



BETTER DATA. DEEPER UNDERSTANDING.
MORE SUSTAINABLE OUTCOMES.

LEARN MORE



High-Resolution Remedial Design Characterization

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Our Sustainable Purpose



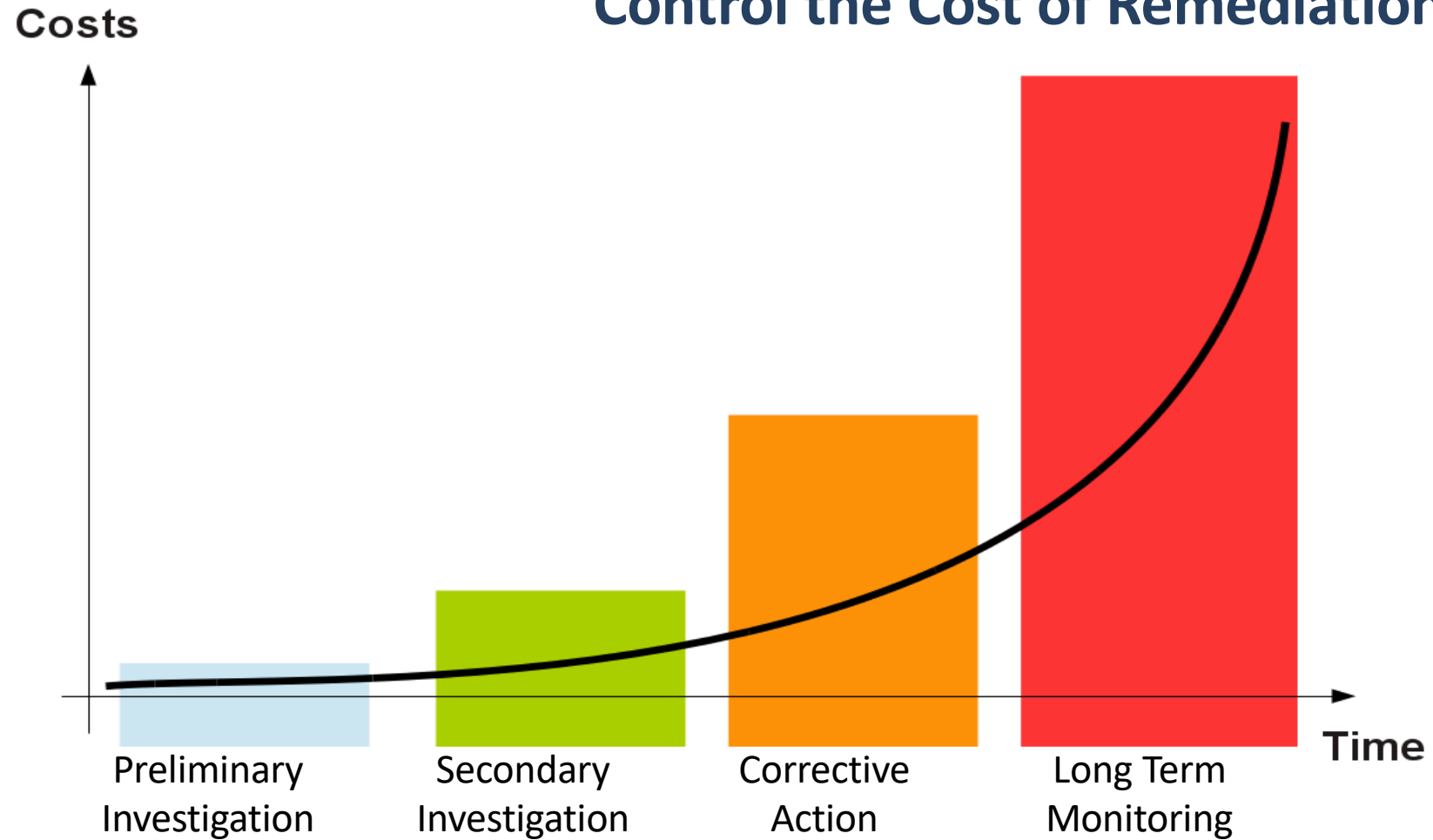
Environment
Economic
Social



WHY HIGH-RESOLUTION?



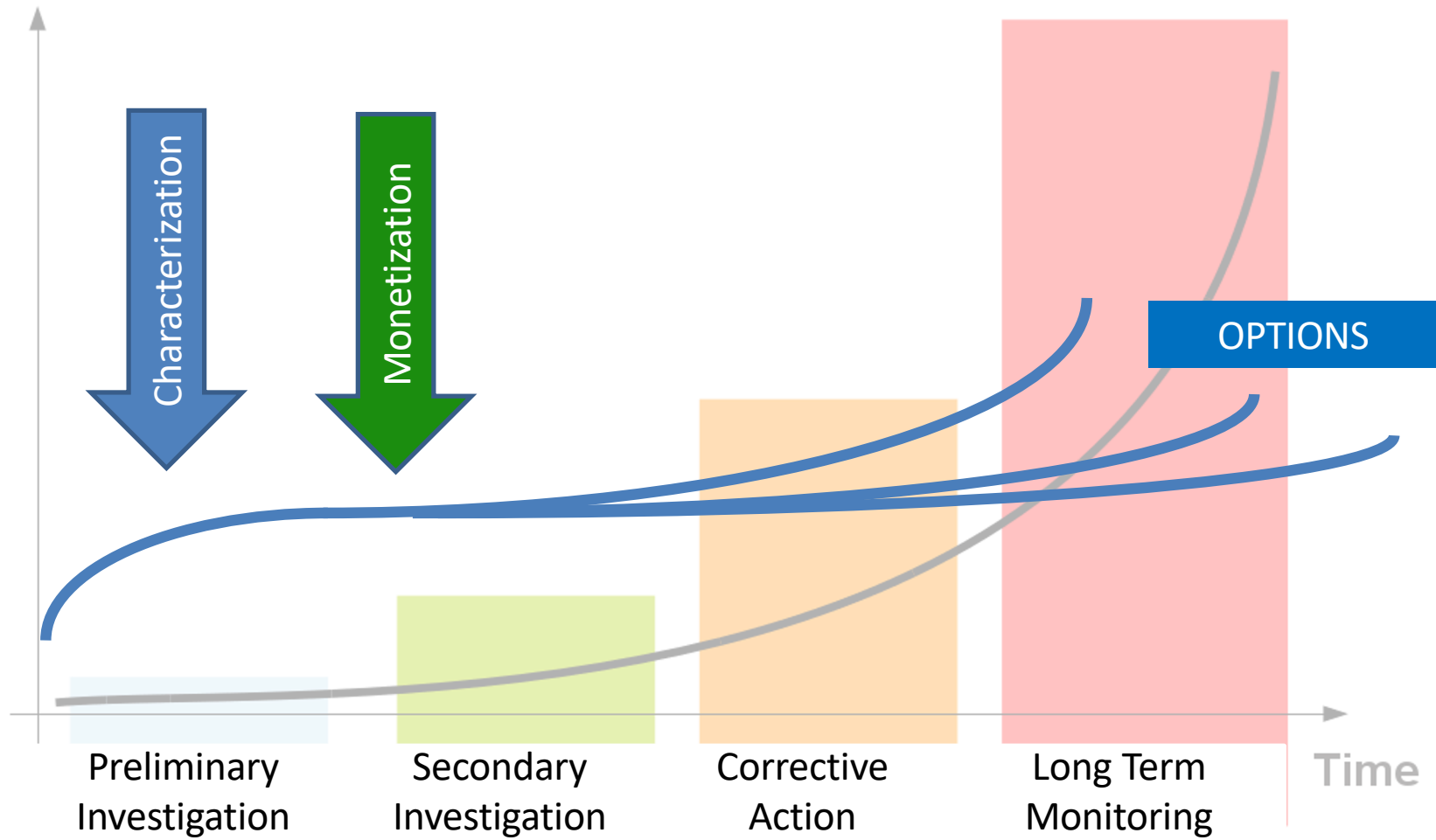
Our Mission: Control the Cost of Remediation





Controlling the Cost of Remediation

Costs



Where we were 10 years ago...

By F Payne: *Remediation Hydraulics*

What's really there...

By F Payne: *Remediation*
Hydraulics

Impact on Conceptual Site Models

1 ft/day

Example: Distribution
of Transport Velocities

1 ft/day

100 ft/day

0.1 ft/day

0.01 ft/day

By F Payne: *Remediation*

Colorado State University
Civil and Environmental Engineering
Center for Contaminant Hydrology

CCH

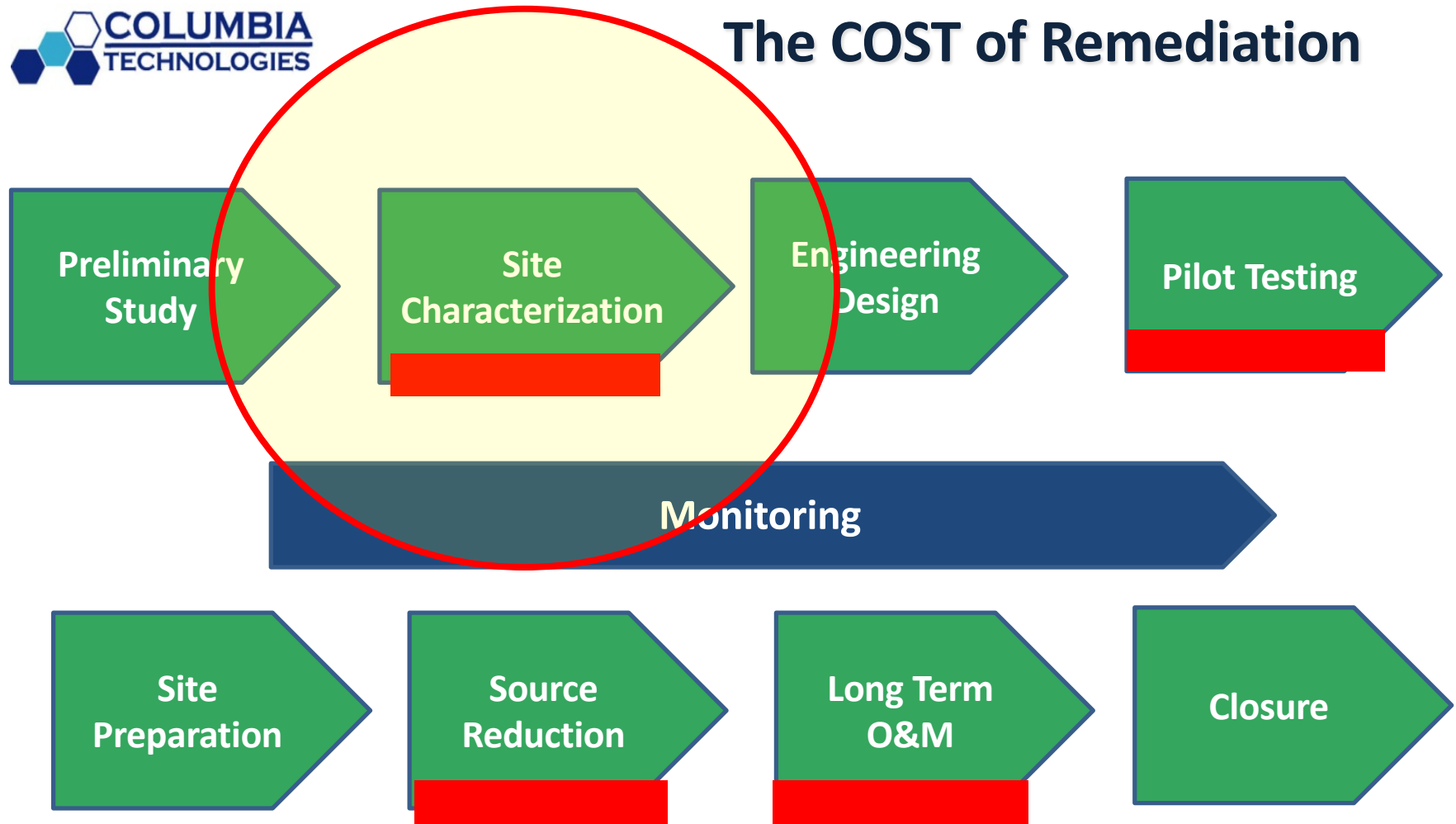


Lee Ann Doner, laruther@engr.colostate.edu

Tom Sale, tsale@engr.colostate.edu



The COST of Remediation



**** TECHNOLOGY**



Example Cost of Uncertainty

Enhanced Bio-Remediation Injection

- 1.0 MG/L PCE CONTAMINATION
- 400 FT WIDE x 1000 FT LONG x 40 FT THICK
- COMPETING ELECTRON ACCEPTORS
 - DO 5 MG/L
 - NO3 5 MG/L
 - **SO4 100 MG/L**
 - MN 5 MG/L
 - FE 50 MG/L
 - CH4 10 MG/L

**Change GW flowrate from
0.5 to 1.0 FT/DAY**

GW Flow Rate	0.5 FT/DAY	1.0 FT/DAY
EVO DEMAND (lbs)	263,210	356,389

35% INCREASE IN AMENDMENT REQUIRED !

