Images at Depth

Clarifying the

Darkness

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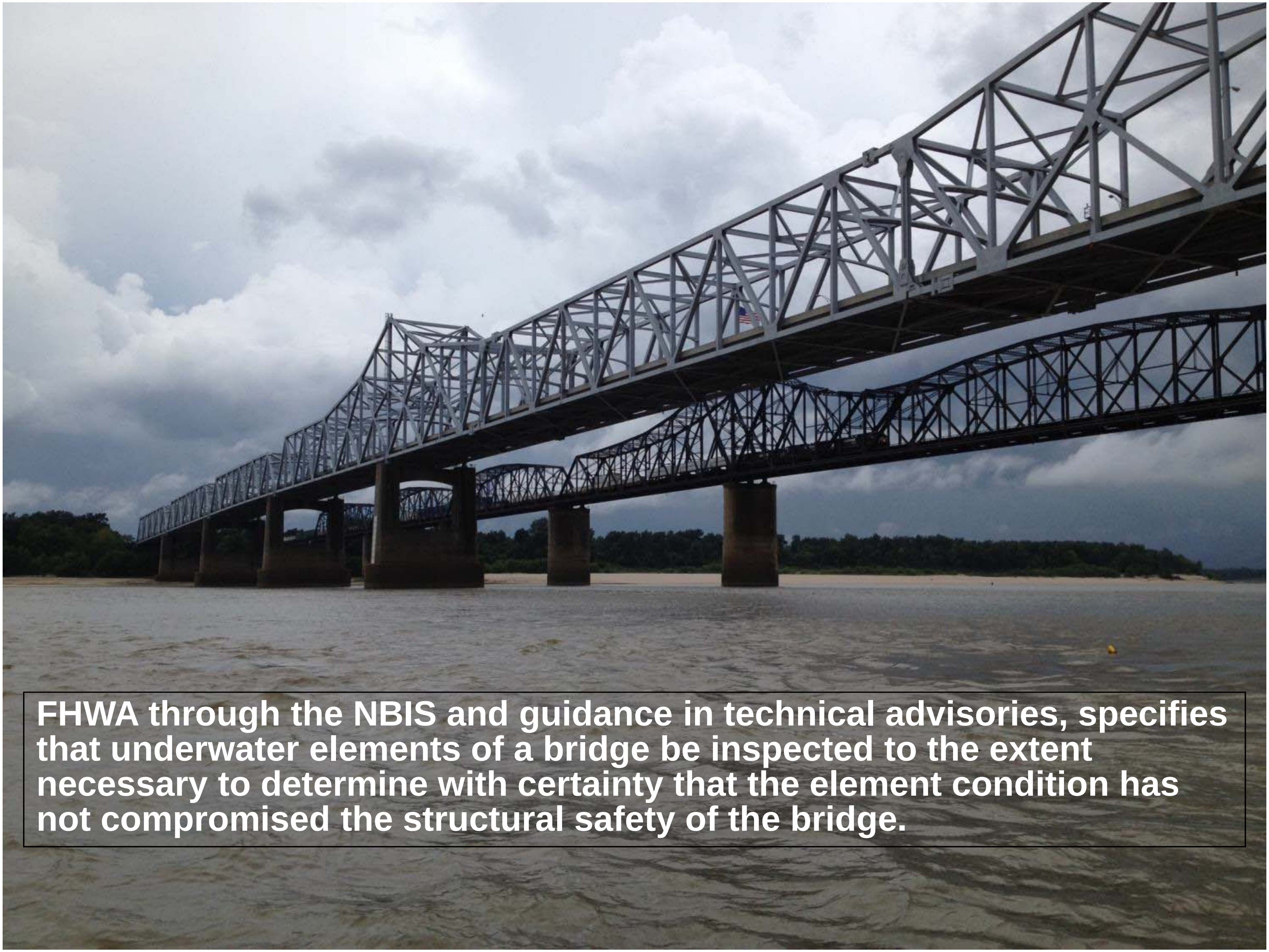
FENSTERMAKER

Crescent City Connection, New Orleans, LA

WHAT WE'LL COVER

- **Background of underwater bridge inspections**
- **Review of underwater acoustic imaging technology**
- **UAI Applications for underwater bridge inspection**
- **Results and lessons learned**

- **Over 502,000 bridges in the US span over water**
- **A significant number have foundation elements in the water**
- **A significant number of those span substantial water bodies**
- **Since 1988 – Inspection of submerged elements are required at least every 5 years**



FHWA through the NBIS and guidance in technical advisories, specifies that underwater elements of a bridge be inspected to the extent necessary to determine with certainty that the element condition has not compromised the structural safety of the bridge.

- **The submerged supports of many bridges are problematic to inspect due to hazardous conditions for divers**
  - ➢ High water flow current
  - ➢ Little or no visibility
  - ➢ Significant floating debris
  - ➢ Intense commercial vessel traffic

Challenge

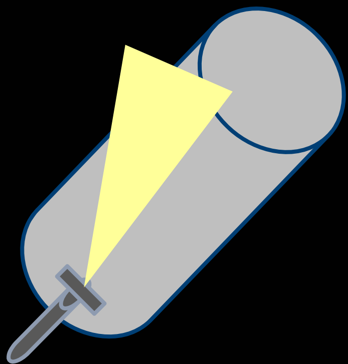
How to inspect large or hazardous river crossings where it is nearly impossible to perform a 100% underwater inspection due to the ***massive size of piers, significant depth, significant flow, zero visibility, and close proximity, high density commercial vessel traffic.***

Solution

Use Underwater Acoustic Imaging technology to accomplish Level 1 Inspections which will ***identify submerged anomalies****, then direct follow-up investigations by divers, inspecting only the identified anomalies when and where possible*

