Subsurface Environmental Characterization, Modeling, Monitoring and Remediation

Thomas J. Nicholson and George Powers
Office of Nuclear Regulatory Research

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Session Issues

- Development of Alternative Conceptual Site Models
- Characterization of Sources and Subsurface Processes
- Integrated Monitoring and Modeling Programs
- Risk-Informed Analysis Using Site-Specific Data
- Decision Whether to and How to Remediate
- Performance Monitoring to Evaluate Remediation Effectiveness

Speakers & Panelists

Speakers:
Robert Ford, Environmental Scientist
EPA, Office of Research and Development, Cincinnati, OH
Vince Adams, Director
DOE, Office of Ground-Water and Soil Remediation, Germantown, MD
Sean Bushart, Senior Program Manager
EPRI, LLW Chemistry & Radiation Management, Palo Alto, CA

Panelists:
Stephen Cohen, Team Leader, New Facility Licensing
U.S. NRC, FSME, DWMEP, DURLD
Richard Raione, Branch Chief, Hydrologic Engineering Branch
U.S. NRC, Office of New Reactors, DSER
Mark Roberts, Senior Health Physicist
U.S. NRC, Region I, DNMS, Decommissioning Branch

Conceptual Site Hydrologic Model

Important to characterize the following:

- Natural and engineered features, structures, backfills and soil-rock interfaces, boundary conditions and time-dependent processes
- Potential sources of accidental, incidental and regulatory releases
- Regional and site hydrologic setting (aquifers, surface- water bodies, springs, wetlands and drainage systems) and relationships
- Local drinking water sources (ground- and surface-water sources)
- Existing ground-water wells and monitoring points onsite and offsite
- Depth to the water table and surface-water body elevations
- Historical details on contaminant releases
- Ground-water gradients, flow directions and velocities

Once surface and/or subsurface contamination is detected, **evaluate its significance and develop an appropriate response**

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Back-Up Slides for Panel Discussion

Detailed discussions and illustrations follow on:

- Conceptual Site Models
- Characterization
- Monitoring
- Modeling
- Remediation
- NRC Information Sources

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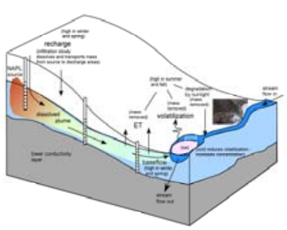
The Conceptual Site Model

- Hypothetical representation of the site
- Select, organize and communicate information
- Subject to testing with new characterization and monitoring data



Conceptual cross-section for the Rocky Flats Facility (Modified from K-H, 2004)

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Uncertainties in Conceptual Models

Sources of Hydrogeologic Uncertainty:

- ✓ Incomplete knowledge of the subsurface system
- ✓ Measurement error in characterizing the system's features, events and processes (FEPs)
- ✓ Natural variability in the system's spatial properties, temporal events and transient external stresses
- ✓ Disparity in scales of sampling, monitoring and simulation relative to actual dimensions of the FEPs
- ✓ Parameter estimation
- ✓ Scenario definition

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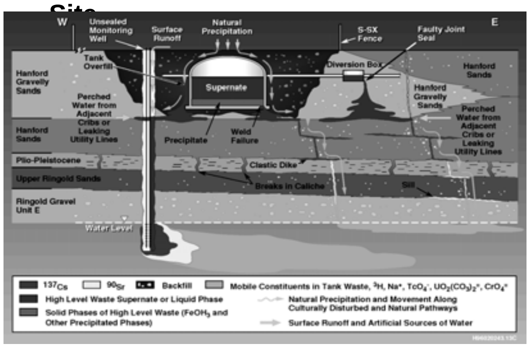
Conceptual Model of a Complex Site



from Ward et al. (1997) after Caggiano et al. (1996)

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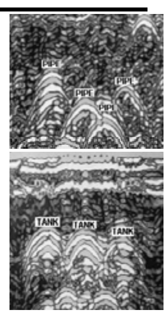
Site-Specific FEP's for Developing Alternative Conceptual Site Models

- Pathways for rapid spread of leaking contaminants
  - pipe or cable trenches
  - gravel backfill
- May drive contaminants in directions not predicted by contouring a few data points on a water-table map
- Local precipitation drainage (roof and storm drains)
- Water-sources of leaks
  - can inject large amounts of water into the vadose zone, sometimes creating perching
  - drive ground water and contaminants in directions not predicted based on water levels from scattered monitoring wells



