Northeast Waste Management Officials' Association
Remedy Selection:
Planning for Success & Lessons Learned

NEWMOA

Case Studies – Full Feasibility Studies & Remedy Selection

Karen Kinsella: GZA, Glastonbury, Connecticut
Maryann Sapanara: GZA, Norwood, Massachusetts

Tuesday, May 7, 2019
Quinebaug Valley
Community College
742 Upper Maple Street
Danielson, CT

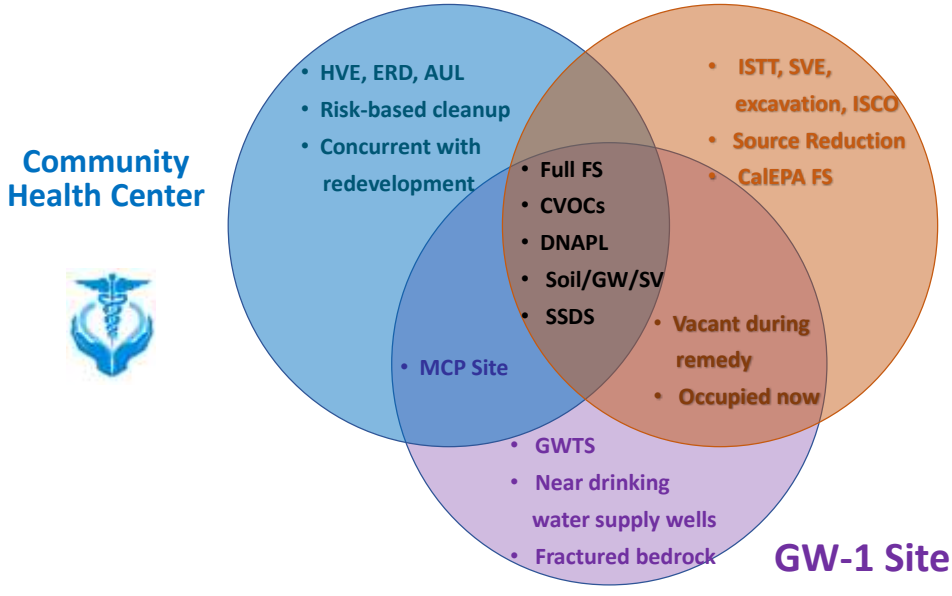
Wednesday, May 8, 2019
UMass Lowell Inn and
Conference Center
50 Warren Street
Lowell, MA

Wednesday, June 26, 2019
Fireside Inn and Suites
25 Airport Road
Lebanon, NH

Overview

- Three sites contaminated with chlorinated solvents:
  - MA Health Center: silt and clay above a river
  - CA Site: two deep sandy aquifers separated by clay and silt
  - MA GW-1 Site: fractured bedrock upgradient of a drinking water source
- Feasibility Study Process
  - National
  - State
- Case Studies
- Summary/Comparisons/Lessons Learned

Overview – Case Studies



EPA FS: Remedial Action Alternatives Analysis

Objectives

(1) Protect human and environmental health
(2) Comply with regulations

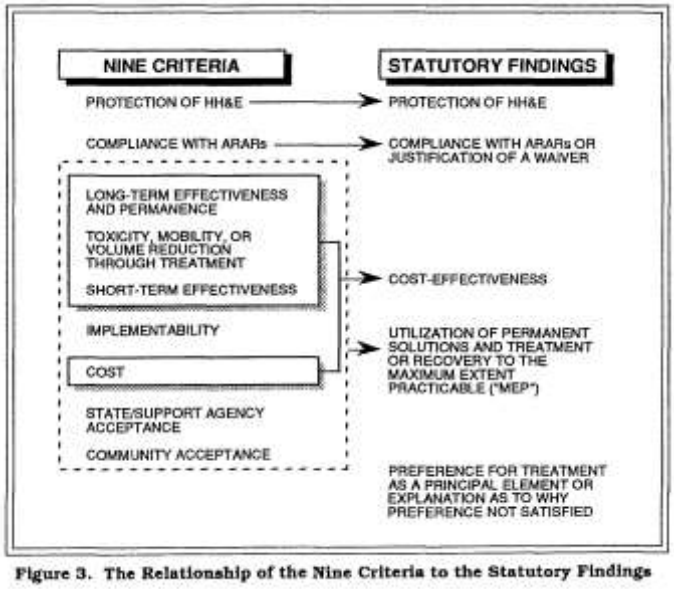


Figure 3. The Relationship of the Nine Criteria to the Statutory Findings

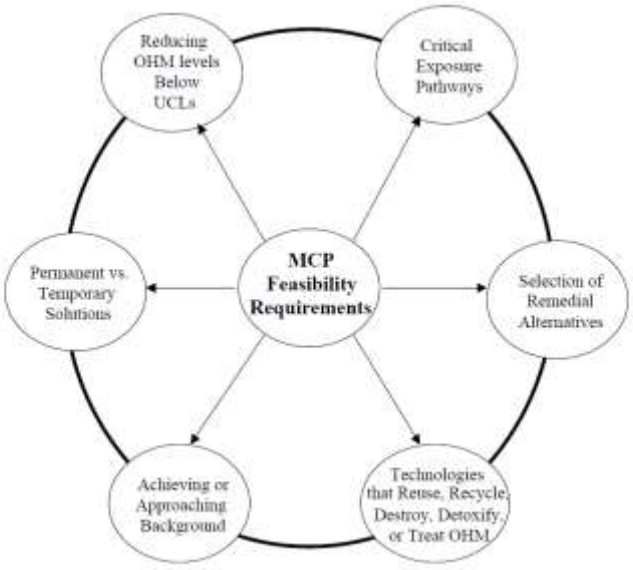
EPA 1990. *The Feasibility Study: Detailed Analysis of Remedial Action Alternatives*

