

Performance Data from Field-Deployed Prototype Scour Monitoring Systems

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Additional acknowledgements:

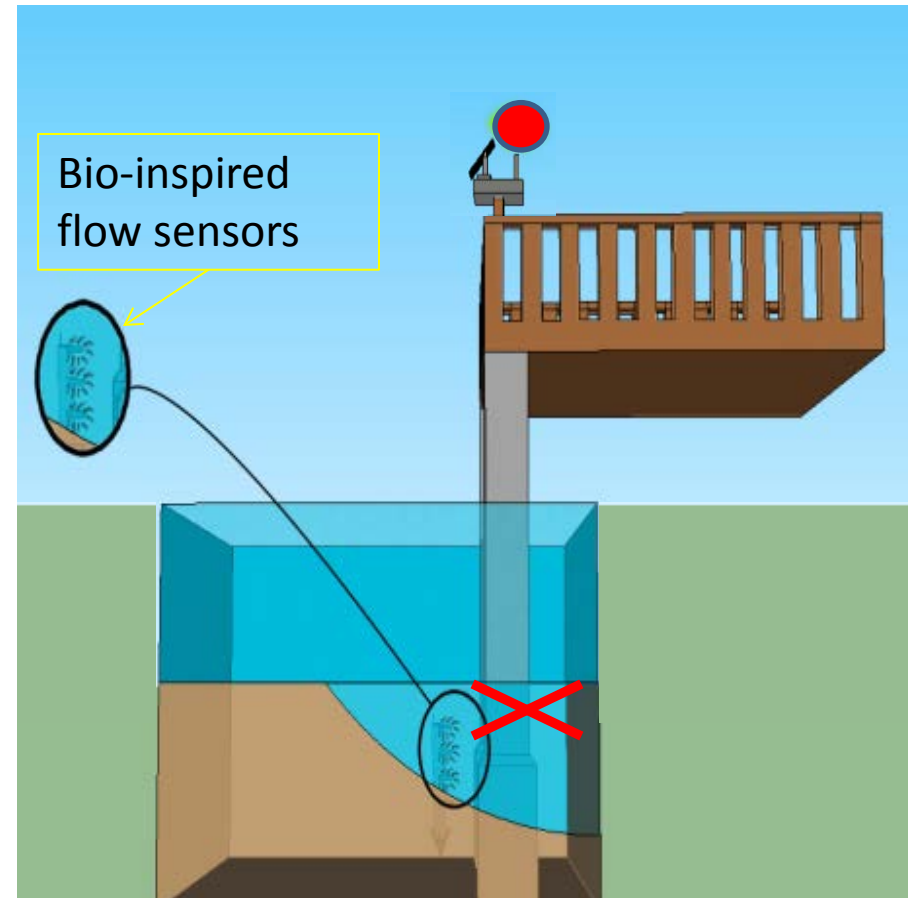
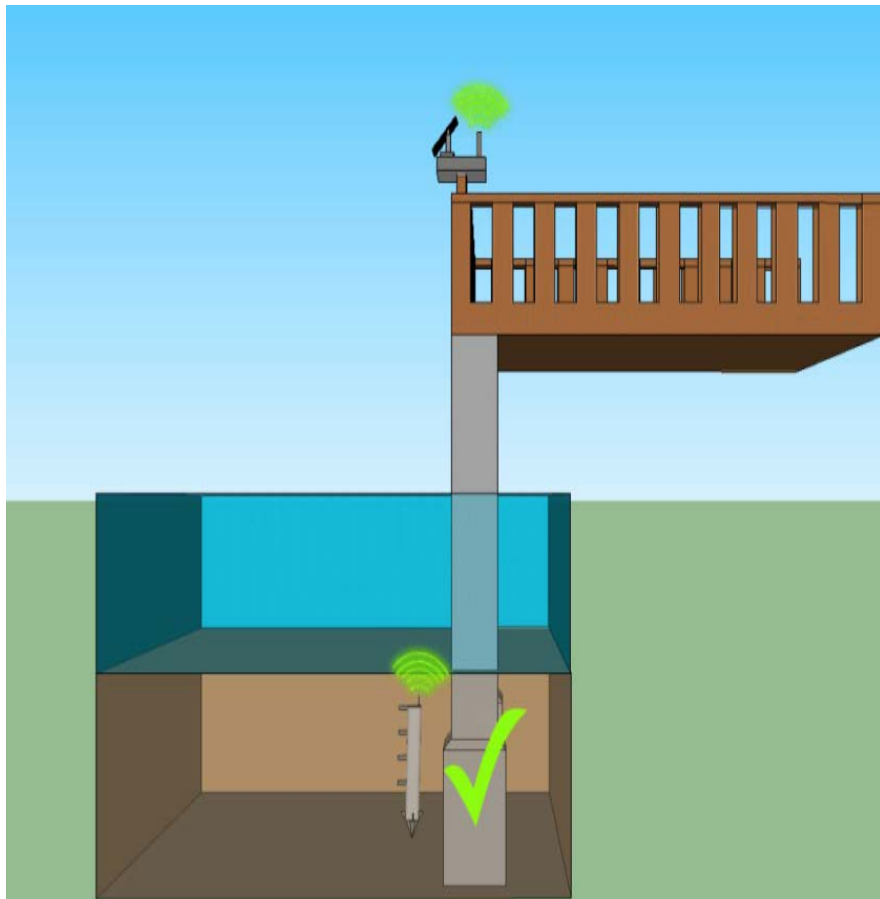
G. Raghunath, K. Yanaga, S. Stebbins,. UMD researcher team

J. Knaub, S. Davis, A. Kosicki, R. Thornton and R. Cooper at MDSHA

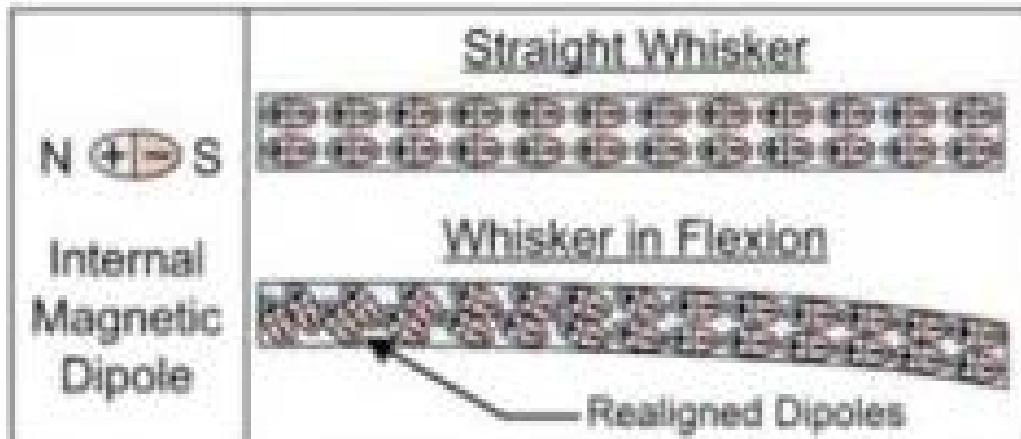
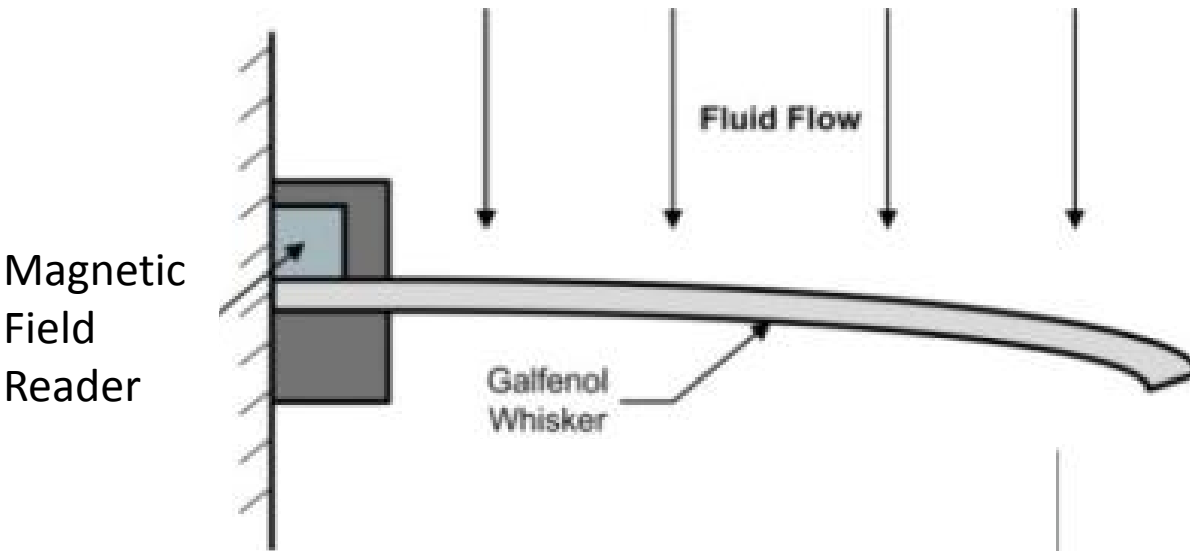
T.H. Hughes, D.C. Flatau, D.C.T. Flatau and A.F. Ross of Tauros Engineering

Overview of Concept

Bio-Inspired Scour Sensor Post Solution

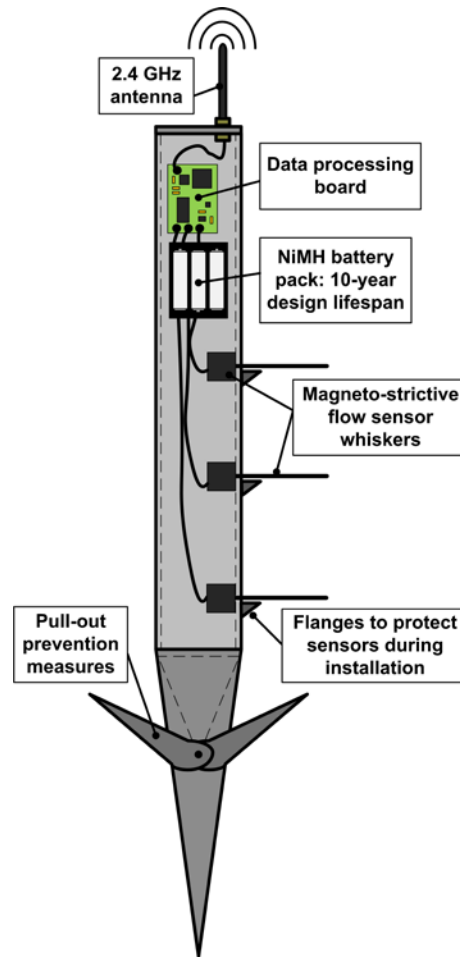


Magnetostrictive whisker sensors for detection of flow



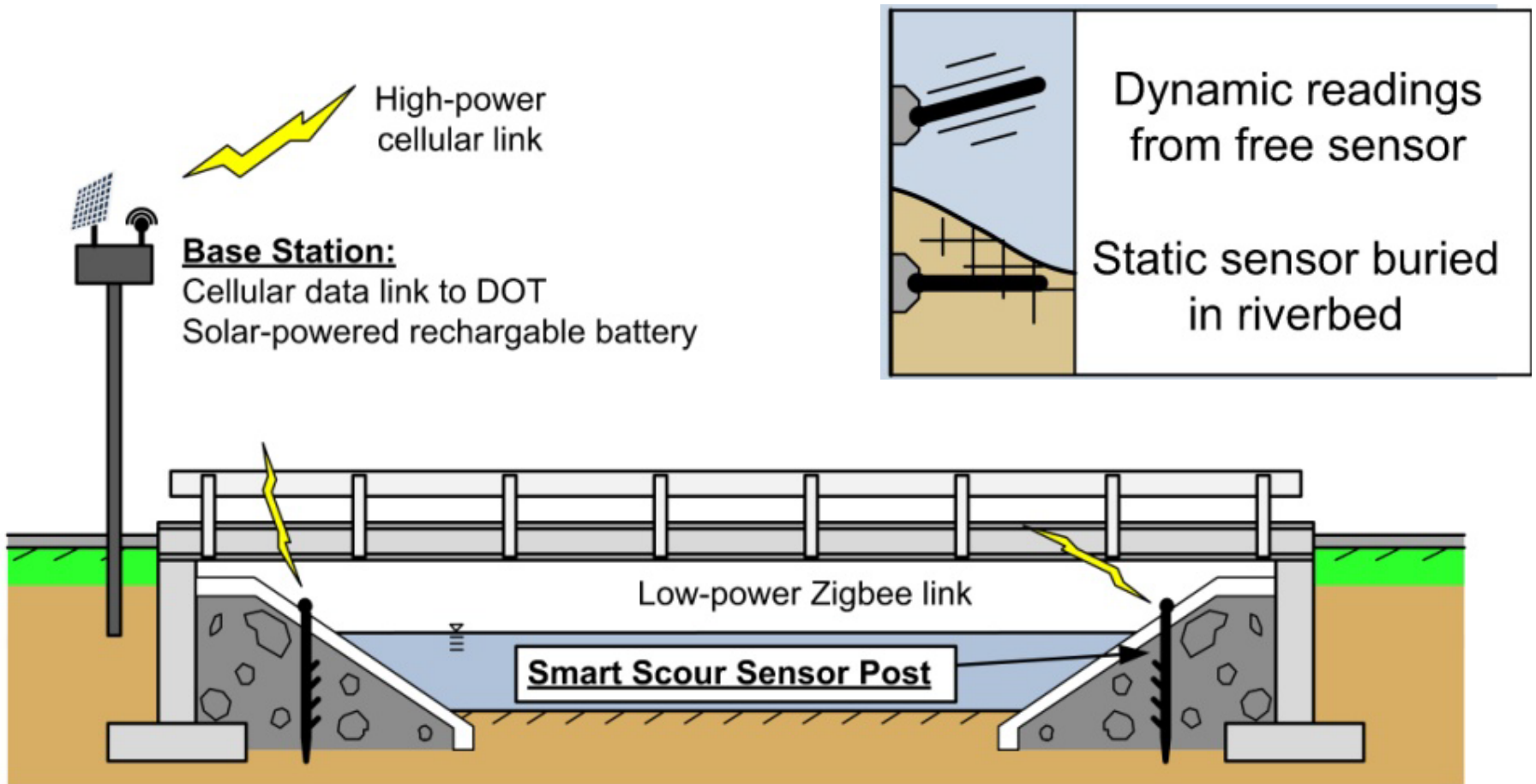
- Patent pending concept developed under grants from the Dept. of Defense for aerospace applications
- Biologically inspired cantilevered beams (whiskers) vibrate and are stressed by fluid flow
- Movement of the whisker changes the magnetic field at field reader and motion is detected
- Magnetic properties makes it very robust and well suited for subsurface environment

