QUALITY ASSURANCE, QUALITY CONTROL AND LONG-TERM PERFORMANCE MONITORING OF ENGINEERED CAPPING SYSTEMS PLACED OVER ENVIRONMENTALLY IMPACTED SEDIMENTS

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Presentation Overview

- Engineered Capping Systems Applicability
- Engineered Cap Design
- Cap Placement Methods
- Cap Thickness Control/Documentation
- Long-Term Monitoring

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Engineered Capping Systems Applicability

Dredge It Or Cap It?

- Physical Constraints
  - Slopes/stability
  - Infrastructure (bridge piers, pilings, etc.)
  - Active terminals
  - Pipeline crossings

Dredge It Or Cap It? (continued)

- Contaminant Type &Concentrations
  - NAPL present?
  - Organics or metals present?
  - Groundwater flux through proposed cap?
  - Concentration of contaminant?

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Dredge It Or Cap It? (continued)

- Depth of Contamination
  - Contaminant at surface or buried?
  - Is area erosional or depositional?
  - Is area subject to scour or prop wash?

Dredge It Or Cap It? (continued)

- Area Subject to Future Navigational Dredging?

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Dredge It Or Cap It? (continued)

- Potential for Uncontrollable/ Unacceptable Post-Dredge Residuals
  - Contaminant specific
  - Physical setting specific
  - Dredge contractor/dredge method specific

Dredge It Or Cap It? (continued)

- Dredged Sediment Disposal Site
  - Location and proper licensing
  - Upland landfill or CDF

Dredge It Or Cap It? (continued)

- Dredged Sediment Disposal Site (continued)
  - Stabilization requirements
  - Transportation availability
  - Public acceptance
- Long-term Monitoring Considerations

Ultimately the Decision to Dredge or Cap is Driven by Cost, Risk and Regulatory Acceptance

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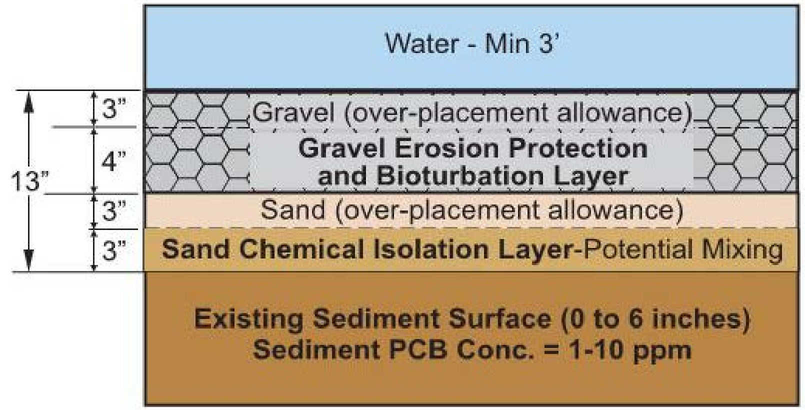
Engineered Cap Design

