TAKING THE CONCEPTUAL SITE MODEL & DETERMINING THE REMEDIATION STRATEGY

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NEWMOA
NORTHEAST WASTE MANAGEMENT OFFICIALS' ASSOCIATION

ISOTEC
REMEDIATION TECHNOLOGIES

SUCCESSFUL REMEDIATION

ISOTEC REMEDIATION TECHNOLOGIES

1. **Treatment Area Characterization**
   - Where is contamination?
   - What is contaminant distribution?

2. **Remedial Design**
   - Design remediation based on conceptual site model

3. **Remedial Action**
   - Utilize remediation tools to implement the design

WHAT MAKES A SITE A GOOD CANDIDATE FOR IN-SITU APPROACHES?

ISOTEC REMEDIATION TECHNOLOGIES

- **Most sites are good candidates – there are numerous tools available**
- Are contaminant(s) amenable to in-situ remediation?
- What is subsurface geology?
  - Is soil permeable enough for moving fluid through pore space?
    - Liquids, slurries, or gases
    - Hydraulic conductivity > 10^{-5} cm/s
  - What are options for low hydraulic conductivity soils?
    - Hydraulic fracturing
    - Soil mixing
    - In-situ thermal remediation

IN-SITU REMEDIATION TOOLBOX

ISOTEC REMEDIATION TECHNOLOGIES

Petroleum Hydrocarbons

- Chemical Oxidation
- Enhanced Bioremediation
  - Aerobic (biosparging)
  - Anaerobic
- Injectable Activated Carbon with Treatment Mechanisms
- Surfactant Enhanced Remediation
- Fluid/NAPL recovery
- Thermal Remediation
- In-Situ Stabilization
- Combined Remedies

Chlorinated VOCs

- Chemical Oxidation
- Enhanced In-Situ Dechlorination
  - Anaerobic bioremediation
  - Abiotic dechlorination via reactive iron (ZVI, FeS)
- Injectable Activated Carbon with Treatment Mechanisms
- Thermal Remediation
- Surfactant Enhanced Remediation
- Fluid/NAPL recovery
- In-Situ Stabilization
- Combined Remedies

Metals

- Chemical Reduction
  - Calcium Polysulfide
  - FerroBlack / FeS
- Chemical Fixation (As)
  - Stabilized hydrogen peroxide and added iron

1,4-Dioxane

- Chemical Oxidation
- Combined Remedies
- Thermal Remediation

FEASIBILITY STUDY

- What are the contaminants?
- Impacted area
  - Hot-spot, plume (PRB?)
- Depth of contamination
- Current Site Use / Future Site Use
- Remediation objective / Criteria
- Remediation schedule
- Budget

Technology screening a critical step
(Universe of Possibilities)

FEASIBILITY STUDY (SCREENING)

EFFECTIVENESS	IMPLEMENTABILITY	COST
Advantages	**Advantages**	**Advantages**
• Treatment technology has been shown to be effective in reducing mass of BTEX and chlorinated VOCs. • Treatment is performed in a short time period. • Does not generate large amounts of waste material.	• Easily implemented because remedial actions are limited to oxidant injection and monitoring. • Does not require particular geochemical conditions.	• Capital costs are relatively low. • Does not generate large amounts of waste material requiring disposal.
Disadvantages	**Disadvantages**	**Disadvantages**
• Change in groundwater pH and/or oxidation state can increase mobility of several metals.	• More than one oxidant injections may be required, depending on the oxidant chosen, and based on the elevated concentrations present. • Delivery of injected substrates less effective in lower permeability soils	• Long term monitoring costs required to demonstrate remediation effectiveness.

- Technology screening is a critical step in remedy selection
- Determines what technologies should (& shouldn't) undergo detailed evaluation

REMEDIATION PLANNING QUESTIONS

ISOTEC REMEDIATION TECHNOLOGIES

- **<u>“Is there sufficient understanding to enable Remediation Decision Making?”</u>**
  - Where does remediation need to target?
  - Is the Conceptual Site Model adequately developed?
  - Should bench-scale and/or pilot-scale testing be performed?

- **Characterization resolution required for remediation <u>is higher</u> than for delineation**
  - Delineation checks if contamination is present
  - Remediation needs to understand how to contamination

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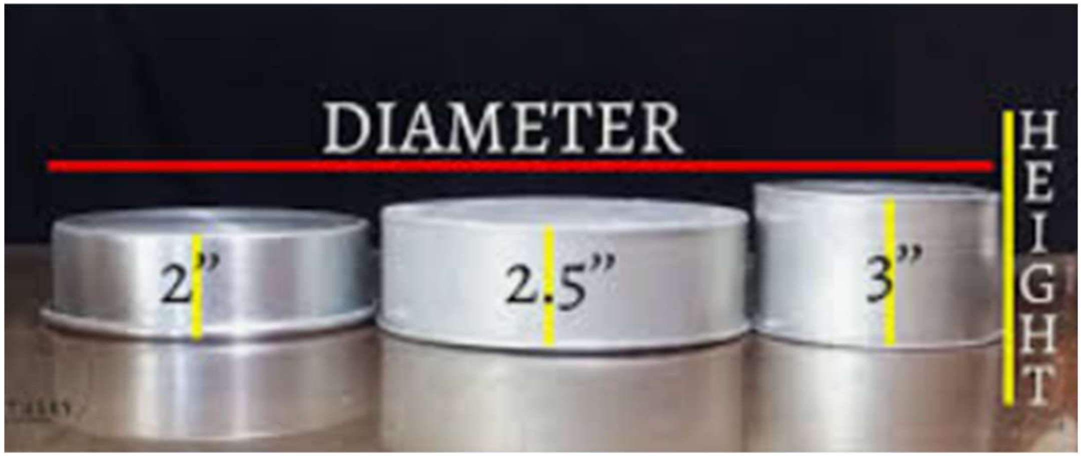
REMEDIATION CHARACTERIZATION

