



ARKANSAS

TRANSPORTATION SUMMIT



ATS: Scour Repair on Fourche Creek

DATE, 2025

TODAY'S
TOPIC

Scour Repair
on Fourche
Creek



ATS: Scour Repair on Fourche Creek



Victoria Elliott, PE

4 Years of Experience

ARDOT Bridge Operations Division

- Chair of ARDOT Scour Committee
- Utilizes underwater survey equipment and sonar for bridge inspections
- ARDOT Dive Inspection Team



Jessica Halbrook, PE

12 Years of Experience

Bridge Rehabilitation & Load Rating Leader

- Performed bridge repairs for over 200 structures including Scour Remediation for I-155 over MS River
- Bridge Evaluation Lead, including unique structure types



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Agenda



Project History



Scour Analysis



Selection of Solution



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Project History



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Tori

Hi, my name is Tori, and as mentioned earlier, I'm with ARDOT. Today I'll be walking you through the history of this project — how we first identified the scour concerns, the monitoring that's been done over time, and the key decisions that were made along the way.

What is scour?

- Scour is erosion around bridge foundations (abutments and piers)
- Biggest cause of bridge failure in the US



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When water flows past a bridge, it doesn't just move straight downstream. It swirls around the piers and abutments, and over time it can wash away the sand, gravel, or soil holding the bridge up. That's what we call scour. And it's a big deal — scour is actually the number one cause of bridge failures in the U.S. We've lost more bridges to scour than to earthquakes, hurricanes, or even crashes.

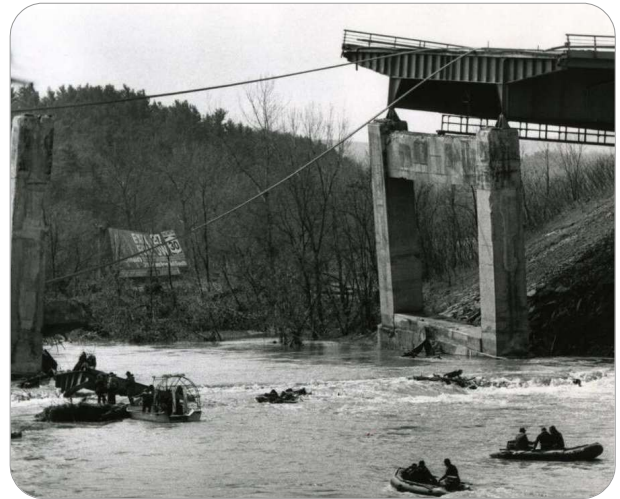
Why does it matter?

New York State Thruway Authority Bridge (I-90) over Schoharie Creek

- Bridge collapses, killing ten people in April 1987
- NTSB reported the probable cause as “...the failure of the New York State Thruway Authority to maintain adequate riprap around the bridge piers, which led to severe erosion in the soil beneath the spread footings.”

Contributing failure mechanisms

- Significant local pier scour due to angle of attack
- Piers founded on erodible soils
- Inadequate riprap protection, inspection, and maintenance



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In April 1987, the Schoharie Creek Bridge on I-90 collapsed during a flood, resulting in the loss of ten lives. Vehicles on the Thruway drove into the section that failed when the bridge gave way.

The National Transportation Safety Board investigated and found that the cause wasn't a design flaw, but a maintenance issue. The protective rock, known as riprap, had been washed away and was never adequately replaced. Without that layer of protection, the fast-moving floodwaters eroded the soil beneath the bridge foundations.

The piers were also founded on erodible soils—layers of gravel, sand, and silt mixed together. These materials don't resist flowing water well. They're loose soils that can be carried away easily by a river.

The key takeaway is that scour is not just an engineering detail. It's a critical maintenance and safety issue. The Schoharie Creek failure led to stronger requirements for scour evaluation and inspection, changes that continue to guide how we manage bridge foundations today.

Why does it matter?

U.S. Route 51 over the Hatchie River

- Bridge collapses in April 1989 resulting in eight fatalities
- NTSB reported the probable cause as *"...the northward migration of the main river channel which the Tennessee Department of Transportation failed to evaluate and correct."*

Contributing failure mechanisms

- Lateral channel migration
- Local pier scour at location designed on the floodplain and not the main channel



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In April 1989, another major bridge failure occurred, this time on U.S. Route 51 over the Hatchie River in Tennessee. The collapse resulted in eight fatalities.

The National Transportation Safety Board found that the primary cause was river channel migration. Over time, the main flow of the Hatchie River had shifted northward.

There were also other contributing factors. One pier had originally been placed in what was thought to be the floodplain, not the main channel. But once the river shifted, that pier was exposed to fast, continuous flow. This created local scour, or erosion around the pier foundation, which weakened it until it failed.

The key lesson from this case is that rivers are dynamic systems. They change course, they meander, and they migrate. Bridge foundations and protection measures must account not just for present-day conditions, but for how the channel may evolve over time.