Source:





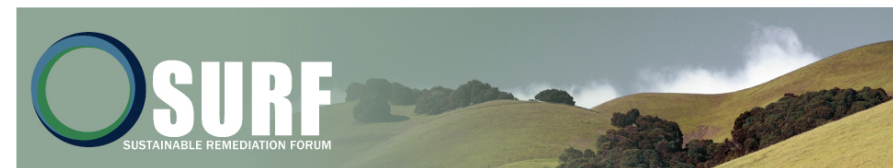
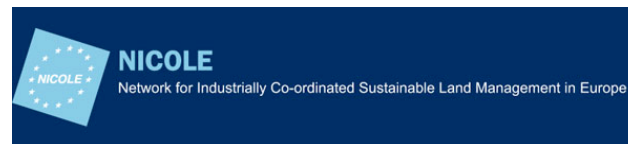
HOW WE DO WHAT WE DO

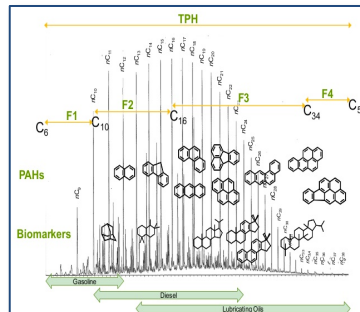


Global Awareness

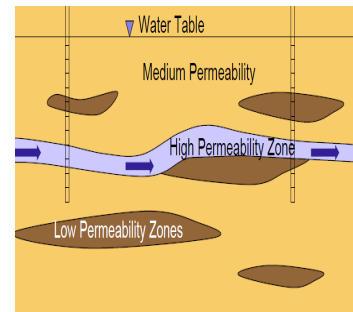


Network for Industrially Contaminated Land in Africa (NICOLA)

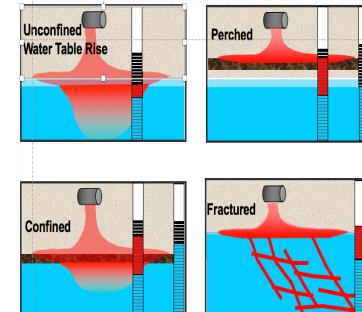




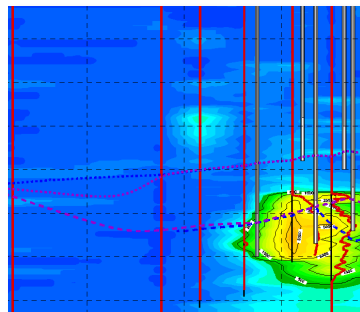
LNAPL
CHEMISTRY



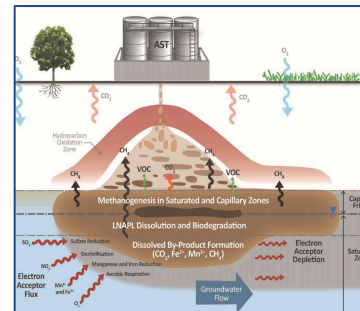
SOIL
PERMEABILITY



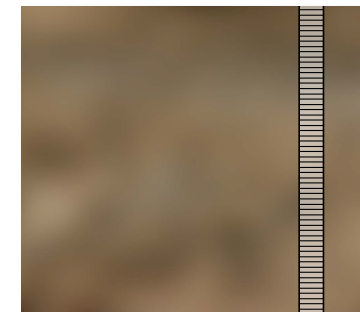
GROUND
WATER



DISSOLVED
PHASE



VAPOR PHASE



SPATIAL
ALIGNMENT

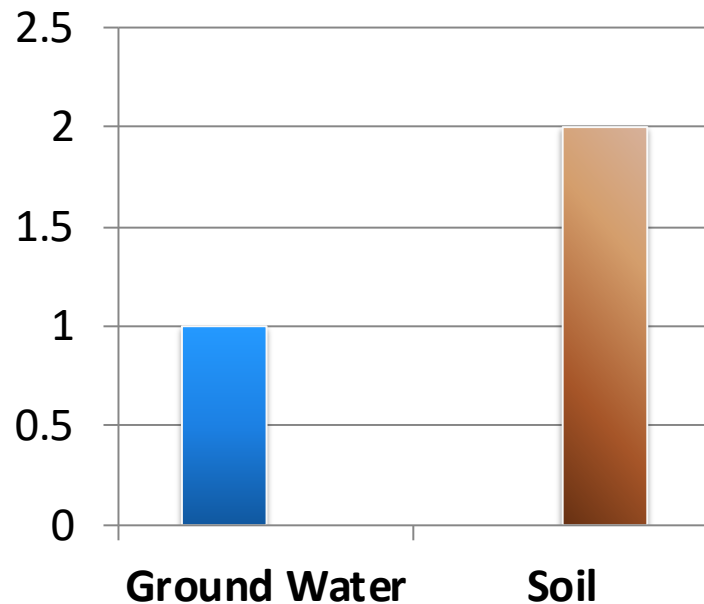


RISK BASED VS. REMEDIATION MEASUREMENTS

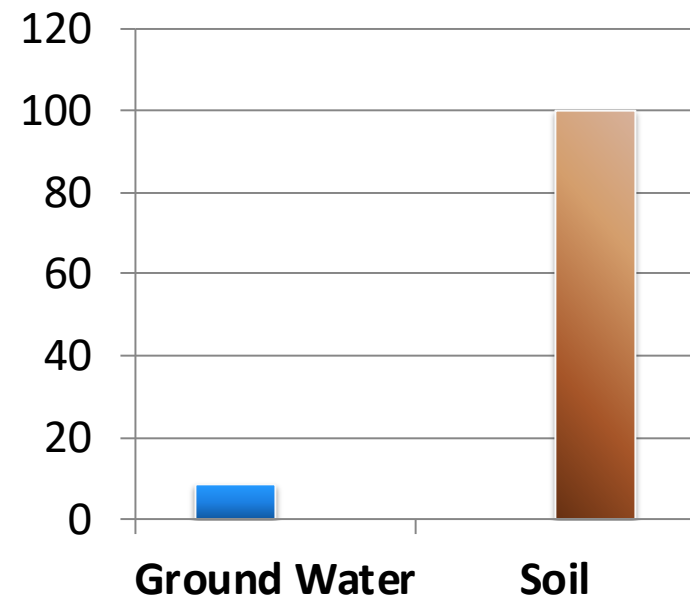


Mass Loading is in the Soil

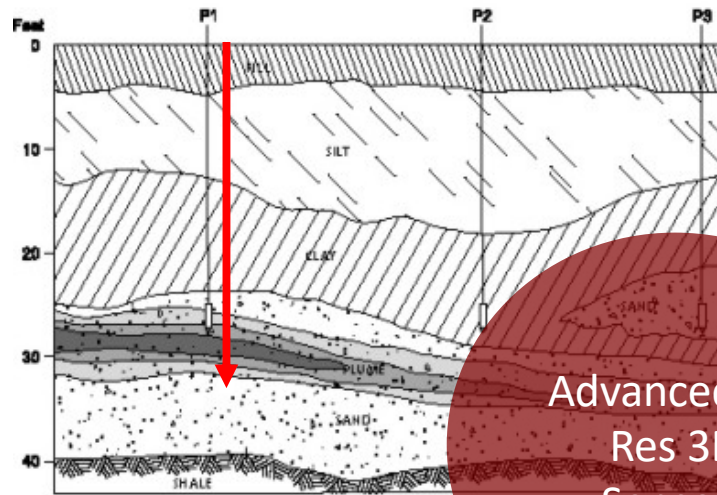
Soil and Ground Water Contamination (ppm)



**Contaminant Load
mg / 100 cu. ft.**



***If you design to only treat the dissolved phase contaminant,
you get REBOUND***

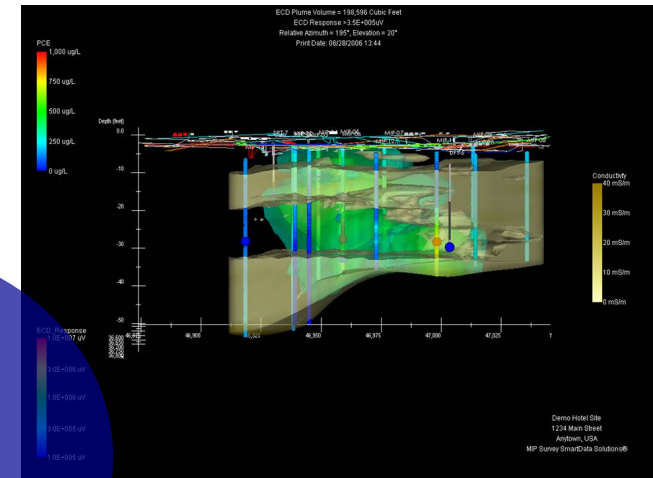


Advanced Hi-
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Sensors

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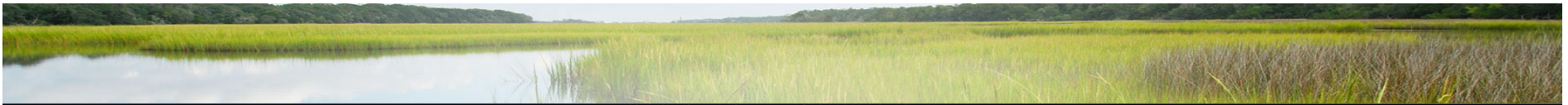
Professional
Services

SmartData Solutions®



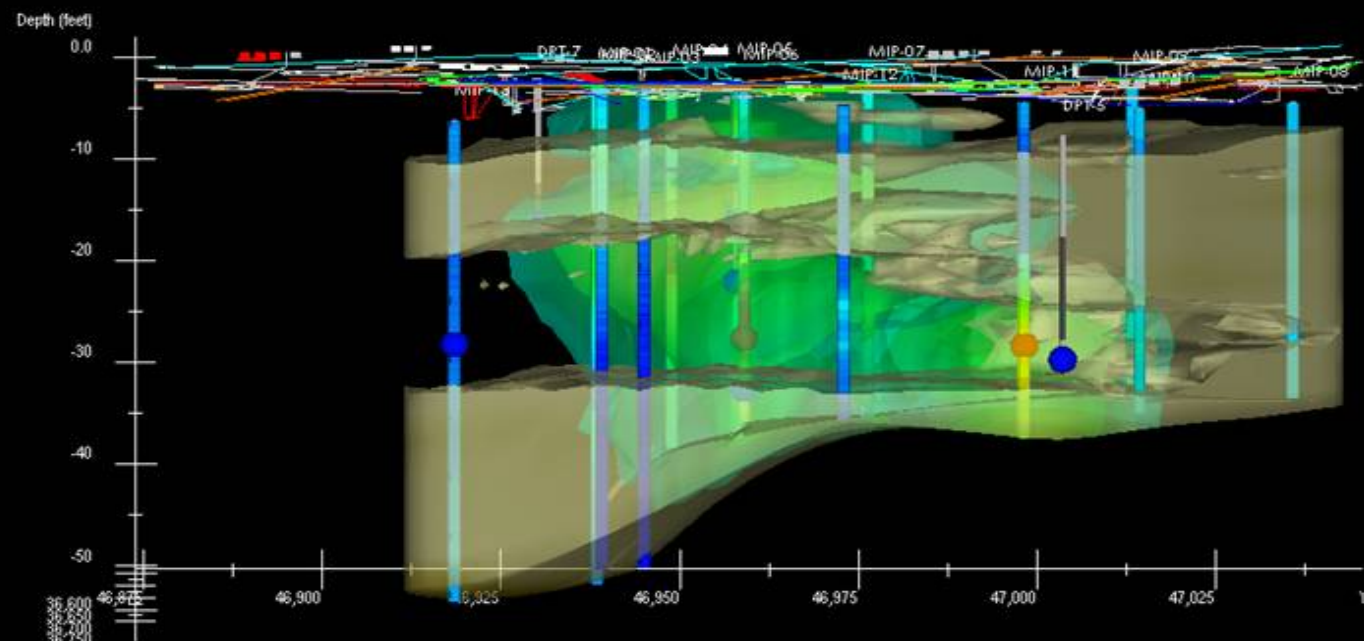
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ECD Plume Volume = 198,596 Cubic Feet
ECD Response >3.5E+005uV
Relative Azimuth = 195°, Elevation = 20°
Print Date: 06/28/2006 13:44

