Answer 8: 23 people responded

Discipline	Response	%
Geotechnical	2	9.09
Hydraulics	7	31.82
Structures-Design	6	27.27
Structures-Inspection	11	54.55
Structures-Management	3	13.64



4.17. Additional Comments

Following the workshop, Michigan Tech received initial feedback from a few individuals:

"[The workshop] was very informative, interesting, and well-organized. Also, breakfast and lunch were far superior to anything I've ever had at a workshop. :) You did a wonderful job!"
Patricia Schriner, Taiga Engineering

"Thank you for hosting the workshop. The level of care and planning was truly first rate. As a speaker I thought it was flawless."
Jerry Richardson, University of Missouri - Kansas City

"It was very well done and gave me an opportunity to learn about MDOT's scour related issues."
Kornel Kerenyi, FHWA

4.18. Project Website

A website overviewing the event was created and is hosted by Michigan Tech; http://mtri.org/mdot_scour_workshop.html (Figure 31). The website contains a brief overview of the event, agenda, and links to each presentation (from whom we received permission to post from the presenter).

Figure 31. Project webpage.

5. Findings and Conclusions

In discussing the workshop with the MDOT program manager and Research Advisory Panel, and the MDOT Bridge Committee, eight main themes emerged from the workshop, which were:

1. It is important to understand uncertainty in scour risk management.
2. There are useful tools and data available online, such as the USGS NWIS stream gage data for Michigan, the ArcGIS High Flow Monitoring Tool, and new bathymetric data platforms.

3. The Observation Method may be useful as captured by the OMS Tool.
4. Advanced Scour Modeling, including 3D capabilities, should be implemented into analysis.
5. Culvert monitoring can be better prioritized.
6. New countermeasures such as matrix riprap, along with good documentation of correct application, are helpful.
7. FHWA is moving towards more numerical scour modeling vs. physical modeling.
8. Plans of Action help with effective response to flooding.

In addition, Program Manager Beckie Curtis shared two main concluding points with the workshop, which were:

- There is a very dedicated scour monitoring group in Michigan keeping people safe
- Michigan can learn from other efforts at the state, federal, and private sector levels.

The central recommendation that emerges from this tech transfer workshop is that MDOT should continue to keep track of and implement bridge scour risk management advancements, using knowledge and capabilities from within Michigan and across the country. Taking advantage of advancements in 3D scour modeling may be particularly important. Jerry Richardson (UMKC) noted that Michigan should be considered a leader in scour risk management; continuing MDOT's scour programs and research will be important to maintaining this leadership.

6. Bibliography

Capers, H. (2016). Findings of the NCHRP 20-68A - "US Domestic Scan Program" Domestic Scan 15-02 "Bridge Scour Risk Management". *Proceedings of the 11th US-Taiwan Bridge Engineering Workshop*, Taipei, Taiwan, October 20-21, 2016, 11 pgs.

Deng, L. and Cai, C.S., 2010. Bridge scour: Prediction, modeling, monitoring, and countermeasures—Review. Practice periodical on structural design and construction, 15(2), pp.125-134.

Landers, M.N. and Mueller, D.S., 1996. Channel scour at bridges in the United States. National Technical Information Service Monograph No. FHWA-RD-95-184). United States Geological Survey (Reston, VA) and Federal Highway Administration (McLean, VA). 140 p.

7. Appendices

A.1. List of Acronyms, Abbreviations, and Symbols

AASHTO	American Association of State Highway and Transportation Officials
CTT	Center for Technology & Training
DOT	Department of Transportation
EFA	Erosion Function Apparatus
FHWA	Federal Highway Association
MDOT	Michigan Department of Transportation
Michigan Tech	Michigan Technological University
MnDOT	Minnesota Department of Transportation
MTRI	Michigan Tech Research Institute
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
NWIS	National Water Information System
RAP	Research Advisory Panel
OMS	Observation Method for Scour
TRB	Transportation Research Board
UMKC	University of Missouri Kansas City
USGS	U.S. Geological Survey

A.2. Organizing the Scour Technology Transfer Event

Michigan Tech led the organization of the event by communicating with invited speakers and agencies, setting up travel to and from the event, providing food and refreshments, and creating/assembling all handout materials and speaker presentations, abstracts, and background information. Additionally, Michigan Tech created the event's agenda, which contained 14 different presentations and 17 speakers split up amongst the five general topic areas. The agenda can be viewed in Appendix A.5. Speakers were from a number of different agencies and organizations including:

- MDOT
- University of Missouri - Kansas City
- USGS
- Texas A&M
- Ayers Associates
- Spicer Group
- Gourdie Fraser
- MnDOT
- FHWA
- Michigan Tech

Invitations

Two invitations were created for the event; one for MDOT personnel and one for other local agencies. Both indicated how to register for the event and who to contact for additional information. Invitations were initially distributed on August 11, 2017 and August 17, 2017 for MDOT employees and local agencies, respectively. Both invitations can be found in Appendix A.6.

Registration

MDOT personnel were directed to register through contacting Sarah Wedley (MDOT). Registration was free and included included refreshments, breakfast, and lunch. All attendees received continuing education credits after the workshop. Michigan Tech worked with Sarah Wedley to receive regular updates on the number of attendees. Registration closed on September 15th, with a total of 51 MDOT registrations.

Non-MDOT personnel were directed to register through Michigan Tech's Center for Technology & Training (CTT) (http://ctt.nonprofitsoapbox.com/bridgescour). The price for attending was set at $26.00 per attendee, which included refreshments, breakfast, and lunch. To keep the total number of attendees below the maximum number of people allowed in the event space (100 maximum), registration was restricted to one person per organization. For attending the event, each attendee received continuing education certifications. During the registration period, Michigan Tech received weekly updates from CTT. Registration closed on September 28th, with a total of 32 non-MDOT registrations.

A.3. Implementation Action Plan

Based on the results of this project, the following Implementation Action Plan is meant to direct the Research Advisory Panel and MDOT executives in applying changes within department policy or practices. This guide provides an overview of the project and the problems

it focused on changing. Additionally, the outcomes and potential values to MDOT are reviewed.

Project Title: Bridge Scour Technology Transfer

Project Number: contract no. 2016-0067 Z4, research no. SPR-1673

Principal Investigator: Colin Brooks

Project Manager: Beckie Curtis

Research Manager: Michael Townley

Implementation Manager: Beckie Curtis

Description of Problem:

New applications of technologies and systems are being developed, tested, and implemented that can reduce bridge scour risk. With scour and flooding being the lead cause of bridge failures in the U.S., technology transfer of advancements in managing bridge scour risk is critical to getting these results implemented at the state level. The National Cooperative Highway Research Program (NCHRP), administered by the Transportation Research Board (TRB), has been actively engaged in domestic scans to help expand the rate of information exchange among transportation practitioners. Scan 15-02, on "Bridge Scour Risk Management", had its active scan period completed during the summer of 2016. The Michigan Department of Transportation (MDOT) asked for assistance in organizing and executing a technology transfer event to host national experts and peer agencies to enable more thorough and faster dissemination of its findings to MDOT personnel and contractors.

Major Discoveries:

The technology transfer event was held in October 2017 and consisted of 14 presentations covering five general scour topic areas:

1. General Procedures and Risk Analysis
2. Scour Modeling and Analysis
3. Monitoring and Field Inspection of Scour Critical Bridges
4. Design, Construction, and Sustainability of Countermeasures
5. Plan of Action

After the event, the MDOT and the project team discussed and reviewed topics that appears in multiple presentations and/or feedback received from participants. Eight main themes were drawn from the event, including:

1. It is important to understand uncertainty in scour risk management.
2. There are useful tools and data available online, such as the USGS NWIS stream gage data for Michigan (waterdata.usgs.gov/nwis), the ArcGIS High Flow Monitoring Tool (mdot.maps.arcgis.com), and new bathymetric data platforms.
3. The Observation Method may be useful as captured by the Observation Method for Scour (OMS) Tool.

4. Advanced Scour Modeling, including 3D capabilities, should be implemented into analysis.
5. Culvert monitoring can be better prioritized.
6. New countermeasures such as matrix riprap, along with good documentation of correct application, are helpful.
7. FHWA is moving towards more numerical scour modeling vs. physical modeling.
8. Plans of Action help with effective response to flooding.

In addition, Program Manager Beckie Curtis shared two main concluding points with the workshop, which were:

- There is a very dedicated scour monitoring group in Michigan keeping people safe
- Michigan can learn from other efforts at the state, federal, and private sector levels.

