Bottom-Sealed Aquatic Filter Barrier Technology for Controlling Suspended Sediments and Turbidity – Long Beach/LA Harbor Experience

WEDA Pacific Chapter
October 2019

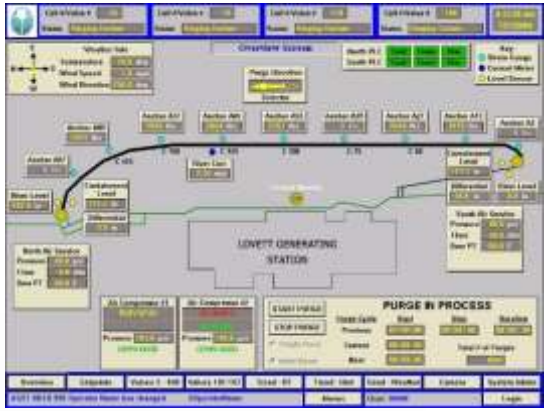
MACKWORTH-ENVIRO
Aquatic Barrier & Screening Solutions

OUTLINE

- About Mackworth-Enviro
- Bottom-Sealed FB Technology
  - Components, Design Considerations
- Silt Curtains, Sheetpile Cofferdams and Bottom-Sealed Filter Barriers
- Applications
  - Examples
  - Case Studies

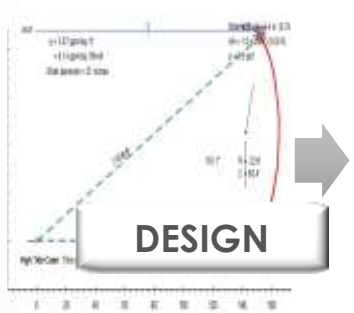


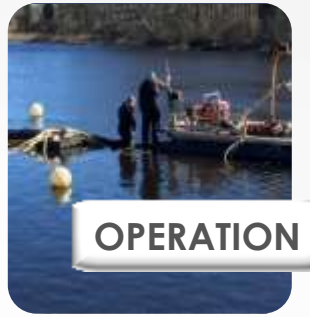


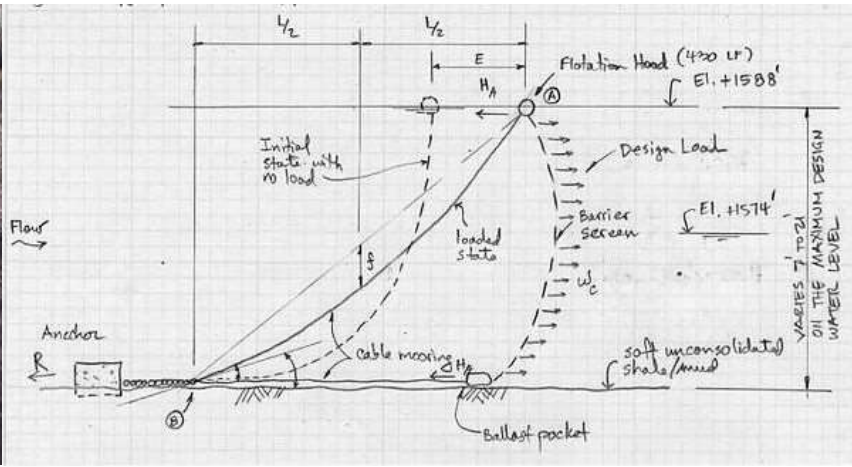



MACKWORTH-ENVIRO

- Small, highly specialized team with wide range of STEM expertise
- Uniquely focused on applications of aquatic filter barrier technology and screening







APPLICATIONS

Sealed Filter Barrier Technology Uses

- **Demolition**
- **Dredging for maintenance or remediation**
- **Protection of aquatic resources**
- **When feasible as a cofferdam alternative**
- **Leachate control**

In Addition…

- **Intake screening** to prevent intake of sediments, planktonic eggs, larvae, juveniles and adult fish or invertebrates
- **Exclusion** of fish or marine mammals from an area
- Protection of **beach** areas; **protection of water bodies from sediment, nutrients, bacteria from an inflow such as stormwater**

BARRIER TECHNOLOGY

Typically

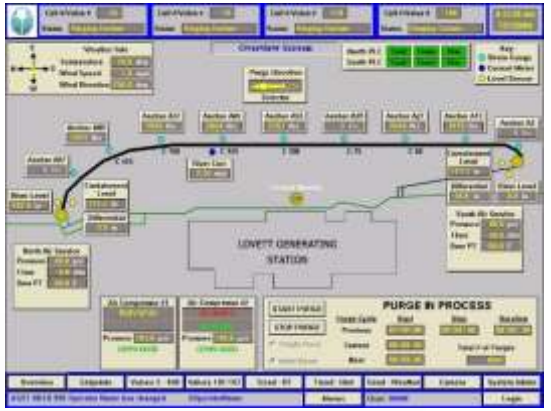
- **Flexible geotextiles** for in-waterbody filtering, containment, flow training
- **Flotation** to support barrier curtain and maintain integrity at water surface
- **Sealed at sides and bottom** to prevent unfiltered flow

For Some Applications

- Impermeable materials, various mesh sizes
- Fixed frame or structure
- Automated air-cleaning systems with feedback instrumentation



