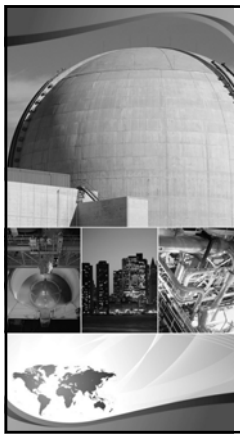

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Monitored Natural Attenuation as a Remediation Strategy for Nuclear Power Plant Applications

Sean Bushart- EPRI
Karen Kim- EPRI

NRC RIC Conference-
Panel on Subsurface Environmental Characterization, Modeling, Monitoring and Remediation
March 11, 2009

What is MNA? (From 1999 EPA Directive)

"The term 'monitored natural attenuation,' as used in this Directive, refers to the reliance on natural attenuation processes to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods."

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Implementing MNA as a Remedial Strategy

- MNA is NOT a "do-nothing" or "no action" alternative
  - Knowledge/science/engineering based remedy
  - Requires *monitoring* of the natural attenuation processes
- Incorporates three important factors:
  - Risk to human health and the environment
  - Contaminant mobility and/or decay
  - Time
- Appropriately implemented MNA saves remediation costs

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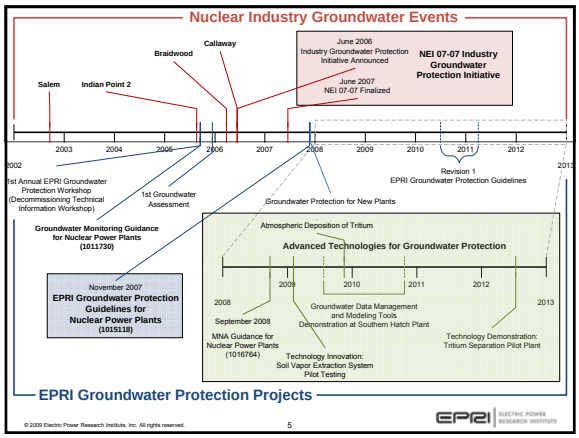
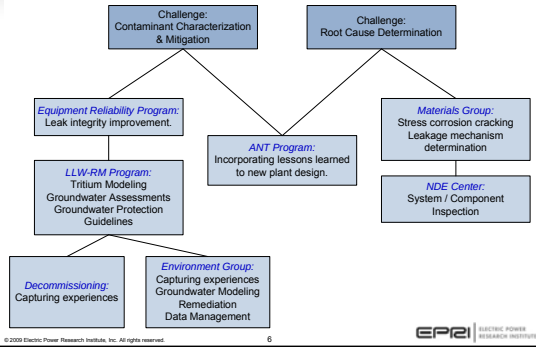
Presentation Overview

- Background: Industry Groundwater Protection Initiative and EPRI Role
- MNA Applications for Non-Radioactive Site Contaminants and for Radioactive Contaminants
- Published EPRI Report on MNA



EPRI Task Force for Groundwater Protection



EPRI Groundwater Protection Guidelines for Nuclear Power Plants (1015118)

Graded Approach
- Baseline Program for all users
- Toolbox of Elevated Program Elements for increased understanding of site hydrogeology.

Evaluation of Systems, Structures, Components (SSCs) and Work Practices
- Risk of groundwater contamination
- Design and condition of SSCs

Understanding Site Hydrogeology and Characteristics
- Transport of potential groundwater contamination
- Developing Conceptual Site Model

Implementing Groundwater Monitoring Program
- Installing and sampling groundwater monitoring wells
- Data analysis and management
- Review and update of monitoring program over time

Examples of Structures, Systems and Components (SSCs) Evaluated in Utility Groundwater Protection Programs

These SSCs contain radioactive liquids and have the potential to contribute to groundwater contamination

- Outside Storage/Transfer Areas
- Spent Fuel Pool & Transfer Canal
- Underground Piping
- Underground Tanks

Which Radionuclides are Most Important in NPP Ground Water Investigations?