GPR Images

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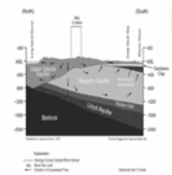
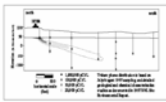
Case Histories - Brookhaven



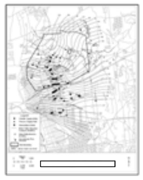
Regional Geologic Setting

Tritium Plume Plan Map

Regional Ground-Water Flow

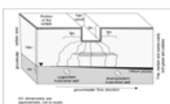


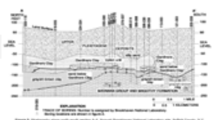
Tritium Plume Cross-Section



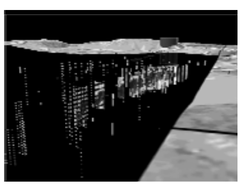
Site Ground-Water Flow

Synthesis of CSM & Flow and Transport Models





- AES developed a CSM that incorporated influence of nearby pumping wells and 3-D visualization of data
- Used flow and transport modeling to validate that our CSM reflected observed monitoring data. (Modeling was done in Excel, MODFLOW under the GMS umbrella)
- Once validated, used flow and transport modeling to evaluate remediation alternatives



Case Histories – Amargosa Desert Research Site (ADRS) Facility Characterization and Monitoring Data

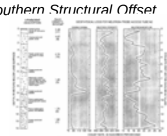
Extensive USGS information on:

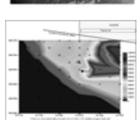
- Monitoring well data from existing wells
- Schlumberger resistivity soundings
- Soil gas data
- Thermocouple psychrometer data
- Neutron probe data
- Vegetation tritium analytical data

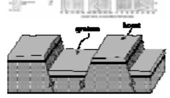
Analysis of this data suggested a fault which acted as a preferential transport path

- Geophysical borehole log data (neutron-moisture, natural gamma, and gamma-gamma)

- Analysis of characterization and monitoring data
  – Re-evaluation and compilation of existing data resulted in the identification of a potential preferential pathway in the unsaturated zone termed the *Southern Structural Offset*

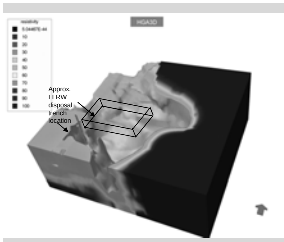






ADRS Conceptual Site Model

- Basis for the CSM:
  - Geology
  - Ground-water flow
  - Contaminant transport



3-D resistivity block model of ADRS.

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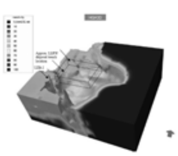
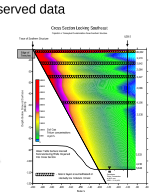
Synthesis of CSM & Flow and Transport Models

- USGS had an existing CSM; however tritium modeling results did not match observed contaminant distributions.
- AES developed an alternative CSM that included this fault. Observed data matched flow and transport simulations
- Modeled resistivity data in 3-D using kriging through HydroGeo Analyst 2.0 Simple Excel spreadsheet model to simulate movement of tritium in vadose zone both laterally and vertically in response to proposed fault
- Contoured tritium in ground water and vadose zone using Surfer code

- Current CSM did not match movement of tritium in vadose zone
- Revising CSM
  - An alternative CSM was proposed
  - Subsequent flow and transport modeling of the vadose zone produced results that more closely matched observed data





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Analysis of Site and Facility Characterization & Monitoring Data

- Geophysical borehole log data (neutron-moisture, natural gamma, and gamma-gamma)
  Monitoring well data from existing wells
- Schlumberger resistivity soundings
- Soil gas data
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- Used Surfer for contouring tritium in ground water and vadose zone

WHAT:
PI Recommendations

- Class 1: tritium concentrations in ground water, soil gas, and plants
- Class 2: vadose zone water flux
- Class 3: incongruous water table shape, modeling congruity, tritium as outliers in ground water

WHERE & WHEN:
Monitoring Points (MP) Recommendations:

- Add vadose zone wells or CPTs near proposed fault to evaluate tritium and barometric pressure
- Ensure site monitoring system is integrated and comprehensive

HOW:
Monitoring Devices (MD)

- Soil vapor, ground water sampling

PERFORMANCE CONFIRMATION MONITORING:
Data Collection & Analysis

FEEDBACK based on analysis of PCM data will be used to update CSM

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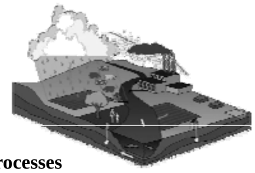
Integrate Modeling with Monitoring

Why monitor and model?