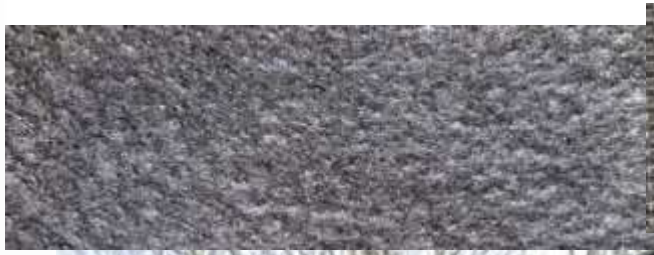


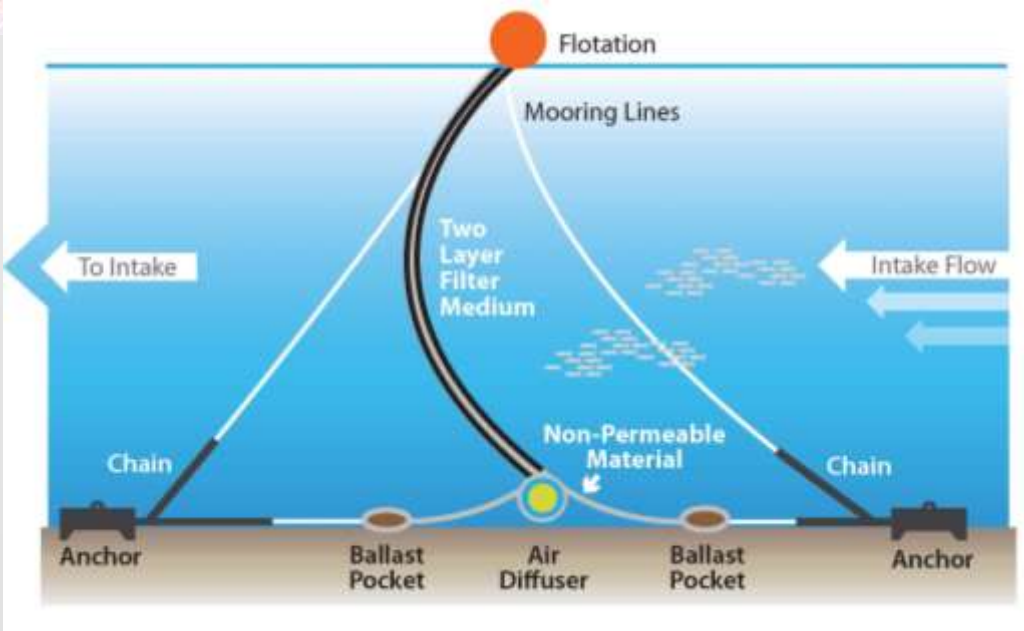
TECHNOLOGY BASICS

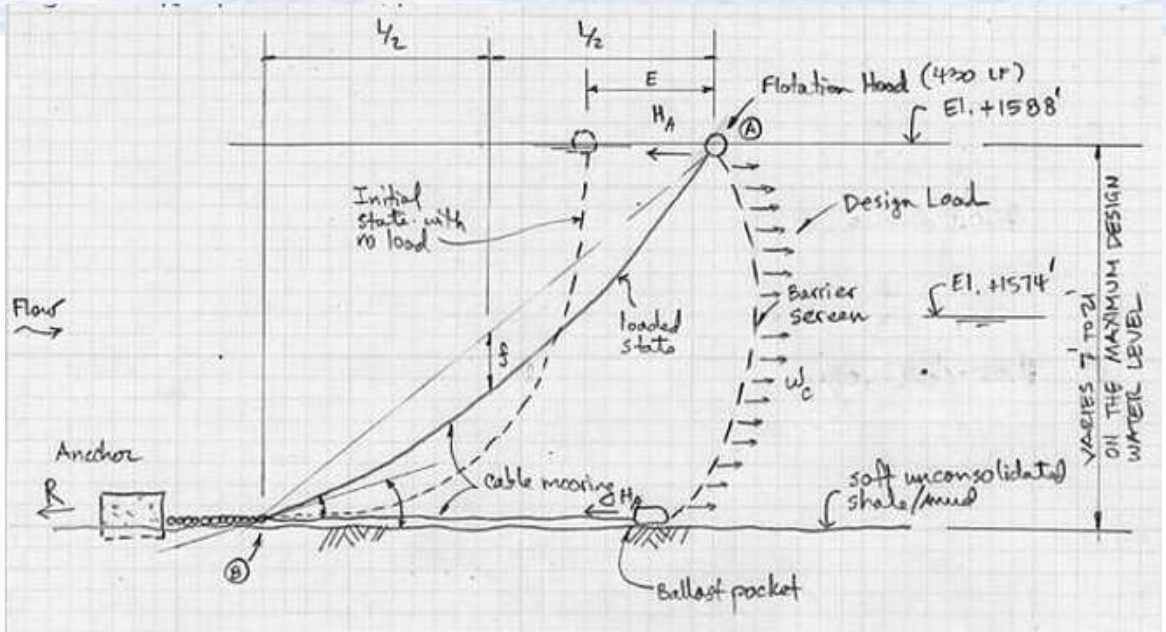
The basic structure typically includes:

- **Flotation hood** – sealed polyurethane flotation or polystyrene billets installed onsite- Design for proper buoyancy and freeboard for the application
- **Permeable, filtering geotextile medium or specialized mesh netting**. Often layered and may incorporate oil or chemical absorbent replaceable material
- **Chain ballast pocket** at bottom, possibly mid. May incorporate an extended impermeable skirt or T-skirt depending on bottom type and water flow direction(s)
- **Nylon strapping structural "skeleton".** Integrated vertical and horizontal members usually of 10,000 lb nylon strapping
- **Mooring hardware-** Integrated, sewn in D-rings or other hardware, below the hood and at the bottom for securing the barrier in place, top and bottom as appropriate



BOTTOM SEALING CREATES FULLY ENCLOSED BARRIER SYSTEM





- Seal to top of water surface with adequate flotation collar
- Seal to bottom with impermeable skirt, chain ballast and either pile supports or, anchor system. Cross-sectional configuration is important to creating an effective bottom sealing system
- Seal at ends by various design & structures.
- *An area of unfiltered flow will flow an order of magnitude greater than through the curtain diminishing the value of a filtering curtain.*