Ranking Based Upon:
- **Inventory (PWR)**
- **Relative Dose**
- **Solubility**
- **Ease of Transport Through Soil (K_d)**

Relative Rank	Radionuclide
1	Sr-90
2	Cs-137
3	Co-60
4	H-3
5	Cs-134
6	I-129
7	Ni-63
8	C-14
9	Pu-238
10	Am-241

Reference: EPRI Report 1011730 "Groundwater Monitoring Guidance for Nuclear Power Plants", 2005

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Original MNA Work: Based upon Biological Decay of Hydrocarbons

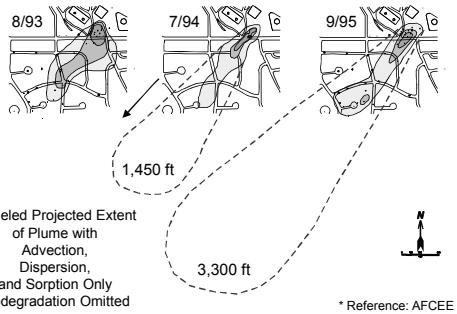
- Ex. For USTs containing BTEX (benzene, toluene, ethylbenzene, xylene)
  - Benzene will biologically decay under the proper conditions:

$C_6H_6 + 7.5O_2 \rightarrow 6CO_2 + 3H_2O$

(aerobic biodegradation* of benzene)

*** Biodegradation... a coupling of an oxidation (electron donor) to a reduction (electron acceptor) to gain energy for the organism**

Example: Total BTEX Projection from MNA Site*



Modeled Projected Extent of Plume with Advection, Dispersion, and Sorption Only Biodegradation Omitted

* Reference: AFCEE

MNA Applications for Radionuclides

- DOE:
  - Sandia Labs: A Natural Attenuation Toolbox for Metals and Radionuclides
  - Decision-Making Framework Guide for the Evaluation and Selection of MNA Remedies at DOE Sites
- IAEA:
  - Applicability of Monitored Natural Attenuation at Radioactively Contaminated Sites (STI/DOC/010/445, 2006)
- EPA:
  - 2007: Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 1: Technical Basis for Assessment

Radionuclides, particularly those relevant to NPPs, can be good candidates for MNA due to their known half lives and in some cases their biogeochemical behaviors

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EPRI Report (1016764) "Technical Guidance for MNA at Nuclear Power Plants"

Why a Utility MNA Compendium?

- **Put in Place a Guidance Document Useful to Utility Site Managers**
- **Need Consistent Utility-Industry Approach**
- **MNA is Global Across Utilities:**
  - Media
    - Soil-groundwater-surface water-sediments
  - Contaminants
    - PAHs, NAPL, metals, PCBs, and other inorganics
  - Waste Streams
    - Oil, combustion by-products, coal tars, transformer oils, solvents

Monitored Natural Attenuation for Nuclear Power Plants

ATTENUATION PROCESS

Biological | Chemical | Volatilization | Sorption | Dispersion | Dilution | Radioactive Decay

U.S. EPA & DOE

Guidance for Superfund RCRA/CERCLA Sites:

Hanford | Lawrence Livermore | Savannah River

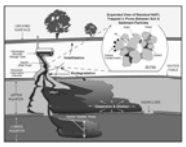
DOE Implementation of MNA for Radionuclides

EPA Guidance

EPRI Environment Sector

Guidance for Manufactured Gas Plants

Inter-EPRI Collaboration



Monitored Natural Attenuation of Chlorinated Solvents, U.S. EPA REMEDIAL TECHNOLOGY FACT SHEET
http://www.clu-in.org/download/remed/ch1-solv.pdf

EPRI Nuclear Sector

Technical Guidance for Monitored Natural Attenuation for Nuclear Power Plants

EPRI Report (1016764)
"Technical Guidance for MNA at Nuclear Power Plants"

Includes Guidance on:

- Mechanisms for Migration and Retention of Radionuclides
- Evaluating Site Suitability for MNA
- Remediation Objectives and Site Remediation
- Monitoring Attenuation
- Assessing MNA Progress and the Contingency Plan

EPRI Report (1016764)
"Technical Guidance for MNA at Nuclear Power Plants"

