Update on Reactive Capping Project in the Anacostia River

http://www.hsrc-ssw.org/anacostia/

Danny D. Reible and W. David Constant
Hazardous Substance Research Center/S&SW
Louisiana State University
Yuewei Zhu
Horne Engineering

RTDF Workshop
Baltimore, MD
February 19, 2004

Workshop Targets and Outline

- What is the basic approach?
- What factors influence the suitability?
- What is the stage of development?
- Where is the technology being applied?
- What are the results and costs?
- What are the implementation considerations?
- Observations?
- Future Directions?
- What tools did we use to characterize the site and help design the caps?
- What are the options for “active” capping and which ones are likely to be effective in the demonstration area?
- How are we going to build the caps and measure success or failure?

Potential of Active Caps

- Sand caps easy to place and effective
  - Contain sediment
  - Retard contaminant migration
  - Physically separate organisms from contamination
- Greater effectiveness possible with “active” caps
  - Encourage fate processes such as sequestration or degradation of contaminants beneath cap
  - Discourage recontamination of cap
  - Encourage degradation to eliminate negative consequences of subsequent cap loss

Active Capping Demonstration

- Compare effectiveness of traditional and innovative capping methods relative to control
- Demonstrate and validate under realistic, well documented, in-situ, conditions at contaminated sediment site(s)
  - Better technical understanding of controlling parameters
  - Technical guidance for proper remedy selection and approaches
  - Broader scientific, regulatory and public acceptance of innovative approaches

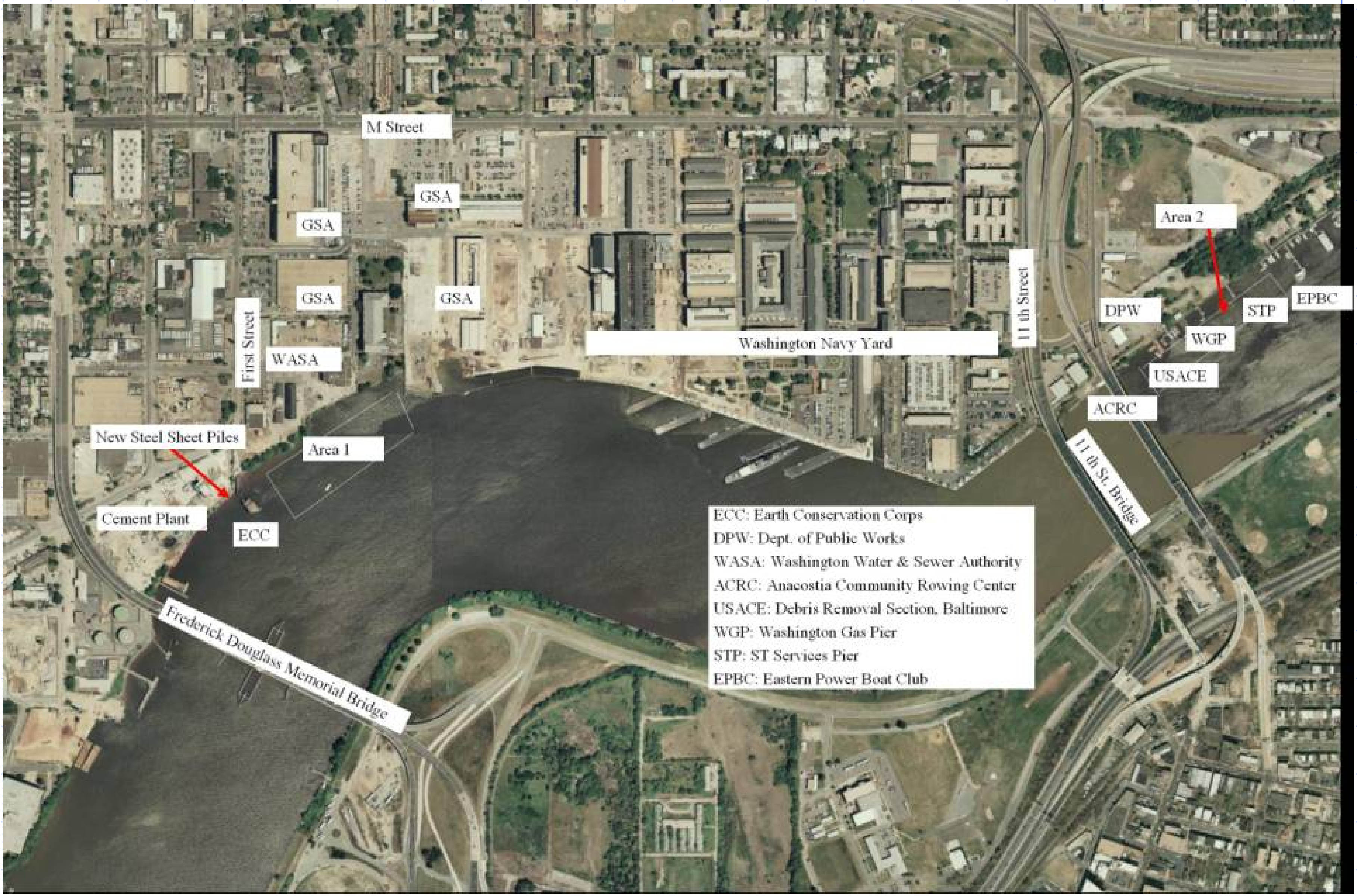
Overall Project Scope

- A grid of capping cells is being placed at a well characterized site:
  - Contaminant behavior before capping has been assessed
  - Various capping types are being deployed within the grid to evaluate placement approaches and implementation effectiveness
  - Caps will be monitored for chemical isolation, fate processes and physical stability
  - Cap types and controls will be compared for effectiveness at achieving goals

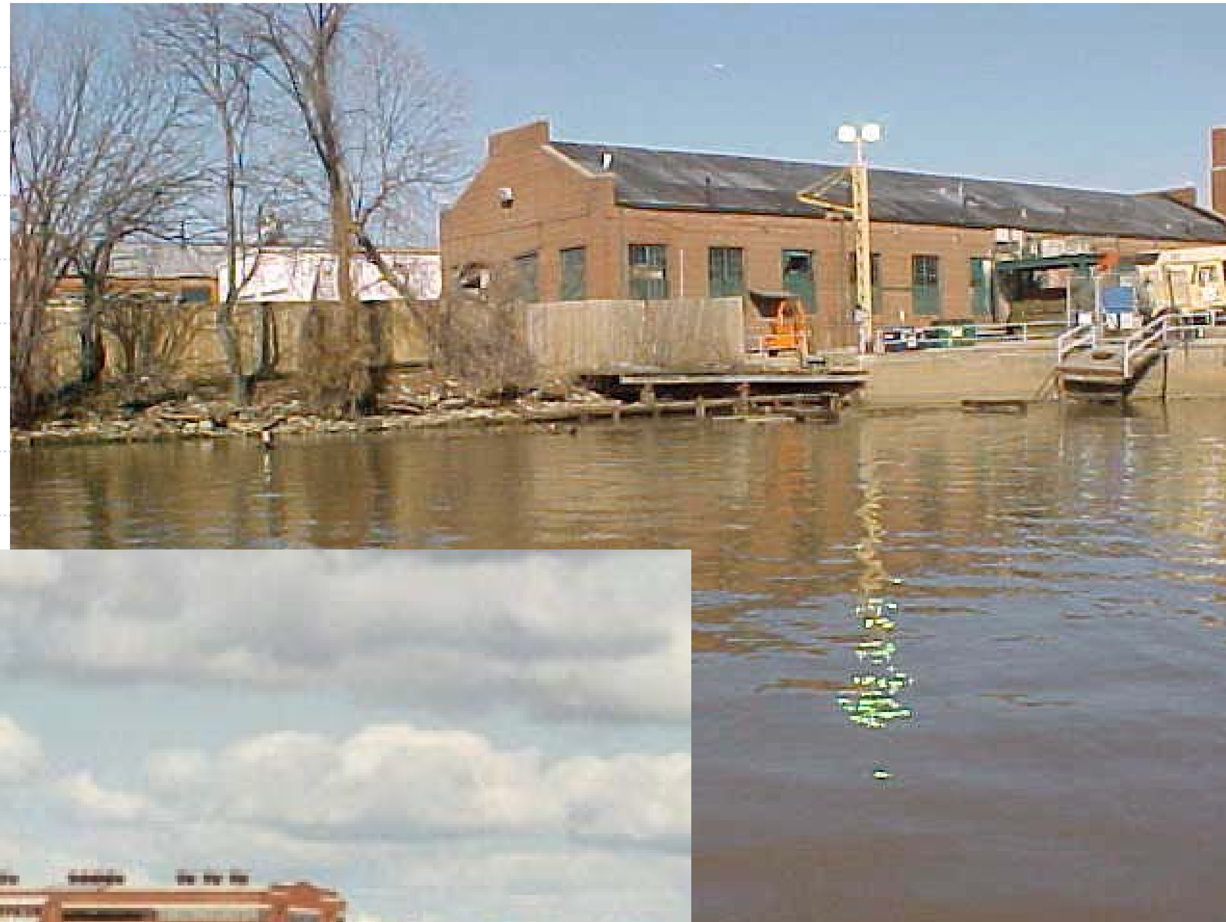
Project Participants

- Anacostia Watershed Toxics Alliance
- LSU – HSRC/S&SW
- EPA SITE Program/Battelle
- Sediment RTDF
- Treatability Studies (in addition to LSU)
  - Carnegie Mellon University
  - Hart-Crowser
  - University of New Hampshire
  - Hull and Associates
- Field Program (in addition to LSU)
  - Horne Engineering
  - Sevenson Environmental Services
  - EA Environmental Consultants
  - Electric Power Research Institute/PEPCO
  - Cornell University
  - Ocean Survey
  - HydroQual

