ICSE-6 2012

PARIS Aug. 27-31, 2012
6th International Conference on Scour and Erosion

New Directions in Scour Monitoring

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New Directions in Scour Bridge Scour Monitoring

- Background
- New developments
- Revisions to U.S. FHWA HEC-18
- Conclusions

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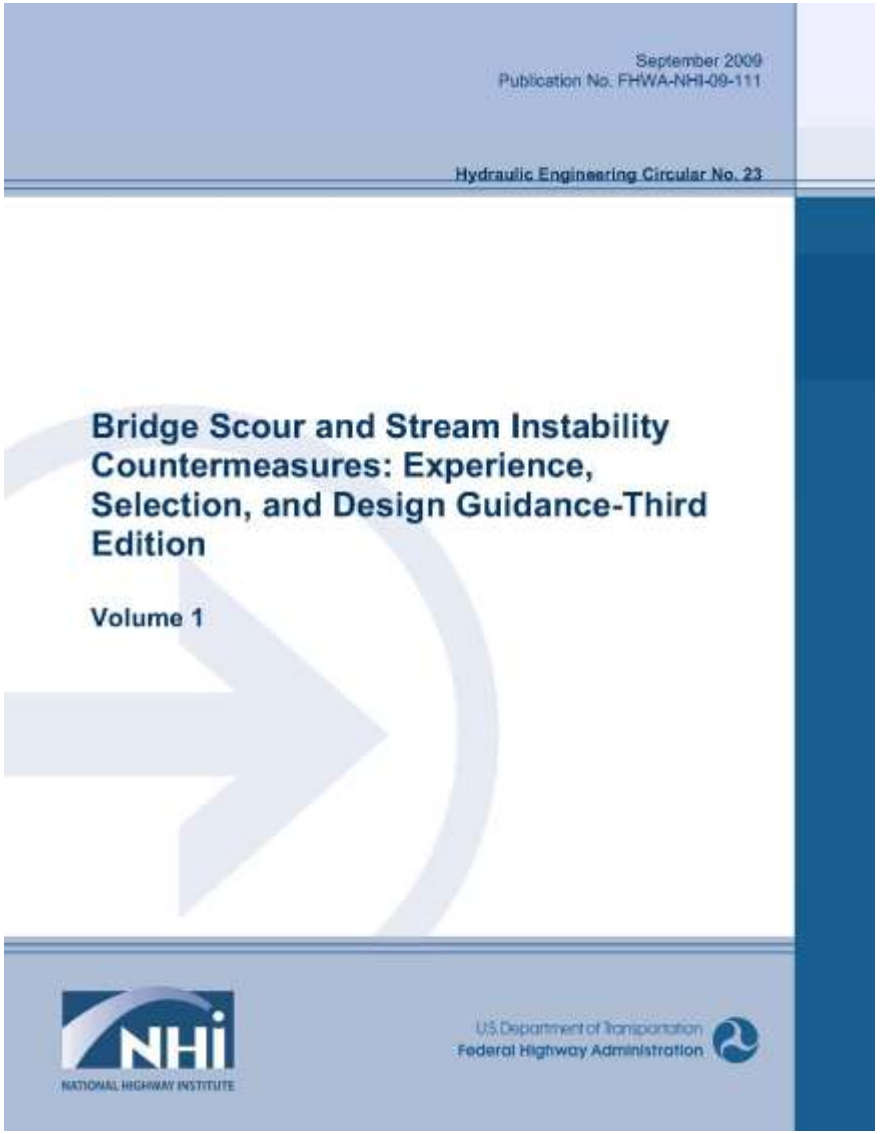
National Guidance – FHWA HEC-23



Bridge Scour and Stream Instability Countermeasures

New Third Edition, 2009

http://www.fhwa.dot.gov/engineering/hydraulics/pubs/09111

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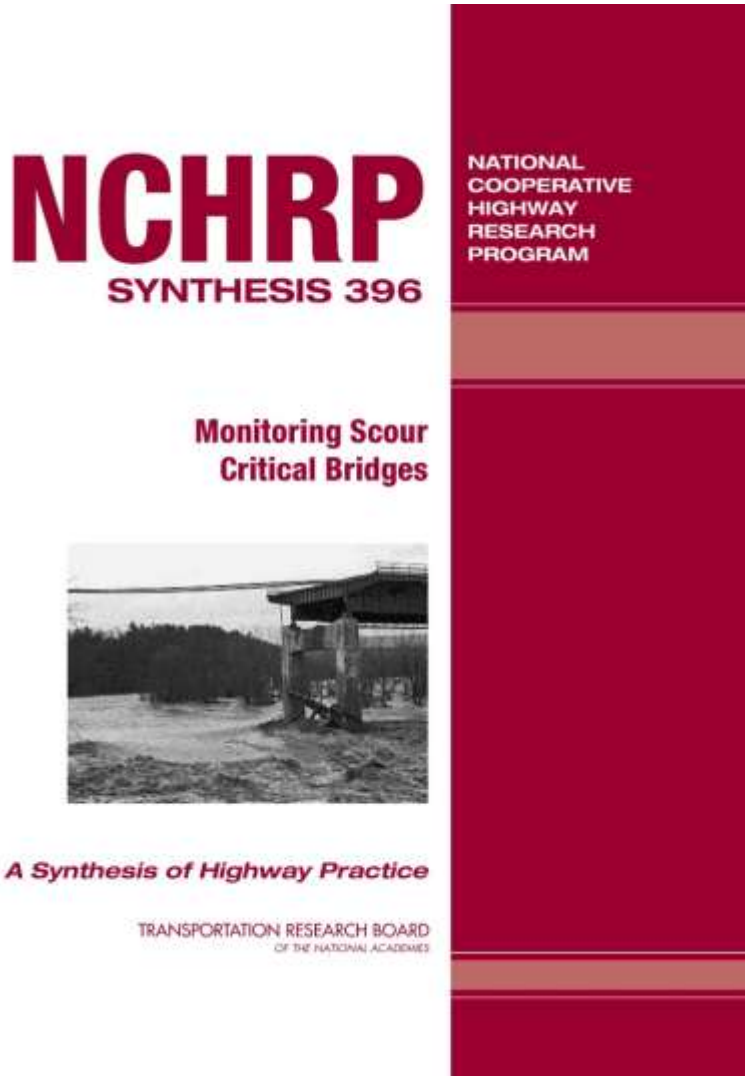
Practice Report - NCHRP Synthesis 396



