NAPL Site Remediation

Trends/Developments/Challenges/Opportunities

Federal Remediation Technologies Roundtable May 2007

Jim Cummings
Technology Innovation/Field Services Division
OSWER/USEPA

MORNING AGENDA

9:50 AM **DNAPL Overview – Progress and Challenges**
- *Jim Cummings, EPA/OSRTI*

10:20 AM **SERDP/ESTCP DNAPL-Related R&D/Demo Projects**
- *Andrea Leeson, SERDP/ESTCP*

10:50 AM **Emulsified Zero-Valent Iron for DNAPL Source Treatment**
- *Jacqueline Quinn, NASA*

11:20 AM **BioDNAPL Treatment – Fact or Fantasy?**
- *David Major, Geosyntec*

(Discuss and Collect Ballots)

11:50 AM **LUNCH (on your own)**

- **AFTERNOON AGENDA**

1:00 PM	**TCE Fate and Transport Determination at the DOE Paducah Gaseous Diffusion Plant, Paducah, KY** - *Steve Hampson KRCEE*
1:30 PM	**Kings Bay, Ga/Pensacola, Fla – Navy DNAPL Treatment stories** - *Mike Singletary U.S. Navy* - *Frank Chapelle,U.S. Geological Survey*
2:10 PM	**BREAK**
2:30 PM	**Flexible, Adaptive Implementation of Combined Remedies – The Future of DNAPL Remediation?** - *Jim Cummings, EPA/OSRTI*
3:10 PM	**Lessons Learned from In Situ Thermal Treatment of Source Zones – Ft Lewis, Washington** - *Kira Lynch, U.S. Army Corps of Engineers*
3:40 PM	**Natural Attenuation System (NAS) – Software for Assessing Combining Source Area Remediation with Natural Attenuation** - *Mark Widdowson, Virginia Tech*
4:10 PM	**Wrap-up/Next Steps/Next Meeting Agenda**
4:30 PM	**ADJOURN**

NAPL Site Remediation – Highlights/Impressions

- **Only in last 5 years have effective NAPL technologies emerged/matured**
- **Monitored Natural Attenuation (MNA) assuming its 'appropriate' role**
- **"Progress toward..." MCLs overtaking requirement for immediate results (?)**
- **Flexible, adaptive application of combined remedies gaining ground**

NAPLs--The Problem

DNAPL – Dense Non-Aqueous Phase Liquid

- Prevalent class of contaminants at NPL Sites – 'We' will be 'doing' DNAPL for a while
- DNAPLS may migrate to considerable depth and below the water table – continuing source of GW contamination
- **'Perfect Storm': Large contaminant mass at many DNAPL sites (1000s of Kilograms) + Low solubility (1100 ppm for TCE) + low MCLs (e.g., 5ppb for TCE) = Protracted timeframe for containment remedies**

DNAPL - Examples

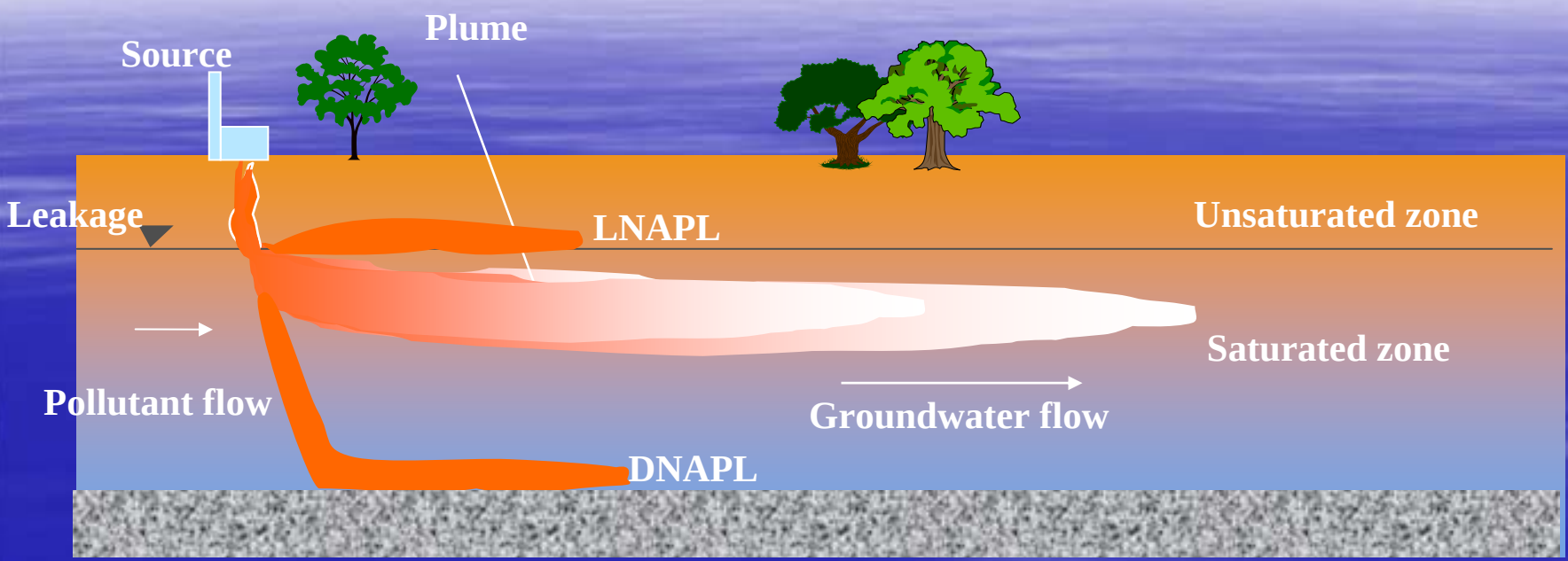
- Trichloroethylene (TCE) – Prevalent de-greasing solvent
- Perchloroethylene (PCE) – Dry cleaners (1000's)
- Polynuclear Aromatic Hydrocarbons (PAHs)
  - Approx 100 wood treaters on NPL
  - 15-20 former Manufactured Gas Plant (MGP) Sites on NPL/1000's in US/Int'l

