A New Paradigm for Managing Chlorinated Solvent Sites

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Porewater Solutions

SMART Remediation
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New Paradigm for Managing Chlorinated Solvent Sites

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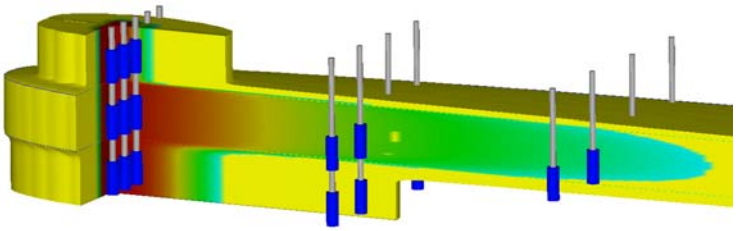

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Grant Carey or Cary Grant?

The Modeler

The Model

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- Consulting (U.S. and Canada)
  - Remedy Enhancement
  - Environmental Forensics / Litigation
  - Modeling
- ITRC
- Model Development →
- Continuing Education

ISR-MT3DMS
NAPL Depletion Model

BioRedox-MT3DMS
SEQUENCE
Remediation ToolKit
Vapor-2D

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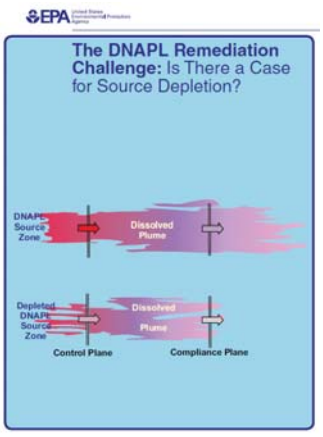
DNAPL Sites: A Decade of Reflection

2003



Research and Guidance

- o DoD / DOE research
- o ITRC
  - o Mass Flux
  - o DNAPL Strategies
  - o Alternative End Points
- o EPA
  - o TI Waivers
  - o Site closure
  - o DNAPL Delineation
- o States
  - o CA – Low Threat Closure

2012

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The New Paradigm

Site Characterization Tools

- *Mass flux and Mass discharge*
- *Modeling back-diffusion timeframe*

Remediation

- *Mass discharge → Attainable interim goal*
- *Focus, Focus, Focus on the mass (Biggest Bang for $$$)*

Management framework

- *Integrated source-plume management*
- *Transition from active to passive source treatment*

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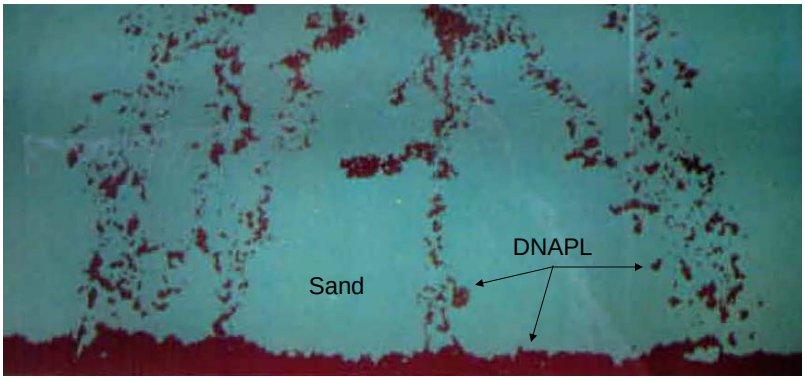
Chlorinated Solvent Sites

Initially released as DNAPL (oil-like) into subsurface.
DNAPL migrates chaotically – difficult to find after a release.



Source: *Schwille, 1988*

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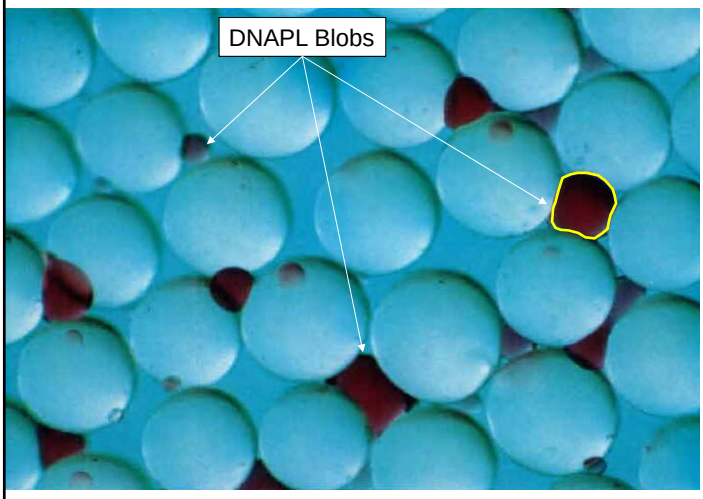
Residual DNAPL



