Standardizing Visual Characterization of NAPL in Sediment Cores to Facilitate Remedial Decision-Making

Prepared for:

Western Dredging Association Midwest Chapter Meeting

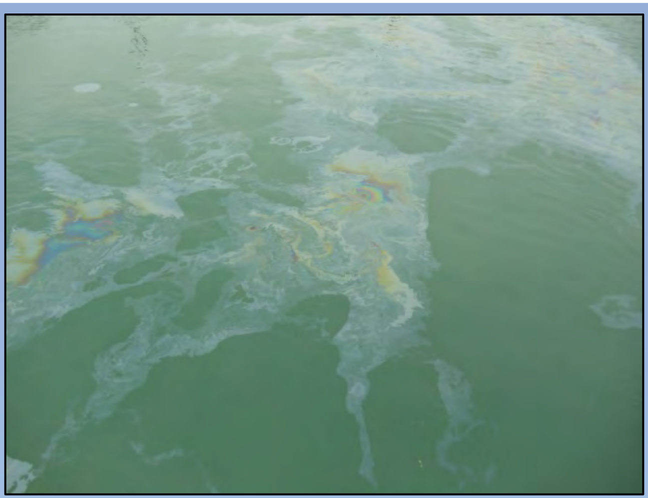
Prepared by:

Mike Ciarlo
Jamie Beaver
Morgan Gelinas
EA Engineering, Science, and Technology, Inc., PBC

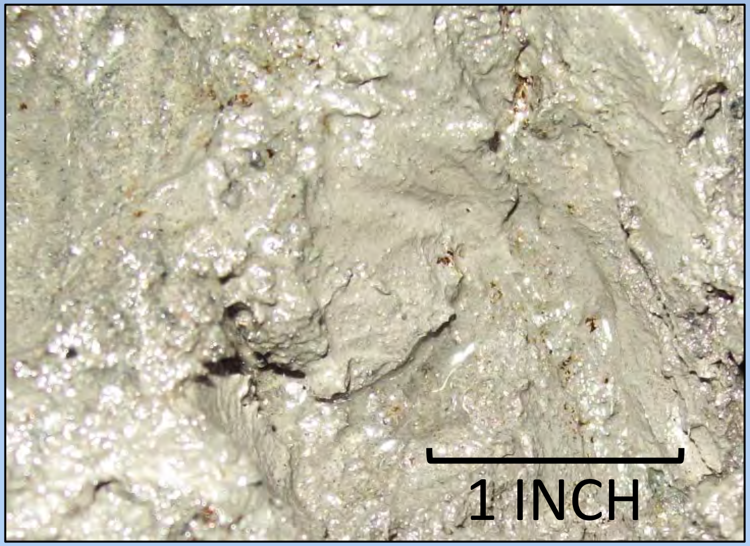
March 2017

Introduction

- Non-aqueous phase liquids (NAPLs) are common driver of sediment remediation
  - MGP wastes and coal tar
  - PCB oils
  - Hydrocarbons mix from outfalls
- Considered special case by regulatory agencies
  - Define by physical phase
  - Pose risk as source and stressor
  - Distinct fate and transport