Currently Available Acoustic Remote Sensing Technology

Basic Types

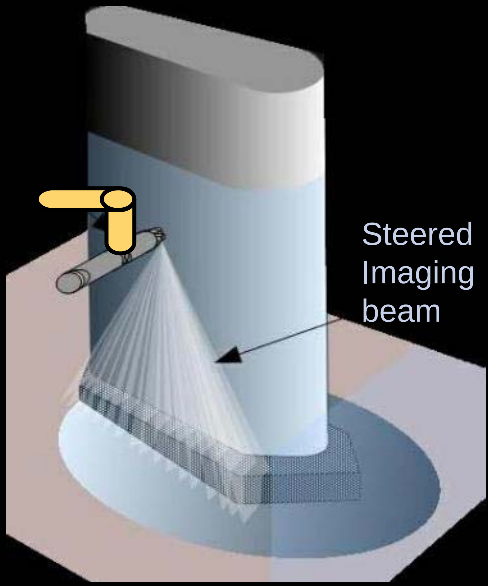


Steered Beam Sonar

Optimal for vertical structures

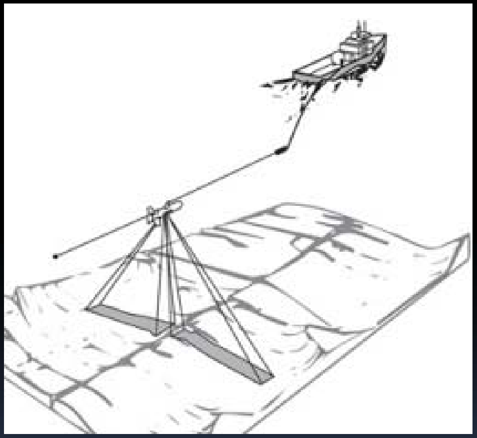
Currently also the most cost effective

Only system applicable to flooded culverts



Side Scan Sonar

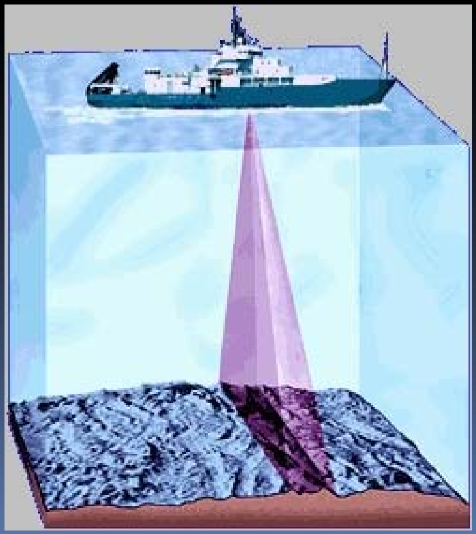
Not applicable for vertical structures

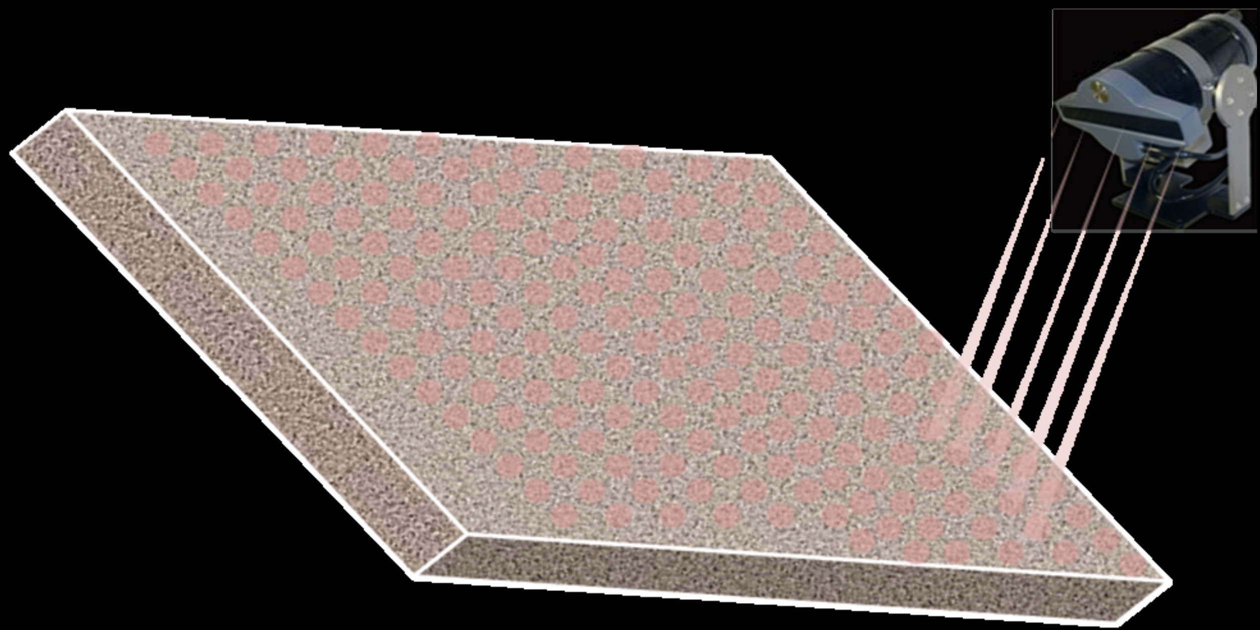


Multibeam Acoustic Systems

Can be adapted to vertical structures

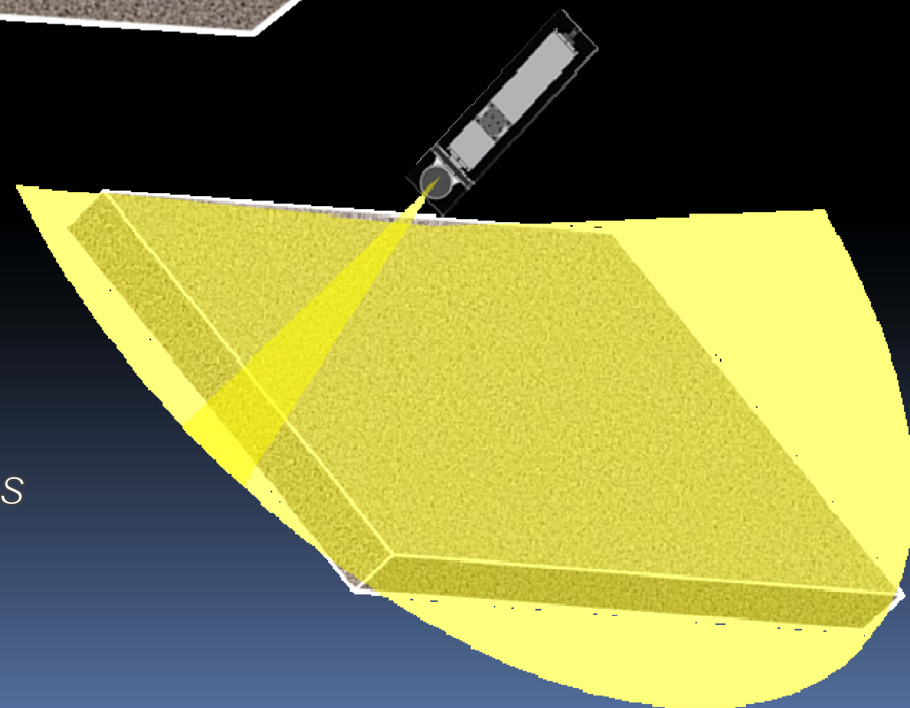
high cost with sub-optimal results on vertical surfaces



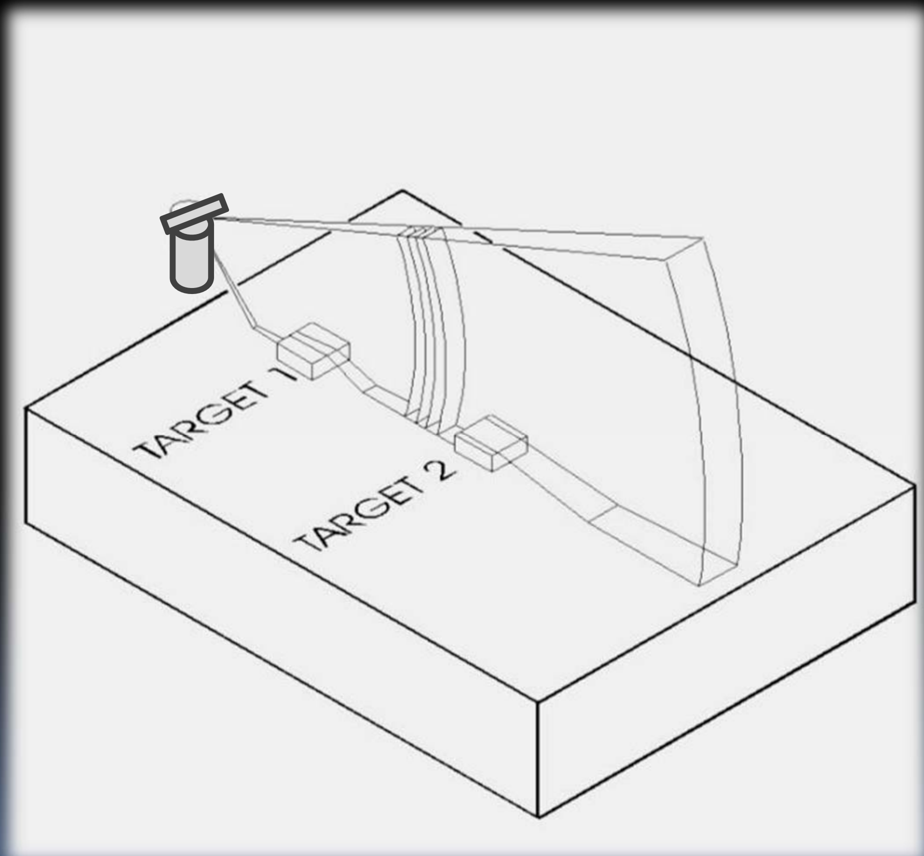


Multibeam record consists of multiple, discrete points corresponding to returns mapped at each transducer element

Mechanically scanned sonar record consists of a continuous record of amplitude reflections from the transducer to the scan range limit providing a seamless image translation



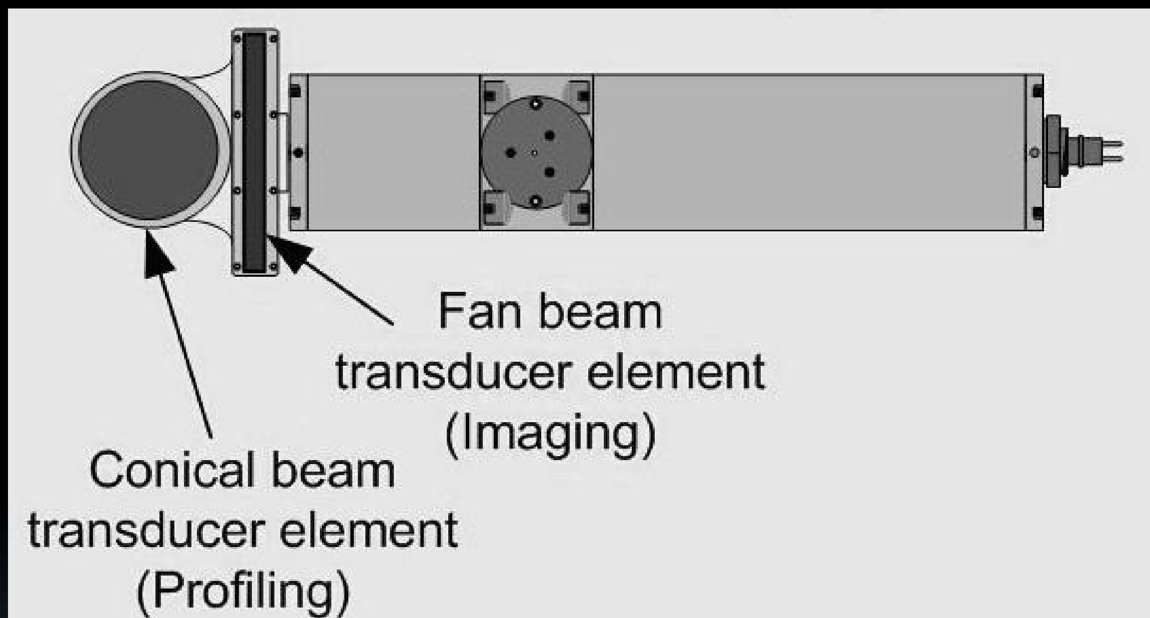
Mechanically Scanned Sonar Surface
Mapping Methodology



Returns recorded from each ping to the extent of the range limit, continuously.

Dual Element – Multi-axis Steered Beam Remote Sensing Unit

Based on A Kongsberg Mesotech MS1000

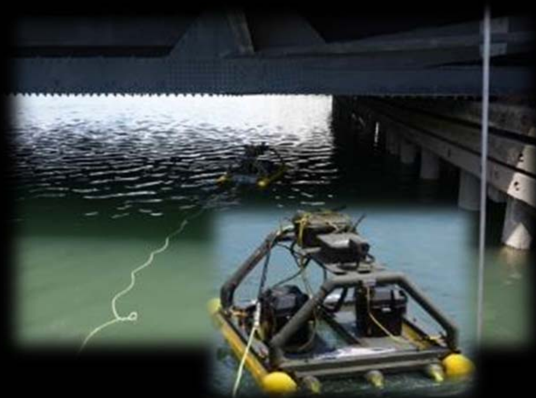


Why this system?