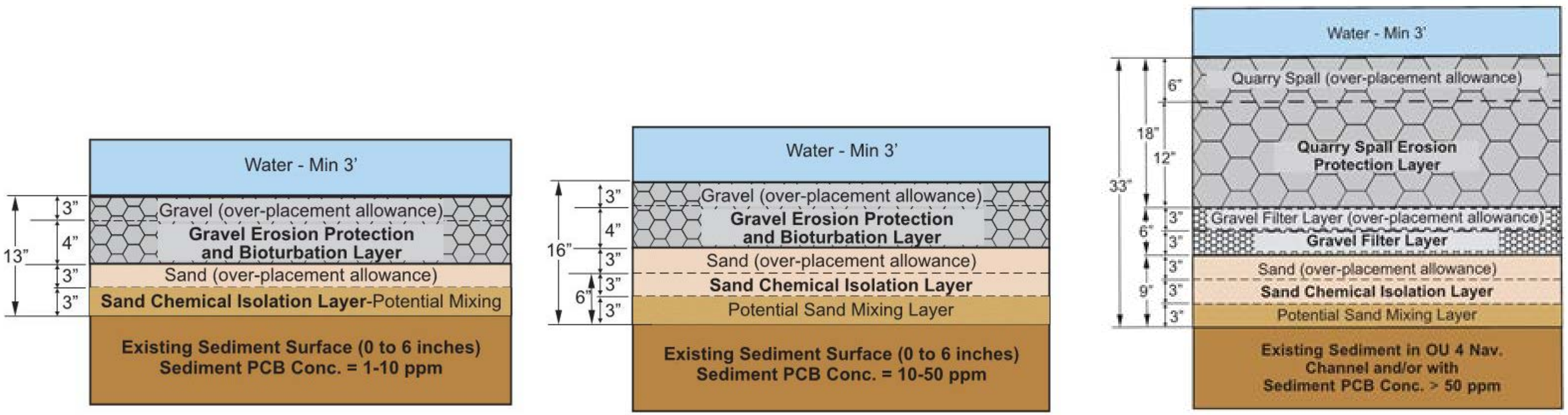
Engineered Cap Design

- Amendment to Natural Capping Materials Required?
- Natural Materials Availability
  - Chemical isolation layer (CIL)
  - Armor layer



Engineered Cap Design (continued)

- Match CIL and Armor to Site Specific Conditions



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Cap Placement Methods

Cap Placement Methods

- Mechanical
  - Excavator/with articulating bucket
  - Clam
  - Telebelt
  - Mechanical means usually best suited for large capping aggregates, very thick caps in deep (> 40 ft) water, or areas with high current

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Cap Placement Methods (continued)

- Mechanical Placement

Cap Placement Methods (continued)

- Hydraulic/Slurry System
  - Best suited for thin layered caps
  - Uniform spreading of thin layers
  - Amendments can be mixed with CIL sand and pumped great distances to spreader barge
  - Can adhere to tight overplacement tolerance

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Cap Placement Methods (continued)

- Hydraulic/Slurry System (continued)
  - Armor layer placement typically limited to maximum of 3-inch diameter armor stone.
  - CIL layer placement accuracy impacted by high current, most notably as water depth increases

Cap Placement Methods (continued)

- Hydraulic/Slurry System Placement

Cap Placement Control/Documentation

Cap Placement Thickness Control

- Specifications - Minimum Layer Thickness and Overplacement Allowance (OPA) for Each Cap Layer
- OPA - Some Percent of Minimum Thickness Requirement
- Contractors Need to Match Efficiency With OPA

Cap Placement Thickness Control (QC)

- Common Thickness Control Methods
  - Core tubes (for sand/CIL layers)
  - Catch pans for armor stone

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Cap Placement Thickness Control (QC) (continued)

- Common Thickness Control Methods (continued)
  - Spread time calibrated to visual thickness determinations (hydraulic)
  - Pre- and post- placement bathymetry
  - Material stockpile surveys (pre- and post-placement)

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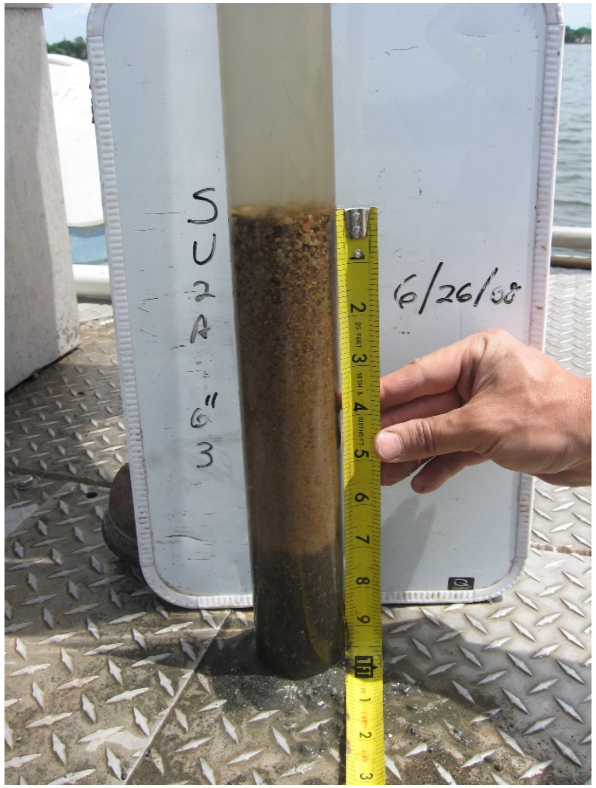
Cap Placement Documentation (QA)