PCE
1,000 ug/L
750 ug/L
500 ug/L
250 ug/L
0 ug/L



ECD_Response
1.0E+007 uV
3.0E+006 uV
1.0E+006 uV
3.0E+005 uV
1.0E+005 uV

Demo Hotel Site
1234 Main Street
Anytown, USA
MIP Survey SmartData Solutions®



CHOOSING THE RIGHT SCALE APPROPRIATE TOOLS TO SUPPORT SUCCESSFUL OUTCOMES

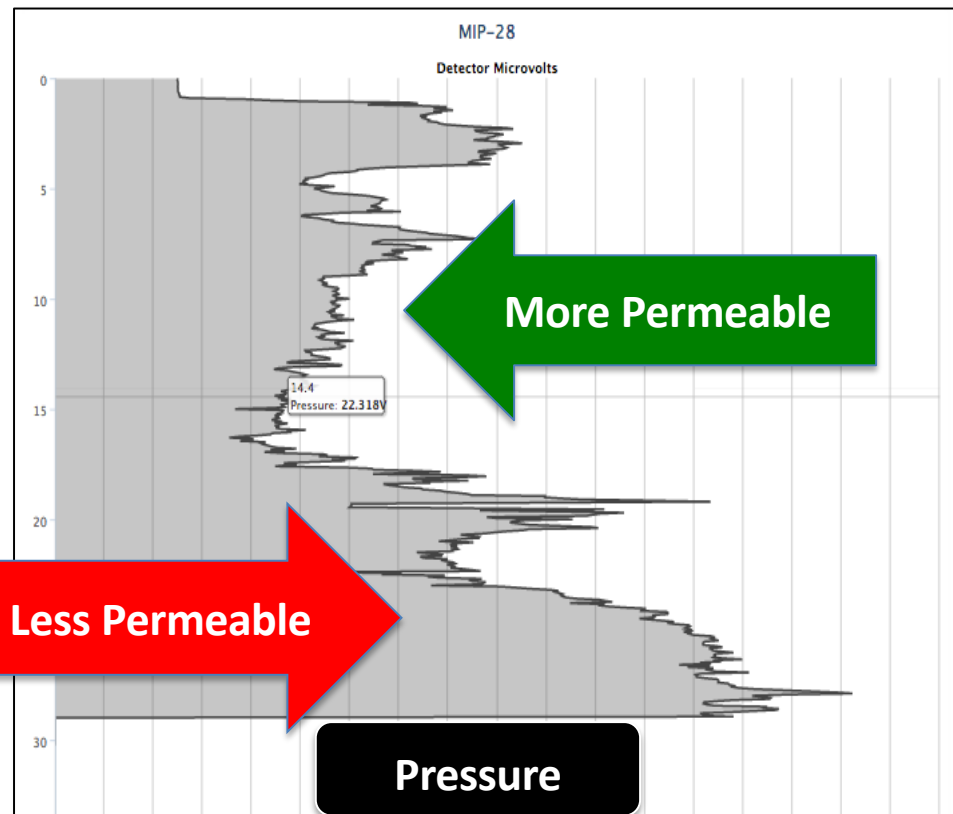


Direct Push Technologies





Use Hydraulic Profiling Tool (HPT) to Measure Soil Pore Pressure





Membrane Interface Probe

MIP (Membrane Interface Probe)



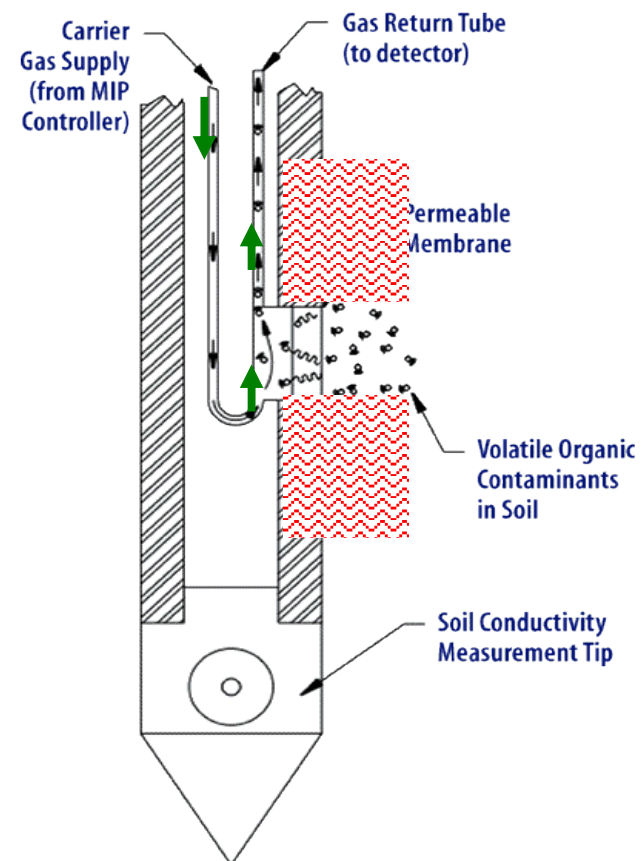


Membrane Interface Probe (MIP)

Quick Notes:

- Volatile Organic Compounds (VOCs)
- Typical Detection Limits:
 - 1 ppm petroleum fuels
 - 200 ppb chlorinated solvents
 - Lower for Low-Level MIP
- Integrated Hydraulic Profiling Tool
- Performance Test Required!

MIHPT INSTRUMENT SETUP



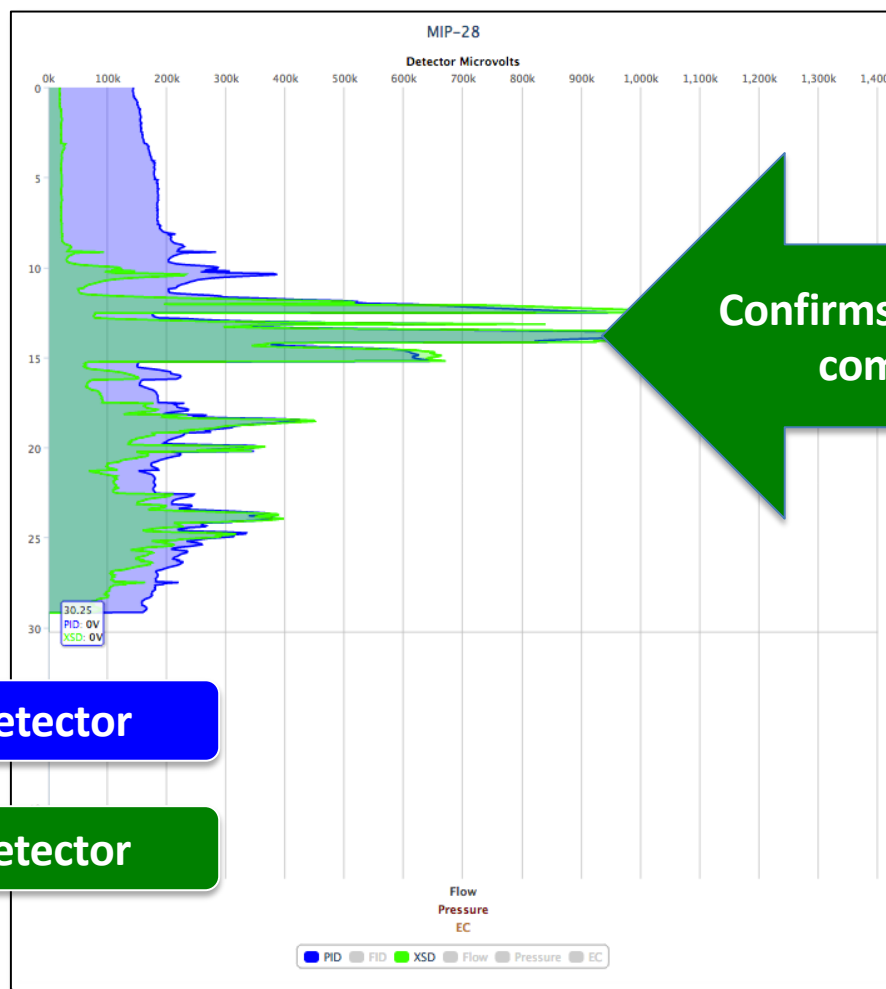


Membrane Interface Probe (MIP)

**Chlorinated
Volatile Organic
Compounds**

Photo Ionization Detector

Halogen Specific Detector





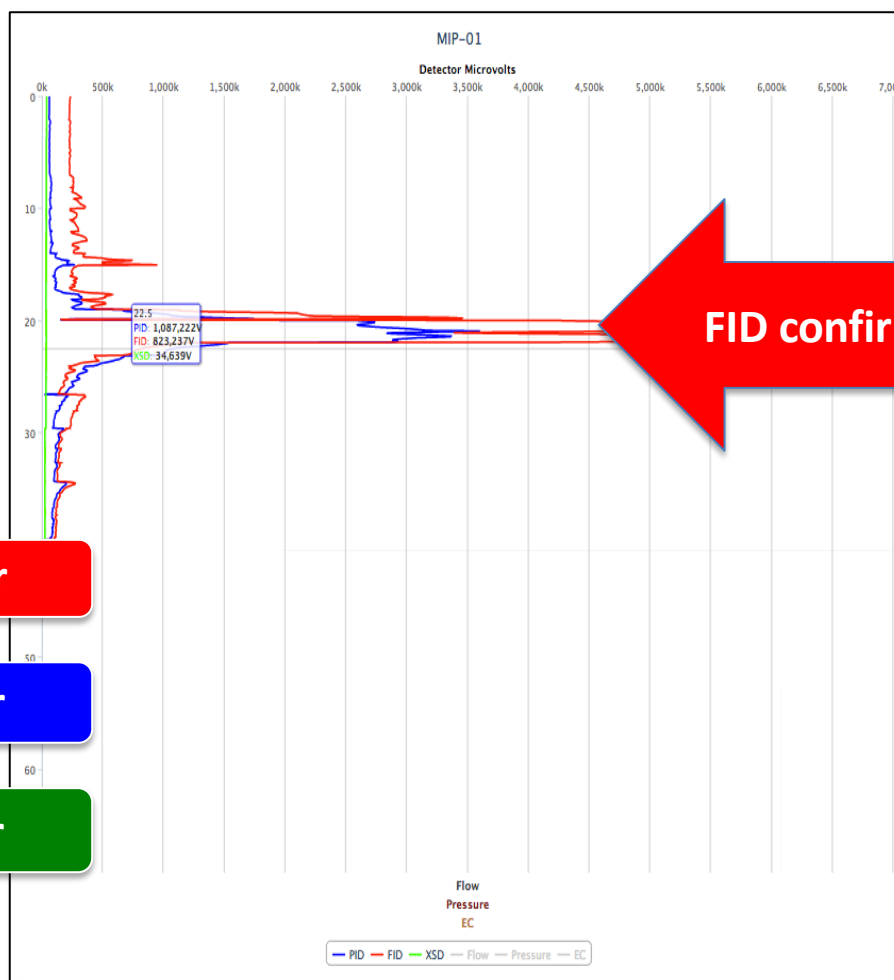
Membrane Interface Probe (MIP)