How the information will be used in MDOT:

The information gained through the technology transfer event should be used by MDOT to track of and implement bridge scour risk management advancements, using knowledge and capabilities from within Michigan and across the country. Taking advantage of advancements in 3D scour modeling may be particularly important and should be investigated in the department. MDOT should continue its scour programs with the addition of the information and technologies discussed during the event.

Value Added to MDOT:

The technology transfer event provided valuable information to MDOT, provided by local, state, and national experts in scour. The presentations overviewed past, current, and future technologies and tools that are being used to model and predict scour. Although MDOT is currently a national leader in scour monitoring, the department should continue to research and implement such tools and technologies into their scour programs. 2-D and 3-D scour models provide not only quantitative information, but also valuable, high-resolution qualitative information.

Checklist:

The following checklist provides a summary for MDOT on understanding of the type of results achieved during this project and what items or actions are needed to implement these results (Table 1).

Table 1: Implementation Action Plan Checklist

Results achieved through this research (check all that apply)		Items/Actions needed to implement results (check all that apply)	
X	Knowledge to assist MDOT	X	Management decision
	Manual change	X	Funding
	Policy development or change	X	Training
	Development of software/computer application	X	Information technology deployment
X	Development of new process	X	Information sharing
X	Additional research needed		Other (specify)
	Project produced no usable results		
	Other (describe)		

A.4. Findings of the NCHRP 20-68A – "US Domestic Scan Program" Domestic Scan 15-02 "Bridge Scour Risk Management" – Harry A. Capers Article

Proceedings of the 11th US-Taiwan Bridge Engineering Workshop
Taipei, Taiwan, October 20~21, 2016

Findings of the NCHRP 20-68A– "US Domestic Scan Program" Domestic Scan 15-02 "Bridge Scour Risk Management"

Harry A. CAPERS

Vice President and Cooperated Engineer, Arora and Associates, P.C., Princeton Pike Corporate Center, No.1200, Lenox Drive, Suite 200, Lawrenceville, NJ 08648-2372, U.S.A.
E-mail: hcapers@arorapc.com

ABSTRACT

Flooding and scour are recognized by the bridge community as the leading cause of bridge failures in the United States. About 83 percent of the structures listed in the National Bridge Inventory cross waterways and are thereby exposed to the threats of flooding and scour. Agencies responsible for bridge safety seek effective threat-mitigation strategies, including installation of scour countermeasures to monitor, control, inhibit, change, delay, or minimize stream instability and bridge-scour susceptibility.

A scan team comprised primarily of bridge engineers from state transportation agencies met with representatives of multiple Departments of Transportation (DOT) that have had successful experience with Bridge Scour Risk Management to assess the state of the practice and share it with others. The scan participants examined 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.

Upon completion, this data will be synthesized and disseminated to interested engineers, bridge owners and other stakeholders to make information about successful Bridge Scour Risk Management applications more available to the transportation industry. The products of this scan will provide insights on the Bridge Scour Risk Management for the benefit of American Association of State Highway and Transportation Officials (AASHTO's) Subcommittee on Bridges and Structures, Subcommittee on Highways and others.

This paper provides an overview of the proposed scan, including the motivation, information gathered to date, and expected benefits.

1. THE DOMESTIC SCAN 15-02 "BRIDGE SCOUR RISK MANAGEMENT"

Flooding and scour are of the structures listed in the National Bridge Inventory cross waterways and are thereby exposed recognized by the bridge community as the leading cause of bridge failures in the United States. About 83 percent to the threats of flooding and scour. Agencies responsible for bridge safety seek effective threat-mitigation strategies, including installation of scour countermeasures to monitor, control, inhibit, change, delay, or minimize stream instability and bridge-scour susceptibility.

This scan examined 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 also considered how innovative bridge owners assess structural vulnerability or bridge scour susceptibility.

The scan team examined innovative approaches such as:

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

The scan team also focused 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. 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.

1.1 What is the 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.

The NCHRP U.S. Domestic Scan Program (NCHRP Project 20-68A) recognizes the value of person-to-person exchange of new technologies and practices in a setting that facilitates "hands on" learning. Launched in 2006 the program was funds up to three scans per year. The scans put state and federal DOT practitioners in touch with innovative peers around the country, speeding the transfer of technology and know-how.