- Placement Documentation Performed by Contractor, Owners Engineer or Agency Oversight Contractor
  - Core tubes (for sand/CIL layers)
  - Catch pans/buckets for armor stone
  - Pre- and post- placement bathymetry

Cap Placement Documentation (QA) (continued)

Fox River
Engineered Cap Design



Cap Placement Documentation (QA) (continued)

- Compensation for Consolidation of Soft Subgrade During and Following Cap Placement
  - Ties back to design of cap (filter design)
  - Core tubes and catch pans
  - Bathymetric survey
  - Settlement plates

Cap Placement Documentation (QA) (continued)

Table 2. Estimated Consolidation in 2007 Cap Placement Test Areas (Differences in Poling Surveys)

2008 Location	Post-armor 2007 (Sept. – Oct., 2007)				Post-armor 2008 (Nov. 3, 2008)				Post-armor 2009 (April 15, 2009)		
	Measured[1]		2007 Model[2]		Measured[1]		2007 Model[2]		Measured[1]		2007 Model[2]
	(days)	(in)	(in)		(days)	(in)	(in)		(days)	(in)	(in)
CCU-1A-1-2008	57.7	12.5	12.2		420	14.9	12.2		583	16.2	12.2
CCU-1A-2-2008	57.5	9.1	9.2		419	11.3	11.3		582	10.7	11.3
CCU-1B-1-2008	55.5	7.3	6.1		417	10.2	6.1		580	8.3	6.1
CCU-1B-2-2008	55.4	5.3	7.4		417	12.1	7.4		580	7.7	7.5
CCU-2-1-2008	35.3	2.9	7.4		397	7.6	16.0		560	6.2	16.0
CCU-2-2-2008	32.6	5.6	7.6		395	9.0	12.7		558	10.6	12.7
CCU-2-3-2008	34.7	4.6	6.0		397	7.2	13.0		560	7.1	13.0
CCU-2-4-2008	34.5	1.8	4.8		396	3.5	7.0		559	2.5	7.0
Average		**6.1**	**7.6**			**9.5**	**10.7**			**8.7**	**10.7**

1. Top of sediment, pre-cap elevations at 2007 locations, interpreted from Brennan 2007 pre-placement hydrographic surveys. Consolidation estimate found from difference of applied thickness at 2007 catch pan locations and measured change in elevation. Times (days) are presented from date of initial sand placement.
2. Empirical time-rate-of-consolidation model, as presented in Appendix C, of *Lower Fox River Operable Unit 1, Final OU1 Cap Design* (Foth and CH2M HILL, 2008).

Cap Placement Documentation (QA) (continued)