Provides the best results along with
multiple application versatility and remarkable reliability

Customized Sensor Deployment Configurations

Boat deployment



Small footprint Remote Controlled Survey Vessel (RCSV)

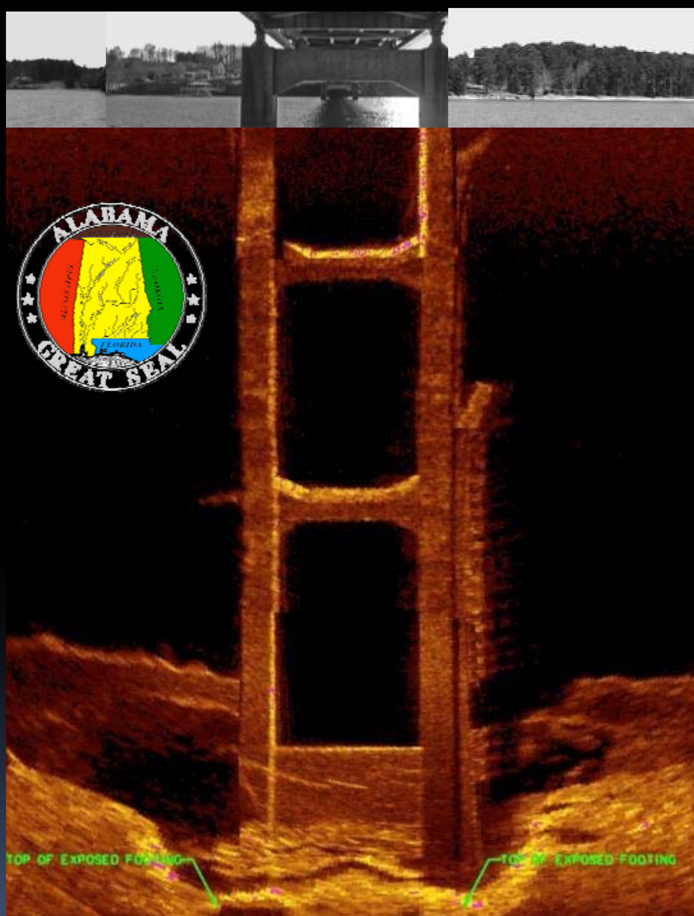
Tripod mounting for stationary, free standing deployment

Deep, high water current - deployment and maneuvering system

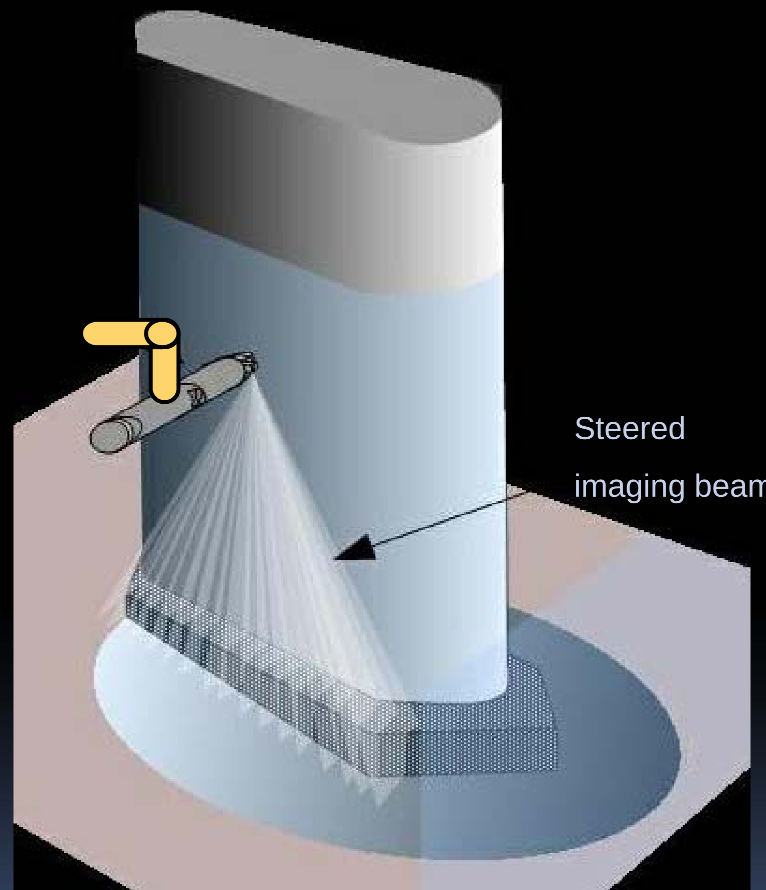
Mobile deployment and maneuvering system

Steered Beam Sonar

Integration of multi-axis steered platform, position and tracking Instrumentation is key to providing optimal visualization results

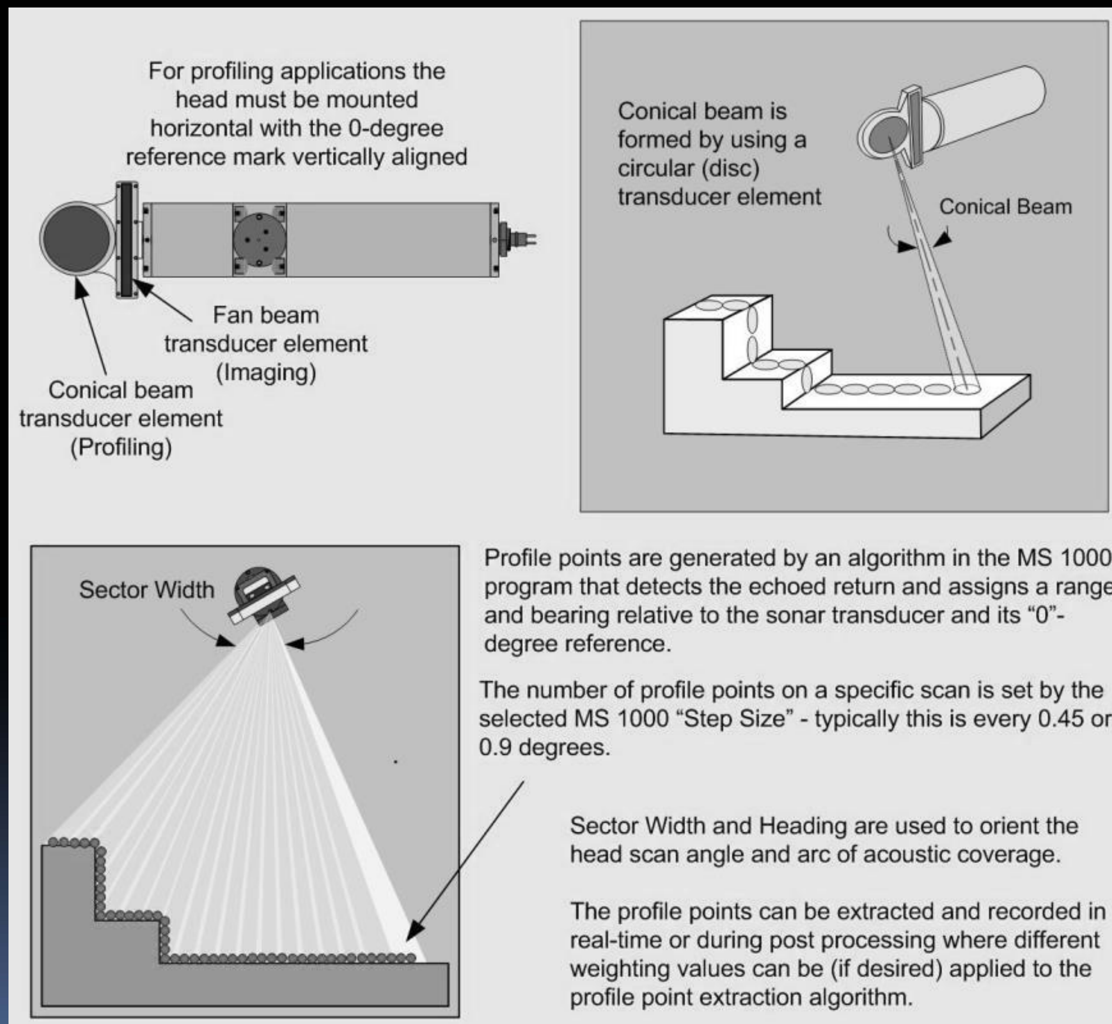


Duncan Bridge - Sipsey River
Winston County, Alabama



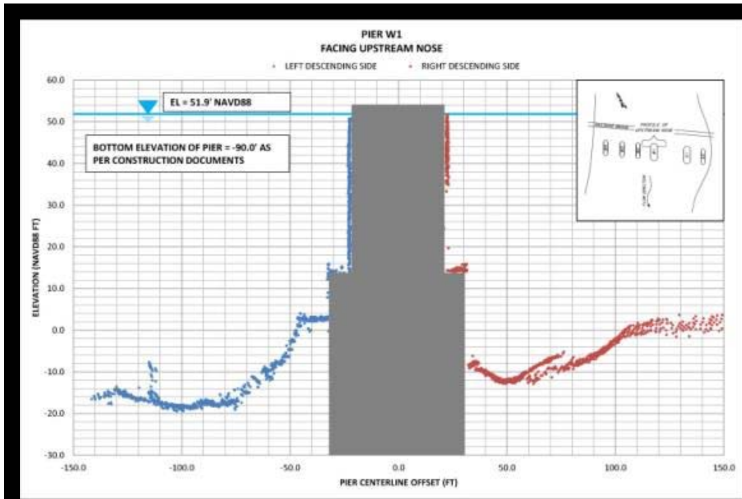
Visualization is accomplished by utilizing steered, fan acoustic beam, which is multi-axis steerable