Monitoring Scour Critical Bridges

2009

*http://onlinepubs.trb.org/onlinepubs/**nchrp/nchrp**_syn_**396**.pdf*

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Bridge Fixed Scour Monitoring Systems

- Real time monitoring
- Remote
- Wireless
- Data loggers
- Web-based
- Automatic alerts
- DATA ANALYSIS
- SENSORS

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Data Being Collected

- Streambed elevations
- Bridge movements

- Water stage
- Velocity measurements
- Rainfall

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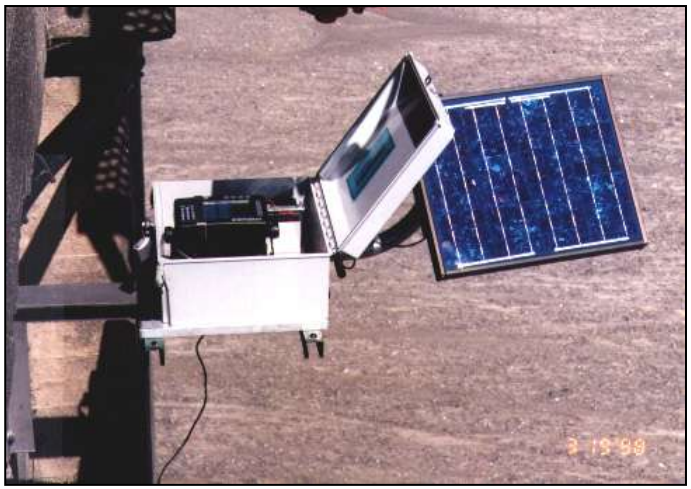
Telemetry Options

Landline



Satellite

Cellular

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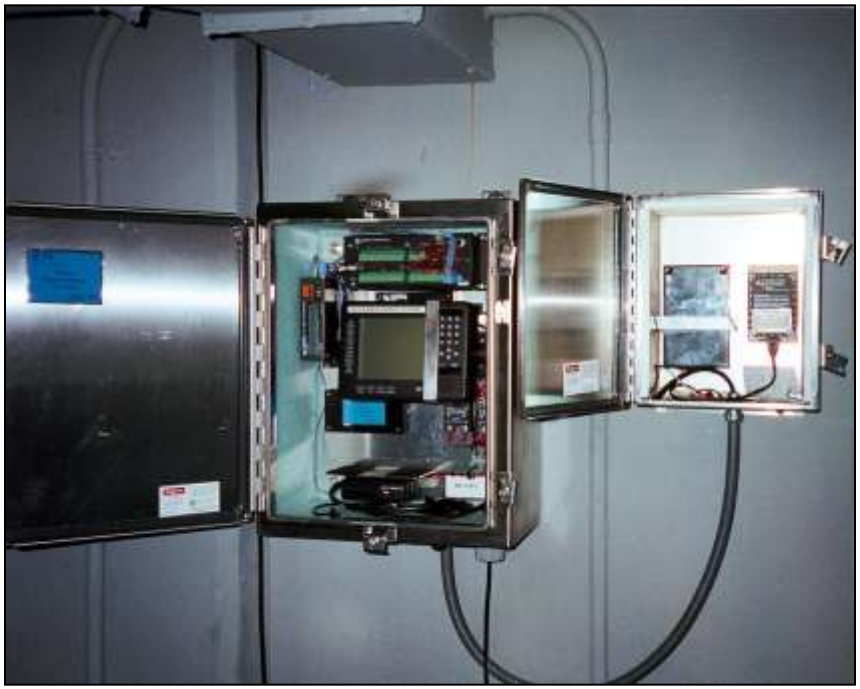
Data Loggers



Internet

Willis Avenue Bridge over the Harlem River / NYCDOT

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Powering the System

Solar

Commercial Power

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Types of Fixed Scour Monitors – FHWA HEC-23 (2009)