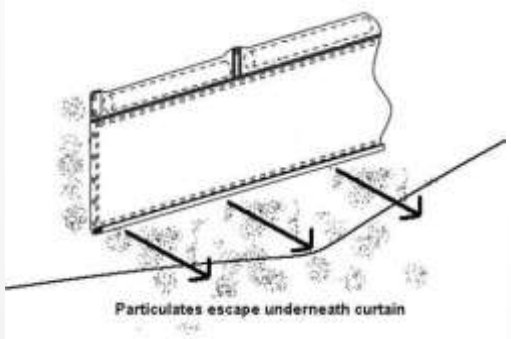
LOADING EFFECTS ON BOTTOM-SEALING BARRIERS VS SILT CURTAINS – WATER MOVEMENT CREATES:

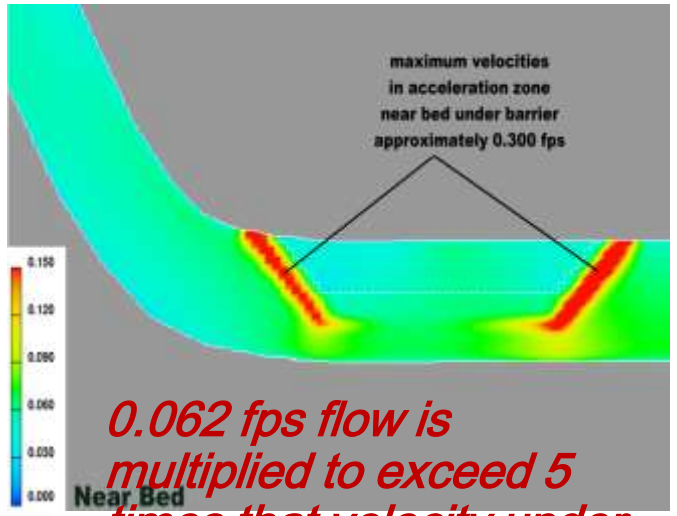
FOR BOTTOM-SEALING FILTER BARRIERS

- Sediments above the apparent opening size of the geotextile are retained within the enclosed area. Also, More time for fines to settle
- With a full-sealing system all water passes through the geotextile fabric. No unfiltered flow
- The resistance to flow creates a large, calculable load which must be accommodated by the anchoring system and the structural strength of the barrier

FOR SILT CURTAINS

- Under low flow, suspended sediments pass out under the bottom of the curtain
- Water that passes by or exits the area enclosed by the curtain moves at a notably higher velocity higher volume in smaller open area
- Also, the curtain lifts with the flow due to the loading





0.062 fps flow is multiplied to exceed 5 times that velocity under the barrier

SILT CURTAIN EFFECTIVENESS - VELOCITY AND LOADING

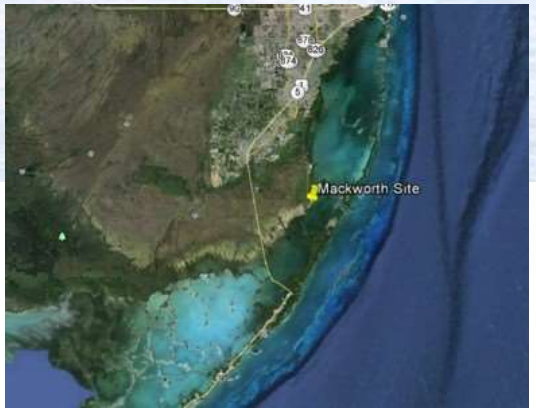
Tidal Creek Creation Mitigation Project in the Florida Everglades

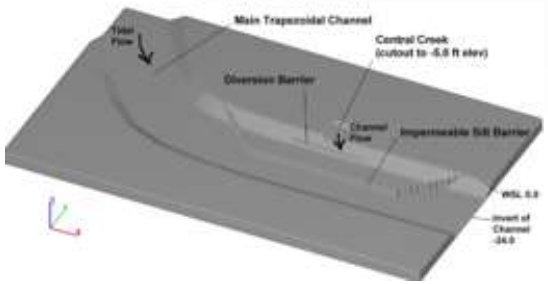
- Extreme Turbidity Limitation -29 NTU's within 30 ft and <1 NTU at Canal Mouth into Biscayne Bay, FL
- 3 Barrier System:
  - Diversion Barrier to blunt the flow
  - Filter Barrier to settle and filter out larger particles causing turbidity and to reduce and diffuse fine (clay) particles
  - Outermost Silt curtain, off the bottom, to allow greater time for particle settlement plus diffusion

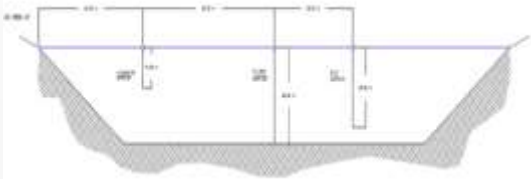
Question –

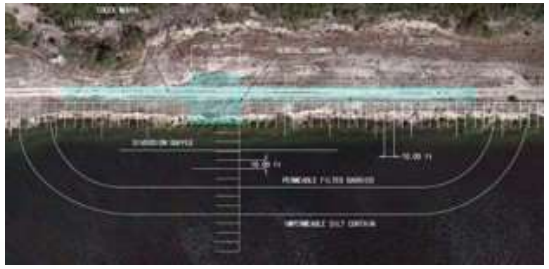
What is Velocity of Water under the Silt Curtain?

What is the load on the silt curtain from tidal water flow?









SILT CURTAIN EFFECTIVENESS – SILT CURTAIN VELOCITY AND LOADING - 2

As the gap between the bottom of a silt curtain increases, as would be expected, the velocity near the bed decreases ultimately until current velocities approach normal velocities.