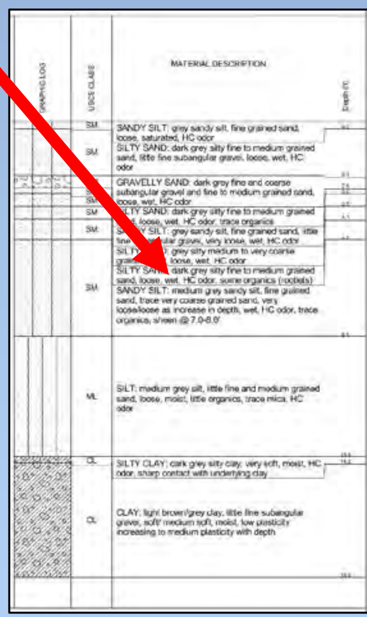


Introduction



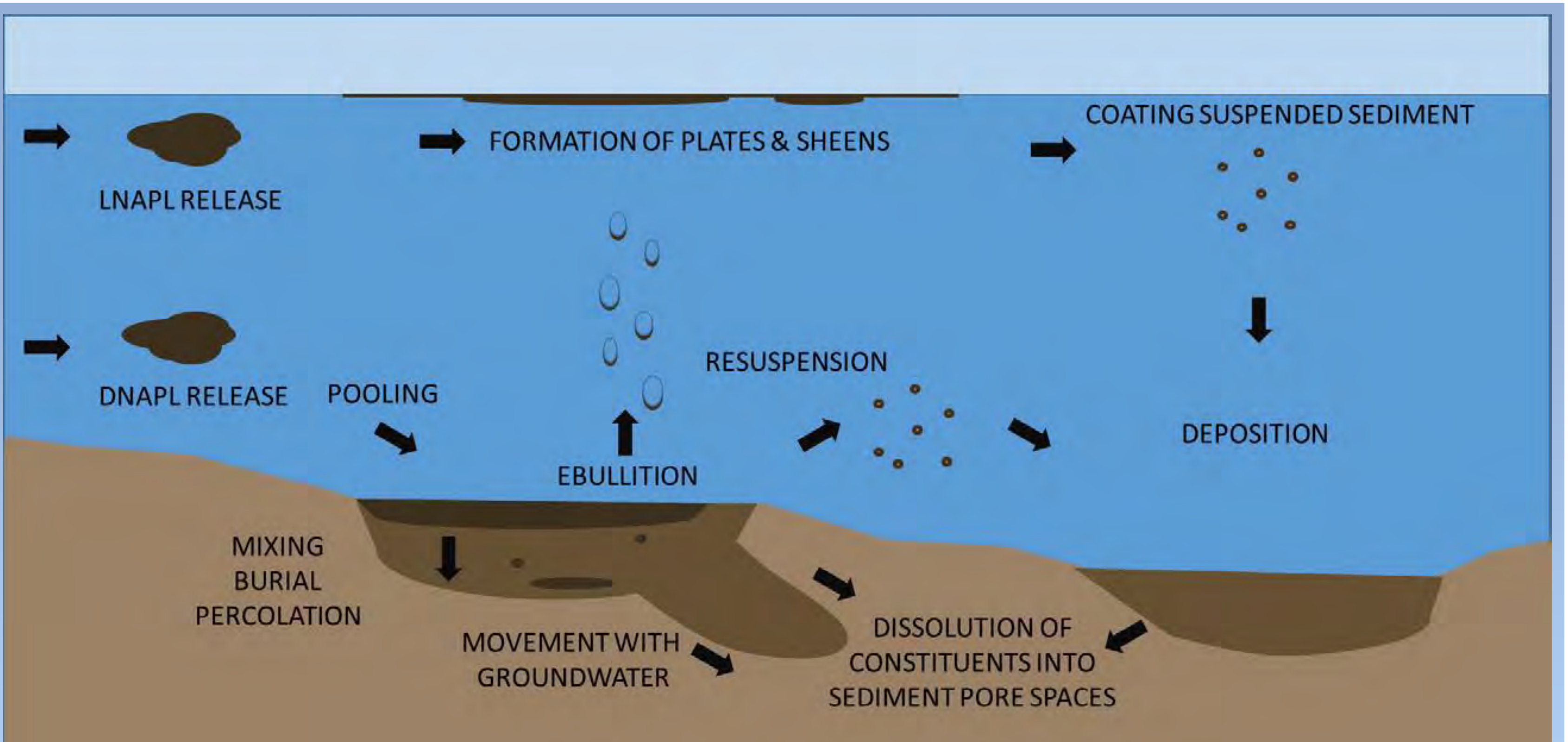
- Past 10 years have improved investigation methods
  - Survey based on fluorescence
  - Analytical methods
  - Immunoassays, sudan dye, etc.
- Visual observation is still a key method
  - Many states consider an observation grounds for remedy
  - Methods are debated

Goals and Approach



- Goal: Defensible, standardized methodology for visual characterization of NAPL
  - Relatable to quantity
  - Relatable to fate and transport mechanisms
  - Implementable in field
  - General enough for range of settings
- Approach:
  - Define influence of fate and transport mechanisms
  - Review existing frameworks
  - Draw from case studies
  - Methods for coring
  - Relate to volume

NAPL Fate and Transport Overview



- Different pathways for LNAPL and DNAPL
- Distinctly different from groundwater fate and transport
- Key role of macro-scale physical processes