National Scour Program

Scour program initiated following these disasters in 1988 (under FHWA)

- Program required scour screening and evaluation under the National Bridge Inspection Standards (NBIS), with evaluations to be completed by 1997
- Plans of Action required for scour critical bridges by 2005



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Following the Schoharie Creek and Hatchie River bridge failures in the late 1980s, the Federal Highway Administration launched a nationwide Scour Program in 1988.

Under this program, every state was required to screen and evaluate its bridges for scour risk as part of the National Bridge Inspection Standards. These evaluations were to be completed by 1997, and for any bridge identified as 'scour critical,' agencies had to develop a Plan of Action by 2005.

ARDOT Scour Team

- ARDOT has a scour team that inspects, assesses, and monitors bridges for scour
- Provides service for bridges on and off the Federal aid Highway System



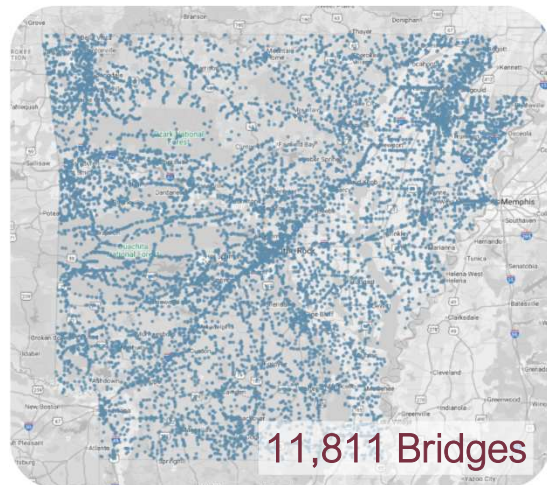
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Here in Arkansas, ARDOT has a dedicated scour team that carries out this work. The team inspects, assesses, and monitors bridges that may be vulnerable to scour. Their role isn't limited to just interstate or federal-aid highways — they also provide support for local bridges across the state.

This systematic approach means that scour isn't left to chance. Bridges are routinely checked, monitored, and, if needed, protected with countermeasures to help prevent failures like those seen in the 1980s.

Scour Appraisals

- Assessment and Observation - Qualitative
- Evaluation - Quantitative
- Updated after Plan of Corrective Action (PCA) from FHWA



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When we talk about scour appraisals, there are really two levels if you want to have a risk-based approach.

The first is qualitative — engineers use field observations and a compilation of channel profiles, hydraulic information, & geotechnical information. We're looking for exposed foundations, unusual water flow, channel migration, or any visible signs that scour may be developing.

The second is quantitative — engineers use hydraulic models, scour equations, and survey data to calculate how much material might be lost under different flood conditions.

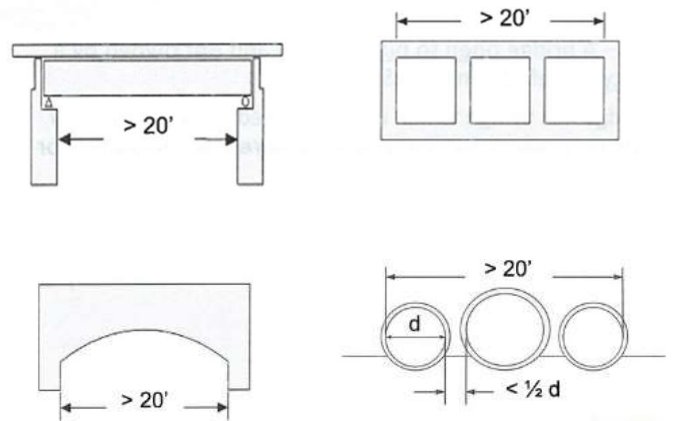
These appraisals are living documents. They get updated as site conditions change or when new information comes in.

To make sure states keep their programs up to standard, the Federal Highway Administration reviews inspection program metrics every year. When FHWA recently reviewed the underwater inspection and scour program for Arkansas, they issued a Plan of Corrective Action, or PCA, requiring updates after the definition of "unknown foundation" was changed.

That oversight ensures that scour inspections and evaluations stay consistent, thorough, and in line with national safety expectations.

What is considered a bridge?

- A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between under copings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it includes multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening. (23 CFR 650.305)



This is the federal definition of a bridge under the National Bridge Inspection Standards.

In plain terms, a bridge is any structure that spans more than 20 feet across an obstacle (**20' Clear opening**)— like a river, road, or railway — and carries traffic or loads across it.

That includes your typical highway bridges, but it can also include multiple box culverts or even groups of large pipes, as long as the openings together act like a single structure.

Bridge Location



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This bridge at Springer Boulevard, Exit 1 off I-440, may look like a small local crossing, but it actually plays an important role in the highway system around Little Rock.

I-440 is part of the loop that connects I-30, I-40, and I-530 — essentially tying together the major interstate corridors through central Arkansas. The Springer Boulevard exit provides access to industrial areas, neighborhoods, and connections to U.S. 70 and the airport corridor.

Because of that, even an off-ramp bridge like this one carries steady traffic volumes, including both commuters and commercial vehicles. If this structure has to be restricted or closed, it doesn't just affect local drivers — it also impacts freight movement and increases congestion on the surrounding interstates.