Sensor post concept



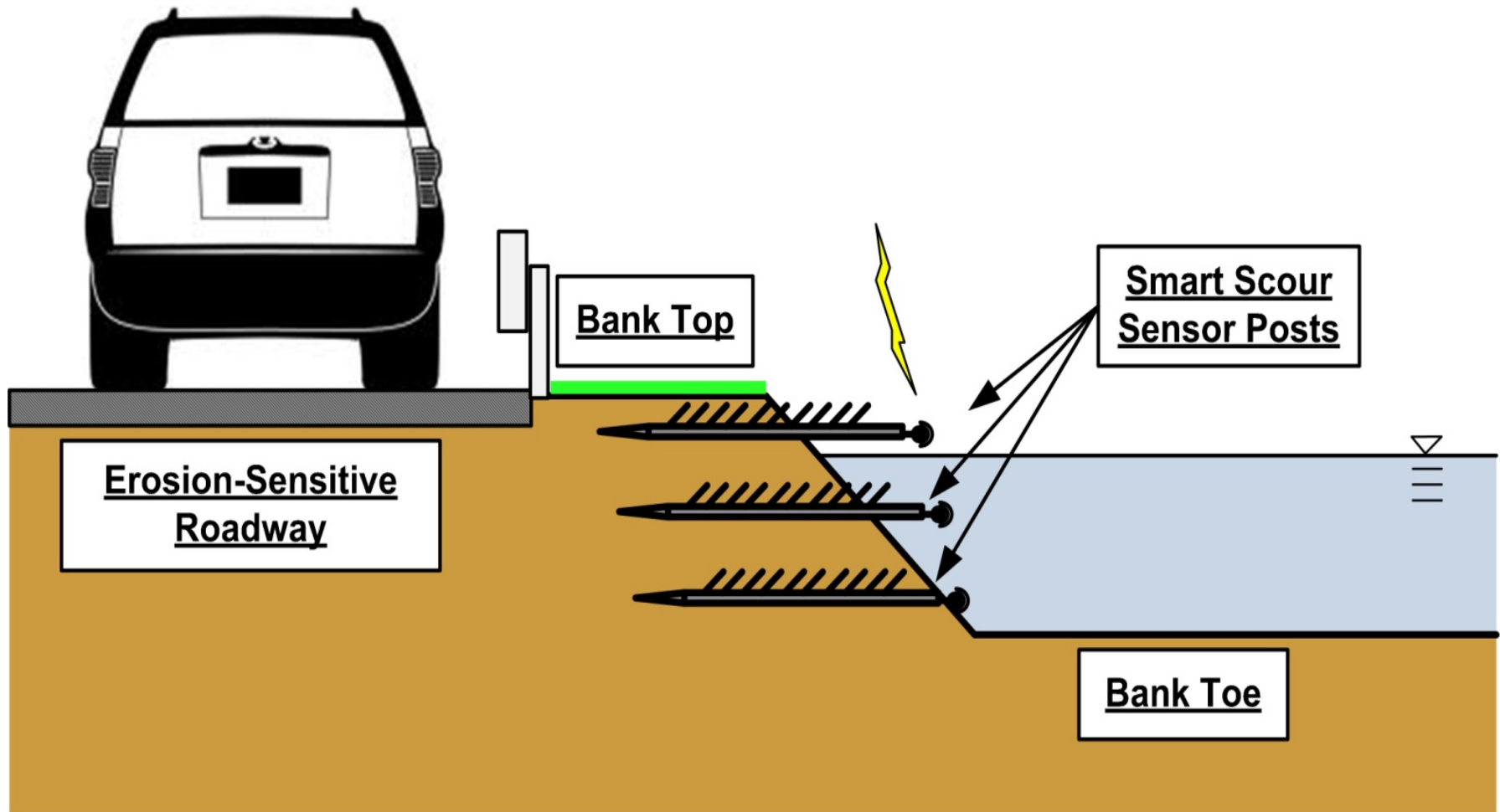
Scour Application

Plan View

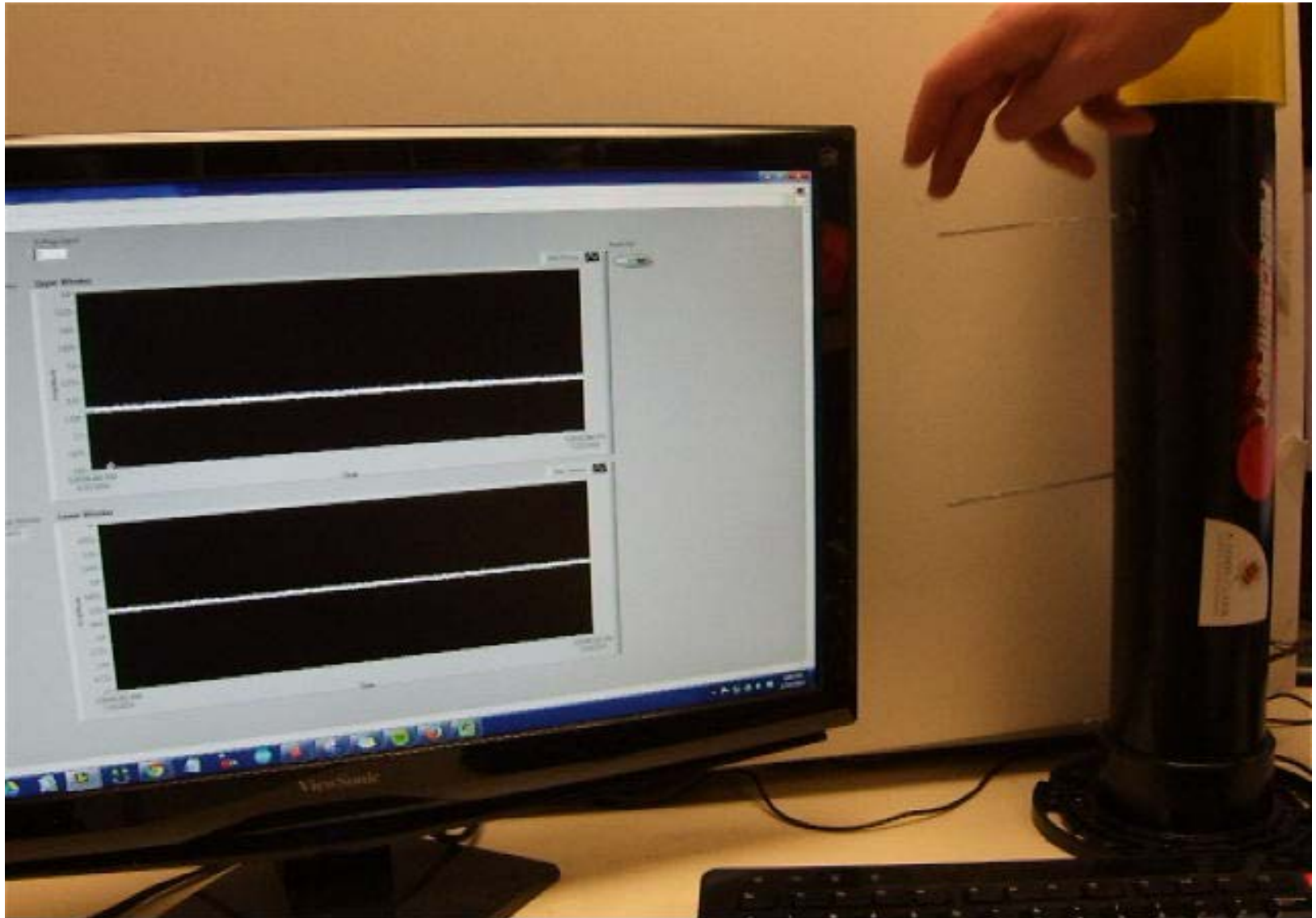


Section A-A

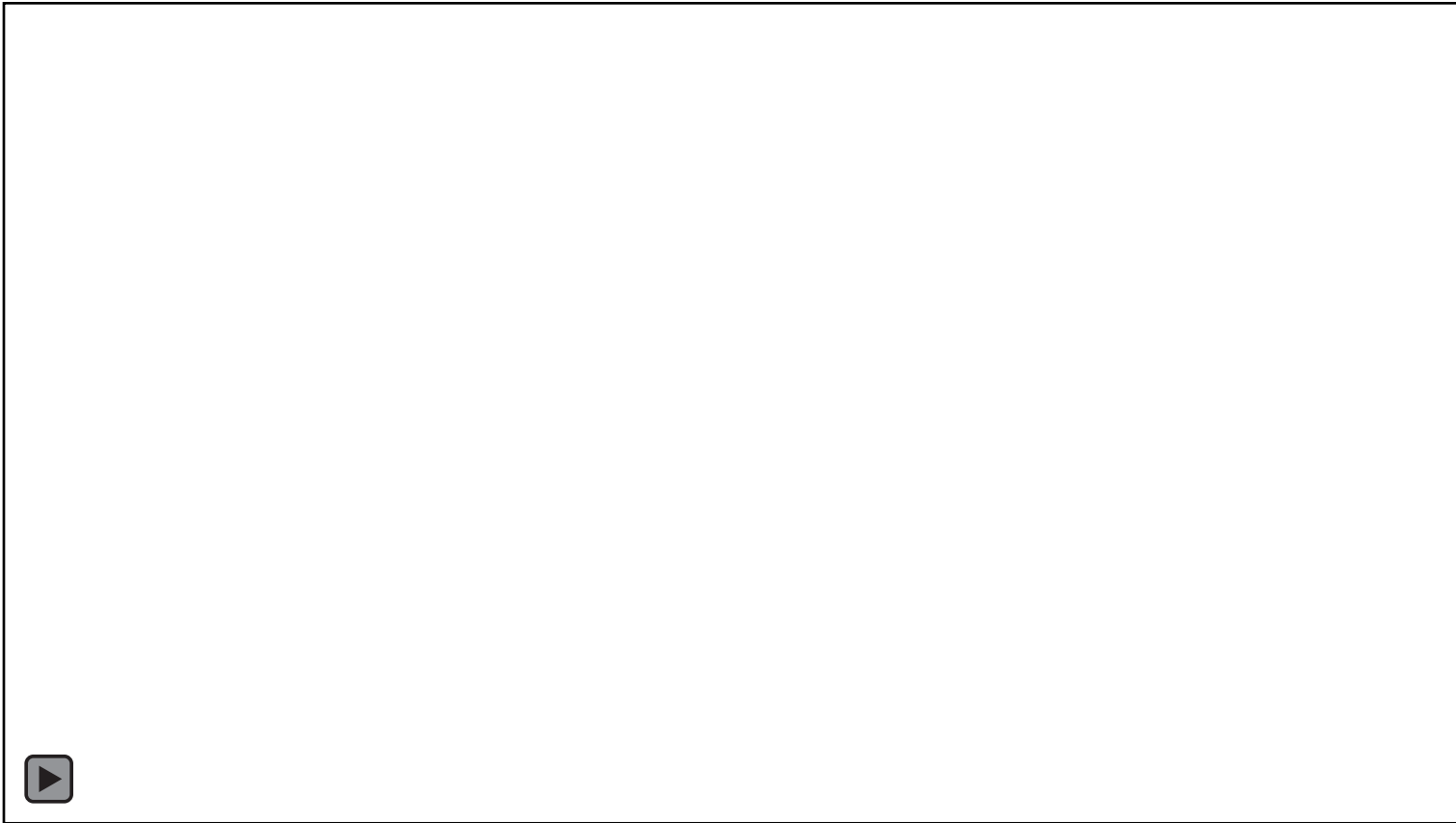
Lateral Riverbed Migration Applications



Mock whisker sensor post demo

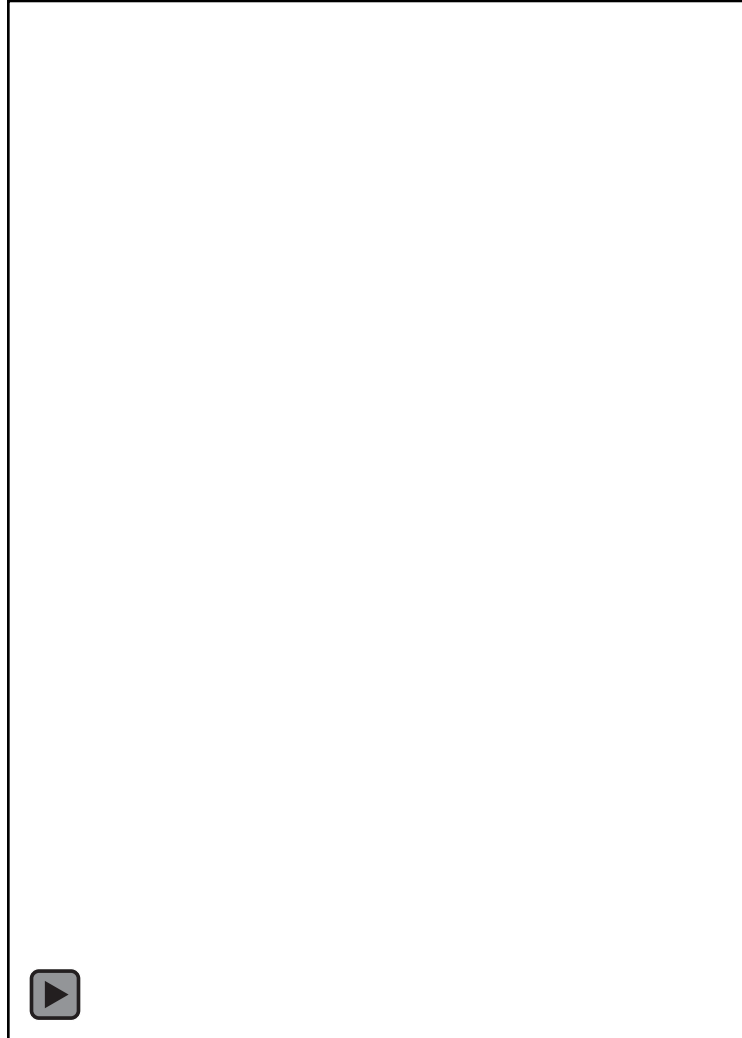


Progress with enhancing whisker mechanical properties

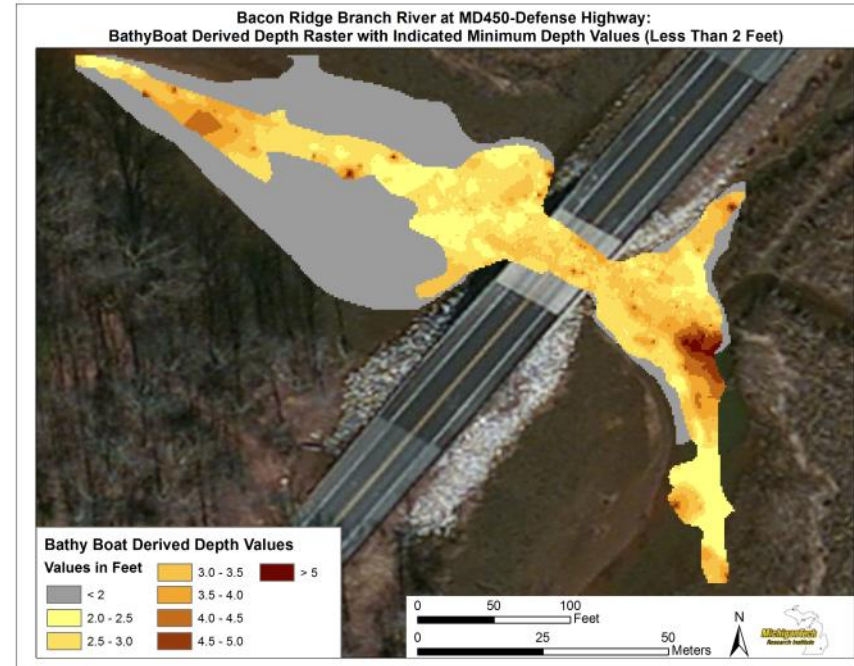




Progress with enhancing whisker mechanical properties



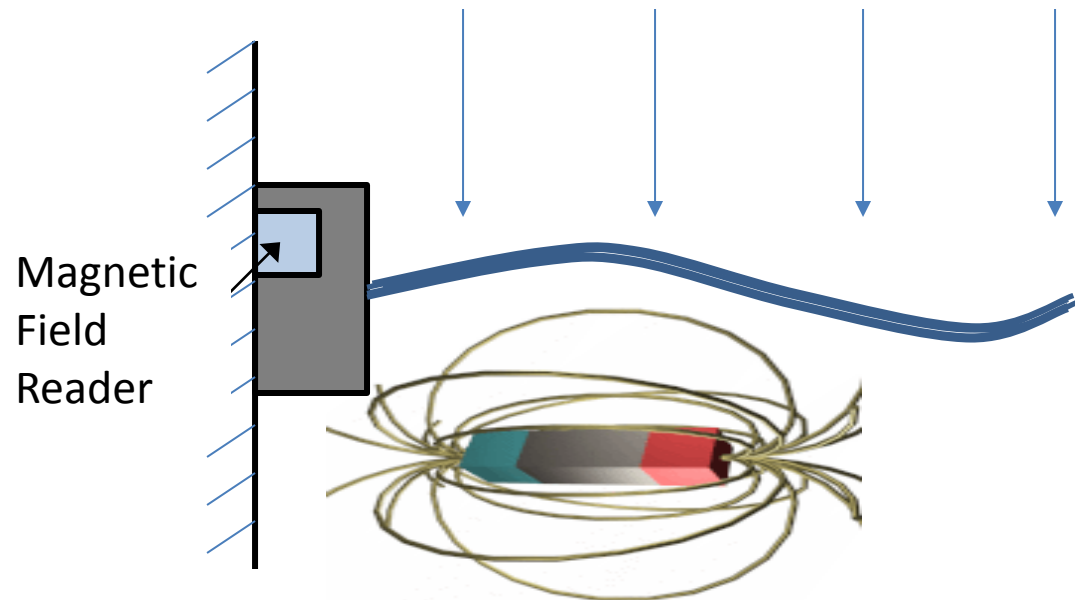
1st prototype test site



Tidal site selected to increase chances of seeing movement of soils. Drawback is fairly low flow velocities.



Magnetic seaweed sensors for detection of flow



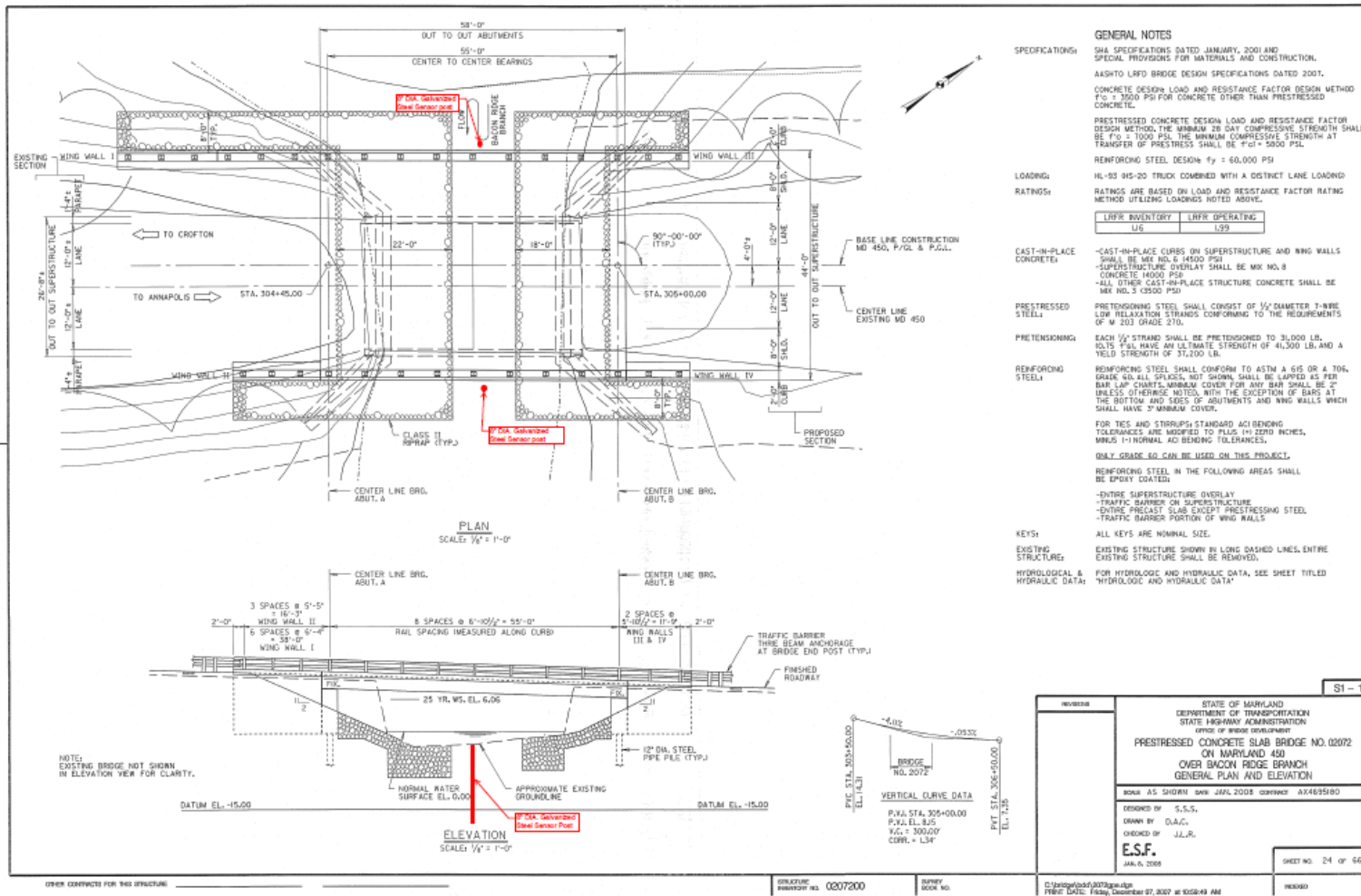
- Patent pending concept developed under grant from the NSF & DOT for scour applications.
- Biologically inspired flexible cantilevered beams and membranes (seaweeds) deflect and are put in motion by fluid flow
- Movement of the seaweed sensor changes the magnetic field at field reader and motion is detected
