Groundwater Monitored Natural Attenuation at Cleanup Sites in the United States

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Overview of Presentation

- EPA Background
- Overview of Groundwater Monitored Natural Attenuation (MNA)
- Applicability, Advantages, and Limitations of MNA
- EPA Policy on the Use of MNA
- Lines of Evidence
- Selection and Implementation of MNA in the Superfund Program
- Case Studies
- Conclusion

Contaminated Site Cleanup Markets in the U.S.

Five major markets

1. Federal facilities, mainly Department of Defense and Department of Energy
2. EPA's Superfund Program
3. RCRA corrective action program
4. Underground storage tanks
5. "Brownfields" and State programs

"Superfund" Statutory Requirements For Remedy Selection

- Protect human health and the environment
- Attain regulatory requirements or provide grounds for a waiver from the requirements
- Are cost effective
- Utilize permanent solutions, alternative treatment technologies, or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces the toxicity, mobility, or volume of the contaminants as a principle element or explain why the remedy does not

Overview of Groundwater MNA

- **Monitored**: Carefully controlled and monitored approach with established cleanup levels
- **Natural:** Relies on natural processes including a variety of physical, chemical, or biological processes that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants
- **Attenuation**: These in situ processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants

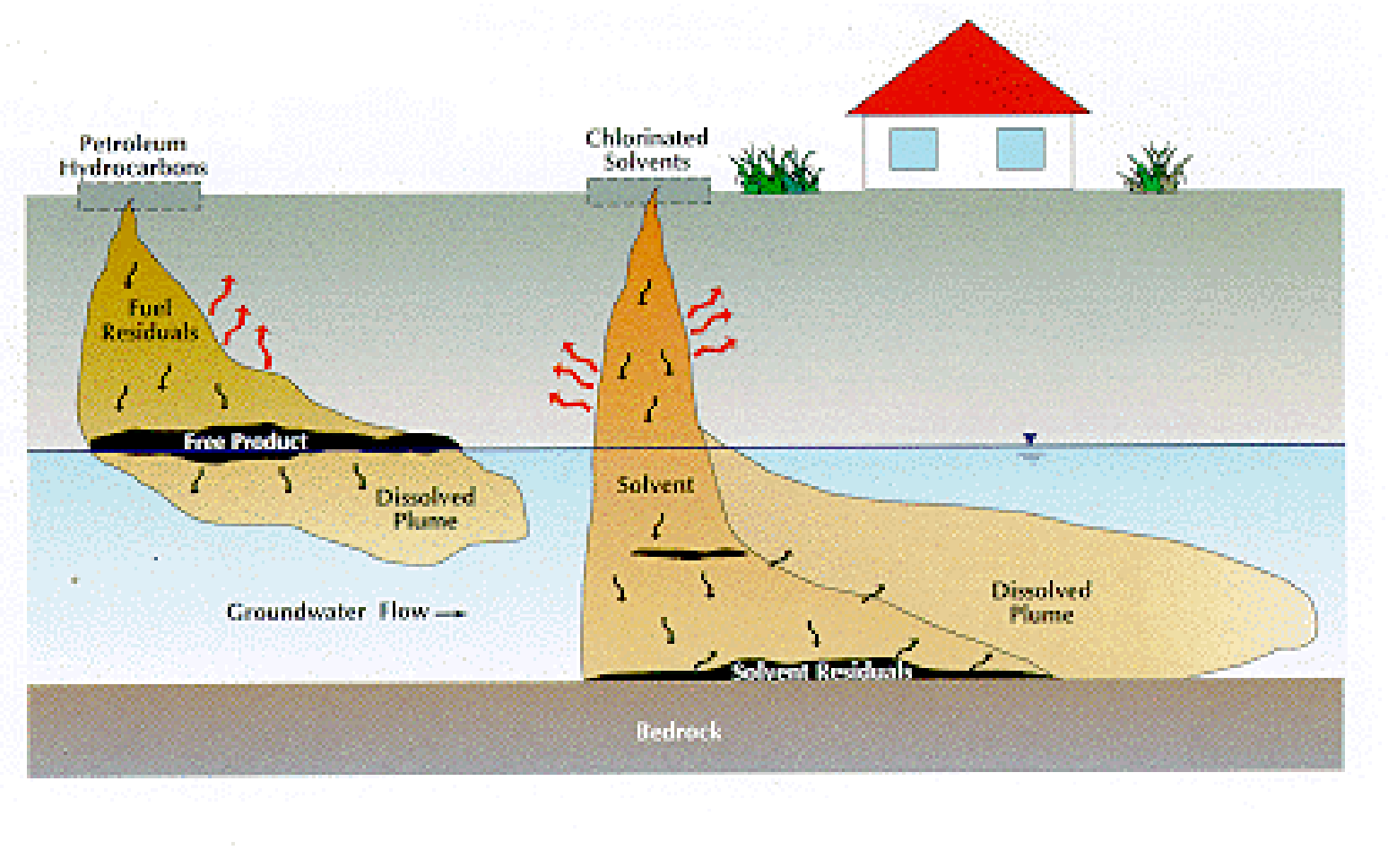
Indications that MNA is Remedy option

- Historical trends indicating a decrease in contaminant concentrations, as well as a stable or retreating plume
- Favorable geochemical conditions
- Presence of breakdown or "daughter" products
- Laboratory "microcosm" studies

Applicability

- MNA is not considered to be a treatment remedy
- Target contaminants include volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), fuel hydrocarbons, and inorganics
  - Fuel and halogenated VOCs are commonly evaluated for natural attenuation
  - MNA may be appropriate for some pesticides, but the process may be less effective and is not applicable to all compounds
  - MNA also may be appropriate for radioactive and non-radioactive inorganic contaminants

MNA: Considerations for Petroleum Hydrocarbons VS Non-Aqueous Phase Liquids (NAPLs)



Advantages of MNA

- May be applied to all or part of a given site
- Less intrusive as few surface structures are required
- Less generation or transfer of remediation wastes
