

Evaluating LNAPL Mobility and Transmissivity: A Route to Closure

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April 11, 2018

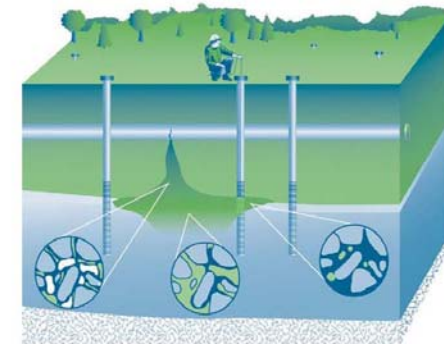
Presentation Overview

- Basic concepts of LNAPL distribution and recoverability
- Case Study:
 - Site background and remedial history
 - Regulatory requirements
 - Project objectives
 - LNAPL mobility study
 - Results



Technical/Regulatory Guidance

Evaluating LNAPL Remedial Technologies
for Achieving Project Goals



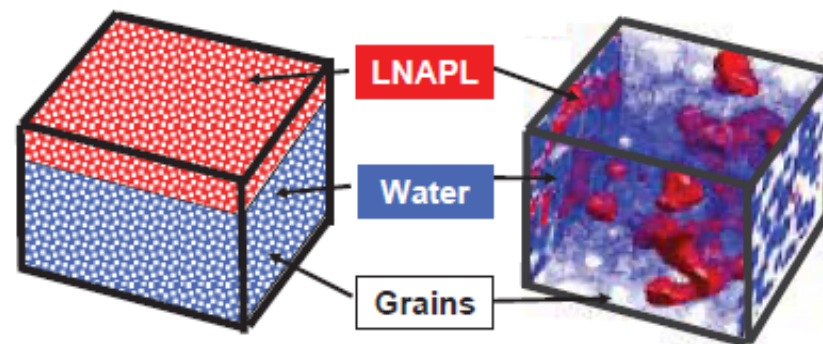
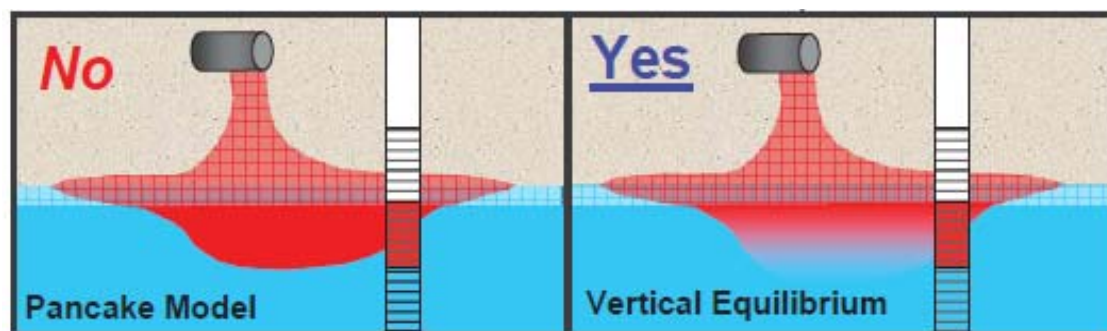
December 2009

Prepared by
The Interstate Technology & Regulatory Council
LNAPLs Team

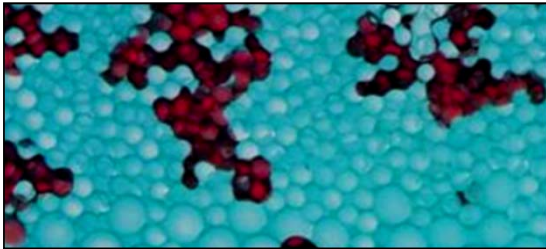
Some Common LNAPL Misconceptions

- LNAPL floats on groundwater and doesn't penetrate water surface
- All LNAPL is mobile
- LNAPL occurrence in a monitoring well means that it is recoverable and/or migrating
- LNAPL completely saturates soil pores
- Changes in LNAPL thickness are indicative of remediation performance