**Petroleum
Volatile Organic
Compounds**

Flame Ionization Detector

Photo Ionization Detector

Halogen Specific Detector



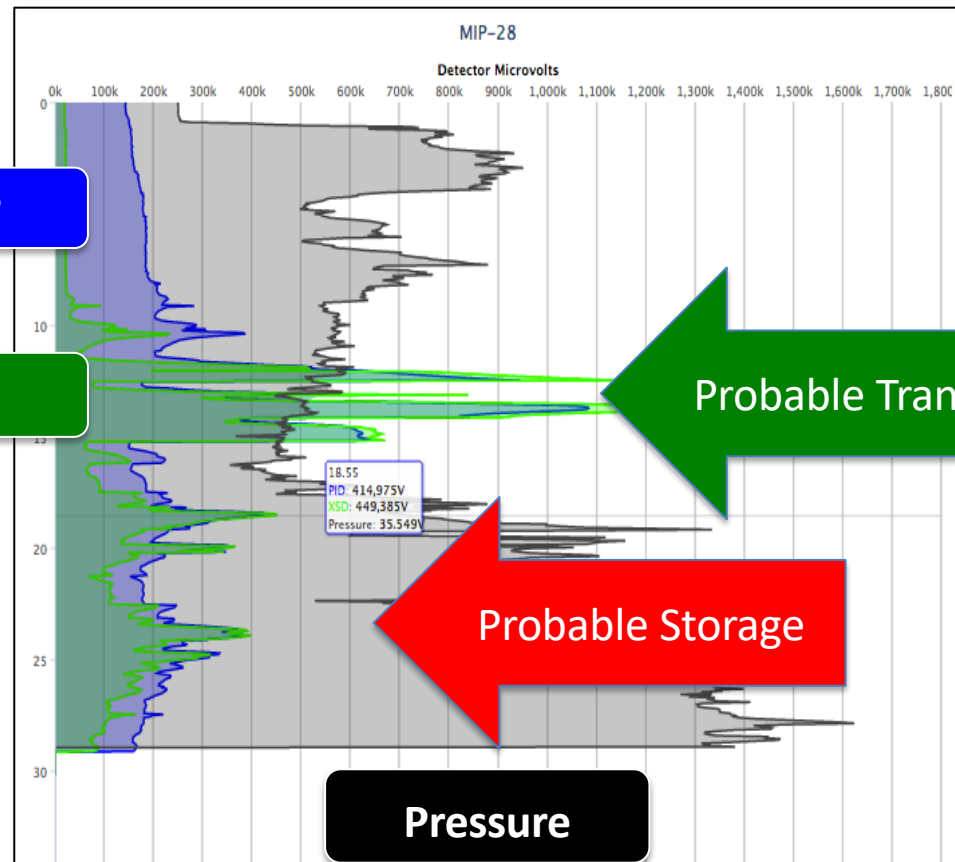
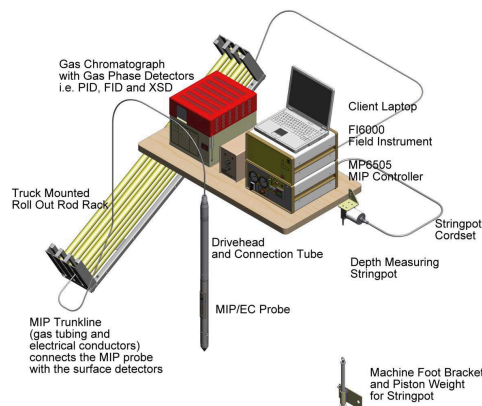
FID confirms PID



Combined Membrane Interface Probe and Hydraulic Profiling Tool (MiHpt)

Photo Ionization Detector

Halogen Specific Detector



Probable Transport

Probable Storage

Pressure



PETROLEUM NON-AQUEOUS PHASE LIQUIDS (NAPL)

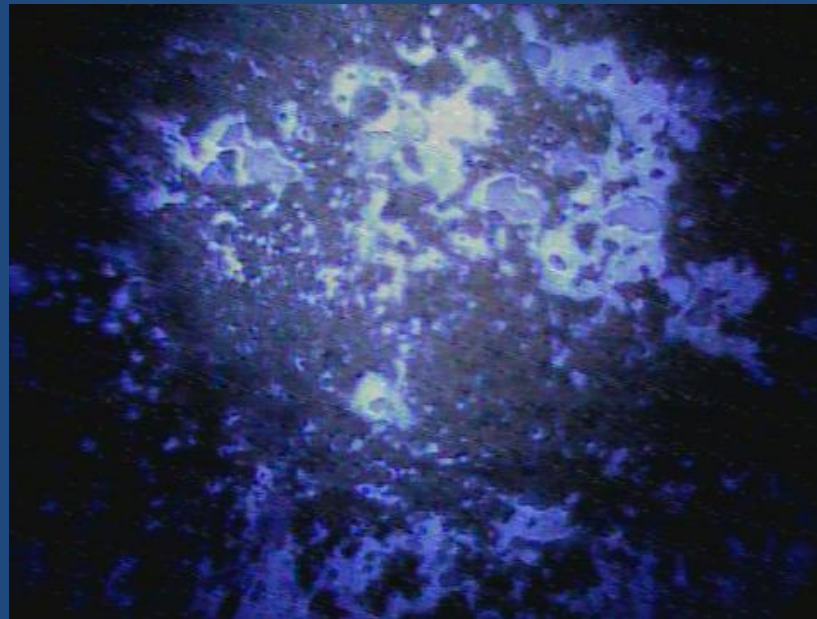
OIP Description

- **OIP Probe:** Robust with simple connection to the trunkline.
- **Driveable:** Using 7822 series machines and drive cushions.
- **Compatible:** With Geoprobe 1.5 inch and 1.75 inch rod systems.



OIP UV Image

9.5 mm

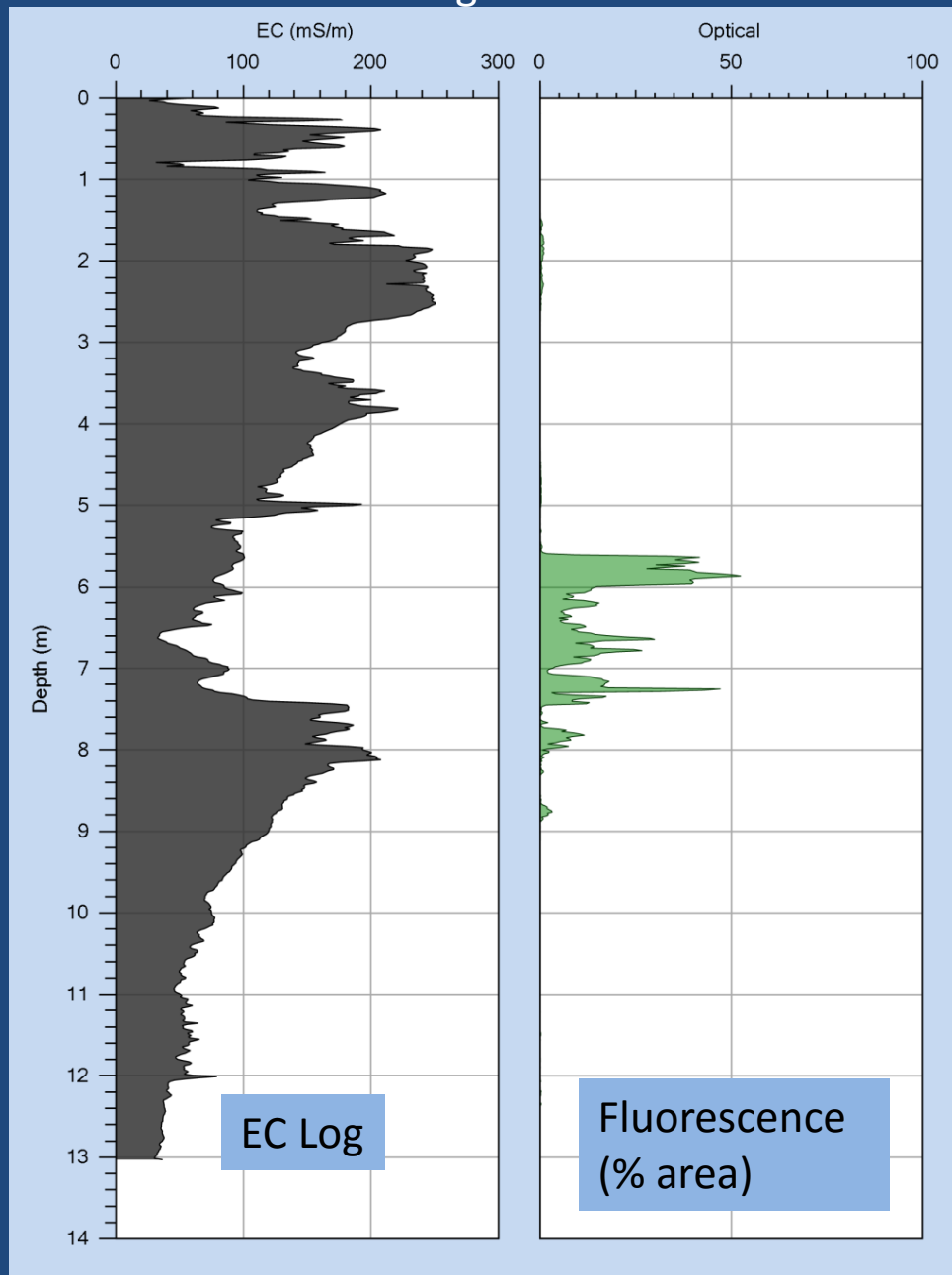


7 mm

Typical OIP image of hydrocarbon fluorescence using the UV light source.



Log 8-1



The OIP Log

- Images captured every 15mm (.05 ft.).
- Images are analyzed for fluorescence in real time.
- The percent of the image area representing fuel fluorescence is recorded on the log.