- Magnetic properties makes it very robust and well suited for subsurface environment

Prototype of seaweed sensor



1st prototype test site

- Bacon ridge branch bridge is a tidal site (near Annapolis, MD)



GENERAL NOTES

SPECIFICATIONS: SHA SPECIFICATIONS DATED JANUARY, 2001 AND SPECIAL PROVISIONS FOR MATERIALS AND CONSTRUCTION, AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS DATED 2007.

CONCRETE DESIGN LOAD AND RESISTANCE FACTOR DESIGN METHOD $f'_c = 3000$ PSI FOR CONCRETE OTHER THAN PRESTRESSED CONCRETE.

PRESTRESSED CONCRETE DESIGN LOAD AND RESISTANCE FACTOR DESIGN METHOD, THE MINIMUM 28 DAY COMPRESSIVE STRENGTH SHALL BE $f'_c = 1000$ PSI, THE MINIMUM COMPRESSIVE STRENGTH AT TRANSFER OF PRESTRESS SHALL BE $f'_c = 5000$ PSI.

REINFORCING STEEL DESIGN $f_y = 60,000$ PSI

LOADING: HL-93 915-20 TRUCK COMBINED WITH A DISTRICT LINE LOADING

RATINGS: RATINGS ARE BASED ON LOAD AND RESISTANCE FACTOR RATING METHOD UTILIZING LOADINGS NOTED ABOVE.