Scans are conducted as one- or two-week traveling tours with visits to five to seven states, or as centralized peer exchanges/workshops. During the intense experience of the scan, participants can see firsthand how a new technology or practice works in the real world and develop close professional relationships that remain readily available to them even years later.

1.2 Why are Scans Effective?

A scan focuses on **face-to-face discussion** of current experience. Scans:

- Hastens the movement of tested **new ideas into widespread practice**
- Develops professional **connections that reach across agencies and geography**
- Provides opportunity for a **unique rich exchange of information**
- Generates a sharing mechanism that is **difficult or impossible to replicate** through written materials, telephone conversations or e-mail correspondence
- Complements published research and professional conferences by **reducing the time lag between the successful application** of a new idea and the point at which others learn about it
- Experience and research show the peer-to-peer communication is one of the most effective ways of learning.

Deployment of technology in any field occurs when new ideas are disseminated and widely adopted by practitioners. Experience illustrates that enabling information exchange directly among practitioners accelerates the rate of the exchange and facilitates adoption into practice.

The face-to-face discussion of current experience provides opportunities for a rich exchange of information that is difficult or impossible to replicate through written materials, telephone conversations, and e-mail correspondence. Even informal discussions and observations among the scan team and their host agencies contribute to the accumulation of useful information.

The program has shown that the "scan" approach is a productive means of spreading information and encouraging innovation. Many domestic scan program participants and observers have noted that new ideas are emerging in state and local transportation agencies around the United States, and that faster dissemination of these ideas can yield substantial benefits. We believe that as a result of this scan and the hard continued efforts of its team members will accelerate the use of effective practices in the area of Bridge Scour Risk Management across transportation agencies in the U.S.

Additional Program details are available at domesticscan.org

1.3 Scan Team

To conduct the scan, a team of experts was identified based on their professional knowledge and training, assignments within their State Departments of Transportation and AASHTO regional affiliation. Due to the technical requirements of the scan an effort was made to insure that professionals with expertise in structures, geotechnical engineering and hydraulics were included in the team and that all geographical areas of the U.S. were represented to insure that regional differences were considered.

Members of the team include:

Rebecca Curtis– AASHTO Chair	**Jon Bischoff**
Bridge Management Engineer	Geotechnical Engineer Specialist
Michigan DOT	Utah Department of Transportation

Xiaohua "Hanna" Cheng, PhD, P.E.
Civil Engineer, Bureau of Structural Engineering
New Jersey Department of Transportation

Stephanie Cavalier, P.E.
Bridge Scour Manager
Louisiana Department of Transportation and Development (LADOTD)

Rick Marz
Bureau of Structures Maintenance Chief
Wisconsin DOT

Kevin Flora
Senior Bridge Engineer, Structure Maintenance and Investigations
California Department of Transportation (CALTRANS)

Hani Nassif, P.E., Ph.D., Professor-SME
Department of Civil and Environmental Engineering

Rutgers, The State University of New Jersey
NCHRP Panel's General Guidance to the Scan Team

2. TEAM ASSESSMENT

Through this desk scan, it is shown that many DOTs can provide meaningful and insightful information on their experiences with Bridge Scour Risk Management processes and practices. However, due to the time limitation, limited numbers of DOTs were selected for follow-up and further investigation. During the organizational meeting, and based on input from the preliminary literature review and discussions with panel members, 14 states were identified and selected for future visits or invitation to attend the workshop. These 14 states are: Florida, New York, California, Iowa, Minnesota, Michigan, Missouri, Pennsylvania, Texas, Tennessee, Idaho, Louisiana, Mississippi, and Colorado. Figure 1 shows the geographic distribution with various regions being represented where green color states represent state with members of the Scan Panel and orange color are invited States.