ISOTEC REMEDIATION TECHNOLOGIES



- Delineation tells how big the cake is
- Remediation characterization tells what is inside the cake to know how to eat it

CHARACTERIZATION RESOLUTION

ISOTEC REMEDIATION TECHNOLOGIES

- Most data is groundwater
  - 10’ screens common
- Soil data often old and 1 or 2 intervals per boring
- Contaminant concentrations can vary orders of magnitude over small intervals

Depth	SB-19	SB-20	SB-21	SB-23	SB-24	SB-26	SB-27	SB-28	SB-30	SB-31	SB-32	SB-33	SB-34	SB-35	SB-36	SB-39	
23			3,370			14,000			3,420								
24	219		ND	1,650		ND						5,760			258		
25		ND	7,180				9,390	214	17,000	4,500	7,050		643	789		4,650	GW High
26	ND		32,200	6,770	5,460	4,030	62,100					15,000					
27		13,900						ND	6,440	ND	7,720	28,200	13,700	14,300	218	ND	GW Avg
28	5,830	ND	2,370	1,480	473	ND	111	ND		28,600					1,610	1,510	
29	153			ND				137	165	12,600	6,500	753	9,330	82		ND	GW Low
30		2,910	258			104							ND			3,170	
31				25,900	ND		412				248	ND	3,060	ND	ND	306	
32		94								ND				5,590		498	
33				270			82						ND				
34				137	729						ND			333		ND	
35																	
36					118									ND			

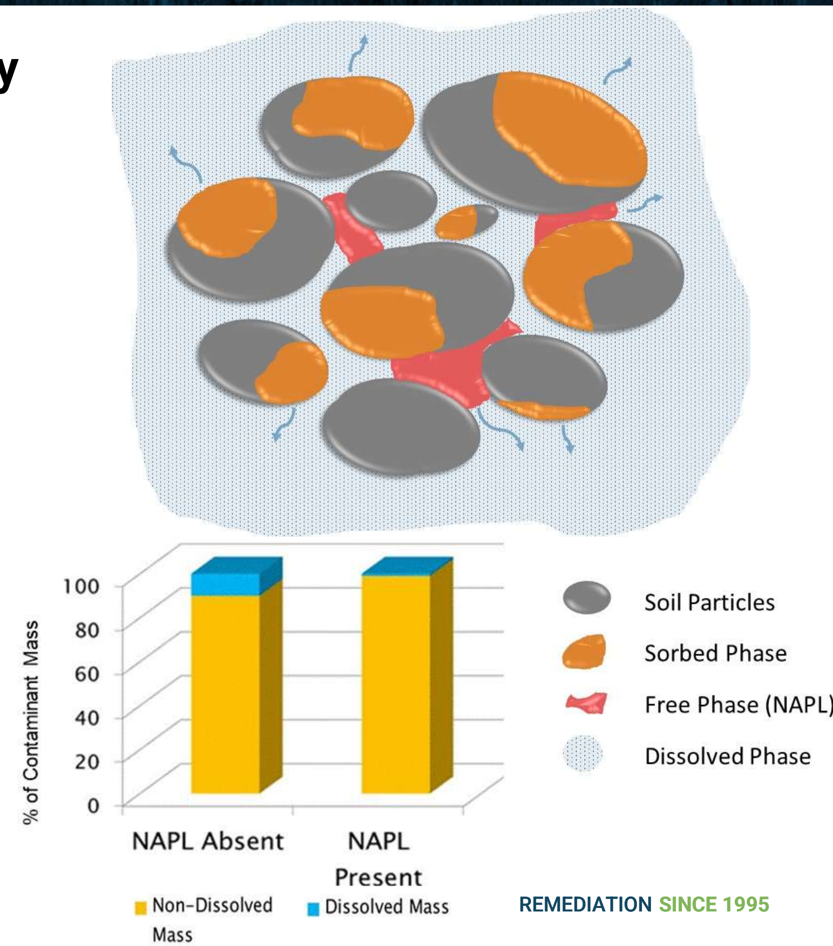
- Goal is to develop a surgical remediation plan