Anacostia River, Washington DC



Study Area 1



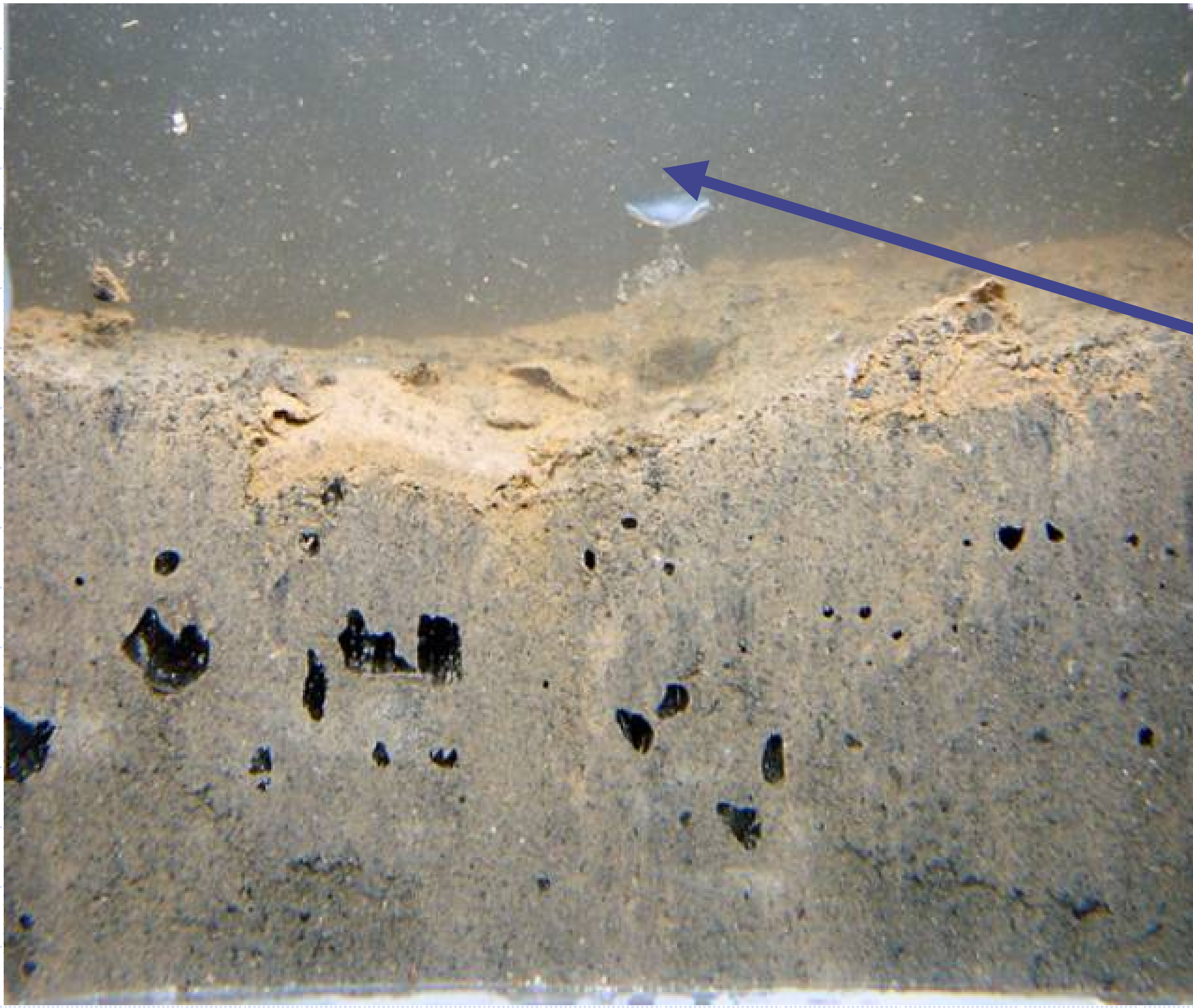
Summary of Field Investigations

- Geophysical investigation with bathymetry measurement, side scan sonar, “chirp” sonar, magnetometry survey
- Sediment profile imaging (SPI) photography survey to visually assess the sediment
- Sampling of the sediment to determine contaminant concentrations and the distribution of contaminant concentrations
- River flow current velocity measurement with the Acoustic Doppler Current Profiler (ADCP)
- Multicoring for sediment radionuclide characterization.
- Geotechnical investigation to evaluate the sediment stability and consolidation behavior under the loadings imposed by the active cap materials
- Benthic investigation

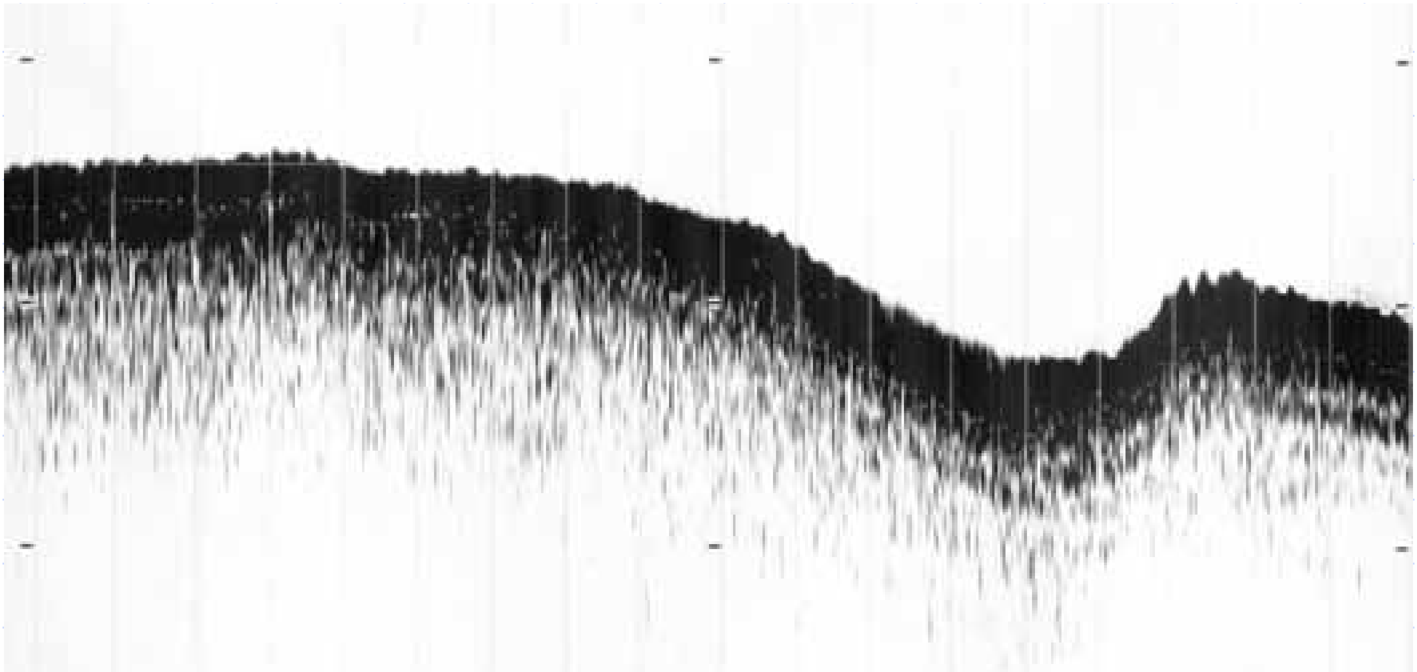
Geophysical Survey Findings

- Area 1 is characterized by a gently undulating surface with few surface irregularities. River bed elevations range from 5’ near shore to 20’ at the southern boundary of the area.
- The riverbed in Area 1 is fine grained sediments ranging from soft aqueous silts and muds to aqueous fine grained sand and silt.
- Subbottom penetration of the profiler system was restricted along all tracklines in the survey areas due to the presence of gaseous-type sediments in the near-subsurface.

