Connecticut Department of Transportation – Bridge Scour

Hydraulics & Drainage Unit

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Scour Overview

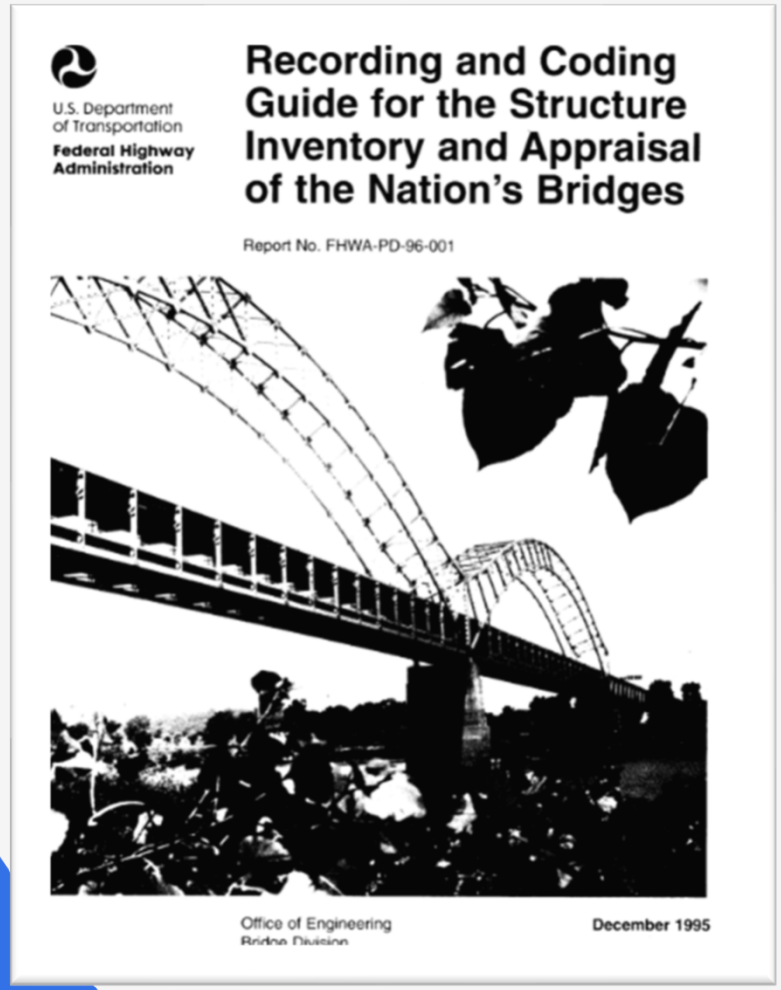
- 60% of Bridge Failures are due to scour (American Society of Civil Engineers, "In Search of Solutions: Proceedings of the Hydraulic Engineering Sessions at Water Forum 92")
- History of Bridge Scour in Connecticut:
  - National Scour Evaluation program initiated in early 1990s
  - Recording and Coding Guide for the Structure Inventory and Appraisal of the Nations Bridges
- Types of Scour:
  - Aggradation and Degradation
  - Contraction Scour
  - Local Scour
  - Lateral Stream Migration
- Scour mitigation/prevention/monitoring:
  - Bridge Foundation Depths
  - Bridge Scour Countermeasures
  - Scour Monitoring (Bridge Watch)

National Scour Evaluation Program

- Push from FHWA for States to evaluate all bridge structures for scour
  - Technical Advisory – Evaluating Scour at Bridges (Oct. 28, 1991)
  - Federal Regulations 23CFR 650 Subpart C – National Bridge Inspection Standards.
  - Connecticut initiated evaluation of all bridge structures.
- This was largely a result of the Schoharie Creek Bridge Collapse in Fort Hunter, New York.
  - Failed due to scour of weak rock under the spread footings.

NBIS Bridge Evaluation Guide

- NBIS Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's bridges.
  - Guidance Document has multiple category's related to different components of the bridge called items.
  - Items most related to scour are Items 113, 71, and 61.



U.S. Department of Transportation
Federal Highway Administration

Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges

Report No. FHWA-PD-96-001

Office of Engineering
Bridge Division

December 1995

Item 61 - Channel and Channel Protection 1 digit

This item describes the physical conditions associated with the flow of water through the bridge such as stream stability and the condition of the channel, riprap, slope protection, or stream control devices including spur dikes. The inspector should be particularly concerned with visible signs of excessive water velocity which may affect undermining of slope protection, erosion of banks, and realignment of the stream which may result in immediate or potential problems. Accumulation of drift and debris on the superstructure and substructure should be noted on the inspection form but not included in the condition rating.

Rate and code the condition in accordance with the previously described general condition ratings and the following descriptive codes:

Code	Description
N	Not applicable. Use when bridge is not over a waterway (channel).
9	There are no noticeable or noteworthy deficiencies which affect the condition of the channel.
8	Banks are protected or well vegetated. River control devices such as spur dikes and embankment protection are not required or are in a stable condition.
7	Bank protection is in need of minor repairs. River control devices and embankment protection have a little minor damage. Banks and/or channel have minor amounts of drift.
6	Bank is beginning to slump. River control devices and embankment protection have widespread minor damage. There is minor stream bed movement evident. Debris is restricting the channel slightly.
5	Bank protection is being eroded. River control devices and/or embankment have major damage. Trees and brush restrict the channel.
4	Bank and embankment protection is severely undermined. River control devices have severe damage. Large deposits of debris are in the channel.
3	Bank protection has failed. River control devices have been destroyed. Stream bed aggradation, degradation or lateral movement has changed the channel to now threaten the bridge and/or approach roadway.
2	The channel has changed to the extent the bridge is near a state of collapse.
1	Bridge closed because of channel failure. Corrective action may put back in light service.
0	Bridge closed because of channel failure. Replacement necessary.

Item 71 - Waterway Adequacy 1 digit

This item appraises the waterway opening with respect to passage of flow through the bridge. The following codes shall be used in evaluating waterway adequacy (interpolate where appropriate). Site conditions may warrant somewhat higher or lower ratings than indicated by the table (e.g., flooding of an urban area due to a restricted bridge opening).

Where overtopping frequency information is available, the descriptions given in the table for chance of overtopping mean the following:

Remote	-	greater than 100 years
Slight	-	11 to 100 years
Occasional	-	3 to 10 years
Frequent	-	less than 3 years

Adjectives describing traffic delays mean the following:

Insignificant	-	Minor inconvenience. Highway passable in a matter of hours.
Significant	-	Traffic delays of up to several days.
Severe	-	Long term delays to traffic with resulting hardship.

Functional Classification

Principal Arterials - Interstates, Freeways, or Expressways	Other Principal and Minor Arterials and Major Collectors	Minor Collectors, Locals	Description Code
N	N	N	Bridge not over a waterway.
9	9	9	Bridge deck and roadway approaches above flood water elevations (high water). Chance of overtopping is remote.
8	8	8	Bridge deck above roadway approaches. Slight chance of overtopping roadway approaches.
6	6	7	Slight chance of overtopping bridge deck and roadway approaches.
4	5	6	Bridge deck above roadway approaches. Occasional overtopping of roadway approaches with insignificant traffic delays.

NBIS 113 Rating

N Bridge not over waterway.

U Bridge with "unknown" foundation that has not been evaluated for scour. Since risk cannot be determined, flag for monitoring duri flood events and, if appropriate, closure.

T Bridge over "tidal" waters that has not been evaluated for scour, but considered low risk. Bridge will be monitored with regular inspection cycle and with appropriate underwater inspections. ("Unknown" foundations in "tidal" waters should be coded U.)

9 Bridge foundations (including piles) on dry land well above flood water elevations.

8 Bridge foundations determined to be stable for assessed or calculated scour conditions; calculated scour is above top of footing. (Example A)

7 Countermeasures have been installed to correct a previously existi problem with scour. Bridge is no longer scour critical.

6 Scour calculation/evaluation has not been made. (Use only to describe case where bridge has not yet been evaluated for scour potential.)

