



# Port Sustainability and Infrastructure Resilience

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**MSI** MARINE SOLUTIONS, INC.

# Critical Civil Infrastructure



Infrastructure is defined as critical if its incapacity or destruction has a significant impact on health, safety, security, economics, and social well-being of a state (Council directive 2008)

# Why Should We Care?

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High levels of uncertainty

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Aging infrastructure/limited investment

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Natural and manmade disasters have become more frequent

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Infrastructure designed now will last 25-50 years – WILL INEVITABLY be subjected to unknown/unknowable design hazards

# Risk vs. Resilience

Resilience & risk are not synonymous but can work together.

## Resilience

- Focus is on maintaining performance even as losses occur

## Risk

- Focus is on likelihood of experiencing loss (and mitigating the risk)

## In the news -

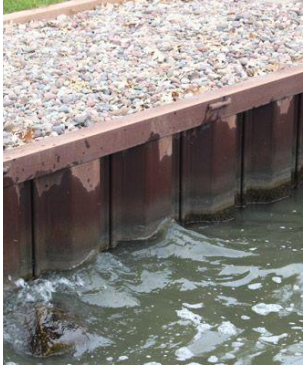
**The Port of Baltimore shipping channel has fully reopened, 11 weeks after the Francis Scott Key Bridge collapsed when it was struck by a cargo ship.**





# Coastal Infrastructure

## Seawall



Prevents or alleviates overtopping and flooding of the land structures behind due to storm surges and waves

## Breakwater



Reduces incoming wave energy, provides a sheltered beach area and shelters vessels from waves and currents

## Bridge



Provides transportation connectivity to safely cross features such as waterways, railways, roadways, and other obstacles

## Outfall



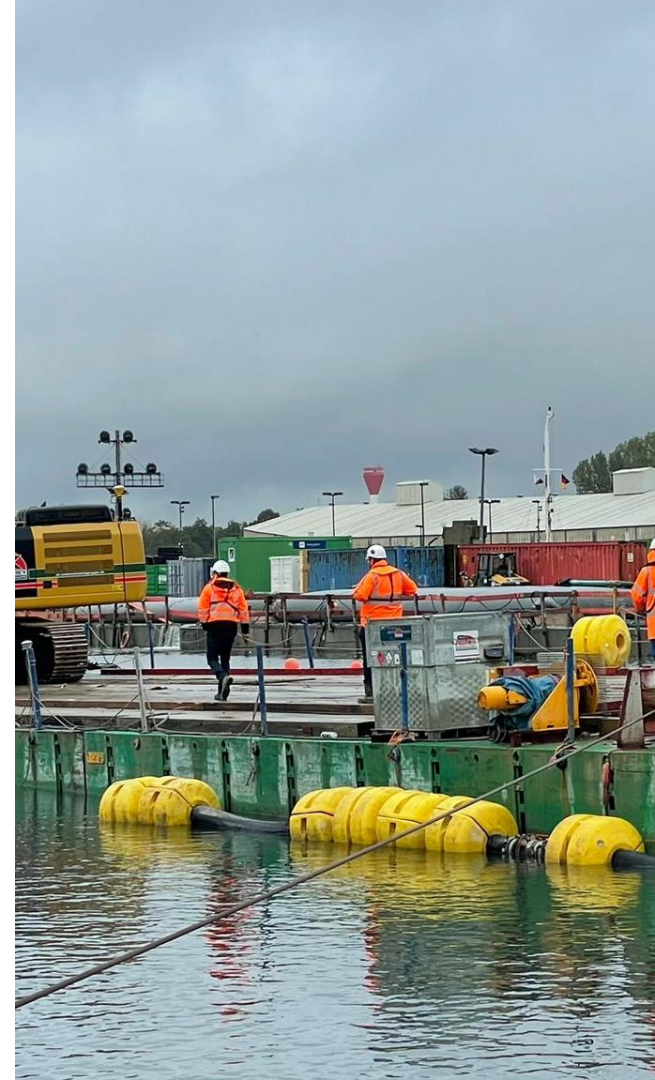
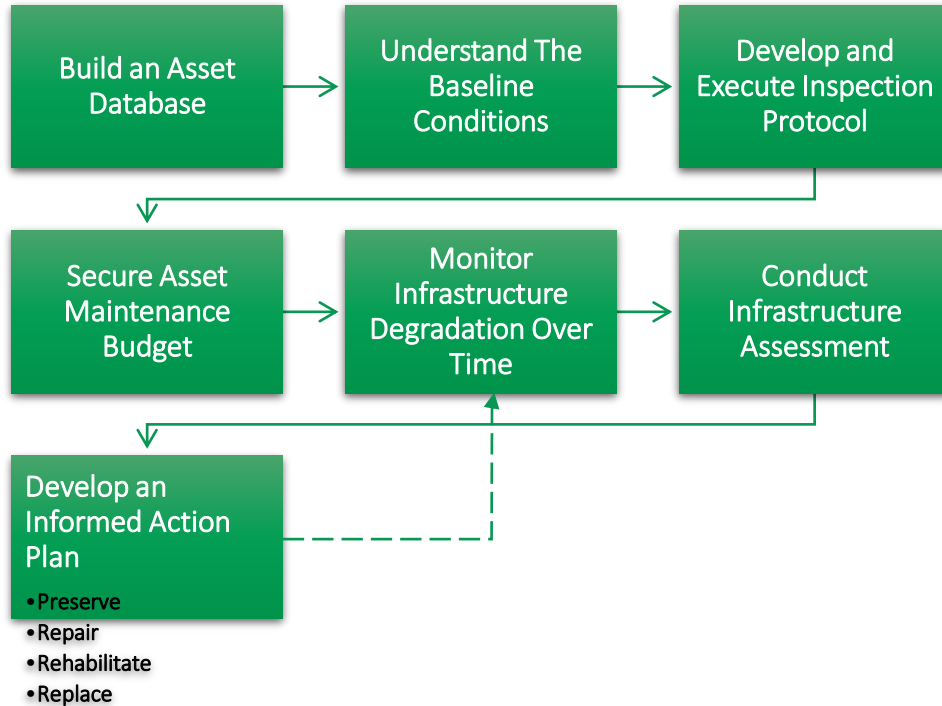
Discharges municipal or industrial wastewater, stormwater, combined sewer overflows (CSOs) into receiving water body

## Causeway



Raises roadway that is often used to cross wetlands or bodies of water

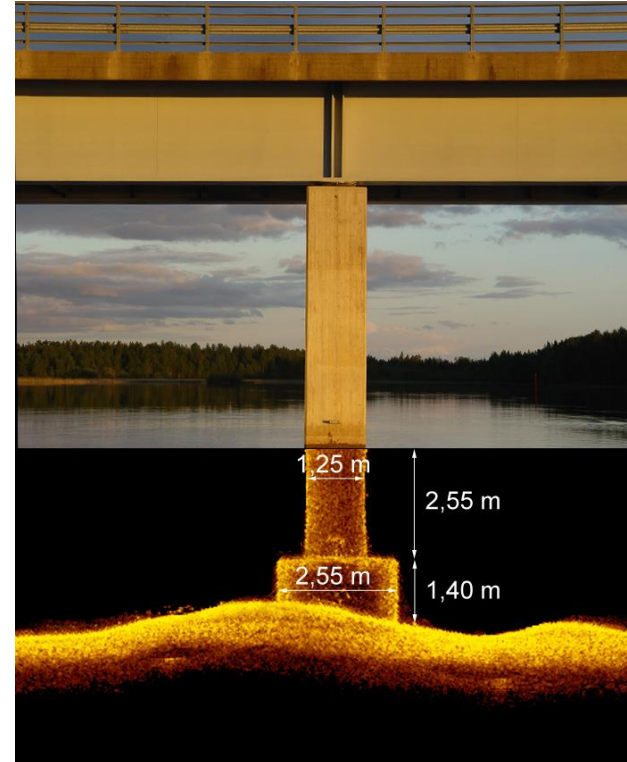
# The Needs of Civil Engineering Asset Management



# Inspections for underwater structures



- Need for inspection
  - Waterfront structures are ageing
  - Reduce vulnerabilities in critical infrastructure systems
  - Post-damage assessment
- Challenges with traditional / diving inspections
  - High current
  - Low visibility
  - Large areas
  - Accurate reports





# The Needs of Civil Engineering Asset Management

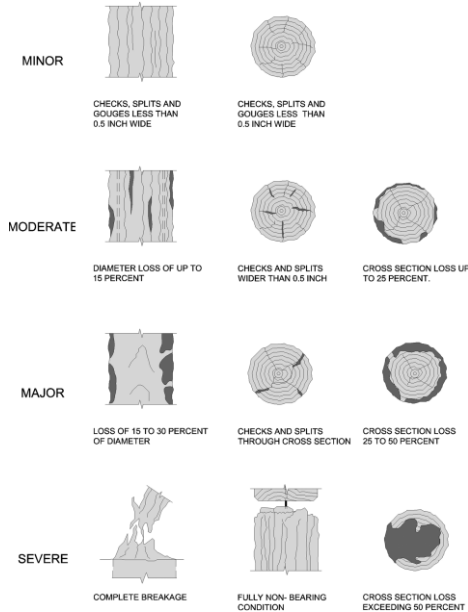


Fig. 2-2. Condition ratings for timber elements  
Source: Courtesy of CH2M HILL, Inc. and Ben C. Gerwick, Inc., reproduced with permission.