DNAPL Mobility

- Contrary to popular opinion, some DNAPLs can be quite mobile

- NYDEC study of former Manufactured Gas Plant (MGP) sites found that free product coal tar PAHs had migrated off-site at 60-70% of sites

Control of pollutant spreading via groundwater



Ranking Criteria for Difficulty in Remediating Ground Water

TIO Update to NRC Table, October 2002

Hydrogeology	Mobile Dissolved (Degrades / Volatilizes)	Mobile Dissolved	Strongly Sorbed, Dissolved	Strongly Sorbed, Dissolved (Degrades / Volatilizes)	Separate Phase LNAPL	Separate Phase DNAPL
Homogeneous, Single Layer	1	1-2	2	2-3	2-3	1-2
Homogeneous, Multiple Layers	1	1-2	2	2-3	2-3	2 ?
Heterogenous, Single Layer	2	2	3	3	3	3 ?
Heterogenous, Multiple Layers	2	2	3	3	3	4
Fractured	3	3	3	3	4	4

Approaches to DNAPL Remediation

Historical Perspective--
Technology and Policy

Pump and Treat (P&T)

- Historically most prevalent remedy for GW
  - However, at DNAPL sites P&T generally addresses the symptoms rather than the problem
- At one time, FS's arbitrarily assigned a 30 yr timeframe to P&T remedies - NOT

Pump and Treat -- Other Perspectives

- **Navy policy--requires Navy Hqtrs approval of new proposed P&T remedies (~2002)**
- **State concerns w/ long** O&M tail for P&T**
- **Adequacy of escrow provisions in CD's/AO's for long-duration containment remedies at private sector PRP-lead sites?**

** decades/ centuries

Role of Technical Impracticability

- **Mid-90's TI waiver guidance equated 'DNAPL' w/ TI waiver**
- **Scientific and technological developments now demand parsing re:**
  - **Specific DNAPLs**
  - **Hydrogeo settings (noted in NRC matrix)**
- **(Important note: TI does <u>not</u> equal 'get out of jail free')**

Role of Monitored Natural Attenuation (MNA) at NAPL Sites

- MNA introduced for Petroleum Hydrocarbon (PHC) cleanups
  - Bugs have had millenia to adapt to PHCs as food/energy source
  - Prevalent, but not universal solution for larger PHC releases
- Late 90's--extended to chlorinated solvents
  - More challenging e.g. PCE/TCE degradation may 'stall' at DCE or vinyl chloride – a carcinogen

MNA--Evolving Role at NAPL Sites

- MNA impact on innovative technologies
  - First posed a threat– Now may be the salvation
  - Remedies don't need to be great - just good

- OSWER MNA Guidance envisions active attention to source zone
  - + Beneficial effects on downgradient dissolved phase contaminant zones – contrary to early concerns that active remediation might frustrate Mother Nature (i.e., kill the bugs)

‘Then Along Came Vapor Intrusion…’ – A Cautionary Tale Regarding Unaddressed Contamination