3.0m
0% detected



5.7m
50.2% detected

High-Resolution Mapping of Petroleum Pipeline Leakage

\$\$ of
Monitoring
Wells

Direction of GW
Gradient

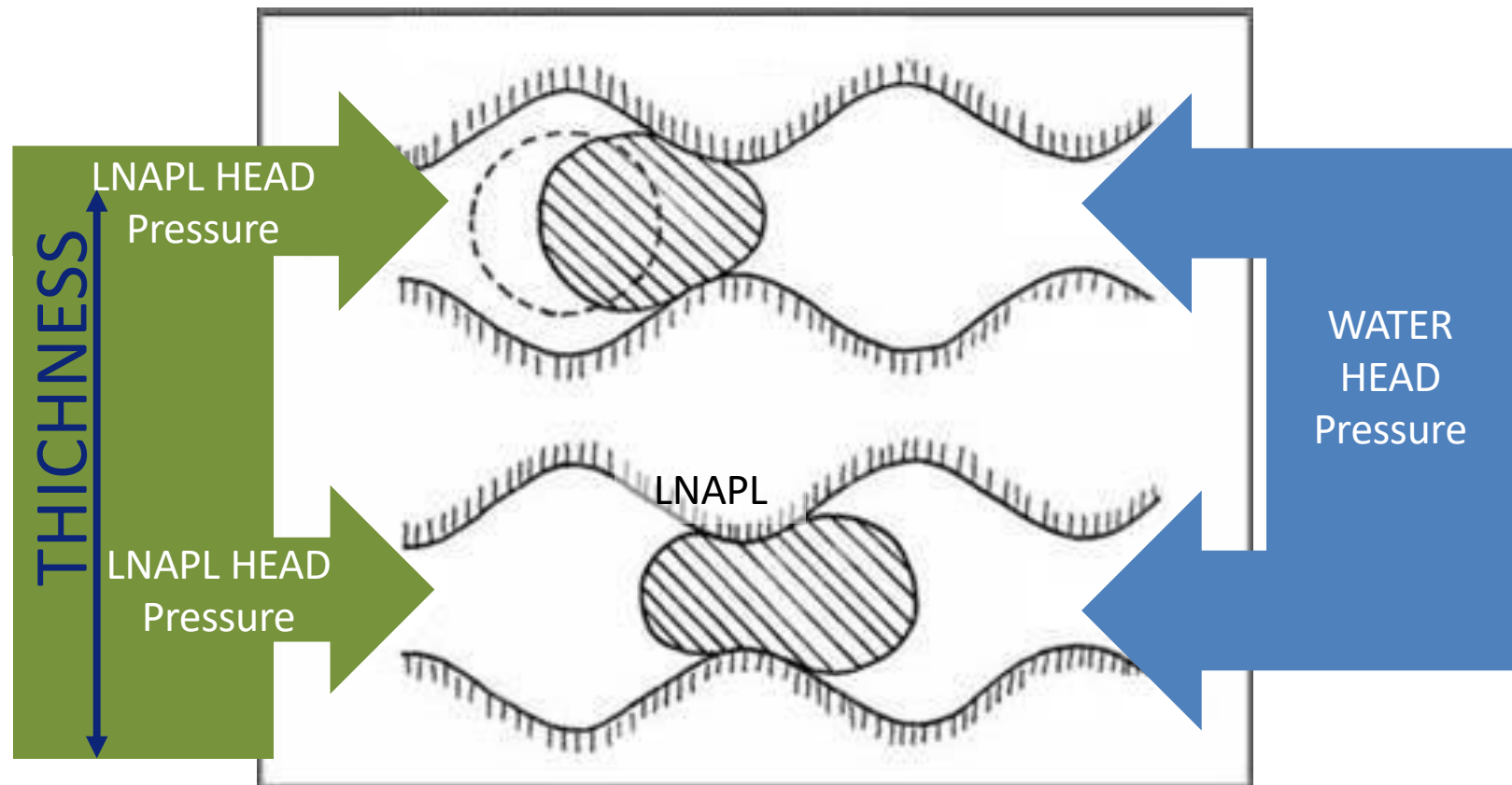
NAPL Distribution

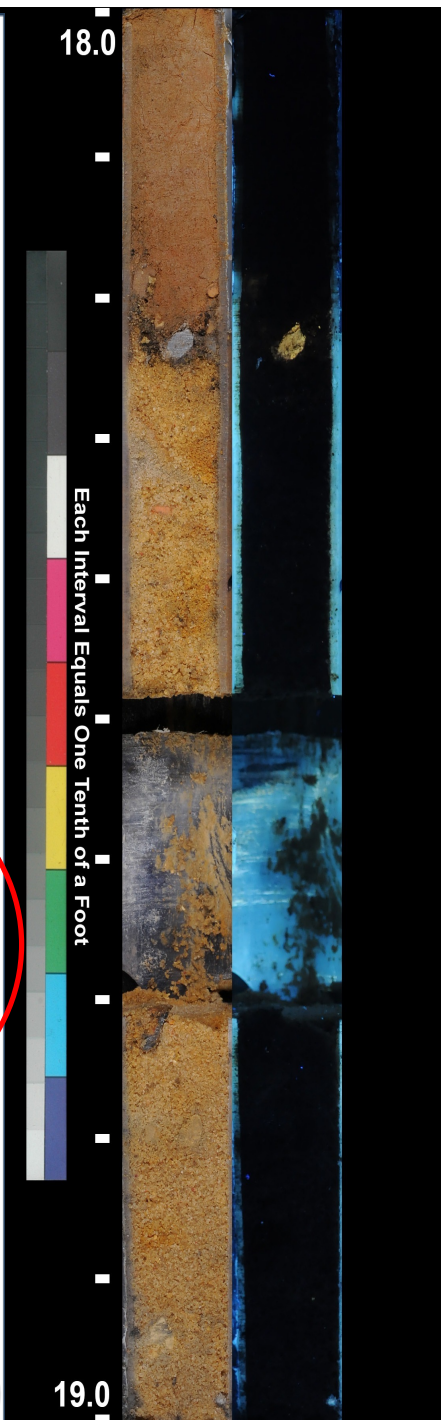
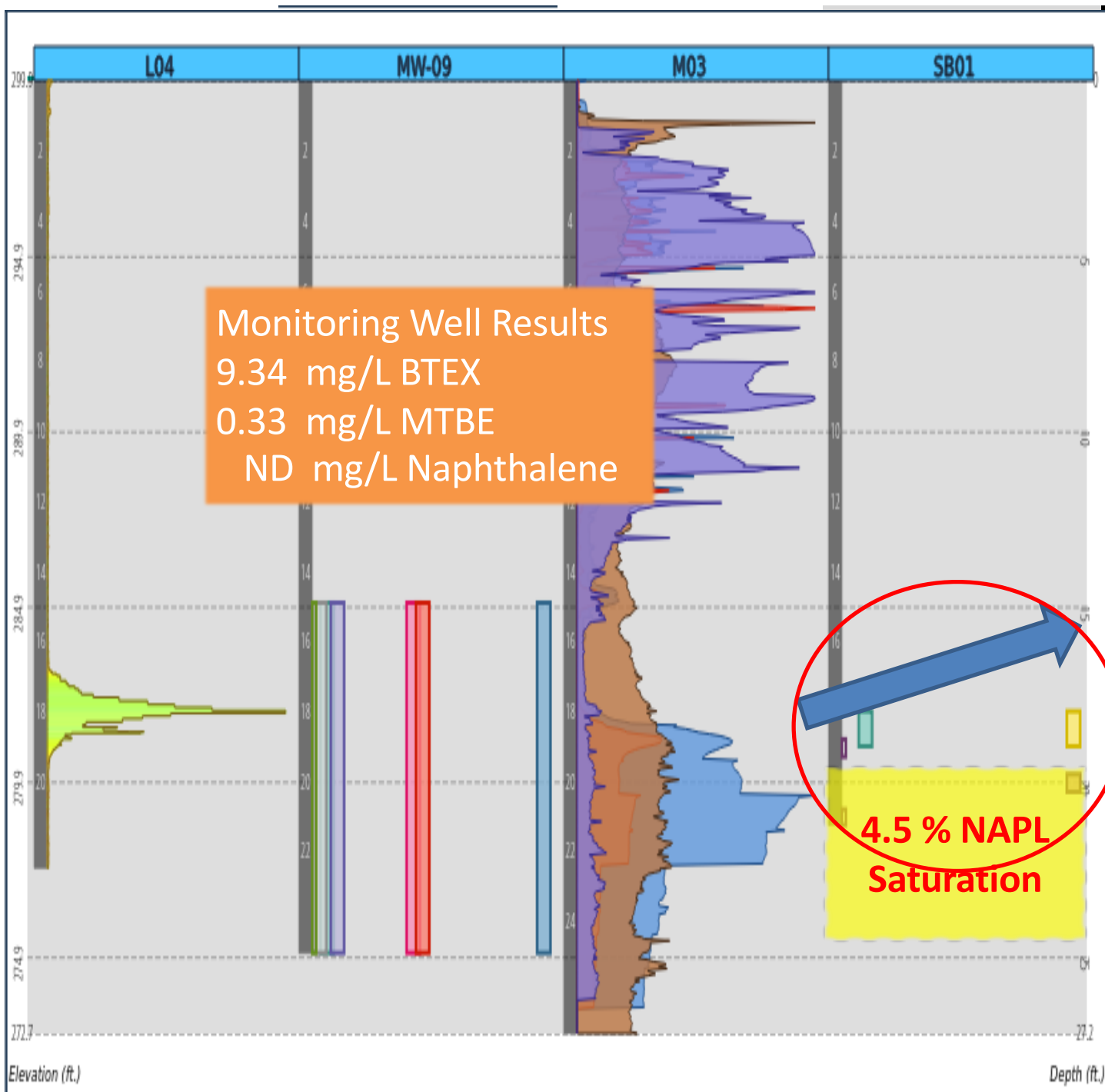
**Petroleum Does Not Follow GW
Gradient**

**Cost-effectively characterize
Contaminated sites**



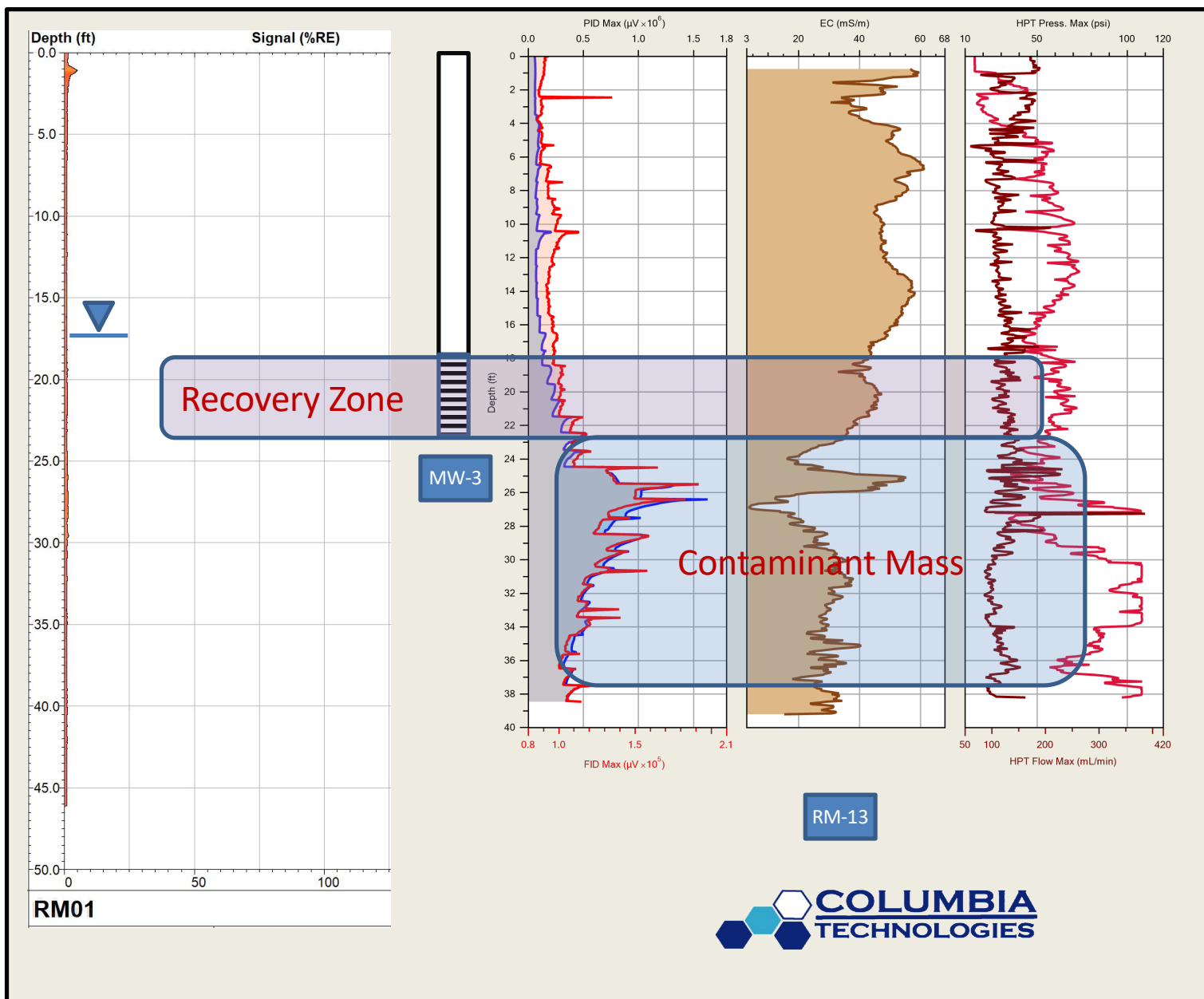
LNAPL Thickness = Pressure Required to Overcome Soil Pore Pressure