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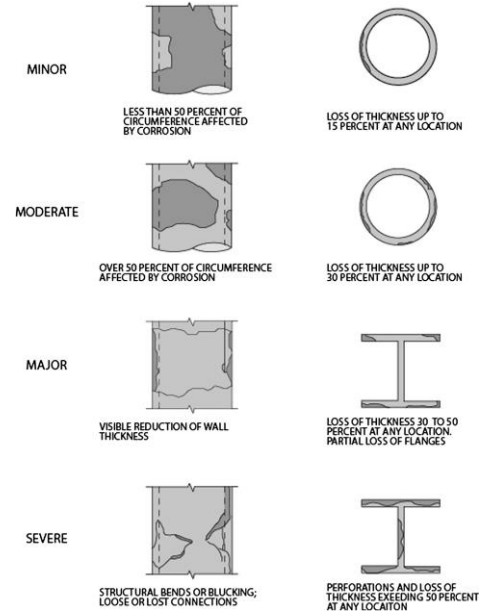


Fig. 2-3. Damage ratings for steel elements  
Source: Courtesy of CH2M HILL, Inc. and COWI, Inc., reproduced with permission.

# The Needs of Civil Engineering Asset Management

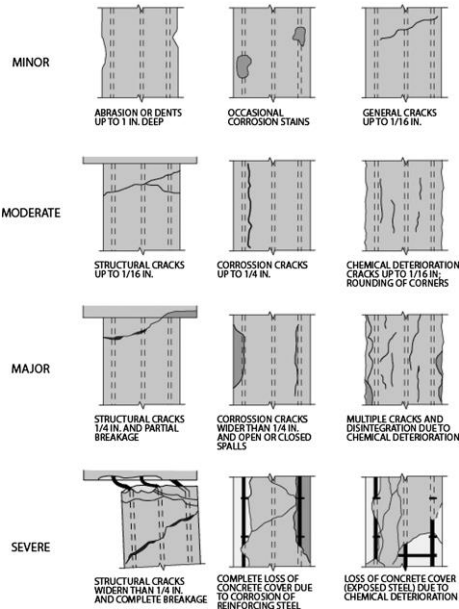


Fig. 2-4. Damage ratings for reinforced concrete elements  
Source: Courtesy of CH2M HILL, Inc. and COWI, Inc., reproduced with permission.

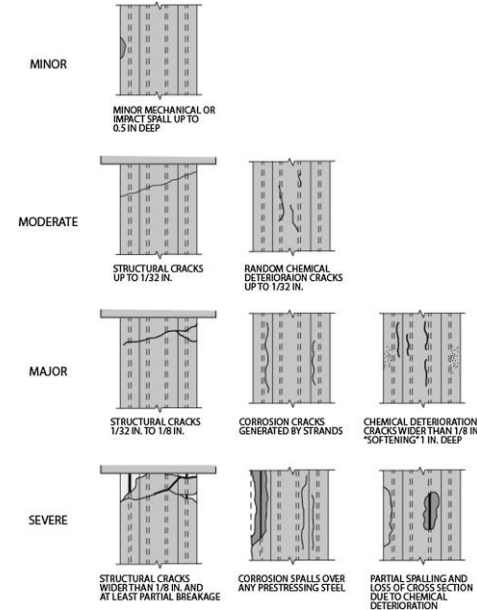


Fig. 2-5. Damage ratings for prestressed concrete elements  
Source: Courtesy of CH2M HILL, Inc. and COWI, Inc., reproduced with permission.

## The Needs of Civil Engineering Asset Management



Fig. B-9. Reinforced concrete pile with loss of section below the high tide level  
Source: Courtesy of Marine Solutions, Inc., reproduced with permission.

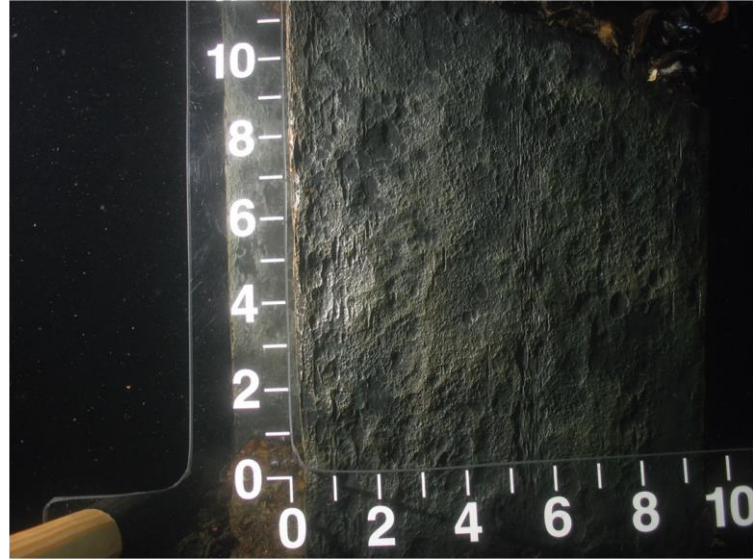


Fig. B-16. Underwater photograph of pitting on a steel pile  
Source: Courtesy of Appledore Marine Engineering, Inc., reproduced with permission.

# The Needs of Civil Engineering Asset Management

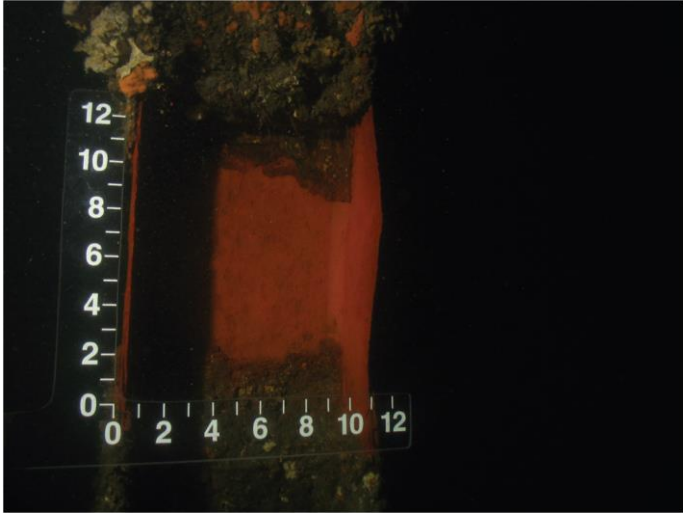
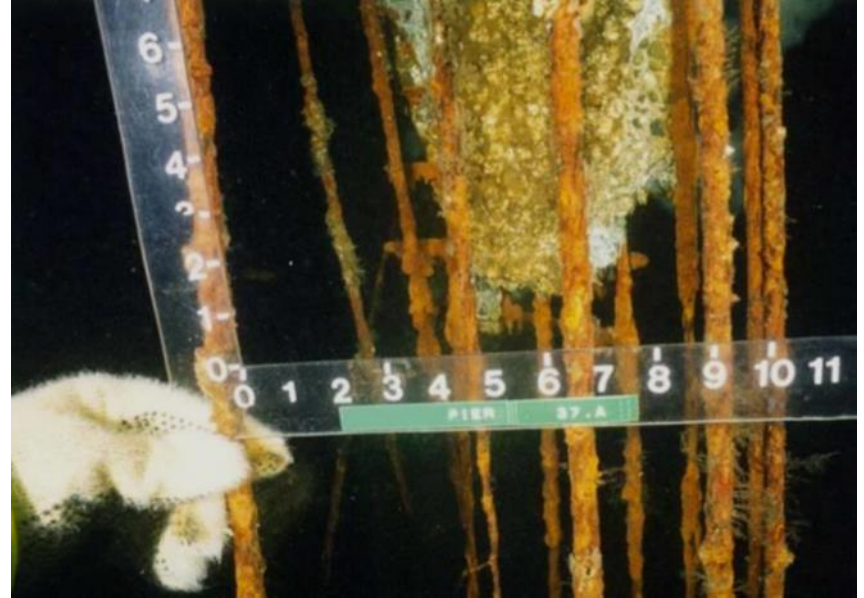


Fig. B-17. Severe corrosion and “knife edging” of a steel H-pile  
Source: Courtesy of Appledore Marine Engineering, Inc., reproduced with permission.