1994



2024



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Rivers and creeks are not fixed in place — they're constantly changing over time.

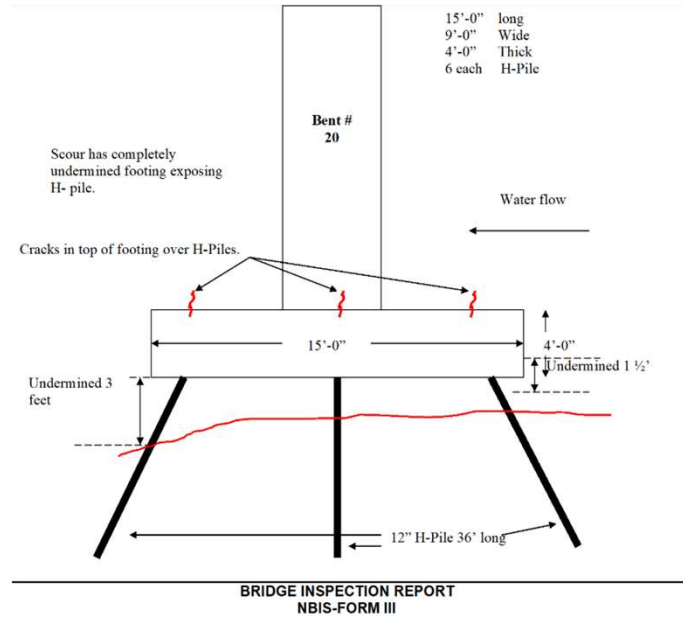
One of the key processes is channel widening. During floods, high-energy flows erode the banks, cutting them back little by little. Over years, that makes the creek wider than it was originally.

Another important process is channel migration. Instead of staying in one spot, the main flow of water gradually shifts sideways across the floodplain. That might mean the deepest part of the channel moves closer to a bridge pier or abutment that wasn't originally in the main current.

When this happens, a pier that was designed to be in calm, shallow water can suddenly find itself in the middle of the river's strongest flow. That sets up conditions for local scour — erosion right around the foundation — which can severely weaken a bridge

Pre-2021

- Known scour issue
- ARDOT was actively monitoring with Scour Plan of Action
- Only soundings had been taken so far



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Before 2021, this bridge was already identified as having a potential scour issue.

ARDOT had a Scour Plan of Action in place, and the site was being actively monitored by District 6 inspectors.

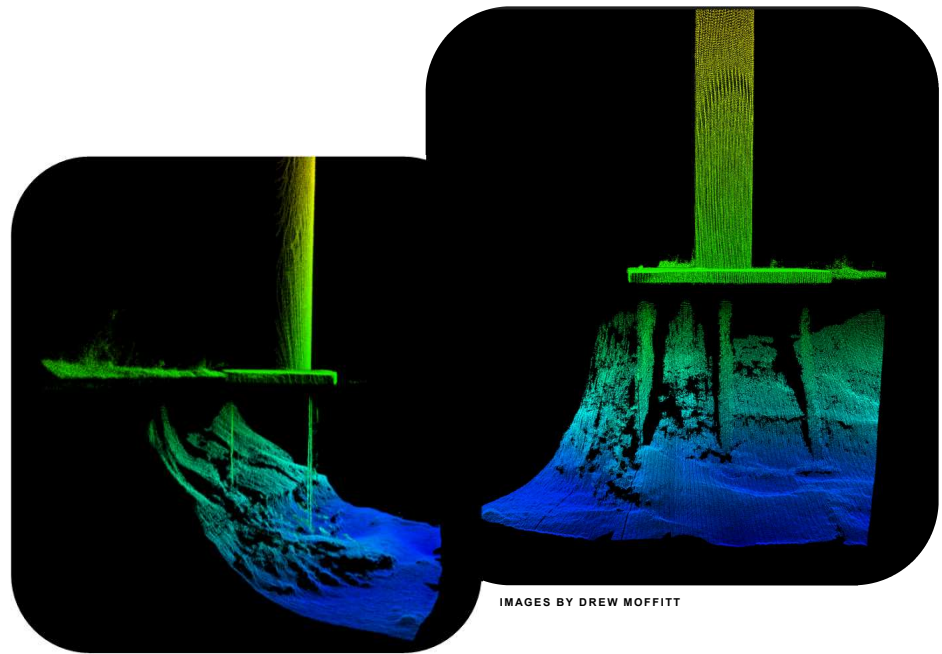
At that time, the tools available to the district were fairly basic. Inspectors could take soundings using a drop tape or a range pole — essentially measuring depths at specific points in the water.

While these methods do provide useful information, they're limited. Soundings give us only a handful of depth readings, not a full picture of the channel bed or how scour might be developing around the foundations.

This is why more advanced survey methods, like sonar mapping, have since become so valuable — they allow us to move from a few point measurements to a complete 3D view of what's happening underwater.