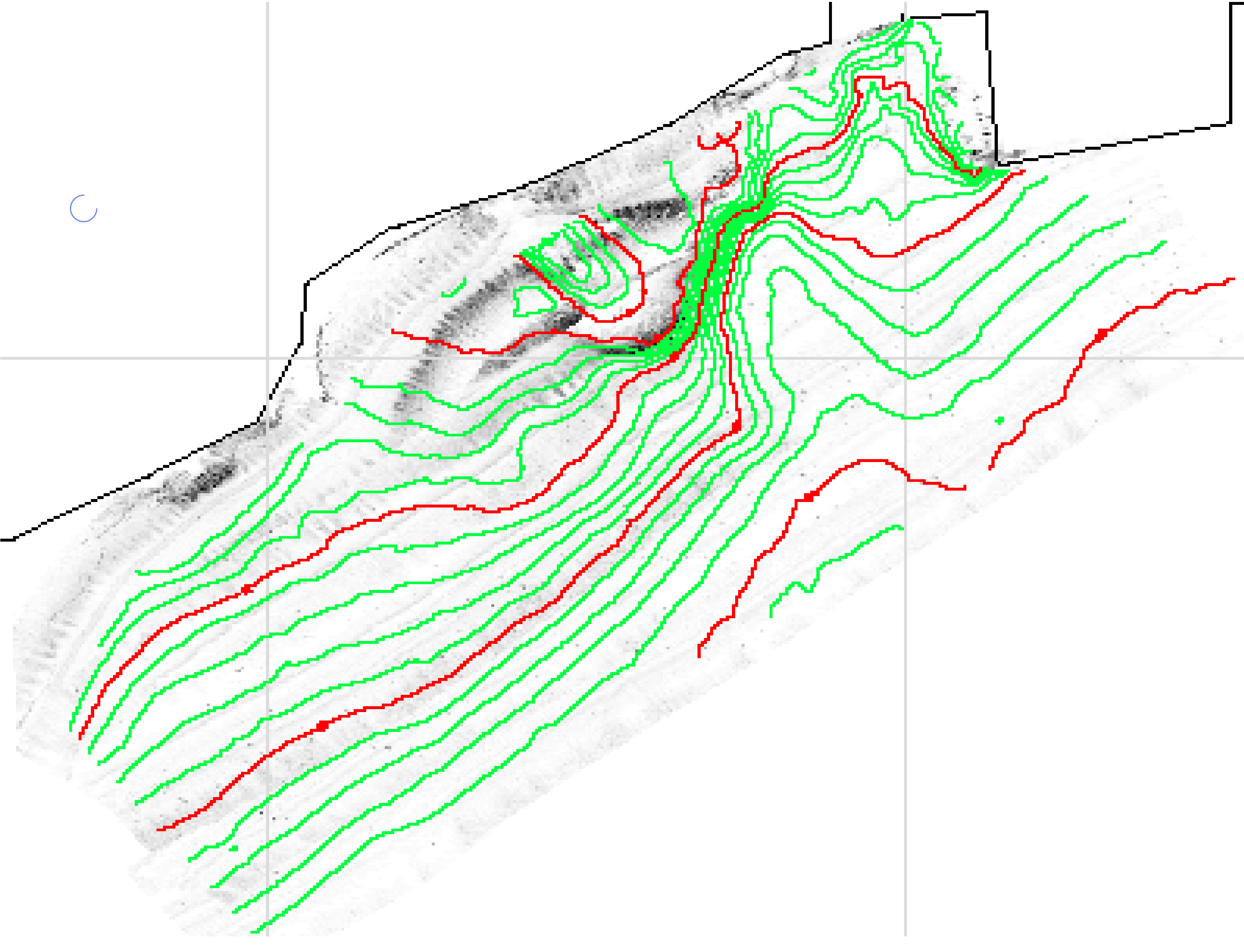
Sediment Camera Image



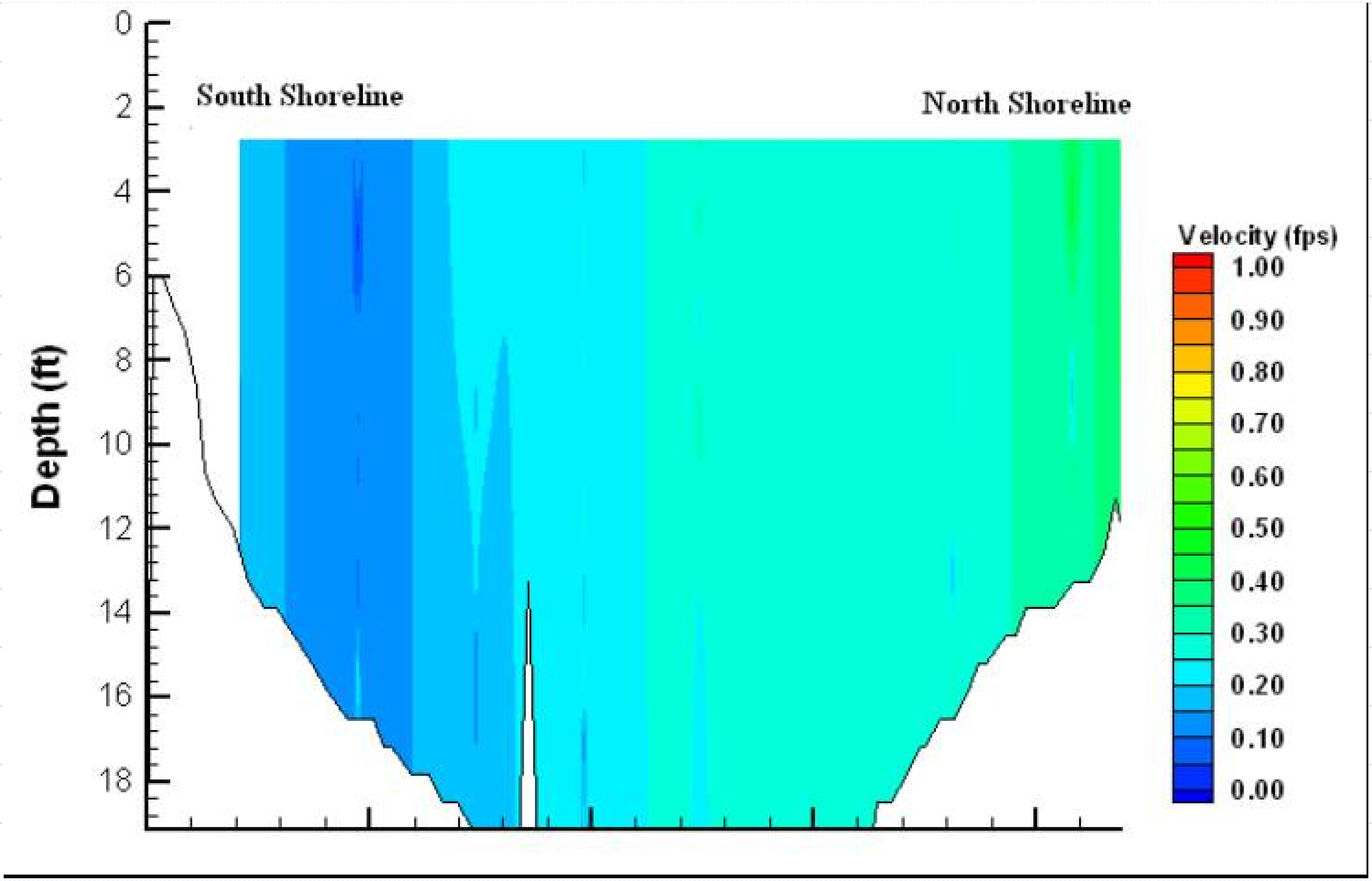
Subbottom profiling - Current



Expect that gas in the sediment will provide an excellent reflective surface to observe cap structure