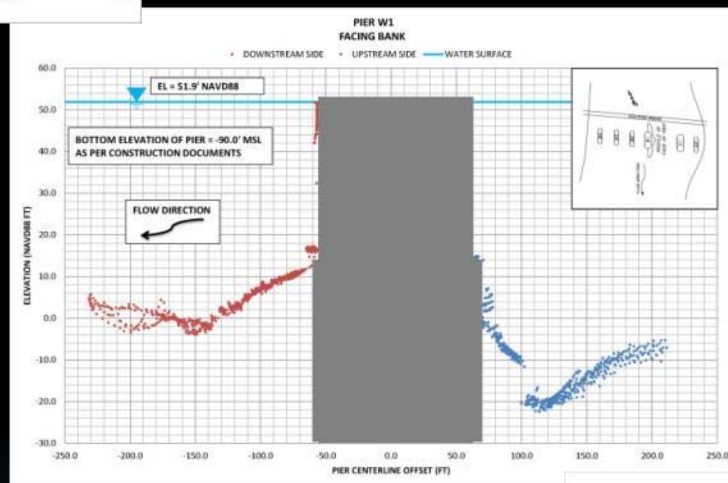
Acoustic Profiling Patterns and Beam Footprint

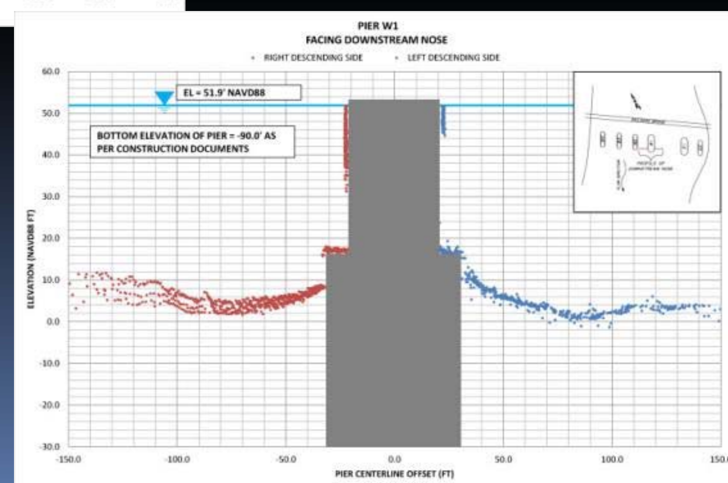


Typical Profiling Data Results:
Comprehensive Cross Channel Representation

Localized scour profile mapping

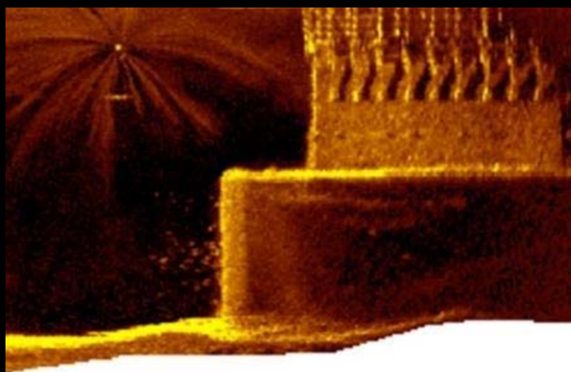


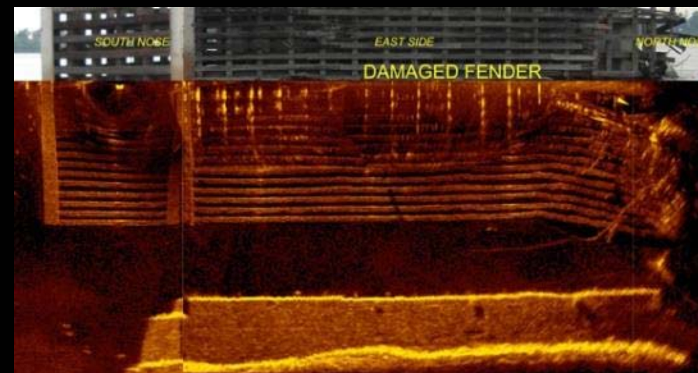




Steered Beam Acoustic Remote Sensing Systems Utilized for Acoustic Imaging & Profiling

Provides the best results over a wide range of conditions

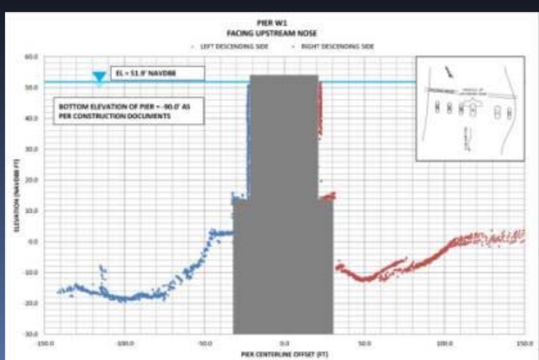




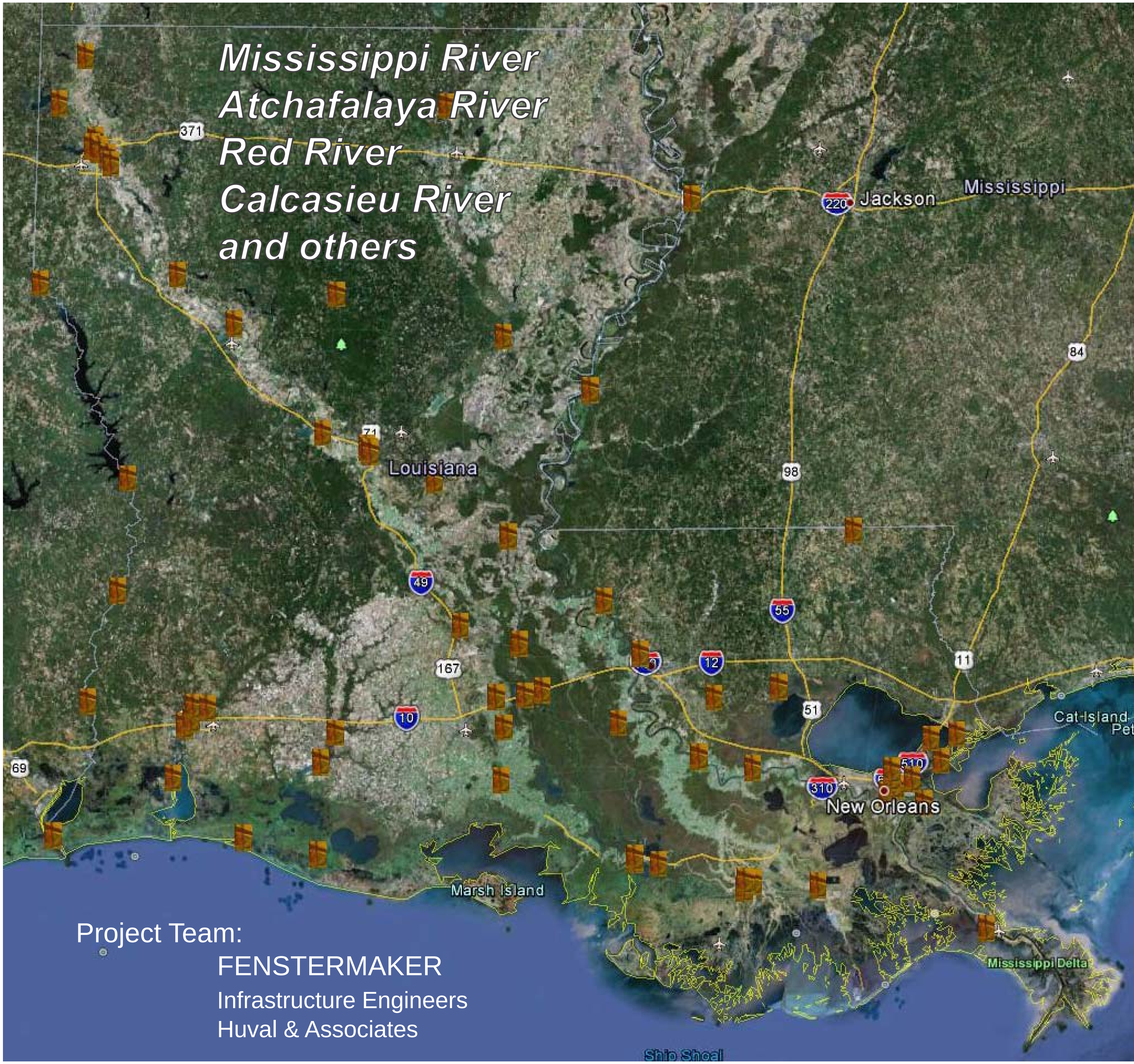
Dual element system, with deployment platforms optimized for

high turbidity, high flow environments

providing imagery visualization and profiling metrology



Mississippi River
Atchafalaya River
Red River
Calcasieu River
and others



Project Team:
FENSTERMAKER
Infrastructure Engineers
Huval & Associates

Large scale Louisiana, Underwater Bridge Inspection Project:

77 bridges in all types of inclement environments located across the state

DOTD LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT

Bridge Substructure Types Examined

- *Caisson founded monolithic piers*
- *Pile-supported spread footings with columns*
- *Mid-water footings supported by Drilled shafts*
- *Pile-supported waterline and above water footings*
- *Flooded culverts*