SPATIAL ALIGNMENT





THE CRITICAL ROLE OF DISCRETE SATURATED SOIL SAMPLING

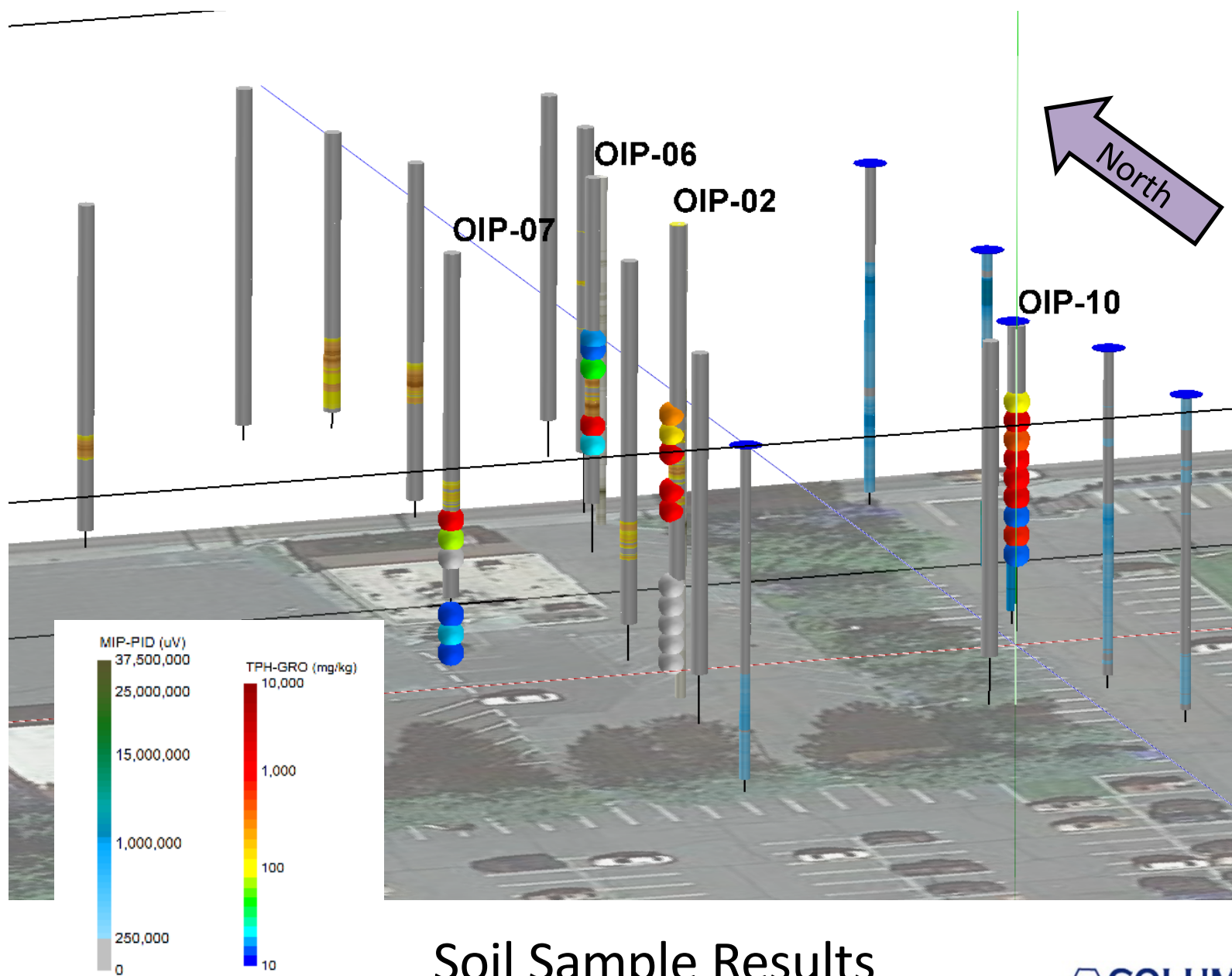


Systematic Screening of Soil

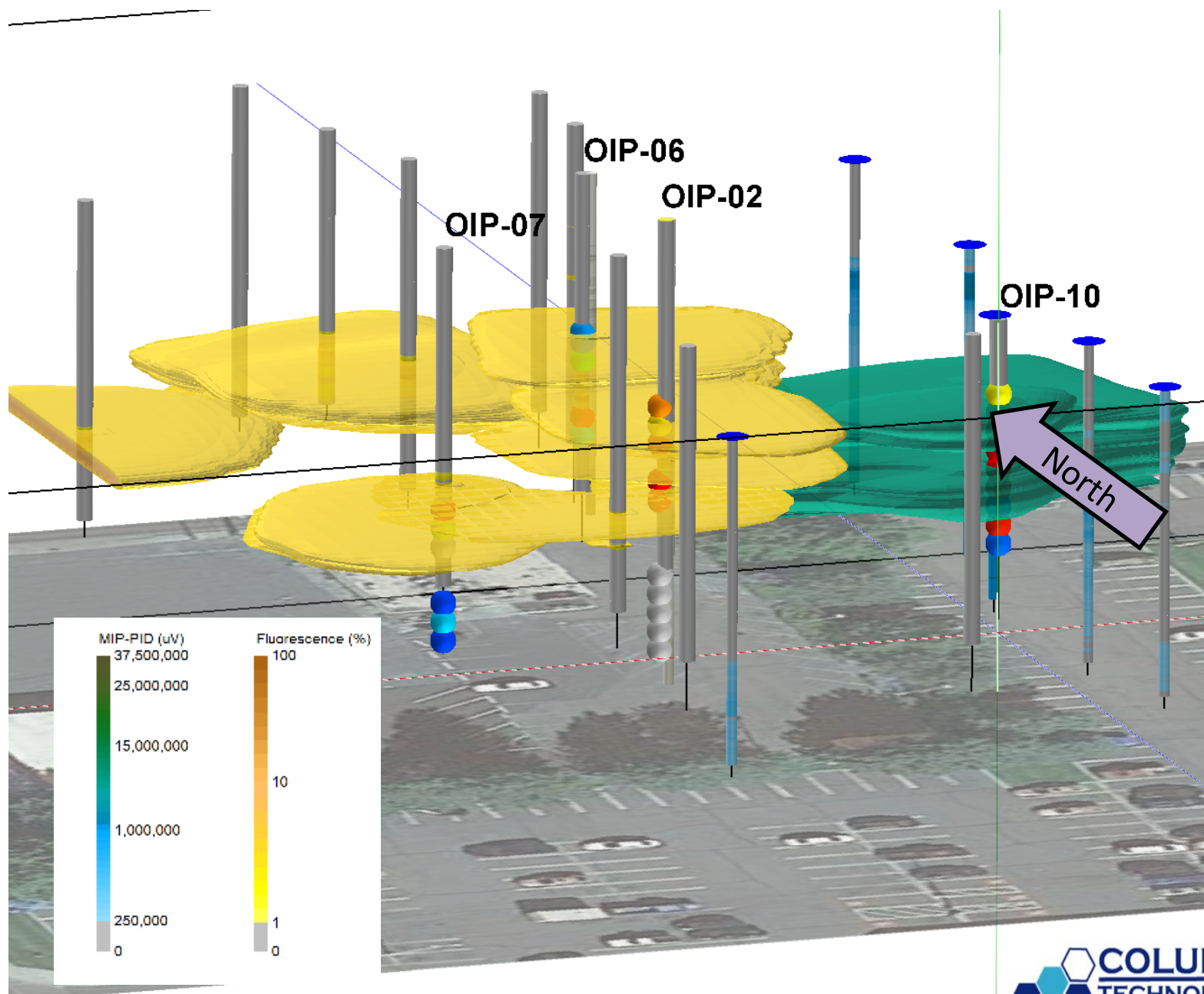




Systematic Sampling

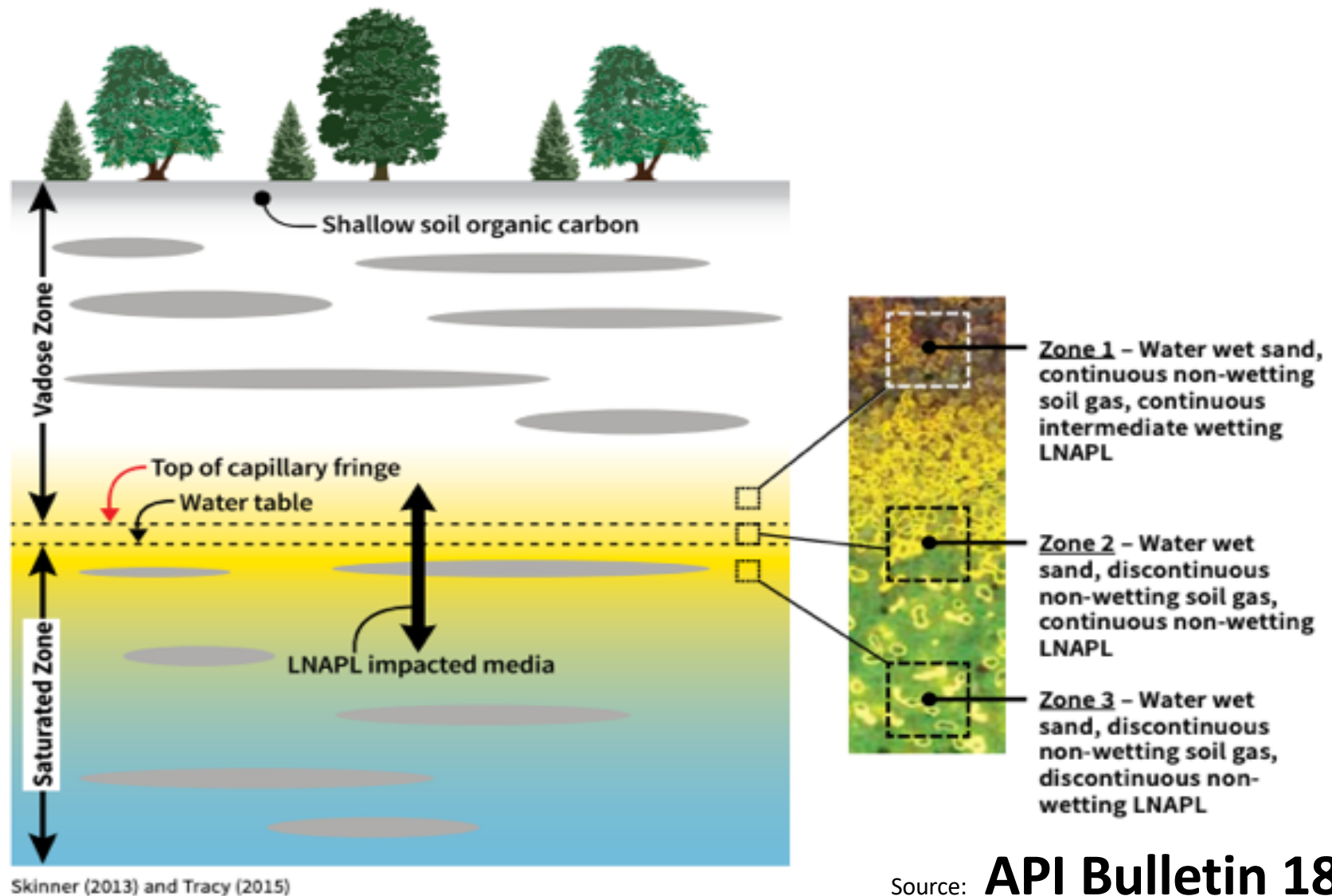