2021

- Sonar data taken

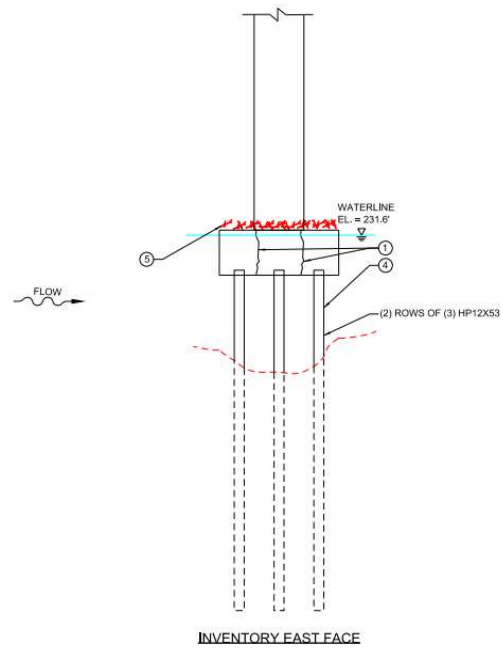


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This slide shows sonar images of Bent 20 on Bridge G5700. What you're looking at here is the footing being undermined and piles exposed as a result of scour. These images were generated from our sonar survey data by Drew Moffitt at Garver. The scans revealed piles sticking out of the bed up to about 9 feet. And when we measured the actual loss of supporting soil, it was closer to 20 feet — which is a significant amount of material gone from around the foundation.

2022

- Confirmed h-pile condition and soundings by consultant divers



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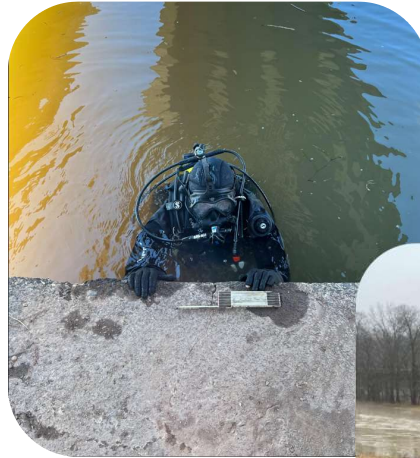
To verify what we were seeing in the sonar data, consultant divers were brought in.

They confirmed the condition of the H-piles and also took soundings — depth checks around the foundation.

So between the sonar scans and the dive inspection, we had both visual confirmation and direct measurements showing the extent of the scour at this location.

2023

- In November, Nate Brown with ARDOT dove in the cold water to place the probe
- Began live monitoring of the bridge
- In December, a storm came through and washed-out receiver/transmitter box



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At the time, we already had a transmitter/receiver box from a previous bridge project where we had been monitoring with strain gauges.

Since we had the hardware available, we reached out to Resensys to see if we could try out their scour probe.

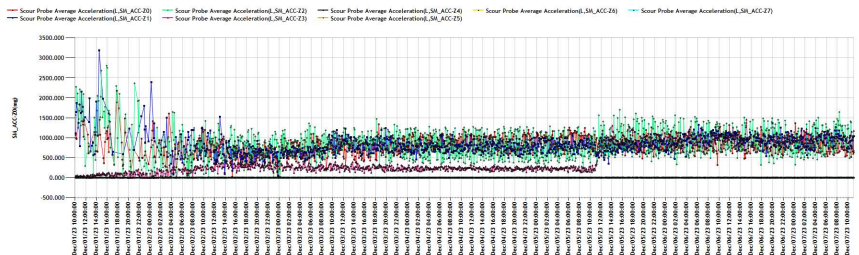
In November, Nate Brown with ARDOT went down in some very cold water to install the scour probe at this bridge. Once it was placed, we were able to begin live monitoring of the foundation.

But just a month later, in December, a storm rolled through the area. The high water and debris were strong enough that they actually washed out the receiver/transmitter box.

Live Scour Monitoring

Wireless Scour Probe SenSpot™

- ARDOT received a scour probe to test out from Resensys






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The Resensys scour probe uses a series of sensors placed vertically in the ground near a bridge foundation. Each sensor is part of a rod that's driven into the soil.

The way it works is interesting: the probe applies small vibrations along the rod. If a section of the rod is buried in soil, the vibrations are dampened. If that section becomes exposed to water because scour has removed the soil, the vibration response changes.

By checking each sensor along the length of the rod, the system can tell us exactly how much of the foundation material has been lost — essentially mapping the depth of scour as it develops.

The data are transmitted wirelessly in real time, so engineers can monitor scour levels during a flood without having to be out on-site.
10am on 12/5 sensors became free

2023

- Transmitter/receiver box had to be replaced
- While at the bridge site, the pile cap was excessively moving and vibrating



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When we returned to install a replacement transmitter/receiver box, we noticed something very concerning. The pile cap — the large concrete block that ties the foundation piles together — was moving and vibrating far more than expected.

Standing on it, you could feel the motion. It was enough that we joked about getting seasick. Even our dive bottles and other equipment wouldn't stay put — they slowly vibrated their way toward the edge of the cap.