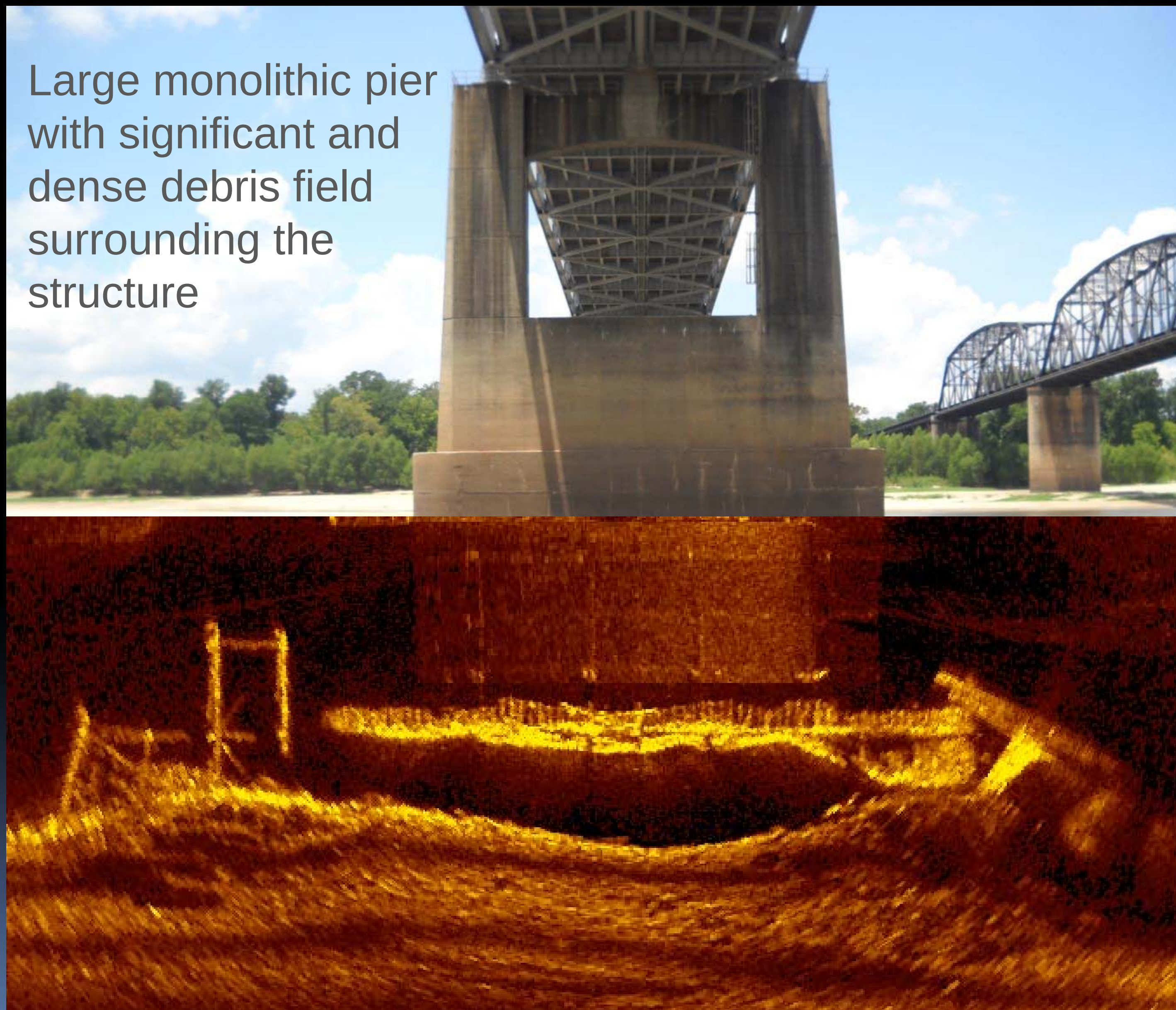
Work-flow used for the Louisiana DOTD Multi Bridge Underwater Inspection Project initiated in 2011

- Step 1 - Perform the UAI inspections on bridges (Level 1)
- Step 2 - Construct sonar visualization mosaics and water bottom profiles
- Step 3 - Review results of UAI and identify “anomalies” warranting further investigation
- Step 4 - Perform follow-up diving investigations as warranted and where possible.
- Step 5 - Generate final report comprised of all data and results

Mississippi River
Massive Monolithic Pier Structures

Crescent City Connection, and Greater New Orleans Bridges New Orleans, LA

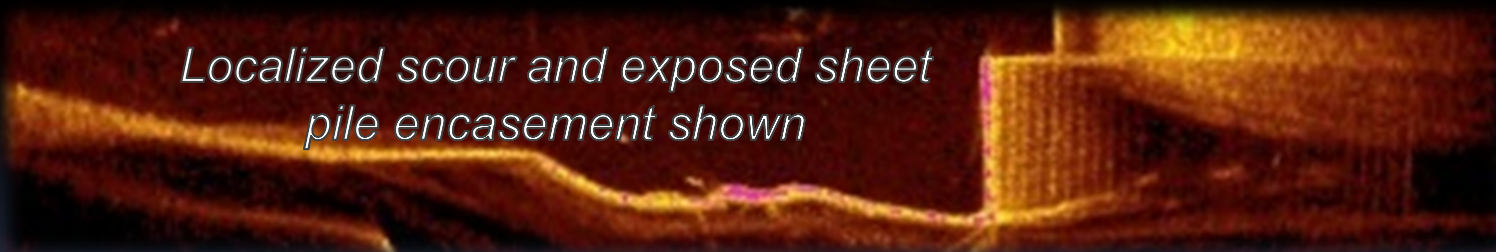
Large monolithic pier with significant and dense debris field surrounding the structure



Mississippi River large monolithic pier structures with localized scour impression

Red River

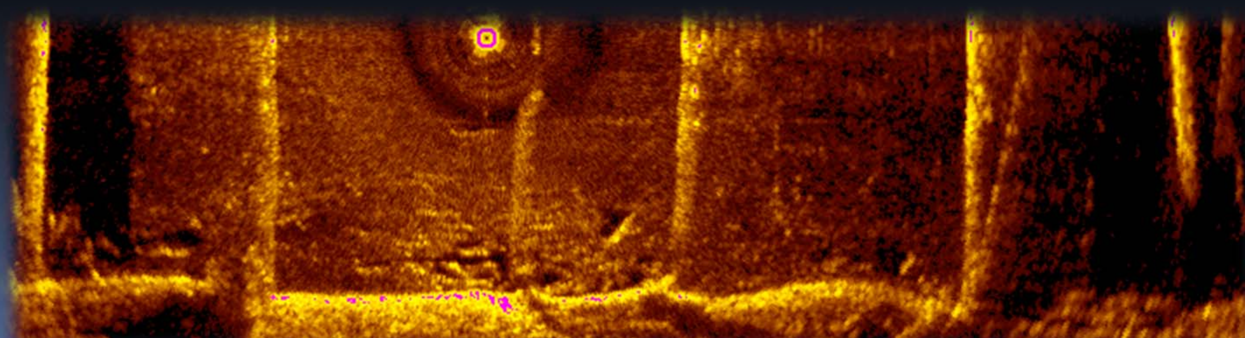
Large structures, rapid flow and rapidly changing river bed



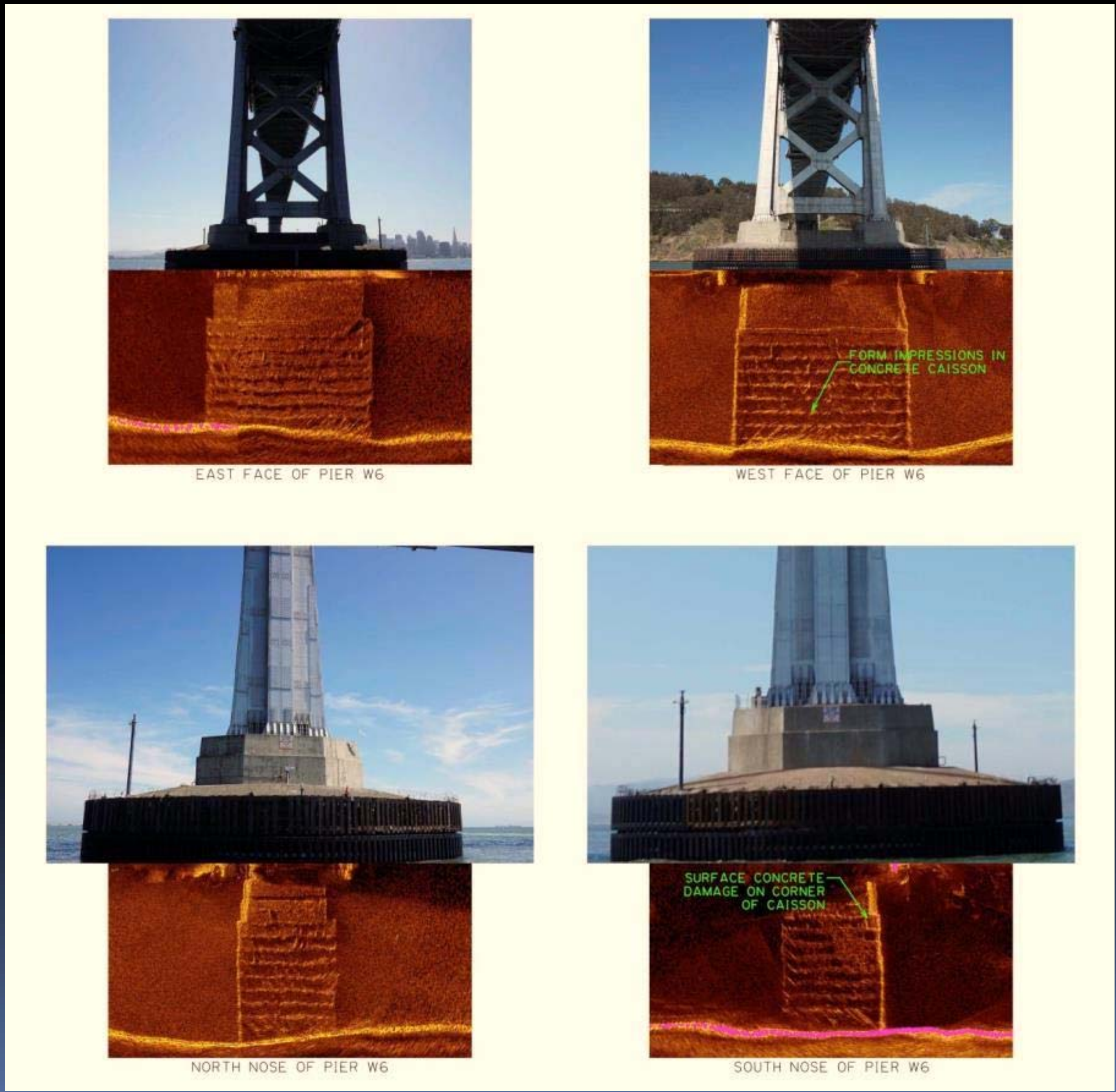
Localized scour and exposed sheet pile encasement shown

