U.S. Department of Energy (DOE)
Office of Legacy Management (LM)

Analysis of Environmental Monitoring Data Following Site Closure

Interagency Steering Committee on
Performance and Risk Assessment

Community of Practice Annual Technical Exchange Meeting

Richard Bush, Program Manager
December 11, 2014

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A Brief History in Time of Legacy Management

- Creation of Office of Legacy Management
- Mission
- Types of sites, regulatory requirements
- Site examples
- Monitoring – modeling
- Data repositories – GEMS, SOARS
- In-house studies
- Could we do interactive monitoring and modeling?

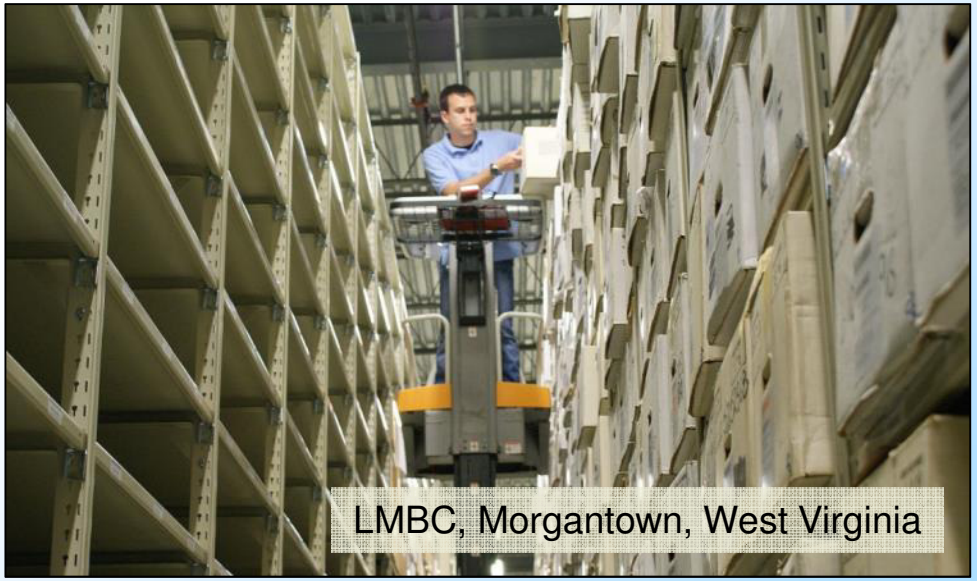
LM History and Major Responsibilities

- Formed in 2003 for post-closure responsibilities at DOE sites
- Long-term surveillance and maintenance (LTS&M) of DOE sites
- Maintain records for sites
- Manage pensions for former site workers
- Beneficial site reuse and land disposition

Groundwater Sampling,
Weldon Spring, Missouri, Site

Falls City, Texas, Disposal Site

Fernald Preserve Visitor Center, Ohio



LMBC, Morgantown, West Virginia

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Types of Sites Managed by LM

- **RCRA –** 1976 Resource Conservation and Recovery Act
- **UMTRCA**– 1978 Uranium Mill Tailing Radiation Control Act
- **CERCLA** – 1980 Comprehensive Environmental Response, Compensation, and Liability
- **FUSRAP** – Formerly Utilized Sites Remedial Action Program
- **D&D** – Decontamination and Decommissioning
- **Other** – Mostly Nevada Offsites or records-only sites

LM's Future

- 35 new sites are expected to transition to LM through fiscal year 2023
  - UMTRCA Title II sites – 16
  - FUSRAP sites – 18
  - DOE Office of Environmental Management (EM) site – 1