That kind of movement is a strong indication that the foundation had already been compromised by scour, and it highlighted the need for both continued monitoring and possibly some emergent follow-up action.

We wanted to send a video to convey the amount of movement happening and decided on a Jurassic Park style water bottle video. :)

2023

After consulting with ARDOT Bridge Design, the structure was closed.



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After these observations, we consulted directly with ARDOT Bridge Design. Based on the condition of the foundation and the risks identified, the decision was made to close the structure.

Closing a bridge is never taken lightly, but in this case it was the only responsible option. The movement we observed in the pile cap and the known history of scour at this site made it clear that continued traffic could pose a serious safety risk.



Scour Analysis



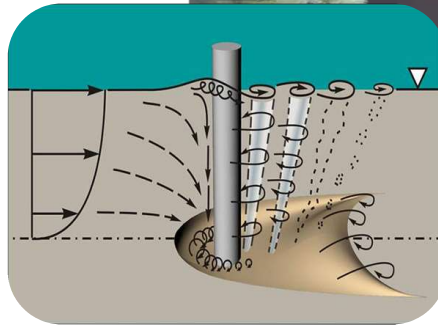
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Kathryn

Pier Scour

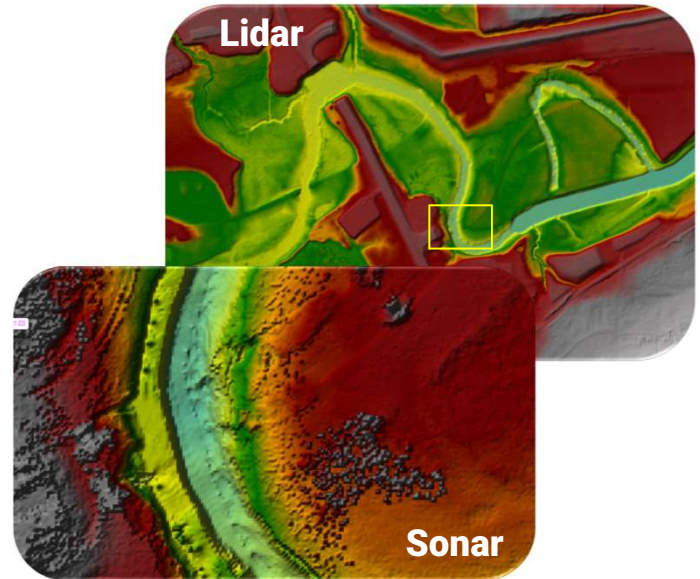
What causes pier scour?

- Flow vortices (horseshoe vortex) cause scour holes
- Function of depth, velocity, pier parameters, angle of flow



Hydraulic Model

- Topographic data limited
 - lidar + some bathymetry (sonar)
- To verify flow patterns and parameters for scour, ran a high-level 2D HEC-RAS model



Scour Calculations

- FHWA HEC-18 Guidance
- Used model results for input
- Ran multiple storm events – 10-year was worst case for velocities at pier (11.6 ft/s)
- Calculated 19.8 ft. of scour potential at pier from current ground line

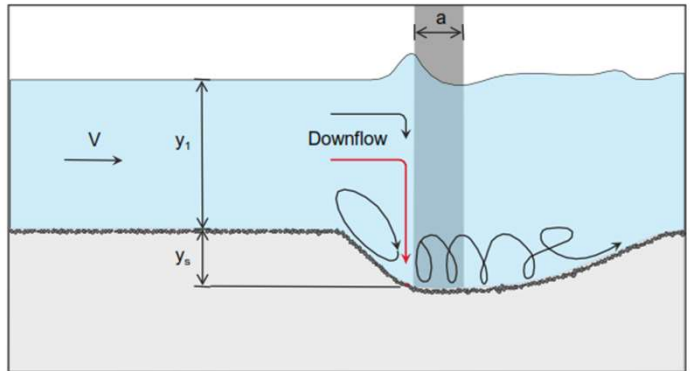


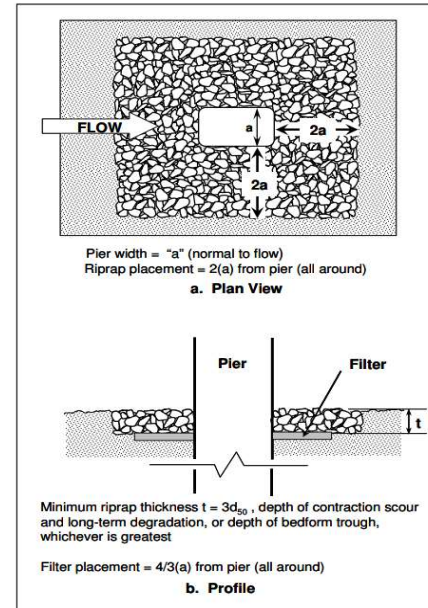
Figure 7.2. Definition sketch for pier scour.