Source: *Schwille, 1988*

Residual DNAPL

- Small mass
- Discontinuous
- Immobile
- Dissolves quickly

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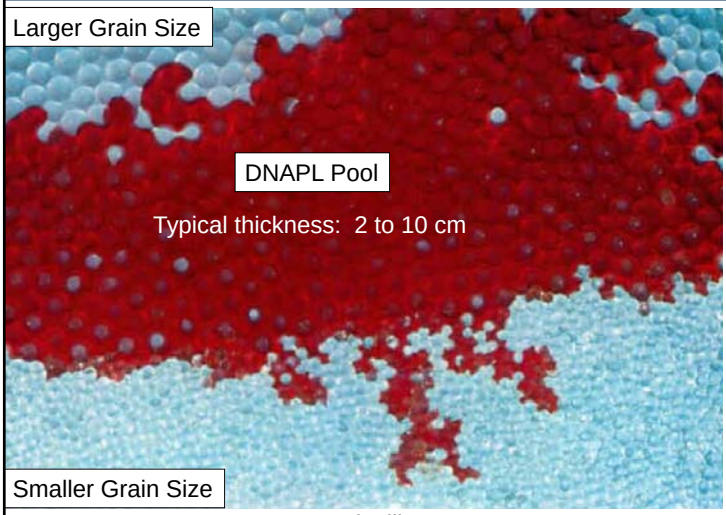
DNAPL Pool (Free Phase / Product)



Source: *Schwille, 1988*

DNAPL Pools

- Large mass
- Continuous
- Potentially mobile
- Dissolve slowly

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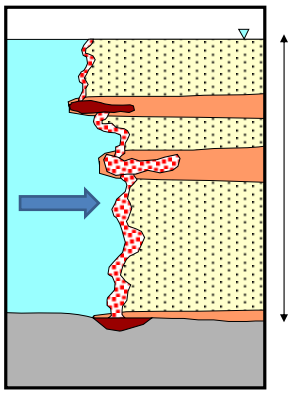
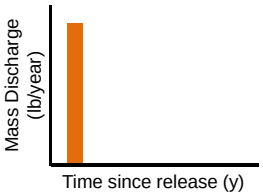
Mass Discharge Trends

Fresh Source



Mass discharge from source zone (kg/y)



Modified from Parker et al., 2003

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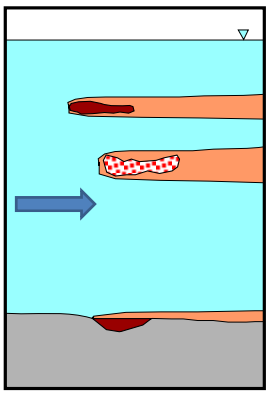
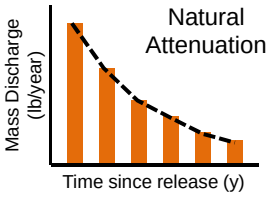
Mass Discharge Trends