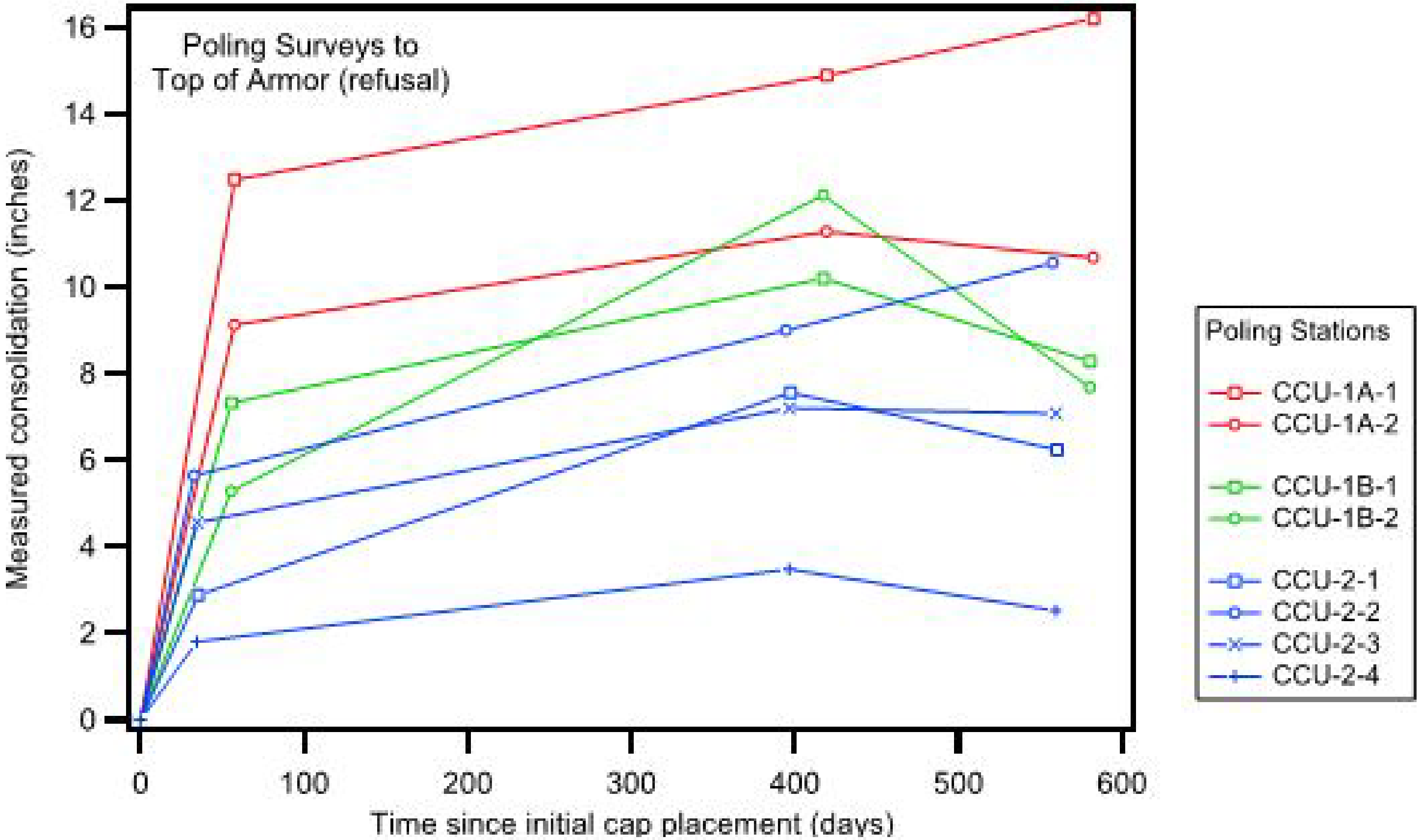


Figure 6. Cap Consolidation Trends.