Pancake Model vs. Vertical Equilibrium

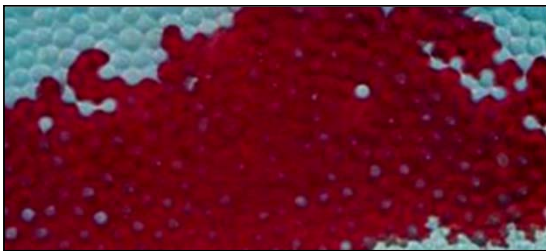


LNAPL Saturation in Subsurface



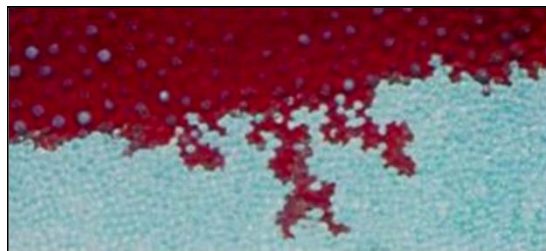
Residual LNAPL

- Small, disconnected droplets and ganglia
- Immobile
- Does not flow into well



Mobile LNAPL

- Any saturation exceeding residual
- Connected pore spaces
- Does not migrate unless significant driving force



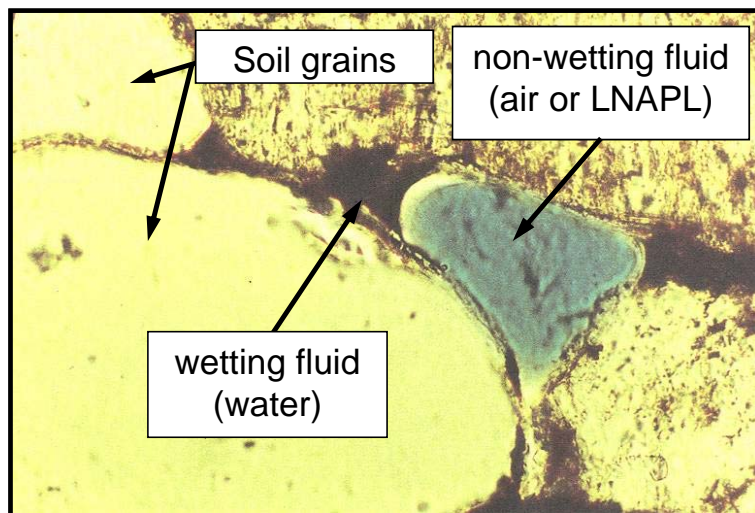
Migrating LNAPL

- An LNAPL body that is observed to spread or expand laterally or vertically or otherwise result in an increased volume of the LNAPL extent

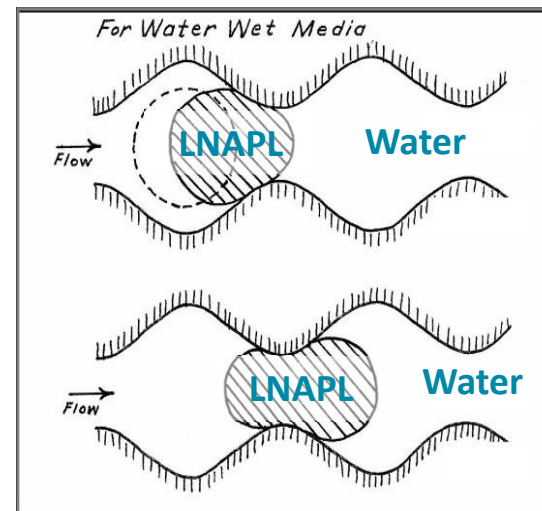
Experimental photos (after Schwille, 1988)

Pore Entry Pressure

- LNAPL will only move into water-wet pores when the entry pressure (resistance) is overcome