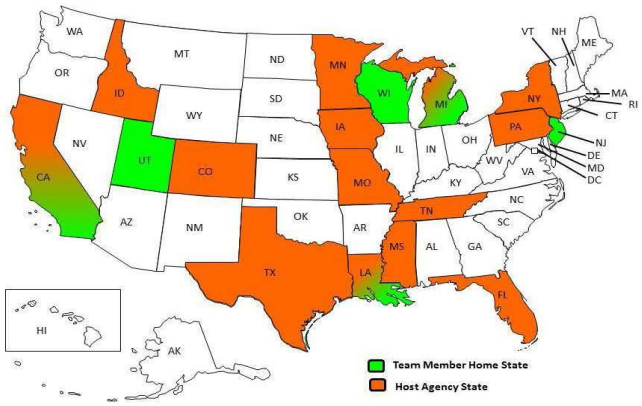


Figure 1: Scan 15-02 team members home state and invited agency states

2.1 Team's Approach

The scan was conducted as a peer exchange during the last week of July 2016. During their concluding discussions the Scan Team identified five key topics that are essential for the understanding of Scour Risk Management as follows:

1. General Procedures and Risk Analysis
2. Scour Modeling and Analysis
3. Monitoring and Field Inspection of Scour Critical Bridges
4. Design, Construction, and Sustainability of Countermeasures
5. Plan of Action (POA)

The following briefly summarizes the preliminary findings, conclusions and recommendations that the team intends to include in its final report on the scan and to U.S.A. as a basis for their dissemination and implementation activities in the future.

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

Conclusions:

- Scour Risk Management is a complex process and requires input and open communication from multiple disciplines (Figure 2).
- 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.

Recommendations:

- States need to form scour committees with interdisciplinary capabilities (i.e., Engineers from Geotechnical, Structural, and Hydraulics areas) to help address various issues related to scour mitigation.
- Additionally, since scour is a nation-wide threat and the number one cause of bridge failures, a scour committee at the national level is needed. It is recommended that AASHTO should create a task force to help form a multidisciplinary body that would develop guidelines and specifications for scour mitigation design and to serve as a clearing house for new innovations.
- Due to limited resources, rather than using vulnerability analysis to identify scour critical bridges only, States should consider using Risk Analysis to prioritize how to best apply their limited resources.

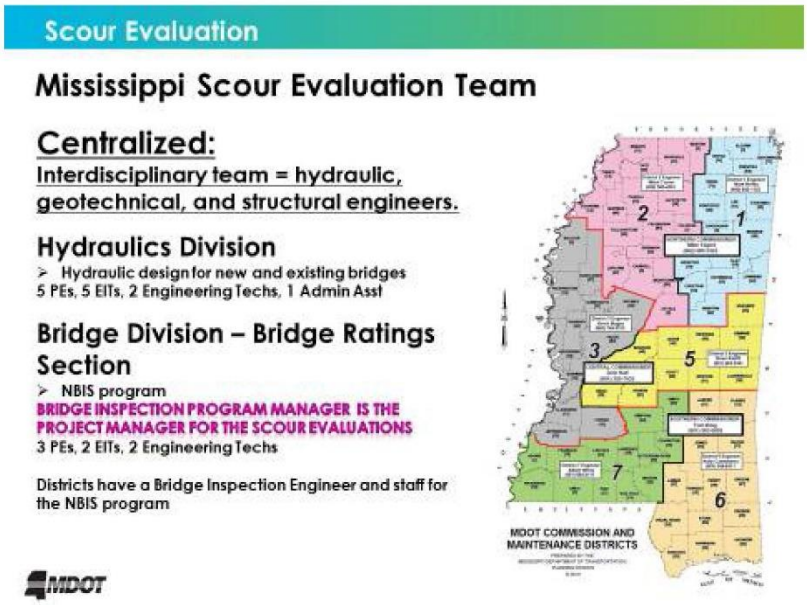


Figure 2: Mississippi scour evaluation teams

Figure 3: Rotating erosion test apparatus (RETA) at Florida DOT

Topic 2: Scour Modeling and Analysis

Findings:

- Better testing methods of soil and rock are needed in practice. Using Erosion test for site-specific type of soils (e.g., rock and clay) would improve scour predictions (Figure 3).
- 2D/3D hydraulic modeling to simulate stream flow can improve modeling and analysis.
- Texas has developed a velocity chart for verifying modeling. Texas Data management for quality control/assurance. Data checks, such as Texas case, can help provide quality control for scour predictions.
- Using Google earth to study historic stream migration patterns should be considered.
- HEC-18 provides a scour methodology for cohesive soils but requires shear stress which requires testing.