LRFR INVENTORY	LRFR OPERATING
UG	L99

CAST-IN-PLACE CURBS ON SUPERSTRUCTURE AND WING WALLS SHALL BE MIX NO. 8 (4500 PSF) SHALL BE MIX NO. 8 CONCRETE (4000 PSF) -ALL OTHER CAST-IN-PLACE STRUCTURE CONCRETE SHALL BE MIX NO. 3 (3500 PSF)

PRESTRESSED STEEL: PRETENSIONING STEEL SHALL CONSIST OF 1/2" DIAMETER 7-WIRE LOW RELAXATION STRANDS CONFORMING TO THE REQUIREMENTS OF AASHTO SPEC. 210.

PRETENSIONING: EACH 1/2" STRAND SHALL BE PRETENSIONED TO 31,000 LB. SOLTS SHALL HAVE AN ULTIMATE STRENGTH OF 41,500 LB. AND A YIELD STRENGTH OF 37,500 LB.

REINFORCING STEEL: REINFORCING STEEL SHALL CONFORM TO ASTM A 615 OR A 706, GRADE 60. ALL SPLICES, NOT SHOWN, SHALL BE LAPPED AS PER BAR LAP CHARTS. MINIMUM COVER FOR ANY BAR SHALL BE 2" UNLESS OTHERWISE NOTED, WITH THE EXCEPTION OF BARS AT THE BOTTOM AND SIDES OF ABUTMENTS AND WING WALLS WHICH SHALL HAVE 3" MINIMUM COVER.

FOR TIES AND STIRRUPS: STANDARD ACI BENDING TOLERANCES ARE MODIFIED TO PLUS (H) ZERO INCHES, MINUS (H) NORMAL AG BENDING TOLERANCES.

ONLY GRADE 60 CAN BE USED ON THIS PROJECT.

REINFORCING STEEL IN THE FOLLOWING AREAS SHALL BE EPOXY COATED:

- ENTIRE SUPERSTRUCTURE OVERLAY
- TRAFFIC BARRIER ON SUPERSTRUCTURE
- ENTIRE PRECAST SLAB EXCEPT PRESTRESSING STEEL
- TRAFFIC BARRIER PORTION OF WING WALLS

KEYS: ALL KEYS ARE NOMINAL SIZE.

EXISTING STRUCTURE: EXISTING STRUCTURE SHOWN BY LONG DASHED LINES. ENTIRE EXISTING STRUCTURE SHALL BE REMOVED.

HYDROLOGICAL & HYDRAULIC DATA: FOR HYDROLOGIC AND HYDRAULIC DATA, SEE SHEET TITLED "HYDROLOGIC AND HYDRAULIC DATA"

STATE OF MARYLAND
DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
OFFICE OF BRIDGE ENGINEERING

PRESTRESSED CONCRETE SLAB BRIDGE NO. 02072
ON MARYLAND 450
OVER BACON RIDGE BRANCH
GENERAL PLAN AND ELEVATION

DESIGNED BY: S.S.S.
CHECKED BY: D.A.G.
DRAWN BY: J.L.R.

E.S.F.
JAN. 6, 2009

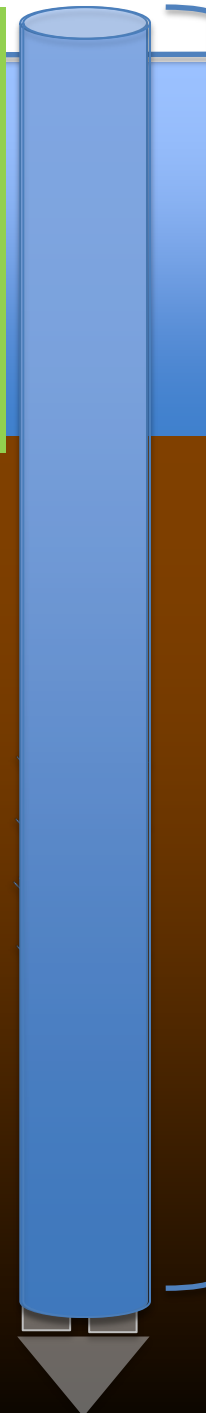
DATE: 07/2007

PROJECT NO. 24 OF 66

Draft installation plan for wired scour detection system

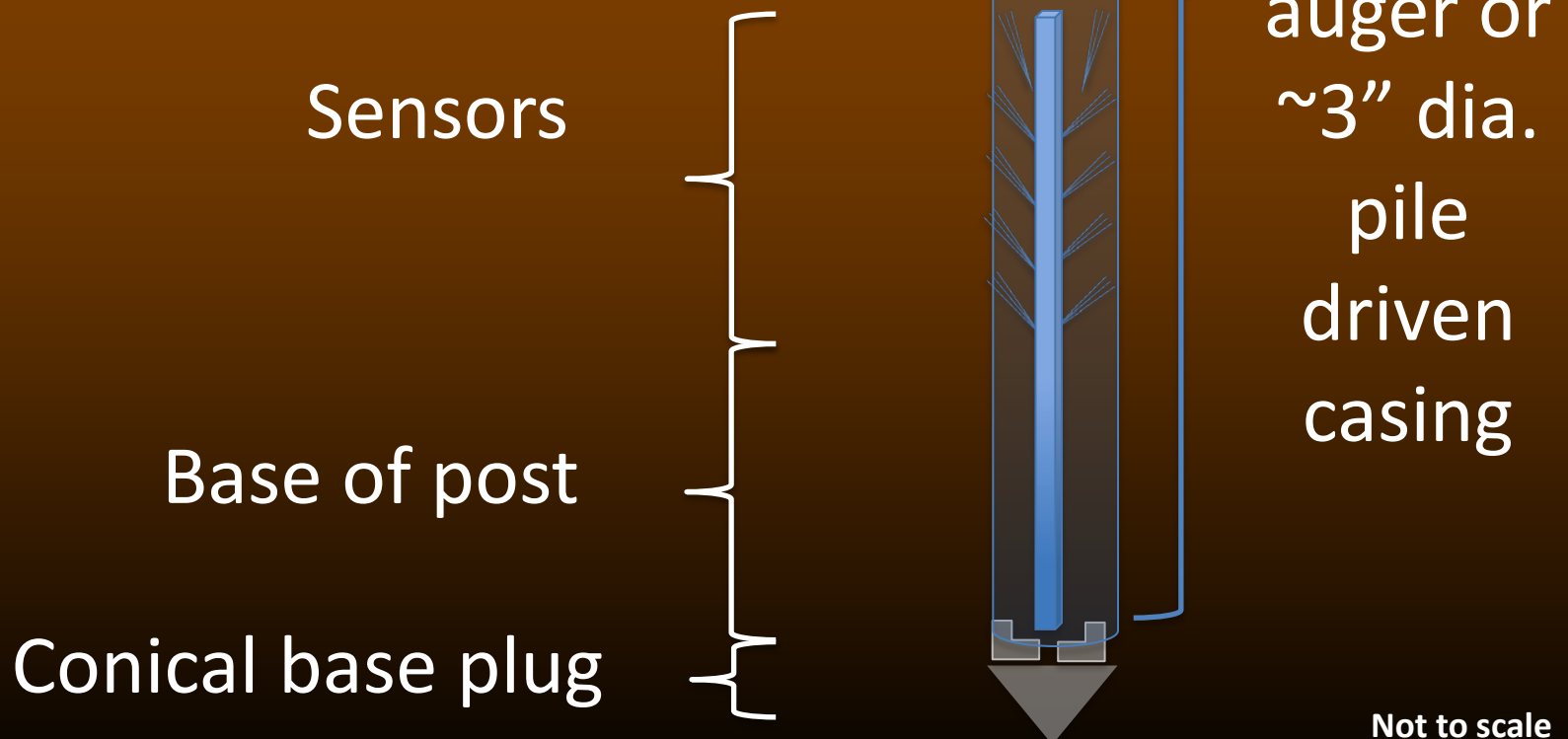
Hollow
stem
auger or
~3" dia.
pile
driven
casing