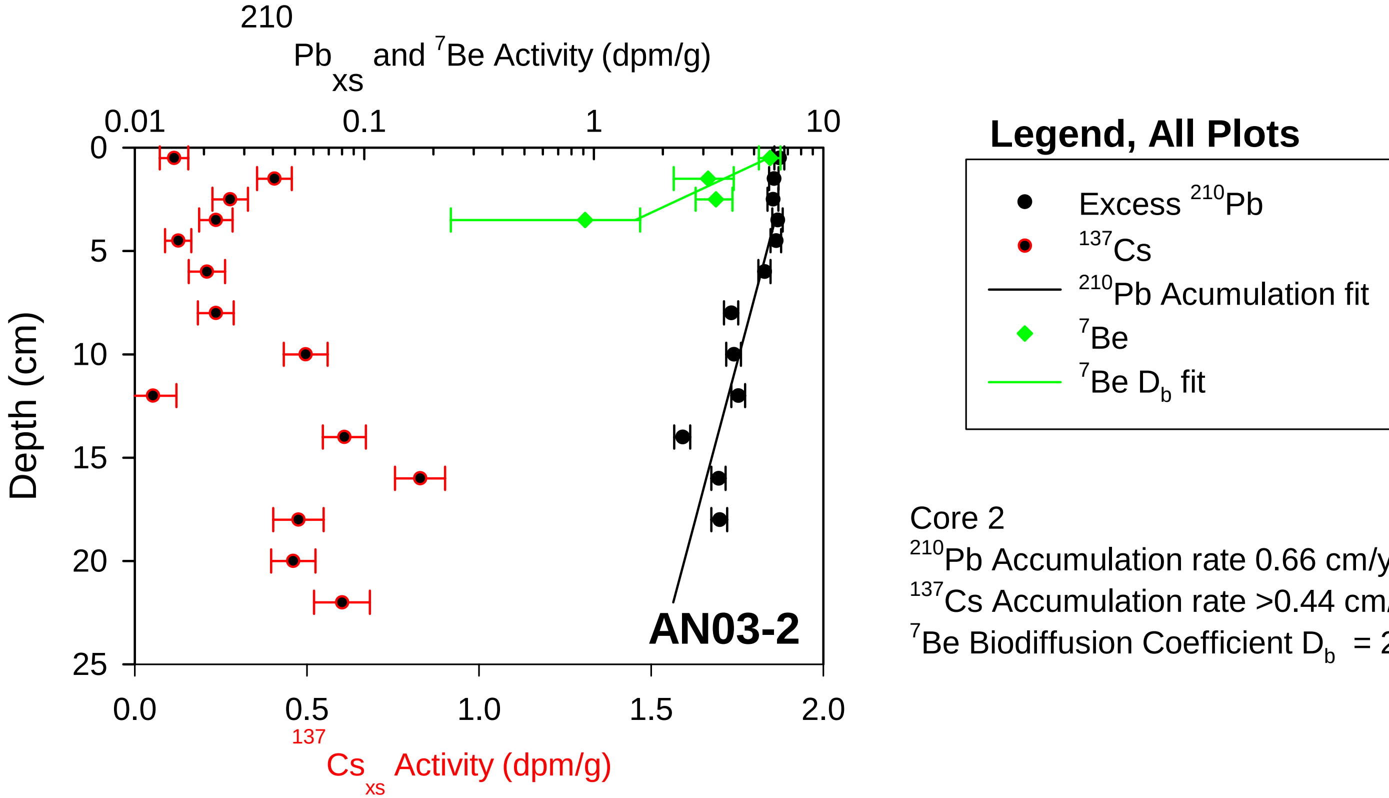


ADCP Results
Velocities During Maximum Flood



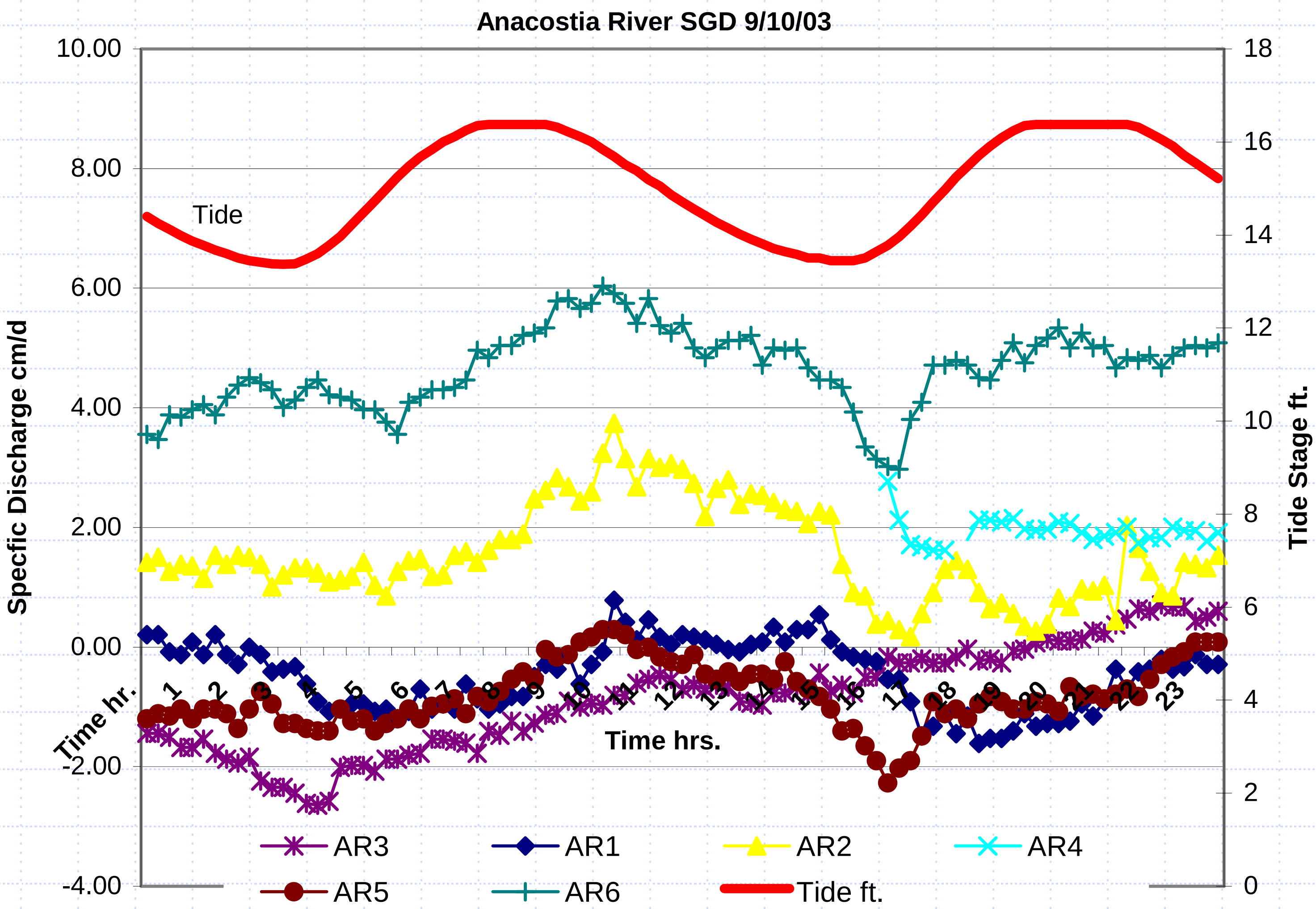
Geochronology from Radionuclide Profiles

- Pb-210 profiles suggest deposition rate of 0.6-1.0 cm/yr
- Cs-137 profiles suggest deposition rate >0.44->0.84 cm/yr
- Be-7 profiles suggest biodiffusion coefficient of 24-34 cm^2/yr



Core 2
^{210}Pb Accumulation rate 0.66 cm/y, r^2 = 0.84
^{137}Cs Accumulation rate >0.44 cm/y
^{7}Be Biodiffusion Coefficient D_b = 24 cm^2/y, r^2 = 0.86

Seepage rates in test area



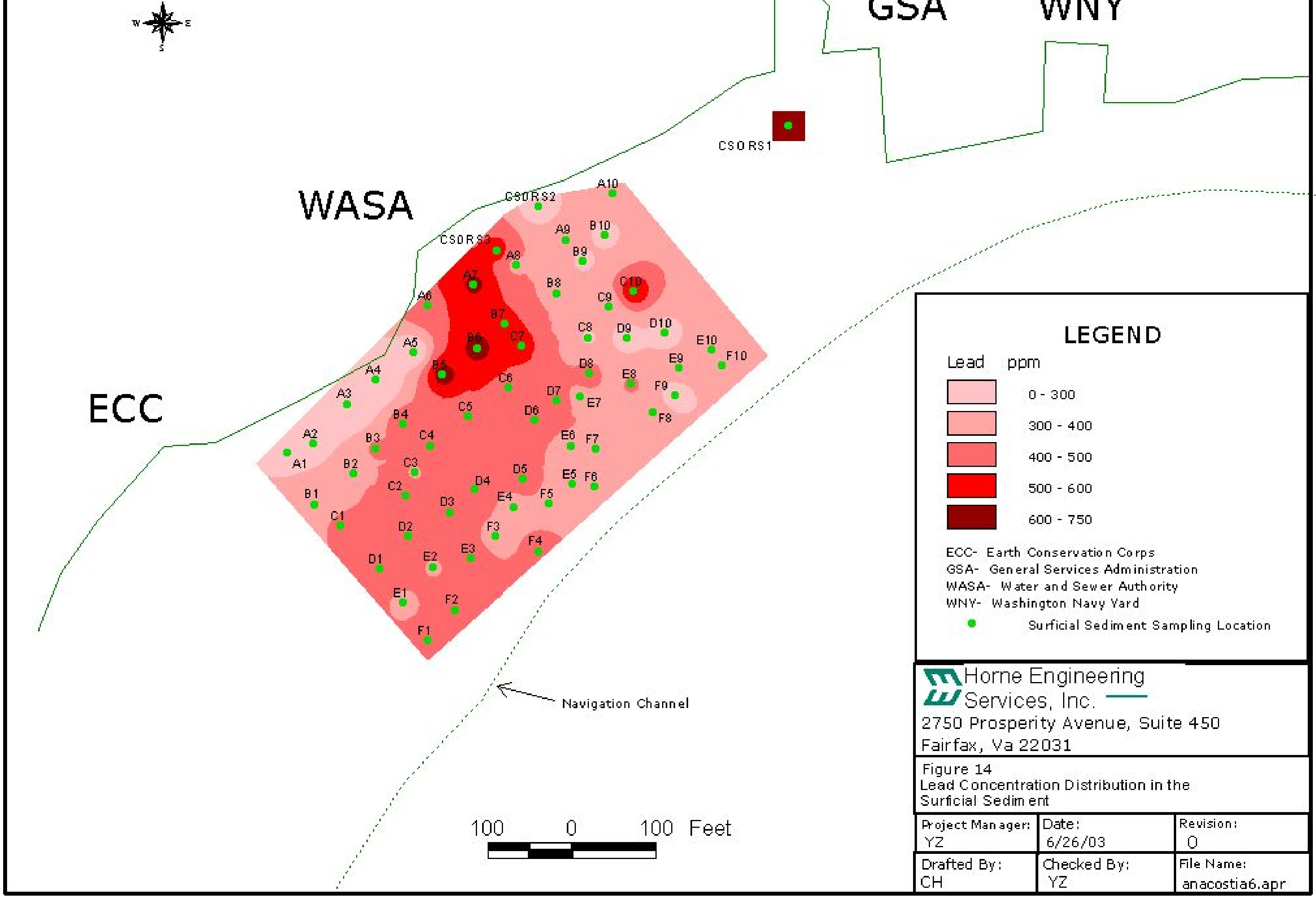
Geotechnical Investigation

- Five deep borings ranging from 21 feet to 27 feet
- Split spoon and undisturbed Shelby Tube (ST) samples collected for engineering properties testing
- Field vane shear tests performed at adjacent location
- Inferred subsurface profile defining sediment strata
  - 15-20’ of high plasticity silty clay at surface
  - Underlain by sand & gravel sometimes intermixed with clay