Panna Maria, Texas, Disposal Site

Split Rock, Wyoming, Site

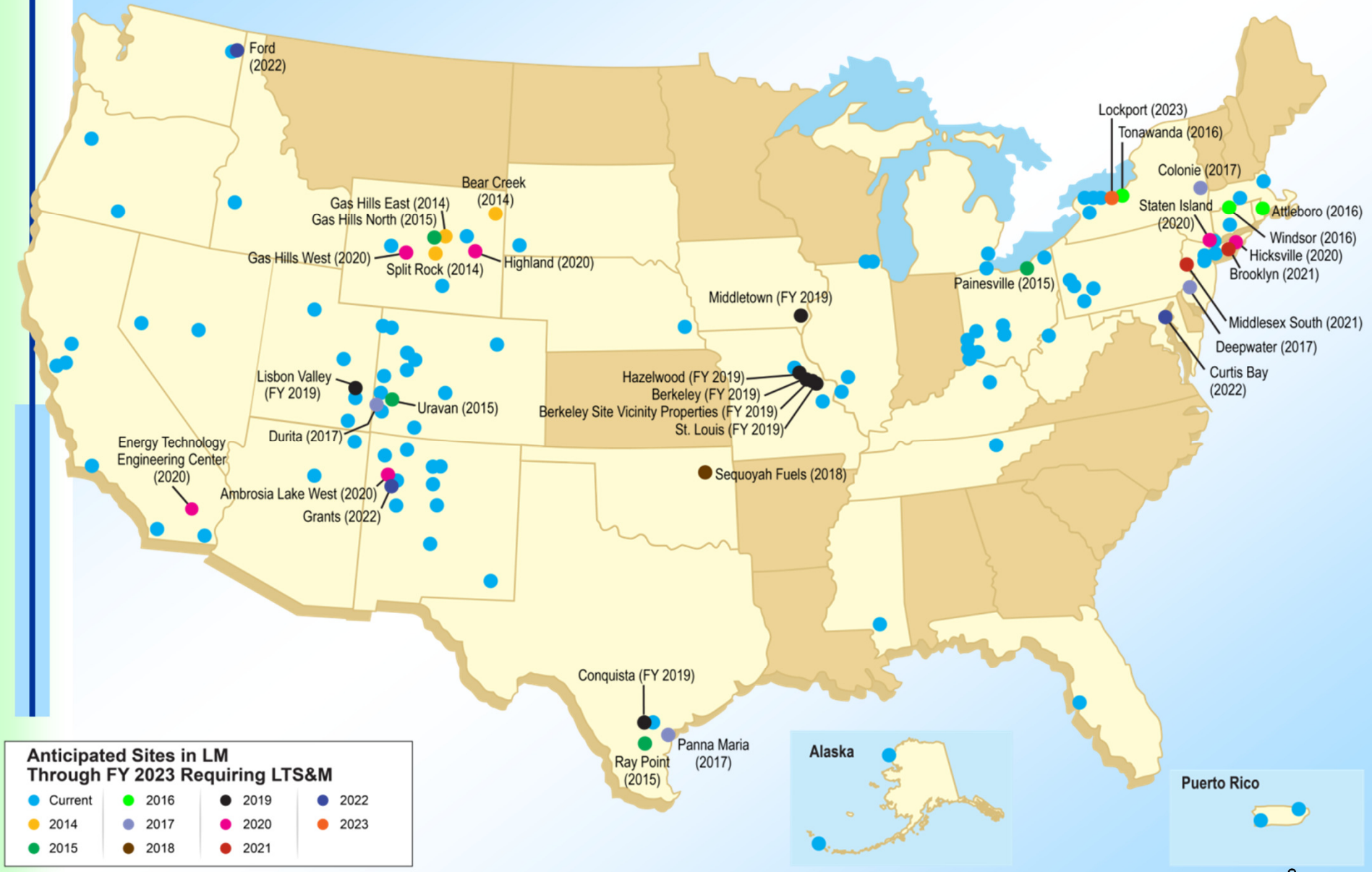
LM's Future: Scope Will Increase

- An increased scope comes with additional responsibilities and requirements
  - Additional evaluation of sites with groundwater contamination
  - Final resolution for several groundwater remedies
  - Learn from the past:
    - Reduce likelihood of future problems by raising due diligence level during site transition for UMTRCA Title II sites

Pinellas County, Florida, Site

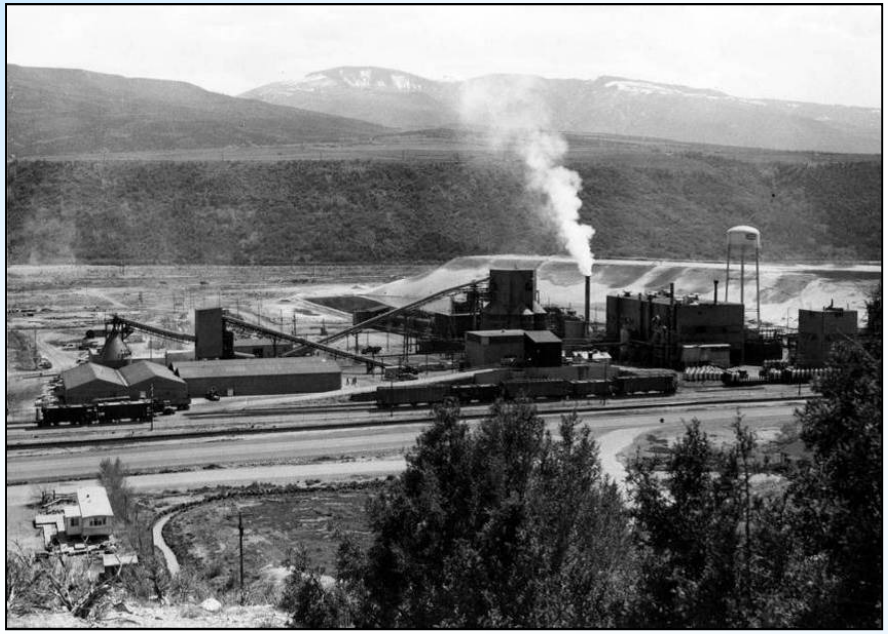
Rocky Flats, Colorado, Site

Anticipated Legacy Management Sites Through FY 2023



Site Profile
Rifle, Colorado, Sites

- UMTRCA Title I sites
- Two uranium- and vanadium-processing sites
- Cleanup took place from 1992 to 1996



Rifle uranium mill operated between 1924–1932 and 1942–1958

Rifle disposal cell

Site Profile

Tuba City, Arizona, Disposal Site

- UMTRCA Title I site
- Former uranium mill
- Cleanup took place from 1988 to 1990