5 Bridge foundations determined to be stable for calculated scour conditions; scour within limits of footing or piles. (Example B)

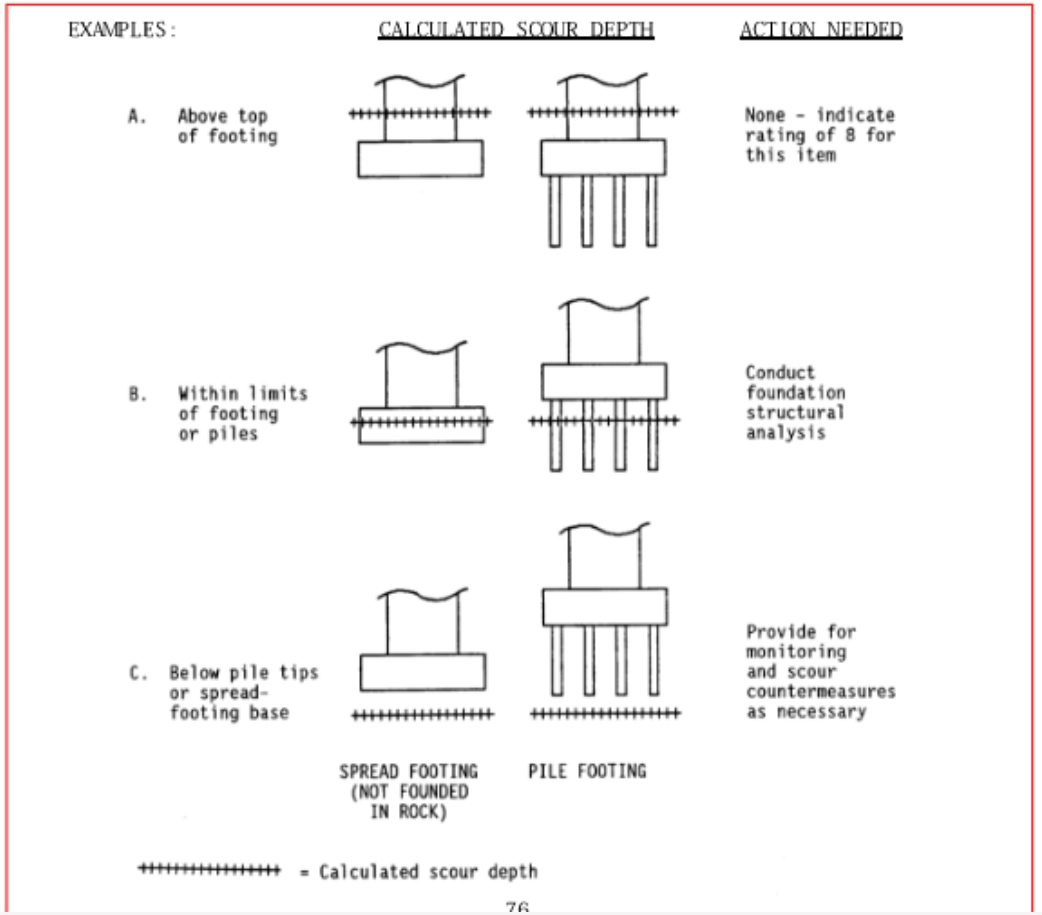
4 Bridge foundations determined to be stable for calculated scour conditions; field review indicates action is required to protect exposed foundations from effects of additional erosion and corrosion.

3 Bridge is scour critical; bridge foundations determined to be unstable for calculated scour conditions:
- Scour within limits of footing or piles. (Example B)
- Scour below spread-footing base or pile tips. (Example C)

2 Bridge is scour critical; field review indicates that extensive scour has occurred at bridge foundations. Immediate action is required to provide scour countermeasures.

1 Bridge is scour critical; field review indicates that failure of piers/abutments is imminent. Bridge is closed to traffic.

0 Bridge is scour critical. Bridge has failed and is closed to traffic.



NBIS Bridge Evaluation Updates

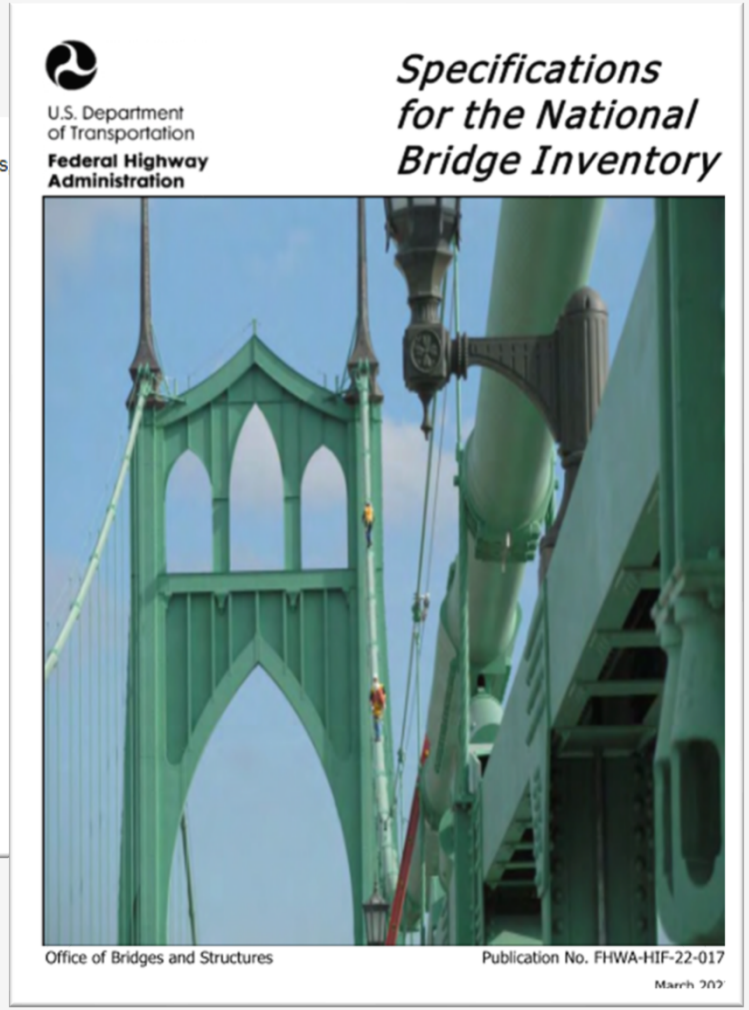
- Updates to the NBIS Bridge Evaluation Guidance.

Updates to the standards have been made over the years, most recently in 2022. These updates recognize technological advancements, research results

- NBIS (eCFR)
- NBIS Technical Correction Final Rule (Amends § 650.313(h) and § 650.313(k)(1)) (Federal Register) (09/22/2022)
- NBIS Final Rule (Federal Register) (05/06/2022)
  - Memorandum – NBIS Final Rule (.pdf)
  - Recording - Overview of the NBIS Final Rule and SNBI (Passcode: 415@=q03)
  - Slide Presentation - Overview of the NBIS Final Rule and SNBI (.pdf)
- Side-by-Side Comparison Between the Previous Regulation and the Final Rule (.pdf)
- Specifications for the National Bridge Inventory (SNBI)
  - Memorandum - Implementation of the Specifications for the National Bridge Inventory (.pdf)
  - Questions and Answers on the Specification for the National Bridge Inventory
- Questions and Answers on the 2022 NBIS (03/01/2023)
- Anticipated Timeline for Implementation of the May 6, 2022 National Bridge Inspection Standards Final Rule (.pdf)
- Memorandum – Inspection of Nonredundant Steel Tension Members (.pdf)
- Memorandum - Inspection Interval Guidance (.pdf)
- Memorandum - Approval of Alternate Bridge Inspection Training Courses (.pdf)
  - Course-specific checklists for NBIS alternate training requirements (*coming soon*)

Superseded NBIS

2009 NBIS revision
2004 NBIS



Aggradation and Degradation

- Long-term streambed elevation changes due to natural or maninduced causes.

Aggradation

Aggradation: Deposition of upstream sediment

- Sediment Deposition is common at multi-box culvert crossings.
- Can be due to poor alignment.