Sonar

Tilt Sensor

Time Domain Reflectometer

Magnetic Sliding Collar

Float-out

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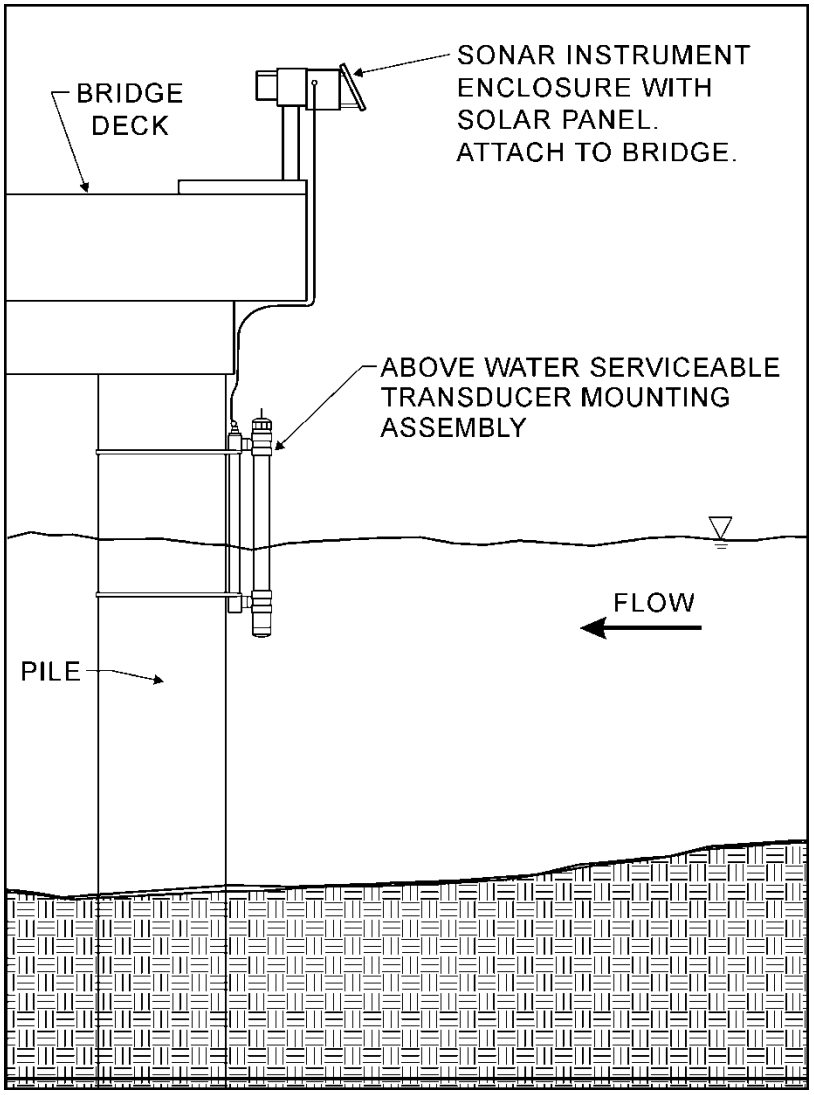
Sonar Scour Monitors