Tuba City uranium mill operated from 1956 to 1966

Tuba City solar panels

UMTRCA Lessons Learned
Shiprock, New Mexico

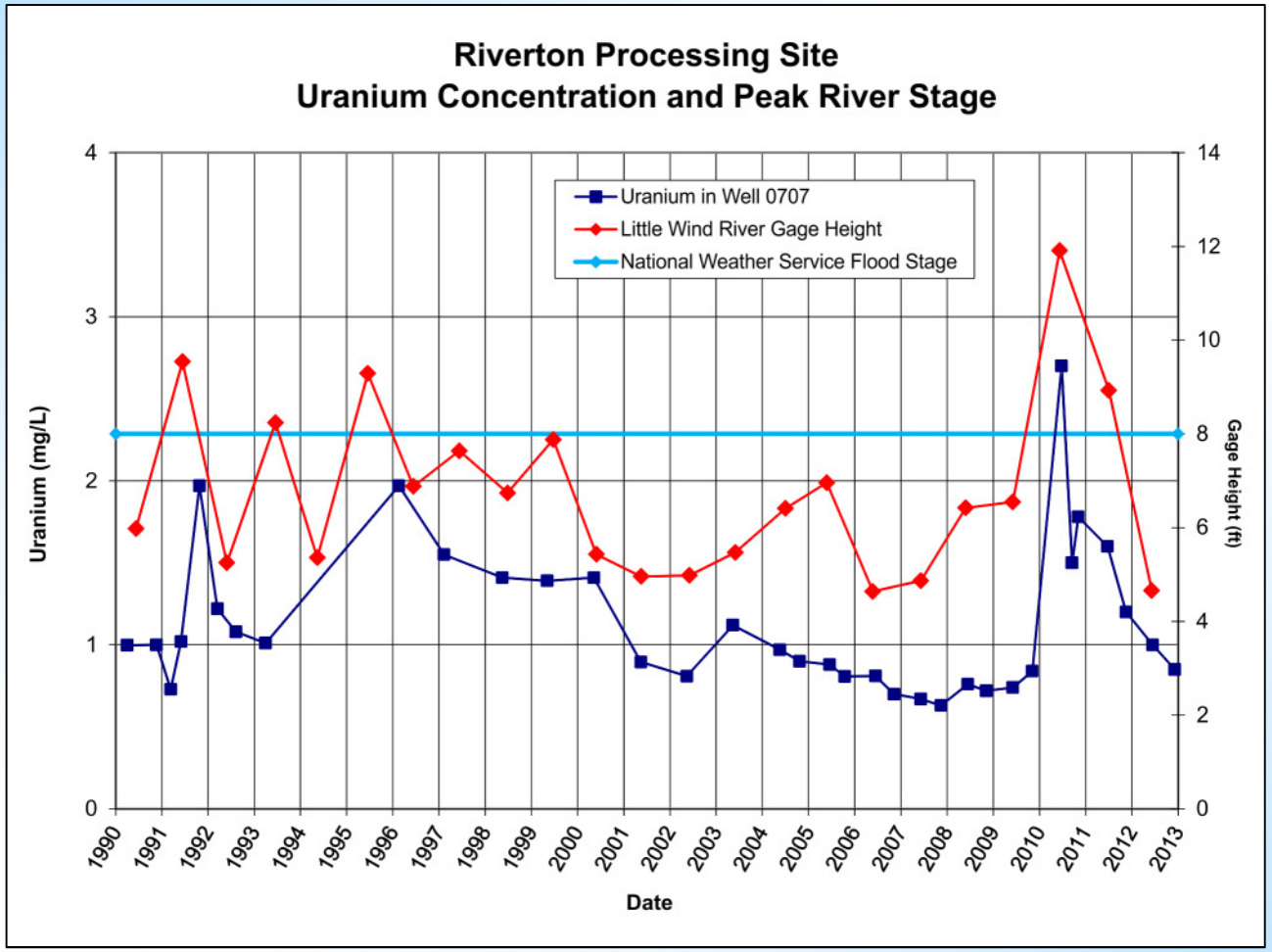
- Erosion

UMTRCA Lessons Learned

Lakeview, Oregon

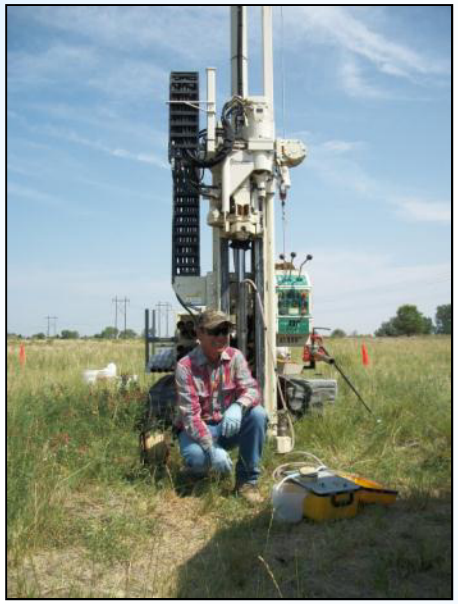
- Crumbling riprap
- Dust deposition over time concentrates silt and clay particles enough that they hold water near the surface of cells, which allows establishment of vegetation