MA Contingency Plan (MCP) Feasibility Requirements

Objectives

(1) Protect human and environmental health
(2) Comply with regulations

Feasibility evaluations are required at six specific points in the MCP site assessment and remediation process.



https://www.mass.gov/files/documents/2016/08/nw/04-160.pdf

MCP Approach

- Phase I – Initial Site Investigation Report (40.0480)
- Phase II – Comprehensive Site Assessment (40.0830)
- Phase III – Identification, Evaluation and Selection of Comprehensive Remedial Action Alternatives (40.0850)
- Phase IV – Implementation of the Selected Remedial Action Alternative (40.0870)
- Phase V – Operation, Maintenance, and/or Monitoring of Comprehensive Response Action (40.0890)
- Remedy Operation Status (ROS) (40.0893)

https://www.mass.gov/lists/waste-site-cleanup-laws-and-regulations

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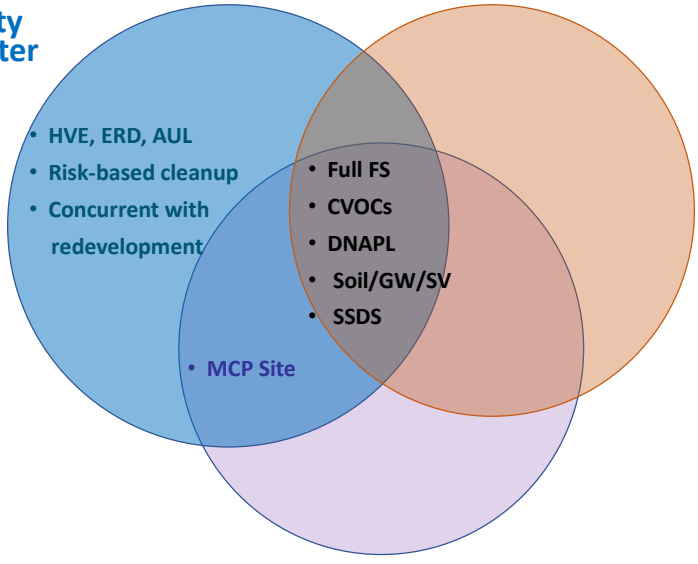
Case Study

Community Health Center



Community Health Center, Massachusetts

Brownfield site owned by the state of Massachusetts
Trichloroethene (TCE) in groundwater up to 200,000 µg/L
Community health organization in need of land to build a new Health Center
Goal: Protect human and environmental health
without interfering with construction and operation of the Health Center

Historical use:
Manufacturing, chlorinated solvent use
State police barracks
DOT maintenance and road salt storage

Why Full FS?

- *Identification, Evaluation, and Selection of Comprehensive RAAs* (MCP Phase III)
- Required under the MCP prior to design and implementation of the remedy

Contaminated Media; Receptors

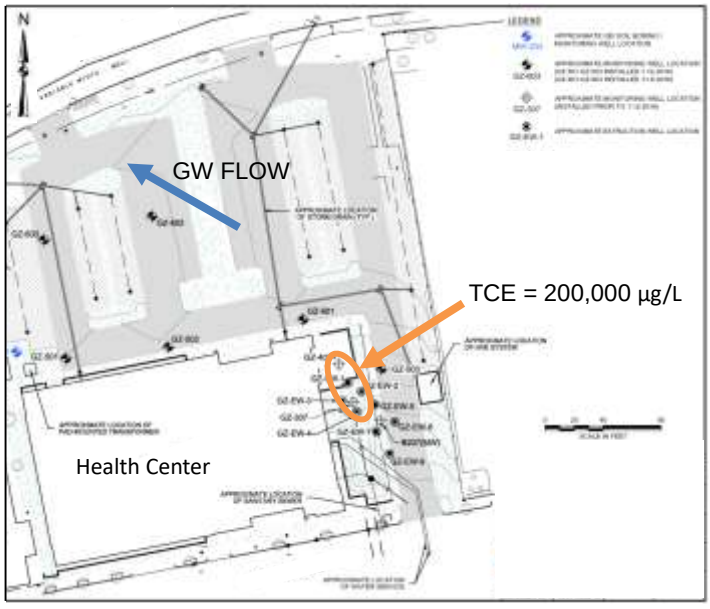
TCE and degradation products in

- Soil
- Soil gas
- Indoor air
- Groundwater

Potential receptors:

- Health clinic
- Neighboring unoccupied commercial properties under redevelopment
- Construction & utility workers, trespassers
- River 200 ft downgradient

Site Plan



ID and Selection of Comprehensive Remedial Action Alternatives

MCP Phase III: *Selection of Remedial Action Alternatives (Remedial Alternatives Analysis, RAA)*

- No further action
- Institutional and engineering controls
  - Activity and Use Limitations (AUL)
  - Sub-Slab Depressurization System (SSDS)
- Monitored Natural Attenuation (MNA)
- Containment Technologies
  - Barriers (cap, slurry wall, permeable reactive barrier)
  - Pump & treat
- In-Situ Technologies
  - Air sparge/soil vapor extraction (AS/SVE)
  - Chemical oxidation (ISCO)
  - Biological and/or chemical reduction
  - Thermal treatment
- Ex-Situ Technologies
  - Groundwater depression pumps
  - High Vacuum Extraction (HVE)
- Excavation and Off-Site Disposal

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RAA: Narrowing Down the Options

Permanent Solution

Source area
High Vacuum Extraction (HVE)
vs.
Excavation and Off-Site Disposal

Downgradient plume
Enhanced Reductive Dechlorination (ERD)
vs.
Chemical Oxidation (ISCO)

AND both:
Sub-Slab Depressurization System (SSDS)
Activity and Use Limitations (AUL)

Compare: Difficulty, Risk, Cost, Timeliness, Benefit

Community Health Center, Massachusetts

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AND both:
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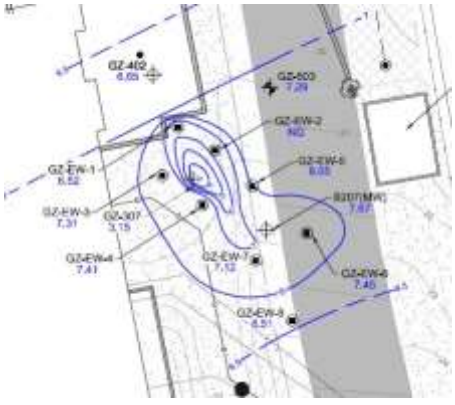
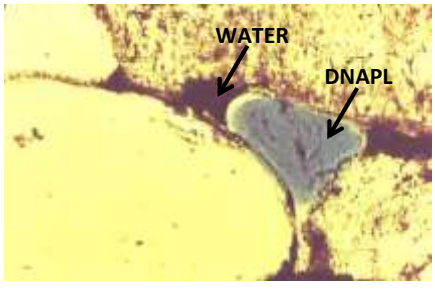
Chosen based on: Cost, Timeliness, Efficacy

High Vacuum Extraction (HVE)

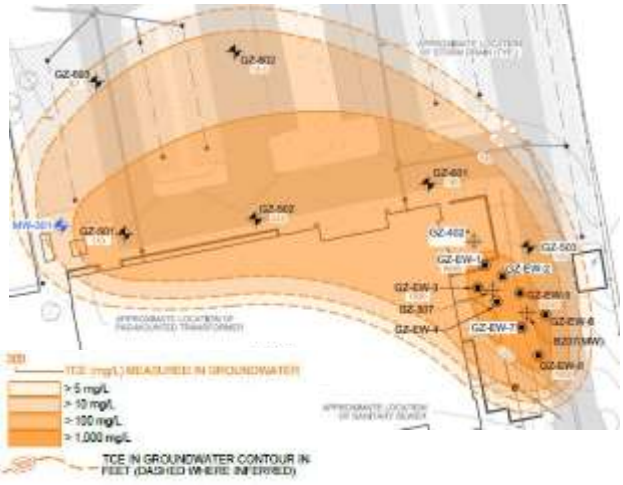
Groundwater contours
during HVE operation





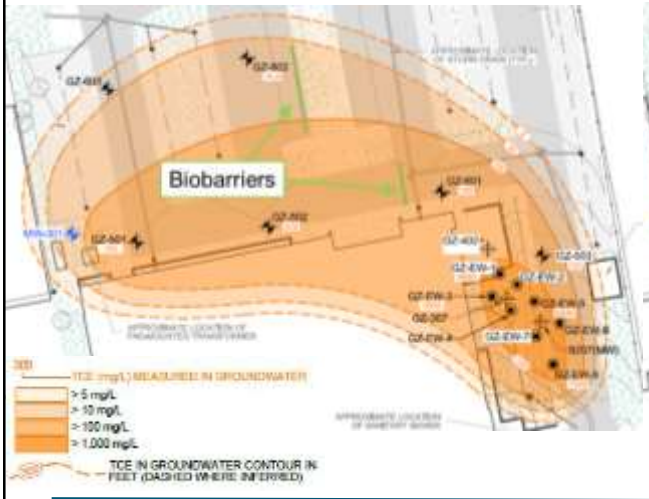
Wilson *et al.* 1990. EPA/600/6-90/004.