Soil Sample Results



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Source: **API Bulletin 18**

Managing Risk at LNAPL Sites 2nd

May 2018



GROUNDWATER DISSOLVED PHASE CONTAMINATION

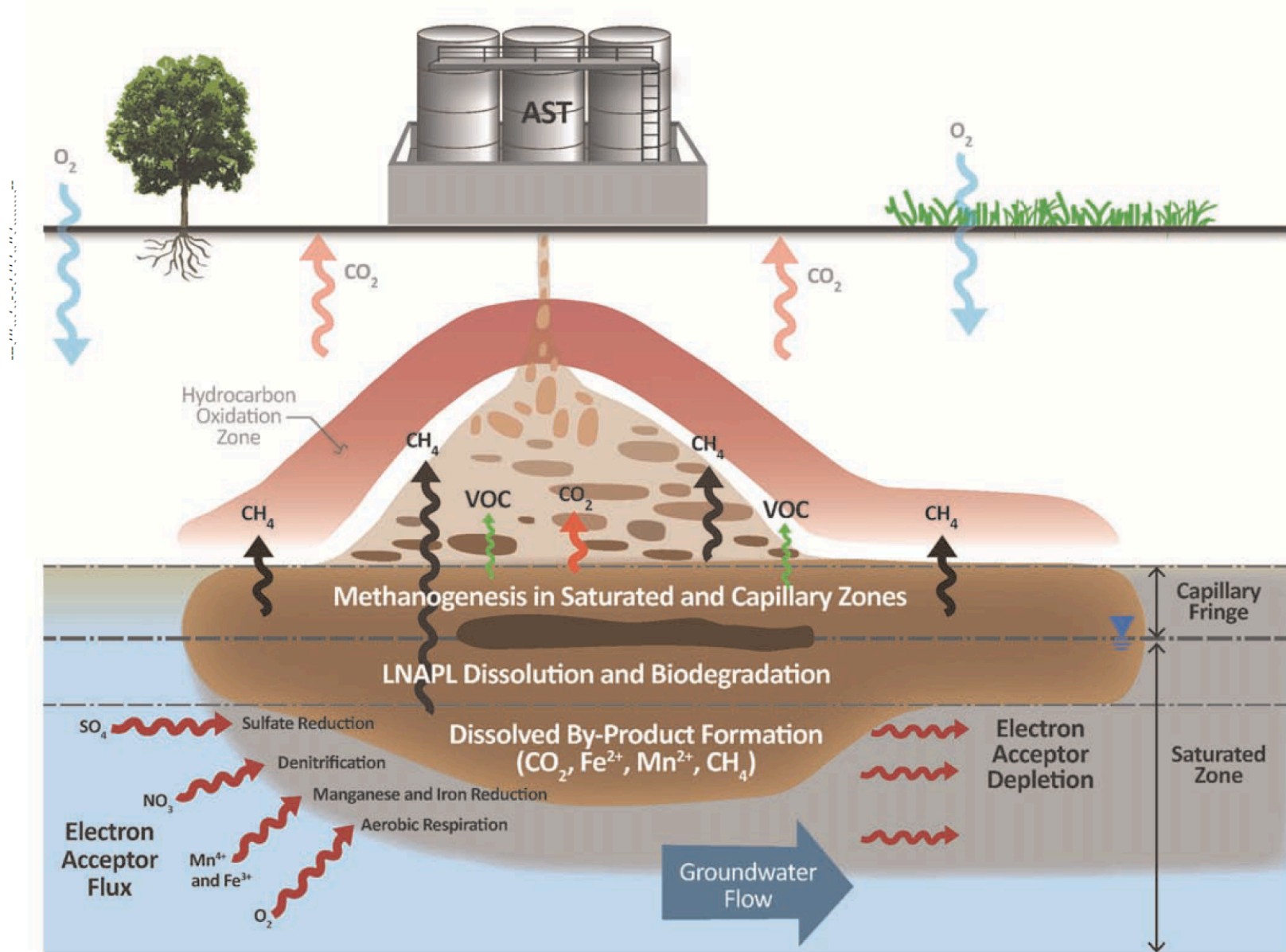
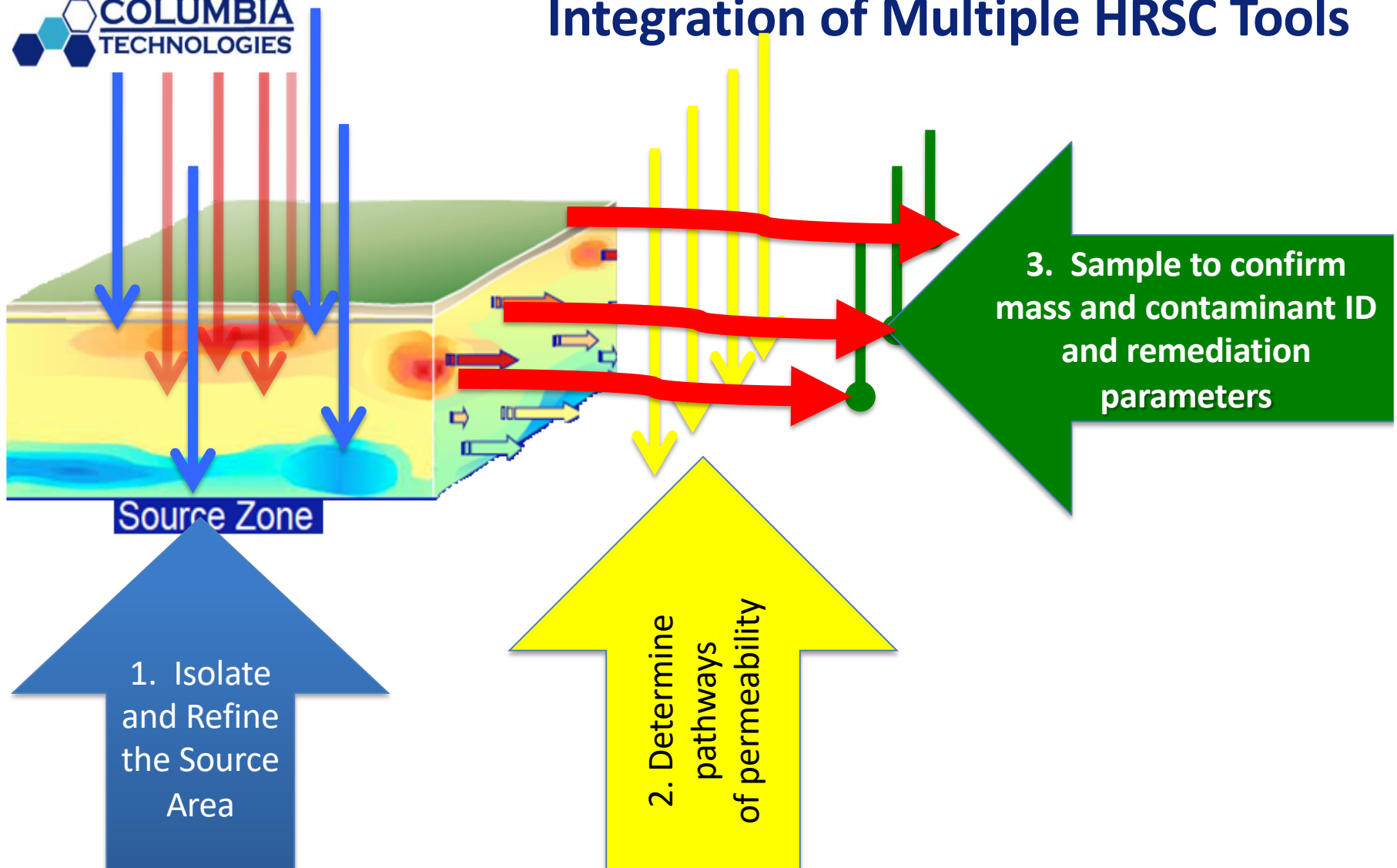