- May be used in conjunction with, or as a follow-up to, other (active) remedial measures, which can shorten the timeframe of active remedies or reduce the quantity of groundwater treated by active remedies
- Overall cost will likely be lower than active remediation

MNA in Conjunction with Treatment of Source

Pre-Remediation:

Partial Mass Removal:

Partial Mass Removal + Monitored Natural Attenuation:

Limitations of MNA

- Is not appropriate where imminent site risks are present
- If free product exists, it may have to be removed
- Requires well-developed conceptual site model to evaluate MNA potential
- Contaminants may migrate before they are degraded
- Intermediate degradation products may be more mobile and more toxic than the original contaminant
- With the exception of nitrate and perchlorate, and radioactive decay, contaminant mass is generally not reduced during MNA for inorganic contaminants

(continued)

Limitations of MNA

- Longer time frames may be required to achieve cleanup levels, compared to active remediation, delaying reuse of the site
  - Institutional controls may be required
  - Long-term monitoring and associated costs
- The hydrologic and geochemical conditions amenable to MNA are likely to change over time and could result in renewed mobility of previously stabilized contaminants and may adversely impact remedial effectiveness
- More extensive outreach efforts may be required in order to gain public acceptance of natural attenuation

EPA Policy on the Use of MNA

OSWER Directive 9200.4-17P (April 21, 1999) *"Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites."*

- Clarifies EPA's policy regarding the use of MNA
- EPA considers MNA as one option that should be evaluated with other applicable remedies
- MNA is appropriate only where its use will be protective of human health and the environment and it can achieve cleanup levlels within a timeframe that is reasonable compared to other alternatives

EPA Policy on the Use of MNA

- The effectiveness of MNA in both near-term and long-term timeframes should be demonstrated through:
  - Technical analyses evaluating multiple lines of evidence
  - Performance monitoring
  - Contingency (or backup) remedies where appropriate

Site Characterization to Evaluate MNA

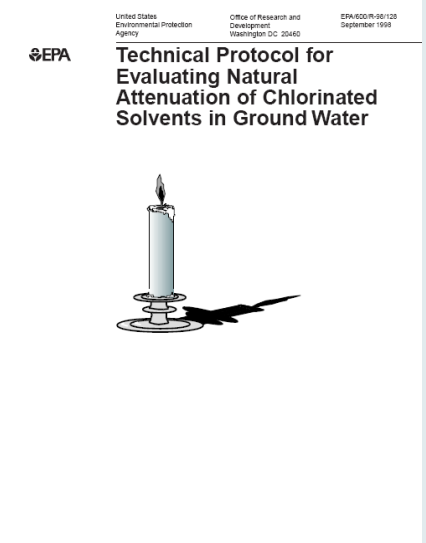
- For organic contaminants
  - Evaluating the mechanism of contaminant degradation, quantifying the risks from transformation products, and calculating the capacity to sustain degradation of contaminant mass within the plume
  - Emphasis on collection and analysis of groundwater samples
- For inorganic contaminants
  - Where immobilization onto aquifer solids is primary means, emphasis on characterization of the solid substrate within aquifer