Fig. B-20. Underwater photograph showing hollowing of the interior of a timber pile from Teredo  
Source: Courtesy of Marine Solutions, Inc., reproduced with permission.

# The Needs of Civil Engineering Asset Management



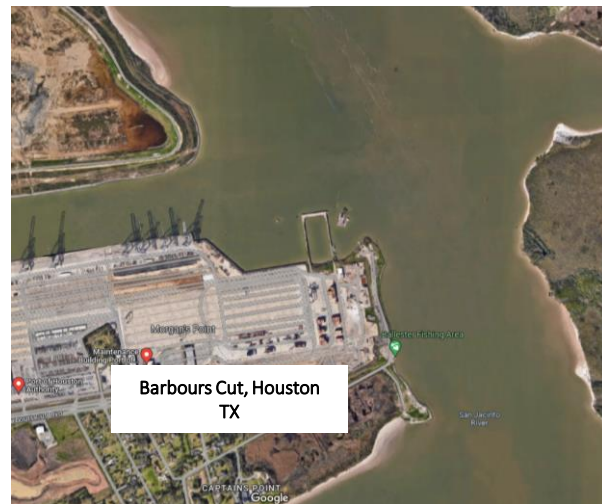
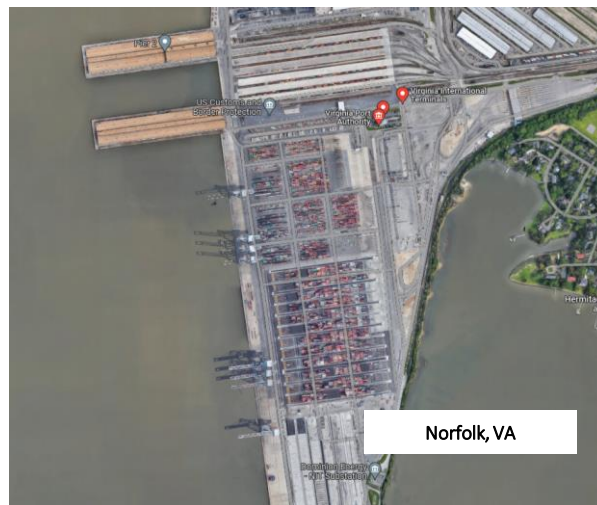


ASCE Port Operations and Maintenance Course – Masonry and Cyclopean Walls

# The Needs of Civil Engineering Asset Management

Engineers deliver technical reports with data, for non-engineers to make financial decisions



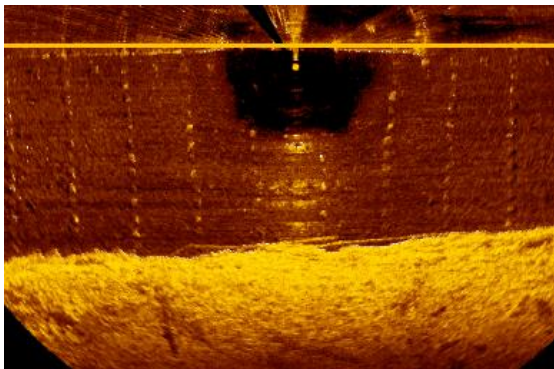




\*Single Beam Scanning Sonar Data courtesy of Brian Abbott

# Coastal/Underwater Infrastructure Building Materials

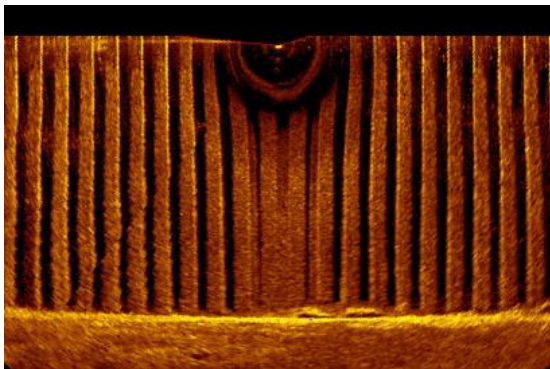
Wood



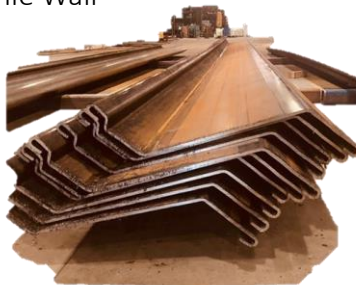
Wood Timber Wall



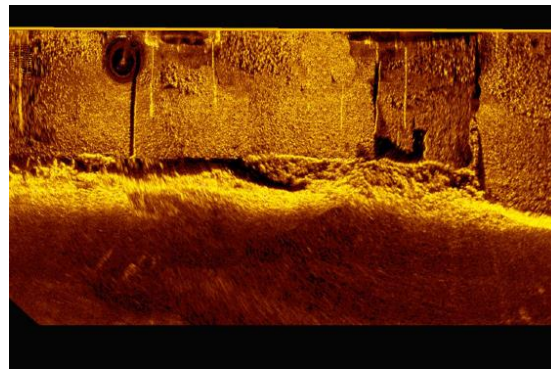
Steel



Sheet Pile Wall



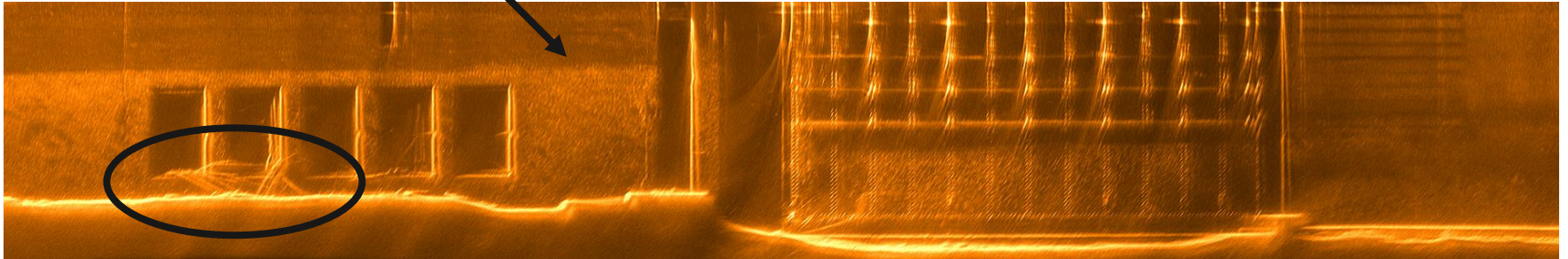
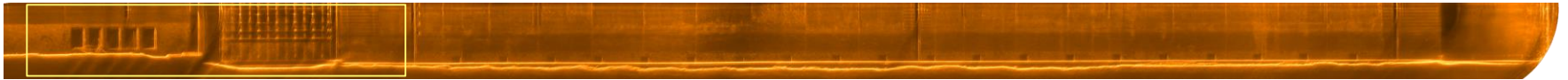
Concrete