Conical base plug



Not to scale

Draft installation plan for wired scour detection system

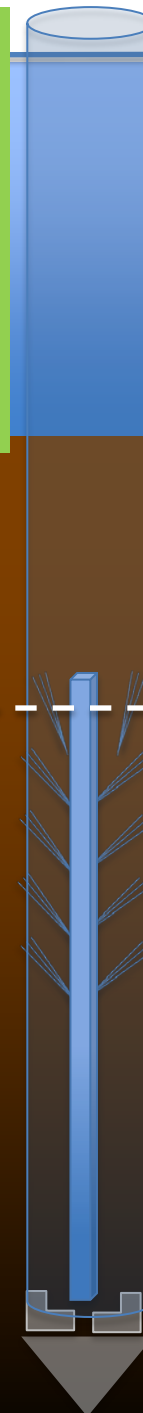


Draft installation plan for wired scour detection system

Sensors

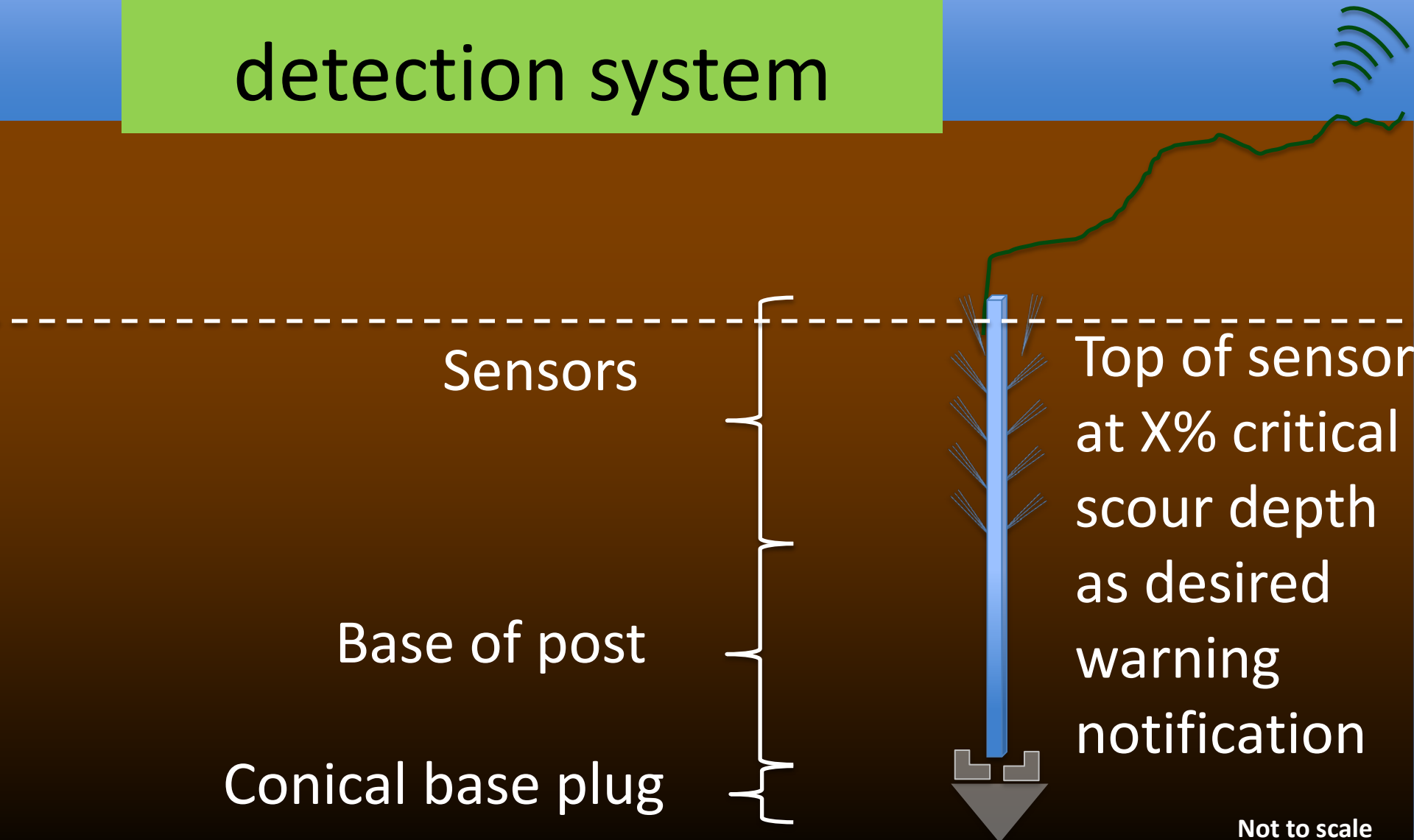
Base of post

Conical base plug

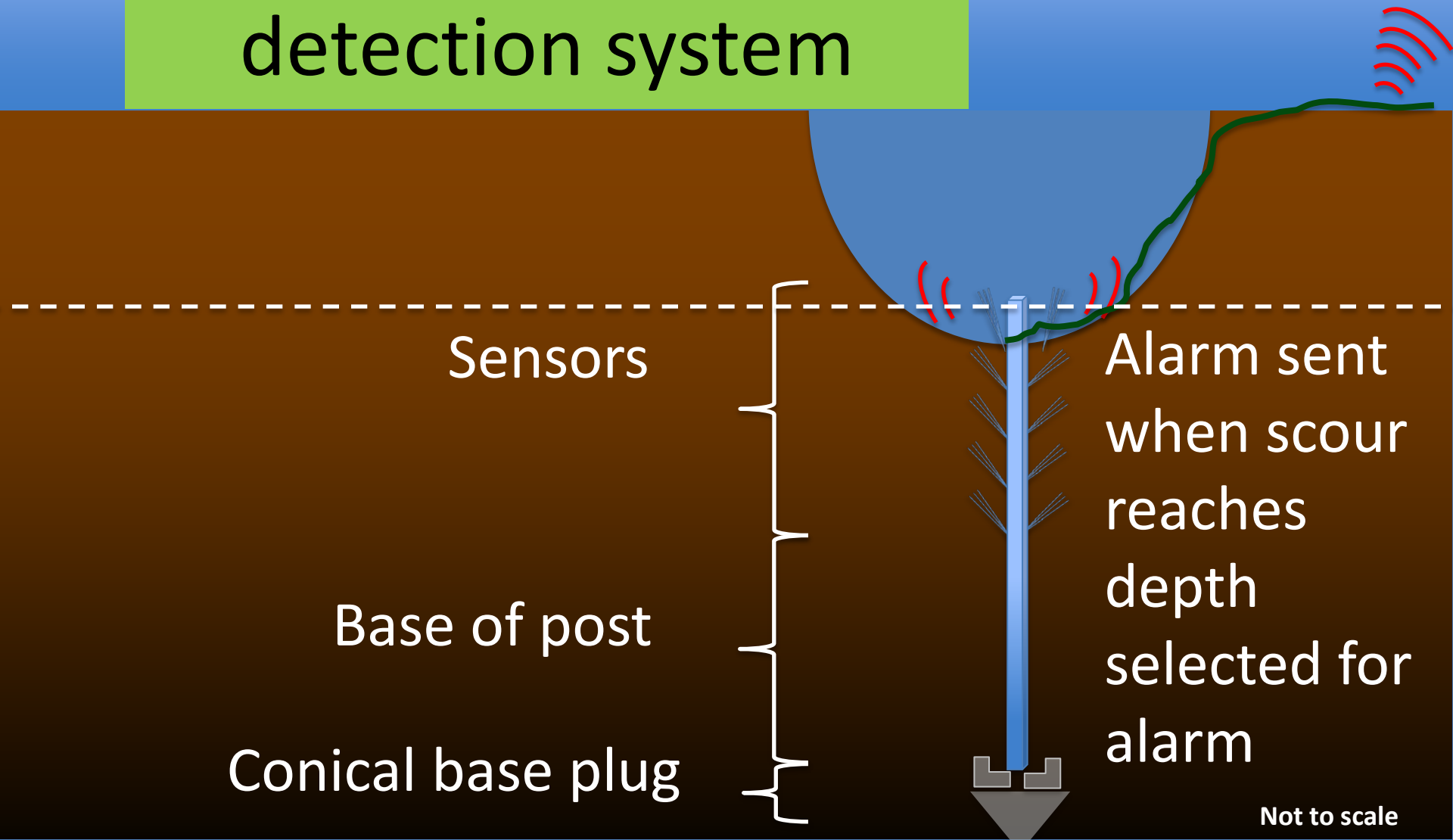


Top of sensor
at X% critical
scour depth
as desired
warning
notification

Draft installation plan for wired scour detection system

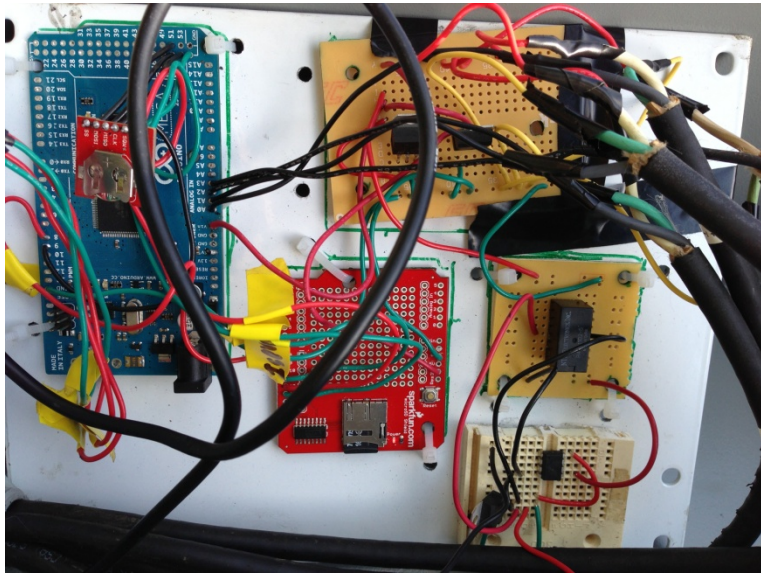


Draft installation plan for wired scour detection system



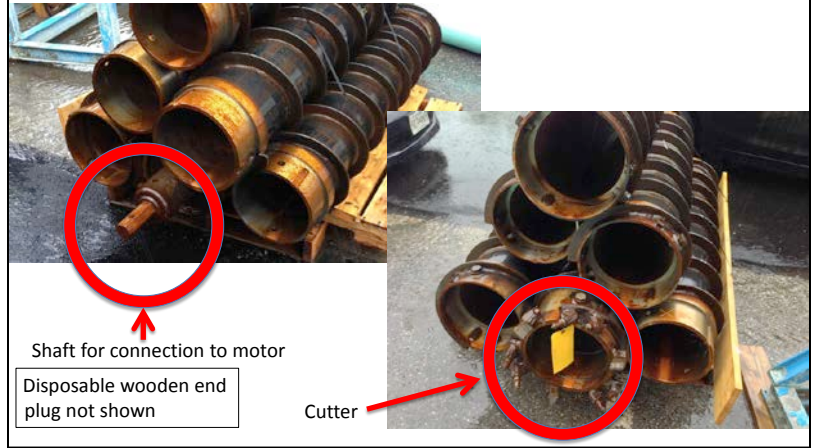




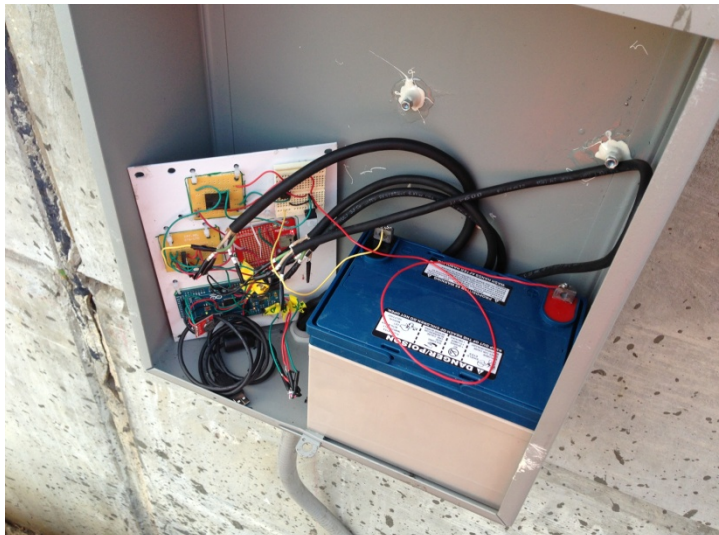




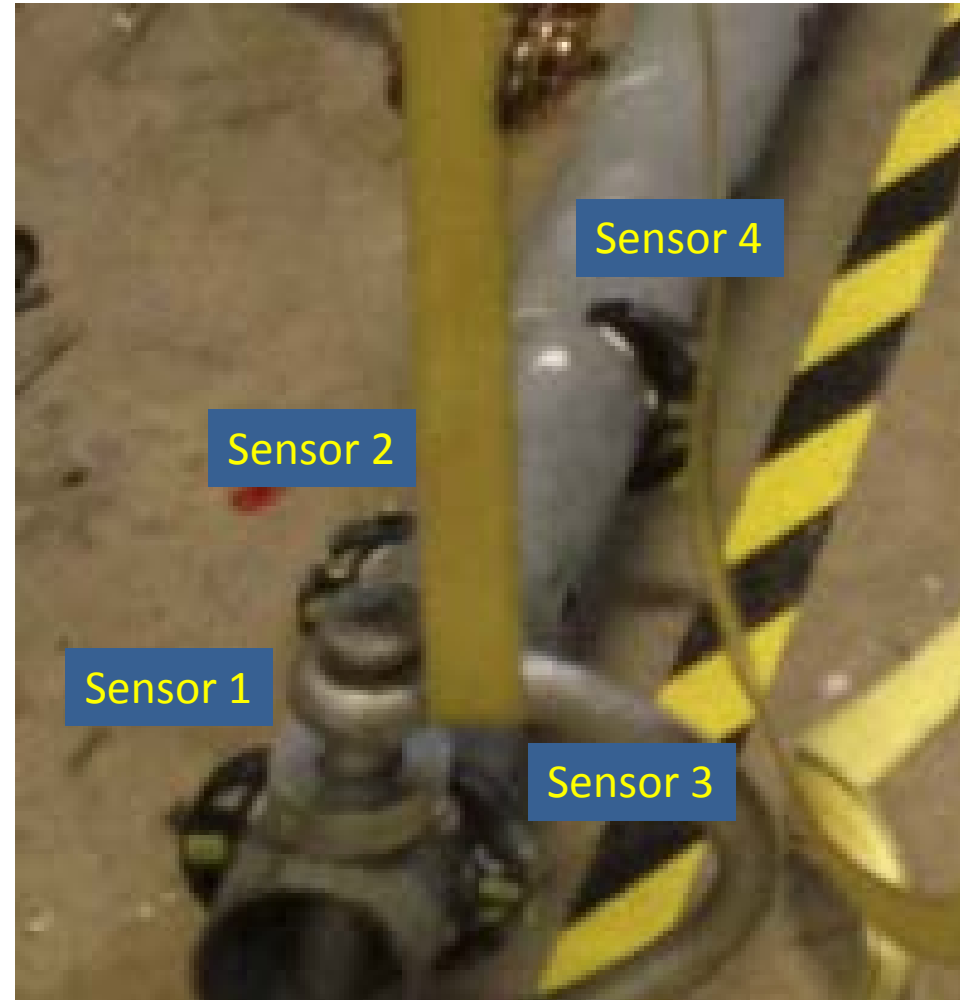
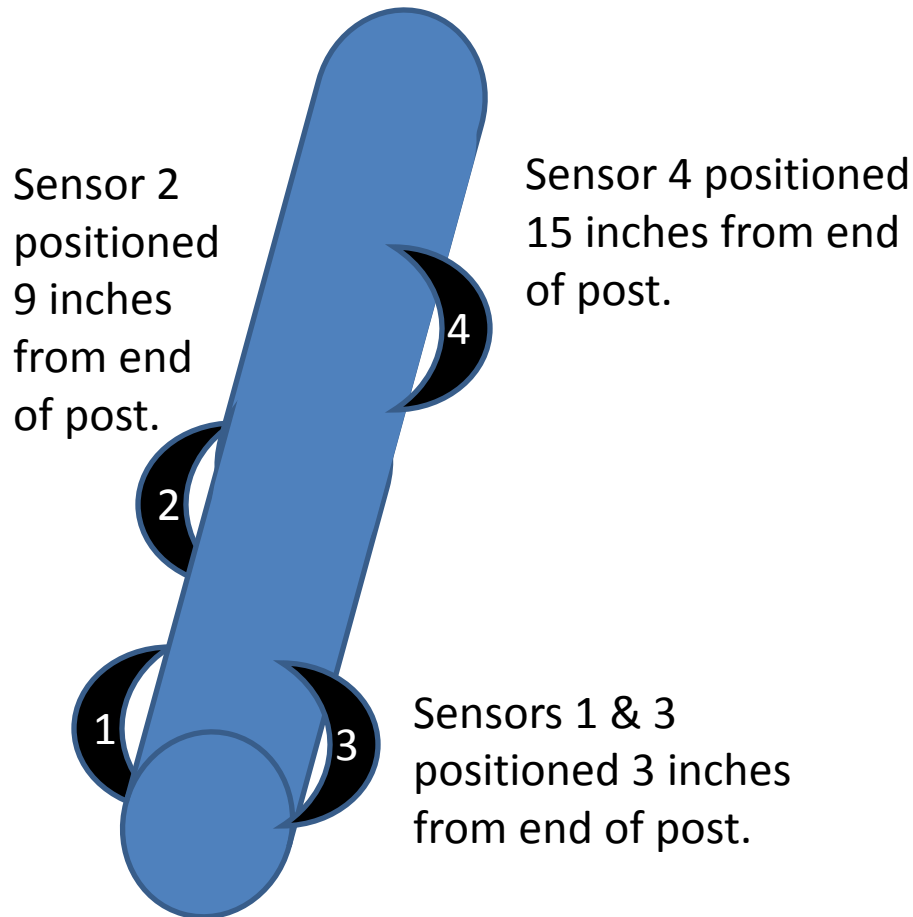
30 foot long (six 5 ft long sections), 10 inch inner diameter hollow stem auger