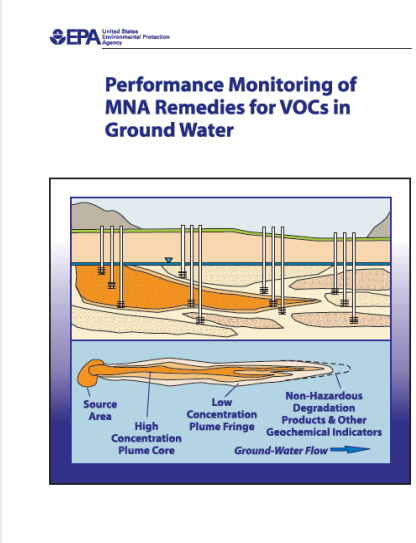
Tiered Approach to Site Characterization for MNA for Inorganics

- Tier I - Demonstrate that the groundwater plume is not expanding
- Tier II - Determine that the mechanism and rate of the attenuation process is sufficient
- Tier III - Determine that the capacity of the aquifer is sufficient to attenuate contaminant and stability of the immobilized contaminant is sufficient to resist re-mobilization
- Tier IV - Establish performance monitoring program and contingency plan

Existing EPA MNA Technical Guidance

- Two technical reports on MNA for organics
  - "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water" 1998
  - "Performance Monitoring of MNA Remedies for VOCs in Ground Water" 2004



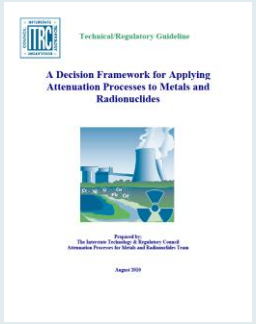


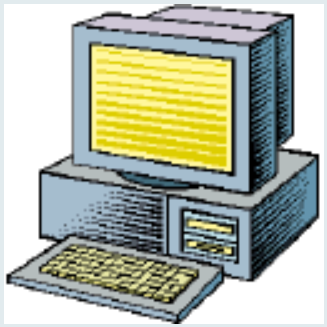
EPA MNA Technical Guidance for Inorganics

- Three technical reports "Monitored Natural Attenuation of Inorganic Contaminants in Ground Water"
  - "Volume 1 - Technical Basis for Assessment" 2007
  - "Volume 2 - Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium" 2007
  - "Volume 3 - Assessment for Radionuclides Including Americium, Cesium, Iodine, Plutonium, Radium, Radon, Strontium, Technetium, Thorium, Tritium, Uranium" 2010