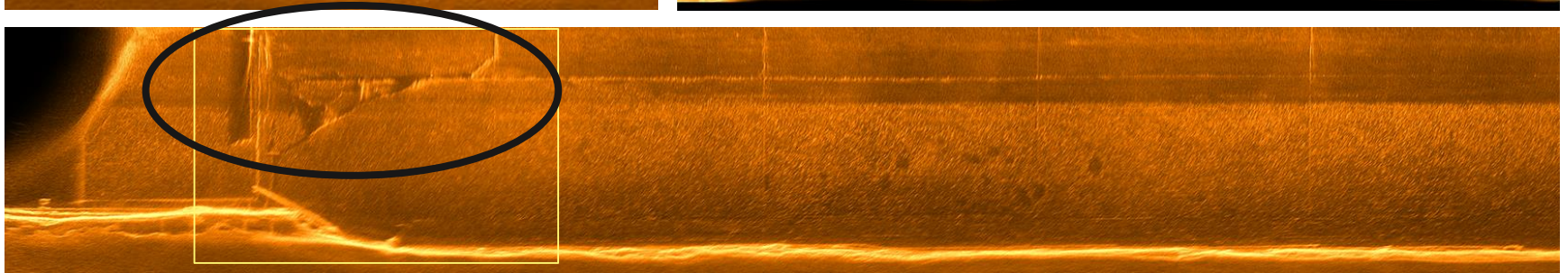
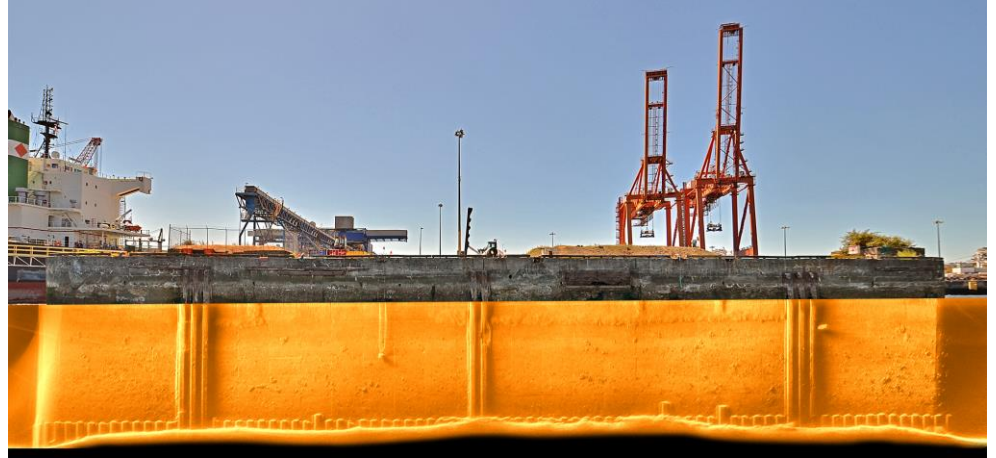
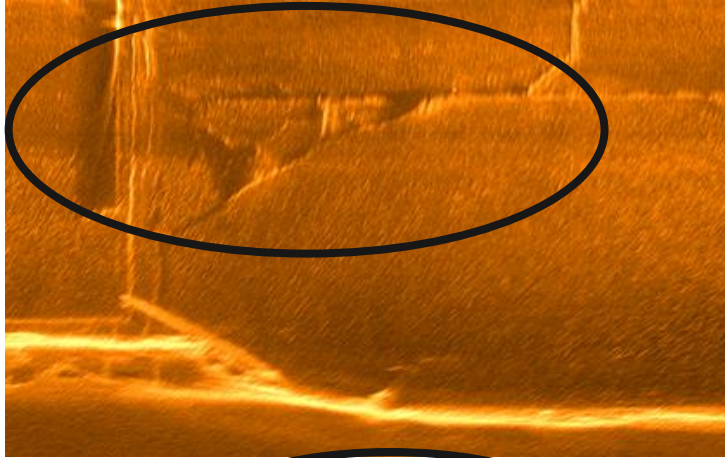
Concrete Wall