One Year after HVE Shutdown

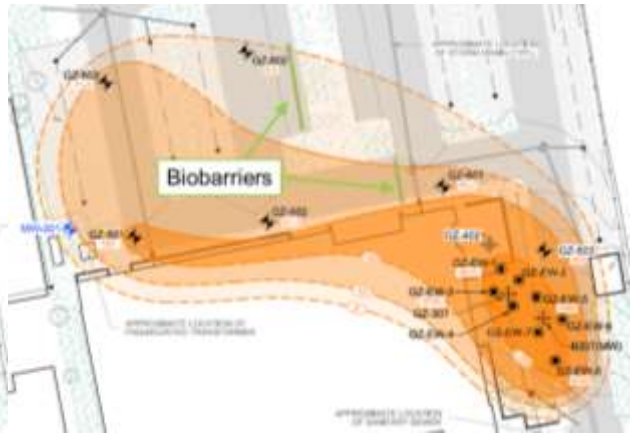


ERD Biobarrier Injection: One Year after HVE Shutdown

Biobarrier injection: one year after HVE shutdown



TCE plume: one year after biobarrier injection



Permanent Solution

Remedy Status (Phase V)

- HVE system
  - Operated 2015-2016
  - Decommissioned Summer 2018
- Biobarrier is enhancing plume biodegradation while minimizing off-Site migration of TCE and its degradation products
- Organic carbon injected into source area former EWs, Fall 2018
- Groundwater and indoor air monitoring are on-going

Conditions required for a Permanent Solution

- Indoor air concentrations in occupied spaces continue to remain below the indoor air threshold values
- Off-site TCE groundwater concentrations are less than 5 µg/L (MassDEP's vapor intrusion threshold)

Summary

New Community Health Center:
Sub-slab membrane
Crawl space vent
Activity and Use Limitation (AUL)
Phased treatment of groundwater initially containing up to 200,000 µg/L TCE

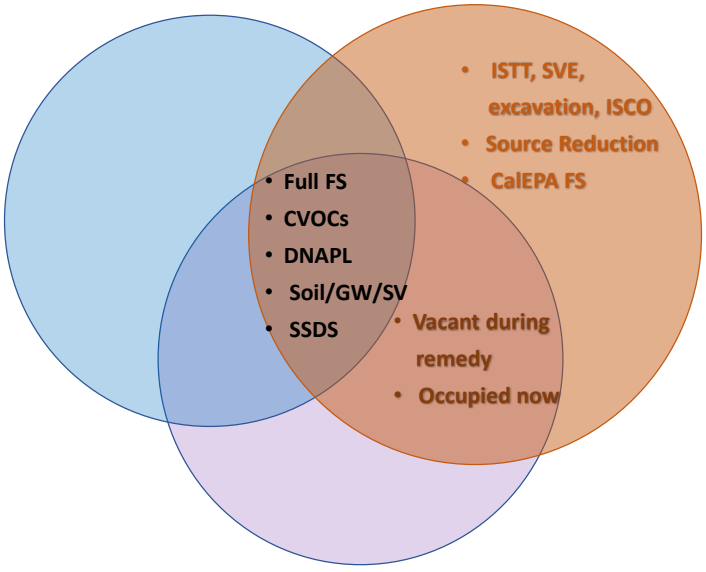
HVE System 2015-2016

Remediation activities simultaneous with construction, continued after opening of the Health Center in 2015.
Environmental restoration is ongoing at the site under Massachusetts Contingency Plan (MCP) Phase V remedial monitoring.

Injecting ERD Biobarrier 2017

Case Study

CA Site



Former Industrial Plant, California

- Industrial Processes (1955-1980s)
- Manufacturer of electronic filters and capacitors
- Associated degreasing and limited PCB usage
- TCE (including DNAPL) in soil and groundwater
- Two sandy aquifers with limited connection (20' and 35' bgs)
- Lead Agency - Department of Toxic Substances Control (DTSC)

Why Full Scale FS?

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* USEPA, 1988
- DTSC Oversight
  - *"The RI/FS process generally applies to larger, technically complicated projects anticipating cleanup action"*
- RI/FS → RAP → Consent Decree & Statement of Work → RDD
  - All requiring approval

https://www.dtsc.ca.gov/SiteCleanup/Brownfields/ri-fs-study-process.cfm

ID and Selection of Comprehensive Remedial Action Alternatives

Remedial Investigation/Feasibility Study

- No further action
- Institutional Controls
- Engineering controls
  - Groundwater Monitoring
  - Vapor Control Systems
  - Soil Vapor Baseline Survey
- Containment Technologies
  - Cap
  - Slurry/Sheet Pile Wall
- In-Situ Technologies
  - Enhanced bioremediation
  - Phytoremediation
  - Thermal Treatment
  - SVE
  - Air sparging
  - Chemical oxidation (ISCO)
  - Permeable Reactive Barrier
  - Surfactant Flushing
- Ex-Situ Technologies
  - Groundwater Extraction/Treatment
  - Excavation
    - Off-Site Disposal
    - Thermal Desorption
    - Incineration
    - Chemical Stabilization

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    - Off-Site Disposal
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    - ~~Incineration~~
    - ~~Chemical Stabilization~~

RAA: Narrowing Down the Options

Permanent Solution

Selective Excavation/ISTT

vs.