Source: API LNAPL FAQs

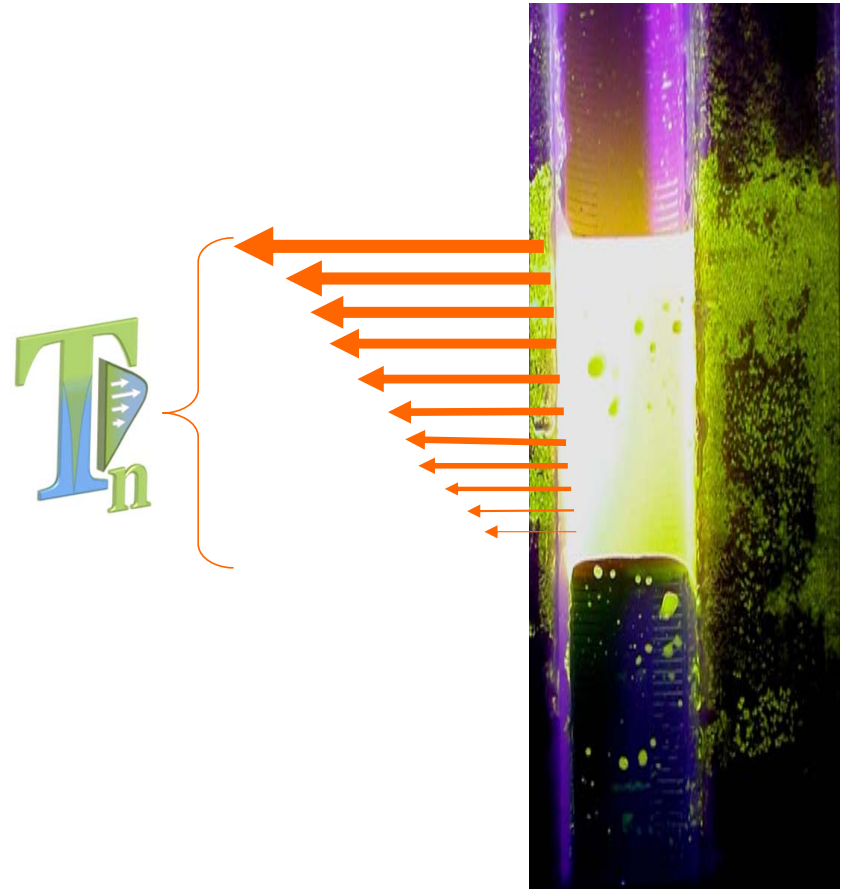


Pressure gradient is too low (immobile)

Pressure is sufficient (mobile)

Transmissivity as an Indicator of Mobility and Recoverability

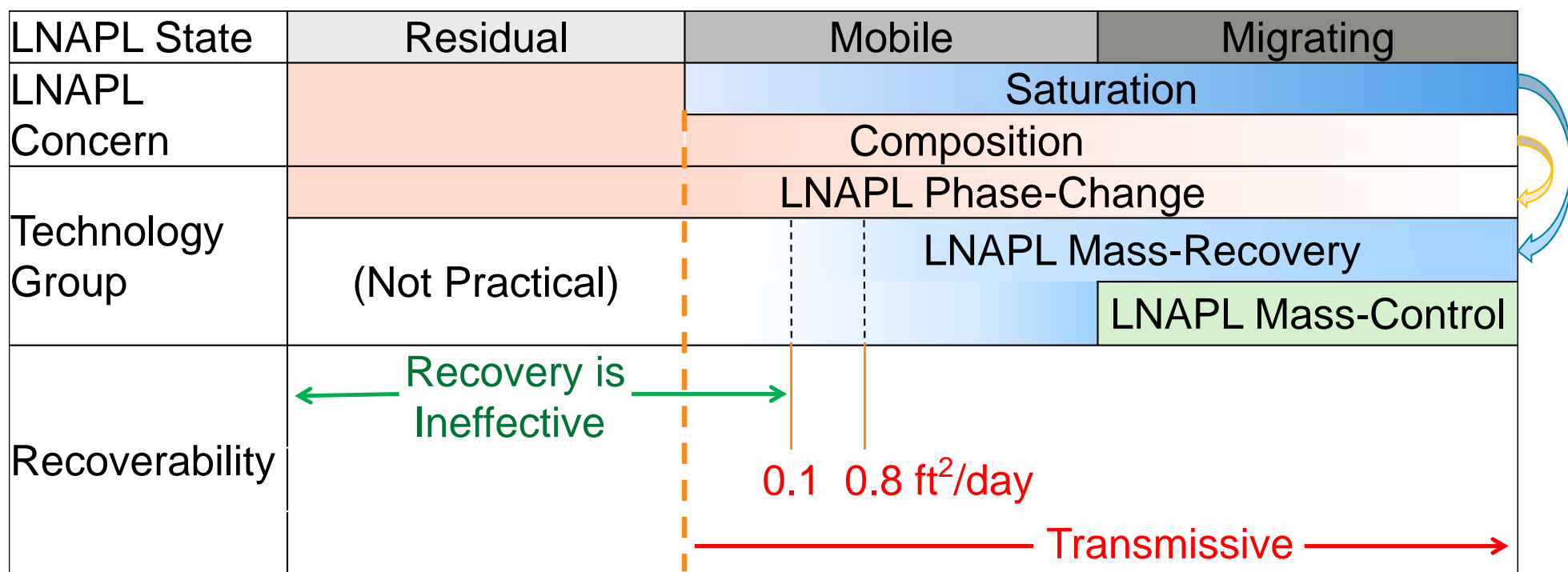
- Incorporates site-specific factors
 - LNAPL physical properties
 - Soil properties
- Proportional to LNAPL saturation
- Proportional to LNAPL mobility/recoverability
- In-well LNAPL thickness is not representative of these factors