Degradation

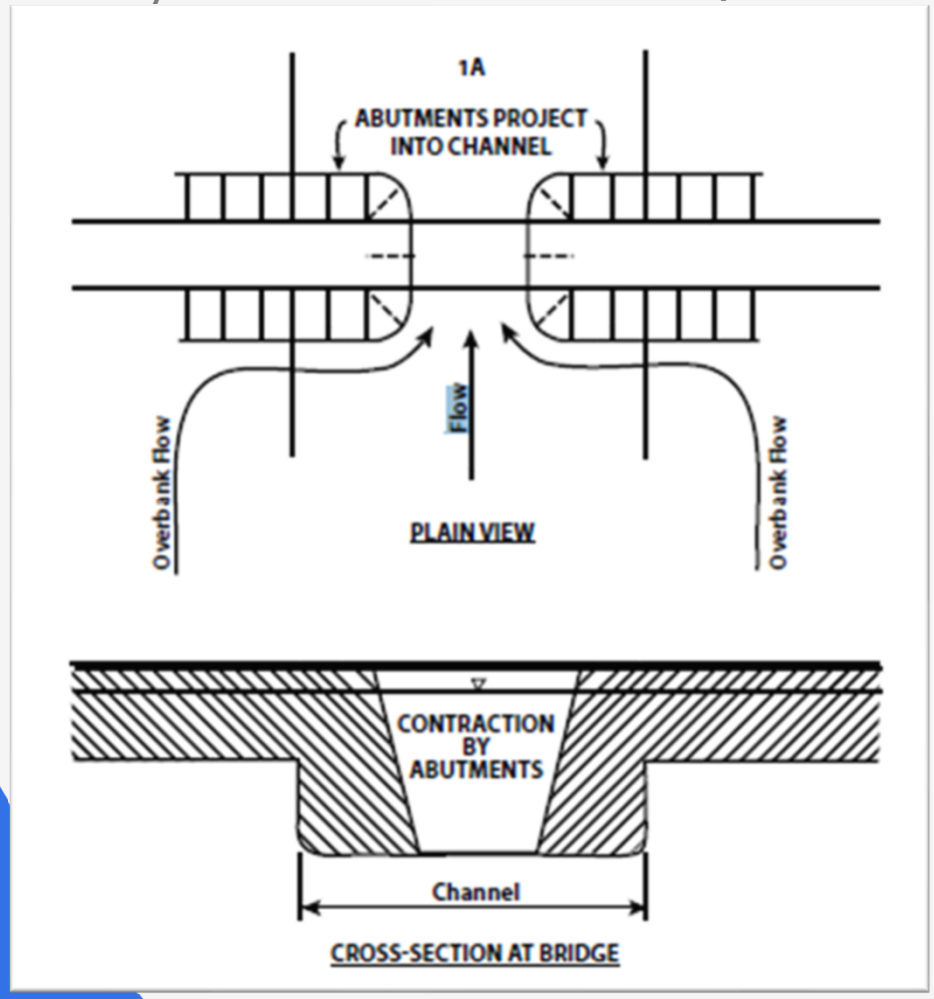
- The lowering or scouring of the streambed over relatively long reaches due to deficit in sediment supply from upstream.
- Downstream exposed utility pipe indicates possible degradation problem.

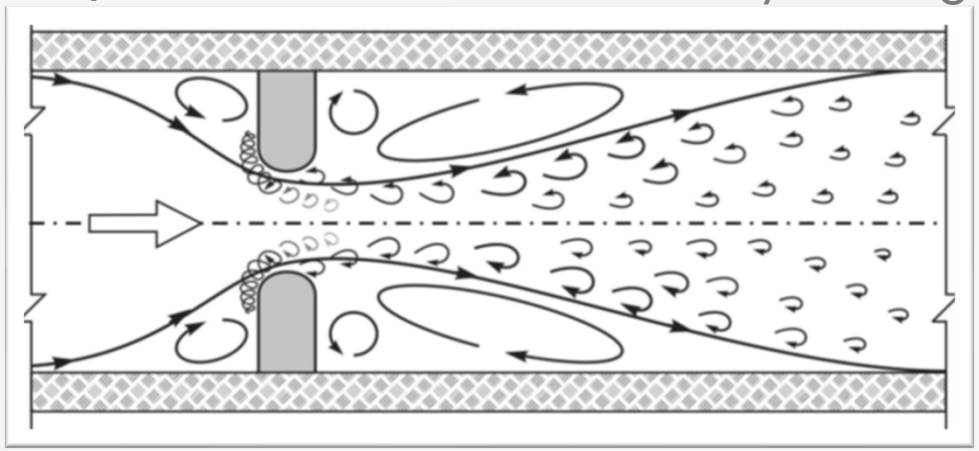
Degradation (Continued)

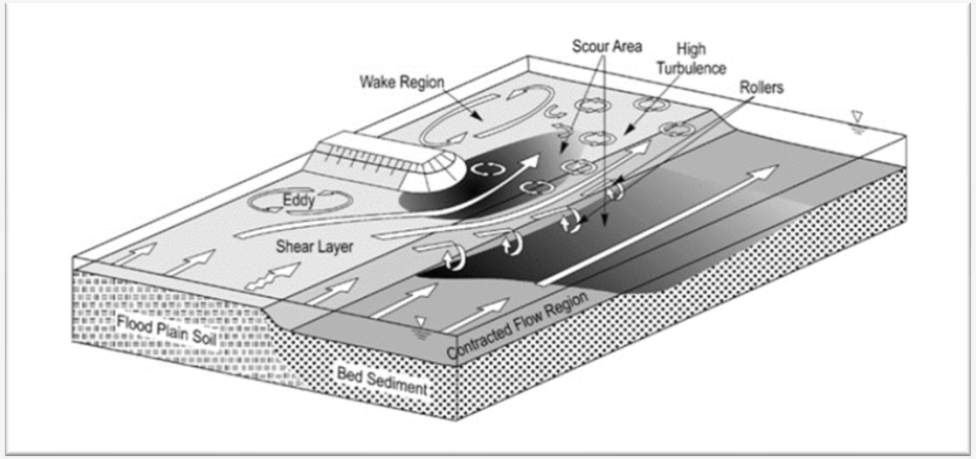
- Project No. 0102-0303: Route 123 in Norwalk, July 2007 Exposed Footings due to Stream Degradation.
- Emergency Repairs in 2003 under Proj. 0102-0313 involved a Grout Bag Revetment, followed by a full Bridge Replacement in 2008.

Contraction Scour

Contraction Scour occurs when the flow area of a stream at flood stage is reduced, either by a natural contraction (or constriction) of the stream channel or by a bridge.





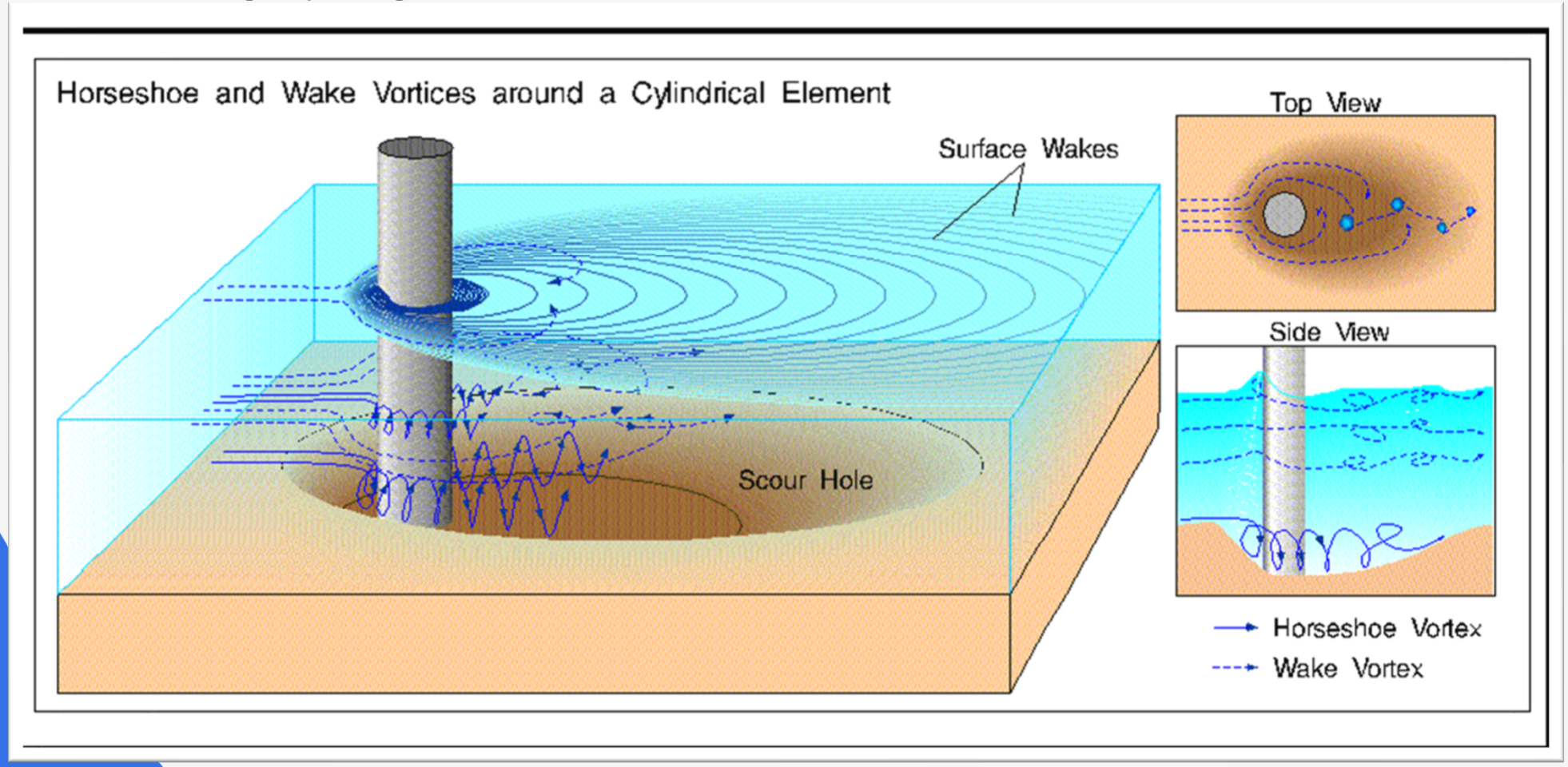


Contraction Scour (continued)

- Proj No. 137-153, Bridge No. 02779 Failure: Rt. 184 in Stonington, March 2010 – Tropical Storm Irene
- Contraction at Inlet Generates High Velocity, Pressure Flow Condition Exacerbating Local Scour, Undermining Outlet Wingwall.
- Proposed: Larger Span Structure with Riprap Spill-Through Abutments on Piles.