Source: RPI Group

CONTAMINANT PHASE DISTRIBUTION

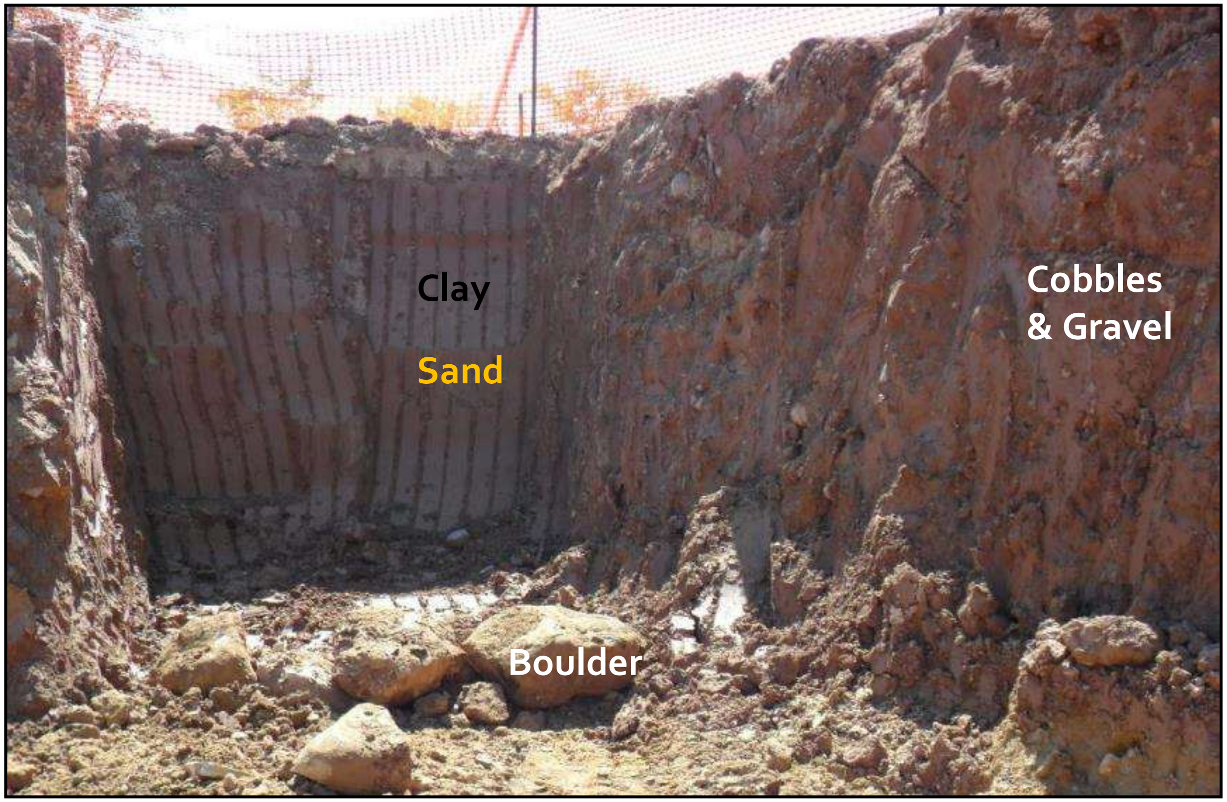
- Many in-situ remediation technologies react directly with aqueous phase contamination

- Most contaminant mass Not in Aqueous Phase
  - Sorbed to Soil
  - NAPL
  - Long term source / source of rebound