Long-Term Monitoring

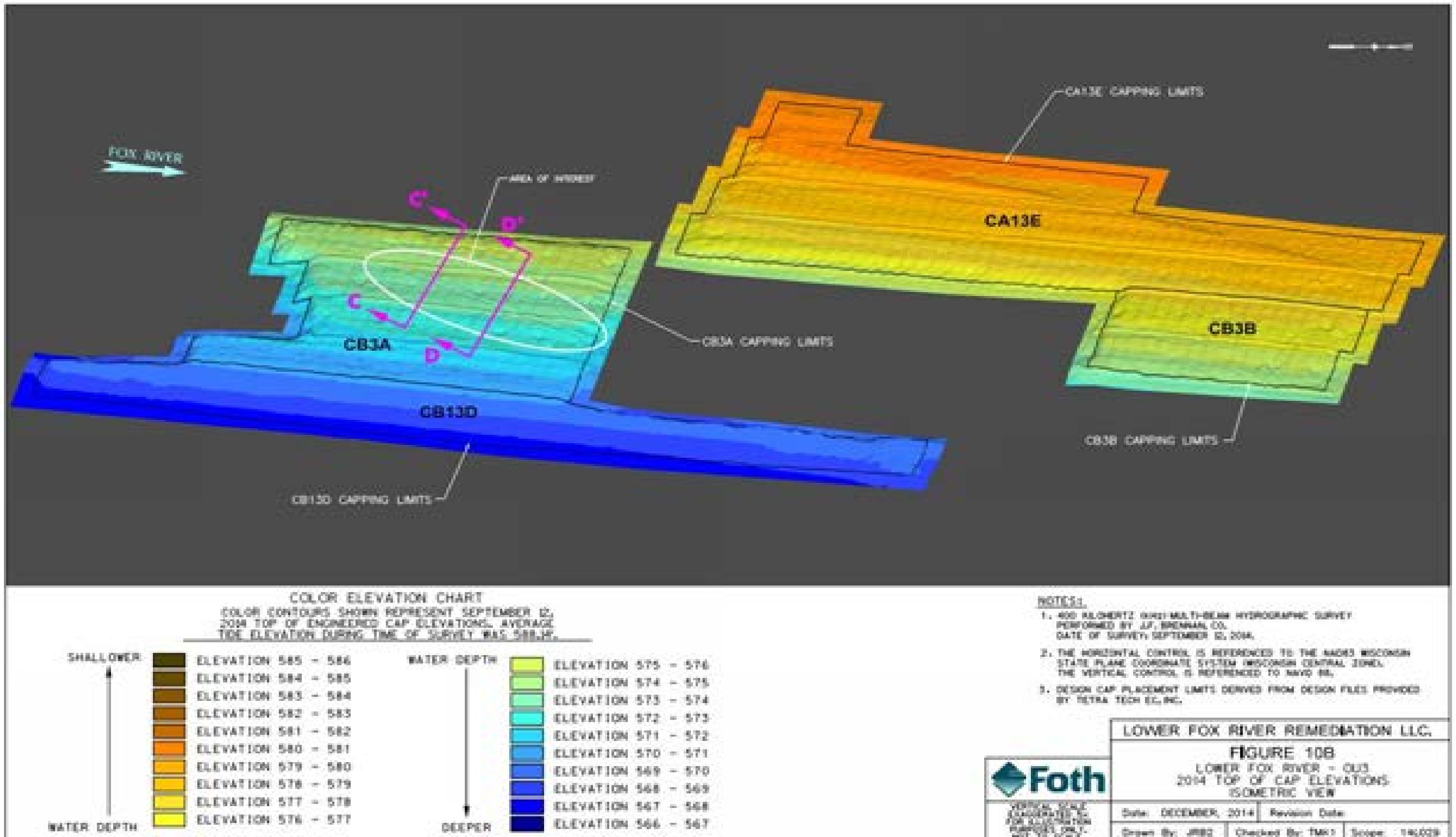
Long-Term Monitoring

- Cap Long-Term Monitoring and Maintenance Plans
  - Routine monitoring frequency - often more frequent up front then relaxed (plus flow event special monitoring)
  - Bathymetry to assess changes in cap elevation over time

Long-Term Monitoring (continued)

- Focus on bathymetry comparison to assess if damage or erosion of armor layer has occurred
- Typically involves verification that armor layer is still present (geophysical means)
- Typically requires repairs of damaged or missing cap materials

Long-Term Monitoring (continued)



Long-Term Monitoring (continued)

- May include sampling of CIL material and/or porewater in the CIL to verify CIL is functioning as designed

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