Local Scour

- Local Scour is the removal of material around piers, abutments, spur dikes, and embankments caused by blow acceleration and turbulence.
- Near bridge sub-structural elements and embankments. Local scour can be exacerbated by accumulation of debris in a bridge opening.

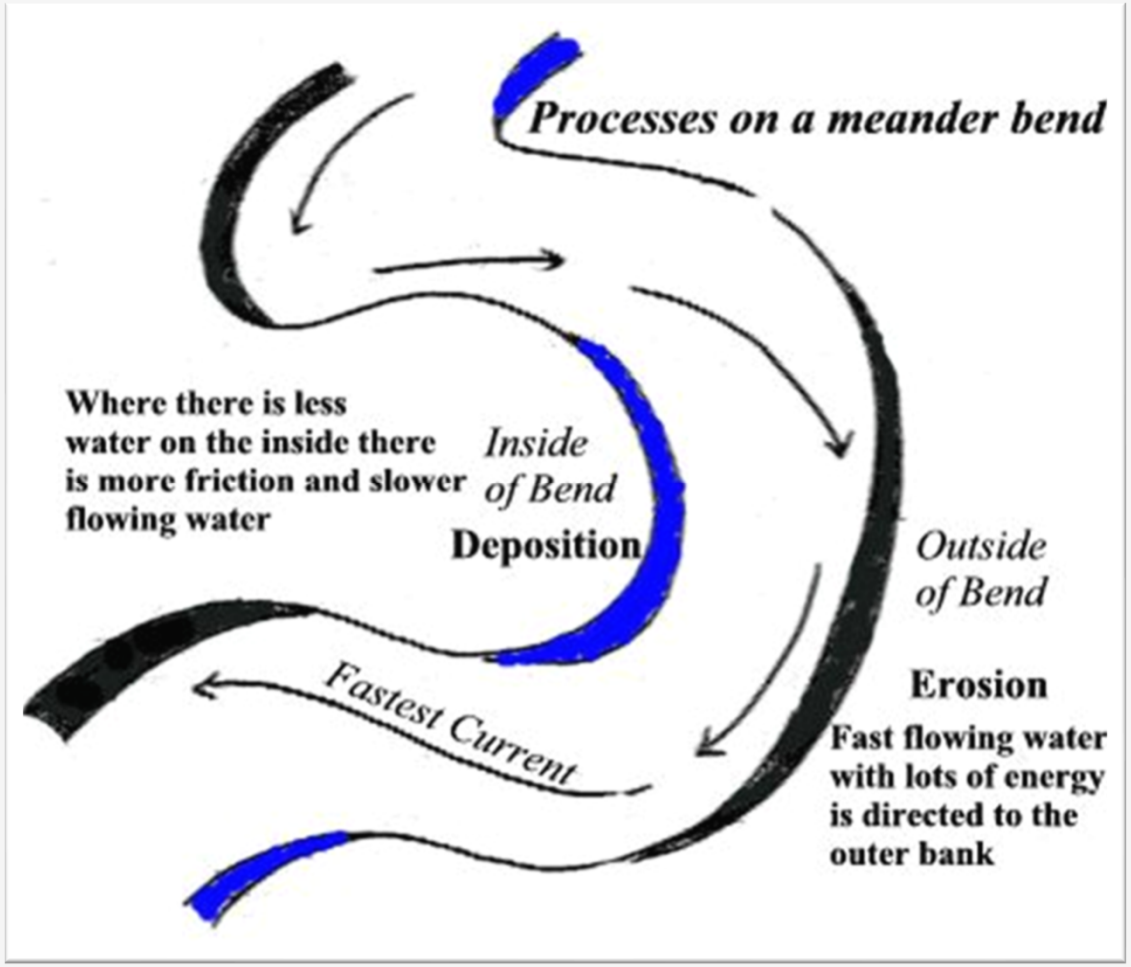


Local Scour (continued)

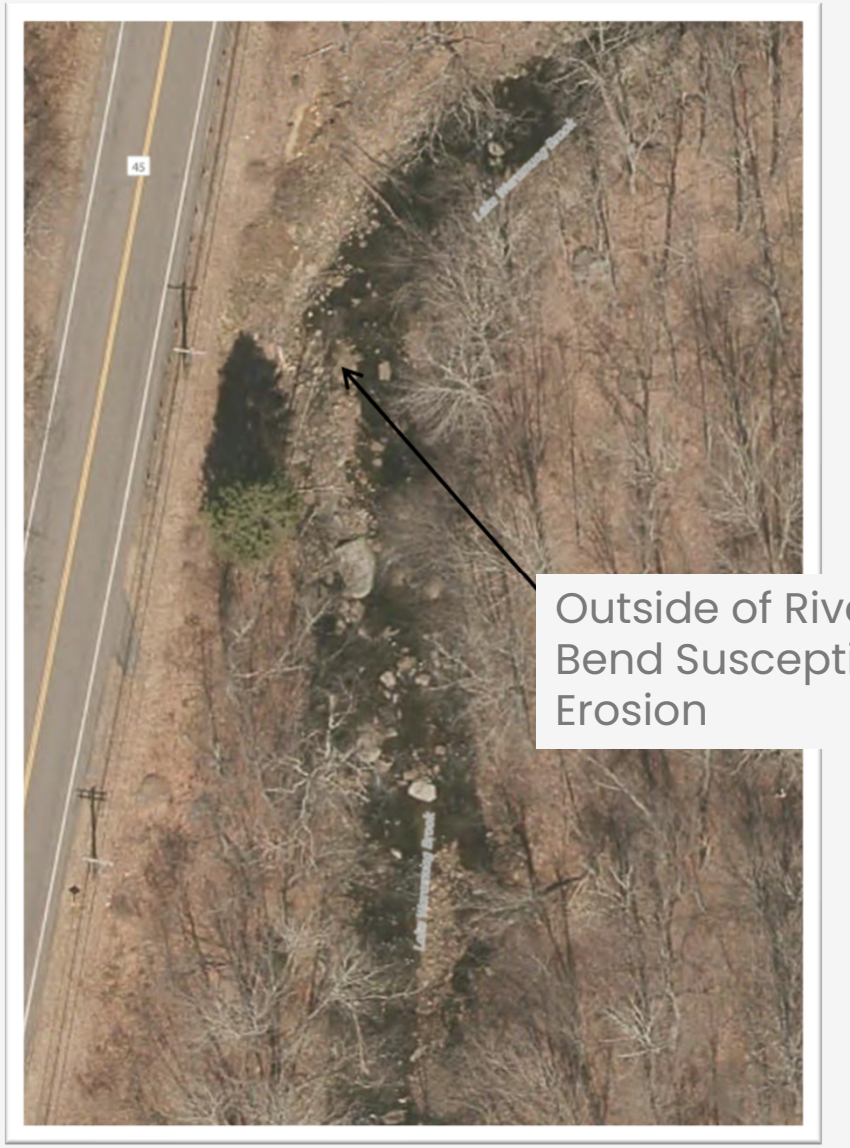
Local Scour at Bridge Pier

Lateral Stream Migration

Lateral Stream Migration such as flow around a bend where the scour may be concentrated near the outside of the bend.