Transmissivity as a Metric

Relation of LNAPL Saturation and Composition to Technology Selection

ITRC Practicable Recovery Limit : 0.1 – 0.8 ft²/day



Source: ITRC LNAPL Update, 2018

Case Study

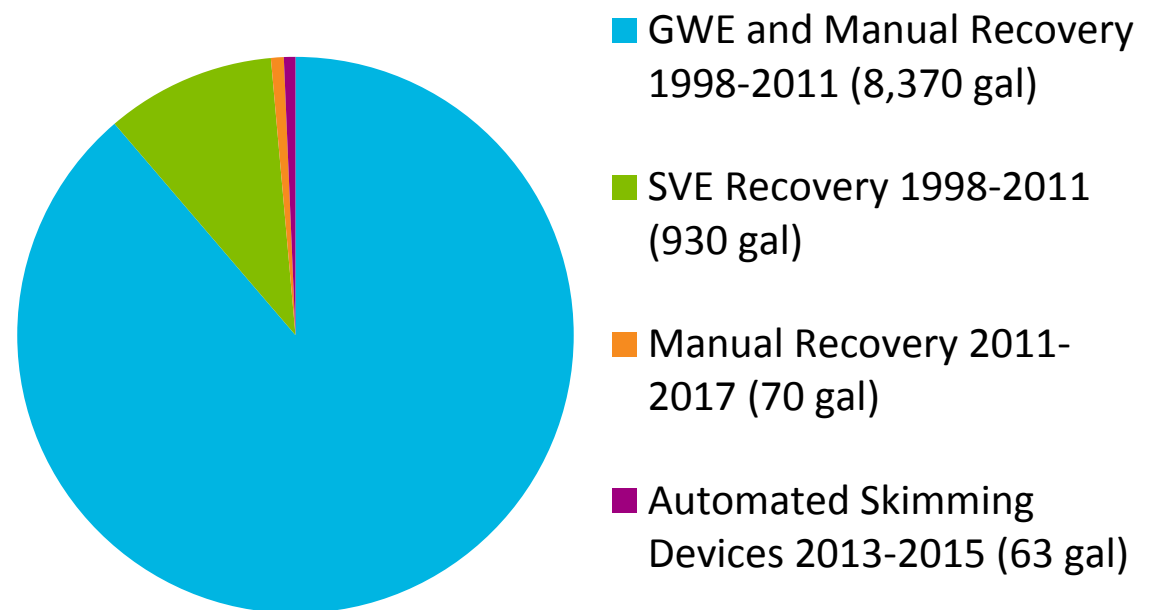
- Former manufacturing facility
- Maryland Coastal Plain
- LNAPL initially encountered during 1995 during UST abandonment
 - No. 2 fuel oil and gasoline
 - Former USTs (gasoline and diesel)
 - Former AST product lines (No. 2 fuel oil)