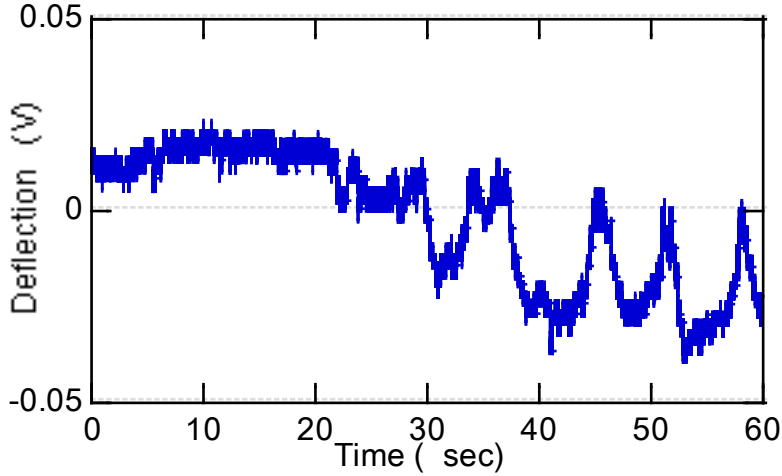


North post sensor configuration

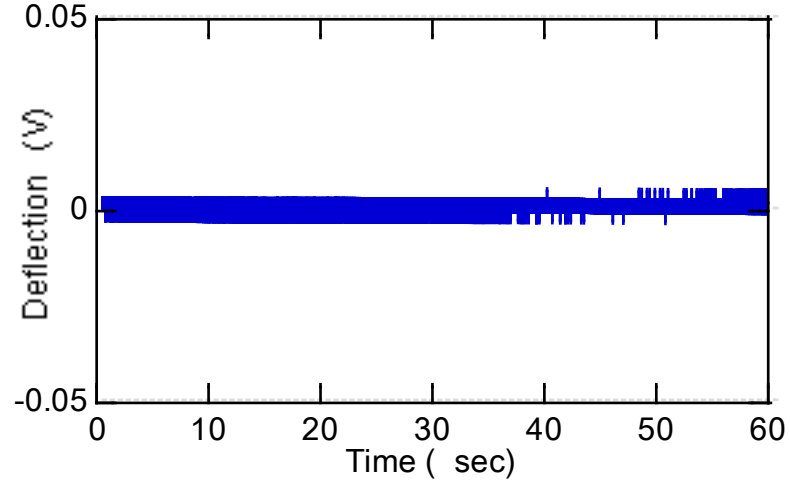


Typical Response – Sensors 2 & 4 Buried

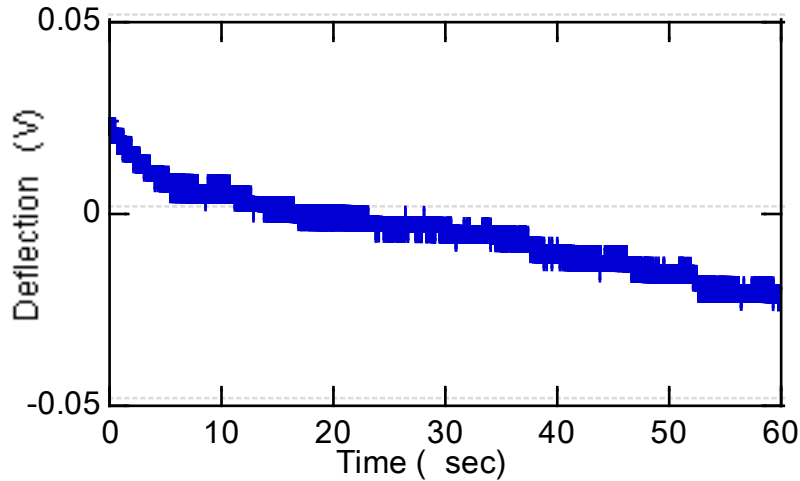
North Post - Sensor 1
10/23/13 05:43



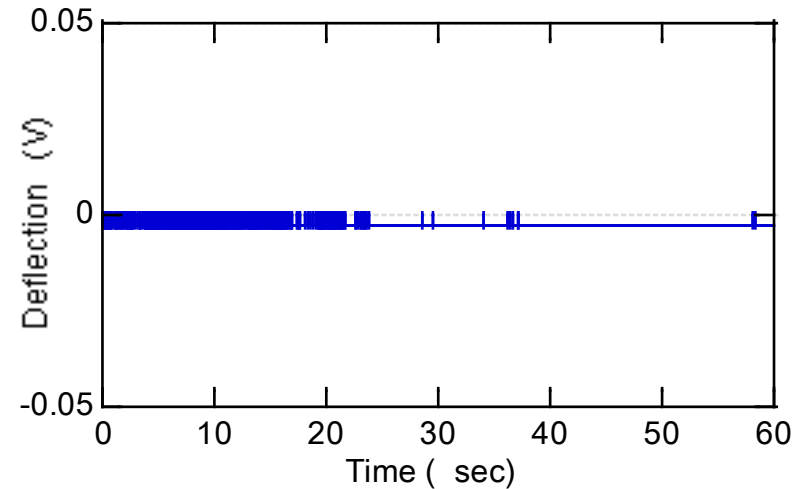
North Post - Sensor 2
10/23/13 05:43



North Post - Sensor 3
10/23/13 05:43



North Post - Sensor 4
10/23/13 05:43



Low tide 10/23/13 - 02:07

High tide 10/23/13 - 07:09

02:23

03:30

04:37

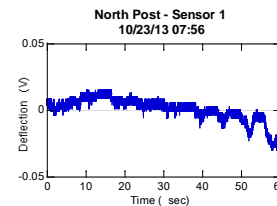
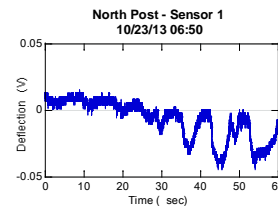
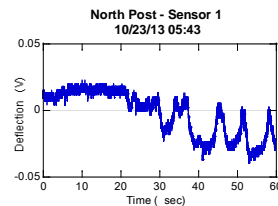
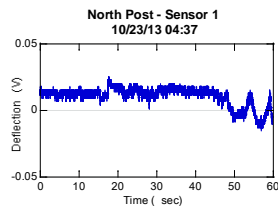
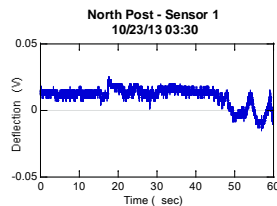
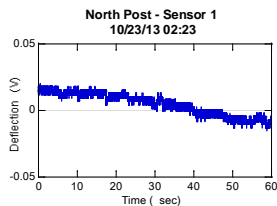
TIME

05:43

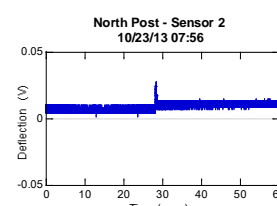
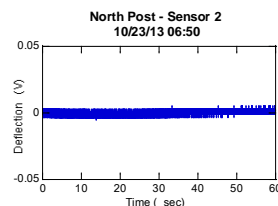
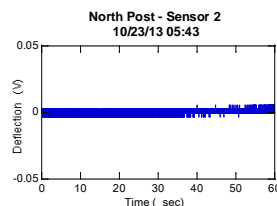
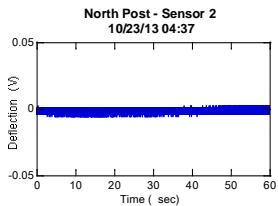
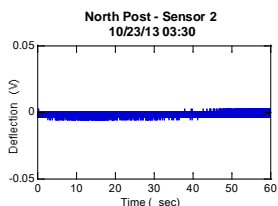
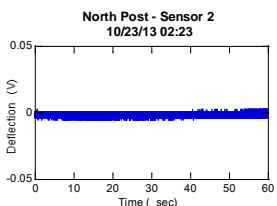
06:50

07:56

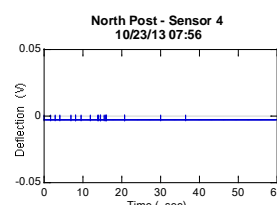
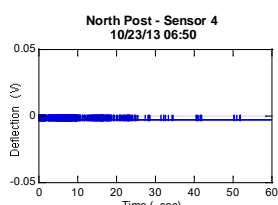
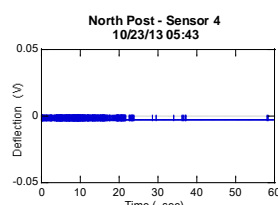
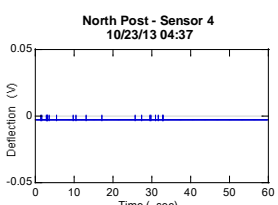
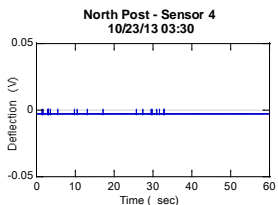
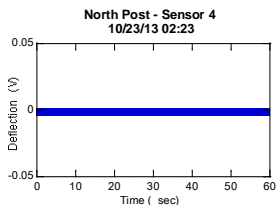
Sensor at -3 inch