NEW ITRC Guidance on MNA for Inorganics

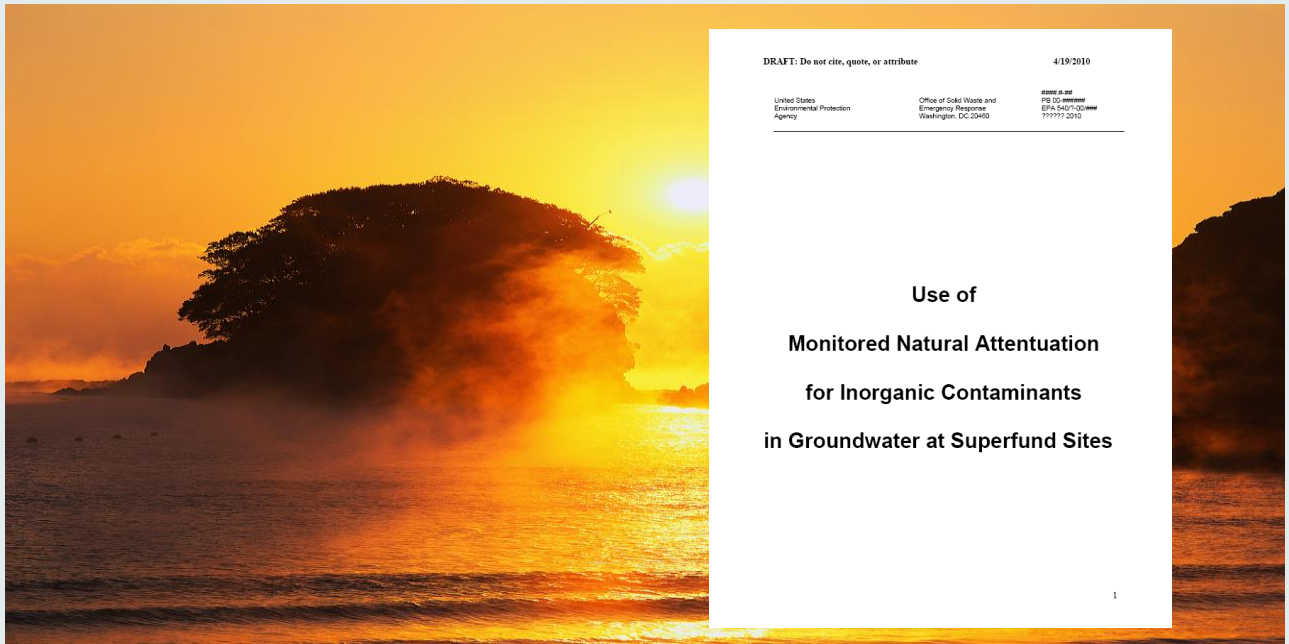
- Complements existing EPA guidance.
- Developed with EPA on workgroup, so also complements draft EPA MNA for inorganics policy guidance
  - Finalized December 2010
  - Accompanied by ITRC on-line training course





Upcoming EPA MNA for Inorganics Guidance Document

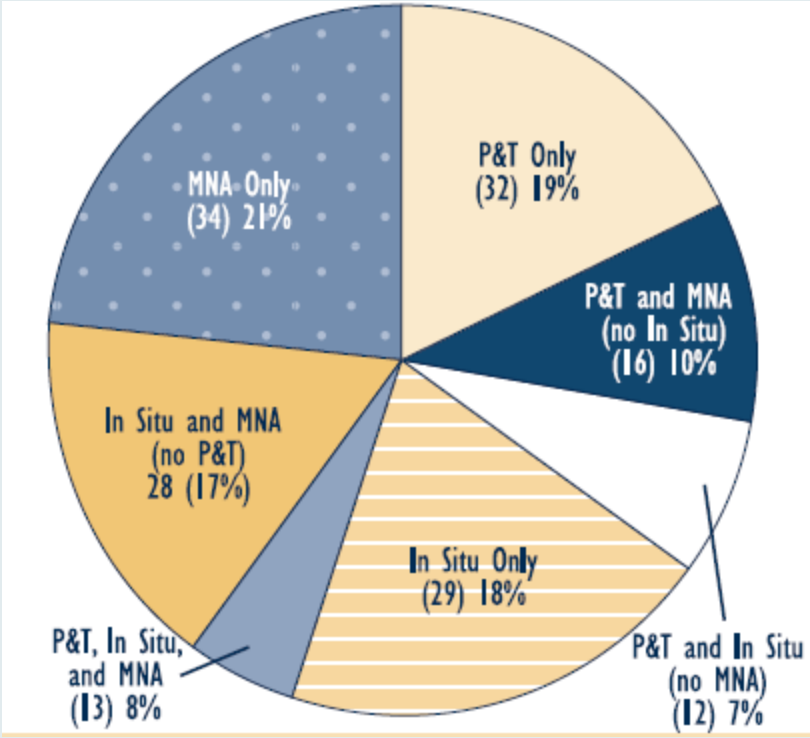
- Will complement 1999 overall MNA policy document
  - Will help clarify policy issues unique to inorganics not addressed in 1999
- Three ORD technical guides on MNA for inorganics will be technical support documents for this policy



Selection and Implementation of MNA In the Superfund Program from 2005 - 2008

- MNA was selected as the sole groundwater remedy at 21% of NPL sites
- MNA often is used in combination with other groundwater treatment remedies:
  - Pump and treat and MNA 10% of sites
  - In situ treatment and MNA 17% of sites
  - In situ treatment, P&T and MNA 8% of sites

NPL Sites with P&T, In Situ Treatment, or MNA Selected as Part of a Groundwater Remedy (2005-2008)