FHWA HEC-23

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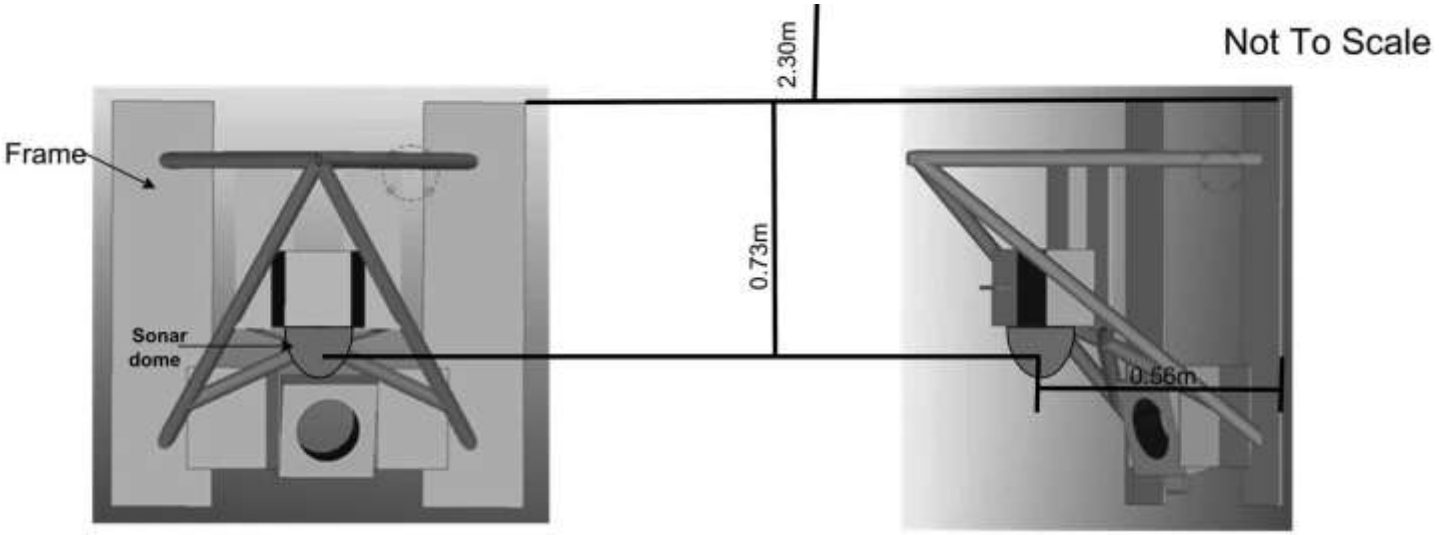
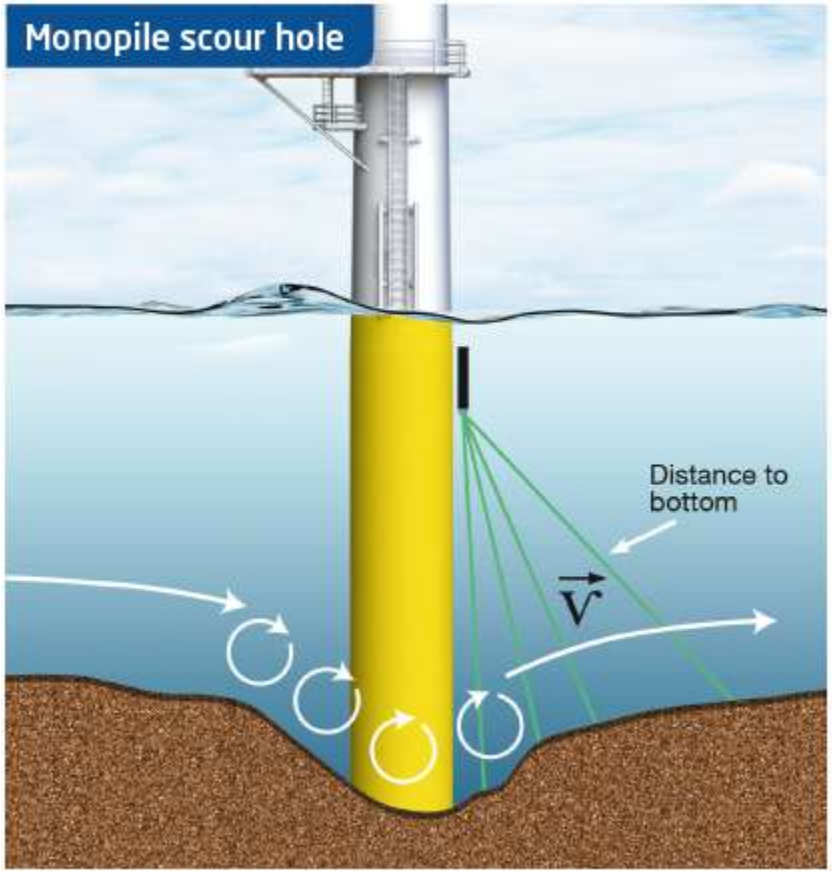
3-D Profiling Scanning Sonars

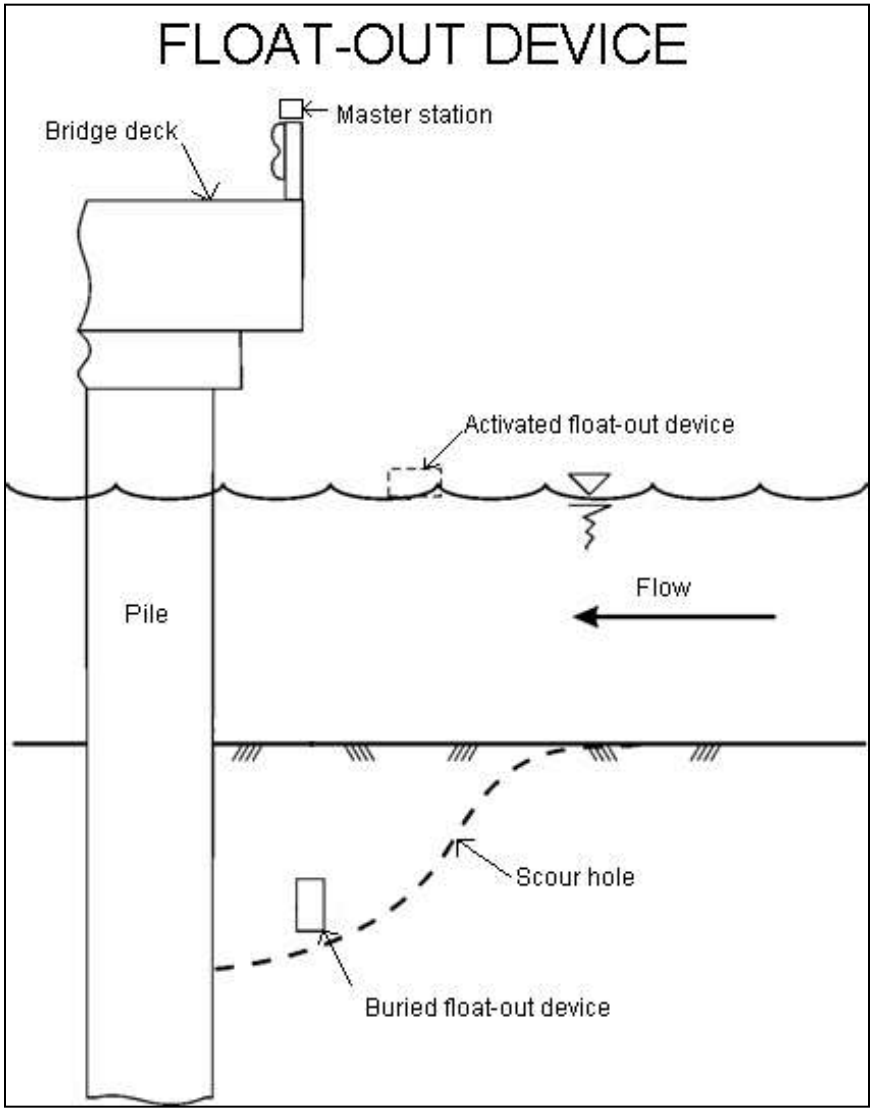


- Can observe wide areas of scour, 19,000 m^2
- Useful for monitoring armoring countermeasures