Aged Source

Typical source zone mass discharge = 1 to 100 kg/year





Newell et al., 2006:
Median TCE DNAPL half-life of 6 years

Mass discharge reduction 30x in 30 years

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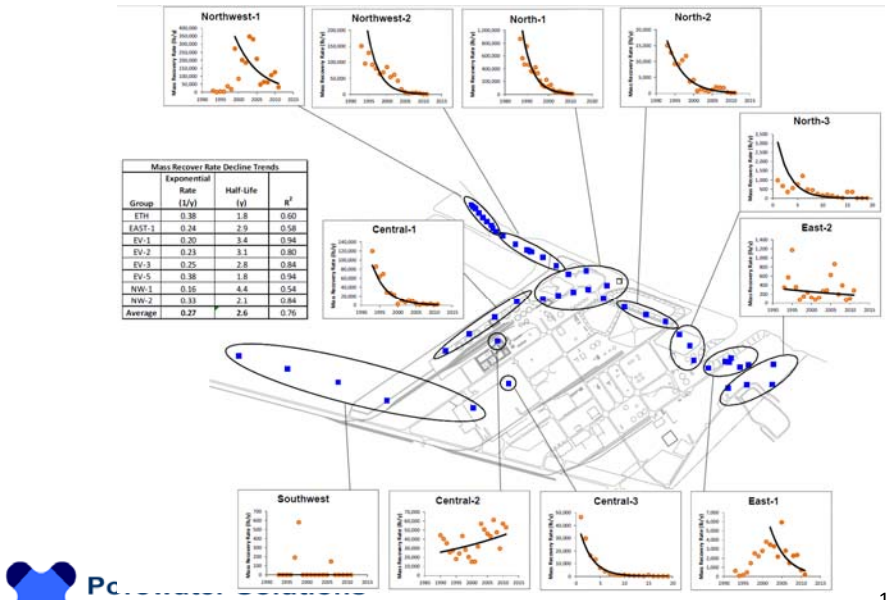
Mass Discharge Decline at Calvert City, KY



Mass Recover Rate Decline Trends

Group	Exponential Rate (1/y)	Half-Life (y)	R^2
ETH	0.38	1.8	0.60
EAST-1	0.24	2.9	0.58
EV-1	0.20	3.4	0.94
EV-2	0.23	3.1	0.80
EV-3	0.25	2.8	0.84
EV-5	0.38	1.8	0.94
NW-1	0.16	4.4	0.54
NW-2	0.33	2.1	0.84
Average	0.27	2.6	0.76

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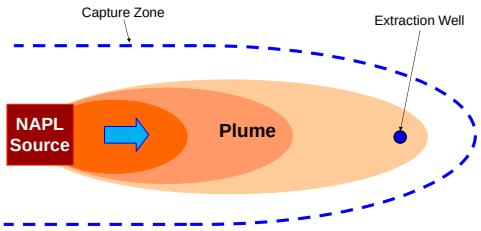
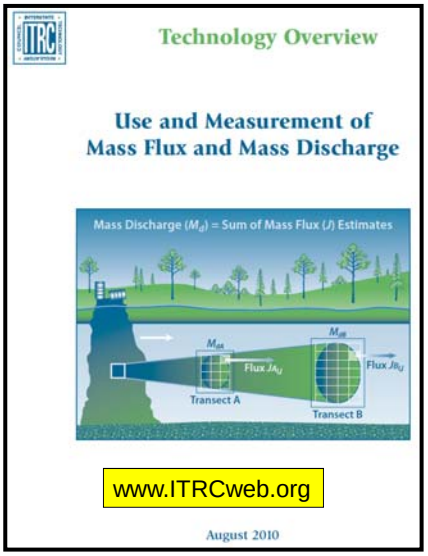
Mass Flux / Mass Discharge



Mass discharge affects plume length, risk.

Easily estimated with pumping wells.

Example: If need 90% reduction in risk, then goal is 90% reduction in mass discharge from source.



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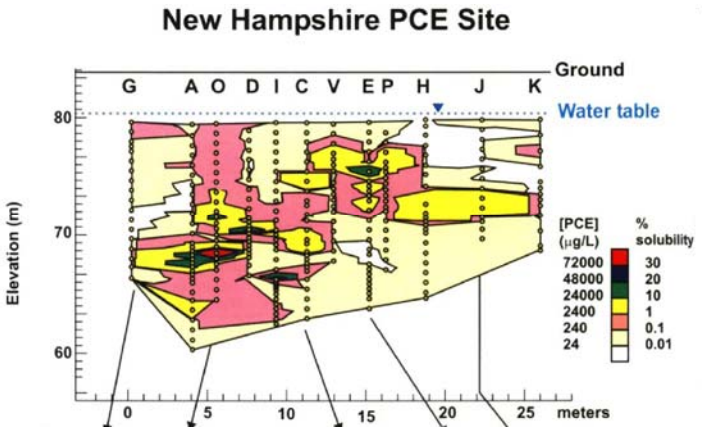
Source Mass Flux - Guilbeault et al., 2005

If we can see where the mass is coming from, we can focus remediation.