# Lock Infrastructure Inspection



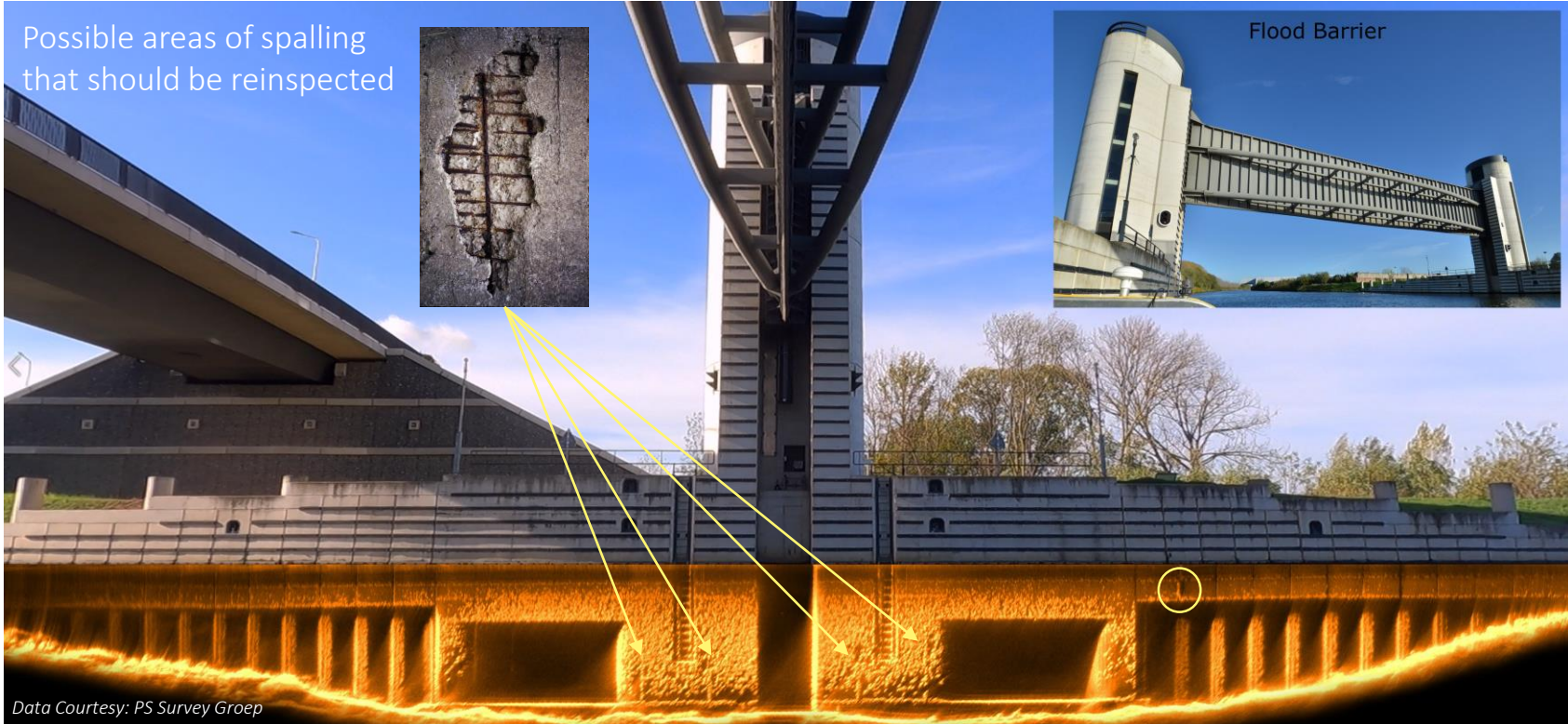
# Ship Strike Damage Inspection





# Flood Barrier Inspection

Possible areas of spalling that should be reinspected



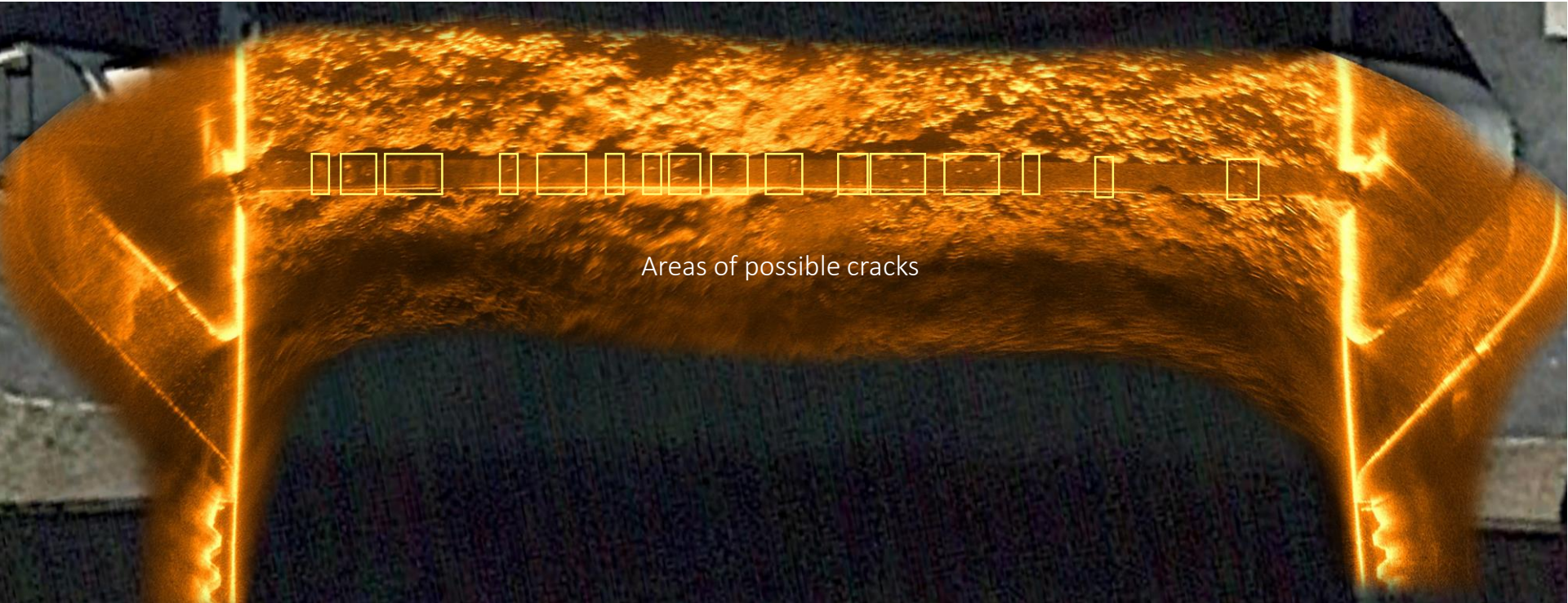
Data Courtesy: PS Survey Groep



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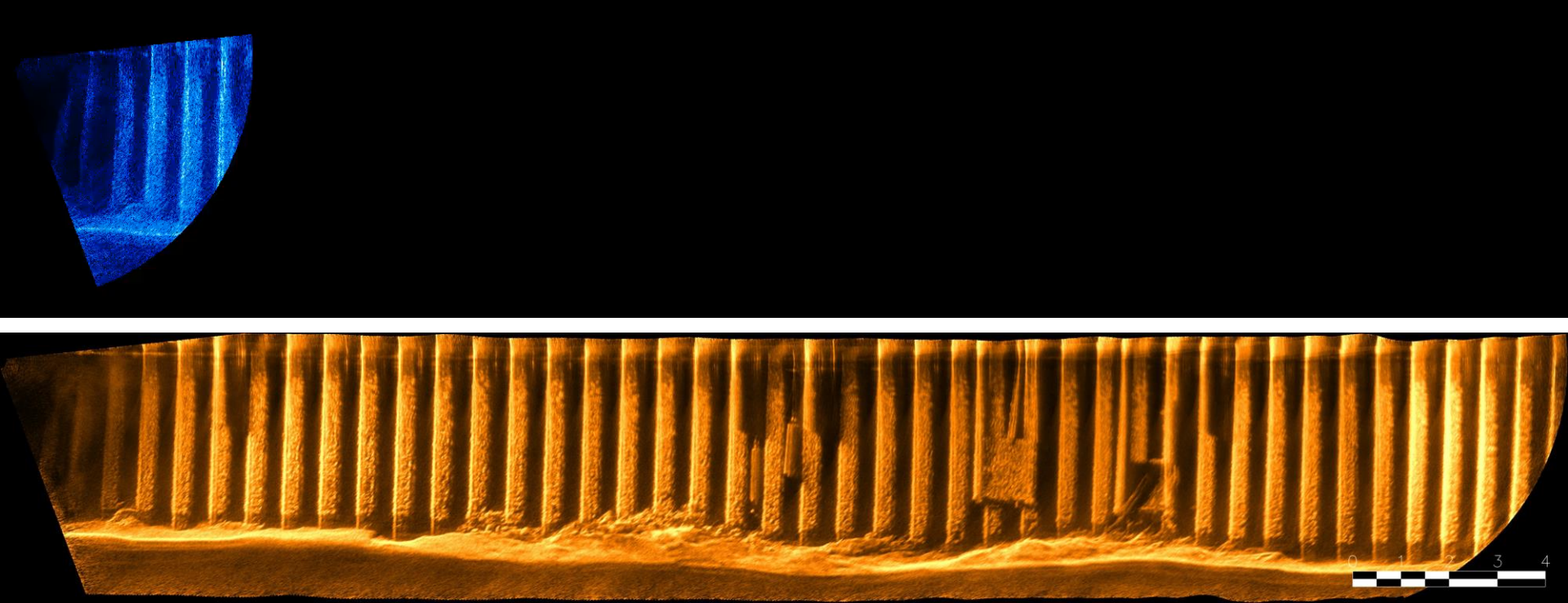
# Flood Barrier Inspection



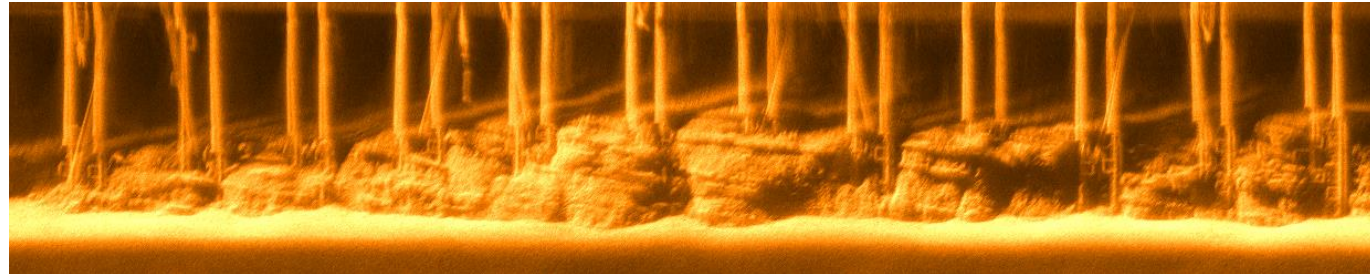
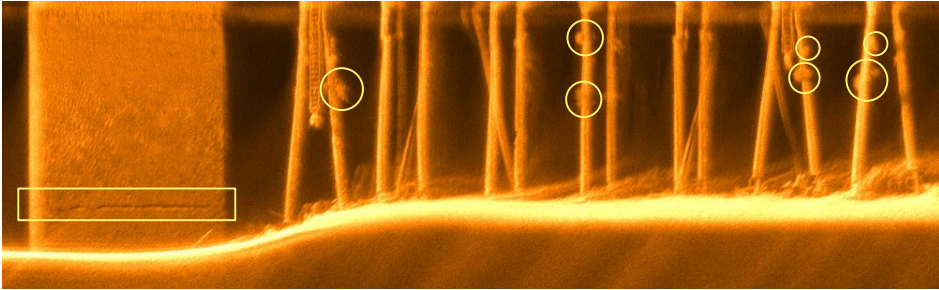
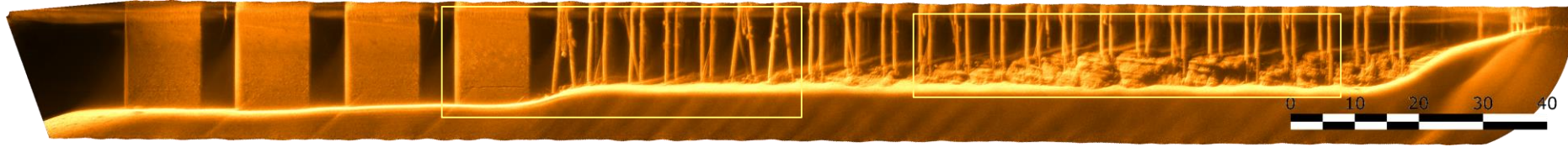
Areas of possible cracks



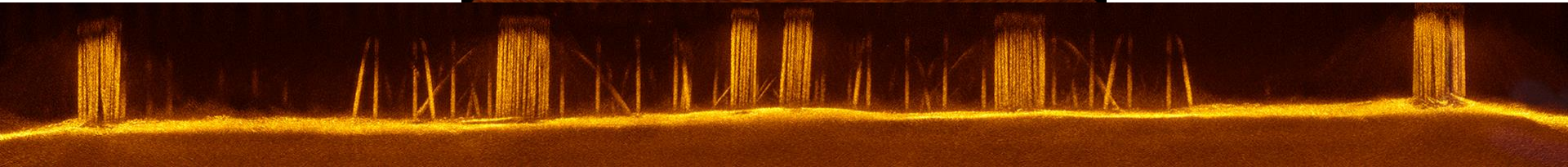
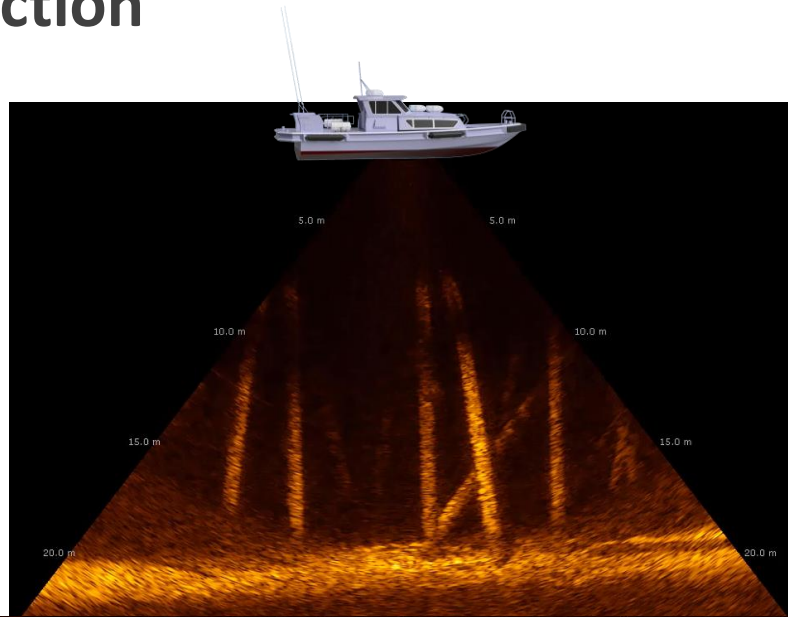
# Metal Sheet Pile Wall Inspection