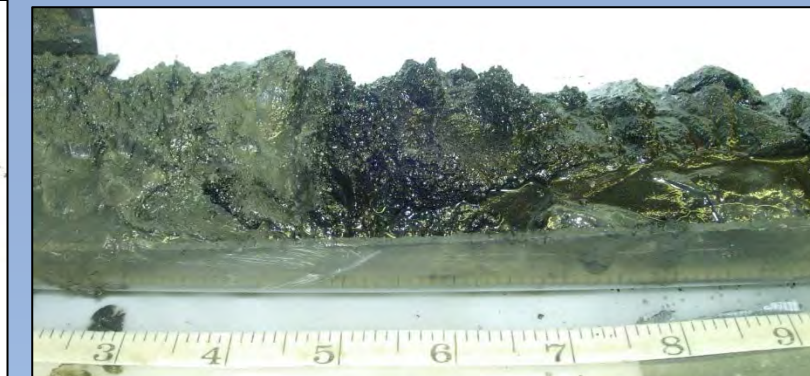
Existing Frameworks

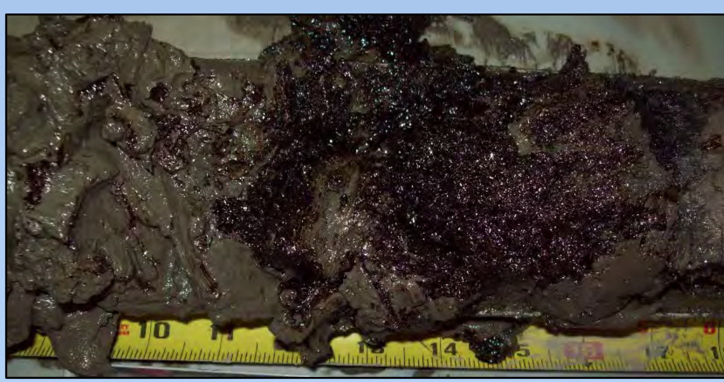
- Groundwater remediation framework
  - Saturation levels (mobile vs. residual) key to dissolved phase
  - Globules of free product considered isolated
- NOAA Shoreline Assessment Manual
  - Specific to petroleum & beach residues
- NYSDEC MGP Guidance
  - Specific guidance for sediment
  - Terminology for different forms
  - Application guidance
  - MGP-specific
- Project and study-specific frameworks

NYSDEC NAMING CONVENTIONS

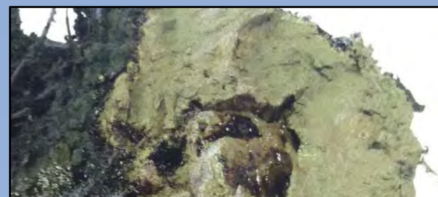
- TAR SATURATED
- COATED MATERIAL, LENSES
- HARDENED TAR
- BLEBS, GLOBS, SHEEN
- STAINING, ODOR
- PETROLEUM IMPACTS - SATURATION & SHEENS
- PETROLEUM IMPACTS - STAINING & ODORS
- PURIFIER WASTE AND ODOR
- NO OBSERVED IMPACTS