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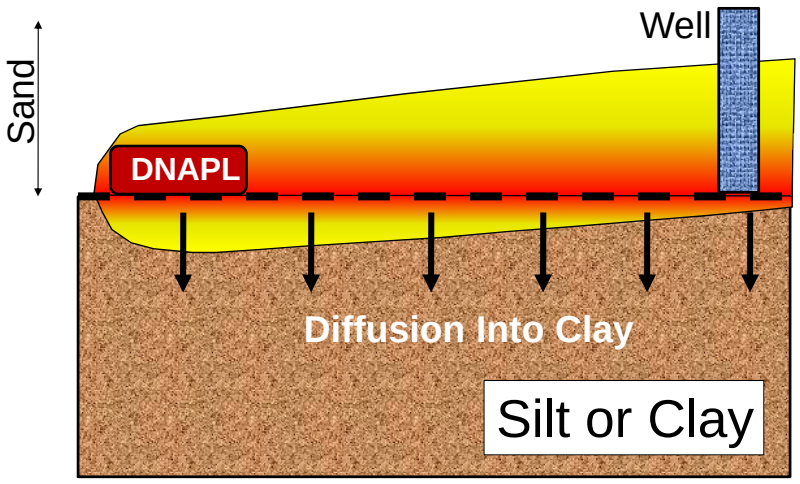
Back-Diffusion



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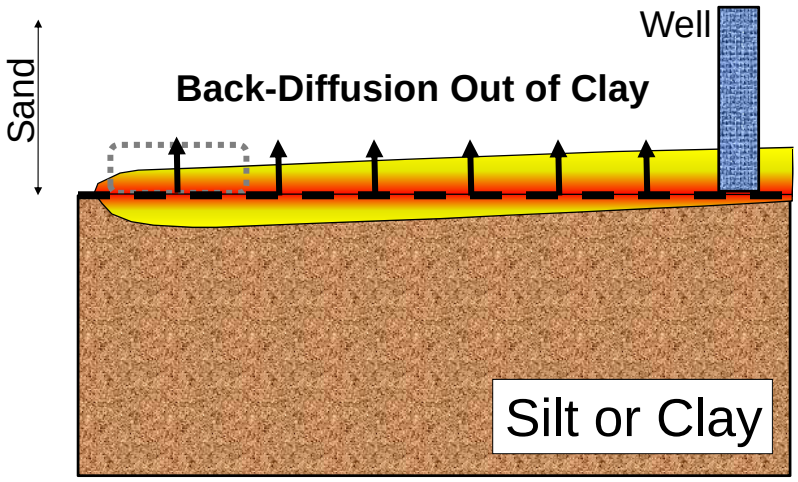
Back-Diffusion



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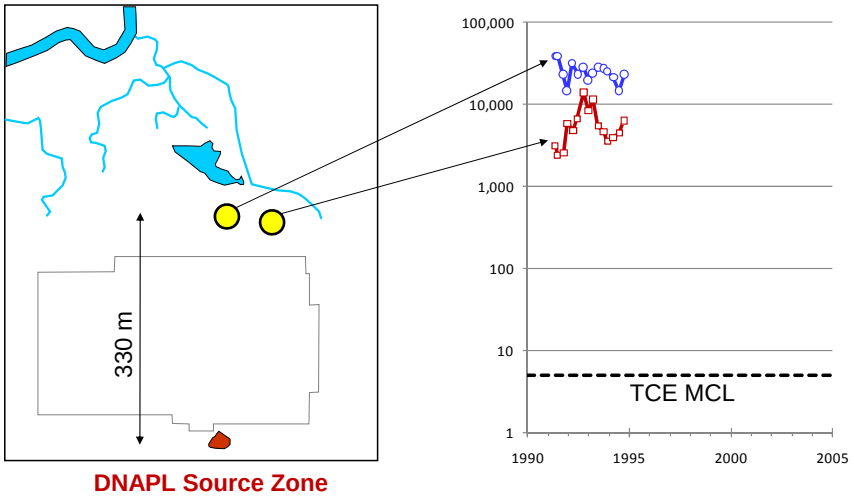
Connecticut Site (Chapman & Parker, 2005)