Selective Excavation/ISCO

AND:

- Sub-Slab Depressurization System (SSDS)
- Potential Deed Restrictions
- Groundwater Monitoring
- Soil Vapor Baseline Survey

Compare: Cost, Timeliness, Efficacy

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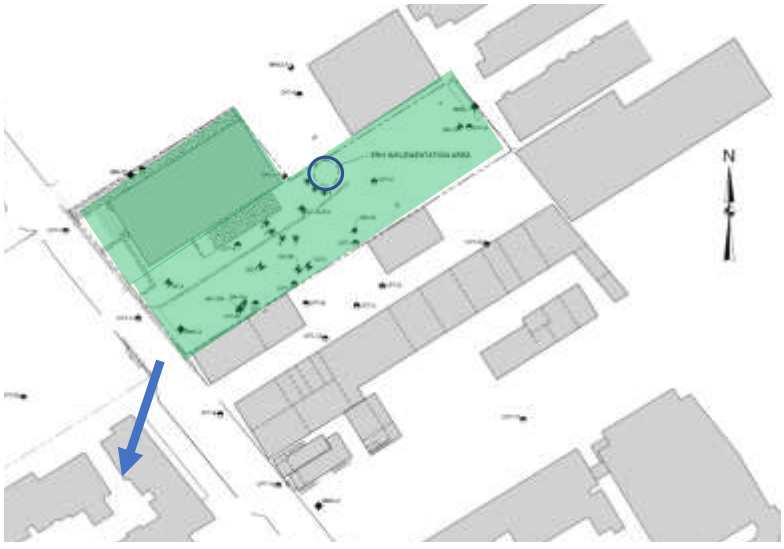
Chosen based on: Cost, Timeliness, Efficacy

Remedial Approach

- PCB Excavation
  Numerical goal– cancer risk below 1 x 10^{-5}
- Long-term groundwater monitoring
  Protect deep aquifer
  Ultimately MCLs
- ERH in source zone
  - SVE
  - ISCO

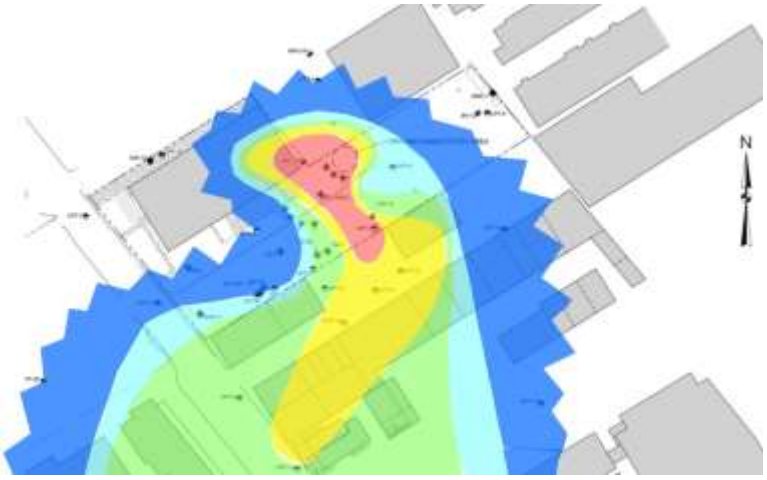
  Source Control - Asymptotic conditions
  Pre-ERH GW concentrations
- Soil Vapor Sampling
  To evaluate the need for future engineering controls

Site Plan



Excavation

Groundwater Monitoring



TCE – Deep Aquifer

LEGEND
- >50 ppm
- 5-50 ppm
- 0.5-5 ppm
- 0.05-0.5 ppm
- 0.005-0.05 ppm

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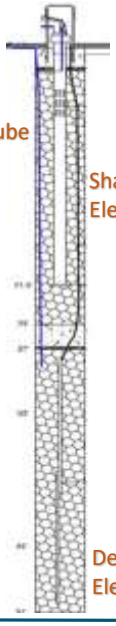
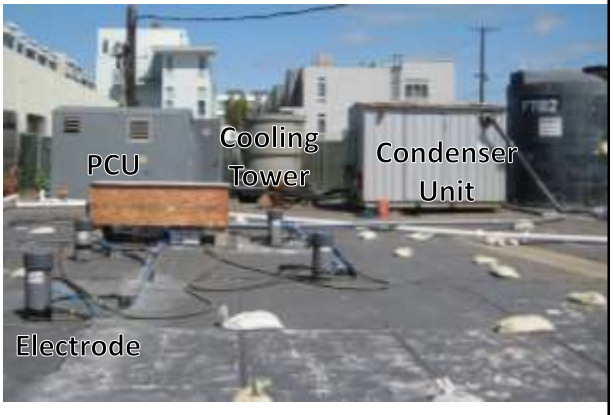
ISTT