Countermeasures

- Traditional countermeasure design in FHWA HEC-23
- Model results were input into calculations
- Riprap design not feasible to construct, would cause rise in floodway

Riprap thickness =	7.7 ft	Calculated D_{50} =	2.6 ft
Riprap thickness (placed underwater) =	11.6 ft	Calculated D_{50} =	30.9 in.
Riprap extent on all sides of pier =	18.0 ft	Size =	30.0 in.
Filter extent on all sides of pier =	12.0 ft		





Selection of Solution

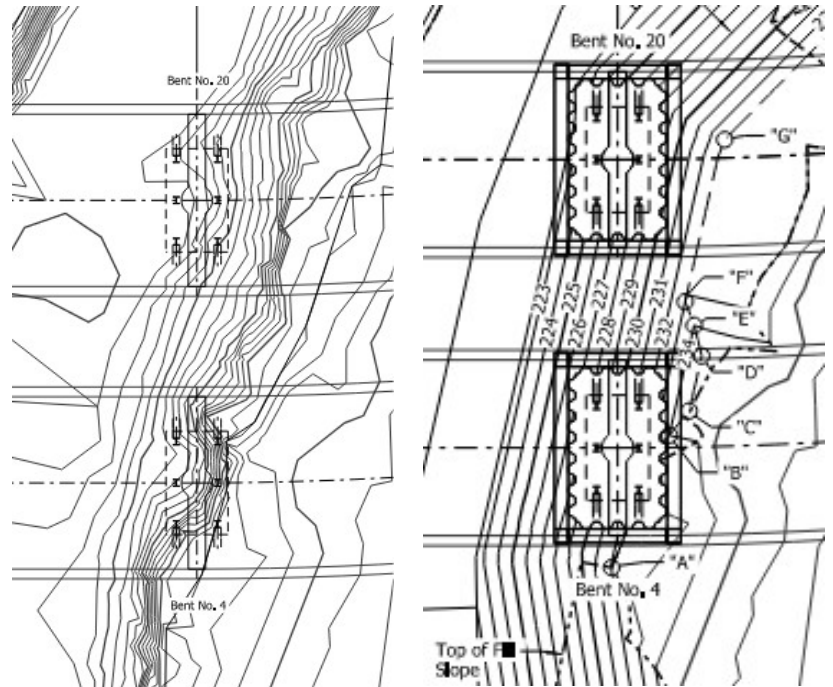


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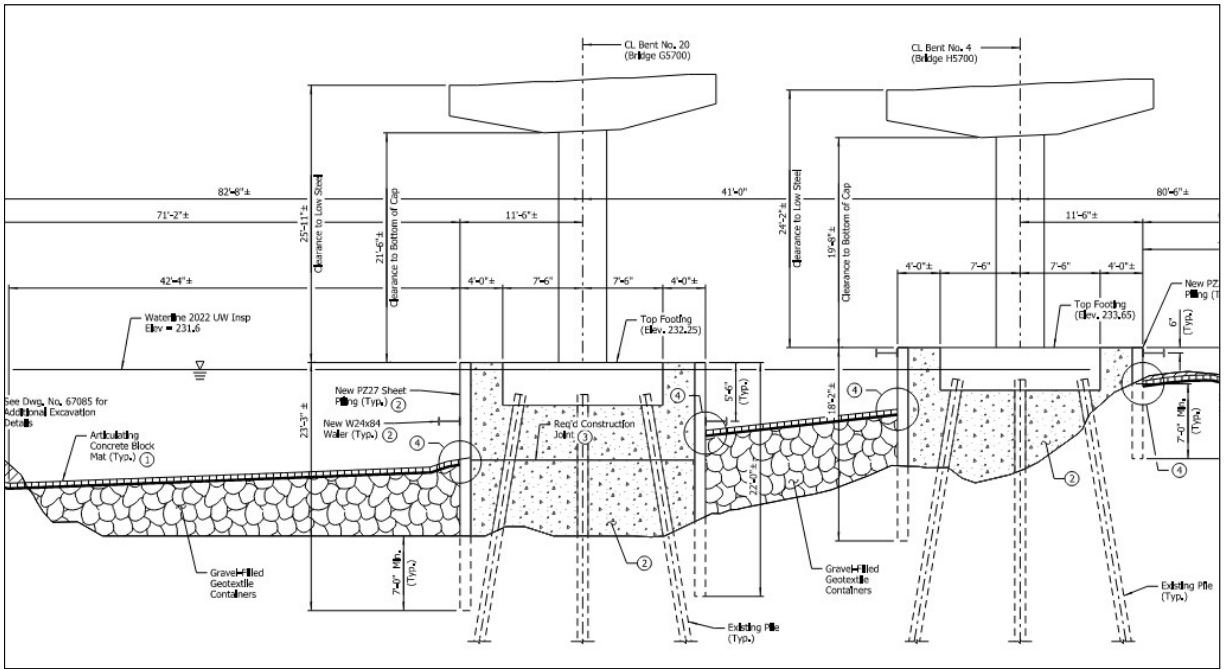
Jessica

Grading

- Existing ground significantly lower than original
- Not practical to return to original condition
- Reasonable bed slope selected