Characterize natural and engineered systems:

- ✓ **Collect information to identify significant Features, Events and Processes**
- ✓ **Develop and evaluate site conceptual models**
- ✓ **Guide data collection including monitoring, sampling and geophysical surveys**

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Integrate Modeling with Monitoring

Site-Specific Modeling Benefits:

- ✓ Integrates disparate characterization and monitoring data into a logical framework
- ✓ Reduces uncertainties and help to identify location of monitoring to confirm hydrogeologic system behavior
- ✓ Forecasts impacts (doses due to exposure and uptake)
- ✓ Provides bases for decision-making on the need to interdict, mitigate and remediation abnormal releases
- ✓ Assists in designing and monitoring remediation program (e.g., monitored natural attenuation thru pump-and-treat)
- ✓ Communicates understanding of the system to the public and facilitates technical interactions

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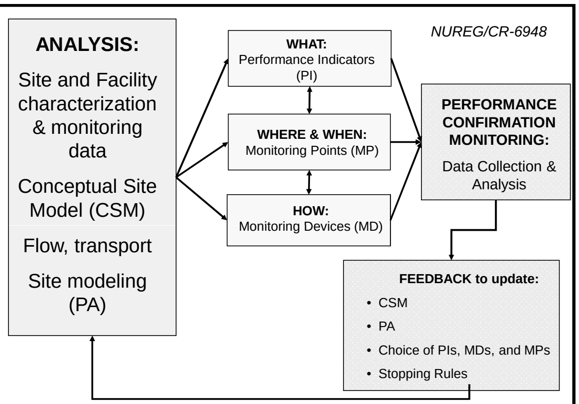
NUREG/CR-6948



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Information Source – NUREG/CR-6948

- Technical bases for developing guidance on ground-water monitoring for NRC-licensed sites
- Systematic methodology to integrate monitoring with modeling
- **http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6948/v1/index.html**


NUREG/CR-6948, Vol. 1

Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion

Prepared for
Division of Fuel, Engineering and Radiological Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

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Information Source – NUREG/CR-6948

- Lessons-Learned for developing guidance on ground-water monitoring for NRC-licensed sites
- Case Studies which includes Brookhaven radionuclide plume remediation and monitoring
- **http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6948/v2/index.html**


NUREG/CR-6948, Vol. 2

Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Case Study Applications

Prepared for
Division of Fuel, Engineering and Radiological Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

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Information Source – NUREG/CR-6973

- Overview of *in situ* uranium bioremediation which identifies and prioritizes field performance indicators for evaluating its effectiveness.
- Performance indicators to be monitored and modeled are based on current biogeochemical understanding of uranium.
- Confirmation monitoring is vital to demonstrating long-term success of U-bioremediation and provides a significant assurance that regulatory goals will be met.
- http://www.nrc.gov/reading-rm/doc-collections/nuregs/contract/cr6973/index.html


U.S.NRC

Technical Basis for Assessing Uranium Bioremediation Performance

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RES Studies in Support of Ground-Water Monitoring and Modeling

- **Assess contaminant transport in soils using ARS's extensive field databases to identify and demonstrate model abstraction techniques, and assess uncertainties (NUREG/CR-6884)**
- **Test PNNL Uncertainty Methodology at Hanford 300-Area to identify and quantify conceptual model, parameter and scenario uncertainties (NUREG/CR-6940)**
- **Apply USGS surface-complexation models of U adsorption and retardation using field data from the Naturita Site (NUREG/CR-6820)**
- **Assess the efficacy of *in situ* bioremediation to sequester U through monitoring and modeling of Performance Indicators (PNNL-17295)**
  - ✓ **Apply AES's "Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites" (NUREG/CR-6948)**

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