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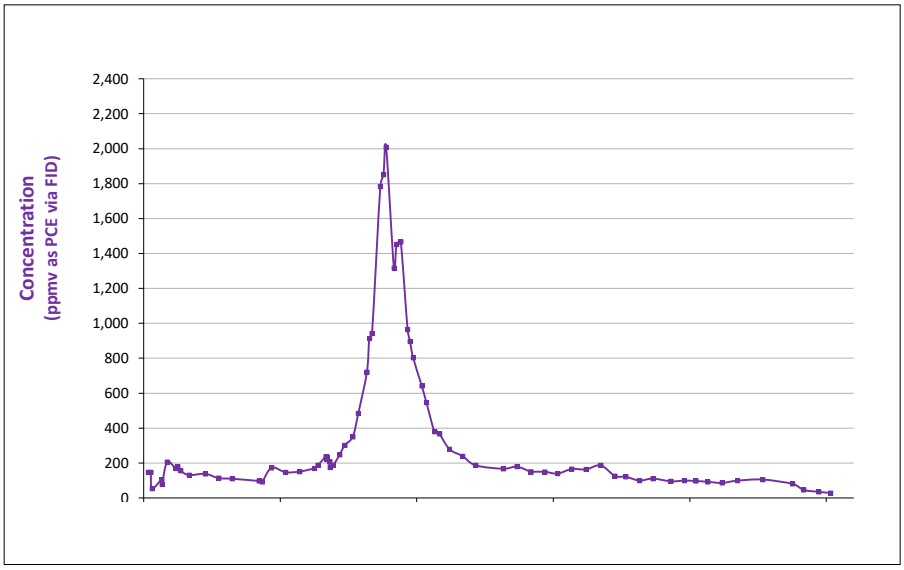
ISTT System Data



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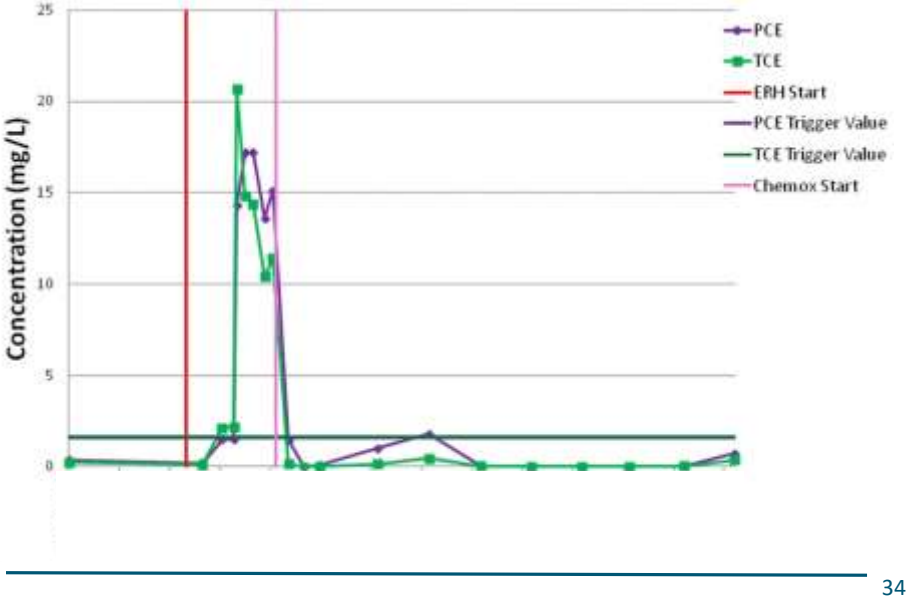
Downgradient Groundwater



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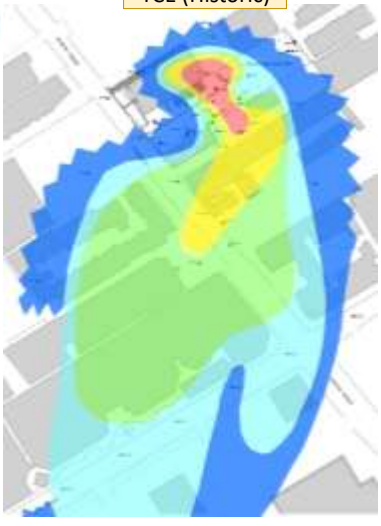
ISCO

Results/Lessons Learned

TCE (Historic)



LEGEND
- >50 ppm
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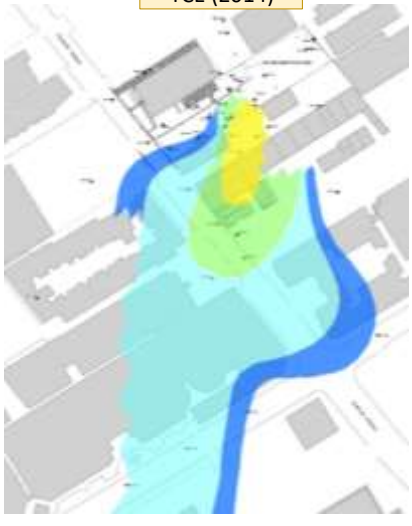
- 0.05-0.5 ppm
- 0.005-0.05 ppm