The Bayou Teche

Very shallow and minor waterway; however, UAI provides value in graphic documentation of voids



Large Caisson Founded Pier
Oakland Bay Bridge – West Span, Pier W6



EAST FACE OF PIER W6

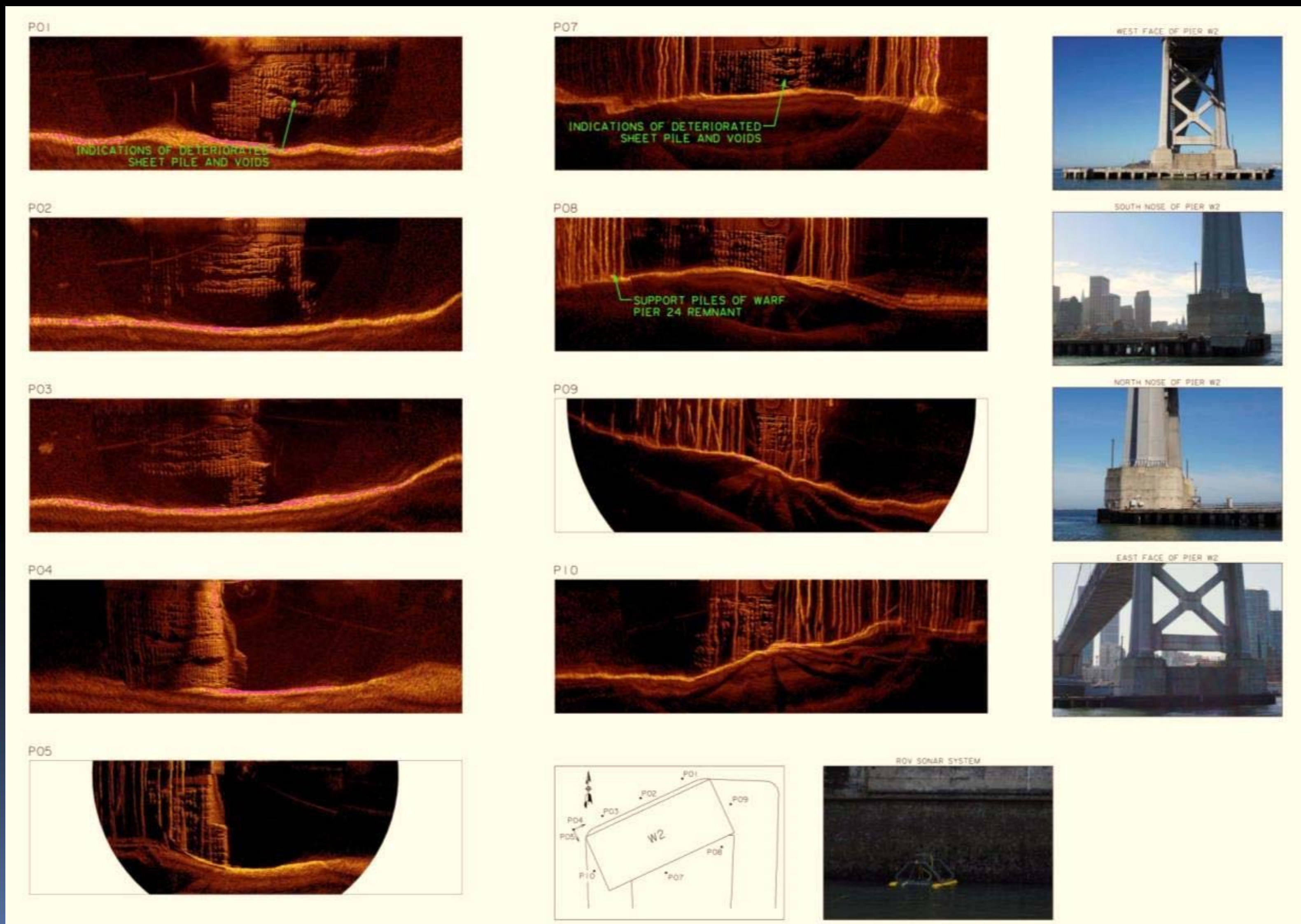
WEST FACE OF PIER W6

NORTH NOSE OF PIER W6

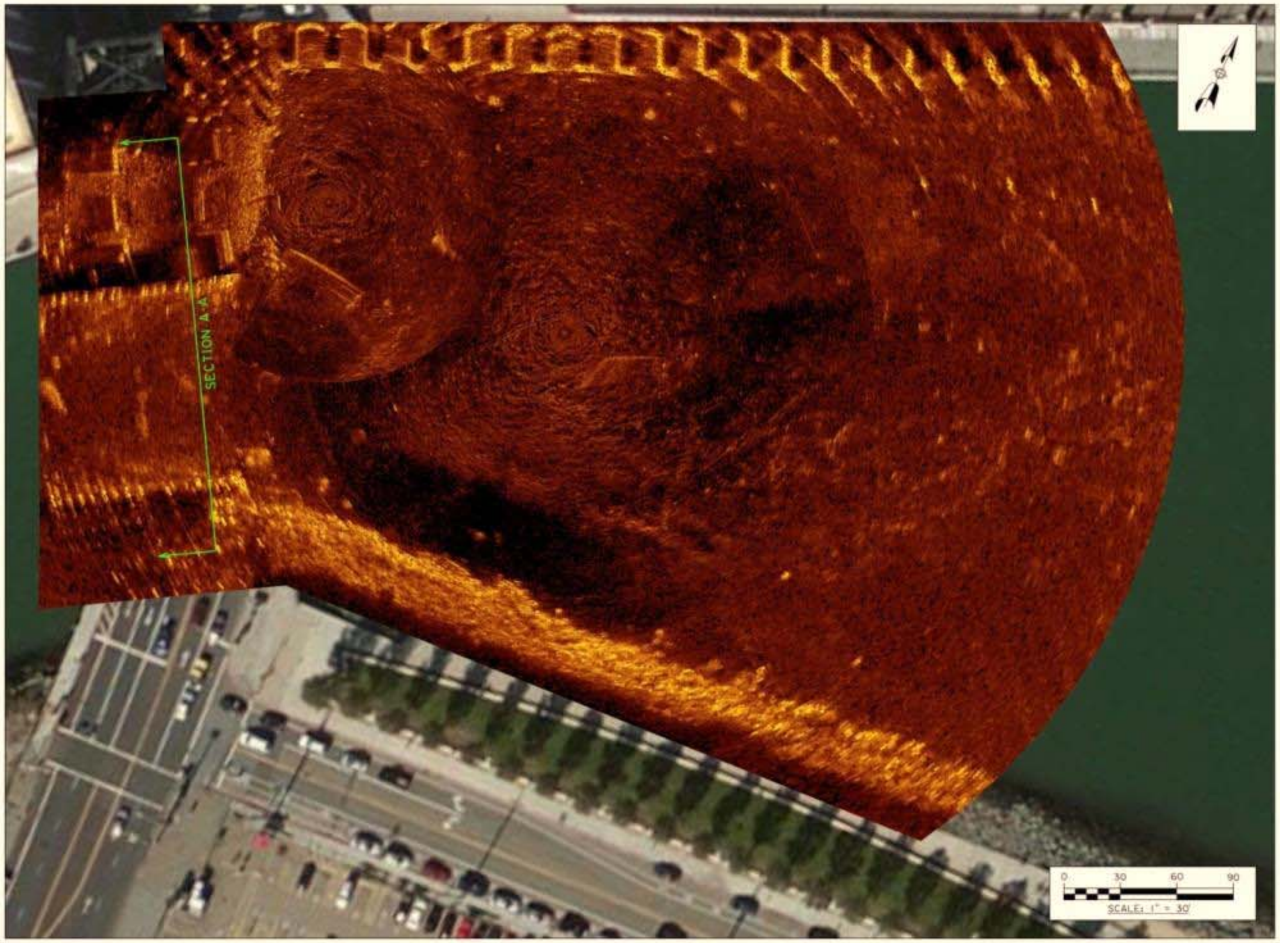
SOUTH NOSE OF PIER W6

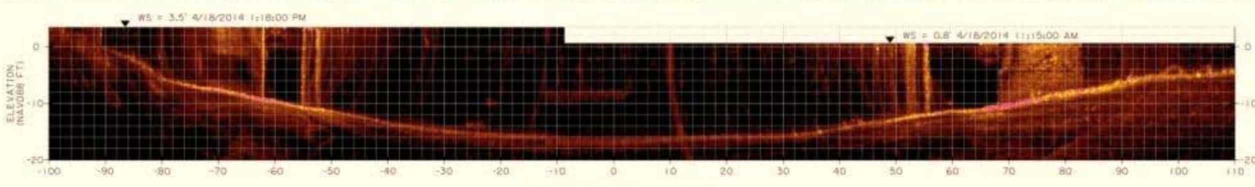
Large Caisson Founded Pier with Encumbered approach to one face