Acoustic Measurements – Four Transducers



Float-out Devices



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Tethered Buried Switches (TBS)

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Wireless Smart Rocks

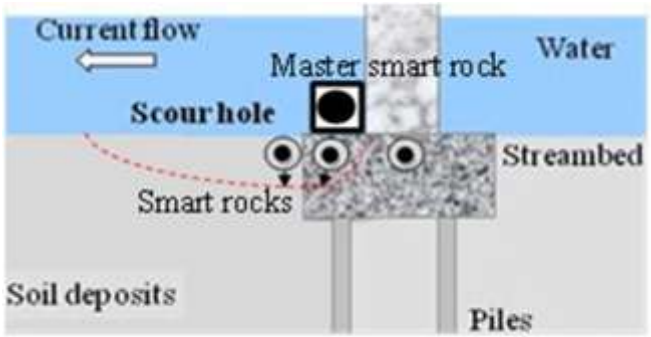


Fig. 1 Maximum Scour Depth Monitoring

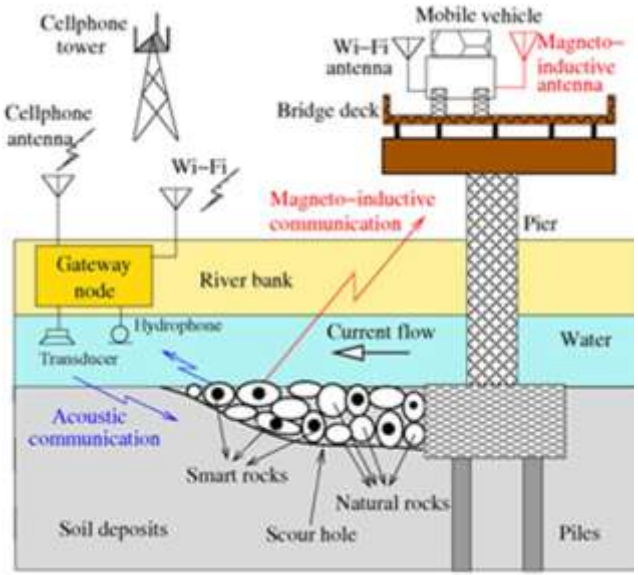
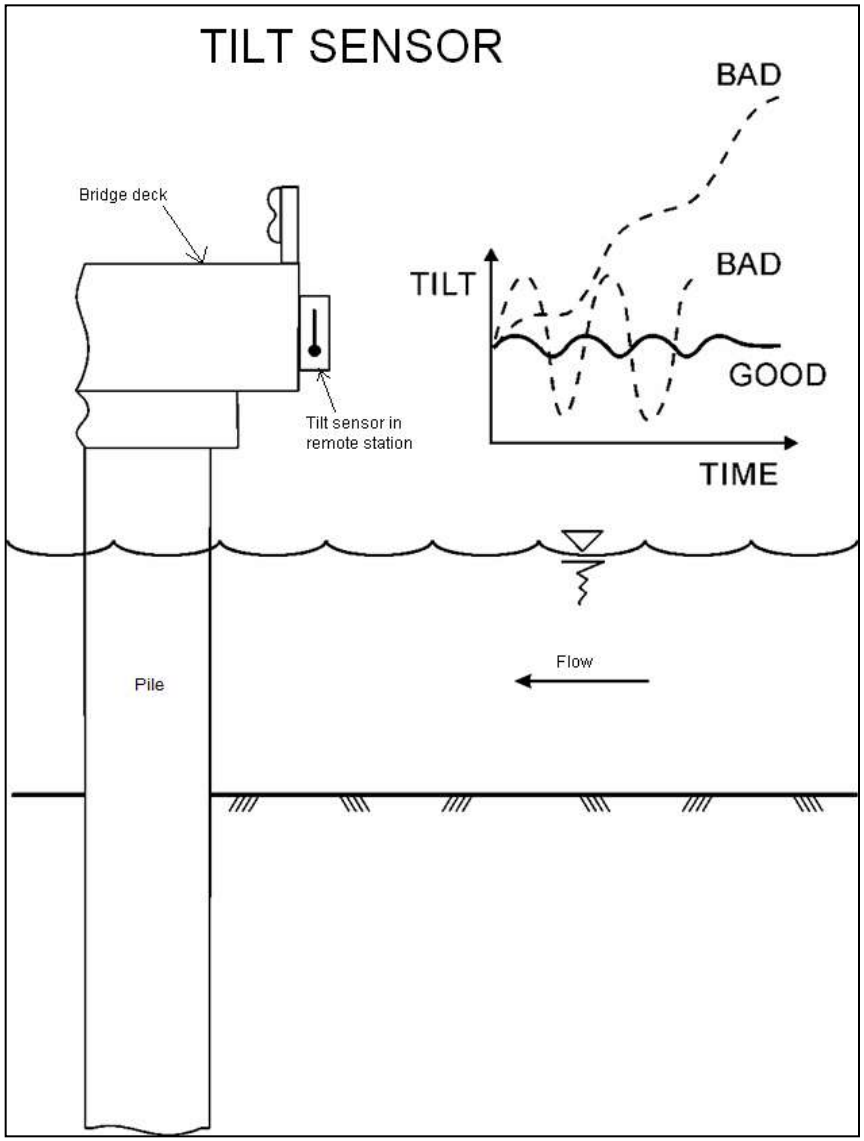