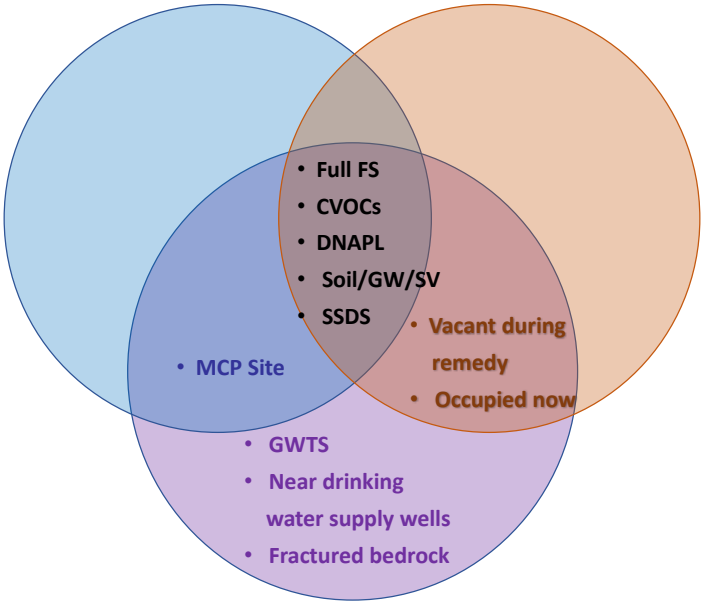
TCE (2014)



- 1,000 lb in 5.5 weeks
- Process may limit innovation after the ROD

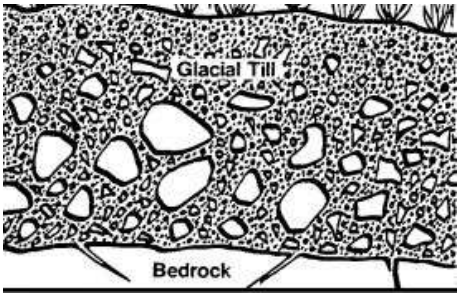
Case Study

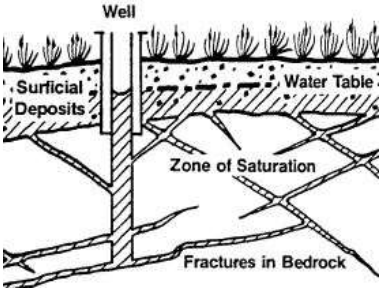
GW-1 Site



Former Manufacturing Plant, Massachusetts

- Historical manufacturing with chlorinated solvent use
- Granular layer and till underlain by fractured bedrock
- Proximate to municipal drinking water source



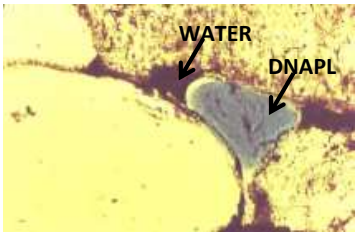


EPA (MA Audubon Society 1993)

Why Full Scale FS?

Goal: Protect the downgradient drinking water

- TCE in groundwater > 10% of the aqueous solubility
- DNAPL – Immediate Response Action (IRA)
- Interim extraction system
- Phase III Feasibility Study



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ID and Selection of Comprehensive Remedial Action Alternatives

MCP Phase III: *Identification and Selection of Comprehensive Remedial Action Alternatives (RAAs)*

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- In-Situ Technologies
  - Air sparge/soil vapor extraction (AS/SVE)
  - Chemical oxidation (ISCO)
  - Surfactant Addition/Recover
  - Bioremediation
- Ex-Situ Technologies
  - Air Stripping
  - UV/Oxidation
  - Activated Carbon
  - Biological Treatment

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RAA: Narrowing Down the Options

Permanent Solution

Source area
No Further Action
vs.
Groundwater Extraction/Treatment

Downgradient plume
Monitored Natural Attenuation
vs.
Groundwater Extraction/Treatment

AND both:
Sub-Slab Depressurization System (SSDS – on planned new construction)
Activity and Use Limitations (AUL - cannot legally limit off-site migration)

Compare: Difficulty, Risk, Cost, Timeliness, Benefit

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AND both:

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Activity and Use Limitations (AUL - cannot legally limit off-site migration)

Chosen based on: Cost, Timeliness, Efficacy

P&T System Operation

- Captured, contained, and treated ~ 50,000 lbs. of chlorinated VOCs (over 4,000 gallons); however, for the past five years the removal rate has stabilized
- Volume of DNAPL remaining unknown; TCE in source area still > 1% aqueous solubility

Can another remedial technology accelerate removal in a cost-effective manner?

Supplemental Site Investigation

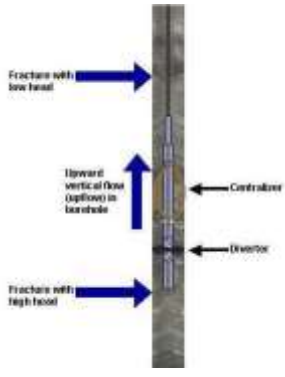
- Shallow Source
  - Resistivity surveys
  - Partitioning tracer test
  - Installation of additional recovery wells
  - Microbial testing
- Deep Source
  - Borehole geophysics
  - Packer testing
  - Microbial testing
- Shallow Downgradient
  - Improve containment
  - Model groundwater flow
- Deep Downgradient
  - Assess groundwater connection to municipal pumping wells