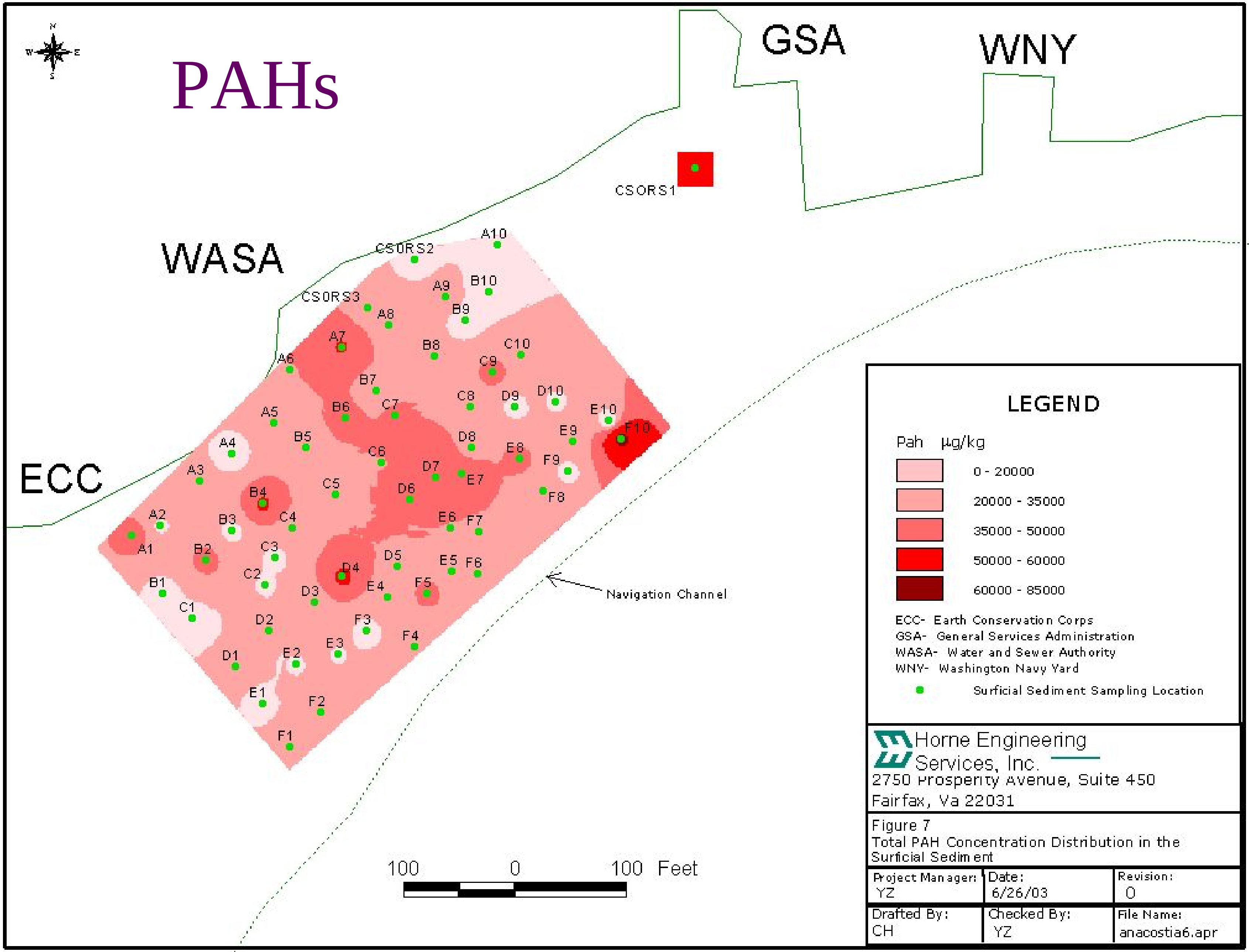
Sediment Contamination Delineation

- 13 EPA priority metals
- PAHs
- PCBs (both aroclors and congeners)
- Pesticides
- Total phosphorus
- Total Kjeldahl nitrogen
- Total organic carbon (TOC)
- Acid volatile sulfide/simultaneously extracted metals

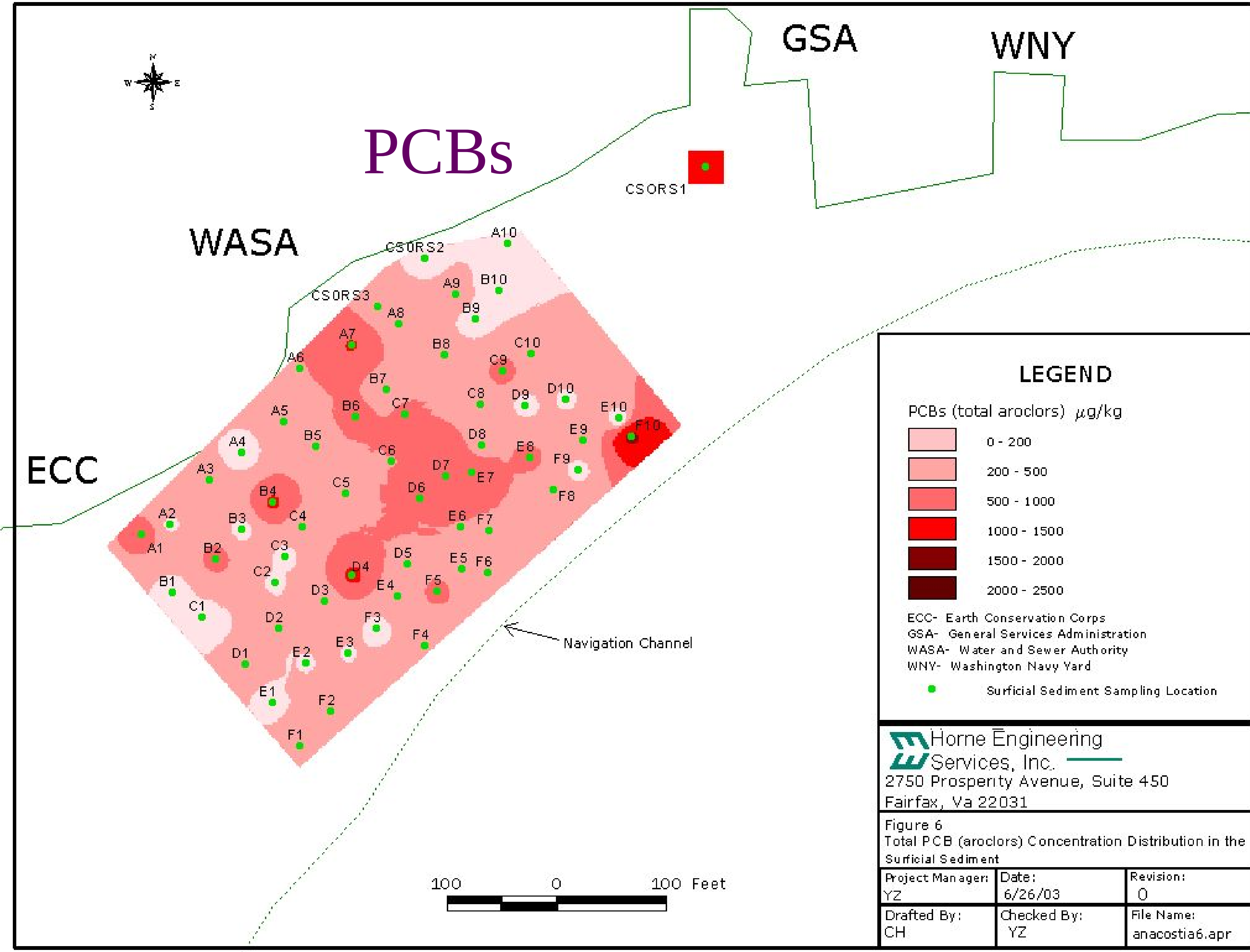
Lead



GSA
WNY
WASA
ECC
CSO RS1
CSO RS2
CSO RS3
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10
B1 B2 B3 B4 B5 B6 B7 B8 B9 B10
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10
E1 E2 E3 E4 E5 E6 E7 E8 E9 E10
F1 F2 F3 F4 F5 F6 F7 F8 F9 F10
Navigation Channel
100 0 100 Feet
LEGEND
Lead ppm
0 - 300
300 - 400
400 - 500
500 - 600
600 - 750
ECC- Earth Conservation Corps
GSA- General Services Administration
WASA- Water and Sewer Authority
WNY- Washington Navy Yard
Surficial Sediment Sampling Location
Horne Engineering Services, Inc.
2750 Prosperity Avenue, Suite 450
Fairfax, Va 22031
Figure 14
Lead Concentration Distribution in the Surficial Sediment
Project Manager: YZ
Date: 6/26/03
Revision: 0
Drafted By: CH
Checked By: YZ
File Name: anacostia6.apr


PAHs
GSA
WNY
WASA
ECC
CSORS1
CSORS2
CSORS3
Navigation Channel
100 0 100 Feet
LEGEND
Pah µg/kg
0 - 20000
20000 - 35000
35000 - 50000
50000 - 60000
60000 - 85000
ECC- Earth Conservation Corps
GSA- General Services Administration
WASA- Water and Sewer Authority
WNY- Washington Navy Yard
Surficial Sediment Sampling Location
Horne Engineering Services, Inc.
2750 Prosperity Avenue, Suite 450
Fairfax, Va 22031
Figure 7
Total PAH Concentration Distribution in the Surficial Sediment
Project Manager: YZ
Date: 6/26/03
Revision: 0
Drafted By: CH
Checked By: YZ
File Name: anacostia6.apr

PCBs



GSA
WNY
WASA
ECC
CSORS1
CSORS2
CSORS3
Navigation Channel
100 0 100 Feet
LEGEND
PCBs (total aroclors) µg/kg
0 - 200
200 - 500
500 - 1000
1000 - 1500
1500 - 2000
2000 - 2500
ECC- Earth Conservation Corps
GSA- General Services Administration
WASA- Water and Sewer Authority
WNY- Washington Navy Yard
Surficial Sediment Sampling Location
Horne Engineering Services, Inc.
2750 Prosperity Avenue, Suite 450
Fairfax, Va 22031
Figure 6
Total PCB (aroclors) Concentration Distribution in the Surficial Sediment
Project Manager: YZ
Date: 6/26/03
Revision: 0
Drafted By: CH
Checked By: YZ
File Name: anacostia6.apr