Lateral Migration (continued)



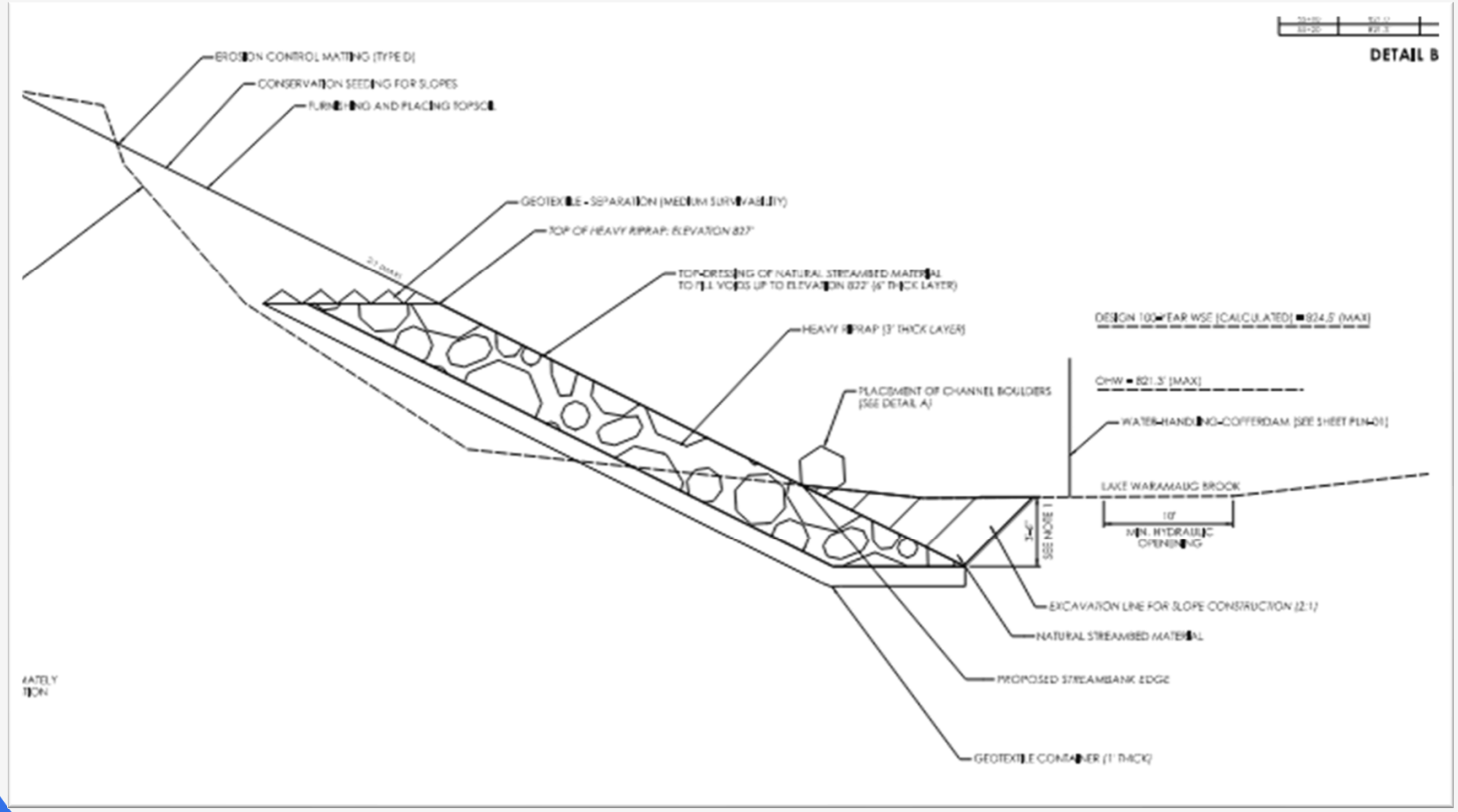
Lateral Migration (continued)

Lateral Stream Migration Case: Bank Erosion on Outside of River Bend.

Project No. 0149-0088: Route 45 in Warren on March 2020 Embankment Failure due to Stream Meandering.