Oakland Bay Bridge – West Span, Pier W2

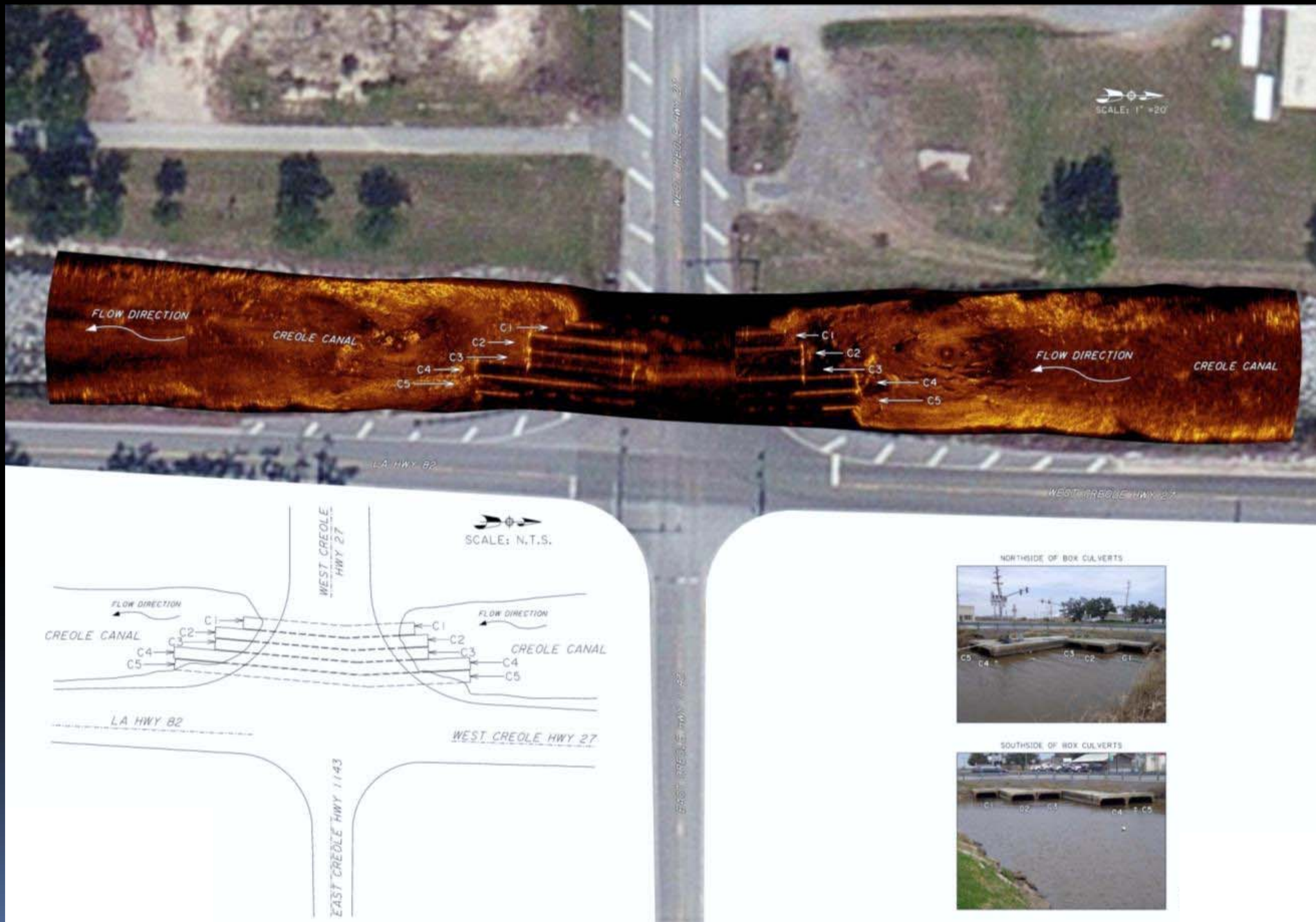


3rd Street Bridge, San Francisco





Culvert Bridge Inspection
Flooded Culverts @ **Creole Canal**, Southwest Louisiana



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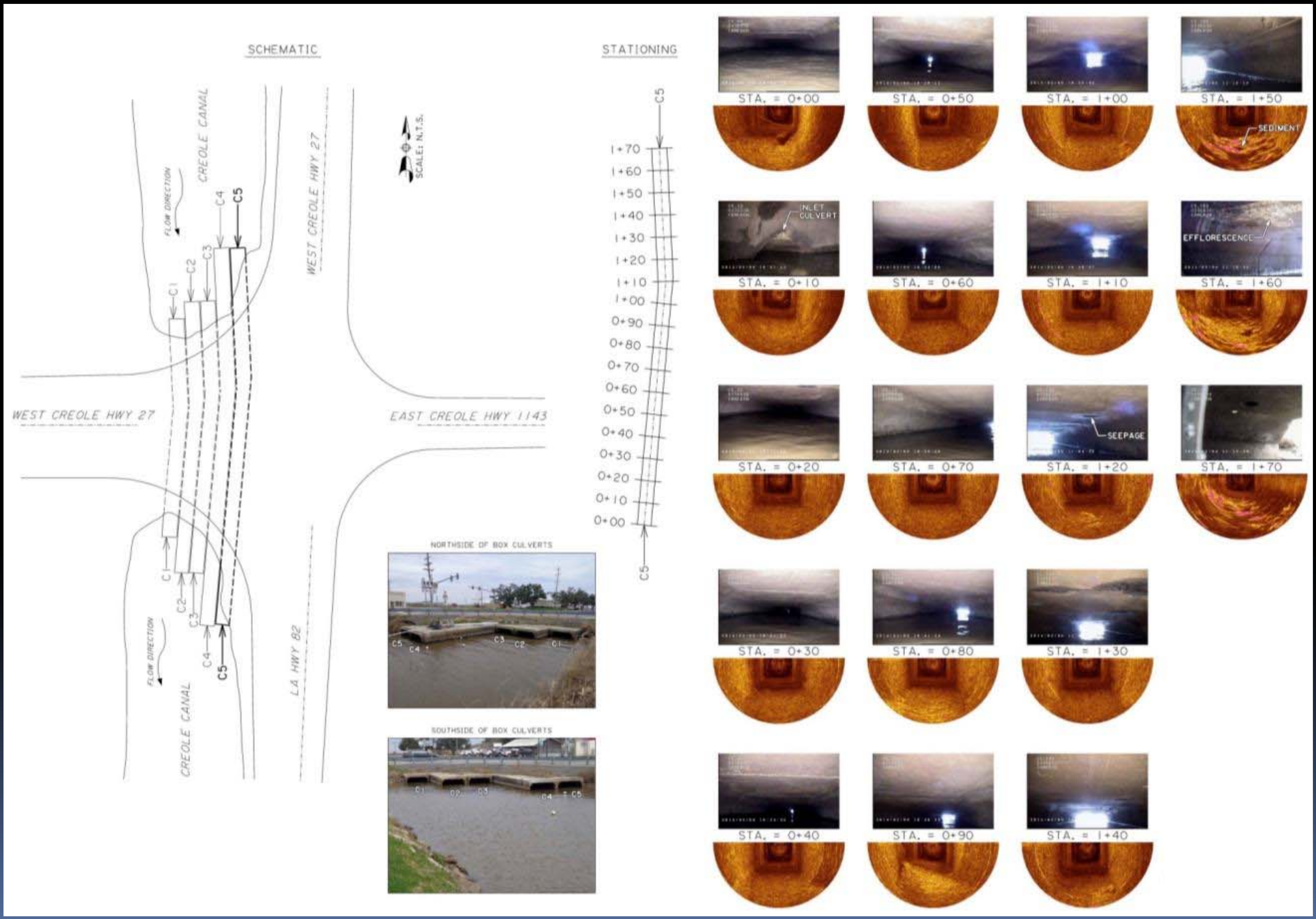


UAI Analysis Review
by Project Team

Diving Inspections
As Dictated by UAI Observations

- *Inspected "anomalies"*
- *Verification of procedure*

Results and Lessons Learned

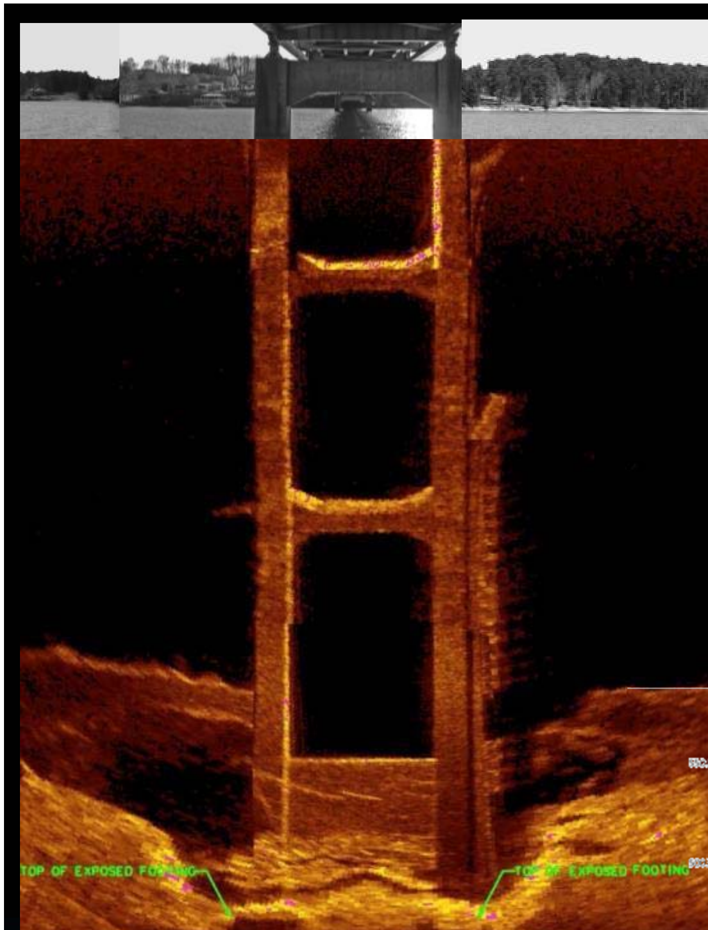
- *Successfully scanned all bridges*
- *Verified UAI scanning observations with diving & investigated observed anomalies where possible*
- *Documented scour*
- *Provided comprehensive reports with element ratings on all bridges*