HETEROGENEITY

- Many models and equations assume homogenous and isotropic



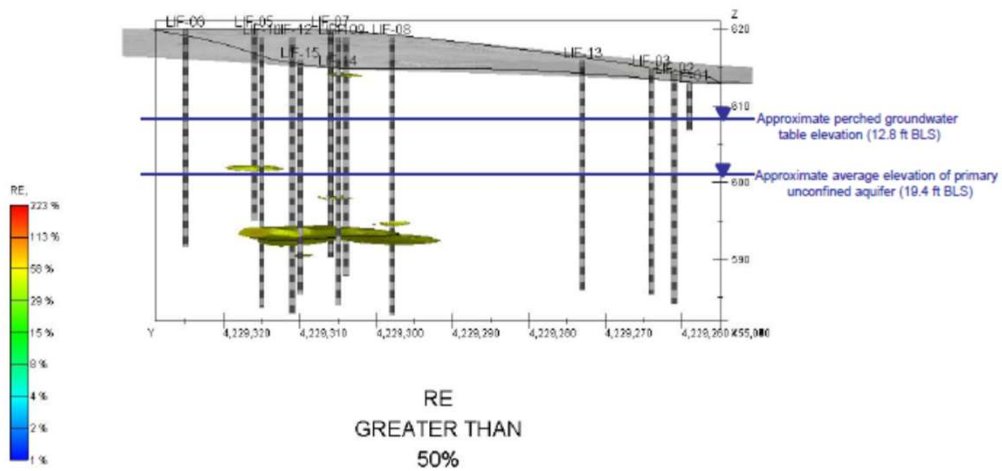
10’ x 10’ x 10’ test pit

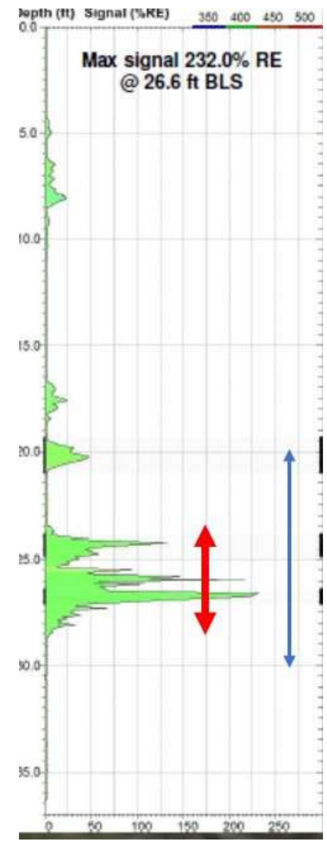
FOLLOW THE CONTAMINANT, NOT THE SAMPLE

ISOTEC REMEDIATION TECHNOLOGIES

- ISCO requested for 10’ injection interval (20-30’) corresponding to MW intervals
- Silty sands and clays
- Targeted Remediation based on Collaborative Data
  - High permeability pebble lens at ~25’ bgs
  - Correlates to highest

    LNAPL detection in LIF

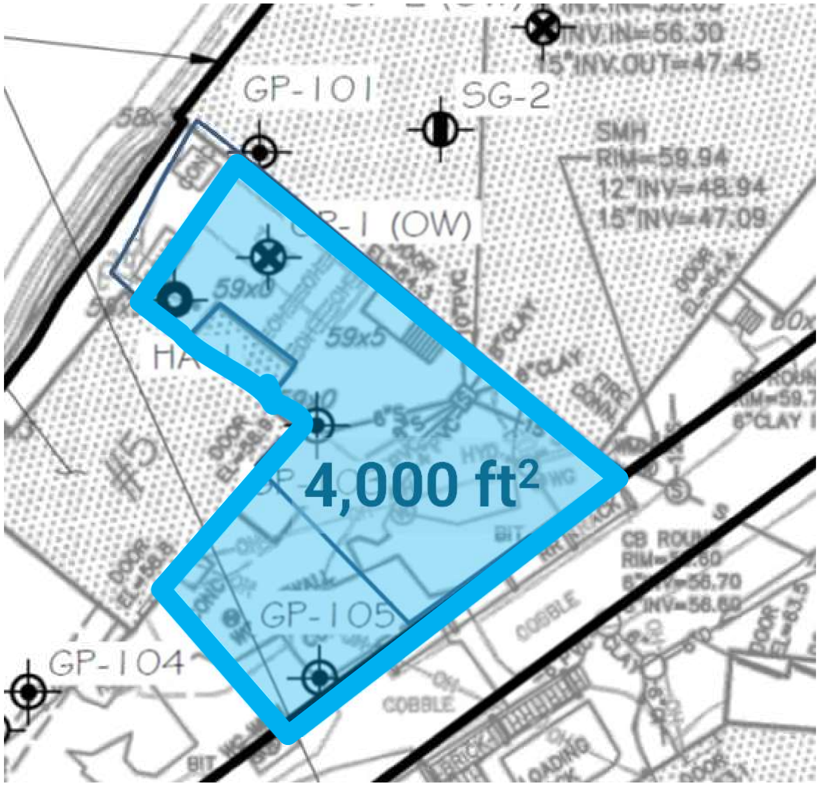




REMEDIAL DESIGN CHARACTERIZATION CASE STUDY

ISOTEC REMEDIATION TECHNOLOGIES

- Redevelopment at Former Mill Facility
- Groundwater and Soil Impacted by PCE and TCE
- Site Soils
  - Fill (sand, gravel, brick, wood) – top 5-10 feet
  - Organic deposit (silt & sand) – to 12-15’ bgs
  - Outwash beneath organic deposit
- Preliminary Treatment Plan
  - 4,000 square feet
  - Injection Interval: 7-15’ bgs
  - Focus on fill and organic deposit
  - Based on limited, historic information