DNAPL Source Zone

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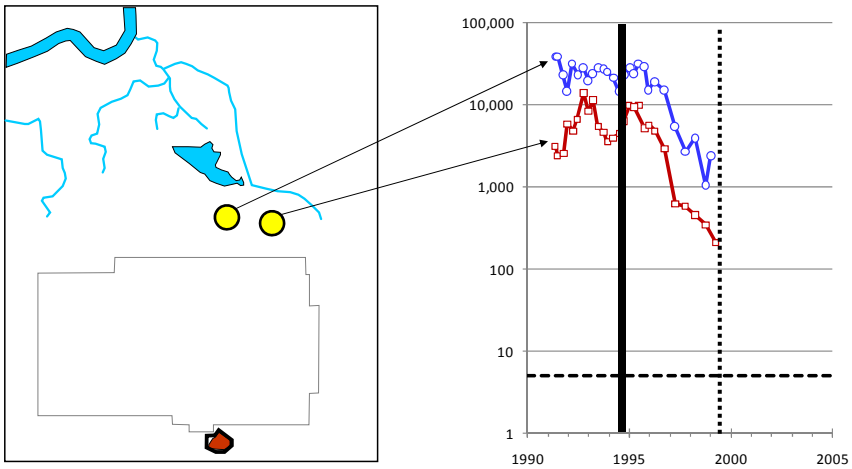
Connecticut Site (Chapman & Parker, 2005)



DNAPL Source Zone

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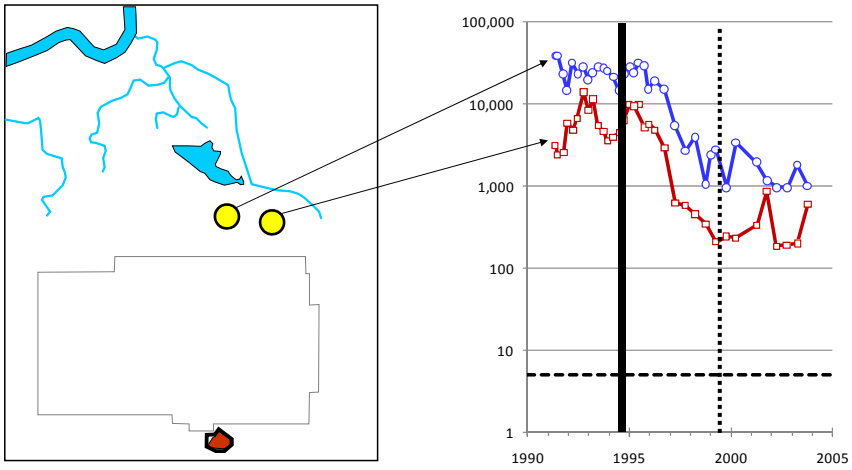
Connecticut Site (Chapman & Parker, 2005)



DNAPL Source Zone

Concentration reduction stalled at 93% (15x)

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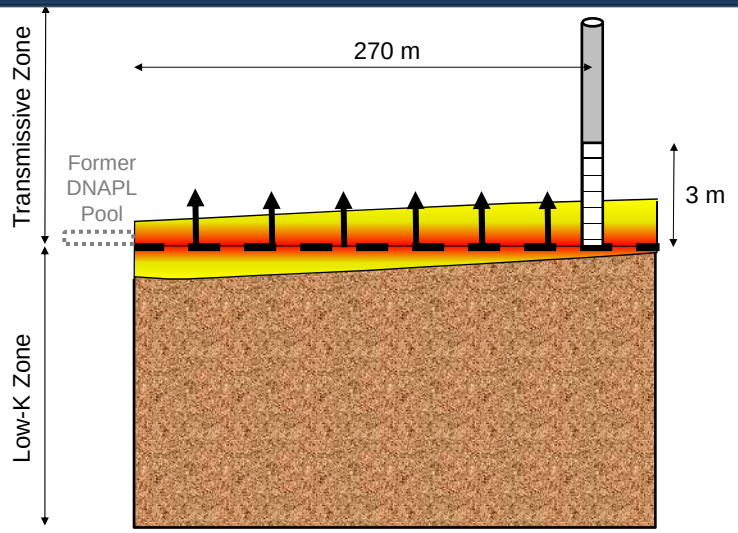
Back-Diffusion Modeling Example