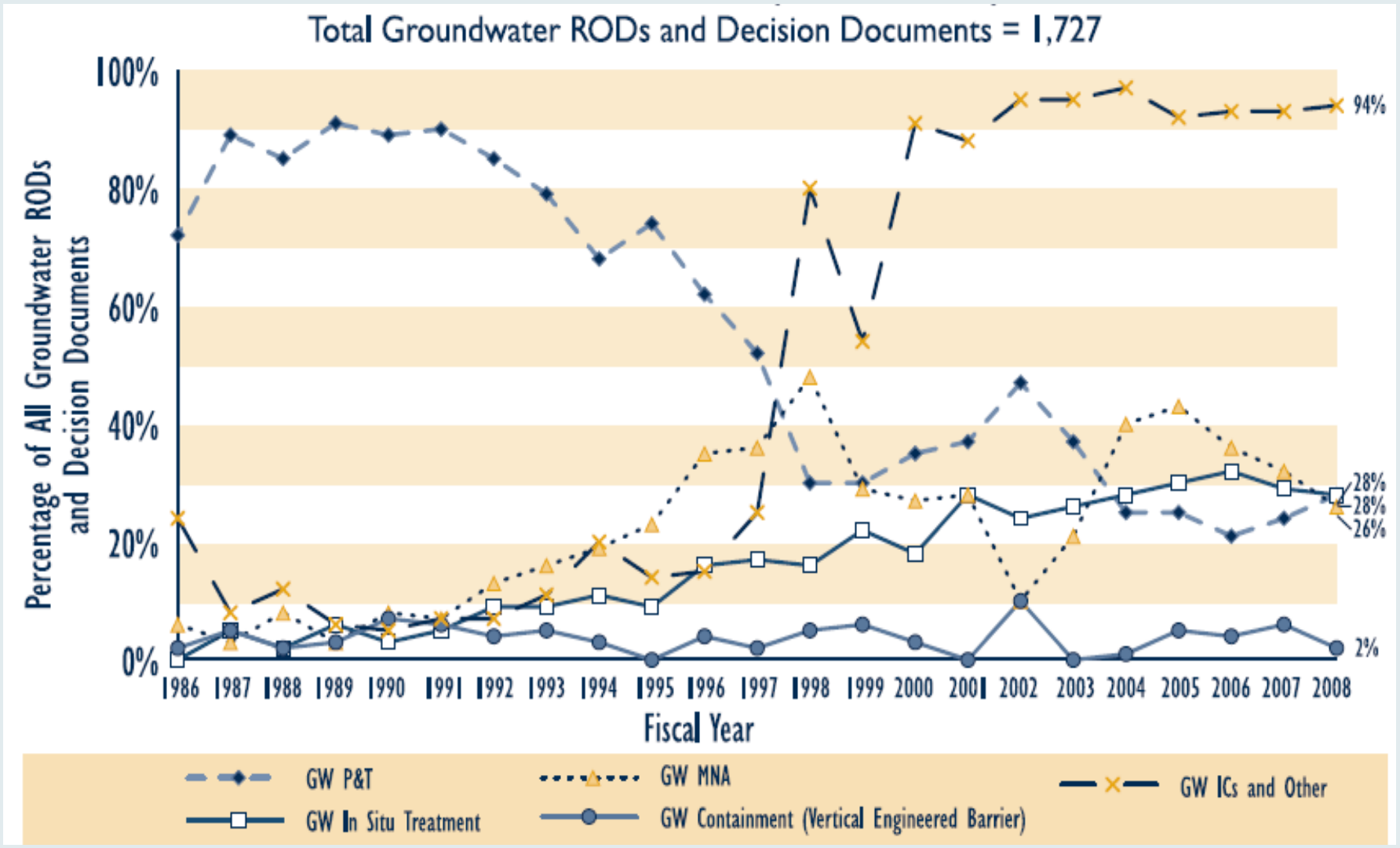
Groundwater Remedies in the Superfund Program (2005-2008)