Evaluation of Active Caps

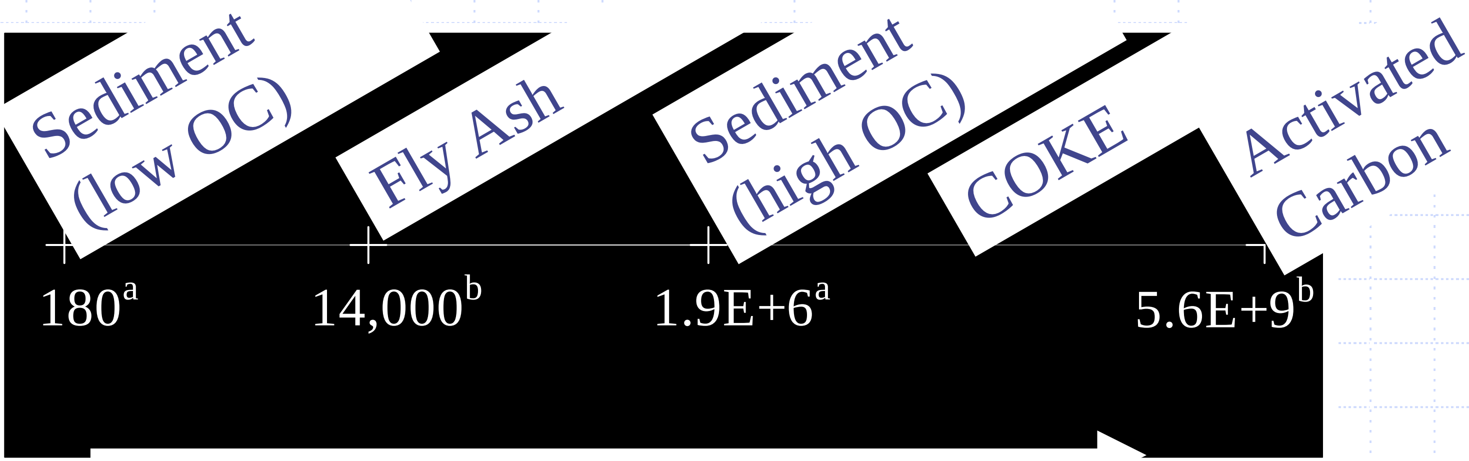
- Seepage control
  - **Aquablok™- included in demo – Hull/EPA/Battelle**
    - Gravel/rock core covered by clay layer
    - Expands in water decreasing permeability
    - Applicable to seep locations
- Sequestration of hydrophobic organic compounds
  - Activated Carbon – cost suggests need for controlled placement technology
  - Organo modified clay – most effective against NAPL, undetermined success against dissolved contaminants
  - Ambersorb – very high cost to effectiveness ratio
  - XAD-2 – very high cost to effectiveness ratio
  - **Coke – low cost but still needs controlled placement technology (included in program) - CMU**

Evaluation of Active Caps

- Sequestration of metals
  - **Apatite – included in program - UNH**
- Encourage degradation
  - Bion Soil – potential for nutrient release, effective primarily against chlorinated organics (contaminants subject to anaerobic degradation)
  - Zero valent iron – small fraction of available metals and low PCB concentrations limits impact, long-term effectiveness of commercial iron for metal reduction or anaerobic dechlorination

Sorptive Media

- Coke (Lowry et al., CMU)
  - Strong PCB sorption (K_d)
  - Less bioavailable (Talley et al. 2002)



SORPTION STRENGTH

K_d (L/kg)

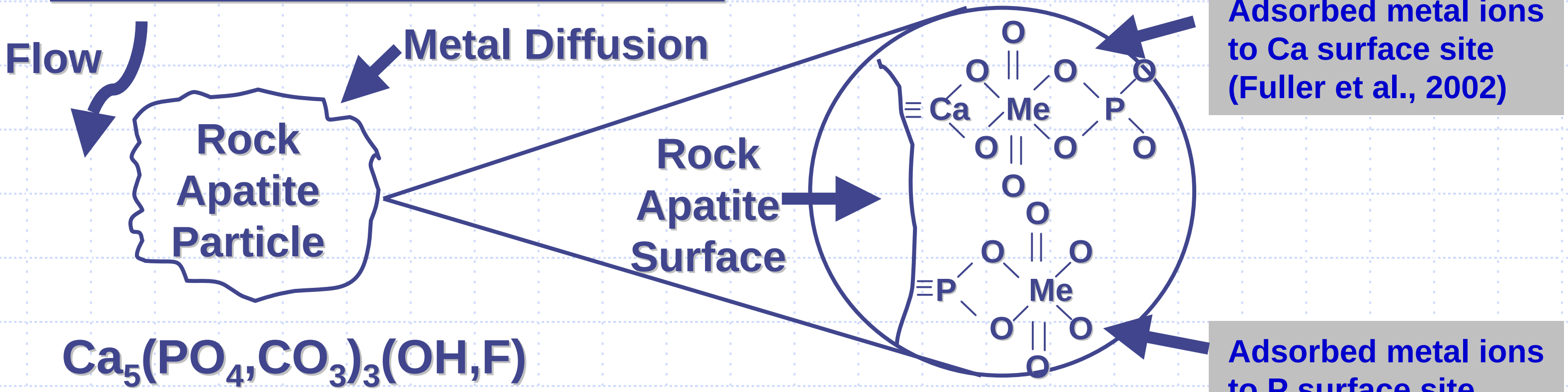
[b] Jonker et al. 2002

Furnace Coke and Coke Breeze

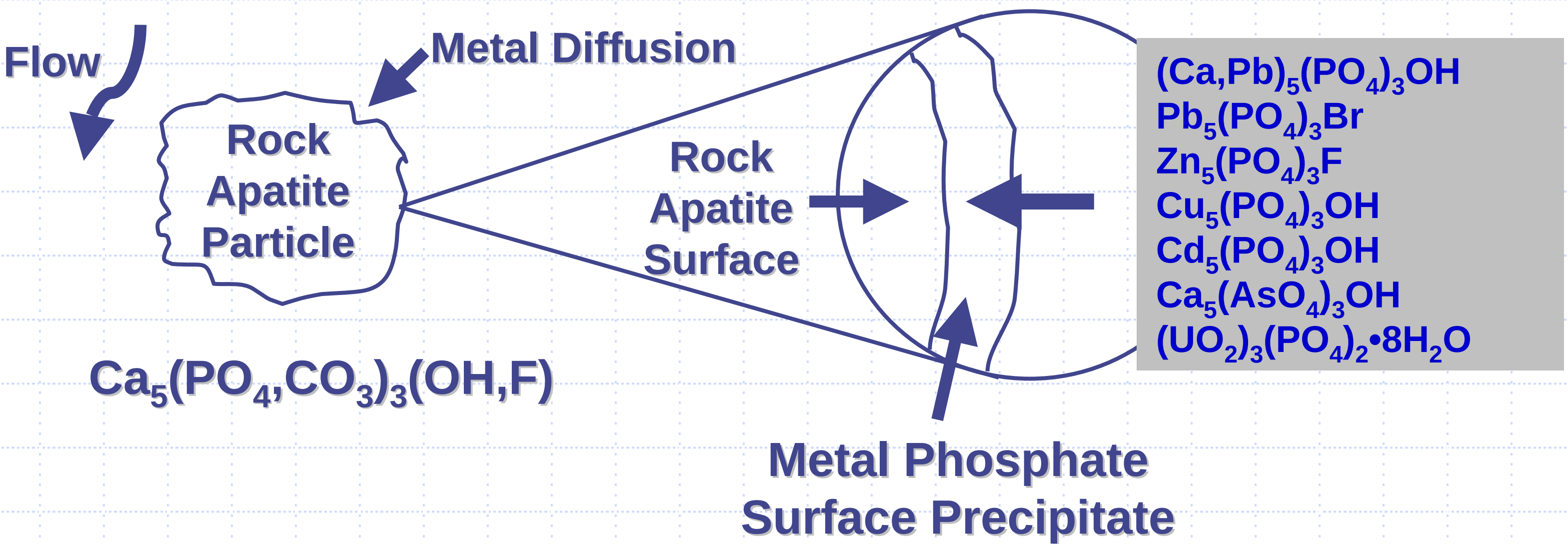
Apatite-Based Barriers and Immobilization – Melton et al., UNH

For:
Pb, Cd,
Cu, Zn,
Ni, As,
U, F,
Br, Cl,
Etc.