Silt Curtain depth below surface (ft)	Gap beneath silt curtain (ft)	Flow Speed magnification factor	Maximum Vertical speed (ft/sec)
20	4	4.8	0.075
15	9	2.0	0.015
10	14	1.1	0.003

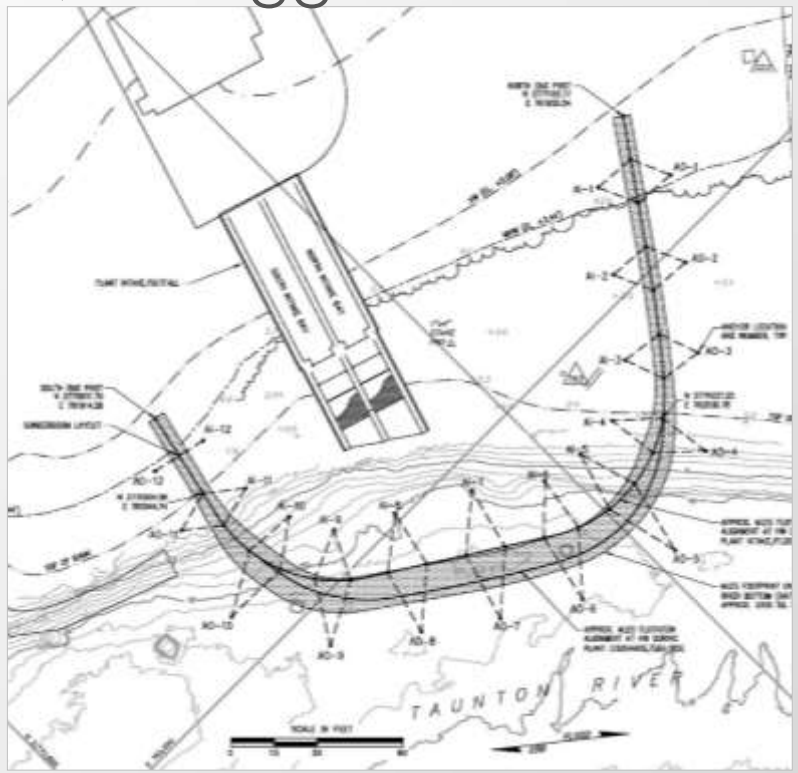
But, of course, greater amounts of the water column are open to the direct release of materials from the demolition.

DESIGN SIZING ASPECTS

- Large surface area has high resistance to flow yielding low Flux (flow/unit area) creating greater opportunity for Settling and improved Filtration
- Operational hydraulic head (Velocity and Permittivity) determines loading per unit area
- Loading on barrier determines required strength, anchoring and buoyancy requirements
- Normal to Water Currents least effective and greatest load
- Deeper = > load per linear ft

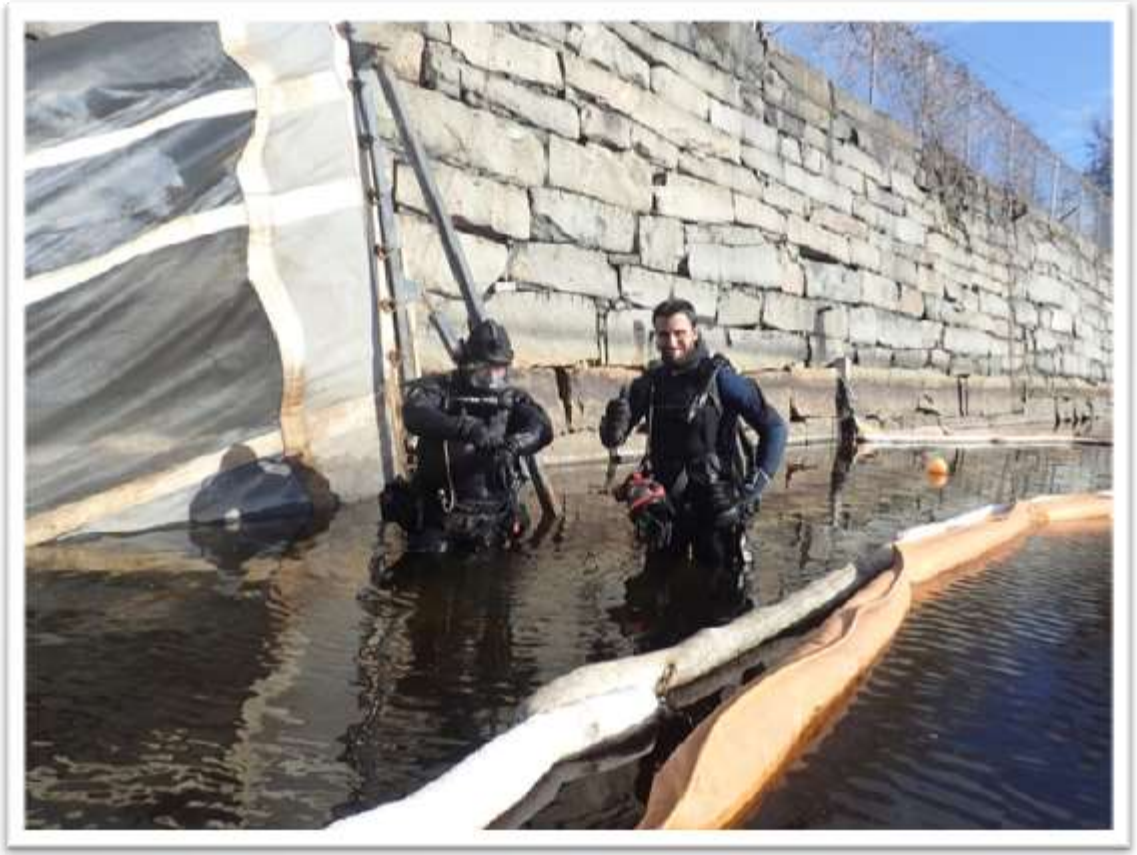
OTHER APPLICATIONS – (ASIDE FROM TEMPORARY SEDIMENT CONTROL)

Taunton River Desalination Plant
Marine Life Exclusion System – Fish, incl Eggs & Larvae



OTHER TYPES OF APPLICATIONS

PAWTUCKET CANAL (NPS HISTORIC SITE) MGP SITE LEACHATE CONTAINMENT BARRIER



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OTHER TYPES OF APPLICATIONS

Lovett Generating Station (Gunderboom) Aquatic Life Intake Exclusion System

Design, Fabrication, Monitoring and Operation (316(b))