Remedy Types and Technologies	2005	2006	2007	2008	Total
Groundwater Pump and Treat	22	20	23	18	83
In Situ Treatment of Groundwater	24	31	28	18	101
Bioremediation	13	20	17	12	62
Chemical Treatment	9	11	14	4	38
Air Sparging	5	2	1	2	10
Permeable Reactive Barrier	3	3	1	1	8
Phytoremediation	0	2	1	0	3
Fracturing	1	0	0	0	1
Multi-Phase Extraction	1	0	0	0	1
Unspecified Physical/Chemical Treatment	0	0	1	0	1
MNA of Groundwater	34	35	30	17	116
Groundwater Containment (Vertical Engineered Barrier)	4	4	6	1	15
Other Groundwater	73	90	88	61	312
Institutional Controls	63	79	77	52	271
Monitoring	62	80	58	39	239
Alternative Water Supply*	6	6	5	9	26
Engineering Control†	0	1	3	0	4
Total of Remedy Types	157	180	175	115	627

* Record of Decision, Superfund pubic document through which a remedy is formally selected.

Source http://Cluin.org/asr

Selection and Implementation of MNA In the Superfund Program (1986-2008)



Source http://Cluin.org/asr

Case Study – Sola Optical USA, Inc. Background

- Manufacturing facility in the State of California operated from 1978 to 2001
- In 1985, 6 USTs and associated soil were removed - no additional soil remedy was conducted
- Pump and treat was selected in 1991 ROD and operated from 1988 until 1997 - concentrations had decreased but stabilized above the MCLs for 1,1-DCA and 1,1-DCE
- During 6 months of monitoring following pump and treat shutdown, no rebound was observed

Case Study – Sola Optical USA, Inc. Data Supporting MNA

- The source of the VOCs in the groundwater had been removed
- The extent of VOC-affected groundwater was limited to shallow saturated sediments and was stable
- The low VOC concentrations in the groundwater did not pose a current threat to surface water or human receptors
- Presence of 1,1-TCA breakdown products indicating that reductive dechlorination was occurring naturally
- Current conditions indicated that concentrations of VOCs in groundwater had reached or were close to reaching cleanup levels
- Alternative technologies to reduce remaining contamination to cleanup levels were limited

Case Study – Sola Optical USA, Inc. Adoption of MNA

- EPA concurred in 2002 and stated that the responsible party would continue groundwater monitoring until all contaminants were below MCLs for at least 2 years
- The 2005 five-year review indicated that MCLs have been achieved in all wells for all contaminants with the exception of 1,1-DCA in one well
- A ROD Amendment was signed in March 2007 that changed the groundwater remedy from pump and treat to MNA and ICs

Conclusion

- MNA is being used as part of long term response actions for groundwater
- MNA works as a finishing step for low levels of contamination, especially petroleum-related, chlorinated solvents, and inorganics
- Current trend in selecting MNA as a remedy is rebounding in recent years
- 35 percent of Superfund sites with MNA combined it with some form of treatment
- 21 percent of sites selected MNA alone with no additional form of source control or groundwater treatment

References

- USEPA, 1999a. "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites". OSWER Directive 9200.4-17p.
- USEPA, 1999,2004. "Understanding Variation In Partition Coefficient, Kd, Values". ORIA, EPA402-R-99-004A,B&C.
- USEPA, 2000. "Soil Screening Guidance for Radionuclides: User's Guide". ORIA/Superfund, EPA/540-R-00-007 PB2000 963307.

References

- Smith, C. and N. Smith. General Chemistry Workbook, Nuclear Chemistry, Chapter 24 pg 308-309. W.H. Freeman and Co. (1971).
- ITRC (Interstate Technology & Regulatory Council). 2010. "*A Decision Framework for Applying Monitored Natural Attenuation Processes to Metals and Radionuclides in Groundwater" APMR-1. Washington, DC: Interstate Technology & Regulatory Council, Attenuation Processes for Metals and Radionuclides Team.*
- *Superfund Remedy Report, Thirteenth Edition* (2010) http://cluin.org/asr.

References

- *USEPA 2007a. "*Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 1 - Technical Basis for Assessment". EPA/600/R-07/139.
- USEPA 2007b. "**Monitored Natural Attenuation of Inorganic Contaminants in Ground Water,** Volume 2 - Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium". EPA/600/R-07/140.
- USEPA 2010. "**Monitored Natural Attenuation of Inorganic Contaminants in Ground Water,** Volume 3 - Assessment for Radionuclides Including Tritium, Radon, Strontium, Technetium, Uranium, Iodine, Radium, Thorium, Cesium, and Plutonium-Americium". EPA/600/R-10/093.

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