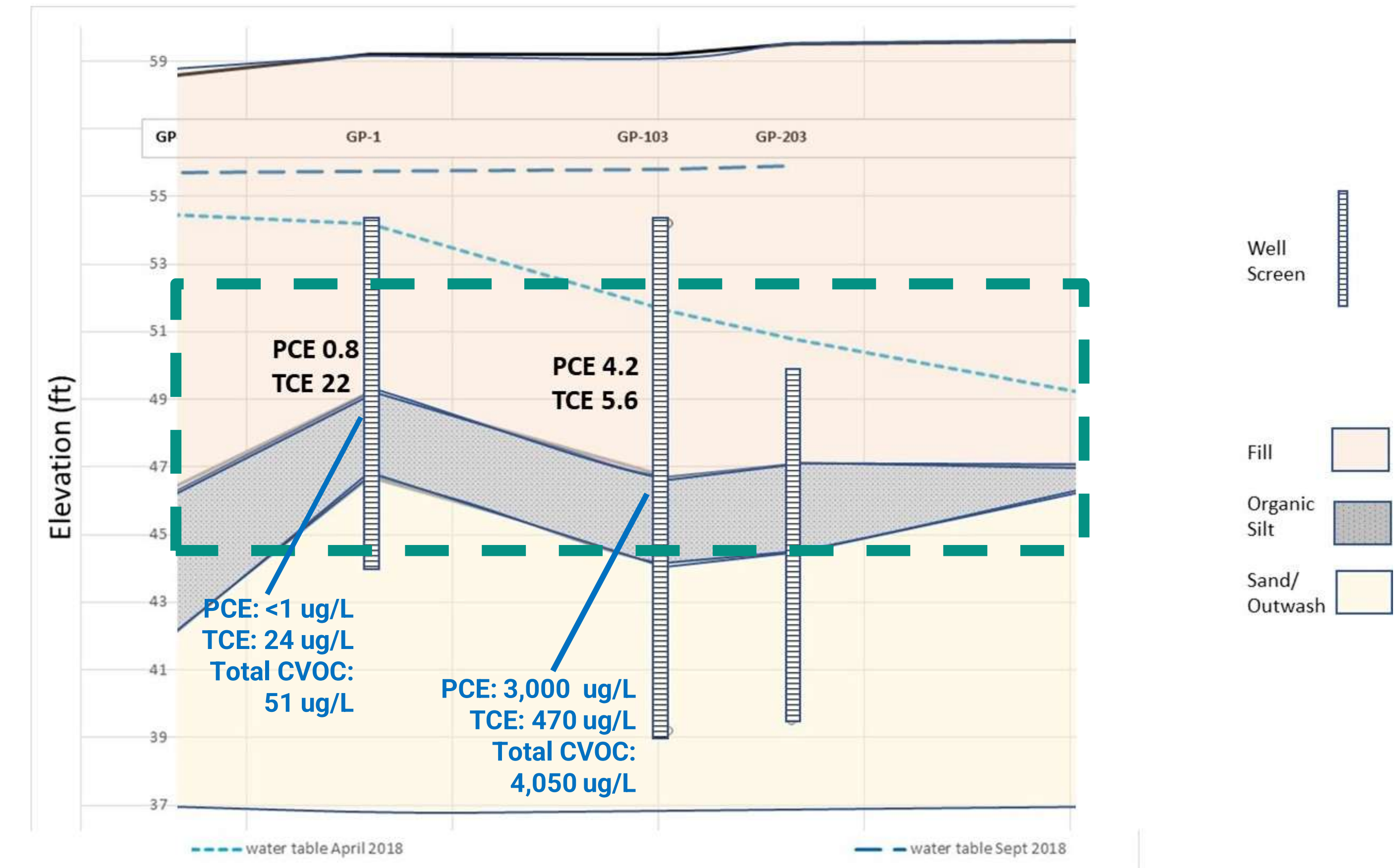


REMEDIAL DESIGN CHARACTERIZATION CASE STUDY

- Preliminary Treatment Plan

- Based on 2 monitoring wells & 1 soil sample at each boring
  - Soil concentrations (mg/kg)