Metal Adsorption (at low ppb)



Metal Surface Precipitation (at high ppb)



Apatite Effectiveness

- Diffusion experiments were conducted on metal spiked sediments in laboratory controlled conditions.
- Effective diffusion coefficients decreased in phosphate barriers up to 1.5 orders of magnitude for some elements including Pb, Cu, Cr, and Zn.
- Mineralogical analysis of the interface shows the formation of highly insoluble lead phosphate minerals from the apatite group.
  - $Pb_5(PO_4)_3OH$

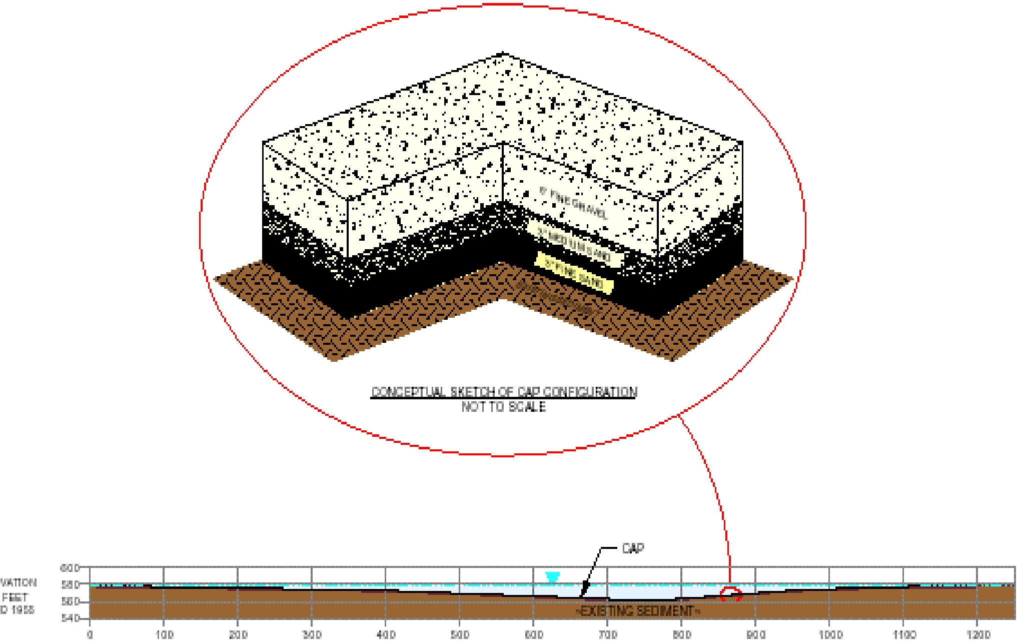
Selected Active Caps

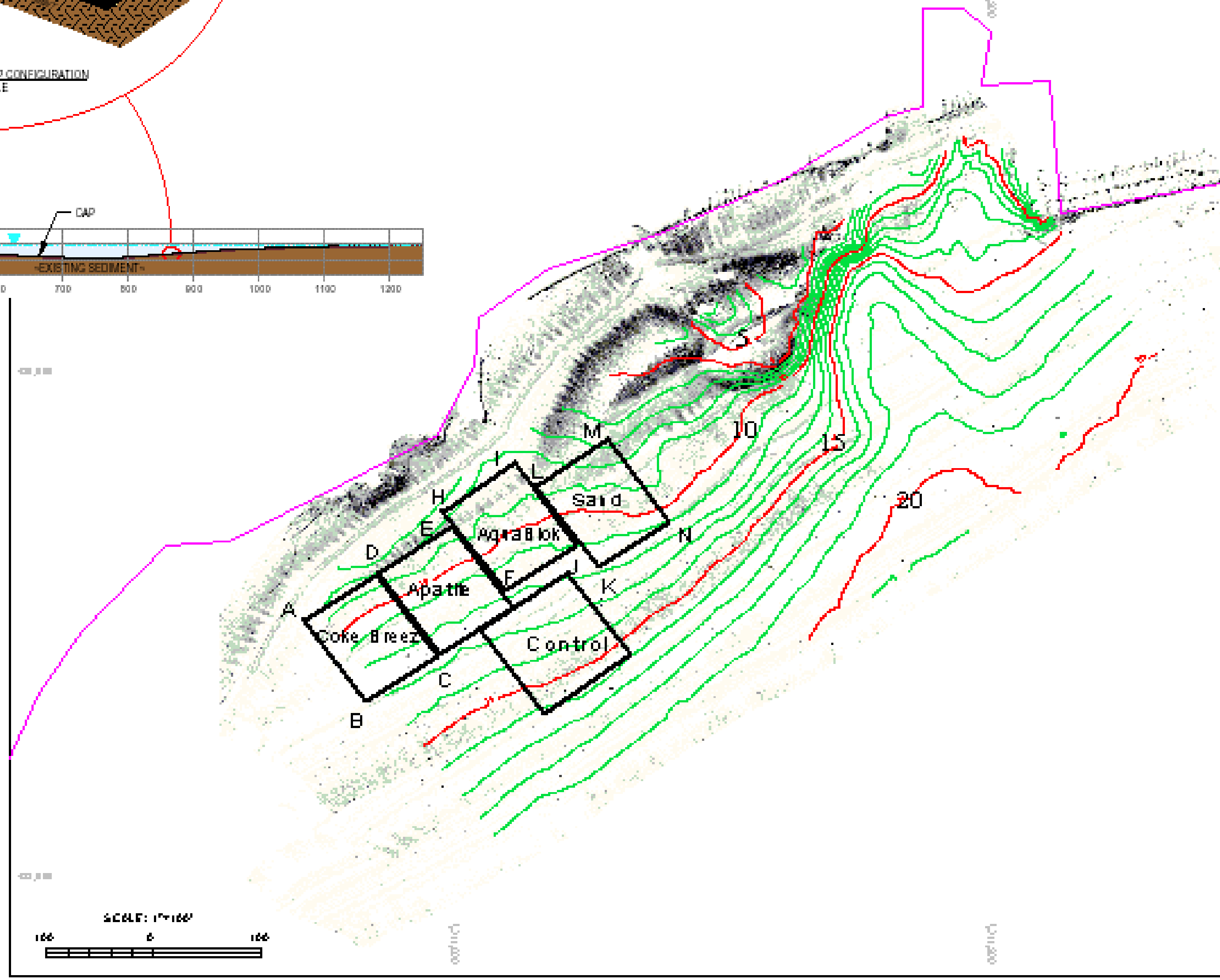
- AquaBlok™ – w/EPA SITE program
  - Tidal seepage control
  - Potential for uplift during tidal range
- Coke
  - PAH sequestration
  - Effectiveness of placement in laminated mat with CETCO
- Apatite
  - Metal sequestration
  - Effectiveness of direct placement
- Sand (for comparison)

Cap Placement

- The cap material will be placed with a clamshell bucket using WinOps for horizontal location control
  - Nominal 15 cm active layer except for coke and Aquablok
  - 15 cm overlying sand layer
- Silt Curtain will be used during the cap placement.
- Cap thickness will be monitored using both instrument and manual (surveyor) methods.
- Required water quality monitoring will be performed accordingly.

Pilot Study Cell Layout

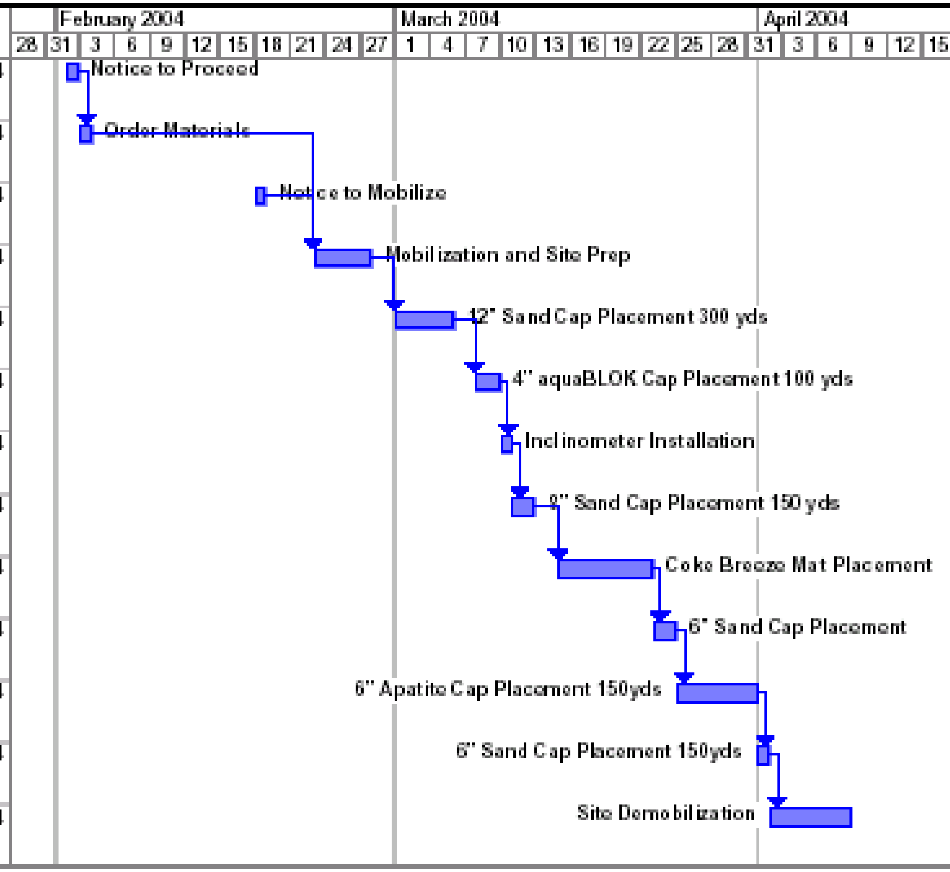




Status of Placement 1st Quarter 2004 (CY)

Anacostia River, Washington, D.C.
'Active Capping Technology'
Pilot Study
Project Schedule

ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	1 day	2/2/04	2/2/04
2	Order Materials	1 day	2/3/04	2/3/04
3	Notice to Mobilize	1 day	2/18/04	2/18/04
4	Mobilization and Site Prep	5 days	2/23/04	2/27/04
5	12" Sand Cap Placement 300 yds	5 days	3/1/04	3/5/04
6	4" aquaBLOK Cap Placement 100 yds	2 days	3/8/04	3/9/04
7	Inclinometer Installation	1 day	3/10/04	3/10/04
8	8" Sand Cap Placement 150 yds	2 days	3/11/04	3/12/04
9	Coke Breeze Mat Placement	6 days	3/15/04	3/22/04
10	6" Sand Cap Placement 150yds	2 days	3/23/04	3/24/04
11	6" Apatite Cap Placement 150yds	5 days	3/25/04	3/31/04
12	6" Sand Cap Placement 150yds	1 day	4/1/04	4/1/04
13	Site Demobilization	5 days	4/2/04	4/8/04