Conclusions:

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

Recommendations:

- Materials testing for cohesive soils or rocks can be 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.

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). Mississippi presented a case study for comparison only (2D versus HECRAS (1D or recent 2D). It is also noted that SRH-2D (2D modeling) is being used by most states.
- Highlight when to use the 2D or 1D-check in NCHRP documents (Minnesota). See Chapter 4 in that document which is related reference in HD-S7 Hydraulic Design of Safe Bridges.
- Improved and safer inspection methods (i.e. Sonar versus diving). For example, the use of "BlueView" Sonar is effective in helping visualize scour conditions.
- 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 to establish stream gauges and monitoring sites (Figure 4).

Conclusions:

- Advanced technology such as 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.

Recommendations:

- States are recommended to establish collaborative partnerships with USGS and other agencies which would help facilitate sustainable data collection for scour predictions.
- It is recommended that AASHTO and FHWA establish partnerships with USGS and other agencies for innovative applications that would help 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.

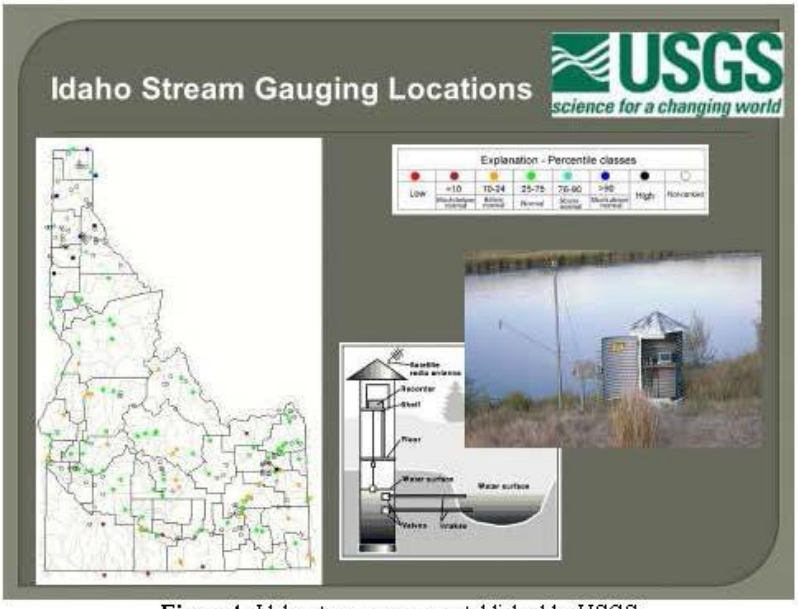


Figure 4: Idaho stream gauges established by USGS

Topic 4: Design, Construction, and Sustainability of Countermeasures

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

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 such as Articulated Mattresses, GeoBags, Caged Blocks, AJAX, rock riffle, in applying countermeasures. (Figure 5).
- Countermeasures have a shorter lifespan compared to the design and service life of the bridge.

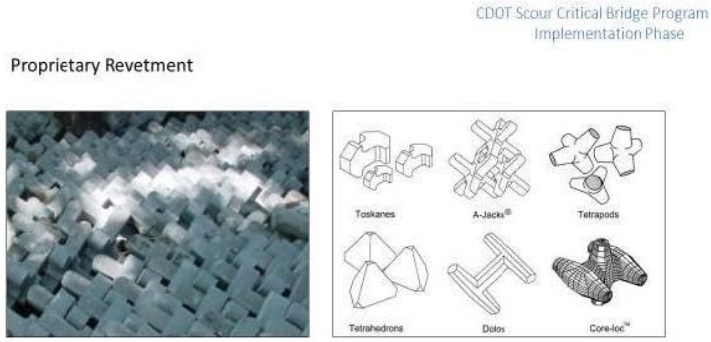


Figure 5: Countermeasures

Recommendations:

- States are encouraged to share lessons learned based on their specific experience with countermeasure design and application.
- States should pay more attention to inspecting countermeasures during construction and routine inspections.
- Establish a body to help disseminate the information related to the performance of various types of countermeasures.

Topic 5: Plan of Action (POA)

Findings:

- Implementing inspection during significant flood events can be a strain on departmental resources.
- Reduced work force in agencies is negatively affecting agencies ability to implement POAs.

Conclusions:

- Only few states included some 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.