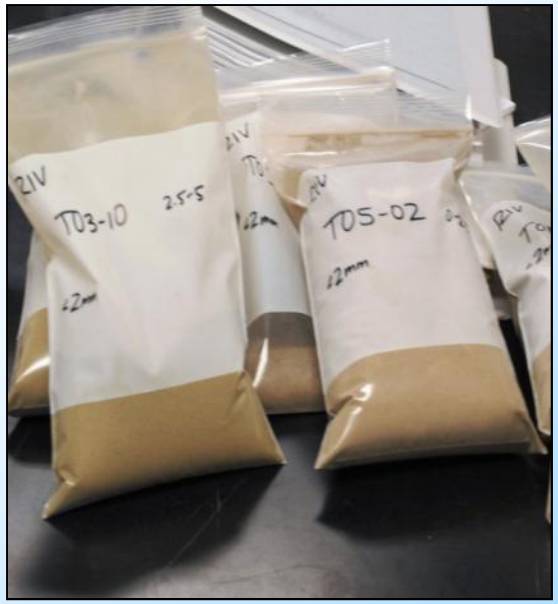
Uranium in Groundwater and Flood Stage



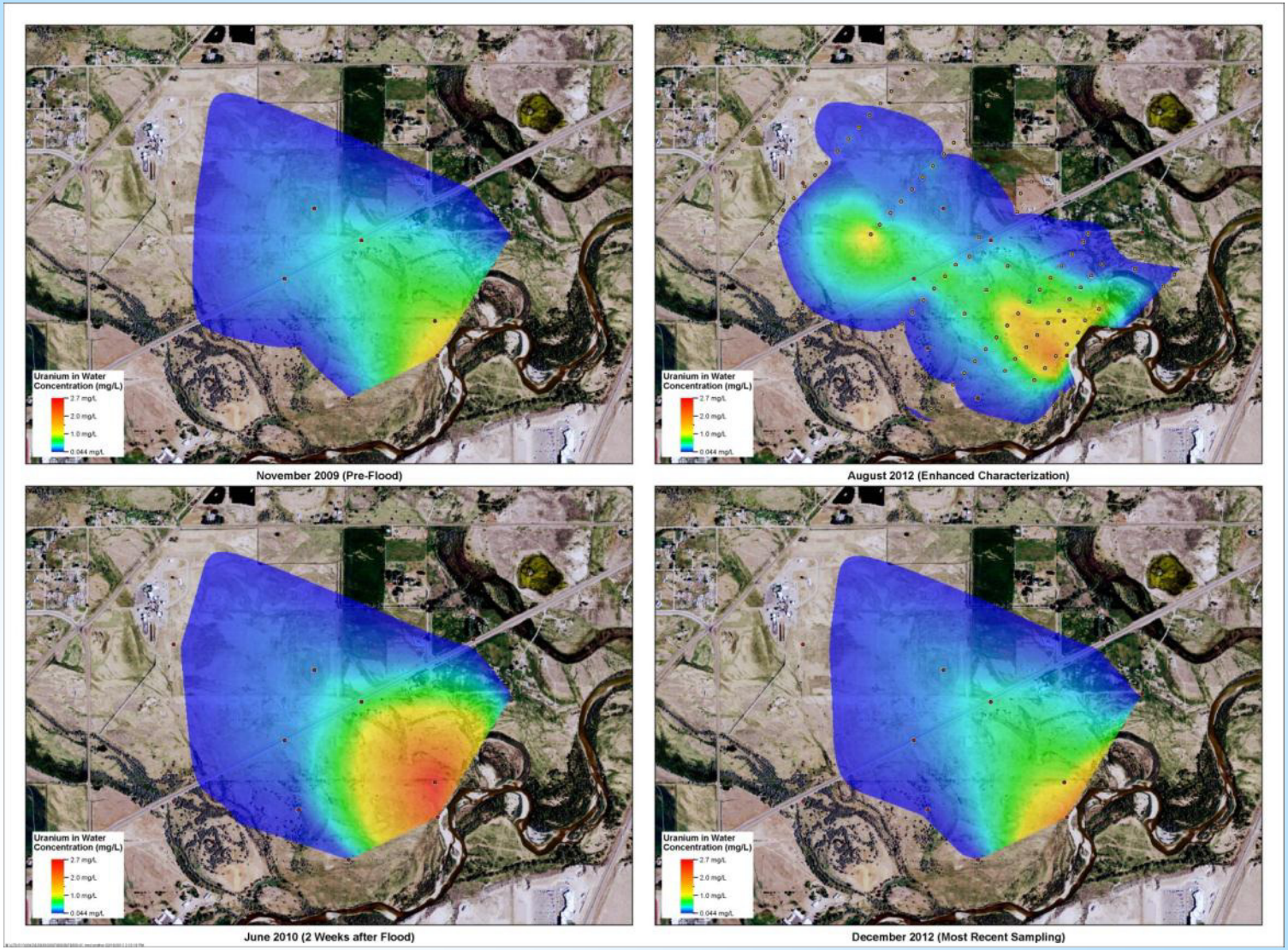
Enhanced Characterization Methods

- Geoprobe: 34 soil and 103 groundwater locations
- Laboratory:
  - Uranium leaching amounts and rates
  - Major ions and COCs
- Models: updating concepts and numerical methods





Groundwater Plume 2009 to 2012



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Risky Business

- Risk analysis
  - Depends on scenario
    - Stated or implied assumptions
    - Complete pathway
    - Exposure, type, frequency, duration
    - Chronic v. acute
    - Risk range 10e-4 to 10e-6
  - Species specific data available?
    - Toxicology data
      - Epidemiological studies
      - Surrogate species extrapolations
      - Concentration and duration extrapolations

Compliance

- Compliance
  - Risk based EPA standards
  - Assumption of drinking water use
  - Alternate concentration limits (ACL)
    - Risk based, higher than standard
    - High background concentration
    - Antidegradation
    - As Low as Reasonably Achievable (ALARA) still required
  - Supplemental Standards, like technical impracticability waiver
    - Regulatory acceptance a problem
    - Qualifying site conditions rare

Ongoing Issues in UMTRCA

- Offsite contamination, what to do?
- Importance of institutional controls
- Title II sites
  - Costs
  - Address problems after transfer, site stable?
- Moving the cell is not an option
  - Still will not result in clean groundwater, e.g., Riverton, Wyoming, and Colorado sites
- Conveying relative risk to stakeholders

Postclosure Challenges

- Erosion
  - Water erosion from short, but high-intensity, storm events have washed out erosion control structures and threatened site features
  - Wind erosion strips open areas, affecting the stability of site features, such as wells and fences
  - Wind erosion causing sand mounding buries fences allowing cattle to access areas where grazing is not desired

L-Bar, New Mexico, Disposal Site

- Located west of Albuquerque
- 100-acre disposal cell
- Area is isolated with no nearby residents
- Engineered erosion prevention structures installed

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LM Data Management Needs

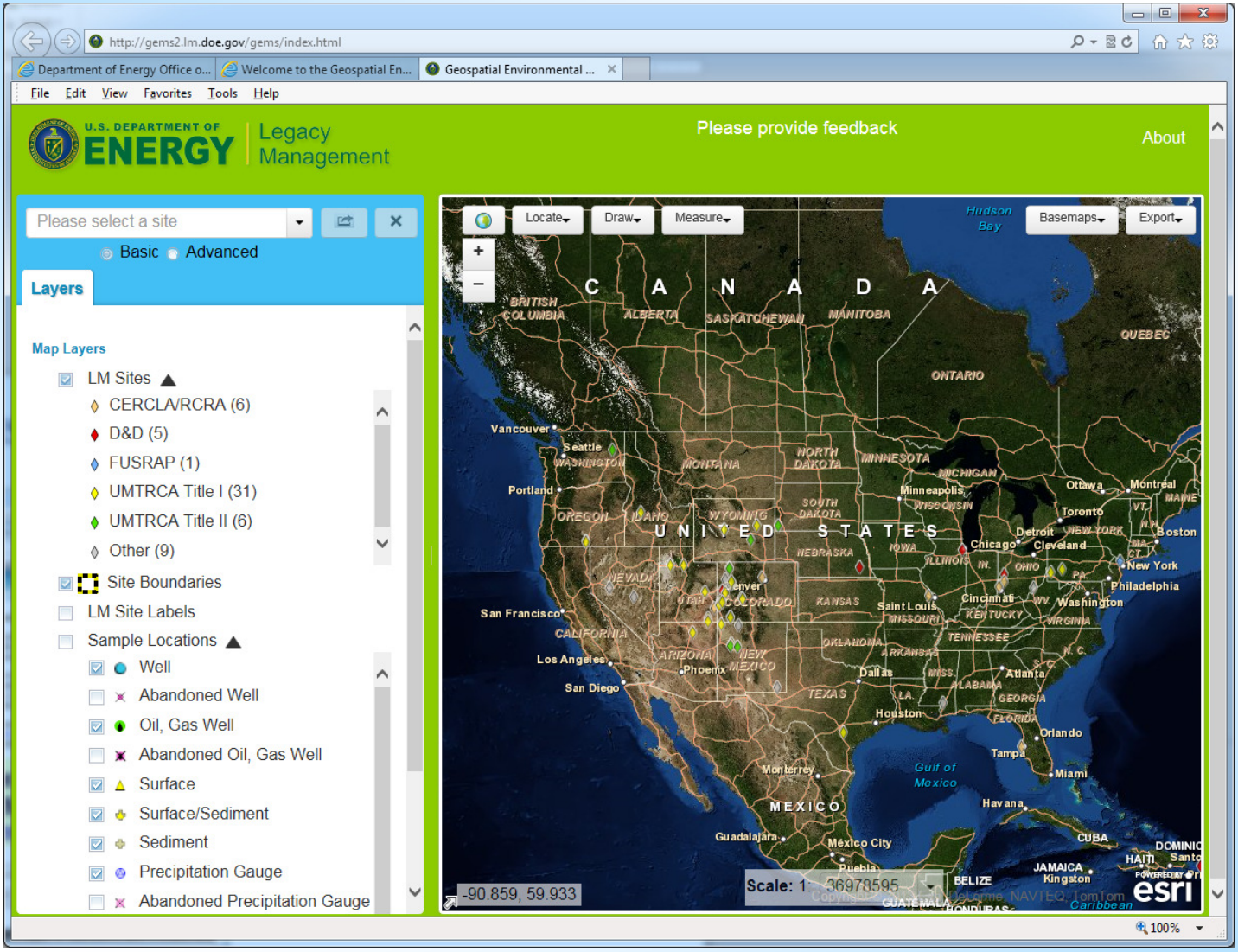
- Efficiently manage large, diverse data sets
- Ensure consistency and comparability in data handling and timely updating of information
- Ensure accessibility of relevant data to stakeholders in a timely fashion
- Incorporate data interpretation and information synthesis, e.g., visualizations
- Provide for easy operation by public users