Sensor at -9 inch



Sensor at -15 inch



Low tide 10/23/13 - 12:43

High tide 10/23/13 - 19:55

13:29

14:36

15:42

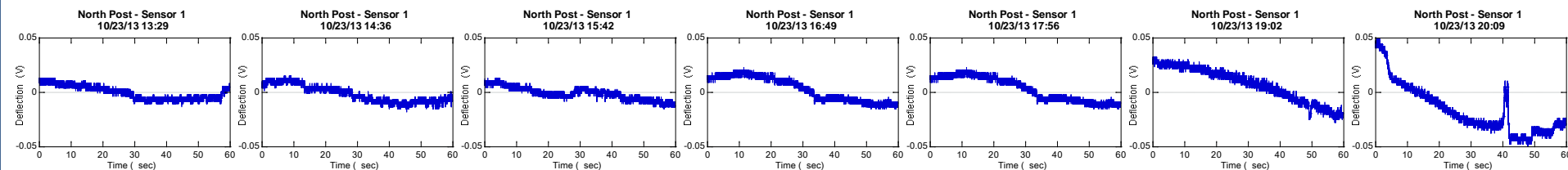
TIME
16:49

17:56

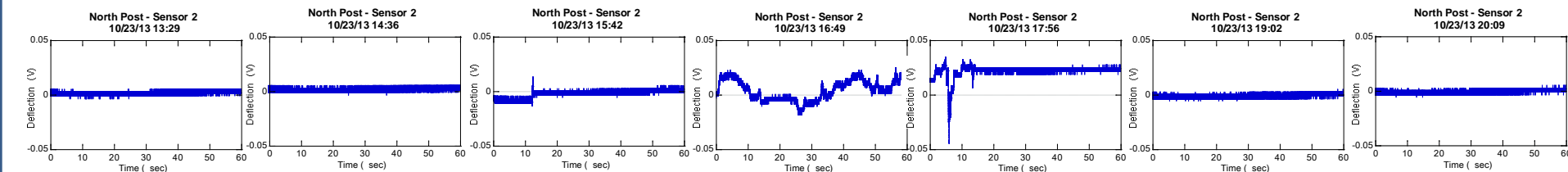
19:02

20:09

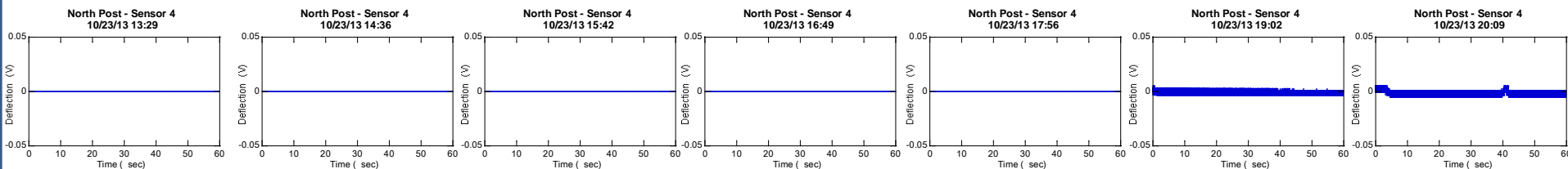
Sensor at -3 inch



Sensor at -9 inch



Sensor at -15 inch



Lateral Riverbed migration site: Bennett Creek, near MD 355



Constraints led to a January installation



Horizontal drilling used. Started ~30 ft from exposed bank

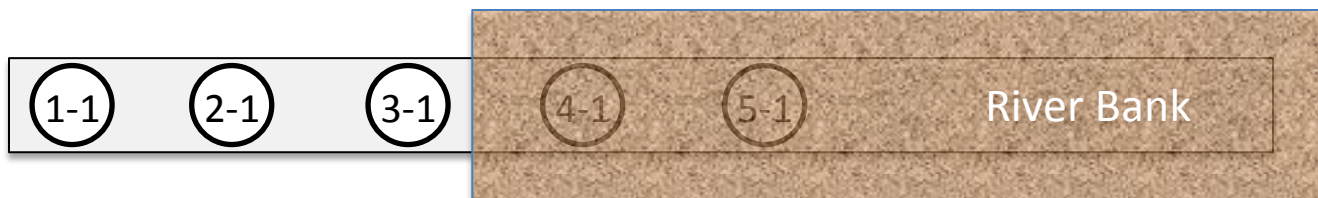
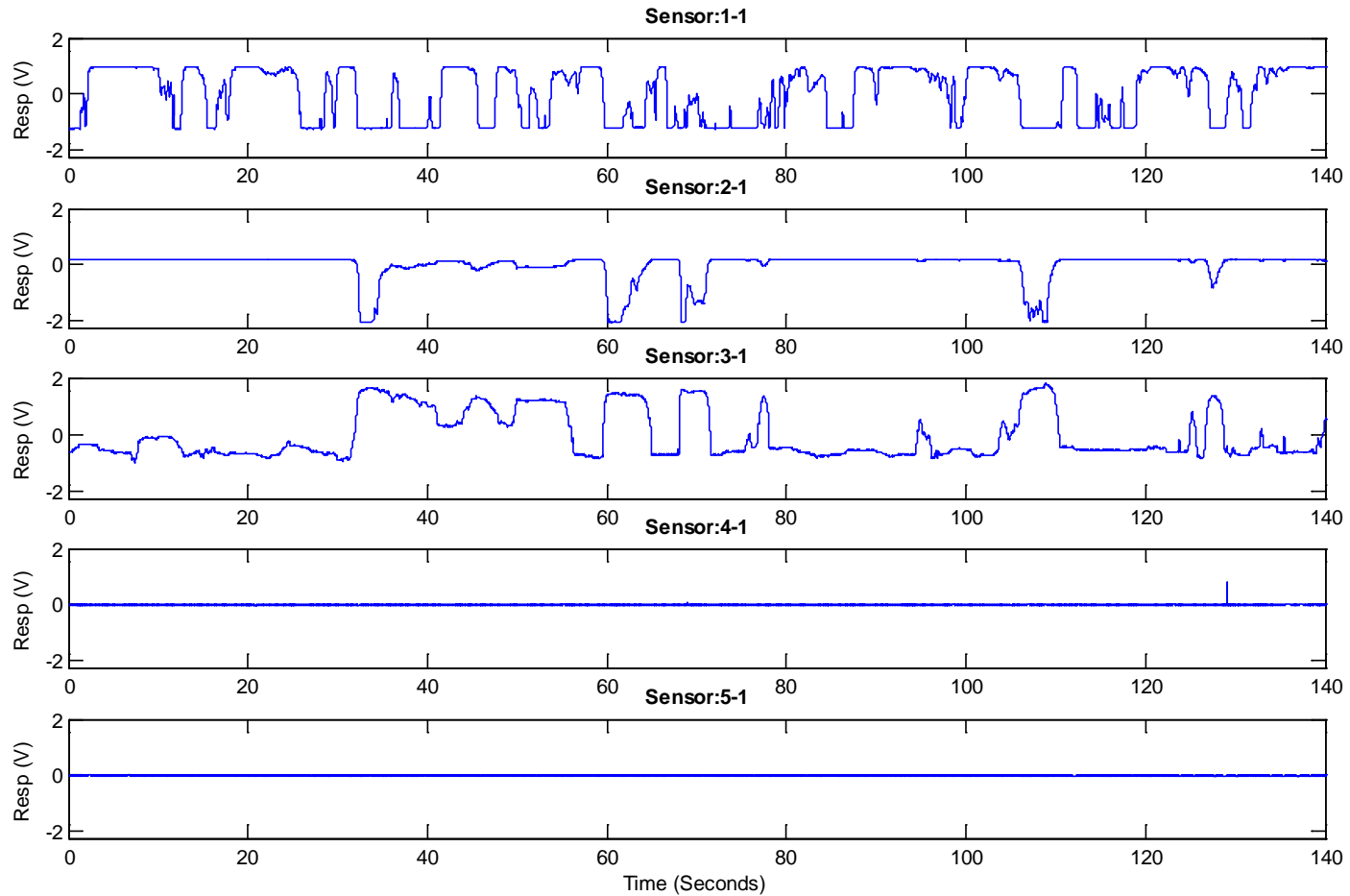




Install Site #2 Sensor Posts



Install Site #2 Underwater Response



Install Site #2 In Air Response

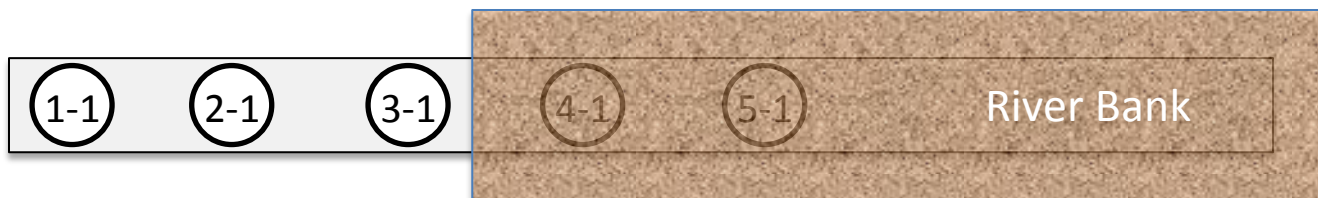
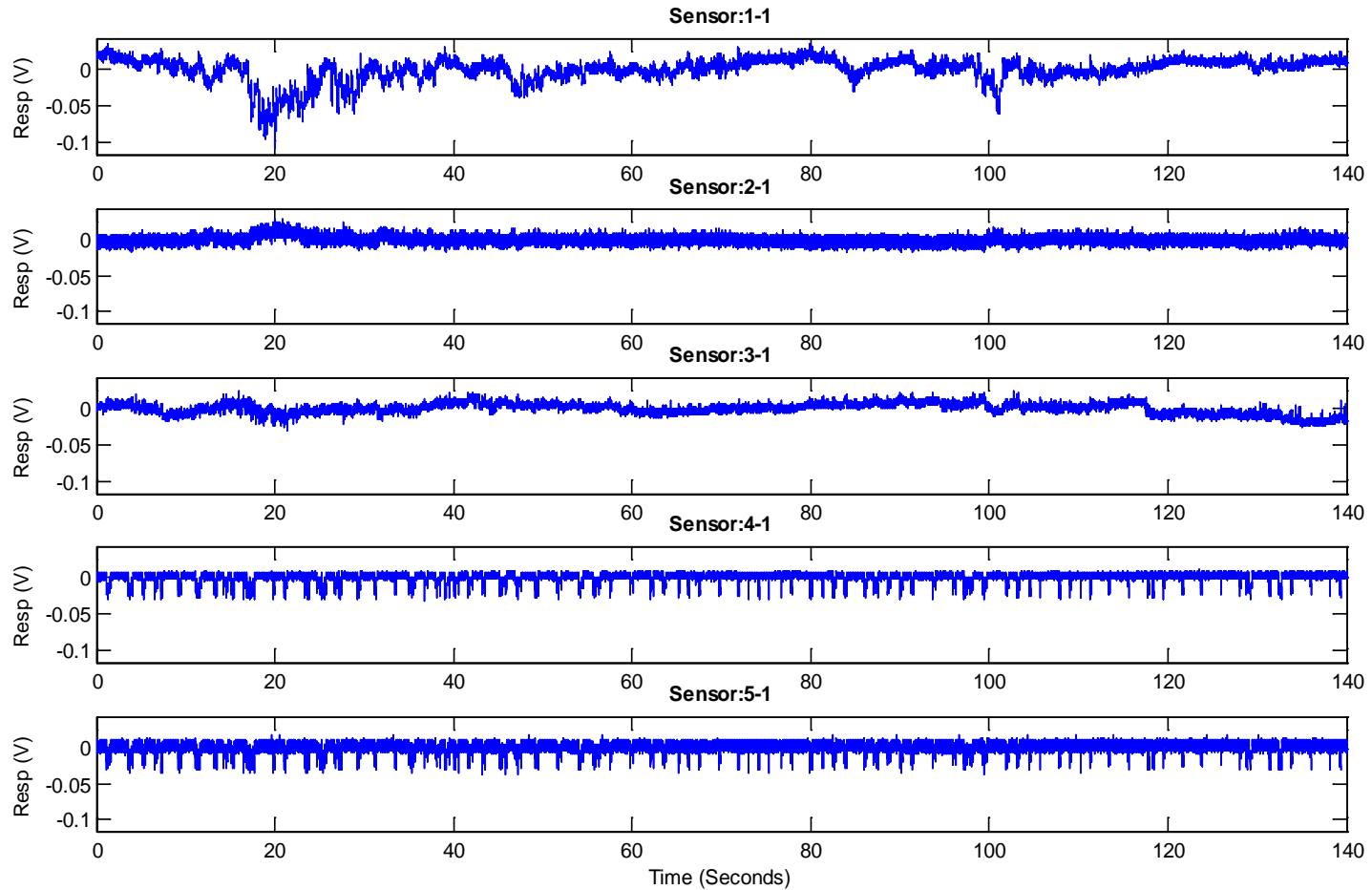


Photo of whiskers installed at the end of the in-air and in-water posts

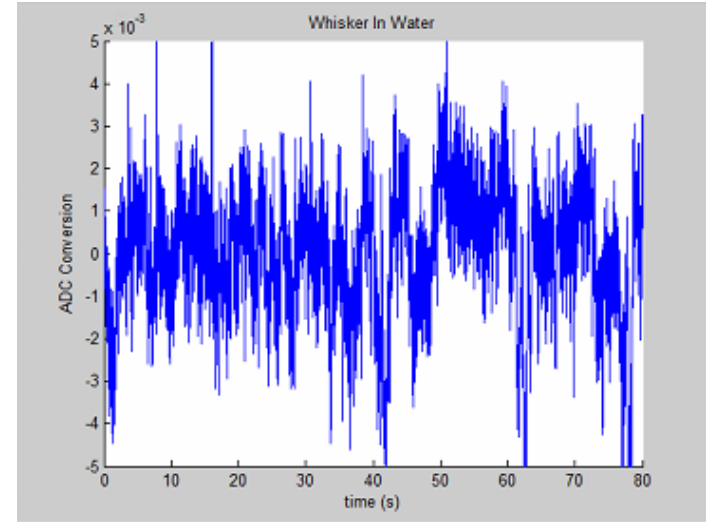
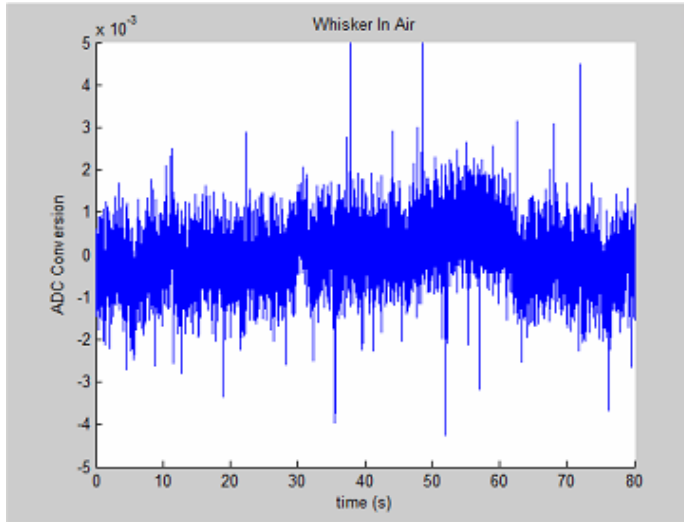