Source: *Carey, McBean, and Feenstra, 2014*

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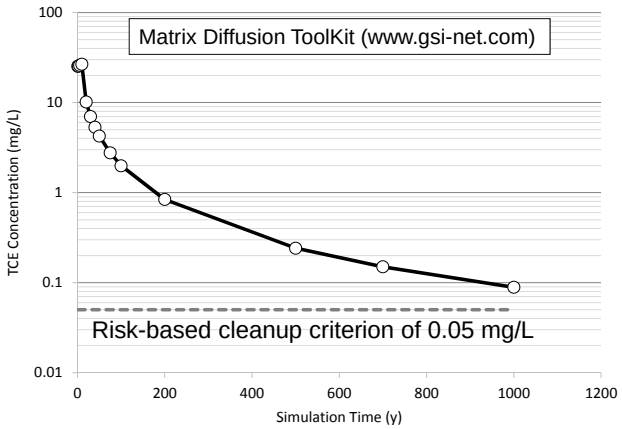
Back-Diffusion Modeling Example

Distance of well from source: 270 m



Source: *Carey, McBean, and Feenstra, 2014*

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DNAPL Source Remediation

- MNA
- Enhanced dissolution
  - ISCO, EISB, Strategic P&T
- Thermal

Question: How much reduction in mass discharge can we expect to attain?

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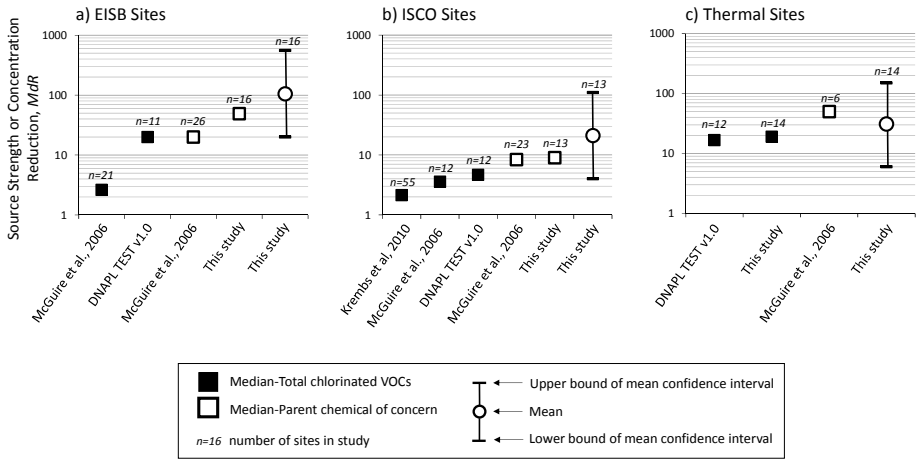
Mass Discharge Reduction: Interim Goal



Source: *Carey, McBean, and Feenstra, 2014*

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Goal Attainability Depends on:

- Conceptual Site Model
  - Where is plume mass coming from?
- Heterogeneity – geology and DNAPL
  - **Site complexity is an important factor.**
- DNAPL chemical properties
- DNAPL accessibility to groundwater flow

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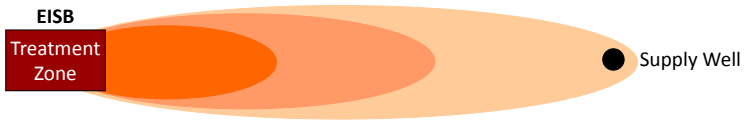
Transition from Active to Passive Treatment

Case Study – Well 12A Superfund Site, Washington

STEP 1: Active source treatment until interim source strength reduction goal is achieved.



STEP 2: After this goal is achieved, transition to MNA in source zone

Upcoming transition checklist: ITRC – Remediation Management of Complex Sites

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Integrated Source-Plume Management

- Source treatment – recognize limitations in:
  - DNAPL removal
    - Attainable, interim reduction in mass discharge
    - Use interim goal to transition to passive src treatment
  - Plume restoration (back-diffusion)
    - Characterize mass stored in silts/clays, and time to deplete once source treated or contained
    - Plume area larger than source – governs timeframe
- Ideally cost of source treatment is balanced with limitations in plume restoration
- Regulatory mechanisms – alternative end points

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Questions?

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