Geophysical Investigation

Objective: *refine understanding of bedrock flow and contaminant transport conditions*

Geophysical Logs

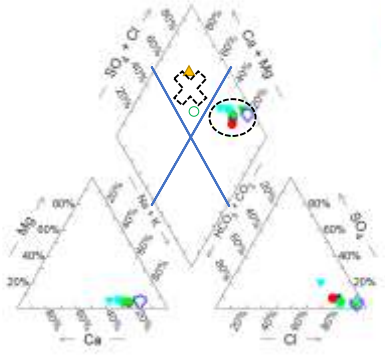
- Caliper
- Fluid properties
  - Resistivity
  - Temperature
- Televiewers
  - Acoustic
  - Optical
- Heat-pulse flow measurements
  - Ambient
  - Pumping



HPFM usgs.gov

Geochemical Assessment

Objective: *evaluate natural water chemistry to support geophysical data*



Water supply wells: ▽ ◇

Waters above 100 ft appear to be from a similar rock source as water supply

Waters below 100 ft appear to be from a different source than water supply

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Reductive Dechlorination Evaluation

Suitability of enhanced reductive dechlorination (ERD) for Site groundwater remediation

- RD minimal in source area wells
- Some RD downgradient:
  - ➢TCE degradation products DCE and/or VC and ethene
  - ➢TOC adequate for fractured bedrock RD
  - ➢pH conducive to growth of dechlorinating bacteria
  - ➢Methane and manganese suggest reducing conditions
- Microbial populations are low, typical of fractured rock in New England

Summary of Conclusions

- Bedrock groundwater: a few fracture sets located in the top ~100 feet
  - Bedrock tends to be less transmissive with depth
  - Treatment system effectiveness limited by fracture communication
- Geochemical assessment: samples collected from wells in the top ~100 feet are geochemically similar to the water supply wells
- ERD is occurring at the site; however, the rate of ERD is generally slow, particularly in the source area
- Current remedy is effective for containment, but not for treatment of source area mass

Supplemental treatment of the source area could reduce containment needs and potentially achieve closure

Potential Next Steps

Source Area Remediation: Remedial Design Considerations

- All *in-situ* remedial additive remedies are limited by the ability for the remedial additive to contact the source material → particularly difficult in fractured rock
- Containment system (P&T) will likely need to remain active until total VOC concentrations are below 1 mg/L in source and downgradient areas
- Many remedial additives produce byproducts which would be detrimental to the treatment system

Source Area Remedial Action Alternatives

Alternative	Effectiveness	Implementability	Cost
P&T	High	Moderate	High
ISCO	Moderate	Difficult	Moderate
ERD	High	Difficult	Low
PRB/ERD	High	Moderate	Moderate
Thermal + P&T	High	Moderate	High
Thermal + ERD + P&T	High	Moderate	High

Remedial Design Concepts

Source Area Remediation

Combined remedies that function in conjunction with the groundwater containment and capture system

Remedial Design Concept A

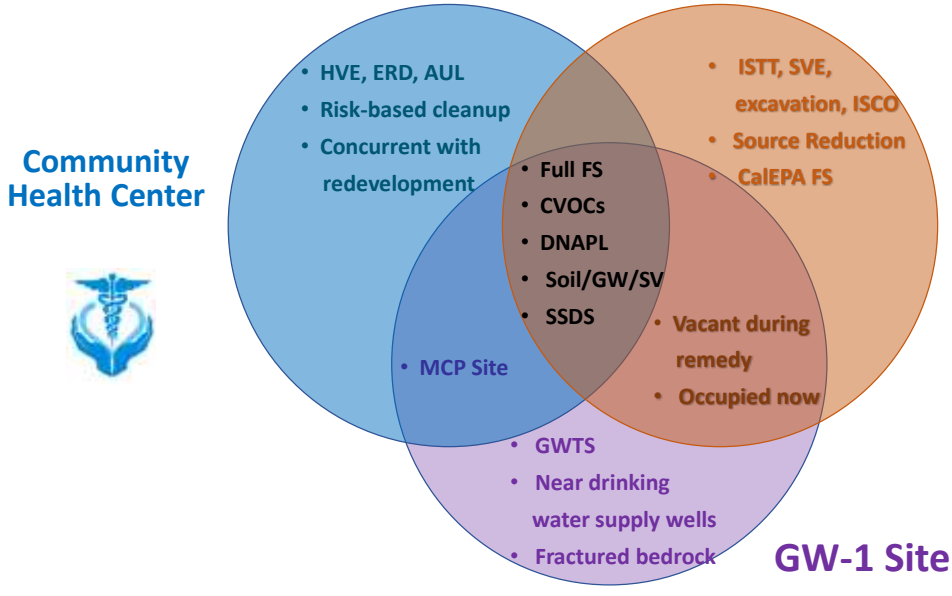
1. Chemical oxidation (ISCO), followed by
2. Enhanced biological reductive dechlorination (ERD) with or without injectable PRB

Remedial Design Concept B

1. Thermally enhanced groundwater extraction, followed by
2. Thermally enhanced biological reductive dechlorination

Screening of Remedial Action Alternatives in progress

Case Studies



Questions?

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