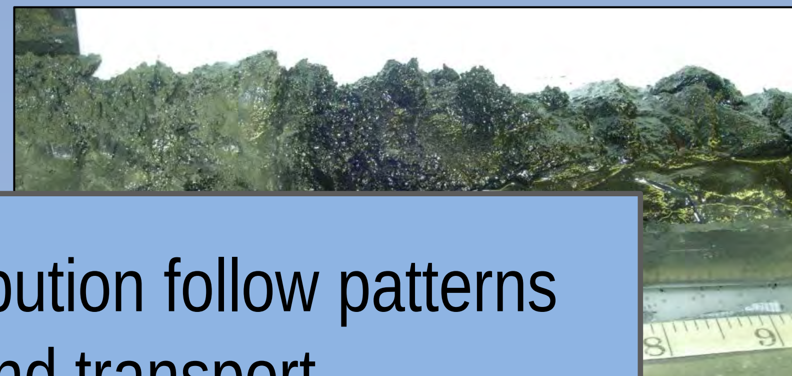
Case Studies





Case Studies

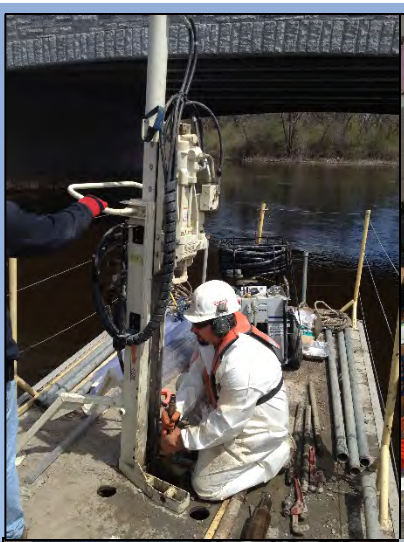


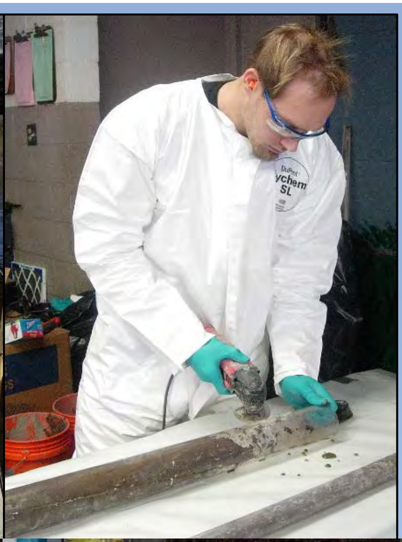


- Layering and distribution follow patterns that relate to fate and transport
- Globs and layer most associated with chemistry
- Sheens hit or miss for chemistry
- Logistics of sampling often a large factor

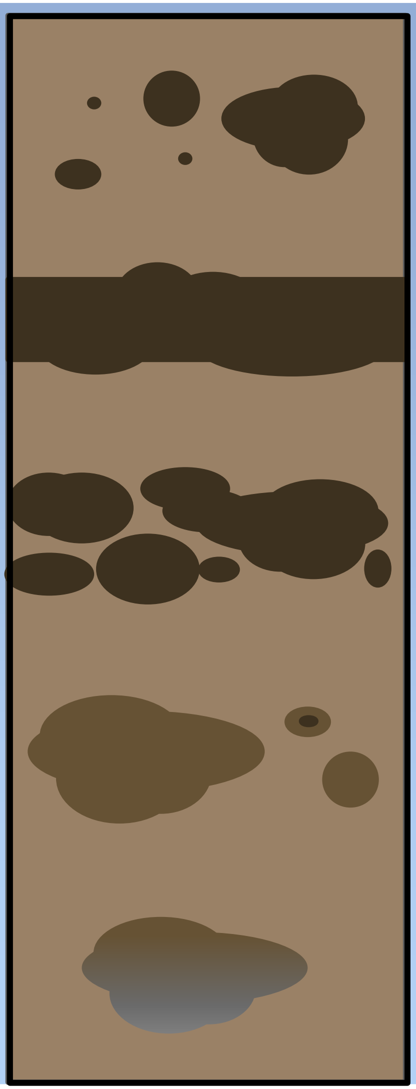
Coring Methods

- Focus on continuity of lithology
- Drilling method
  - Continuous coring provides best continuity; issues of penetration versus recovery
  - Hollow stem auger poses challenges
- Core processing
  - Split cores disturb interior but expose fresh surface
  - Unsplit – issues with drawdown
- Visual survey
  - Variable needs based on type and setting
  - Lighting, color, luster, resolution
  - Fluorescence and Sudan dye can help but pose challenges





Distribution versus quantity



Blebs and Inclusions
- Volume of sphere or oblong
- Key metrics - diameter or length & width

Layers
- Volume of cylinder
- Record thickness

Network
- Volume of cylinder times percent occupied by channels
- Record thickness; estimate percent sediment vs. NAPL

Stained or coated sediments
- Start with total zone volume
- Field determination of grain size/sediment type used to estimate pore space
- Separate inclusion volumes

Sheens or plating
- Measure area
- Apply nominal thickness based on viscosity
- [Often an indicator of other forms]