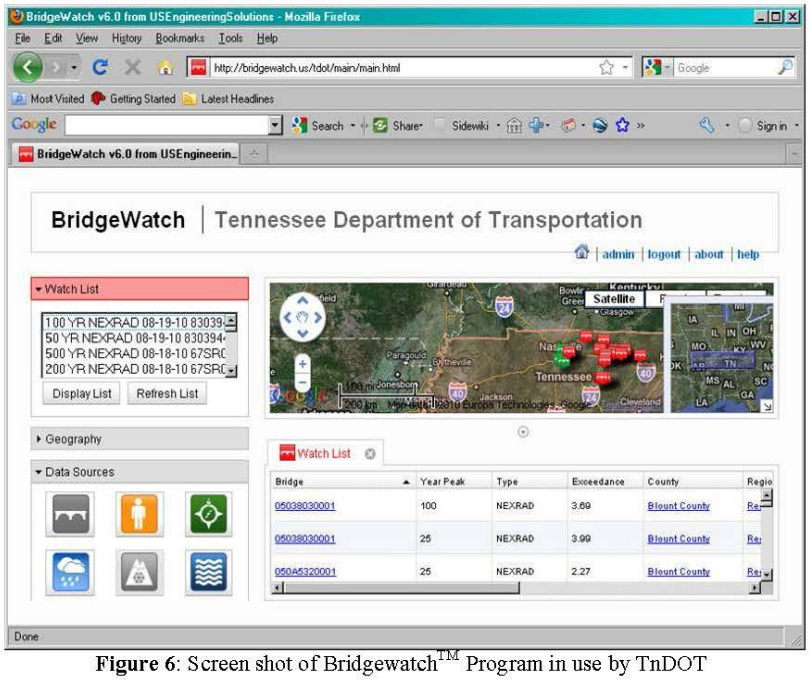


Figure 6: Screen shot of Bridgewatch™ Program in use by TnDOT

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.
- It is recommended that States 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.

3. THE FUTURE

A final report of scan activities and findings will be produced by the early part of 2017 and be made available as a free downloadable pdf document soon afterwards by NCHRP.

Compilation and interpretation of facts and insights from this scan are expected to help accelerate the adoption of new successful strategies, emerging technologies and sharing of lessons learned across the U.S. and internationally as well. It will be the responsibility of the scan team to share the team's findings among AASHTO members and the engineering community as a whole.

4. ACKNOWLEDGEMENTS

The project described in this paper is funded by the National Cooperative Highway Research Program, identified as NCHRP 20-68A Domestic Scan 15-02 **"Bridge Scour Risk Management"**. A special thanks is also extended to the hard working scan team and their invited successful agencies for their contributions to the success of this scan.

A.5. Bridge Scour Technology Transfer Agenda

Bridge Scour Technology Transfer

Location: Horatio Earle Learning Center
7575 Crowner Drive, Dimondale, Michigan 48821
October 5, 2017 – 8:00 AM - 5:00 PM