SEVENSON ENVIRONMENTAL SERVICES
2749 LOCKPORT ROAD
NIAGARA FALLS, NY 14305

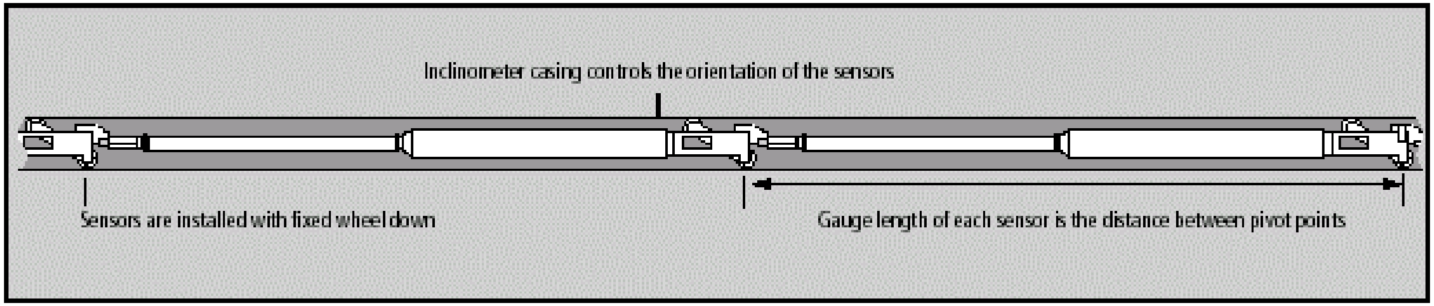
Monitoring Cap Effectiveness

- Employ high resolution cores to define placement and cap effectiveness
  - Bottom of core – undisturbed sediment
  - Middle of core – cap/sediment interface
    - Examine interlayer mixing
    - Examine contaminant migration/fate processes
  - Top of core – cap/water interface
    - Examine recontamination
    - Examine recolonization
- Supplement with physical monitoring
  - Water column (flow, suspended sediment, chemical)
  - Non-invasive (sonar, bathymetry)
  - Invasive (sediment profiling camera)

Monitoring Cap Effectiveness

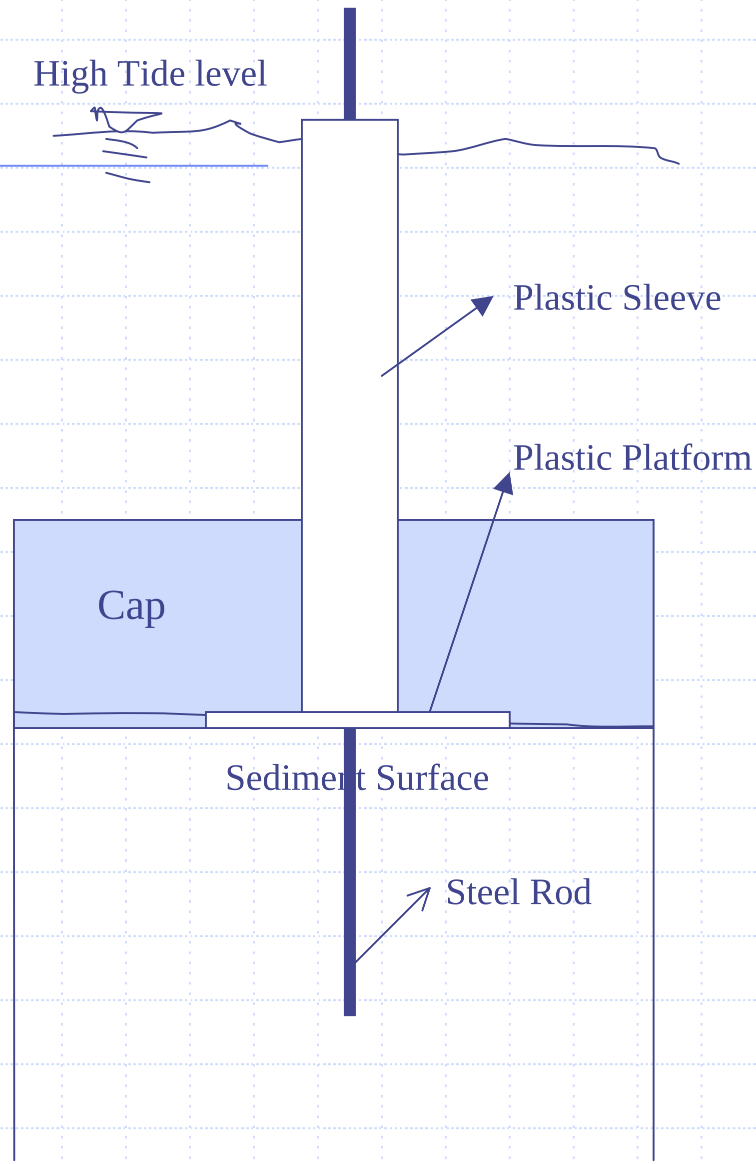
- Inclinometer for Aquablok
  - Model predictions suggest uplift potential due to gas and tidal forces
- Chirp sonar to evaluate cap homogeneity and thickness
  - Underlying gas will help gain better resolution from the sonar
- Seepage meters and Piezometers
  - To assess potential for and seepage flows

Horizontal EL In-Place Inclinometer

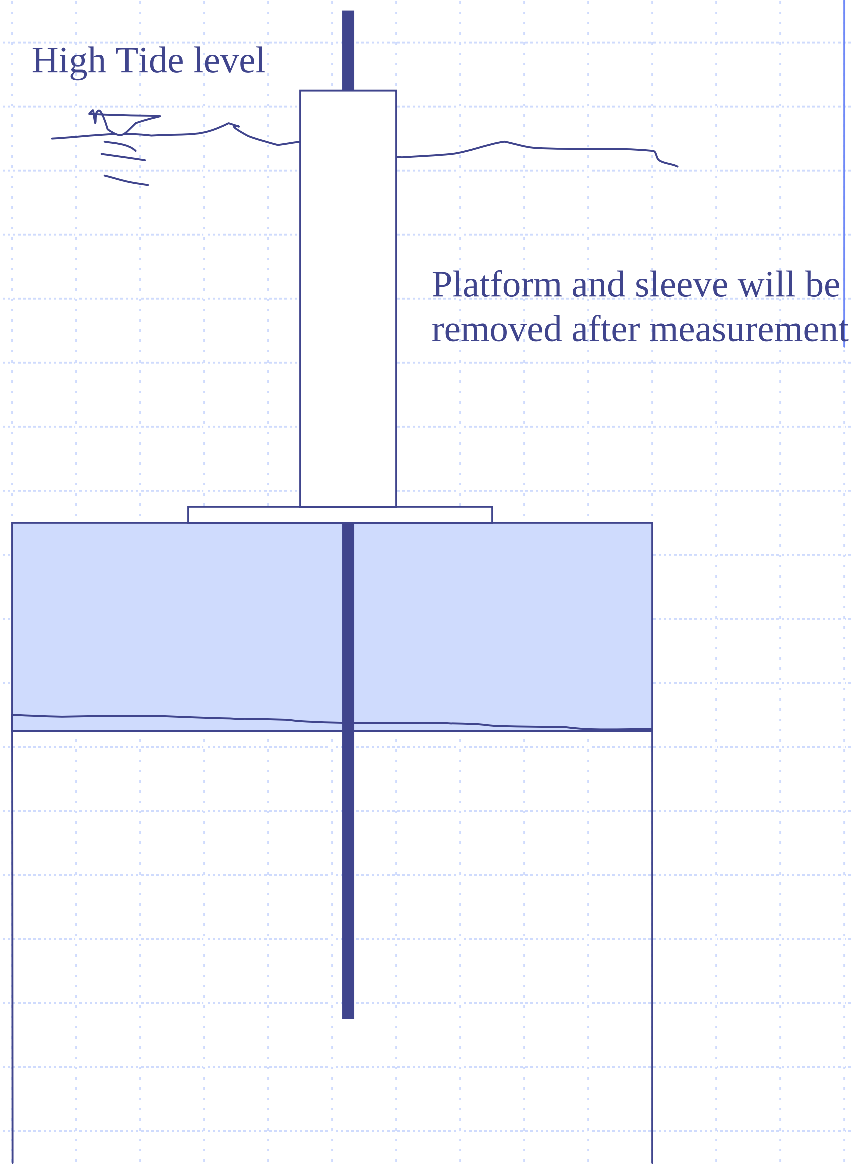


Sonar Fish

Seepage Meters



Rod 1 - Sediment Consolidation Measurement



Rod 2 – Cap Thickness Measurement

Some Lessons So Far and Points to Consider

- Information Transfer to Stakeholders
- Site Selection/Characterization
- Technologies/Treatability Testing
- Permits/Approvals – DC EHA, USACE, NPS, GSA, Coast Guard, etc.
- Contracting/Subcontractors – Characterization, Placement, Monitoring
- Staging Area - GSA
- Characterization/Construction/Monitoring Documents
- www.hsrc-ssw.org/anacostia/

Thank You

Questions?

- Each sampling event
  - Water, biological sampling inclinometer, piezometer
  - Surficial sediment (sand) collection - PCBs, PAHs, metals
  - Cores - 3 cores per cap material for visual observation photograph and record, measure layers, physical measurements (Eh, Ph probe), grain size distribution
  - 3 cores for low resolution chemical measurements
    - Upper 3 inches provide sample of surficial sediments
    - Active layers - PCBs, PAHs, metals+porewater
    - Underlying sediment - upper 2-3 inches for PCBs, PAHs, metals + porewater
  - 3 cores (duplicates of above) for high res chem measure at LSU
  - 3 cores (duplicates) of Coke Breeze to CMU, 3 cores (duplicates) of apatite to UNH
  - Other - LSU will evaluate porewater peepers, SPMDs and other samplers)