Remedial History

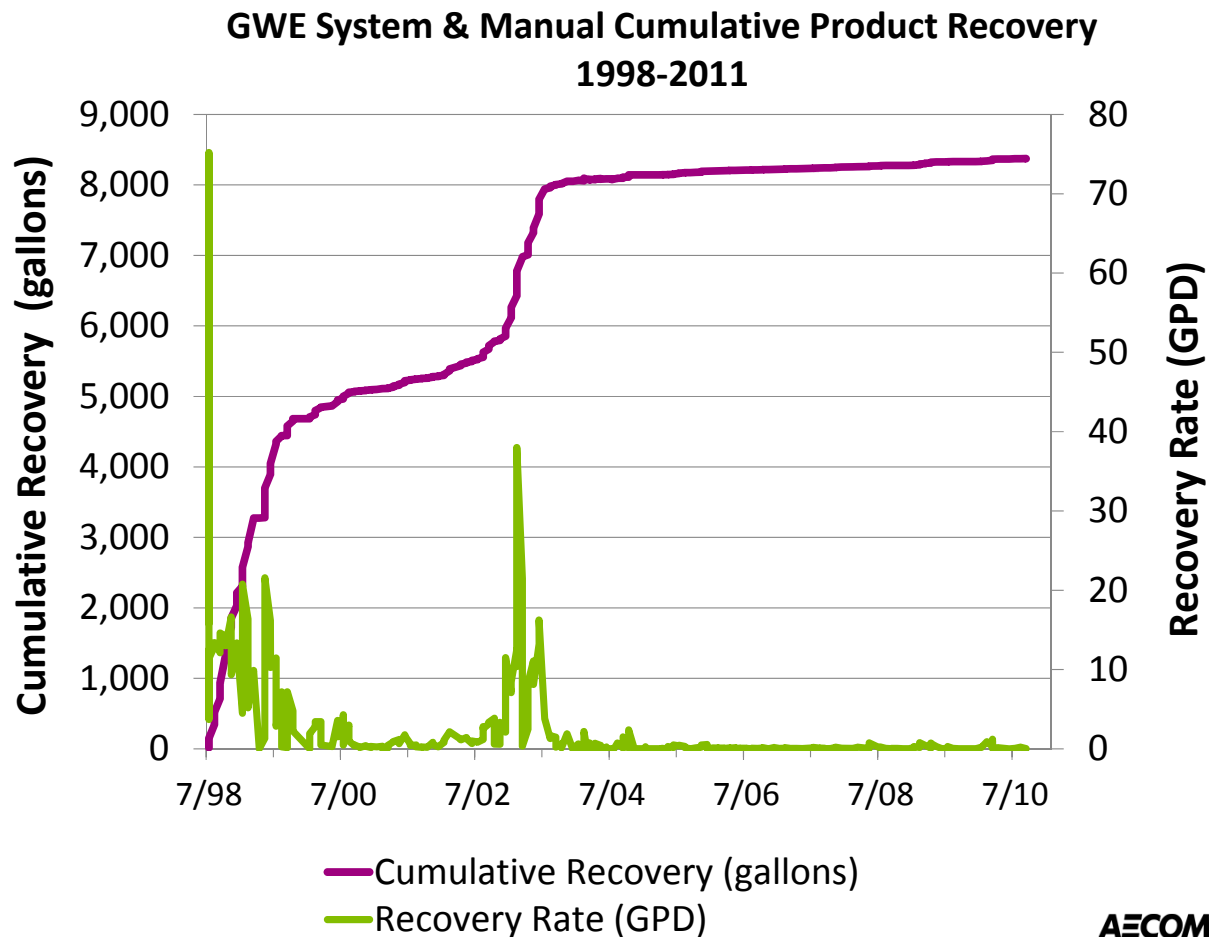
- Remedial investigation and manual recovery began in July 1995
- GW remediation system with SVE:
 - 1998 to 2011
- Automated LNAPL skimming devices:
 - Three monitoring wells
 - 2013 to 2015