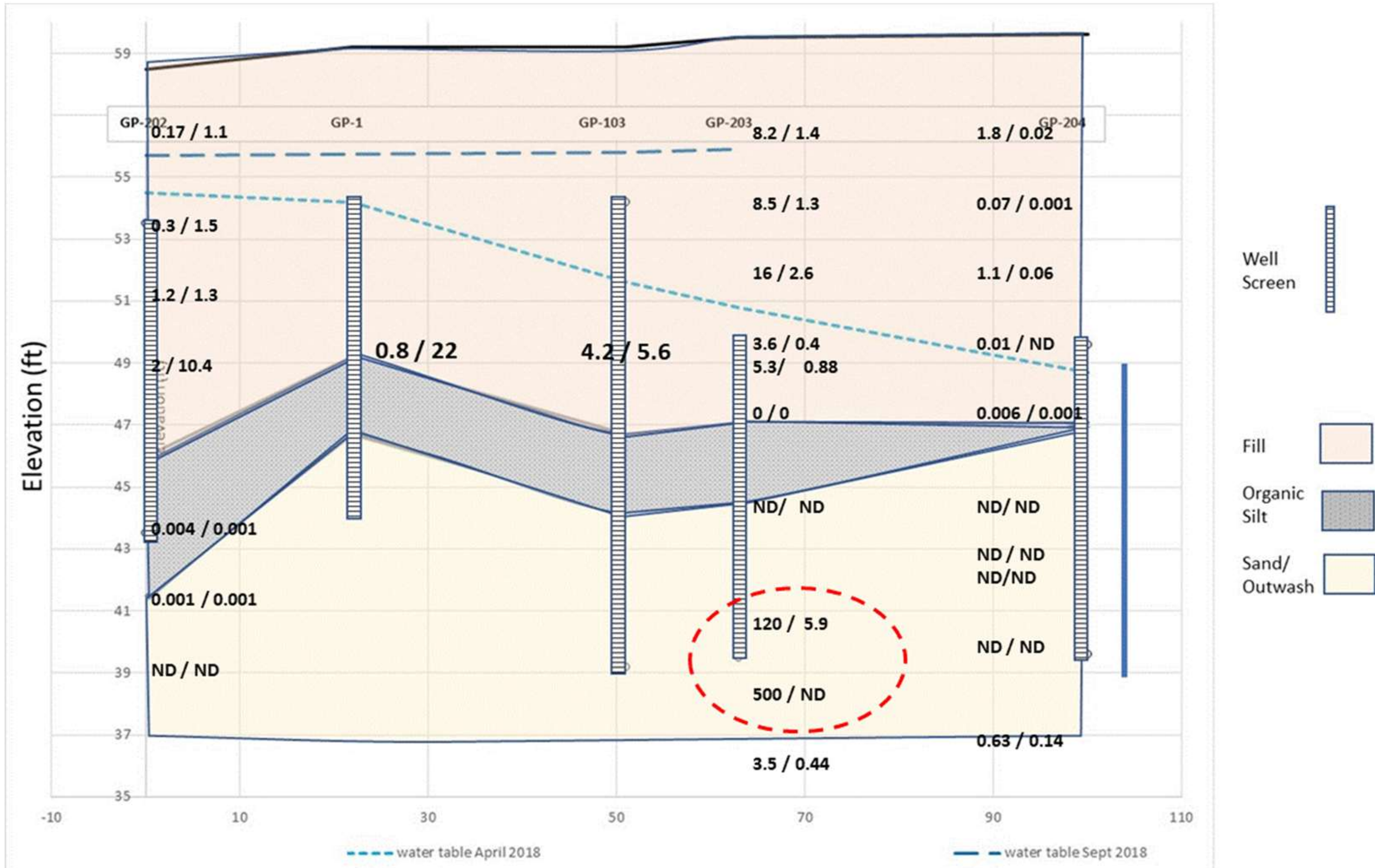
- Focus on fill and organic silt



REMEDIAL DESIGN CHARACTERIZATION CASE STUDY

ISOTEC REMEDIATION TECHNOLOGIES

- 6 additional soil borings
- Soil samples collected every 2.5'
  - PCE / TCE soil concentration (mg/kg)



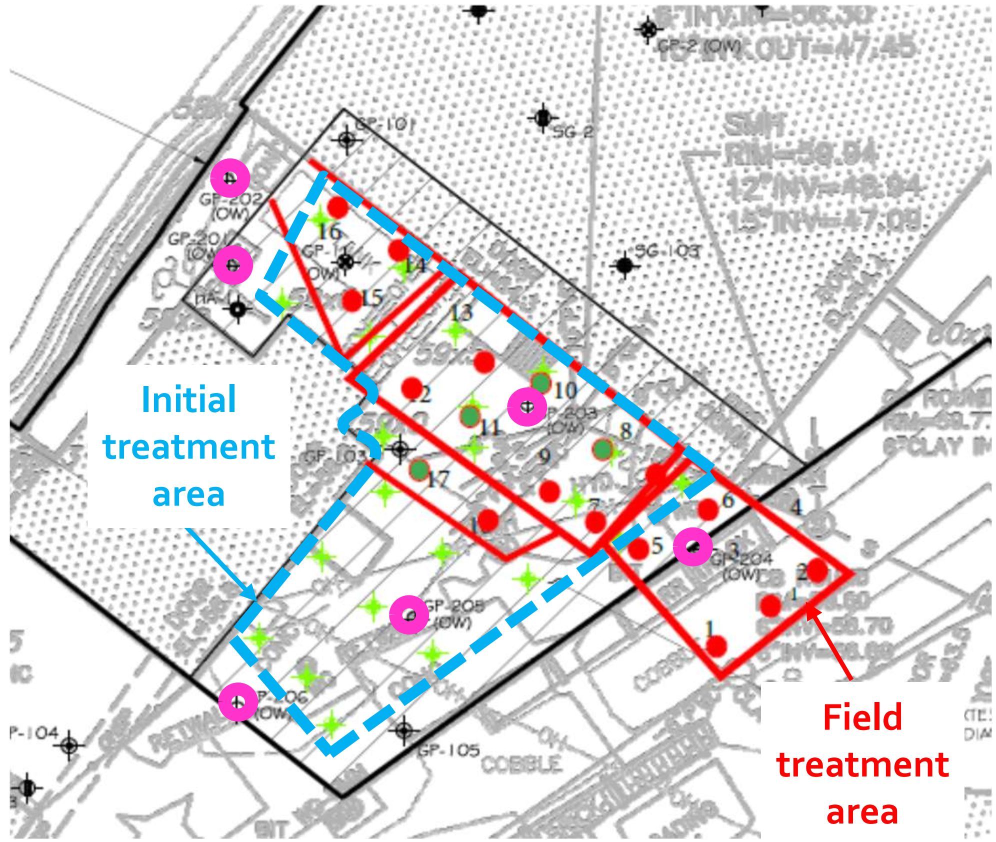
REMEDIAL DESIGN CHARACTERIZATION CASE STUDY

ISOTEC REMEDIATION TECHNOLOGIES

- Remedial Design Characterization
  - 6 borings/monitoring wells (pink dots)
  - Soil samples every ~2.5 feet