LM Data Management Needs (continued)

Desired characteristics of a robust information management system should include:

- Screening – relevancy of data to support mission
- Quality assurance – ensuring that all data have undergone appropriate high-level, and traceable, quality assurance reviews
- Curating/archiving – maintaining the integrity of data while allowing for significant additions and efficient retrieval
- Security – data must be readily available to internal and external users in such a way that it does not impose a security risk

GEMS 2.0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Legacy Management
Please provide feedback
About
Please select a site
Basic
Advanced
Layers
Map Layers
LM Sites
CERCLA/RCRA (6)
D&D (5)
FUSRAP (1)
UMTRCA Title I (31)
UMTRCA Title II (6)
Other (9)
Site Boundaries
LM Site Labels
Sample Locations
Well
Abandoned Well
Oil, Gas Well
Abandoned Oil, Gas Well
Surface
Surface/Sediment
Sediment
Precipitation Gauge
Abandoned Precipitation Gauge
Locate
Draw
Measure
Basemaps
Export
Hudson Bay
C A N A D A
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
Vancouver
Seattle
Portland
San Francisco
Los Angeles
San Diego
Phoenix
Denver
Minneapolis
Chicago
Detroit
Cleveland
Toronto
Ottawa
Montreal
Boston
New York
Philadelphia
Washington
Cincinnati
Saint Louis
Dallas
Houston
Atlanta
Orlando
Tampa
Miami
Gulf of Mexico
Havana
Monterrey
Guadalajara
México City
Puebla
MEXICO
UNITED STATES
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HAITI
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What Is in GEMS?

- Sampling locations
- Analytical chemistry data
- Groundwater depths and elevations
- Well construction and lithology logs
- Boundaries – site, disposal cell
- Base map entities (roads, fences, water bodies, rivers)
- Aerial imagery
- Topographic maps
- Onsite photographs

Capabilities of GEMS

- Interactive mapping
- Environmental data querying
- Applying reported data in many ways
  - Graph to identify trends
  - Post as labels on the interactive map
  - Add analyte concentration symbols to the map
- Exporting data
  - Export to a spreadsheet
  - Export map to a PDF

System Operation and Analysis at Remote Sites (SOARS)

- LM's remote telemetry system
- Attributes
  - Field instrument monitoring, data transmission, data storage/backup, post processing
  - Remote operation of valves and pumps
  - Early notice for maintenance issues
  - Better understanding of temporal variations
  - Surrogate analysis of contaminants
  - 3-point solutions for groundwater flow
  - Better data evaluation with less travel

Typical SOARS Station Green River, Utah

Additional LM Data Management Cooperation

- Broader cooperation with DOE offices
- Communication with LM, SC, EM
- Cooperation with EM sites prior to transfer of site
- Early data management and transfer
- Institutional knowledge
- Records transfers
- Realty considerations
- LM research needs to SC and EM for solicitation

Evaluation of Background Concentrations of Contaminants in an Unusual Desert Arroyo Near a Uranium Mill Tailing Disposal Cell

Rich Bush
U.S. Department of Energy Office of Legacy Management (LM)