Fig. 2 Scour Countermeasure Monitoring

- Smart rocks - sensors packaged in rocks
- Passive sensors/rocks - directly read by instruments above water
- Active sensors/rocks - connected to a mobile vehicle with wireless communication systems
- Localization of smart rocks for scour information mapping on a GIS platform

Tilt Sensors



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Caltrans

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Motion Sensors / Accelerometers

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Monitoring of 3 Bridges for Scour
New York City Department of Transportation

STRAAM™

Mosholu Bridge
(4th Vibrational Mode)

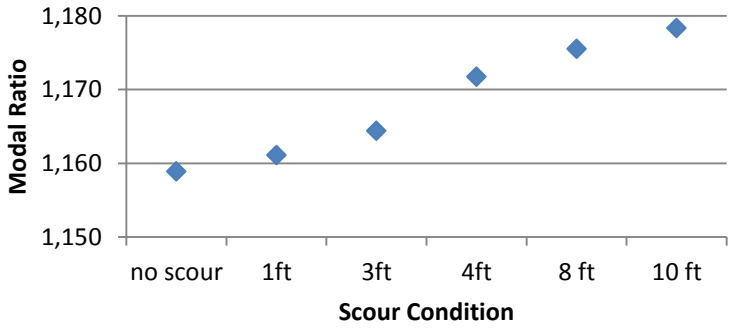
No Scour
16.41 Hz.

With Scour
16.19 Hz.

With 1ft Scour on Downstream Side of Pier #3
16.35 Hz.

	no scour	1ft	3ft	4ft
Frequency	14.16	14.09	13.99	13.86
	14.73	14.70	14.69	14.67
	15.58	15.55	15.52	15.48
	16.41	16.36	16.29	16.24
Modal ratio				
1 to 2	1.040	1.043	1.050	1.058
2 to 3	1.058	1.058	1.057	1.055
3 to 4	1.053	1.052	1.050	1.049
1 to 4	1.159	1.161	1.164	1.172

Scour effect on modal ratio (4th to 1st)