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OTHER TYPES OF APPLICATIONS

Astoria Generating Station
Gunderboom
Marine Life Exclusion System
Cartridge Design

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OTHER TYPES OF APPLICATIONS

Mamaroneck Beach
Beach Protection System

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OTHER TYPES OF APPLICATIONS

Kansas Lovewell Reservoir
Fish Exclusion Barrier

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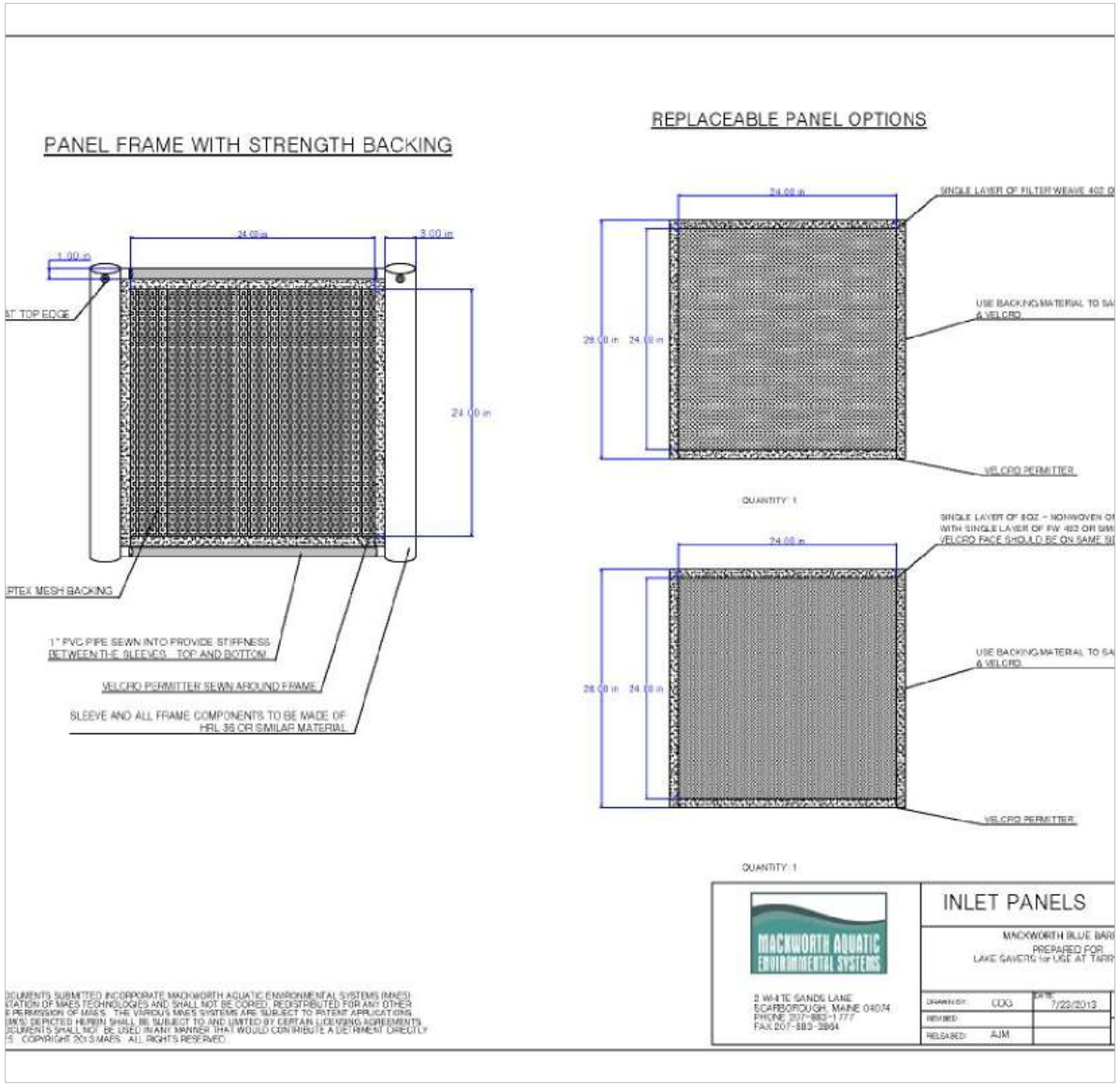
OTHER TYPES OF APPLICATIONS

Various Locations
Nutrient Reduction Barrier Systems



OTHER TYPES OF APPLICATIONS – DESIGN ONLY

ASHDOD HARBOR, ISRAEL, INTAKE PROTECTION SUSPENDED SEDIMENT BARRIER

PHASE I ALIGNMENT

DREDGING AND REMOVAL OF ALL BREAKWATERS.

AS DEPICTED. ACTUAL QUANTITY AND LENGTH MAY VARY.

1. SOUTH BARRIER REQUIRES 13 PILES.
2. SOUTH BARRIER IS 420 m IN LENGTH.
3. NORTH BARRIER REQUIRES 13 PILES.
4. NORTH BARRIER IS 420 m IN LENGTH.

PHASE II ALIGNMENT

APPROXIMATE LOCATION OF TURBIDITY BARRIERS SHOWN. ACTUAL USE AND LOCATION TO BE DETERMINED BY CONTRACTOR. MULTIPLE ALIGNMENTS SHOWN HOWEVER ALIGNMENTS MAY BE ACCOMPLISHED WITH A SINGLE BARRIER WHICH MOVES WITH THE PILE DRIVING OPERATION.

