Innovative NAPL Characterization Methods to Select In-Situ Stabilization Target Areas for Gowanus Canal

2019 Battelle Sediment Conference

February 2019

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Agenda

1. Gowanus Canal Overview
   – ROD Requirements for mobile NAPL areas
2. NAPL Mobility Characterization in Upper Canal
   – Saturation
   – Mobility
3. NAPL mobility assessment
4. Mobility Correlation to TarGOST Response
5. Selection of In Situ Sediment Stabilization Areas
Acknowledgements

• U.S. EPA

• Potential Responsible Parties and their consultants/suppliers
  – Geosyntec
    • Figures are adapted from submittals to EPA
  – Dakota Technologies
Gowanus Canal Superfund Site

- 1.8 mile long canal in Brooklyn, New York City
- Constructed in 1860s
- Primary Constituent of Concern Sources
  - Three MPG plants
  - Many historic waterfront industries
  - Two major combined sewer overflows
- Designated a Superfund Site in 2010, ROD 2013
- Currently in Remedial Design for Upper Canal
Gowanus Canal Impacts
EPA Record of Decision Issued September 30, 2013

• Selected Remedy Summary
  – Soft sediment removal
  – In situ sediment stabilization of native sediment containing mobile NAPL
  – Treatment Cap
    • Oleophilic clay mix
    • Carbon mix
    • Armor
NAPL Mobile Layer Identification

• For NAPL to be hydraulically mobile to the sediment surface
  – NAPL saturation above residual
  – Upward hydraulic force (for DNAPLs)
  – Proximity to the sediment surface

• How was the NAPL architecture in native sediment be characterized?

Figure adapted from EPA Ground Water Issue, 2009
NAPL Mobility to Field Measurement

NAPL Mobility

- Direct tests of NAPL hydraulic mobility
- Post-test analysis of NAPL pore fluid saturation
- Cannot be measure directly in field

Pore Fluid Saturation

- NAPL mobility thresholds based on saturation
- Cannot be measure directly in field

TarGOST Response

- Can be measure directly in field
TarGOST use in Upper Canal

67 TarGOST locations
But TarGOST does not directly measure mobility, so how can the response be correlated?
Data Collection for Mobile NAPL Determination

Pore Fluid Saturation
- Seven sediment cores
  - UV Photography
  - 149 pore fluid saturation tests
  - Frozen Core LIF on 144 core slices

Mobility Tests
- 9 water drive
- 9 centrifuge
- 28 controlled gradient
- 20 controlled flux mobility tests
NAPL Saturation Threshold for Mobility
NAPL Saturation Threshold for Mobility

- Four different NAPL mobility tests were performed
- A total of 18 samples demonstrated NAPL mobility (out of 66)
- Each test has its advantages and disadvantages
- EPA selected 20 percent pore fluid saturation as the threshold for NAPL mobility considering all the data
TarGOST Frozen Core Analysis Method

Provides:
- TarGOST (or UVOST) measurements ex situ
- Average measurement core face
- Core is preserved for additional analysis

Removes:
- Variability of using adjacent borings

Allows:
- Better correlations between TarGOST output and pore fluid saturations
Gowanus Data Sets Allow Confidence Interval Calculations

- 144 data points
- Correlation of 0.5
- Upper and lower confidence limits calculated

- EPA considered all the data and selected 244 %RE response to represent the migration threshold of 20 percent NAPL saturation

MGP 2017
TarGOST Reference Emitter Threshold Exceedances

The threshold %RE of 244 percent (20 percent pore fluid) compared to TarGOST logs showed:

- 40 of the total 67 polygons exceeded within 10 feet of dredge line
- Threshold exceedances were further evaluated:
  - Thickness above
  - Proximity to dredge line
- A Volume Accommodation Model was proposed by the Potential Responsible Parties to account for these factors
Potential Migrating Layer Characteristics

- Potential migrating layers were analyzed for all 40 borings with threshold exceedance.
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- Potential migrating layers were analyzed for all 40 borings with threshold exceedance
  - Some were thin but near the dredge line
  - Some were thicker but further from the dredge line
  - Some were more saturated but further from the dredge line
NAPL Volume Accommodation Model
NAPL Volume Accommodation Model

- Convert RE response to NAPL saturation
NAPL Volume Accommodation Model

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- Area of concern 10 feet below dredge line
NAPL Volume Accommodation Model

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- Area of concern 10 feet below dredge line
- Potential migrating layer identified

Potential migrating layer
1.97 feet thick
30% maximum saturation
NAPL Volume Accommodation Model

- Convert RE response to NAPL saturation
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- Overlying sediment NAPL impact characterized
NAPL Volume Accommodation Model

- Convert RE response to NAPL saturation
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- Overlying sediment NAPL impact characterized
- Analyze NAPL impact for “accommodation”
Uncertainties - DNAPL Architecture and Boring Data

Model assumes overall NAPL architecture is represented by the TarGOST boring

In nature, NAPL distribution is not that simple and very nonuniform

How do we account for the layers off the 1-d flow path in a sensitivity analysis?

Migration Layer Sensitivity Analysis—Characteristics of Migrating Layers

Thickness of Migrating Layer ($Z_{ML}$)

- 1.7 feet
- 1.0 feet

PFS in Migrating Layer ($PFS_{ML}$)

- 45%
- 30%

PFS = pore fluid saturation

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Sensitivity Analysis Review on TarGOST Logs

Locations reevaluated with adjusted migrating layer thickness and DNAPL saturation using:

- Upper confidence limit values
- Maximum values

Not all migrating layers “fit” into profile, and some were excluded
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Not all migrating layers "fit" into profile, and some were excluded
40 threshold exceedance out of 67 total

10 identified migrating without sensitivity

26 migrating with sensitivity
EPA Selected ISS Sections

• EPA reviewed and decided for ISS to be applied as shown
• The decision took into account:
  – Migrating layer analysis
  – Proximity of migrating layers to other impacts
  – Potential effect on groundwater discharge
Conclusions

• Key data analyses were:
  – Establish a NAPL residual mobility saturation
  – Correlate TarGOST to NAPL saturations
    • TarGOST analysis of ex situ cores is a significant improvement
  – Use TarGOST response to establish mobile NAPL areas

• The volume accommodation model was useful since it accounted for:
  – Thickness above saturation
  – Proximity to dredge line
Thank you!