Whisker Response

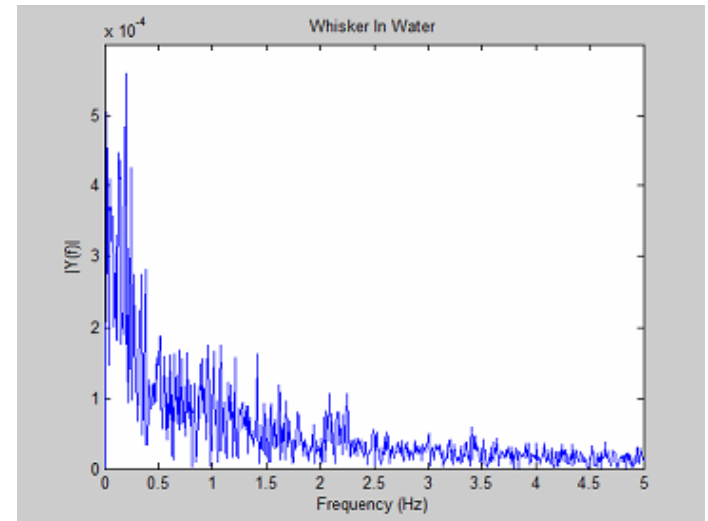
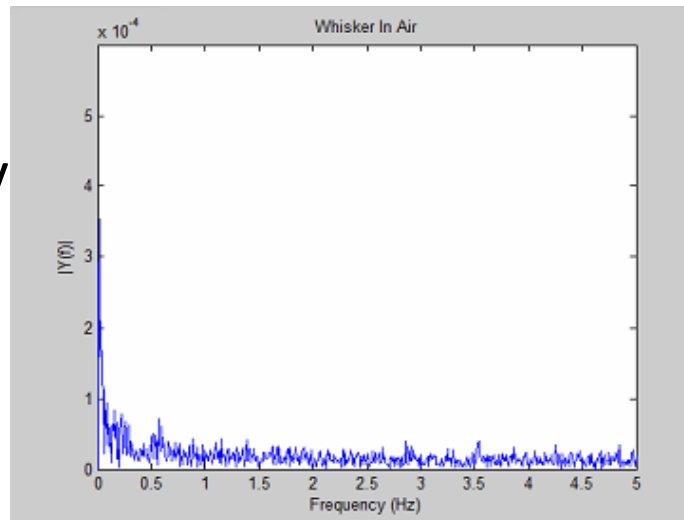
In Air

In Water

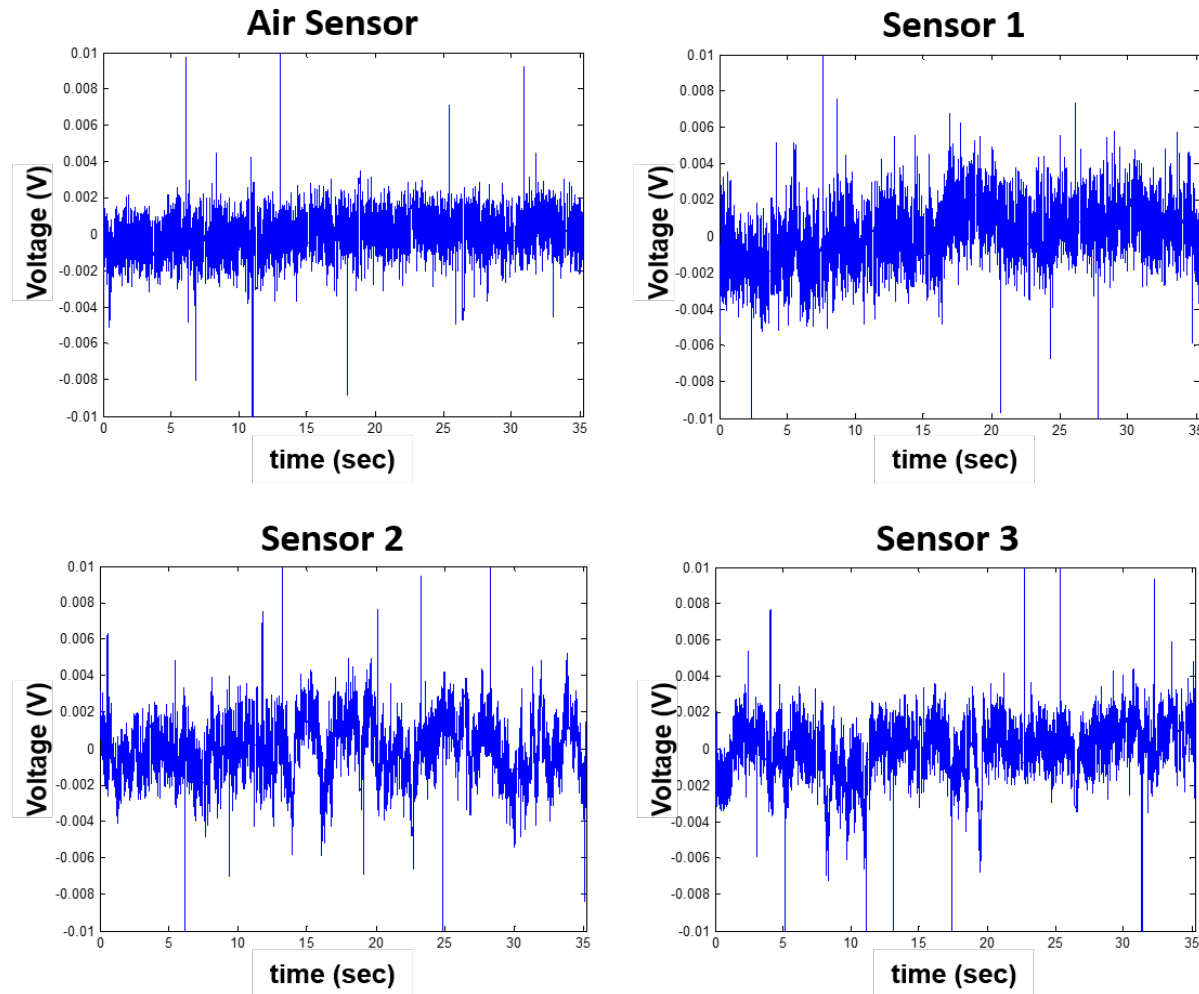
Time
Response



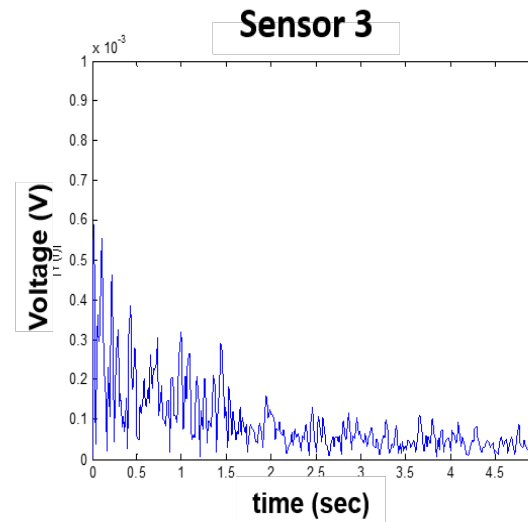
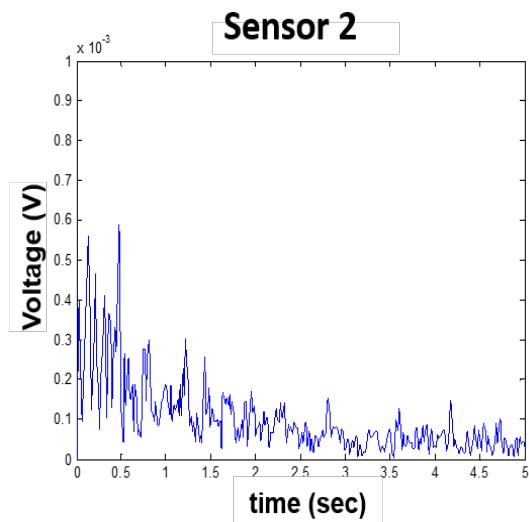
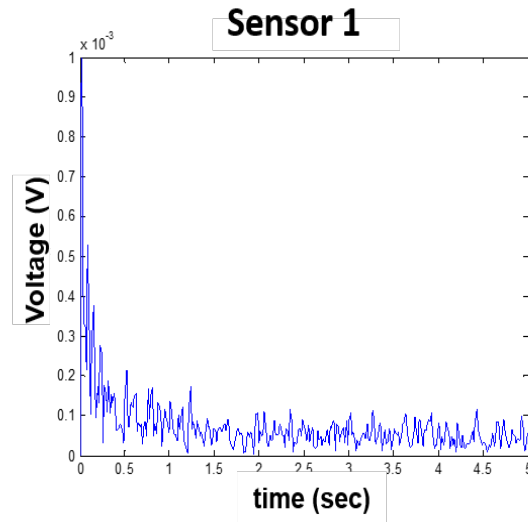
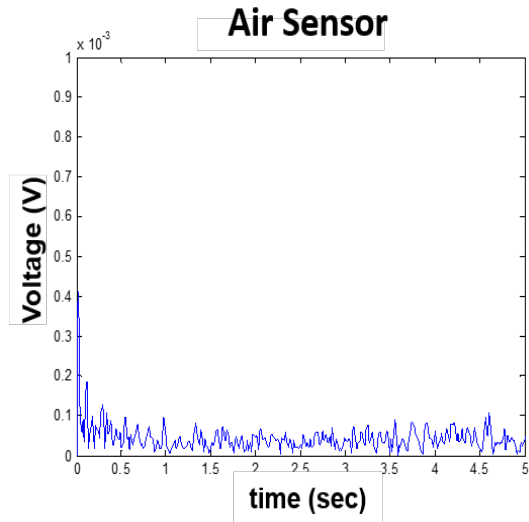
Frequency
Domain
Response



Comparison of in-air and in-water time domain data



Comparison of in-air and in-water frequency domain data

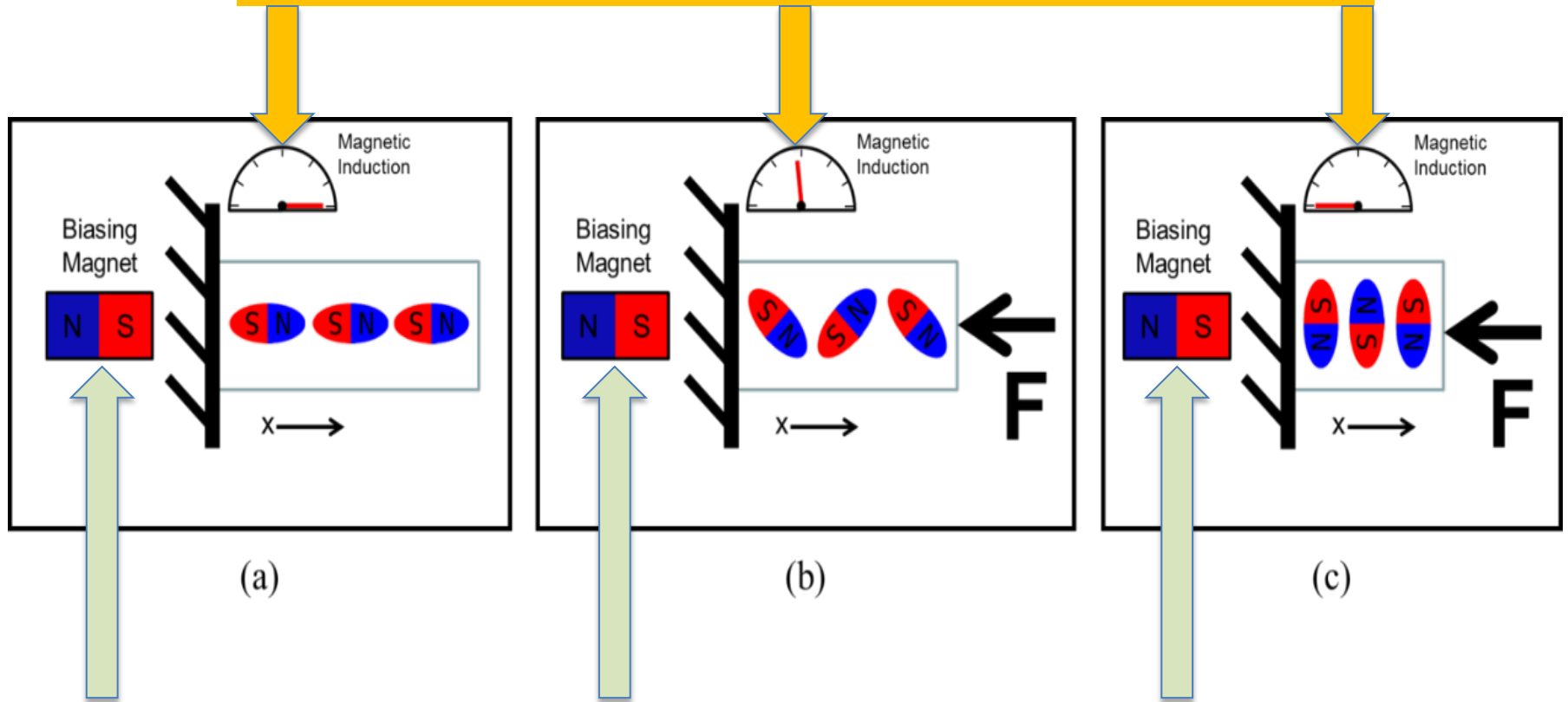


Acknowledgements and Disclaimers

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The views, opinions, findings, and conclusions reflected in this presentation are the responsibility of the authors only and do not represent the official policy or position of the USDOT/OST-R, MDOT, MDSHA, or any other entity.

Hall sensor measures change in magnetization due to stress



Permanent magnet to provide initial magnetization