1. MOBILE BARRIER MAY BE ANCHORED WITH STANDARD FLUKE STYLE ANCHORS.

PHASE III ALIGNMENT

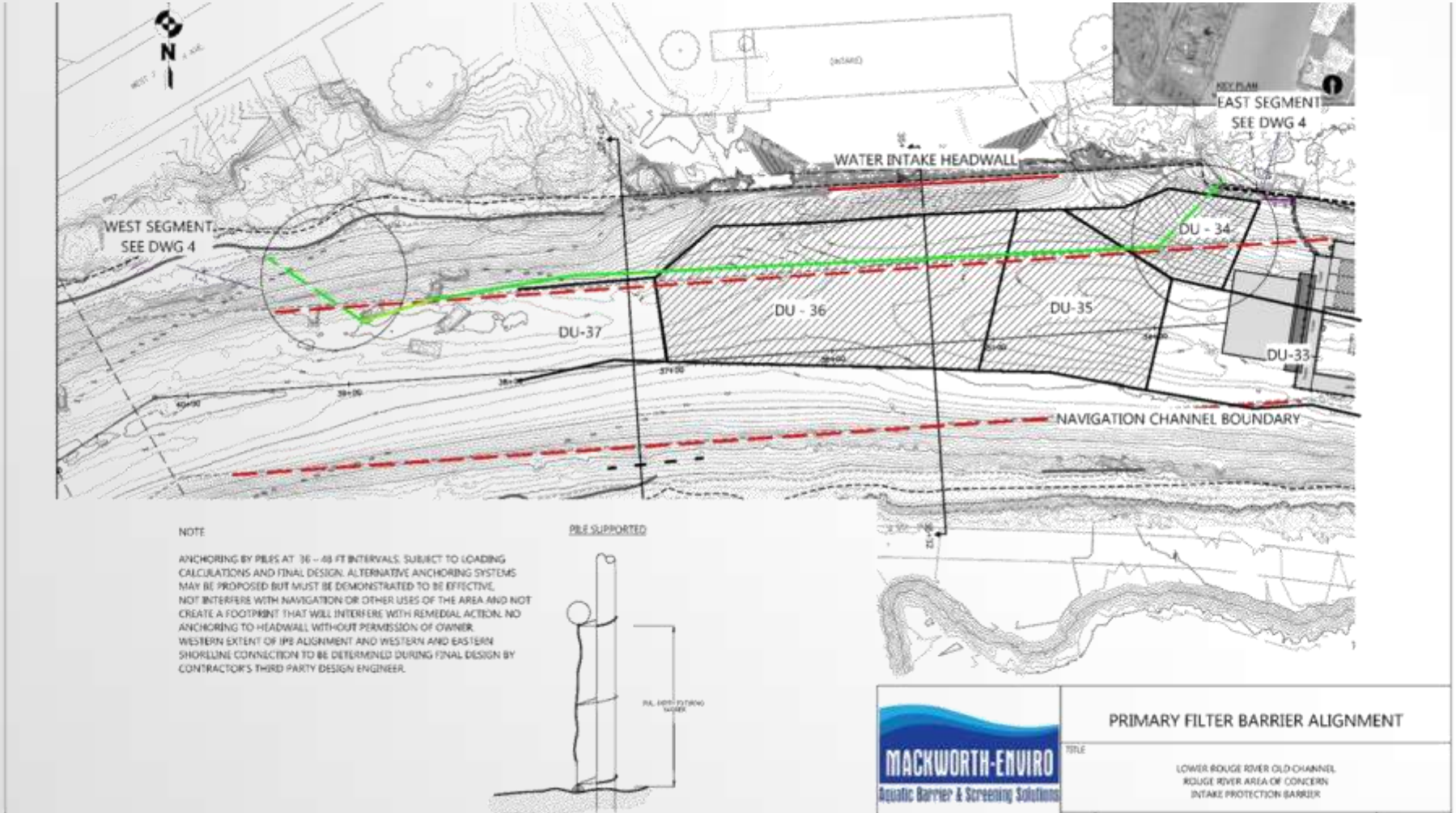
DREDGING IN AREAS IN CLOSE PROXIMITY TO INTAKES.

ASSUMES ALL BREAKWATERS HAVE BEEN REMOVED. DREDGING BARRIER DESIGNED TO BE MOBILE AND MOVE TO CONTAIN TURBIDITY AROUND DREDGE UNIT. MULTIPLE ALIGNMENTS DEPICTED HOWEVER A SINGLE BARRIER MAY BE USED TO ENCLOSE THE DREDGE IN ITS GIVEN LOCATION.

OPERATION OF INTAKES MAY BE REQUIRED TO BE ADJUSTED DURING CLOSE PROXIMAL DREDGING.

OTHER TYPES OF APPLICATIONS – DESIGN ONLY

LOWER ROUGE RIVER REMEDIATION INTAKE PROTECTION SEDIMENT BARRIER



ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – SE FLORIDA

Design Process

- Concept development through final
- Use existing limited bathymetric data, water current Information, and lack of survey data on adjacent structure
- Assume no obstructions to bottom seal

Design Aspects

- Single layer barrier based on:
  - projected maximum currents,
  - limited obstacles, and
  - demolition duration
- Sorbent boom for sheen
- Anchored to trestle piles and RR bridge piers
- Recommended separate barrier systems for each of 3 bridge piers