Total LNAPL Recovered

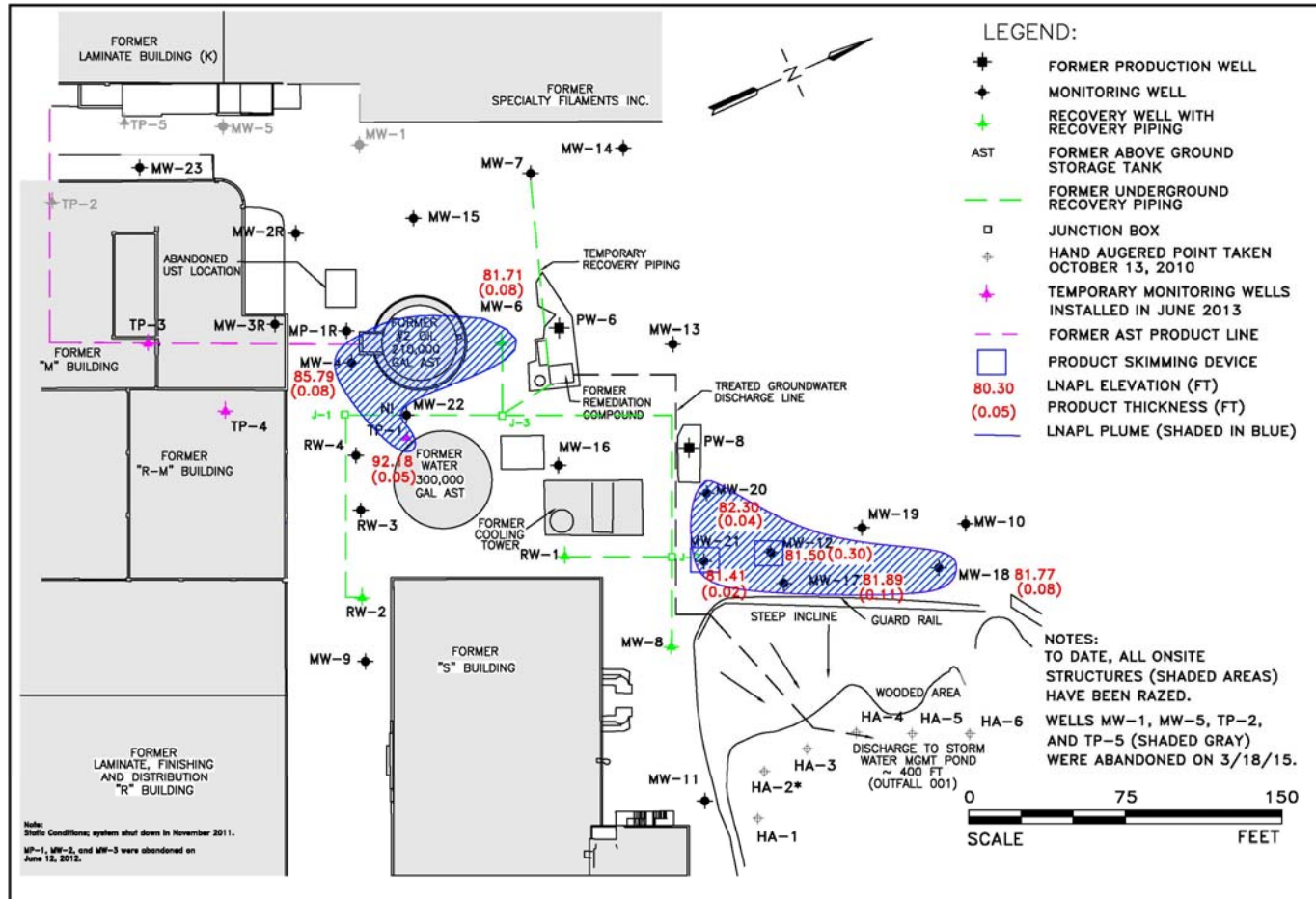


Observations

- Asymptotic recovery for all remedial phases
- LNAPL only migrated approx. 240 feet downgradient of the suspected source since release prior to 1995
- No LNAPL observed in the farthest downgradient wells



Post-Remediation LNAPL Plumes



Purpose

Regulatory Requirements:

- Maryland Department of the Environment (MDE) requires that LNAPL be removed to the maximum extent practicable
- Historically interpreted by MDE as a non-measurable sheen

Objective:

- Provide quantitative evidence that LNAPL has been removed to the maximum extent practicable despite the expected long-term occurrence of LNAPL

Site Activities

LNAPL Mobility Study:

- Manual Skimming Test
- LNAPL Fluid Properties Analysis
- Soil Borings
 - Chemical analytical analysis
 - Analysis of soil physical properties

Other Data Utilized:

- Long term fluid gauging data
- Groundwater analytical results



Designation: E2856 – 13

Standard Guide for
Estimation of LNAPL Transmissivity¹

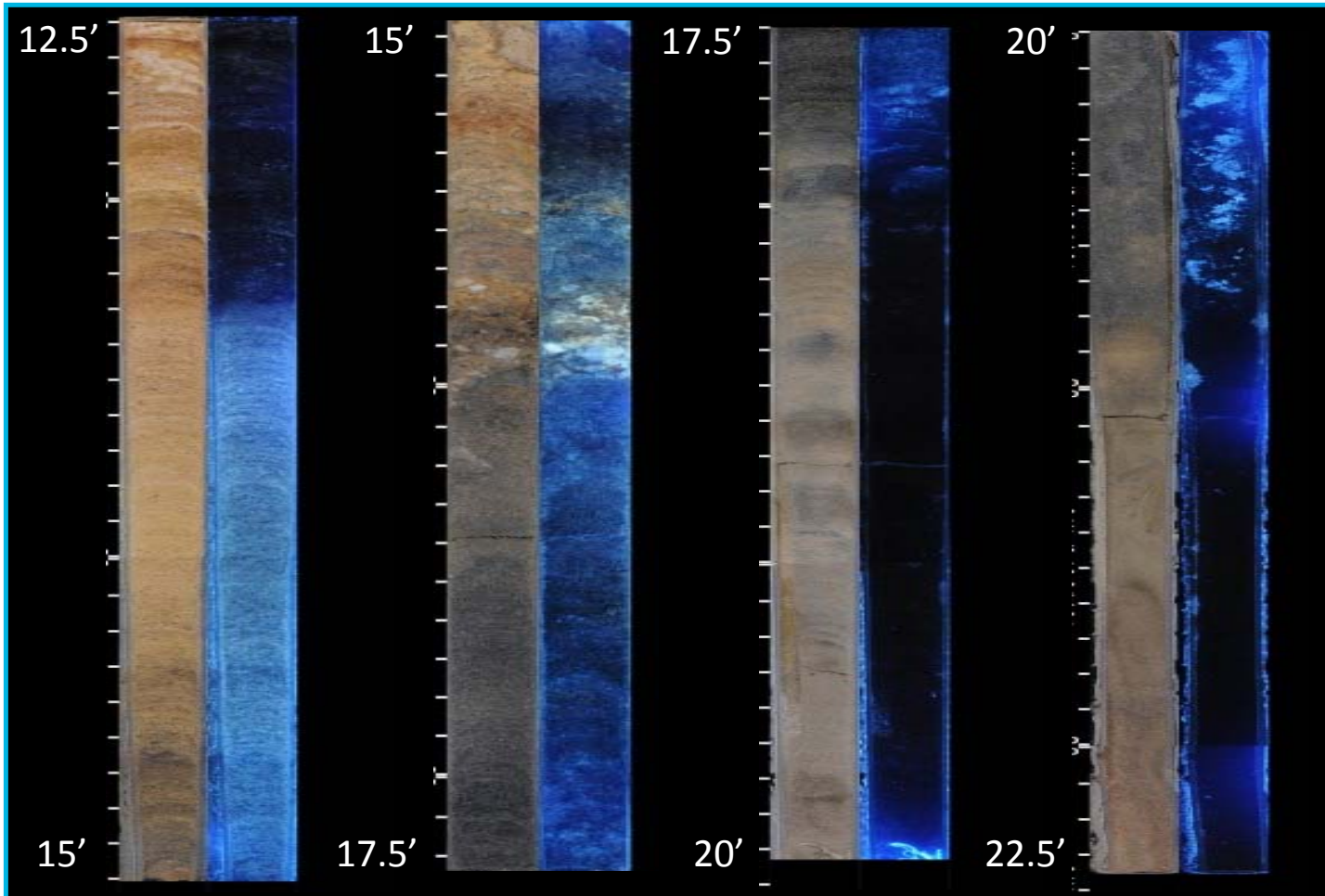


Soil Sampling

- Soil borings were advanced at eight locations to collect samples for TPH, and oil and grease analysis
- One undisturbed soil core was collected and immediately frozen with liquid nitrogen to preserve pore structures and fluid saturation



LNAPL Core Photography



Selected Analyses:

- Pore Fluid Saturation
- Grain Size
- Mobility
- Capillary Pressure

Transmissivity Results

Recent LNAPL Recovery:

- Approx. 130 gallons of LNAPL recovered from 2011 to 2017 via manual recovery and the automated skimming devices; extremely low LNAPL recovery

Manual Skimming Results:

- LNAPL transmissivity values were all less than 0.01 ft²/day

The Interstate Technology and Regulatory Council (ITRC) states that LNAPL recovery via physical methods is not practical at transmissivity values less than 0.1 to 0.8 ft²/day.