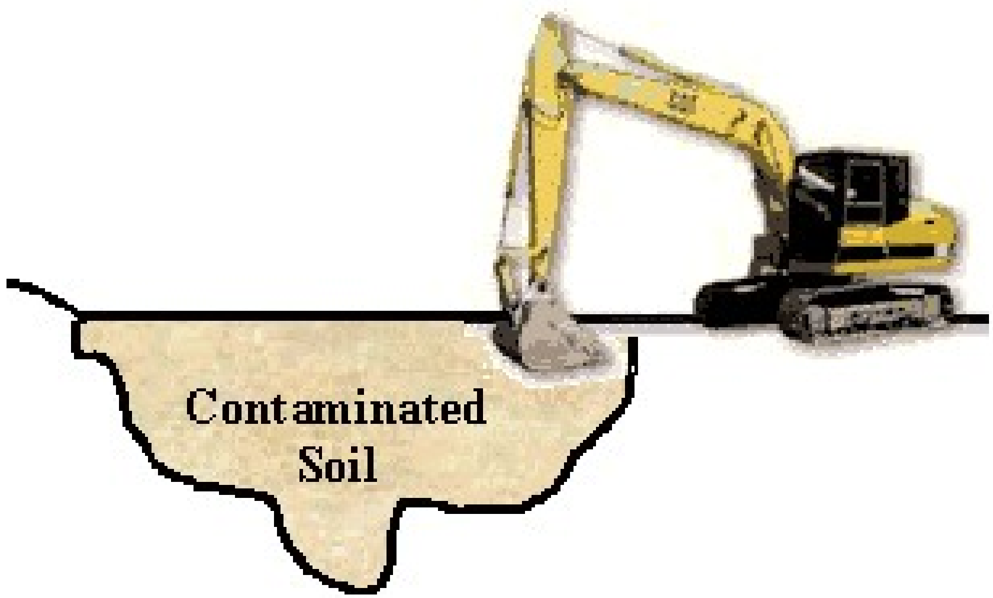
- Remedial Design Modification
  - Smaller treatment area (2,750 sf vs 4,000 sf)
  - Added treatment area to south
  - Deeper Treatment Interval (6-21' bgs)
  - Similar overall treatment volume (and cost)

- <u>Apply remediation where it is needed!</u>



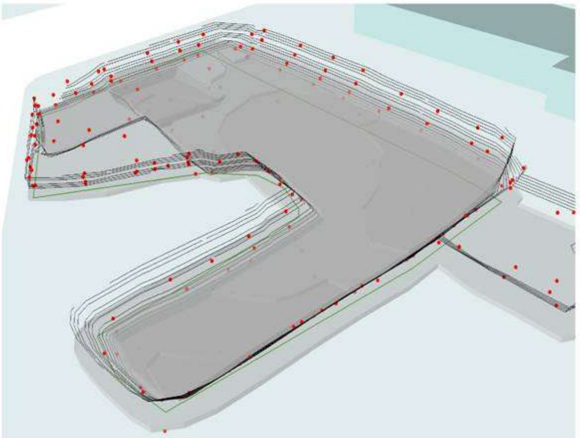
REMEDIATION EXCAVATION

- Physical removal of contaminated material (soil, sediment)
  - Can also remove tanks, drums, pipes
- Readily available equipment
- Widely accepted technology
- Relatively fast implementation



REMEDIATION EXCAVATION

- When Might "Dig & Haul" Be the Best Option?
  - Schedule
  - Accessible
  - Shallow
  - Unsaturated soil
  - Well-delineated contamination
  - Excavation as part of redevelopment



REMEDIATION EXCAVATION

ISOTEC REMEDIATION TECHNOLOGIES

- When Might "Dig & Haul" NOT Be the Best Option?
  - Subsurface Utilities
  - Depth
  - Adjacent Buildings
  - Contamination below water table
  - Receptors
  - Disposal options/cost
  - Regulatory preference for destruction

Mitigations

Benching

Requires shoring

Dewatering

Odor/dust control

MONITORED NATURAL ATTENUATION (MNA)

ISOTEC REMEDIATION TECHNOLOGIES

- Natural attenuation relies on natural processes to decrease or attenuate" contaminants in soil and groundwater *<u>without human intervention</u>*.
  - Biodegradation, dispersion, dilution, sorption, volatilization, chemical reaction, or transformation.
- Monitored natural attenuation involves collecting soil and groundwater samples to assess contaminant concentrations and other site characteristics.
  - **<u>MNA is not a "do nothing" alternative</u>**

A Citizen's Guide to Monitored Natural Attenuation

EPA

What Is Monitored Natural Attenuation?

Natural attenuation relies on natural processes to decrease or "attenuate" concentrations of contaminants in soil and groundwater. Scientists monitor these conditions to make sure natural attenuation is working. Monitoring typically involves collecting soil and groundwater samples to analyze them for the presence of contaminants and other site characteristics. The entire process is called "monitored natural attenuation" or "MNA." Natural attenuation occurs at most contaminated sites. However, the right conditions must exist underground to clean sites properly and quickly enough. Regular monitoring must be conducted to ensure that MNA continues to work.

How Does It Work?

When the environment is contaminated with harmful chemicals, nature may work in five ways to clean it up:

- *Biodegradation* occurs when very small organisms, known as "microbes," eat contaminants and change them into small amounts of water and gases during digestion. Microbes live in soil and groundwater and some microbes use contaminants for food and energy. (*A Citizen's Guide to Bioremediation* [EPA 542-F-12-003] describes how microbes work.)