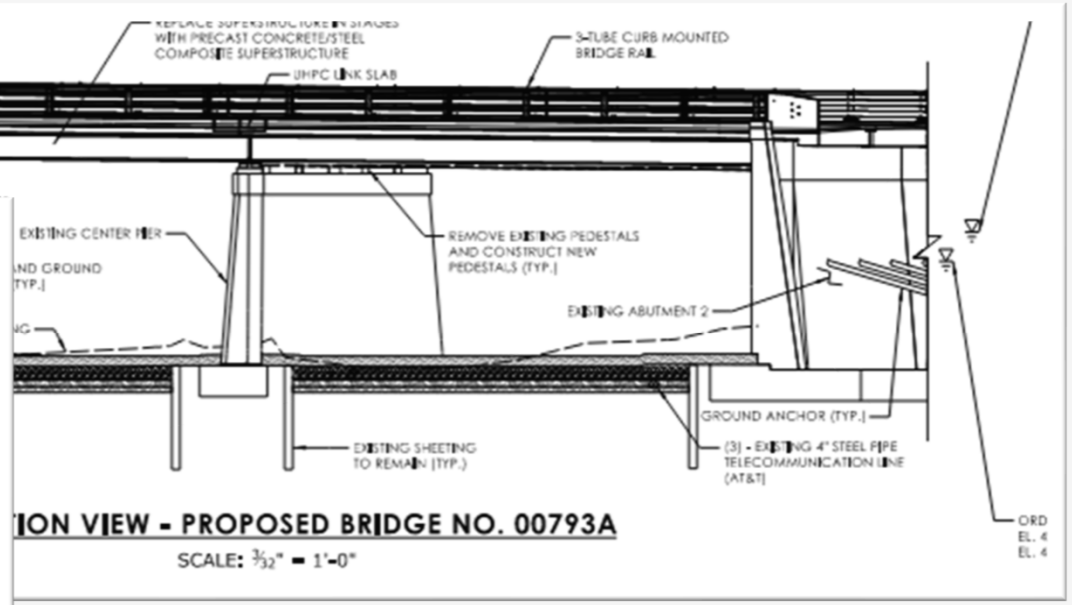
Proposed: Riprap Revetment

Project 0149-0088 Roadway Embankment Revetment Design

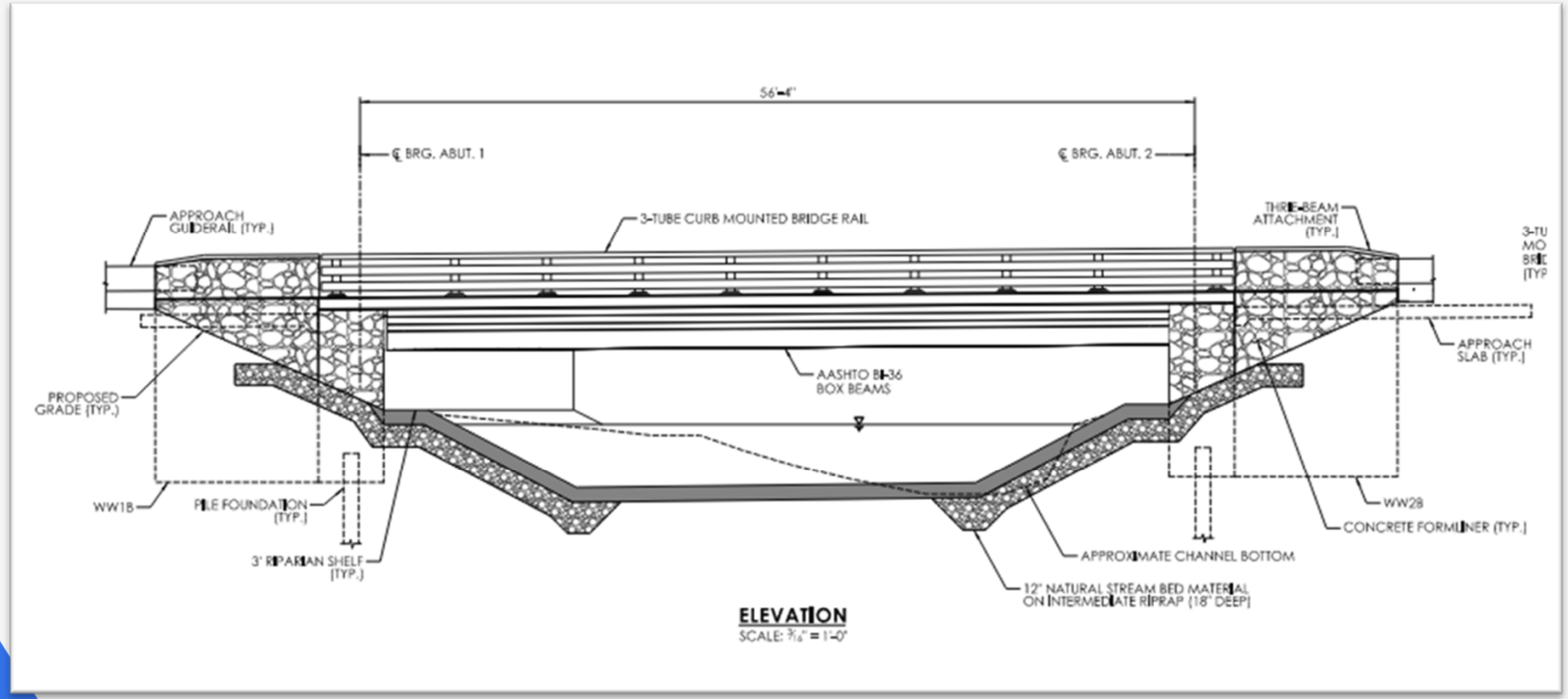


Scour Mitigation/Prevention/Monitoring

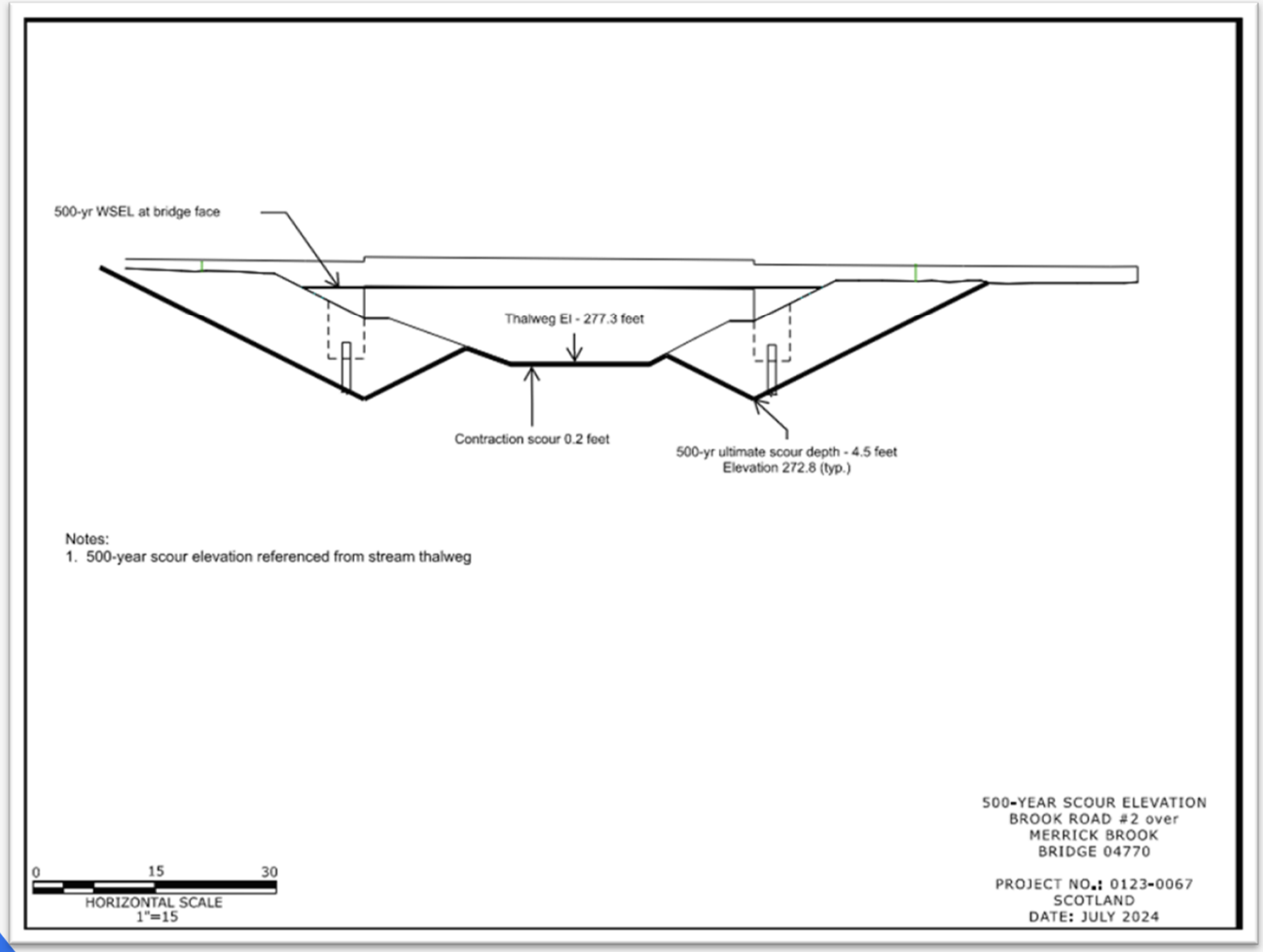
- Bridge Foundation Types and Depths
- Bridge Scour Countermeasures
- Scour Monitoring



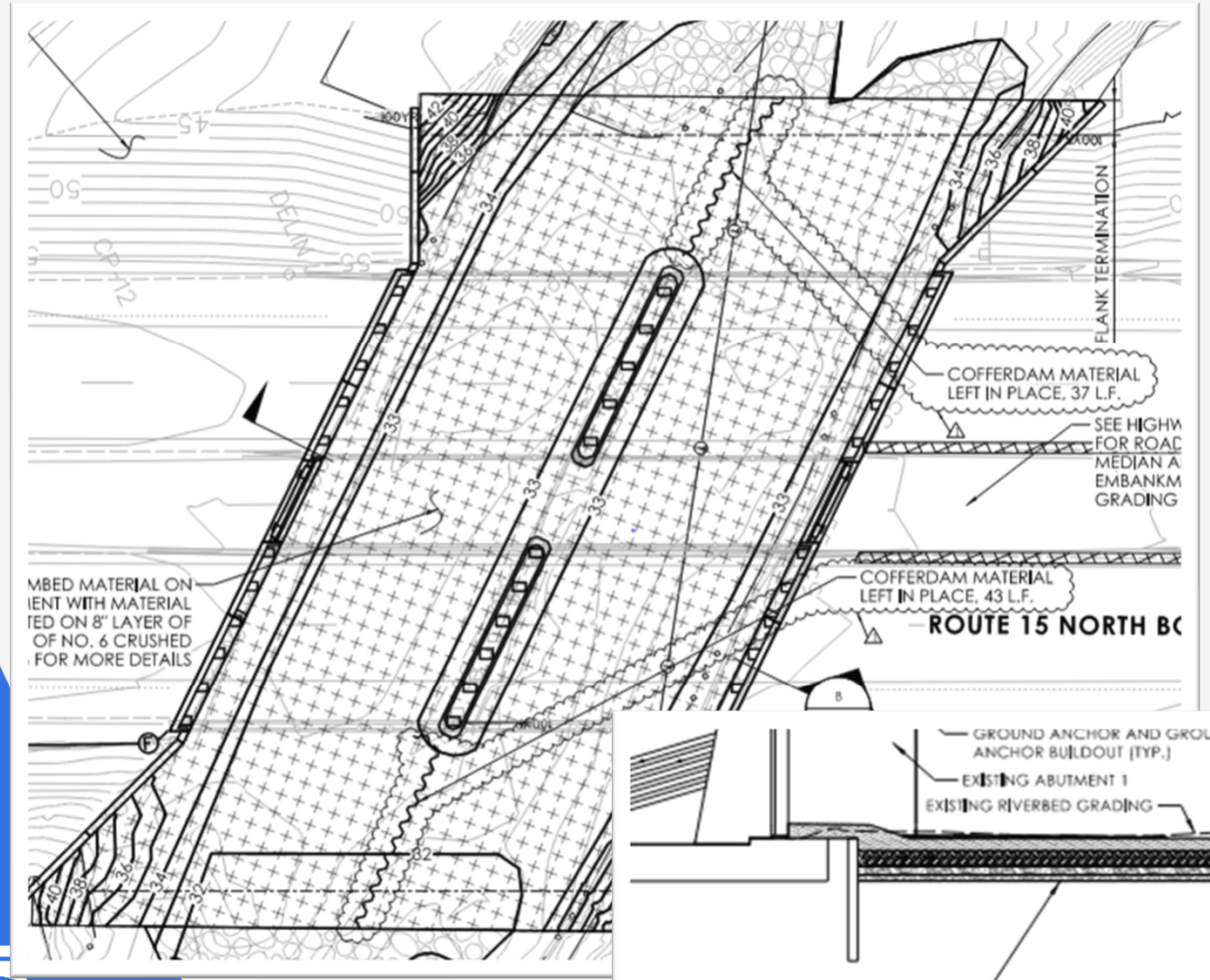
Bridge Foundation Types and Depths

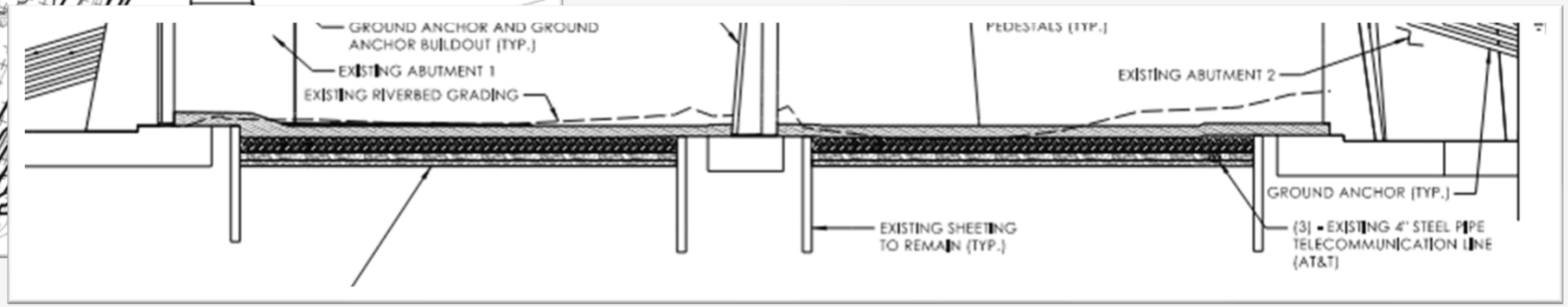


Bridge Scour and Foundation Depth at Bridge No. 04770



Bridge Scour Countermeasures





Project 148-0213

- Scour countermeasures are used when foundations cannot be designed to resist scour.
- The scour countermeasures prevent scour from occurring.