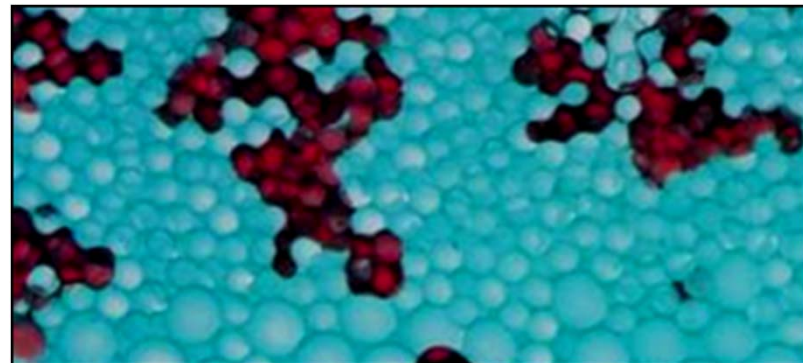
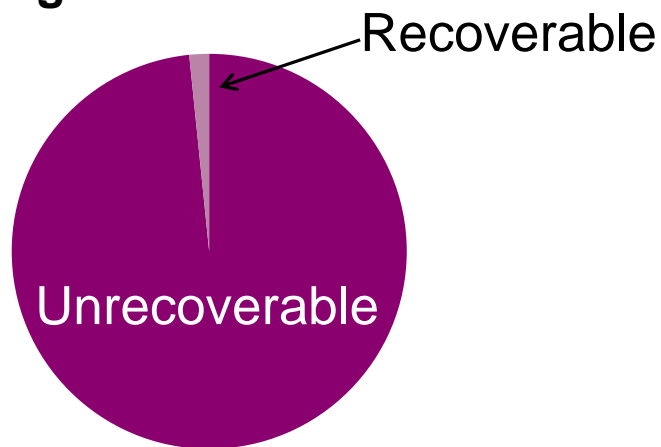
The remaining LNAPL has low mobility and recoverability.

Mobile Fraction of LNAPL

- Four samples from the undisturbed core were centrifuged at 1000xG
- LNAPL saturation was measured before and after centrifuging
- Results indicate that more than 98% of the LNAPL remained within the soil

The majority of remaining LNAPL is residual.

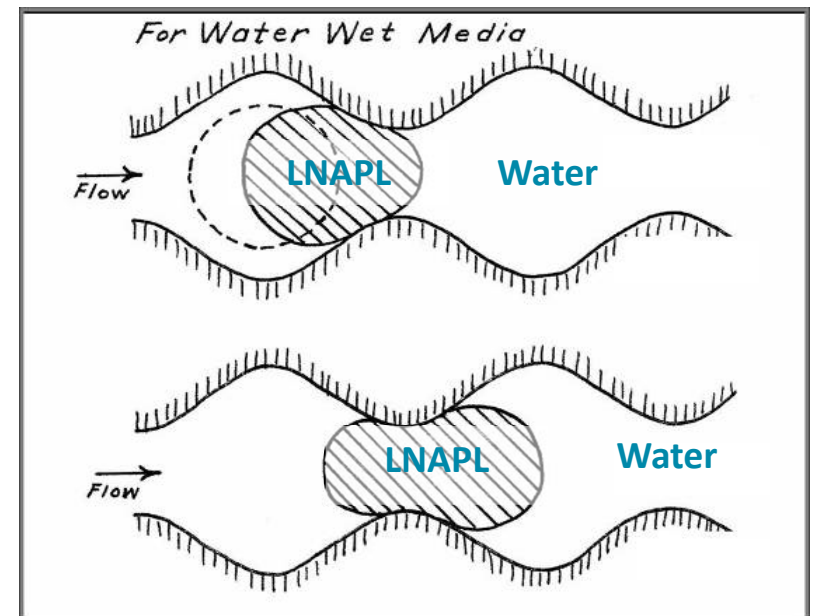
Remaining LNAPL:



Capillary Properties

- LNAPL will only move into water-wet pores when entry pressure (resistance) is overcome
- LNAPL entry pressure head was estimated using the capillary properties of the soil
 - Thickness of over 1.9 feet is required for LNAPL to migrate

The potential for LNAPL migration is very limited.



Conclusions

Successfully demonstrated that:

- Remaining LNAPL does not pose a threat for future migration
- Continued remediation will not significantly reduce remaining risk

On the merit of these observations, MDE has allowed LNAPL to remain in place and case closure has been achieved.

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Thank You!

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