- Protectiveness decisions to write off groundwater based on (flawed) modeling

  - *Reality trumps models…*

DNAPL Source Remediation

Developments and Challenges

Evolution of DNAPL Source Treatment

- Despite 20+ years of remedial activity, only in last 5-8 years have we seen aggressive DNAPL Treatment
- New, primarily *in situ* remedies capable of addressing the source term/free product
  - In Situ Thermal Treatment (IST)
  - In Situ Chemical Oxidation (ISCO)
  - Surfactant/Cosolvent Flushing
  - In Situ Bioremedation
- 'Birthing' pains are over, 'growing' pains persist – e.g. Rebound for ISCO projects
- Next Frontier – Flexible application of combined remedies (aka 'treatment trains')

Challenge ($64k Question)

- Whether sufficient mass can be treated/ removed to reduce/eliminate need for P&T?
  - Subject of policy debate in last 10 years in NRC-level reports
    - Some NRC reports pre-date advent of effective NAPL remediation tools
    - Necessary data on plume fate not yet available--despite efforts
  - Finessing the issue: MNA following source reduction

‘Late-Breaking News…’

- SERDP/ESTCP-funded project to collect data on In Situ thermal cleanups (Paul Johnson, Arizona State) has identified several plume fate candidates:

  - Hunter AAF
  - Former Alameda NAS

- Opportunity for FRTR collaboration (??)

'$64k Question' – State of Knowledge

- Documented cases of achievement of MCL's in source zone and/or Remedial Action Objectives (RAO's) at point of compliance
  - Pinellas, Fla former DOE facility - solvents
  - Visalia, Ca NPL wood treater – PAHs
- Numerous cases where regulatory authorities have issued No Further Action (NFA) letters

Increasing Interest in Active Source Zone Remedies to Avoid P&T

- Dublin, Pa. NPL site
  - PRPs will implement in situ chemical oxidation in fractured bedrock (the 'last frontier…') at 150' to avoid need for pump and treat contingent remedy
- Cortese Landfill, NY
  - TIFSD working w/ R 2 and NYDEC to explore alternatives to P&T specified in ROD

Desired End State/Least Cost Solutions

- Adequate Use of Robust Source Term Removal Technologies
- Timely transition to cost-effective 'polishing' step(s)
- Reduce/Eliminate Need for Pump and Treat
- Appropriate Reliance on Monitored Natural Attenuation (MNA)

PLUME RESPONSE

Pre-Remediation:

Partial Mass Removal:

Partial Mass Removal + Enhanced Natural Attenuation:

Financial Implications of Different Strategies

- P&T may ‘win’ on a Net Present Value basis, but = higher total life cycle cost
- As noted, remedies w/ long-term O&M source of considerable friction w/ states
- Property transfer/redevelopment sites likely to view time as having value

Regulatory Willingness to Allow Use of MNA as a Final Polishing Component

- King's Bay. Ga
  - State allowed Navy to discontinue P&T following in situ chemical oxidation (ISCO) and enhanced biodegradation at former dry cleaner
- See TIFSD Compilation of No Further Action (NFA) Determinations

State of Florida MNA Default Criteria

Groundwater Cleanup Target Level **Natural Attenuation Default Concentration**			1 **100**	40 **400**	30 **300**	20 **200**	14 **140**	5,000 **50,000**
Sample Location	Sample Date	Purpose	Benzene	Toluene	Ethylbenzene	Xylenes	Naphthalene	TRPH
MW-1R	01/18/05	Baseline	**1.26**	1.01	< 1.00	< 3.00	< 5.00	< 400
	04/15/05	First Quarter	< 1.00	< 1.00	< 1.00	< 3.00	< 5.00	< 400
	07/28/05	Second Quarter	< 1.00	< 1.00	< 1.00	< 3.00	< 5.00	< 400
MW 8DR	01/18/05	Baseline	255	17.6	**132**	**33.6**	**30.2**	2,040
	04/15/05	First Quarter	**88.7**	8.89	**52.1**	16.7	**14.6**	580
	07/28/05	Second Quarter	< 1.00	< 1.00	< 1.00	< 3.00	< 5.00	< 400

Combined Remedies for DNAPL Remediation

The Way Forward? – Stay Tuned

For Larger Sites, NAPL Remediation is 'Different' (in kind and degree…)

- Multi-component nature of problem requires a multi-disciplinary team approach
  - Engineering
  - Chemistry
  - Hydrogeology
  - Geology
  - Micro-biology
- Poses communications and coordination challenges for decision-maker(s)
  - Web-based communications tools and 3-D visualization pkgs

Characteristics of Future DNAPL Cleanups

- **Adaptive, flexible implementation**
  - ***"Sources begin to reveal themselves as remediation progresses"***

    - Consultant Pittsburgh Envl Conf
- **Combinations of technologies**
- **Remedies which address all components of the site subsurface contamination situation**
- **Increasing use of 3-D Visualization and Web-based tools to facilitate discussion and decision-making**