Results and Lessons Learned

UAI worked well and very useful for:

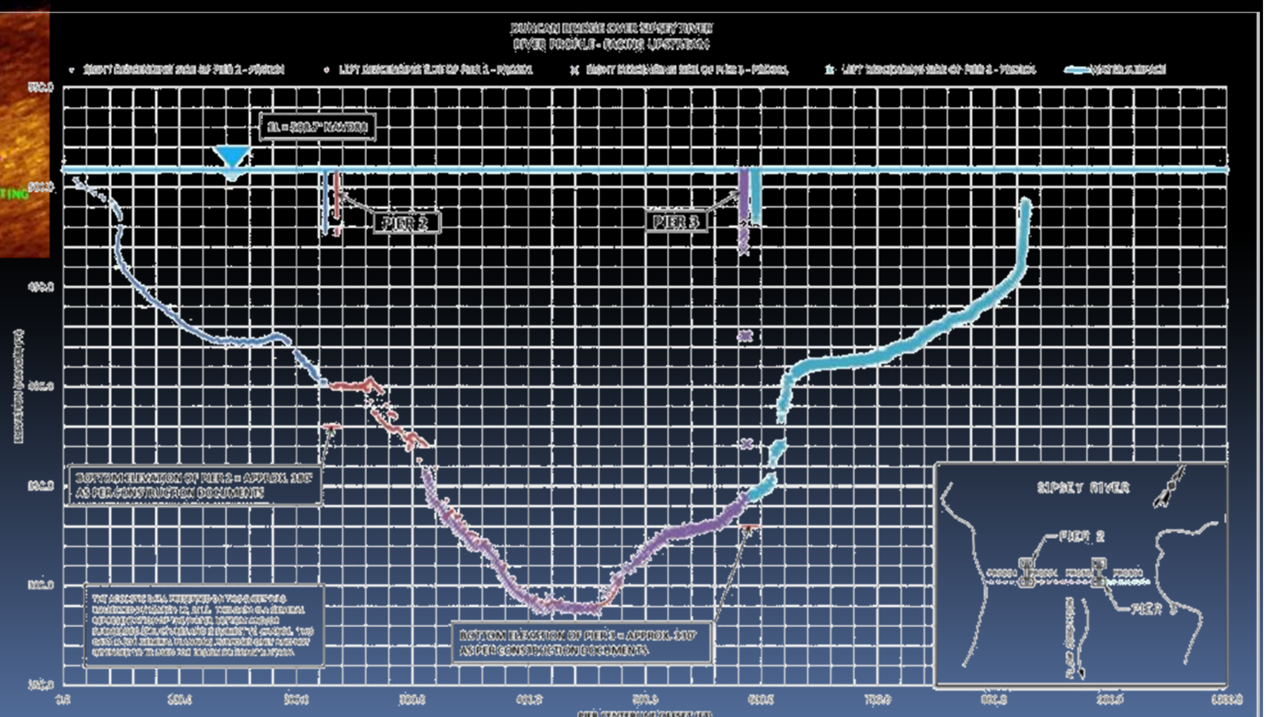
- *Bridges with massive piers*
- *High flow combined with significant depth*
- *No visibility with significant debris*
- *Significant scour and need to document*
- *Significant, close proximity commercial vessel traffic combined with any of the above*
- *Flooded culverts with no visibility*

Exemplary example of results for UAI Inspection @ Duncan Bridge



Imagery Results

Profiling Results



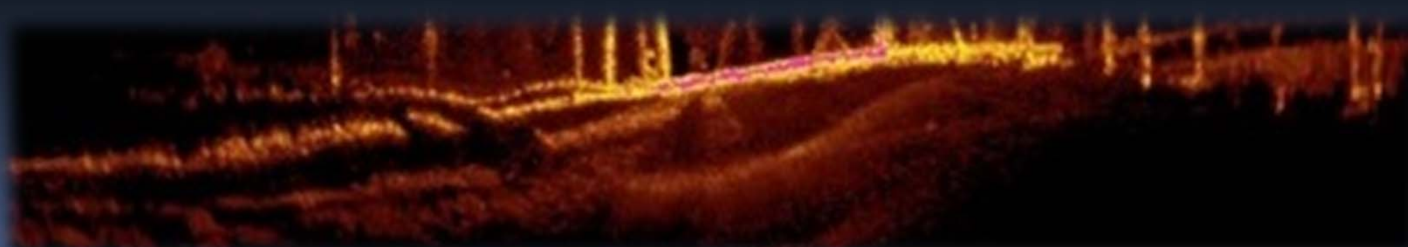
Results and Lessons Learned

UAI did not work as well for:

- *Waterline or above waterline footings with piles or drilled shafts below*
- *Shallow conditions <15' where the substructure consisted of multiple closely spaced piles or had fender systems very close to the support structures, especially in conditions without propensity for scour*

Mermentau River

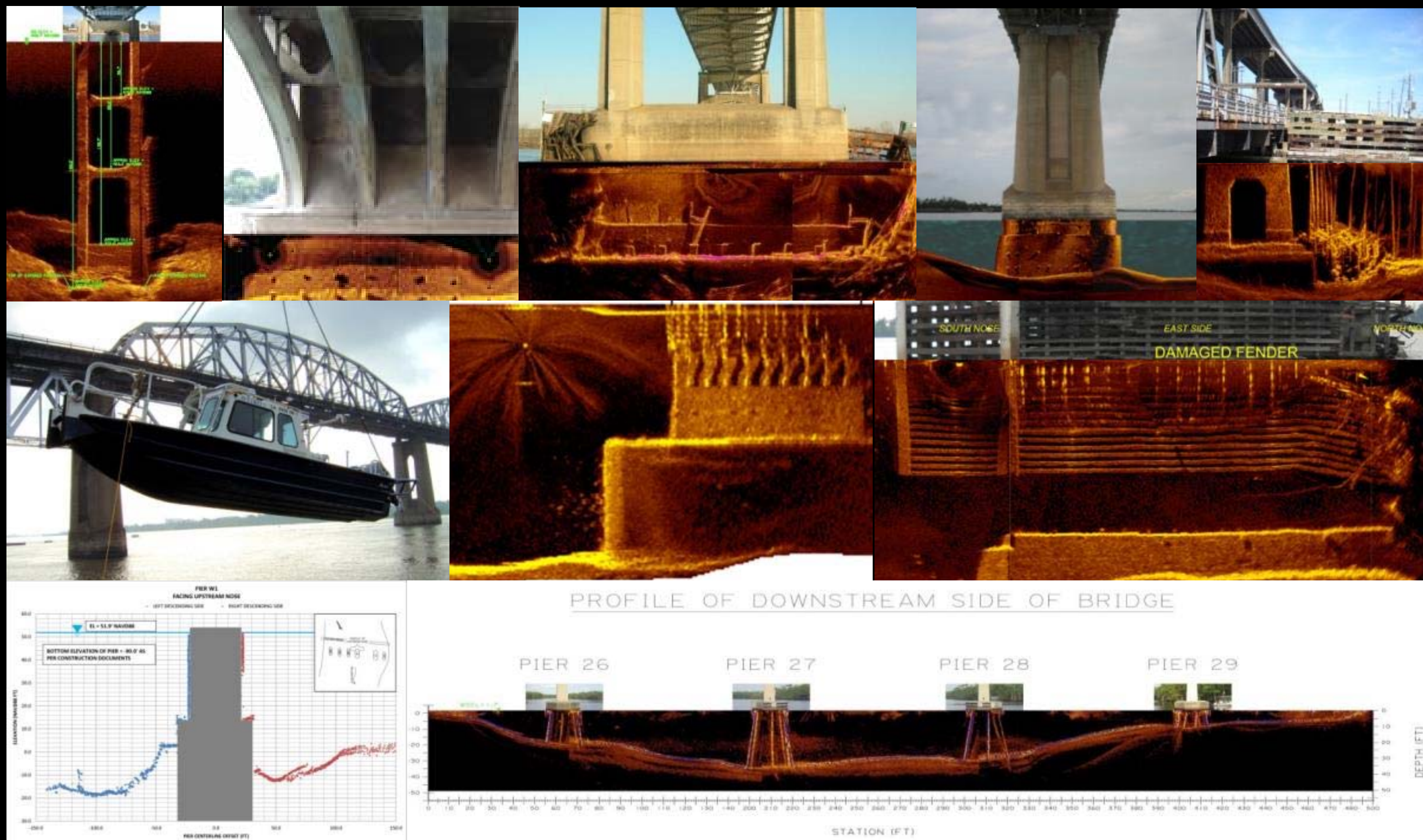
High density of closely spaced piles and close proximity of fender system produces difficulties for UAI effectiveness



Benefits Provided by Underwater Acoustic Imaging

- *Comprehensive overall perspective*
- *Implementation in all environment conditions*
- *Visualization and metrology of localized scour conditions*
- *Added element of safety*

Questions?



Thanks to our partners and Program Manager, and to the Structure Owners.