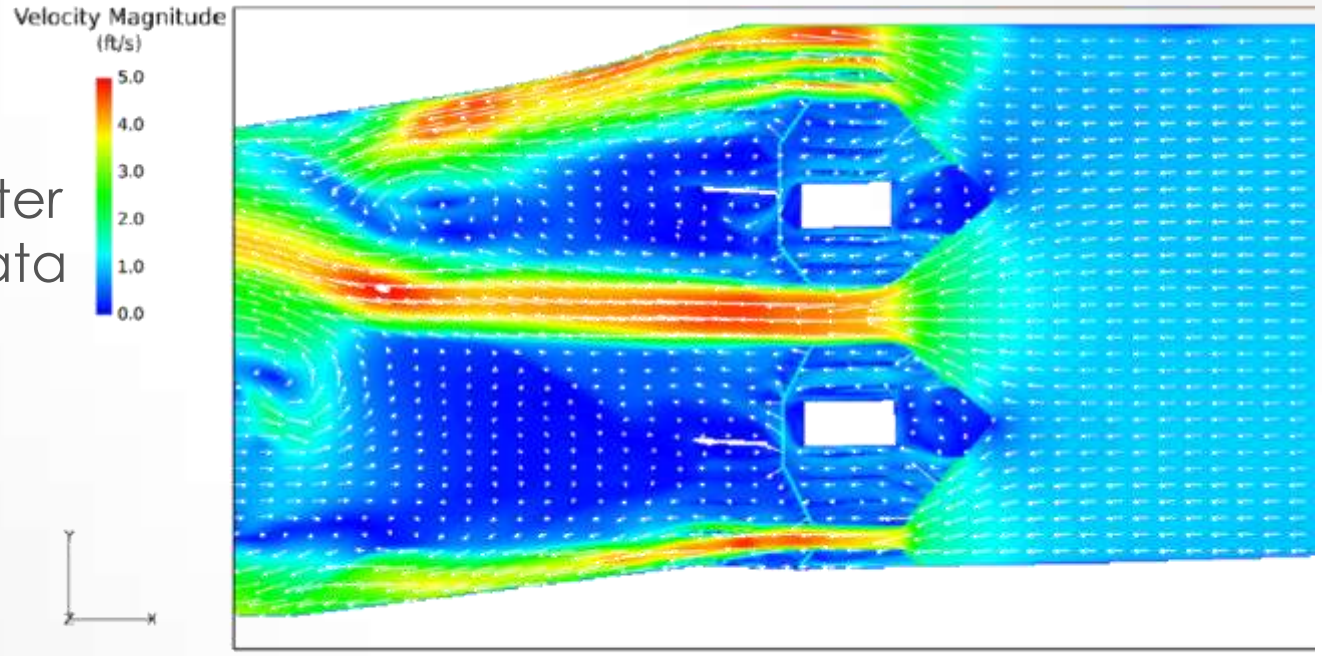
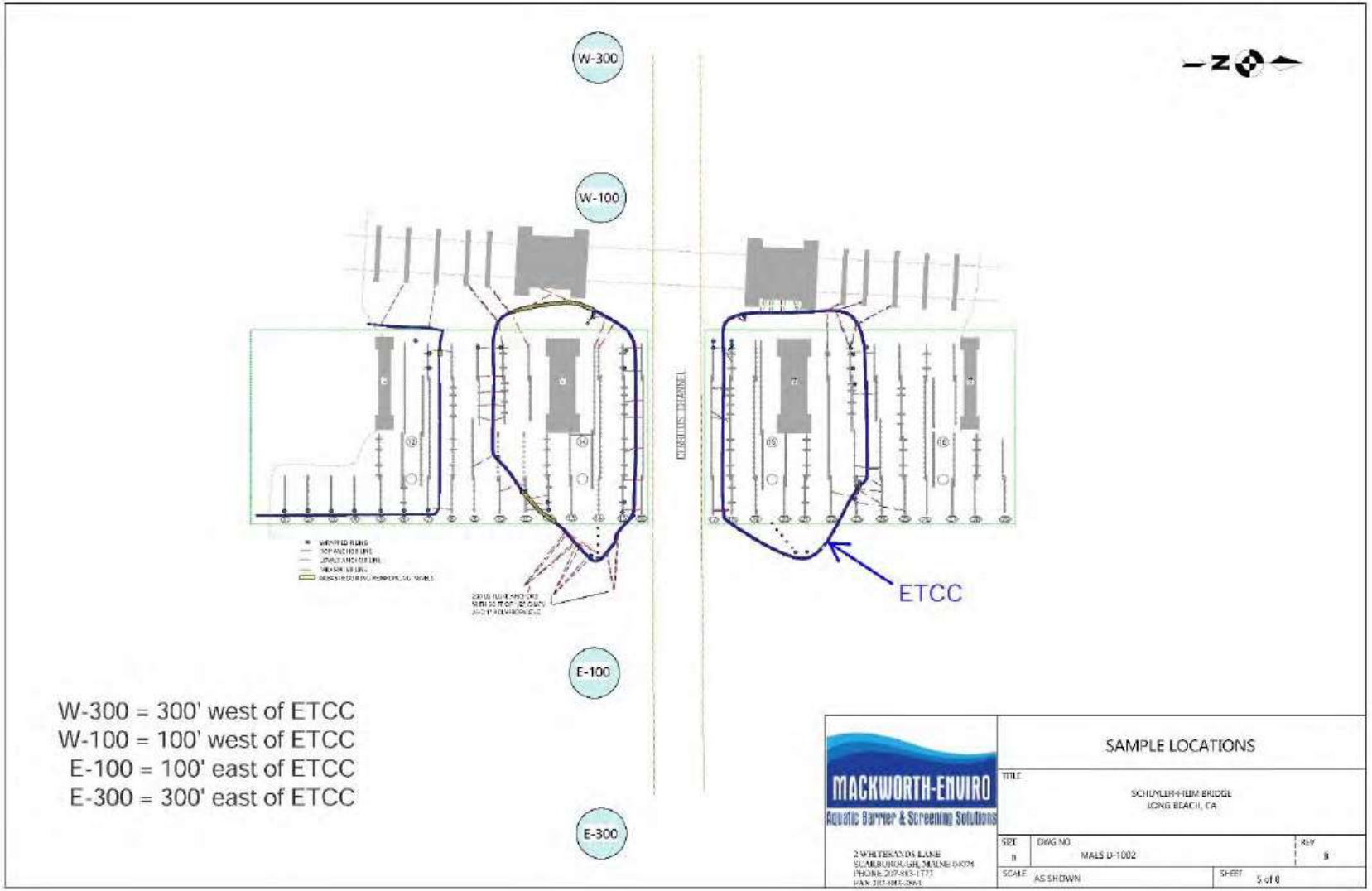


Figure A - 12. **Incoming Tide, 45 degree ETB apex alternative, near the top of the water column.**

ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – LONG BEACH



ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – LONG BEACH

- **CalTrans Project**
  - Construction PM contracted Mackworth-Enviro until demolition subcontractor involved
- **Sought Alternative to Cofferdam**
  - Cofferdam determined to be infeasible for enclosure of demolition releases during deconstruction of concrete piers
  - CalTrans and Construction PM originally thought that impermeable silt curtains, above the bottom, or possibly to the bottom, would meet requirements
- **Urgency & Limited Design Information**
  - New construction underway, demolition of old bridge superstructure nearing completion
  - Included requirement for approval by So Cal Water Board

ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – LONG BEACH

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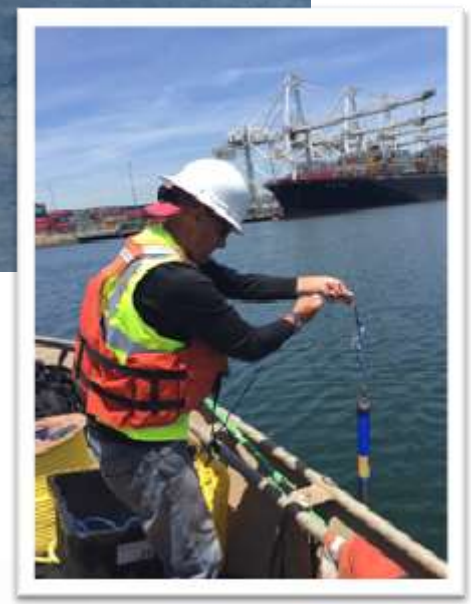
ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – LONG BEACH

O&M

- Monthly Site Visits
  - Inspections and diver interface
  - Implementation of adjustments and repairs
  - Significant and frequent curtain movement with "random" shifts due to location
- Address New Conditions
  - Pre-existing underwater debris and new driving of additional piles created damage
- Additionally, Mackworth-Enviro:
  - Prepared the Turbidity Control Plan and Water Quality Monitoring Program
  - Conducted the Water Quality Sampling Program



WATER QUALITY OBJECTIVES

WATER QUALITY MONITORING PLAN

- Test upstream of project (100 meters)
- Test downstream of project (100 meters & 300 meters)
- At each location test: near surface, mid-water, at bottom

WATER QUALITY OBJECTIVES

- Turbidity – 30% or less change
- Temperature – 5 degrees or less change
- pH – between 6.5 to 8.5 and 0.5 units or less change
- Dissolved Oxygen – 6.0 mg/L or more
- Total Suspended Solids

INSPECTION PROCEDURES

- Visual Observations
  - Turbidity, Discoloration, Visible Films or Materials, Odors, Depression of Dissolved Oxygen
- Sampling Equipment
  - Multiparameter Meter(DO, pH, Temp, salinity)
  - Turbidimeter – Hach 2100Q
  - Dissolved Oxygen Meter – Extech D0210
  - Water Samplers – Van Dorn horizontal samplers, bottled and sent to lab

CHALLENGES

- Direction of current flow
  - Changed mid-day and with tides
- Boat traffic
- Stormwater discharges

CHALLENGES

- Overtopping
- Pier substructure

HIGH TIDES AND NON-STRUCTURAL PILINGS

EFFECTIVE CONTAINMENT OF ALL POLLUTANTS

ENCLOSED TURBIDITY CONTROL CURTAIN COFFERDAM ALTERNATIVE – LONG BEACH

Performance

- **NO Exceedances attributable to operations**
- Pre-existing underwater debris and new driving of additional piles created damage
- Project extended to two years from 6 months with Demo contractor fired

Lessons (Re-?)Learned

- If no time in schedule for full pre-op data acquisition, conduct post-design verification of assumptions, including:
  - survey of planned alignments,
  - water current velocity checks, and
- Research potential risks associated with modified operations
  - extension of deployment duration
  - addition of piles
- Measure risk of reduced robustness in fabrication based on project design assumptions

AND,
IN CONCLUSION

1. ***Turbidity curtains can be engineered to be effective cofferdam alternatives in some circumstances.***
2. Bottom-sealed barrier curtain designs are the only ones that will actually contain suspended sediments or contaminants if there is any water movement or water level fluctuations.
3. Effective designs can be developed and implemented for many different situations, even if they have not been previously employed.
4. Important to know currents, water level fluctuation, bottom characteristics along alignment, and ***account for potential condition changes during the implementation*** of the project.
5. Insufficient or inaccurate data or faulty assumptions can lead to otherwise addressable design shortfalls.
6. Where schedule or other project considerations force design and fabrication to proceed on the basis of assumptions, for some situations, it is better to ***verify those assumptions while fabrication proceeds*** and to make adjustments, if needed, prior to deployment.

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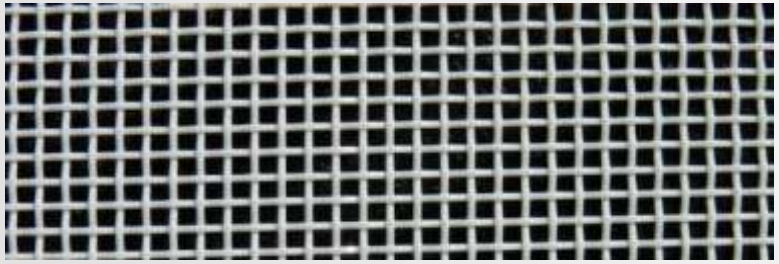
Support Personnel in Maine, Connecticut, Florida, North Carolina and California

GEOTEXTILE FILTER MEDIA

Non-woven; 0.150 mm AOS

Woven; 0.425 mm AOS



Fine Mesh Grid; 1.0 - 5.0 mm

DESIGN, FABRICATION, INSTALLATION - Example

Victoria, BC for Dock Removal and Sediment Remediation
Public Works and Government Services Canada

FABRICATION

SEWED-IN LOAD-BEARING SKELETON

SHIPPED

ASSEMBLED ON LAND OR BARGE

DEPLOYED FROM LAND OR BARGE

PILE SUPPORTED OR ANCHORED