- *Sorption* causes contaminants to stick to soil particles. Sorption does not destroy the contaminants, but it keeps them from moving deeper underground or from leaving the site with groundwater flow.
- *Dilution* decreases the concentrations of contaminants as they move through and mix with clean groundwater.
- *Evaporation* causes some contaminants, like gasoline and industrial solvents, to change from liquids to gases within the soil. If these gases escape to the air at the ground surface, air will dilute them and sunlight may destroy them.
- *Chemical reactions* with natural substances underground may convert contaminants into less harmful forms. For example, in low-oxygen environments underground, the highly toxic "chromium 6" can be converted to a much less toxic and mobile form called "chromium 3" when it reacts with naturally occurring iron and water.

MNA works best where the source of contamination has been removed. For instance, any waste buried underground must be dug up and disposed of properly, or removed using other available cleanup methods. When the source is no longer present, natural processes may be able to remove the remaining, smaller amount of contaminants in the soil or groundwater. The site is monitored regularly to make sure that contaminants attenuate fast enough to meet site cleanup objectives and that contaminants are not spreading.

How Long Will It Take?

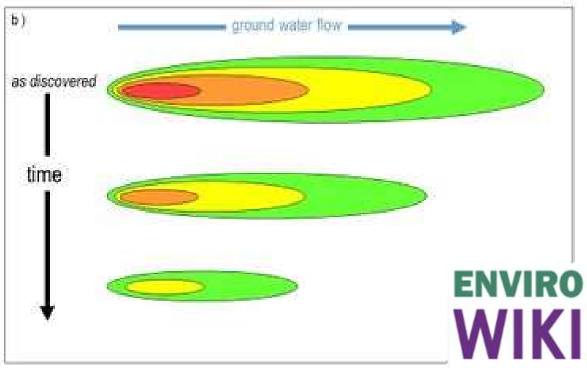
MNA may take several years to decades to clean up a site. The actual cleanup time will depend on several factors. For example, cleanup will take longer when:

- Contaminant concentrations are higher.
- The contaminated area is large.
- Site conditions (such as temperature, groundwater flow, soil type) provide a less favorable environment for biodegradation, sorption or dilution.

These factors vary from site to site.

MONITORED NATURAL ATTENUATION

- Natural attenuation occurs at most contaminated sites (to some extent)
  - Do the right conditions exist?
- Existing trend
- Biodegradation



Evolution of a plume when the source and concentrations in groundwater both attenuate.

MONITORING PARAMETERS – WHAT TO LOOK FOR?

- Contaminant(s) of concern
- Contaminant Reaction Products
  - Reductive Dechlorination:
    - Lesser chlorinated daughter products
    - ethene & ethane
  - Petroleum: CO_2, CH_4
- Target bacteria
- ***YSI Parameters***
  - ***DO, pH, ORP, specific conductivity, temperature***
- Electron acceptors (for bioremediation/MNA)
  - Nitrate, Mn, Fe, sulfate

Water quality field parameters (pH, DO, ORP)
ARE REALLY IMPORTANT!

RECOMMENDED RESOURCES

ISOTEC REMEDIATION TECHNOLOGIES

- ENVIRO WIKI https://enviro.wiki/index.php?title=Main_Page
- SERDP ESTCP https://serdp-estcp.mil/
- CLU-IN https://clu-in.org/remediation/
- EPA Citizen's Guide to Excavation of Contaminated Soils
  https://semspub.epa.gov/work/HQ/189970.pdf
- EPA Citizen's Guide to Natural Attenuation
  https://clu-in.org/download/Citizens/a_citizens_guide_to_monitored_natural_attenuation.pdf
- USGS A Framework for Assessing the Sustainability of Monitored Natural Attenuation
  https://pubs.usgs.gov/circ/circ1303/pdf/circ1303.pdf

THANK YOU

ISOTEC
REMEDIATION TECHNOLOGIES

Chemical Oxidation & Surfactant Injections

Bioremediation

Activated Carbon Injectates

Soil Mixing

Metals Remediation

Bedrock Injections

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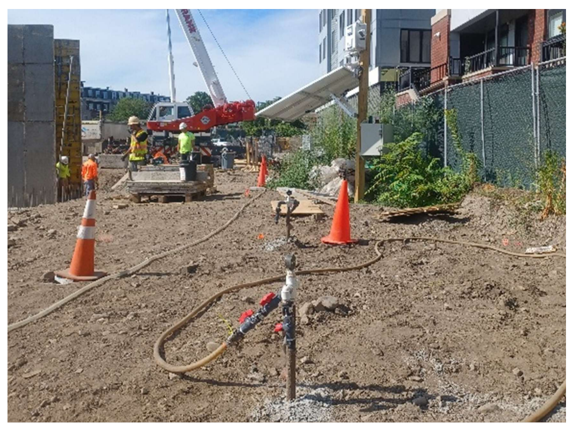
Treatability Laboratory

COMPLEXITIES ABOVE AND BELOW GROUND

ISOTEC REMEDIATION TECHNOLOGIES



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