Stan Morrison
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February 2012

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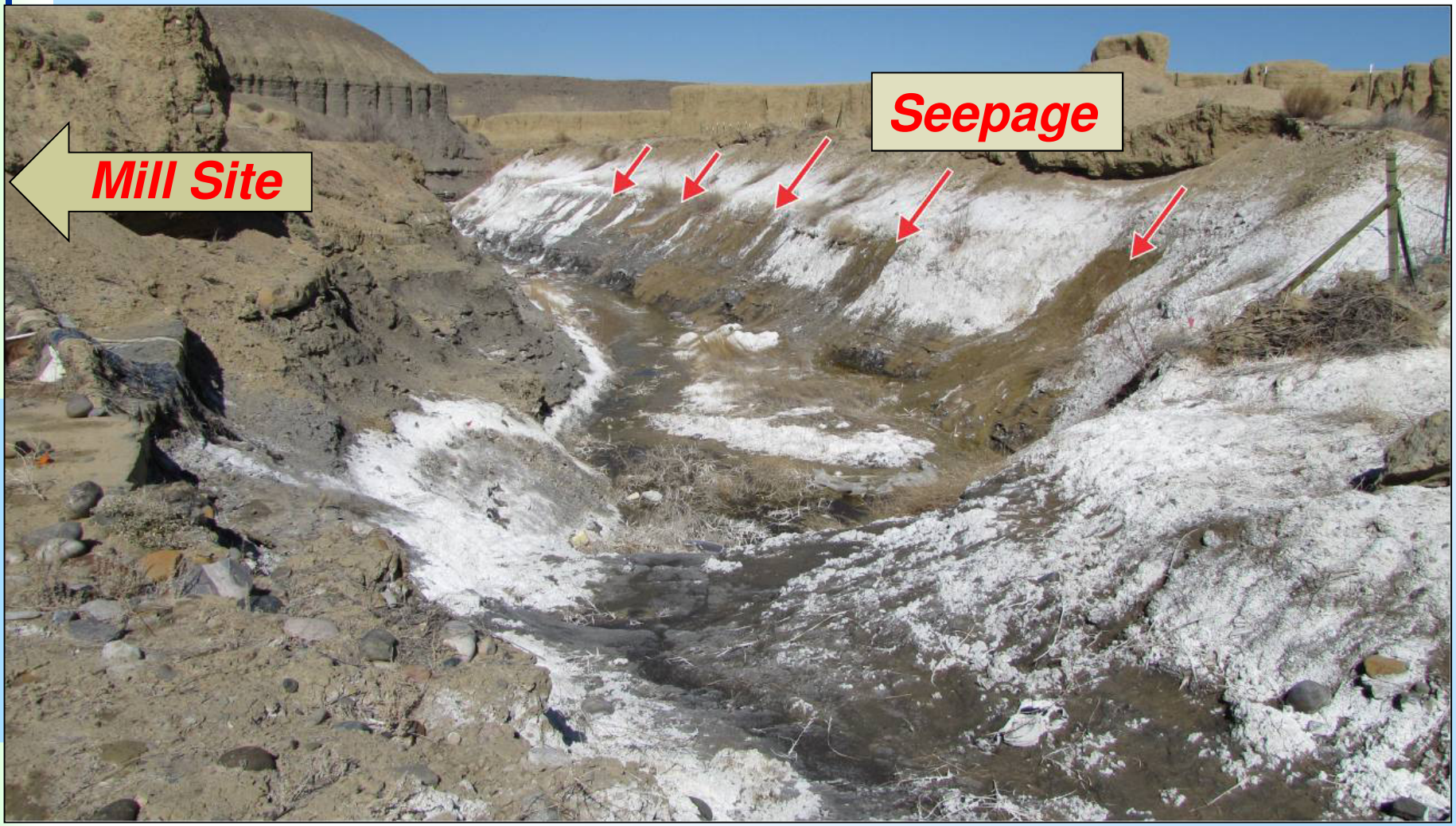
Evaluation of Background Concentrations of Contaminants in an Unusual Desert Arroyo Near a Uranium Mill Tailing Disposal Cell

- 27 sites with uranium in groundwater
- Determination of background
- Distal plumes often have over 50 ppb of uranium
- Naturally occurring Mancos Shale contaminants
  - Uranium, nitrate, selenium, and sulfate
- Distinguish mill-related contamination from background
  - Geologic analogs
  - Uranium isotopic signatures

Many Devils Wash

- Contaminants of concern
  - Nitrate, selenium, sulfate, and uranium
  - Assumed to be site related
- DOE committed to remediate Many Devils Wash
- Seeps occur on the opposite side of the tailings site
- May be from a natural source

Seeps in Many Devils Wash



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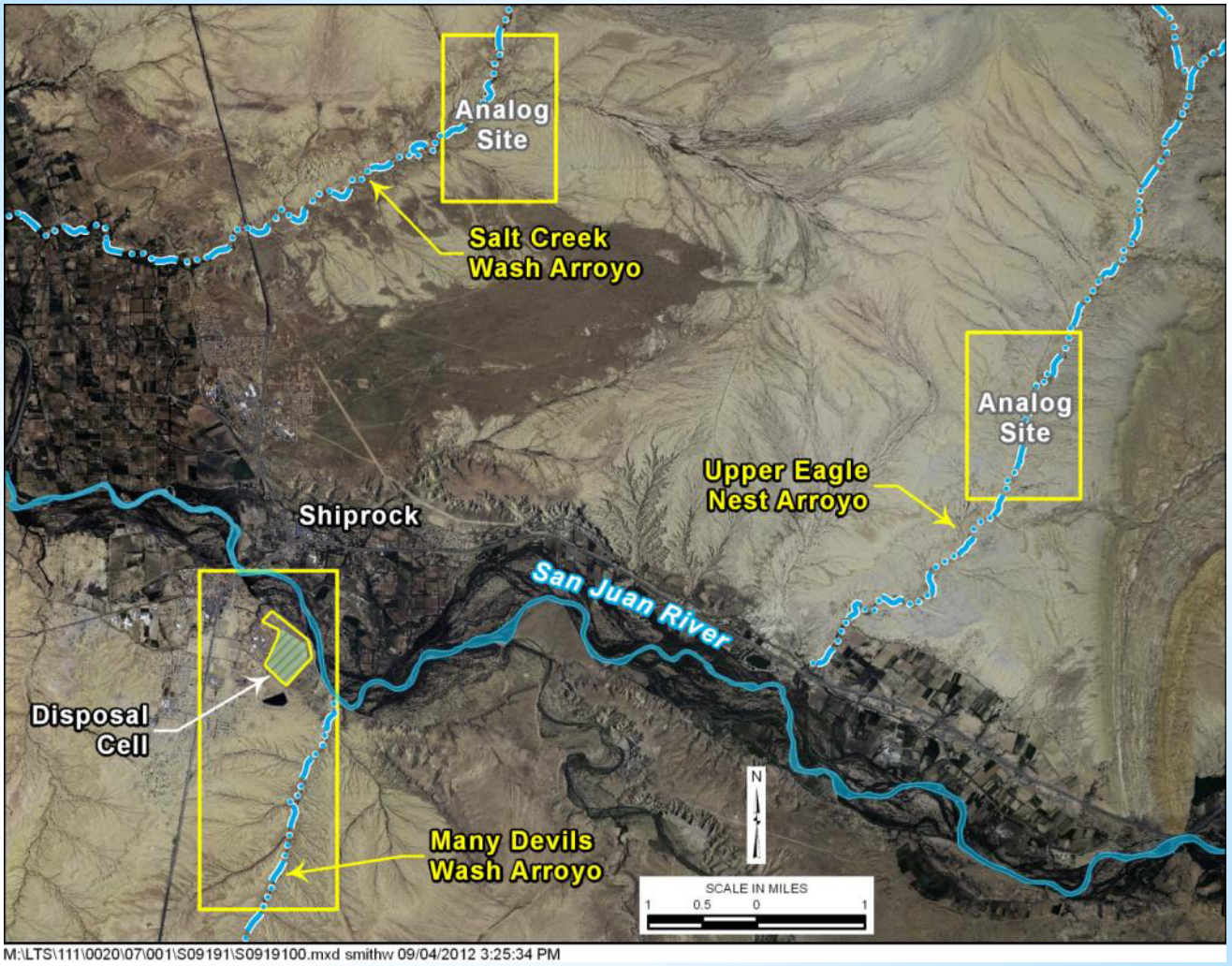
Study Area Locations