# Pier with Concrete and Steel Pilings

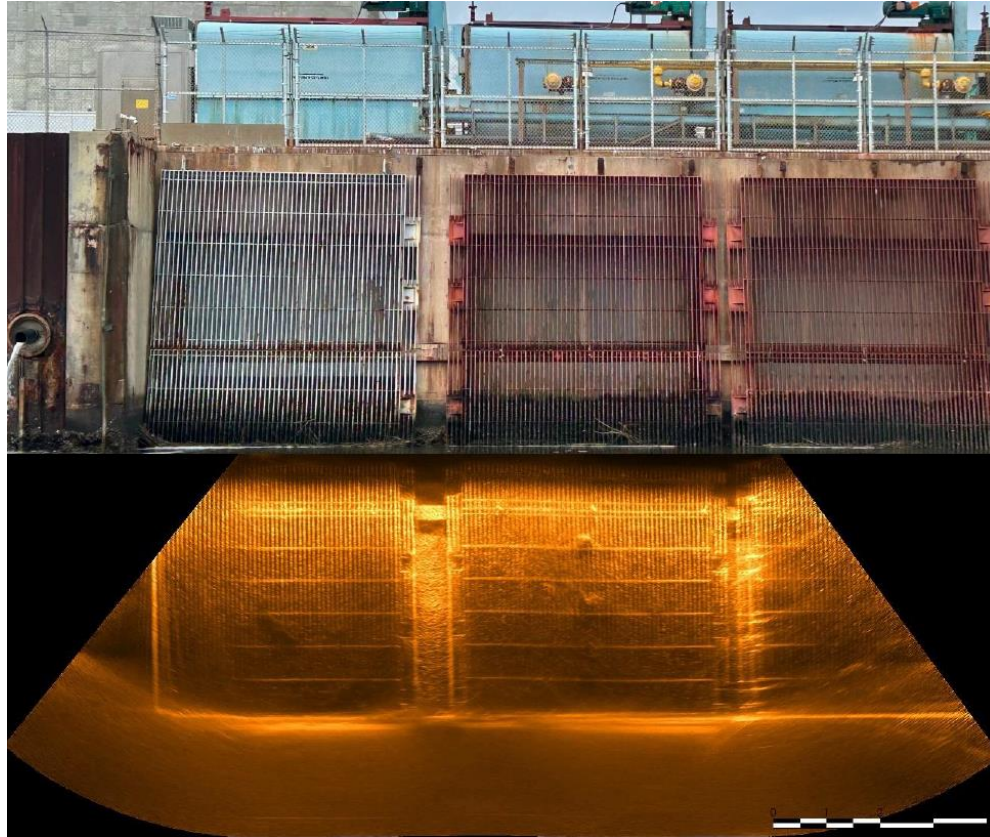


# Wood Pile Inspection

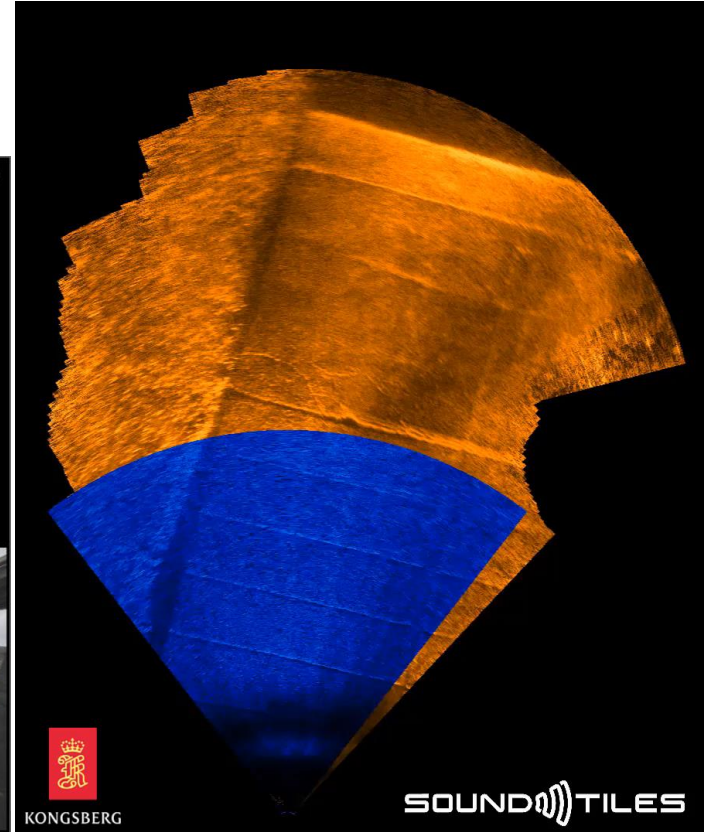
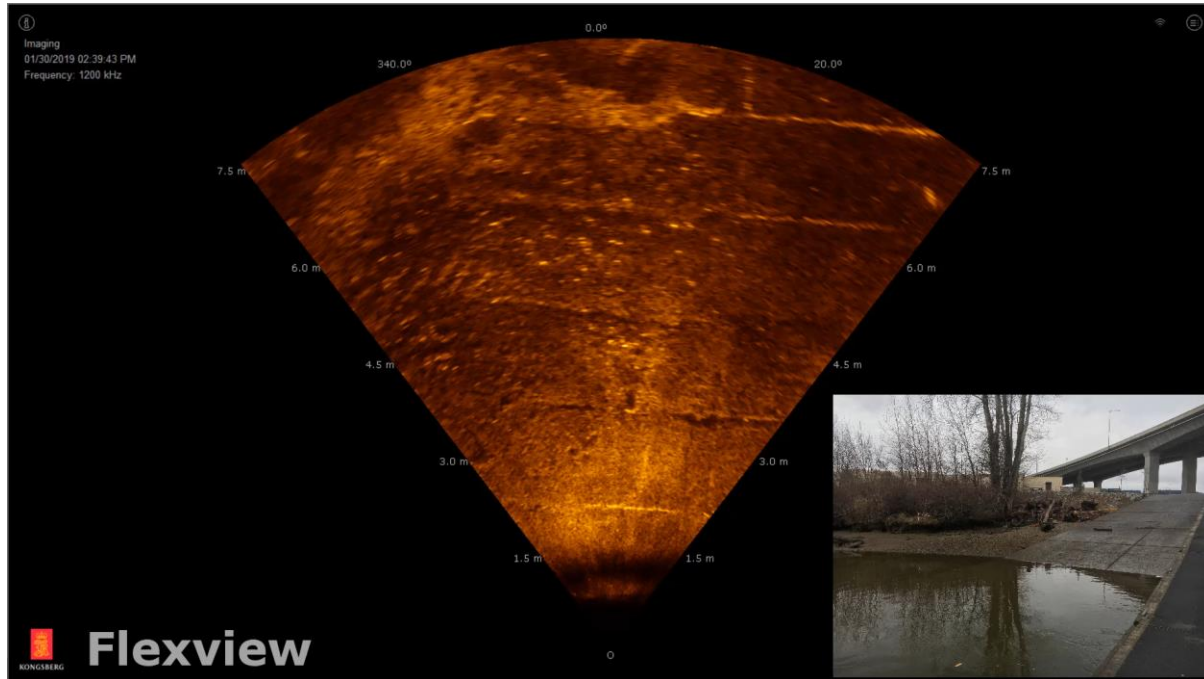