Various Scour Countermeasure Designs

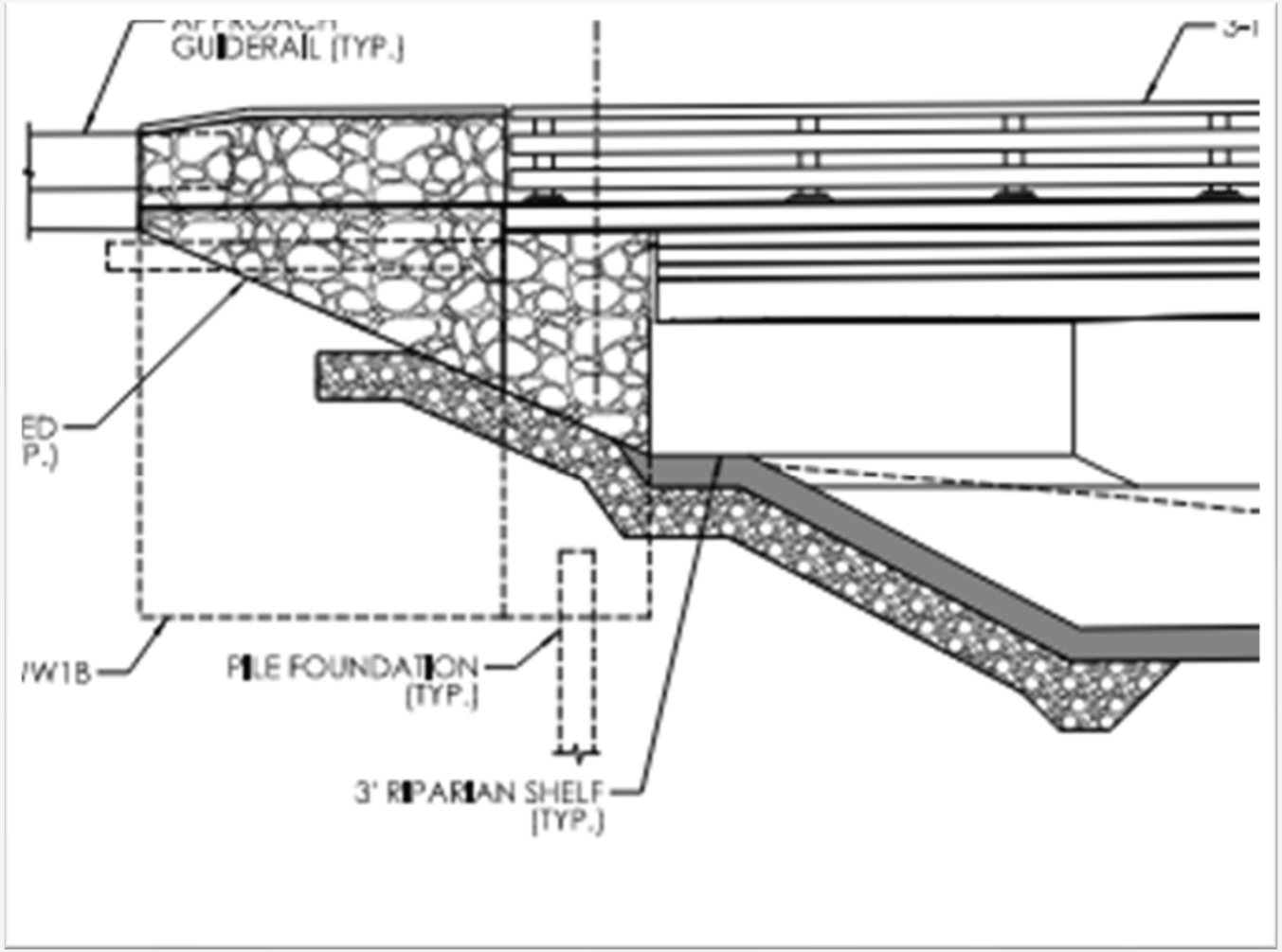
SECTION 2 - COUNTERMEASURES FOR STREAMBANK AND ROADWAY EMBANKMENT PROTECTION

SECTION 3 - COUNTERMEASURES FOR BRIDGE PIER PROTECTION

SECTION 4 - COUNTERMEASURES FOR ABUTMENT PROTECTION

CTDOT

Most Common Countermeasure is Riprap



Scour Monitoring

- Scour Critical Structures NBIS Item 113 Rating of 3.
- Scour Monitoring Systems
- Bridge Watch

Scour Monitoring Systems

- Active Sonar Monitoring Station

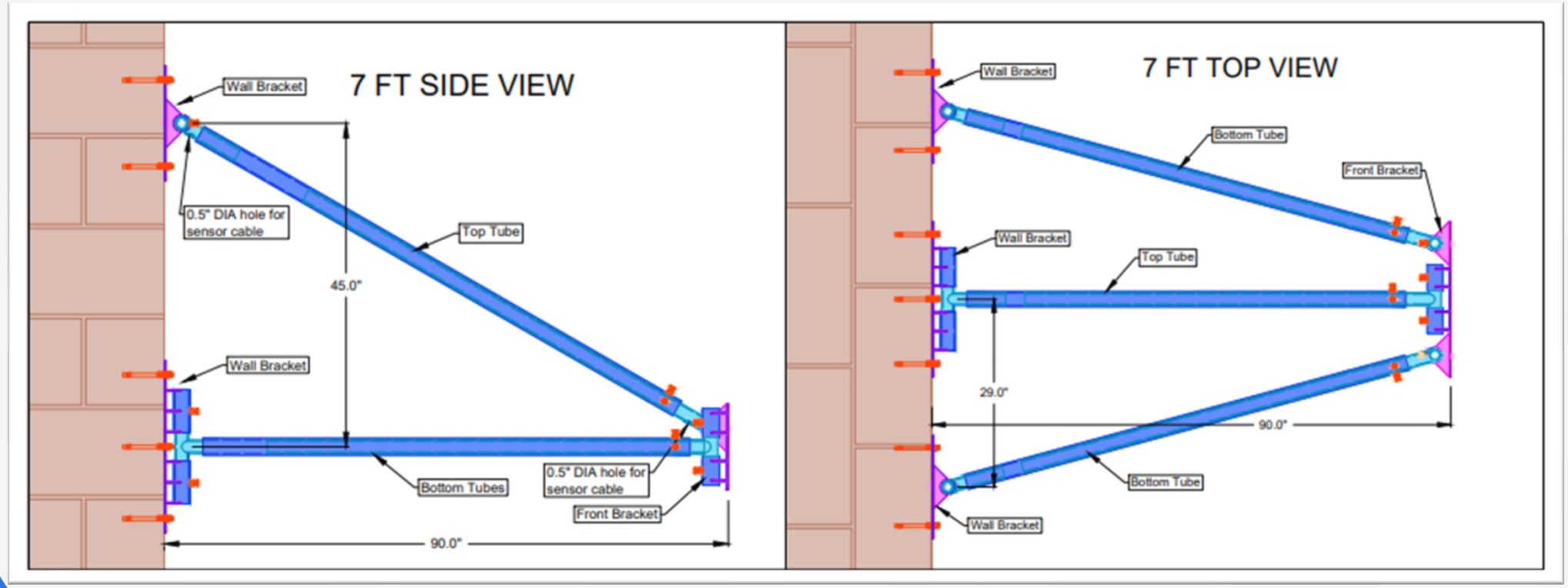
Pros	Cons
•Continuous Real Time Monitoring •Records erosion and deposition	•Interference caused by biological material (plants/fish) •Requires intensive installation process