www.straam.com STRAAM Contact: twinant@straamllc.com

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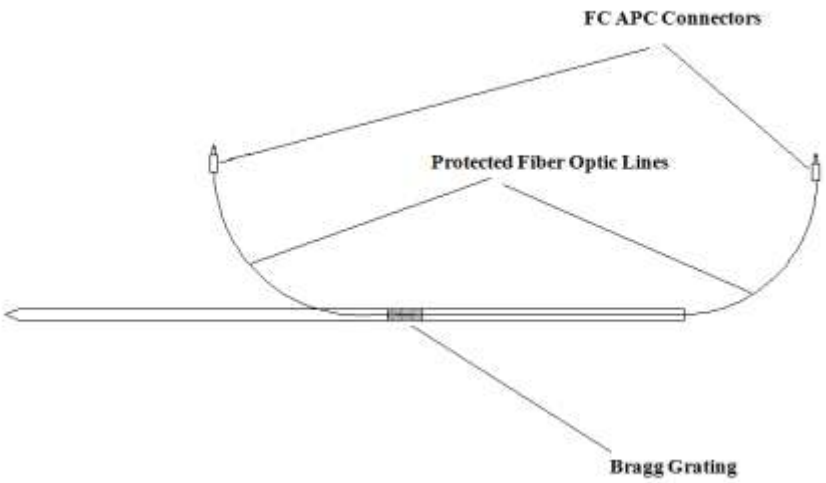
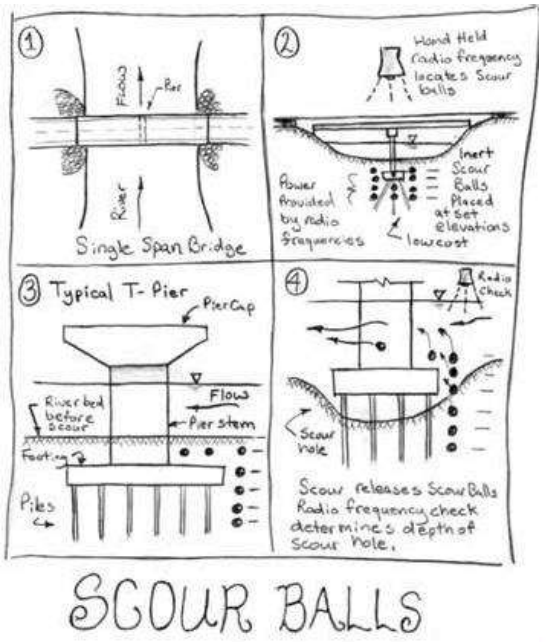
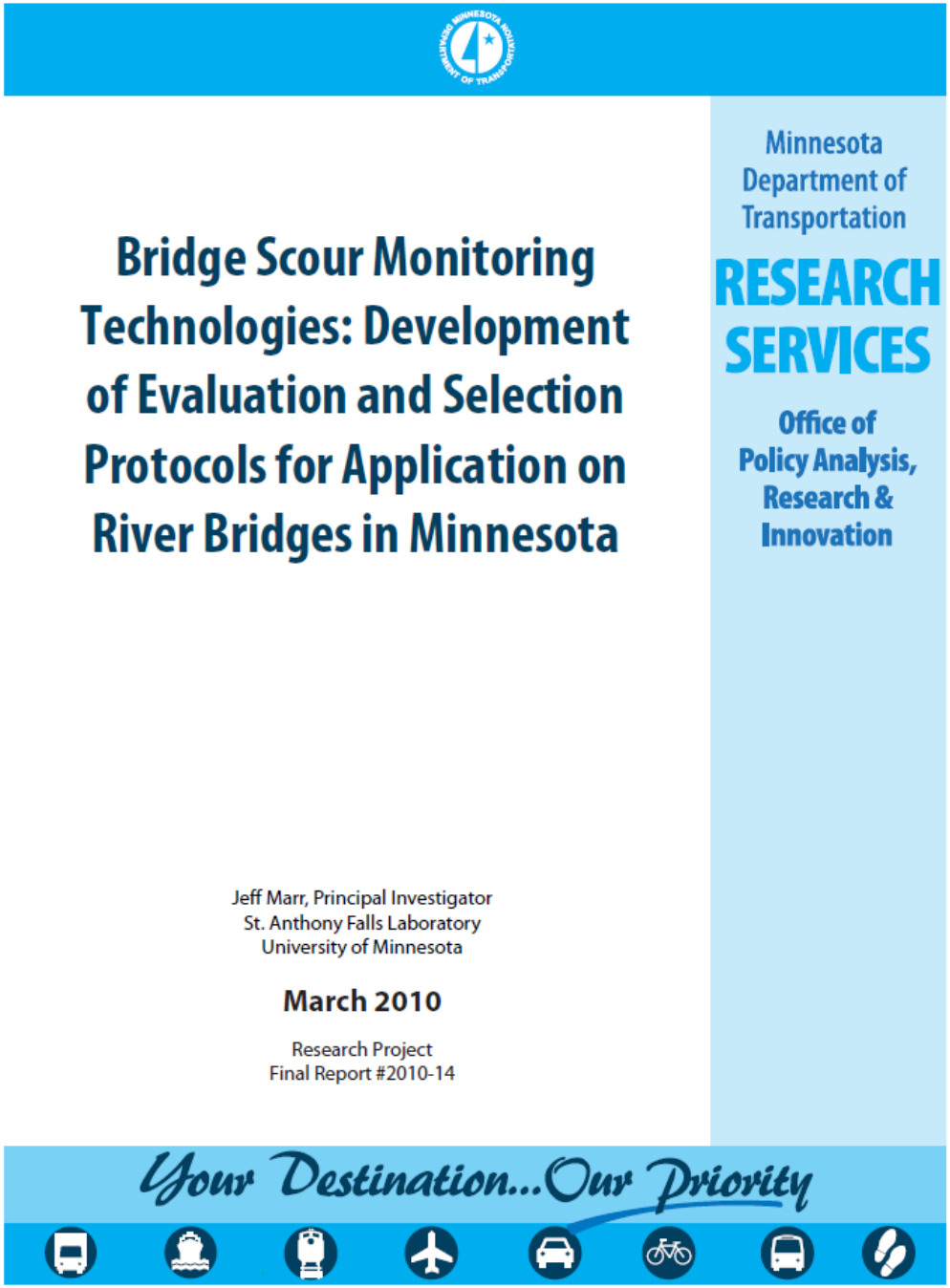
Additional Studies

- Fiber Bragg Gratings (FBG) sensors – University of Illinois at Chicago (March 2011)
- Radio Frequency Identification (RFID) systems – The University of Iowa (January 2010)






Minnesota Department of Transportation
RESEARCH SERVICES
Office of Policy Analysis, Research & Innovation
Bridge Scour Monitoring Technologies: Development of Evaluation and Selection Protocols for Application on River Bridges in Minnesota
Jeff Marr, Principal Investigator
St. Anthony Falls Laboratory
University of Minnesota
March 2010
Research Project
Final Report #2010-14
Your Destination...Our Priority

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Future Needs in Scour Monitoring Technology

- More robust devices - increased reliability and longevity
- Decreased costs
- Simpler installation techniques
- Less maintenance and repairs
- Devices more suitable for smaller and larger bridges
- Combine scour monitors with devices that measure additional hydraulic variables, structural monitors or cameras
- Funding for the scour monitoring program post-installation