Figure 2-1—Conceptualization of Saturated Zone NSZD Processes

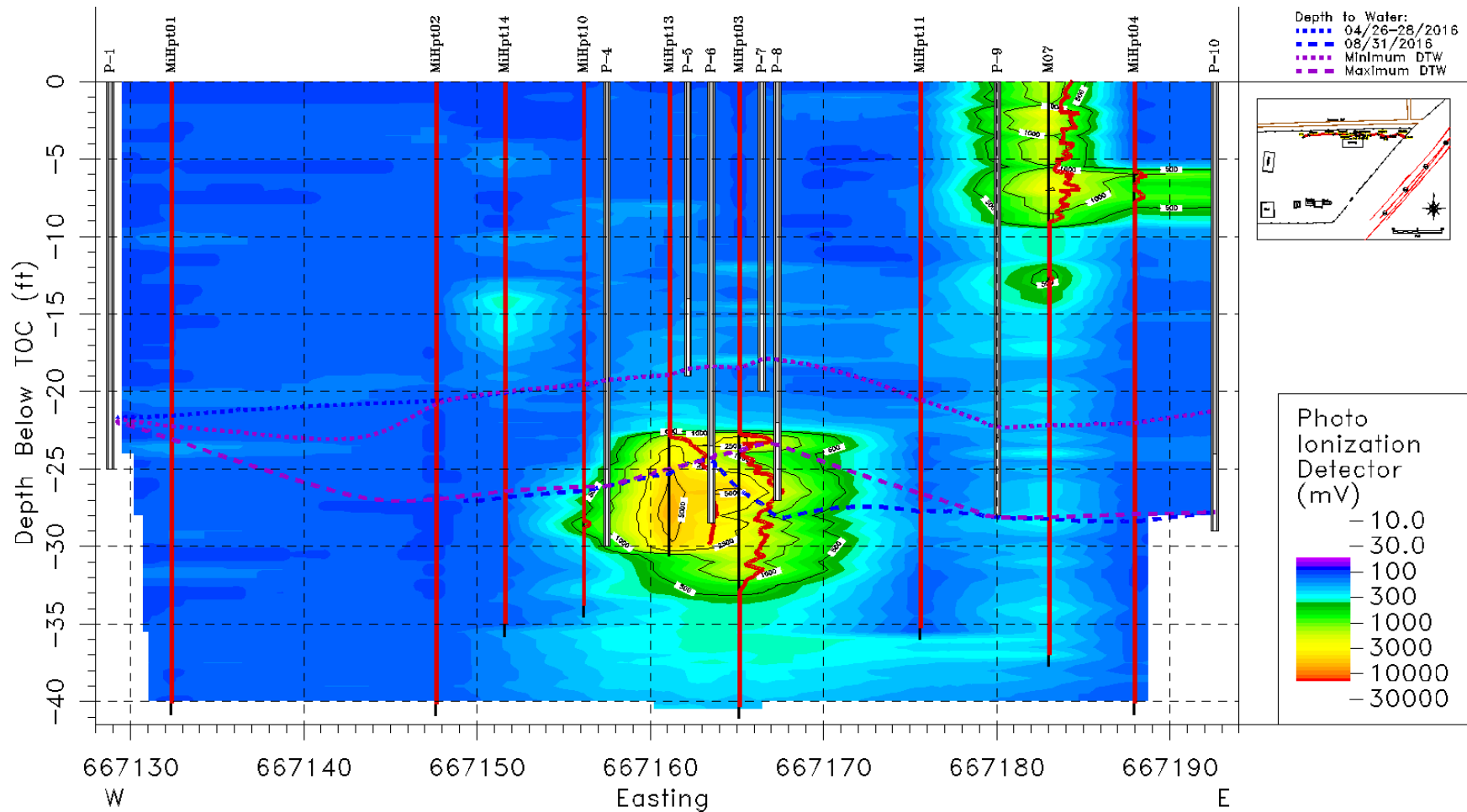


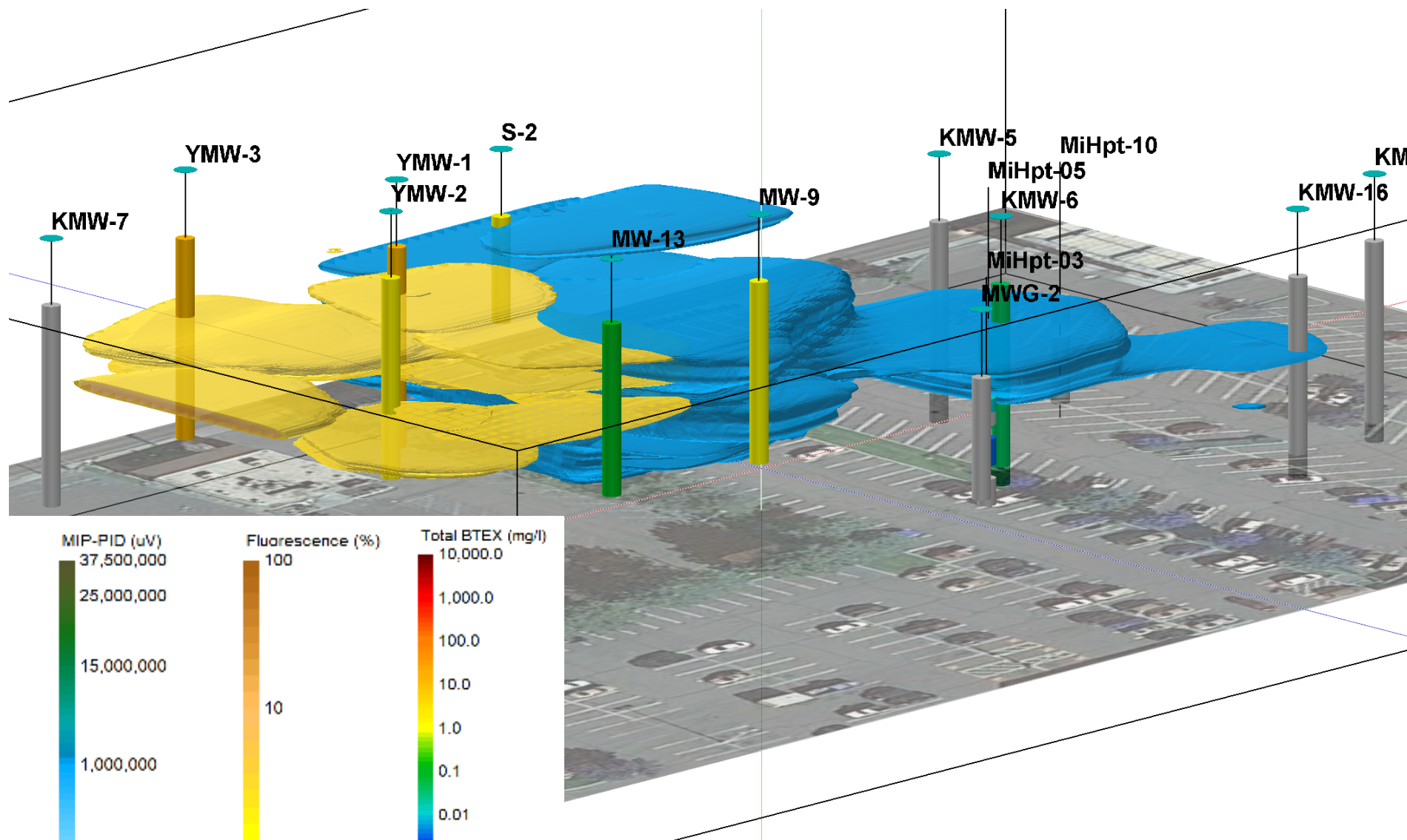
Integration of Multiple HRSC Tools





Mass FLUX Diagram





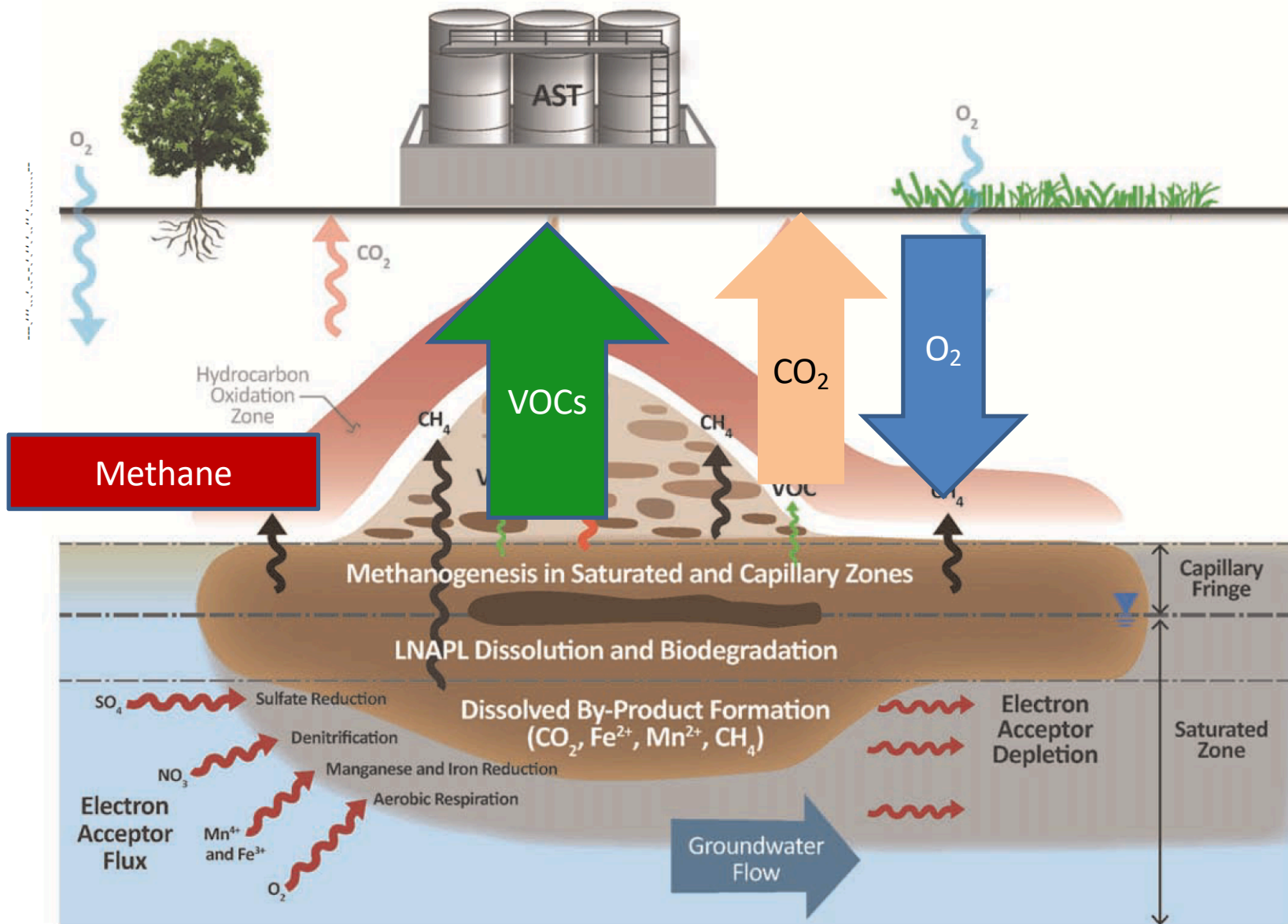
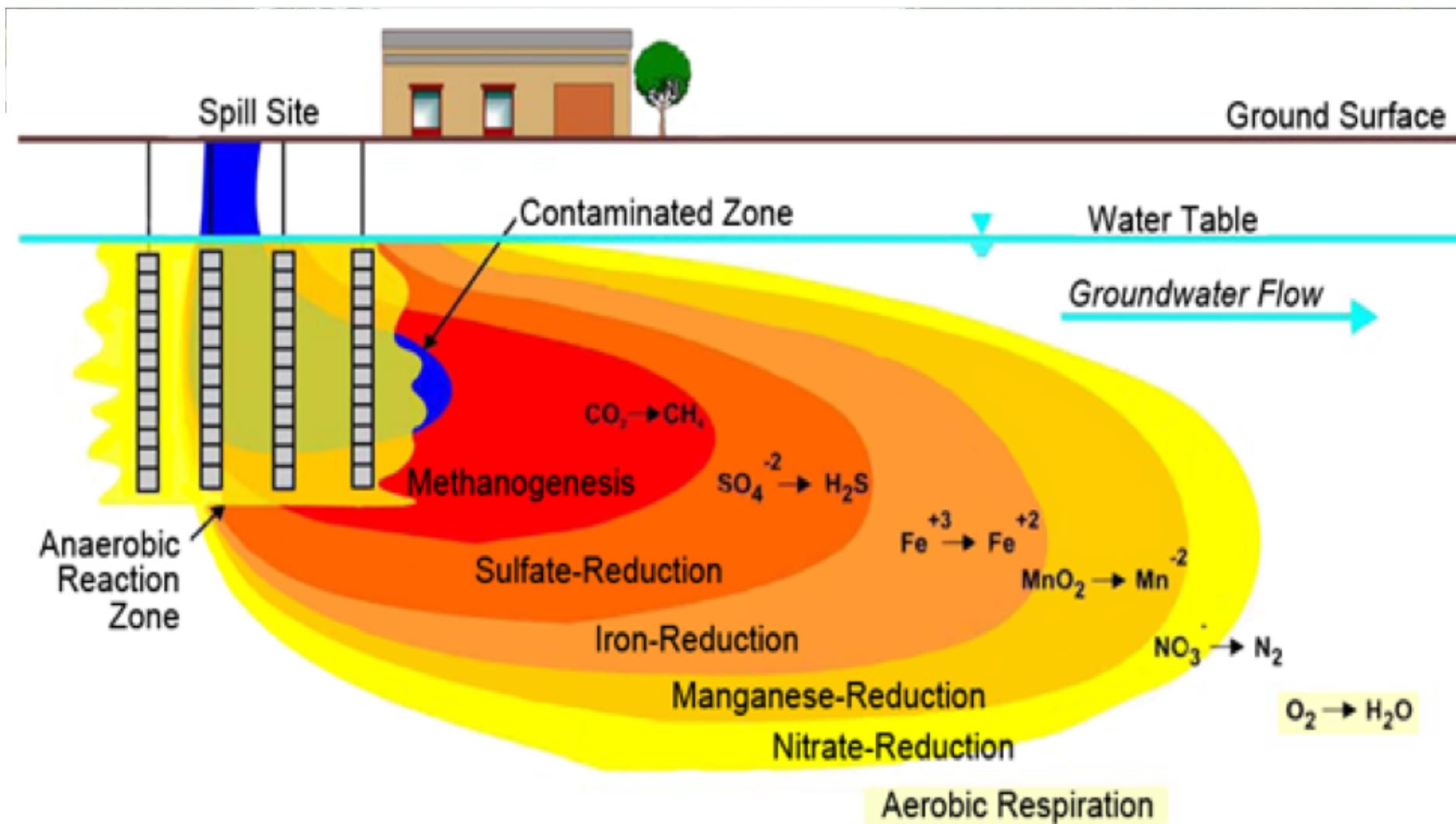



Figure 2-1—Conceptualization of Saturated Zone NSZD Processes



Source: API Bulletin 18 Managing Risk at LNAPL Sites 2nd edition, May 2018



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REAL TIME DATA ACCURATE RESULTS

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Soil Contamination Site

My Site Assessments My Account

Map Report Data Settings Team Members Edit Stations

Labels

283.00 (ft)

Clear Selection Hide Unselected Markers

Disable All

SOIL-LABS DATA

WATER-LABS DATA

LIF DATA

MAGNITUDES

Grouped Individual

OR

CH1 (BLUE) Contour Map %

CH2 (GREEN) Contour Map %

CH3 (ORANGE) Contour Map %

CH4 (RED) Contour Map %

CH5 (PINK) Contour Map %

TOTAL SIGNAL Contour Map % RE

DETECTORS

Select All

CH1 (Blue)

CH2 (Green)

CH3 (Orange)

CH4 (Red)

Total Signal

STATIONS / MAX DETECTOR VALUES

HPT DATA

Selected Sites (1)

Plotting (ft)

Depth (ft)

Value Scale

Individual Collective (selected) Collective (all)

Depth Scale

Individual Collective (selected) Collective (all)

Options

Fill Chart Area Transparency Zoom To Depth Range

Save As Save



Key Takeaway Points

- Remediation of contaminated land is a process with many links (steps) in the **Value Chain**
- You can't skip a step without losing time & money
- Technology is just one piece of the process but not the most expensive piece
- An accurate **Site Conceptual Model** is the critical leverage point to ensure proper cost-effective remediation design and success
- **High-resolution** information is critical to minimizing the uncertainty in the Site Conceptual Model



Partnering for Smarter Sustainable Solutions

THINK.
RESTORE,
Sustainably



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