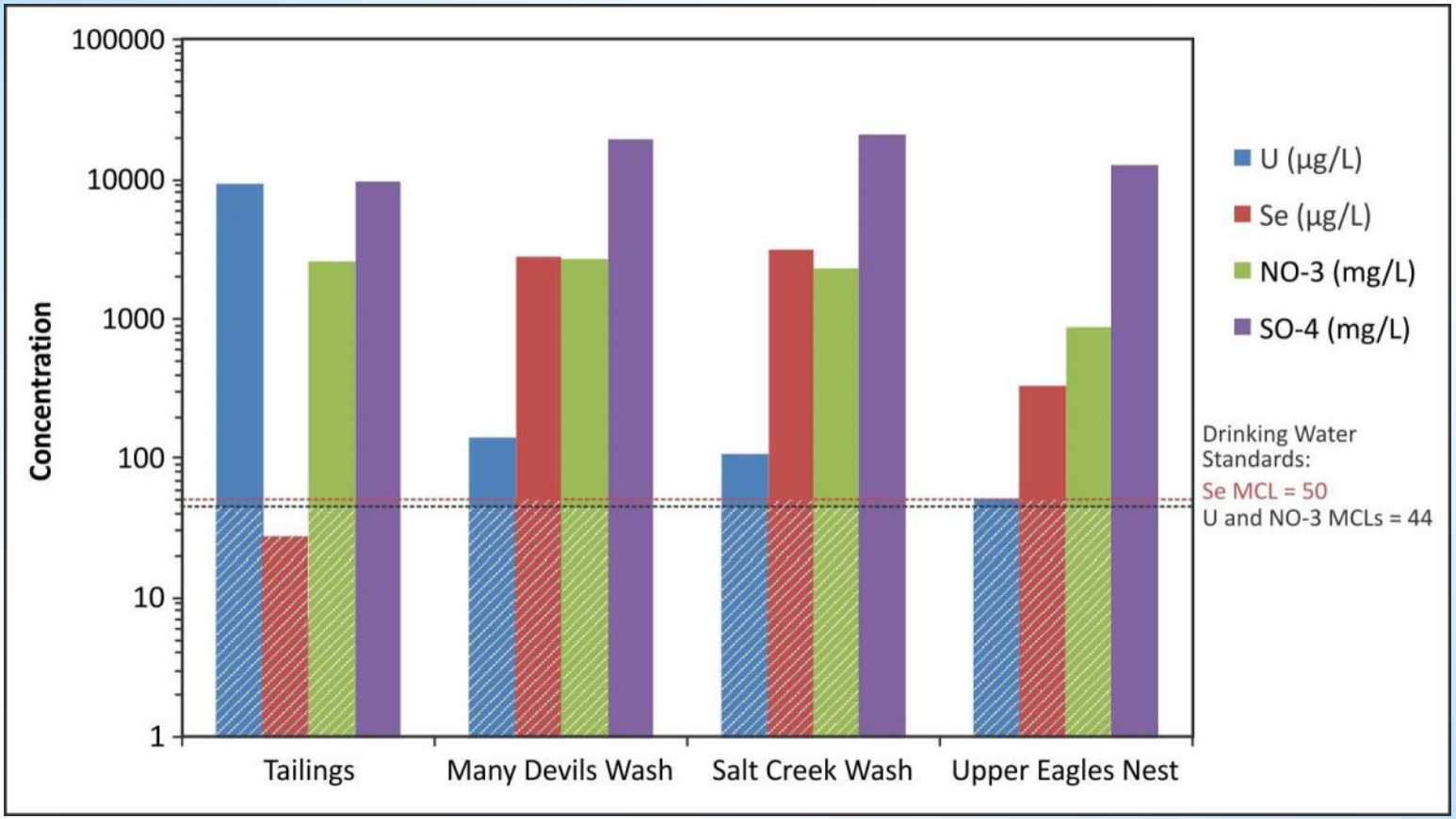


Salt Creek Wash

Constituent	MCL	Value
SO_4		23,411 mg/L
NO_3	44 mg/L	2,270 mg/L
U	44 µg/L	126 µg/L
Se	50 µg/L	3,300 µg/L
Sp. Cond.		45,340 µS/cm
DOC		110 mg/L