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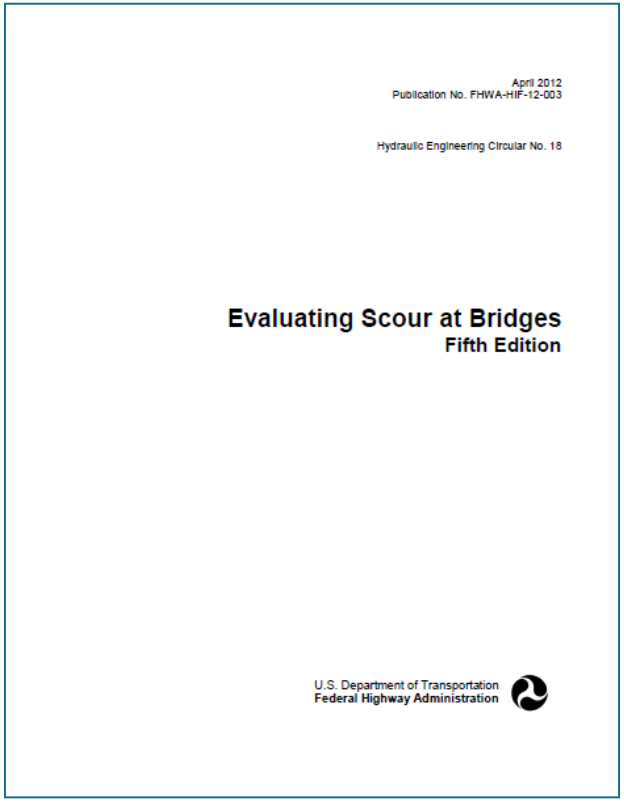
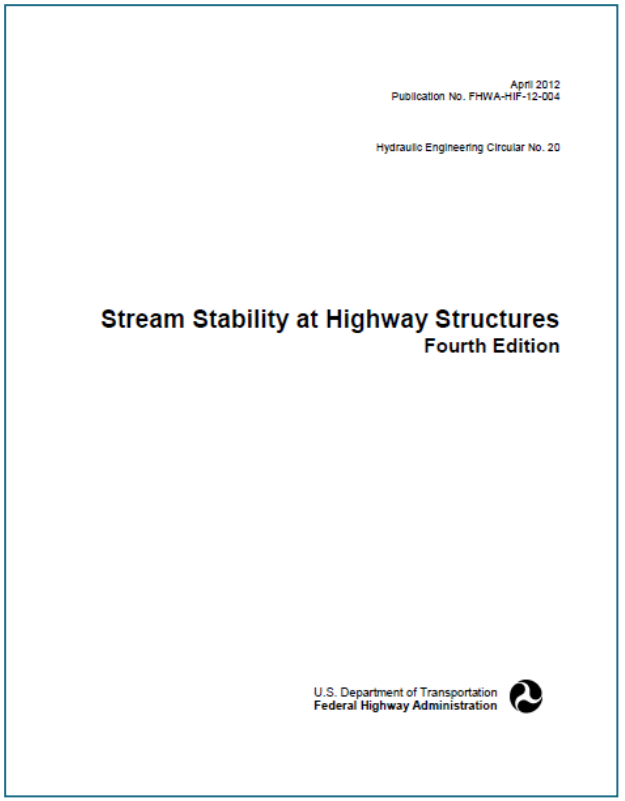
2012 Revisions - FHWA Hydraulic Engineering Circulars



- 1991 – 1st Edition
- 2001 – 4th Edition
- 2012 – 5th Edition



- 1991 – 1st Edition
- 2001 – 3rd Edition
- 2012 – 4th Edition

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New Edition of HEC-18

- Scour Program – Policy & Regulatory Basis
  - Scour Evaluations
  - Plans of Action
  - Scour Countermeasures
- Alternative Scour Equations
  - Contraction
  - Abutments
  - Piers
  - Bottomless Culverts
- New Chapter on Geotechnical Considerations
- Revisions to Chapter on Tidal Scour (HEC-25)

FHWA Design Philosophy

- 2010: U.S. Congress Recommendations
  - For infrastructure initiatives and bridge program goals
  - Apply risk-based and data-driven approaches
    - Importance of the structure
    - Provide safe and reliable waterway crossings
    - Consider the economic consequences of failure
- 2011: FHWA implements risk/data to National Bridge Inspection Program (NBIP)
- 2012: FHWA issues Memorandum to apply risk/data to FHWA Scour Program
  - Scour evaluations, unknown foundations, POAs and countermeasures

FHWA Policy & Regulatory Basis

Tables 2.1 & 2.3: Hydraulic Design, Scour Design, Scour Design Check & Scour Countermeasure Design Flood Frequencies

Hydraulic Design Flood Frequency (Q_D)	Scour Design Flood Frequency (Q_S)	Scour Design Check Flood Frequency (Q_C)	Scour Countermeasure Design Flood Frequency (Q_{CM})
Q_{10}	Q_{25}	Q_{50}	Q_{50}
Q_{25}	Q_{50}	Q_{100}	Q_{100}
Q_{50}	Q_{100}	Q_{200}	Q_{200}
Q_{100}	Q_{500}	Q_{500}	Q_{500}

Note: Table developed from 2012 FHWA HEC-18. Numbers shown in red are recommendations from FHWA guidance prior to 2012.

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Conclusions

- Developments in sensors and data analysis are most needed
- Proof of concept in laboratory and fields tests are ongoing
- Goals for the monitoring systems:
  - Robust
  - Ease of installation, maintenance and repairs
  - Better long-term power
  - Longer transmission distances and through various surfaces
  - Simplification of data analysis
  - Lower costs
- Alternatives with revised U.S. FHWA HEC-18 guidance – re-evaluations and prioritization

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Thank You

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