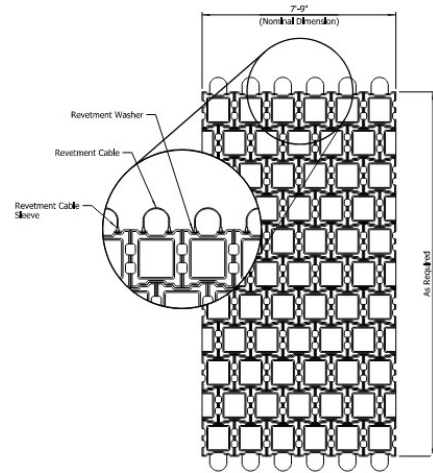
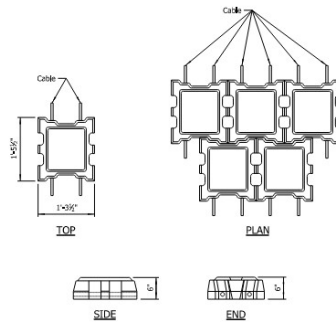


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Articulating Concrete Block Mat



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Wire rope vs. none

Structural Repairs

- Repair cracks in concrete footing
 - Epoxy injection
- Reduce unbraced length of piles
 - Pile capacity considerations
 - Geotechnical exploration by ARDOT

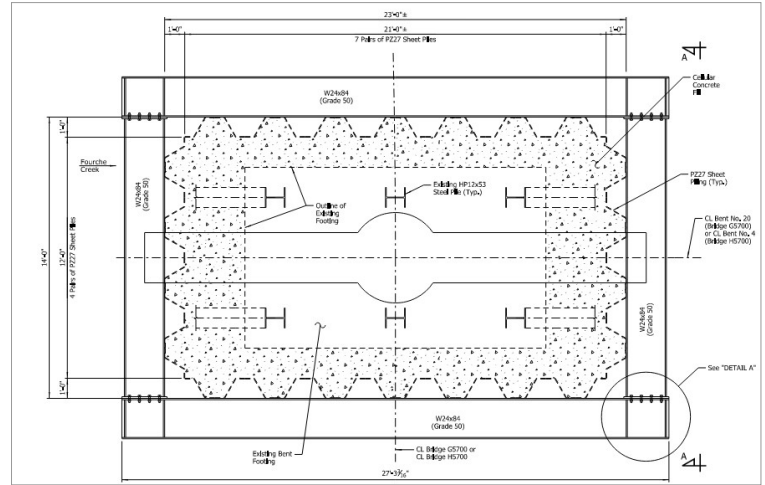


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Capacities
As constructed 170 kips
Current Condition 125 kips

Permanent Cofferdam

- Cellular concrete
- Sheet piling with whalers



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Method of Construction

- Temporary haul road
 - Allowed due to emergency nature of project and rapid timeline
- Cofferdam installed under flow conditions





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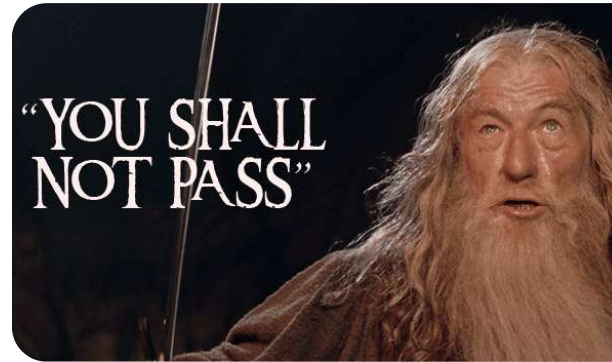


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Method of Construction

Contractor chose to dewater the stream to ease construction activities such as:

- Grading of gravel
- Placement of ACB mat
- Construction of ACB mat toe





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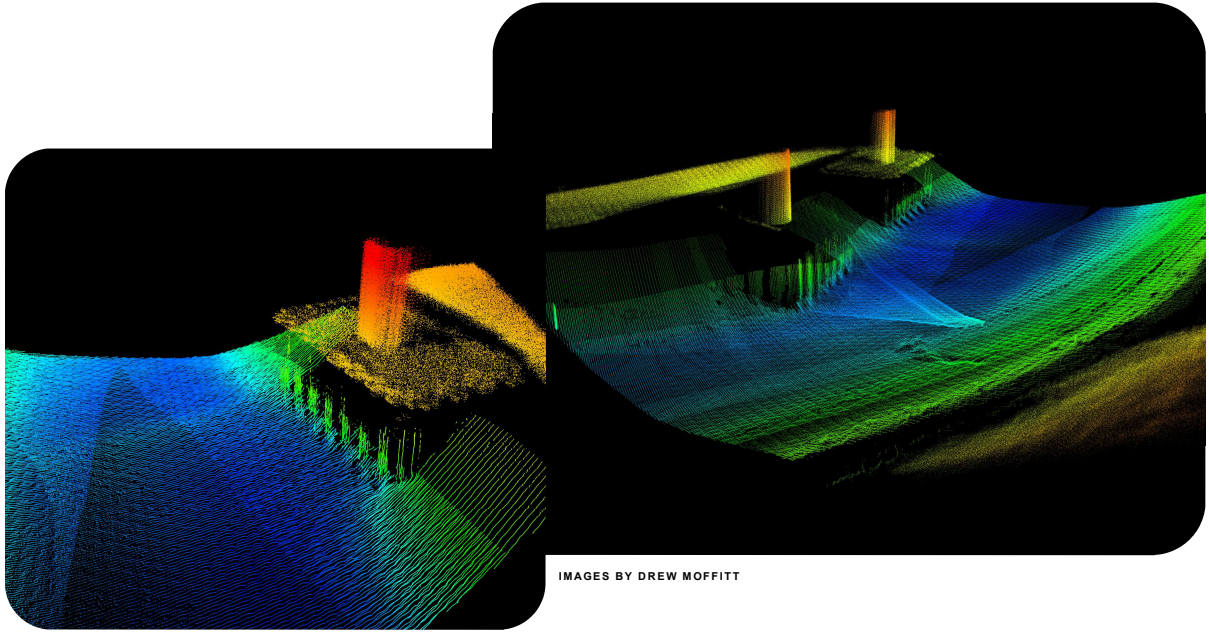
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IMAGES BY DREW MOFFITT

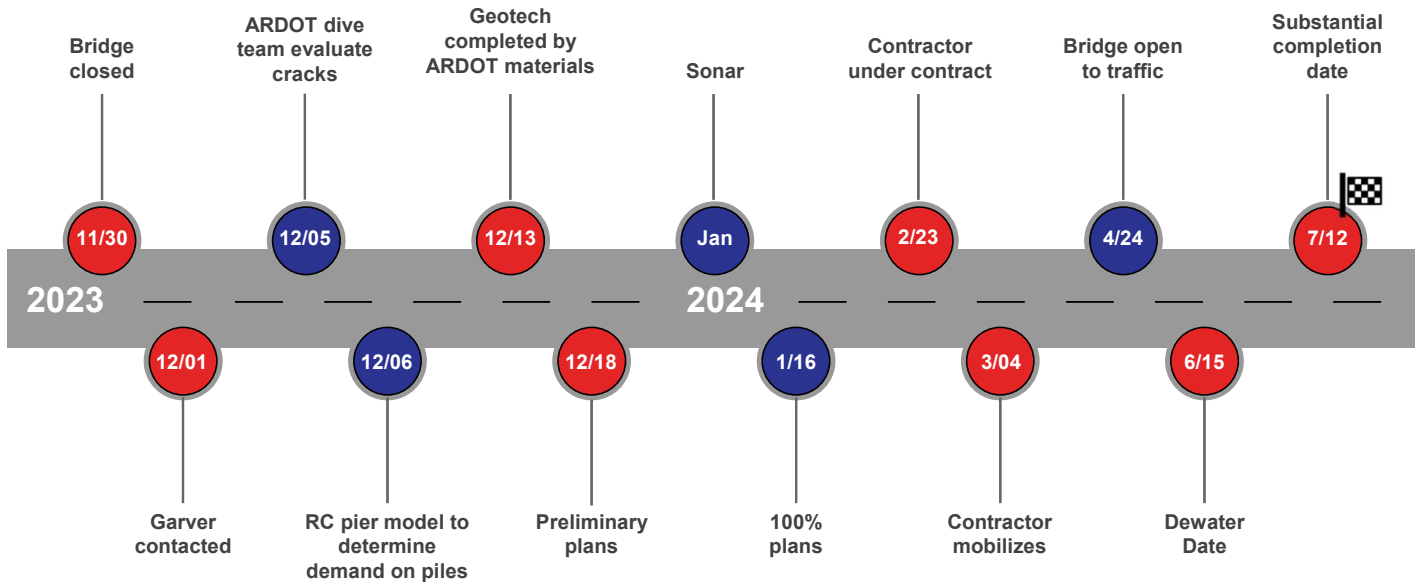


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Bridge Construction Timeline



Innovative Solutions (All Sources)

- **ARDOT District 6 Bridge Inspectors** identified initial scour issue
- **ARDOT Bridge Operations** monitored, collected data (sonar and scour probe), and identified when critical actions needed to be taken
- **eO** provided underwater bridge inspection
- **Garver H&H** analyzed/modeled hydraulics and scour
- **Garver Bridge** analyzed and designed unique structural solution
- **ARDOT Materials** provided geotechnical boring and remaining pile capacity calculations
- **Contech** provided the materials for ACB and innovative approach of hand cabling during construction
- **Kiewit** was the contractor that introduced Aquadam approach and construction

Without **EACH** member performing their role, our goal would not have been met!



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Key Takeaways

- Scour can cause **dangerous situations**. The timeline is **not predictable**.
 - Inevitability of scour is **predictable and monitorable**
- **Accurate inspections and data** are important for tracking any significant changes.
- Innovative solutions come from **all** team members
- Collaboration is **key**



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Thank you!



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