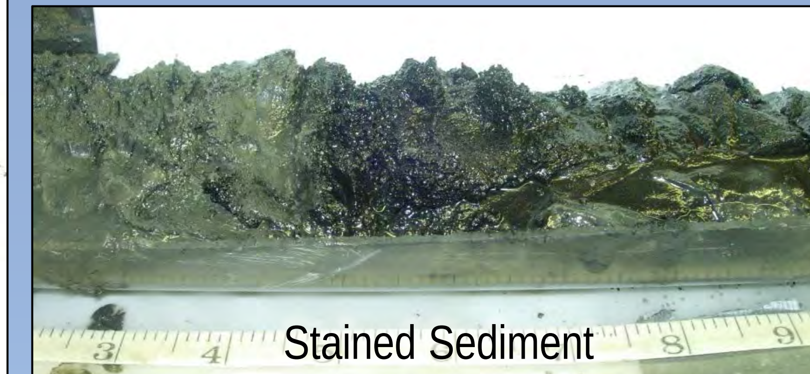
Proposed Framework

NAMING CONVENTION	DEFINITION	RECORDED FIELD PARAMETERS
INCLUSIONS	**Zones where oils form a distinct and separable pocket from surrounding sediment matrix**	
BLEBS	Isolated pockets < 2 mm	Color, luster, diameter, abundance / frequency
GLOBULES	Isolated pockets > 2 mm	Color, luster, abundance / frequency, geometry, size
TAR	Solid or semi-solid	Color, luster, abundance / frequency, geometry, size
LAYER	Inclusionforms continuous layer	Color, luster, thickness
NETWORK	Series of small channels and globules	Color, luster, layer thickness, ratio of channel space to matrix
PERMEATION ZONES	**Zones where oil is distinguishable but mixed with sediment matrix such that it is not readily separable**	
STAINED SEDIMENT	Color & texture indicate NAPL	Color, luster, abundance, size of zone, sediment texture, inclusions, % saturation
GREASY SEDIMENT	Luster and texture indicate NAPL	Color, luster, abundance, size of zone, sediment texture, inclusions, % saturation
FILMS	**Zones where oil forms thin plates or sheens distinct from the underlying sediment and water matrix**	
PLATES	Thin layer riding surface tension, fractures	Color, luster, area; seek other forms
SHEENS	Thin layer riding surface tension, does not fracture	Color, luster, area; seek other forms

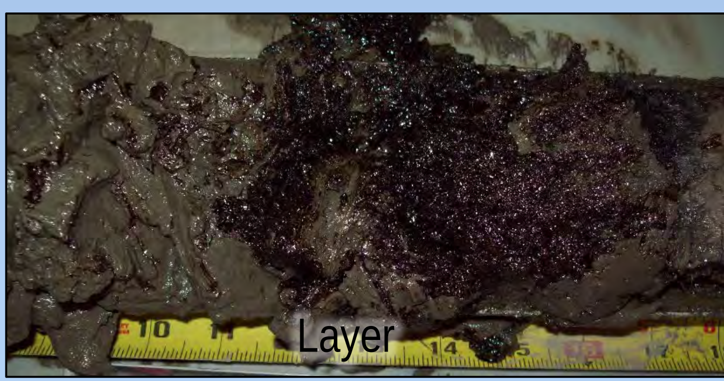
Case Studies


Blebs & Globules


Network


Stained Sediment


Blebs & Globules


Layer


Greasy Sediment

Conclusions

- Fate and Transport
  - Form provides indication of key fate and transport processes
  - Different from groundwater and between DNAPL and LNAPL
- Existing frameworks
  - Developed for specific purposes but provide useful terminology
- Case studies & Coring Methods
  - Definite patterns in NAPL distribution
  - Continuous coring preferred with careful processing
  - Site specific variation
- Distribution and quantity
  - Blebs, globules, and layers are readily relatable to volume/quantity/mass
  - Networks, stained & greasy sediments pose challenges
  - Sheens are poor indicators of chemistry
  - Framework terms expected to be good indicators
  - Considered modeling

Framework and Path Forward

- Proposed approach for visual characterization relies on a framework of
  - Inclusions, permeation zones, films
  - Notes on indicators of presence
  - Records of size, geometry, and NAPL-matrix ratio
- Next step is field trial
  - Identifying several trial sites
  - Field data sheets that allow rapid recording of observations
  - Compile data from data sheets and compare to analytical results
  - Analyze predictive strength of multiple levels of framework hierarchy
  - Track ease of use and incorporate field team input
  - Evaluate potential use as indicator of which forms are actual risk drivers