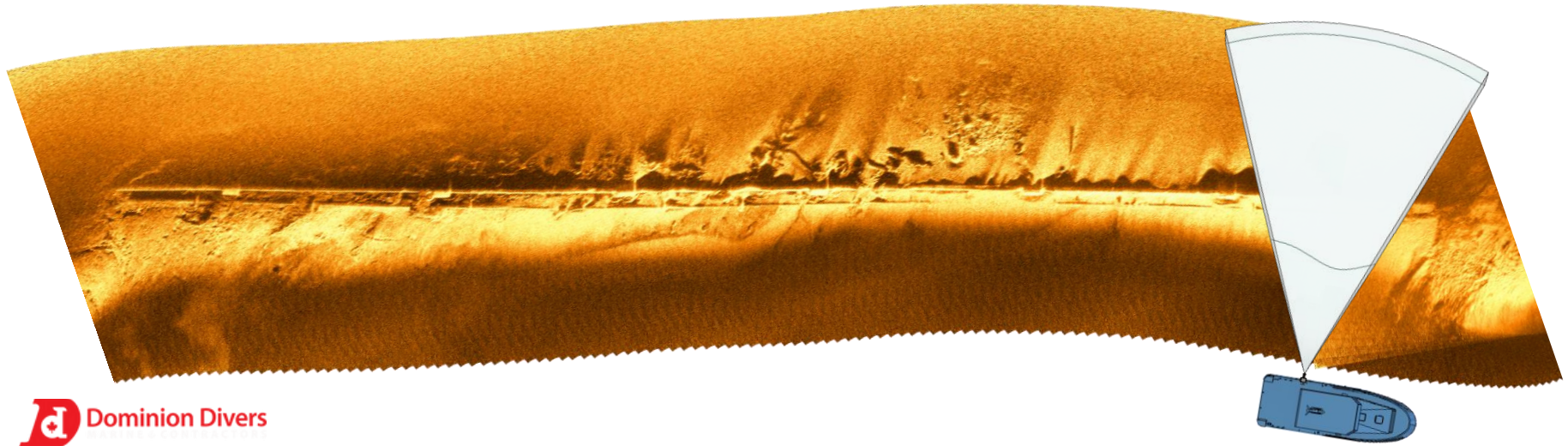
# Trash Rack Inspection



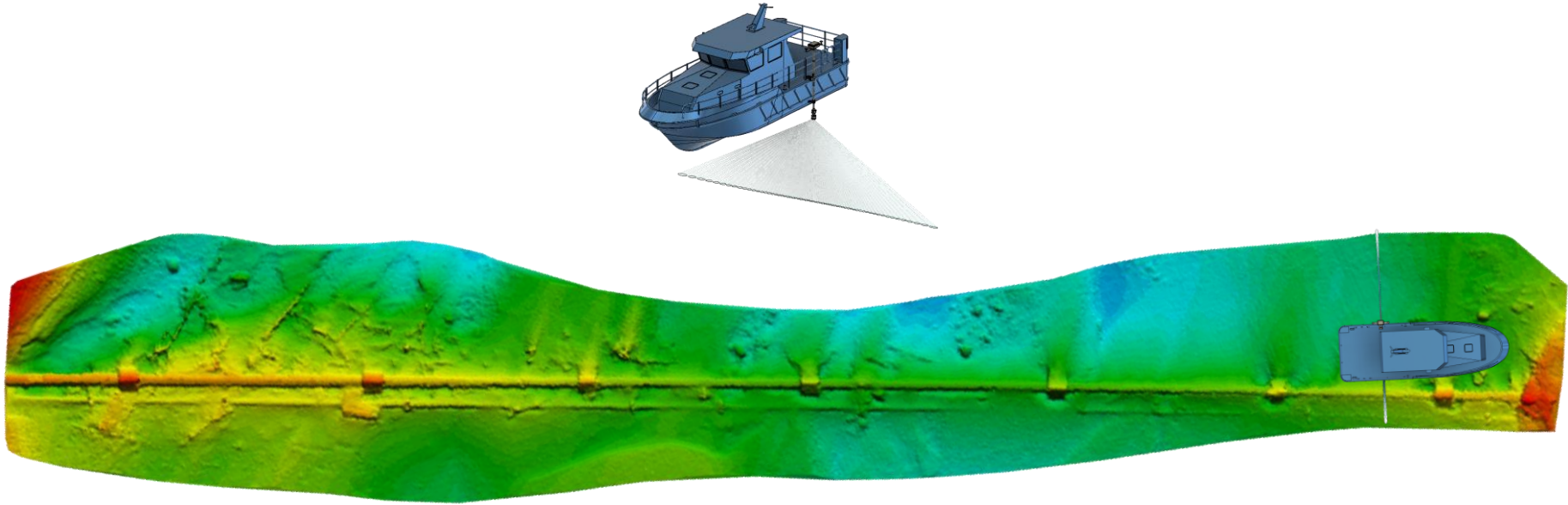
# Boat Launch Inspection



# Pipeline 2D Imaging Mosaic

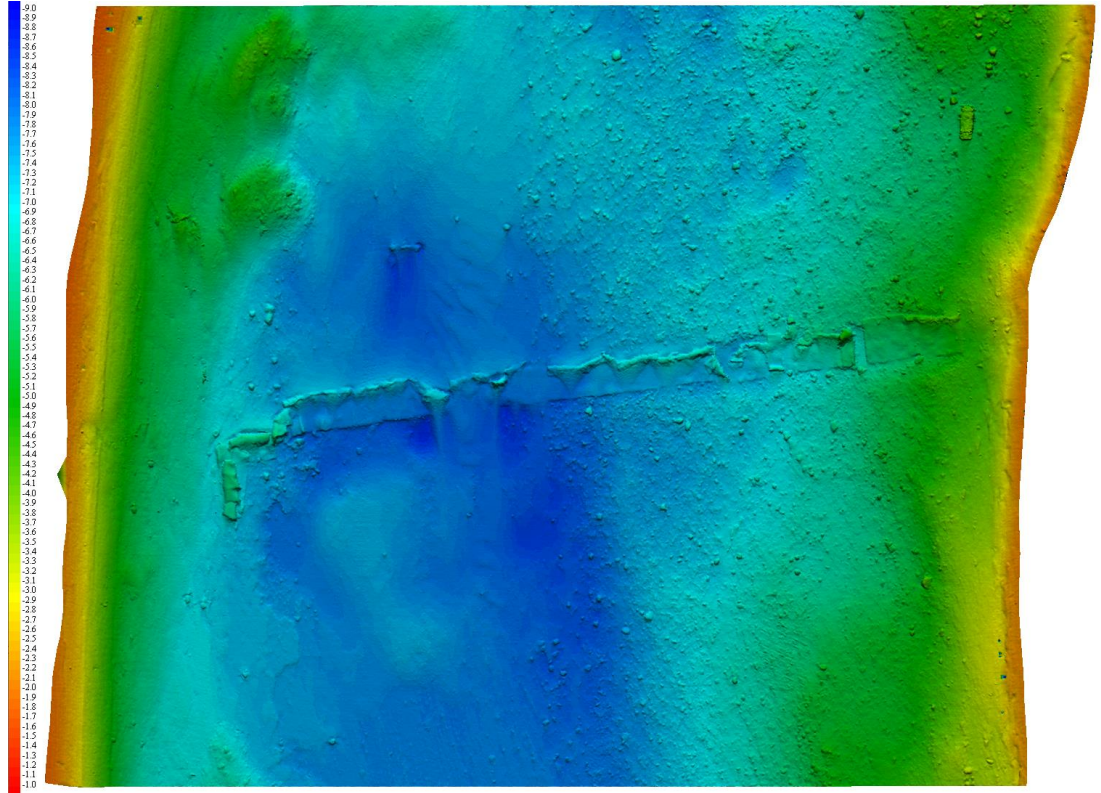
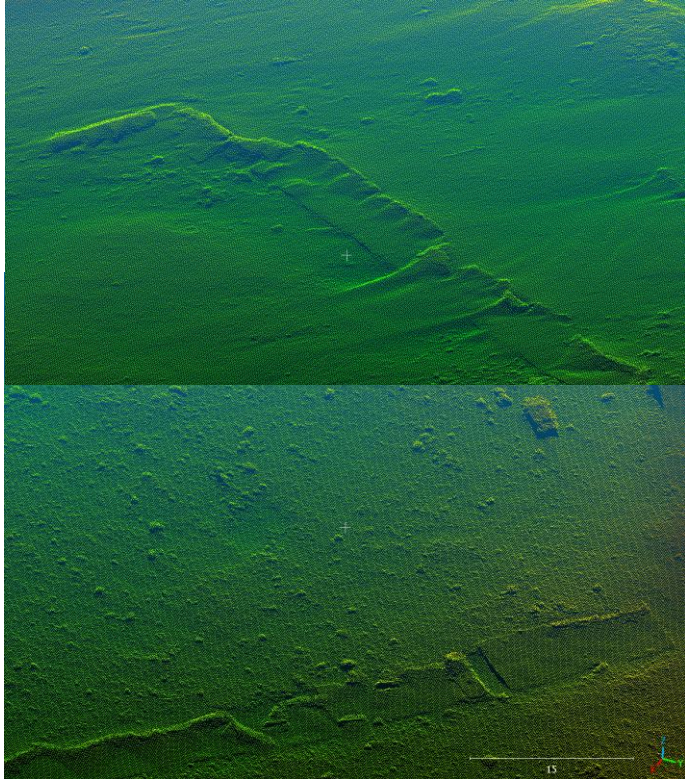