TIME	EVENT	SPEAKER(S)
8:00 AM – 8:30 AM	Registration and Breakfast	
8:30 AM – 8:45 AM	Welcome and Introduction	Matt Chynoweth, MDOT
8:45 - 8:50 AM Topic: General Procedures and Risk Analysis (Moderator: Beckie Curtis)		
8:50 AM – 9:20 AM	General Procedures	Beckie Curtis, Erik Carlson, Ryan Snook, MDOT
9:20 AM – 9:50 AM	Scour Risk Management & QA/QC	Jerry Richardson, Univ. of Missouri-Kansas City
9:50 AM – 10:20 AM	Stream Gage Monitoring and Coordination	Thomas Weaver, USGS
10:20 AM-10:30 AM	Break	
10:30 - 10:35 AM Topic: Scour Modeling and Analysis (Moderator: Brad Wagner)		
10:35 AM – 11:20 AM	Cohesive Scour Modeling & Analysis	Jean-Louis Briaud, Texas A&M
11:20 AM – 11:50 PM	Scour Modeling & Analysis	Jerry Richardson, Univ. of Missouri-Kansas City
11:50 PM – 12:45 PM	LUNCH	--
12:45 - 12:50 PM Topic: Monitoring & Field Inspections of Scour Critical Bridges (Moderator: Dick Endres)		
12:50 PM – 1:10 PM	MDOT High-Flow Monitoring and Field Inspections	Rich Kathrens, MDOT Mike Halloran, MDOT
1: 10 PM – 1:30 PM	MDOT Bathymetric Boat Survey research project	Brian Schroeder, Ayres Associates
1:30 PM – 1:50 PM	Multi-beam sonar case study	Lucas Hanson, Spicer Group
1:50 PM – 2:10 PM	Bathymetric survey boat case study	Phil Case, Travis Stricker, and Jon Arleth Gourdie Fraser
2:10 PM – 2:25 PM	Field Inspection and Monitoring of Scour of Bridge Width Culverts	Therese Kline, MDOT
2:25 PM - 2:35 PM	Break	
2:35-2:40 PM Topic: Design, Construction, and Sustainability Countermeasures (Moderator: Taylor Snow)		
2:40 PM – 3:10 PM	Countermeasure Design, Implementation, and Monitoring	Nicole Bartelt, MnDOT
3:10 PM – 3:30 PM	FHWA's Future Scour Design Approach	Kornel Kerenyi, FHWA
3:30 PM – 3:50 PM	Countermeasures to Protect Bridge Abutments from Scour	R. Andrew Swartz, MTU
3:50 – 3:55 PM Topic: Plan of Action (Moderator: Eric Burns)		
3:55 PM – 4:15 PM	Implementing MDOT Plans of Action	Chad Skrocki, MDOT Rich Kathrens, MDOT
4:15 PM – 4:45 PM	Ending Q&A Discussion	All speakers
4:45 PM – 5:00 PM	Conclusions	Beckie Curtis, MDOT

A.6. Invitations (MDOT and Non-MDOT)

YOU ARE INVITED

TO THE MICHIGAN DEPARTMENT OF TRANSPORTATION'S

MDOT
Michigan Department of Transportation

BRIDGE SCOUR TECHNOLOGY TRANSFER WORKSHOP

OCTOBER 05, 2017
8:30 AM TO 5:00 PM

REGISTRATION AND BREAKFAST 8:00 TO 8:30 AM
HORATIO EARLE LEARNING CENTER
7575 CROWNER DRIVE, DIMONDALE, MICHIGAN 48821

The Michigan Department of Transportation (MDOT) and the Michigan Tech Research Institute (MTRI) invite you to attend the upcoming **Bridge Scour Technology Transfer Workshop**.
The workshop, which will overview and share the results of the NCHRP Domestic Scan 15-02, "Bridge Scour Risk Management", is inviting national experts and peer agencies to attend and discuss current topics and trends in scour analysis, modeling, and monitoring.

The workshop includes refreshments, light breakfast, and lunch.

Please email Sarah Wedley (Wedley, Sarah (MDOT) WedleyS@michigan.gov) by Sept. 15, 2017, if you plan on attending the workshop. Continuing education certifications will be issued after the workshop.

For questions, please contact Michelle Wienert (mwienert@mtu.edu; 734-913-6870) or David Banach (dmbanach@mtu.edu, 734-994-7225).

Michigan Tech
Research Institute

Topics
- General Procedures & Risk Analysis
- Modeling Scour
- Monitoring & Field Inspection
- Sustainability & Countermeasures
- Plans of Action

Benefits
- Continuing Education Credits
- Panel Discussion with state and national experts
- Knowledge Sharing on Bridge Scour Technology Advancements

Presenting Agencies
- MDOT and other state-DOTs
- USGS
- FHWA
- University Researchers
- Gourdie Fraser
- Ayers Associates
- Spicer Group

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- **Due to limited space, we are asking only one registrant per organization.**
- **$26 participant fee will include refreshments, light breakfast, and lunch.**
- **Continuing education certifications will be issued after the workshop.**

Please register by September 28 at http://ctt.nonprofitsoapbox.com/bridgescour.

For questions, contact Michelle Wienert (mwienert@mtu.edu; 734-913-6870) or David Banach (dmbanach@mtu.edu, 734-994-7225).

No-shows or cancellations within three business days of the workshop will be charged the full registration fee. Substitutions are accepted.

Michigan Tech
Research Institute

Topics

- General Procedures & Risk Analysis
- Modeling Scour
- Monitoring & Field Inspection
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