- Tilt Monitor

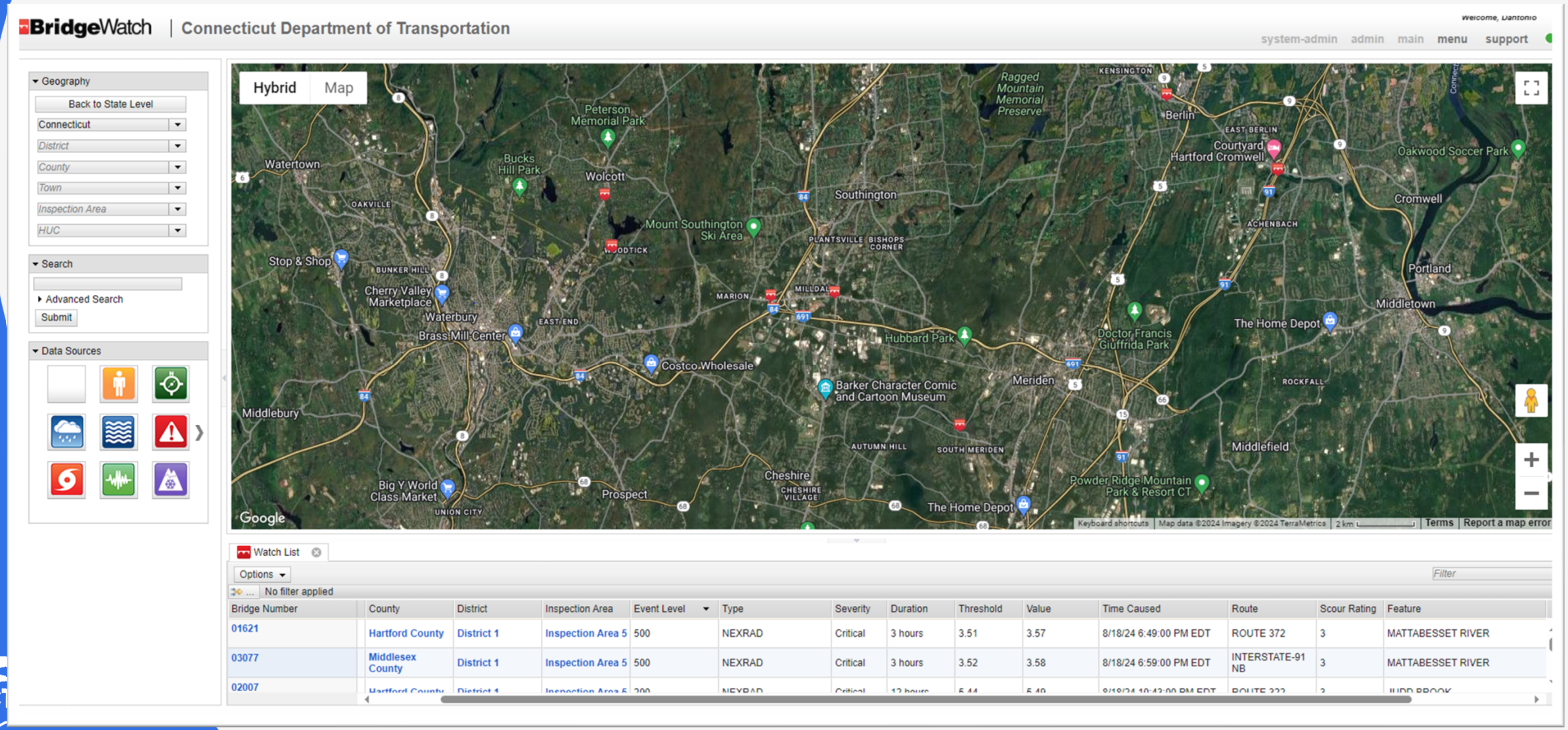
Pros	Cons
•Continuous real time monitoring •.1 degree resolution •Easy installation	•Provides only limited information about the scour occurring, only the health of the bridge

Scour Monitor System Example

- Detail of sonar scour monitoring system for Project 0200-0038 Rail structure over the Willimantic River.

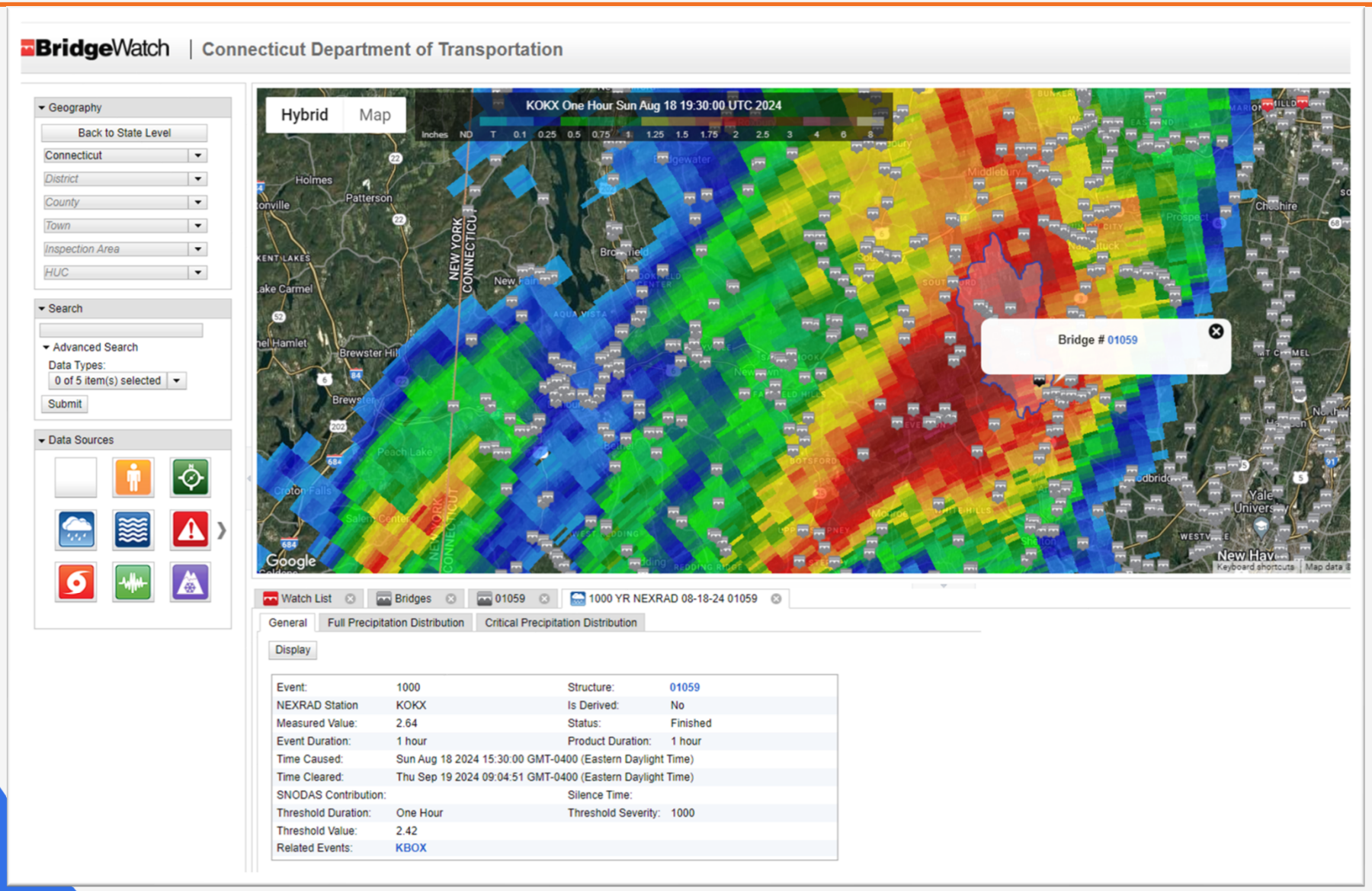


Bridge Watch



Bridge Number	County	District	Inspection Area	Event Level	Type	Severity	Duration	Threshold	Value	Time Caused	Route	Scour Rating	Feature
01621	Hartford County	District 1	Inspection Area 5	500	NEXRAD	Critical	3 hours	3.51	3.57	8/18/24 6:49:00 PM EDT	ROUTE 372	3	MATTABESSET RIVER
03077	Middlesex County	District 1	Inspection Area 5	500	NEXRAD	Critical	3 hours	3.52	3.58	8/18/24 6:59:00 PM EDT	INTERSTATE-91 NB	3	MATTABESSET RIVER
02007	Hartford County	District 1	Inspection Area 5	200	NEXRAD	Critical	12 hours	5.44	5.49	8/18/24 10:42:00 PM EDT	ROUTE 322	3	JUDD BROOK

BridgeWatch NEXRAD Data



THANK YOU FOR YOUR TIME AND ATTENTION

Q & A