# Pipeline 3D Bathymetry



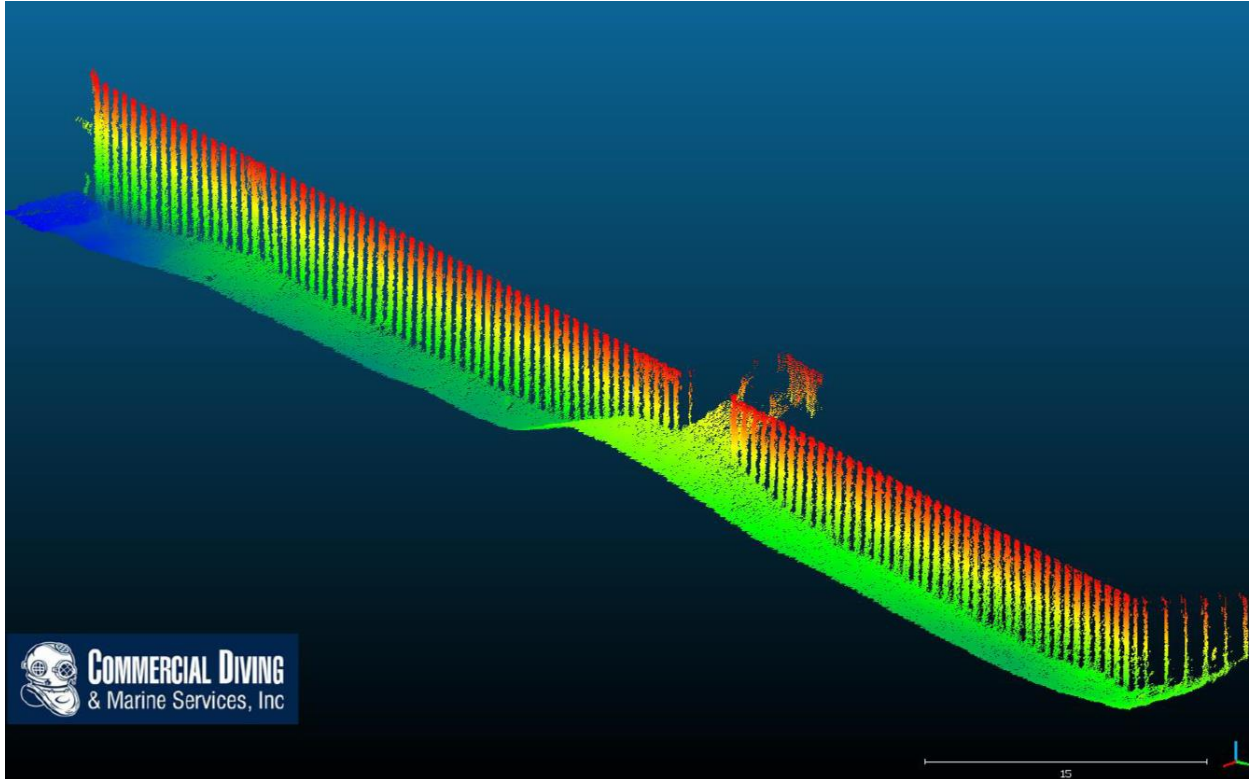


# Erosion control mats

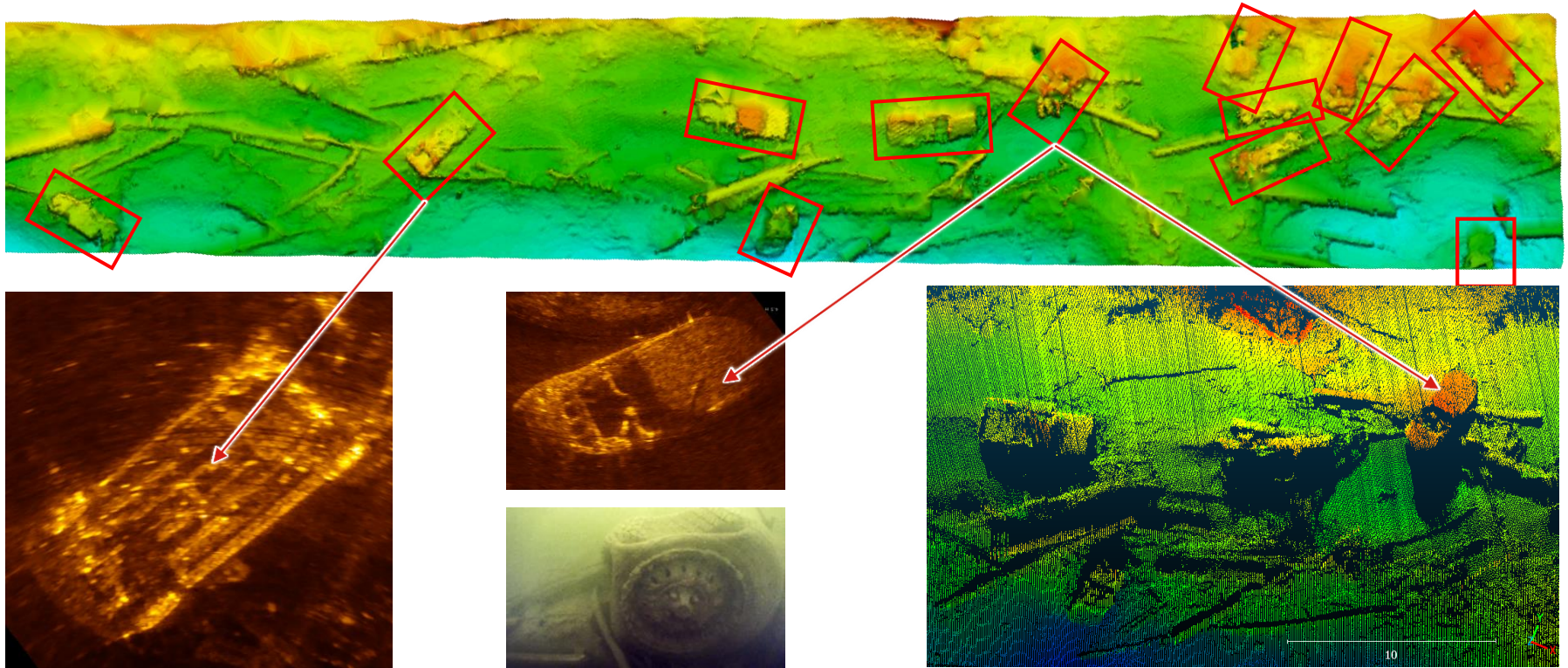




# Metal Sheet Pile Wall Inspection



# Abandoned Car Search



# Port Sustainability and Infrastructure Resilience

## What Can We Do?

- For High levels of uncertainty:  
Conduct Risk Assessment
- For Aging infrastructure:  
Conduct Asset Condition Inspection above, below waterline
- Since Natural and manmade disasters have become more frequent:  
Develop a budget for ongoing rehabilitation and preservation
- Infrastructure designed now WILL INEVITABLY be subjected to unknown/unknowable design hazards





# Resources for Maritime Civil Engineers

- ASCE Manual of Practice MOP 130 – Waterfront Facilities Inspection and Assessment
  - [Link](#)
- ASCE Manual of Practice MOP 156 – Navigation Channel Sedimentation Solutions
  - [Link](#)
- ASCE Port Operations and Maintenance (ODG1623) – on demand course
  - [Link](#)
- Ports Australia Wharf Structures Condition Assessment Manual
  - [Link](#)





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# Thank you for your time!

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