Evaluating Site Suitability for MNA

- Site conceptual model integrating:
  - plant layout
  - potential contaminant sources
  - site operating history
  - site hydrogeology
- Site characterization to evaluate:
  - nature and extent of the radioactive contamination in soil and groundwater
  - hydrogeological and geochemical features of the site
  - a stable or diminishing groundwater plume
- Evaluation of near-site receptors and near-site land and water use

EPRI Report (1016764)
"Technical Guidance for MNA at Nuclear Power Plants"

"Triggers" for Assessing MNA Progress

- Are radioactive contamination levels decreasing at rates that meet or exceed predictions?
- Migration of contaminants beyond established plume or compliance boundaries
- Contaminants detected at locations that potentially will pose unacceptable risks to receptors
- Contingency soil and groundwater remediation options should be evaluated

Triggers should be set so as to ensure that seasonal fluctuations or sampling variability do not trigger a contingency unnecessarily

Summary: Monitored Natural Attenuation for Nuclear Power Plants

Benefits of MNA for NPPs

- Effective, technically sound remediation methodology
- Relatively low cost compared to traditional remediation methods (i.e. excavation and soil replacement)
- Does not produce secondary waste

Applications of MNA at NPPs

- Decommissioning
  - Yankee Rowe, Connecticut Yankee
- Operating Plants

Conclusions: Implementing MNA as a Remedial Strategy

- MNA is NOT a "do-nothing" or "no action" alternative
  - Knowledge/science/engineering based remedy
  - Requires *monitoring* of the natural attenuation processes
- Incorporates three important factors:
  - Risk to human health and the environment
  - Contaminant mobility and/or decay
  - Time
- Appropriately implemented MNA saves remediation costs

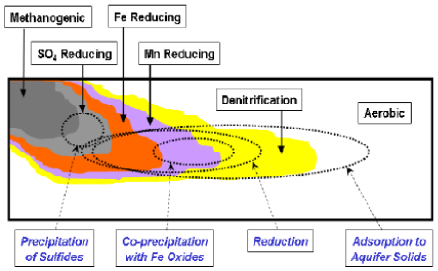
BACKUP SLIDES

EPRI Groundwater Protection/Remediation Guidance and Other Key MNA References

- Technical Guidance for Monitored Natural Attenuation at Nuclear Power Plants 1016764, EPRI, Sep.08
- Groundwater Protection Guidelines for Nuclear Power Plants: Public Edition 1016099, EPRI, Jan. 08
- Groundwater Monitoring Guidance for Nuclear Power Plants 1011730, EPRI, Dec. 05

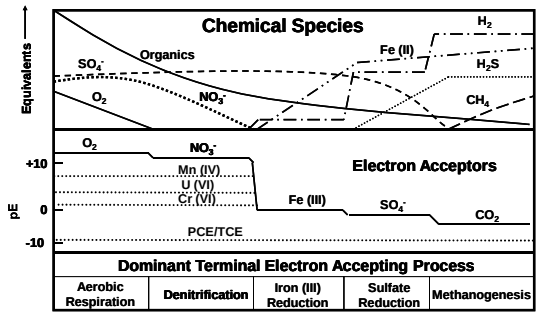
- EPA 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. Directive 9200.4-17P. U.S. Environmental Protection Agency. April 1999
- EPA 2007. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 1 – Technical Basis for Assessment.* EPA/600/R-07/139. U.S. Environmental Protection Agency. October 2007.
- IAEA 2006. *Applicability of Monitored Natural Attenuation at Radioactively Contaminated Sites*. International Atomic Energy Agency. Technical Reports Series No. 445.
- Sandia 1999. *Site Screening and Technical Guidance for Monitored Natural Attenuation at DOE Sites.* SAND99-0464. Sandia National Laboratories. March 1999.
- *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination in Groundwater*, Volume I and Volume II. Air Force Center for Environmental Excellence (AFCEE). 1995.

Monitoring MNA Biogeochemistry
(for advanced investigations)



Reference: USEPA: Site Characterization for MNA of Radionuclides in Ground Water

MNA Biogeochemistry



Reference: DOE LBNL VIMSS Institute

Together…Shaping the Future of Electricity

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