MCL = maximum contaminant levels

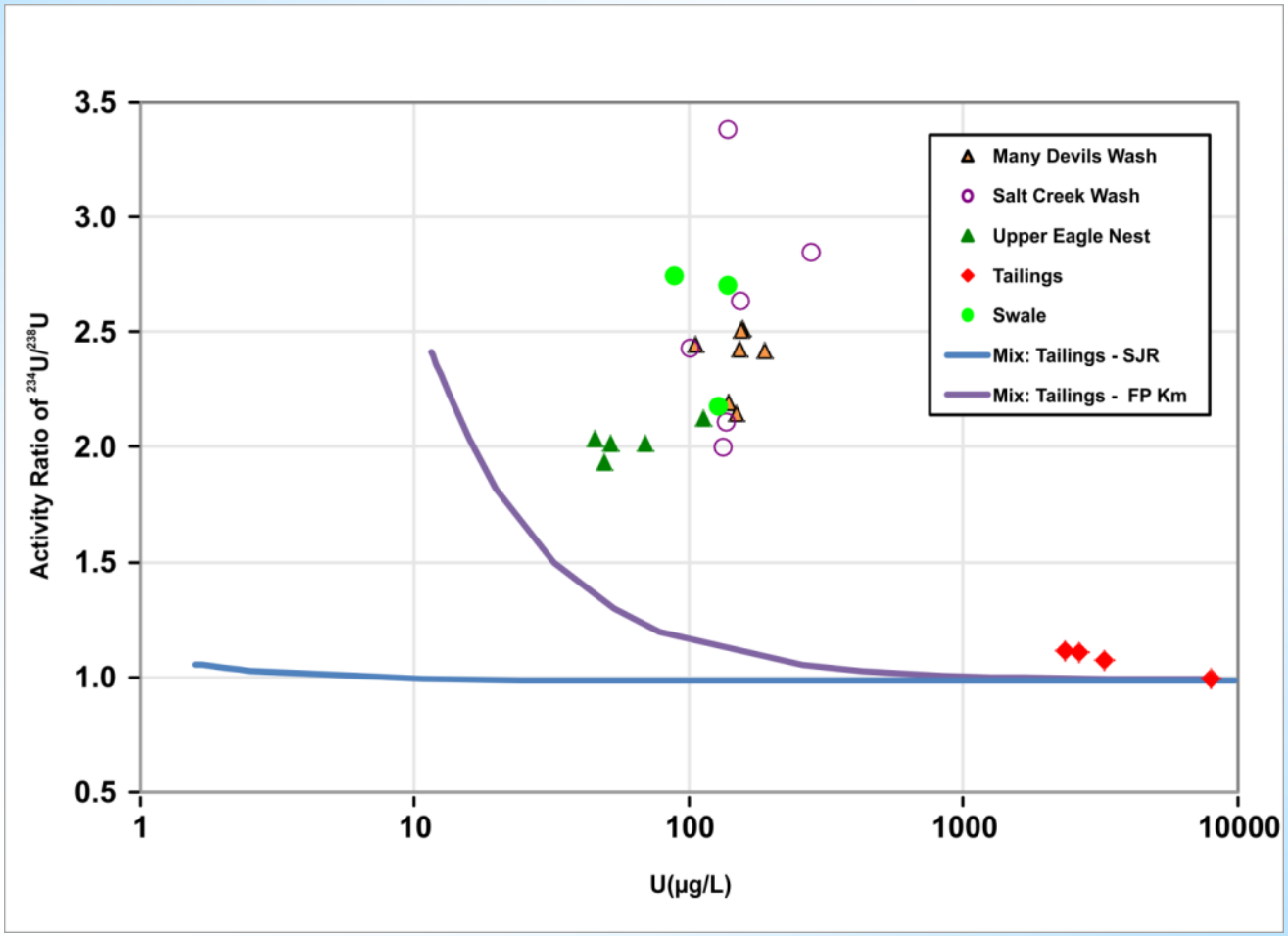
Contaminants Near Tailings and in Arroyo Seeps



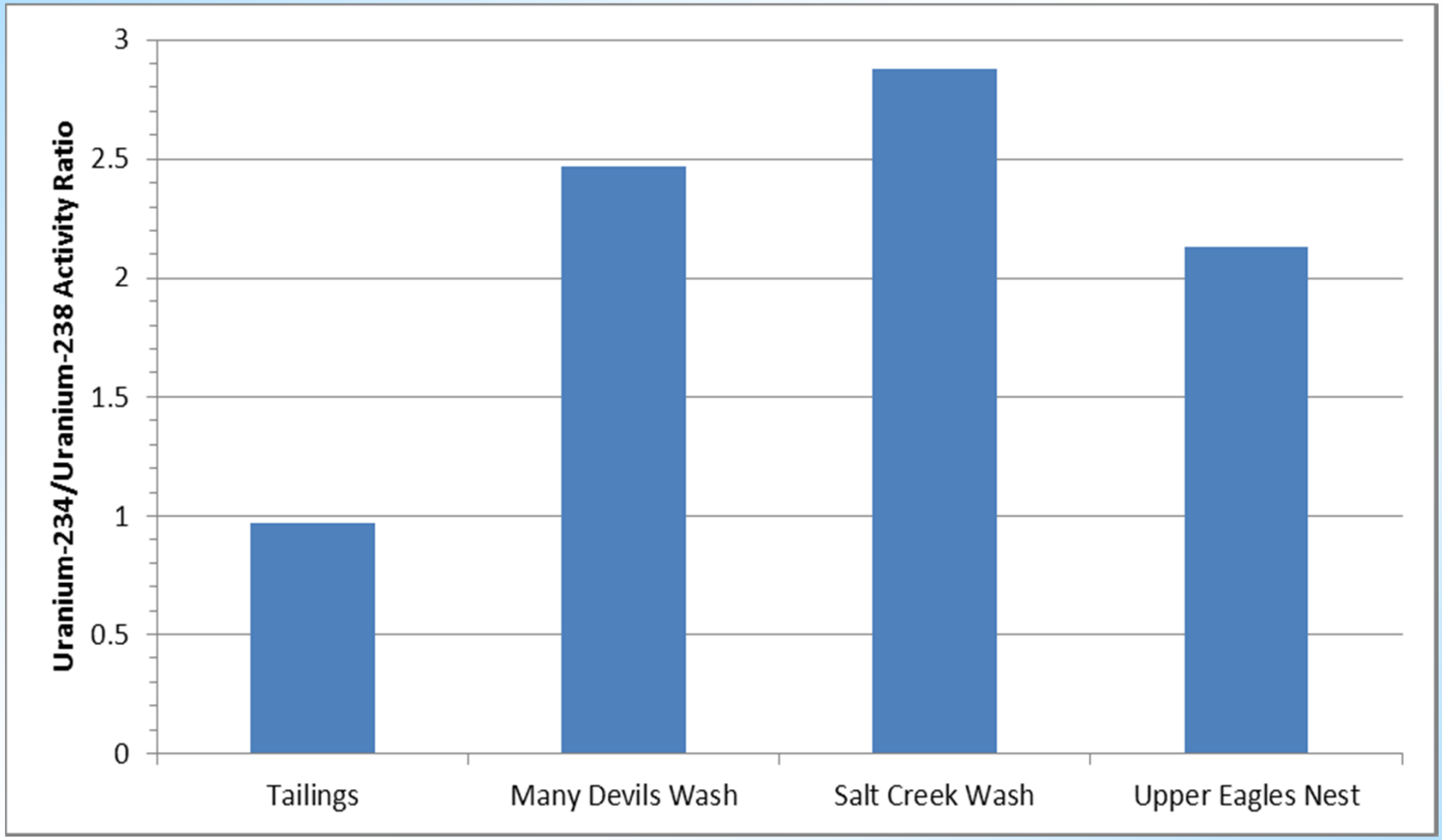
Uranium Isotopes

- $^{234}U/^{238}U$ activity ratios (AR) near 1
  - Uranium ores
  - Mill tailings
- Natural groundwater systems
  - AR 2 or more
- How's that?
  - Alpha recoil
  - Preferential dissolution of ^{234}U

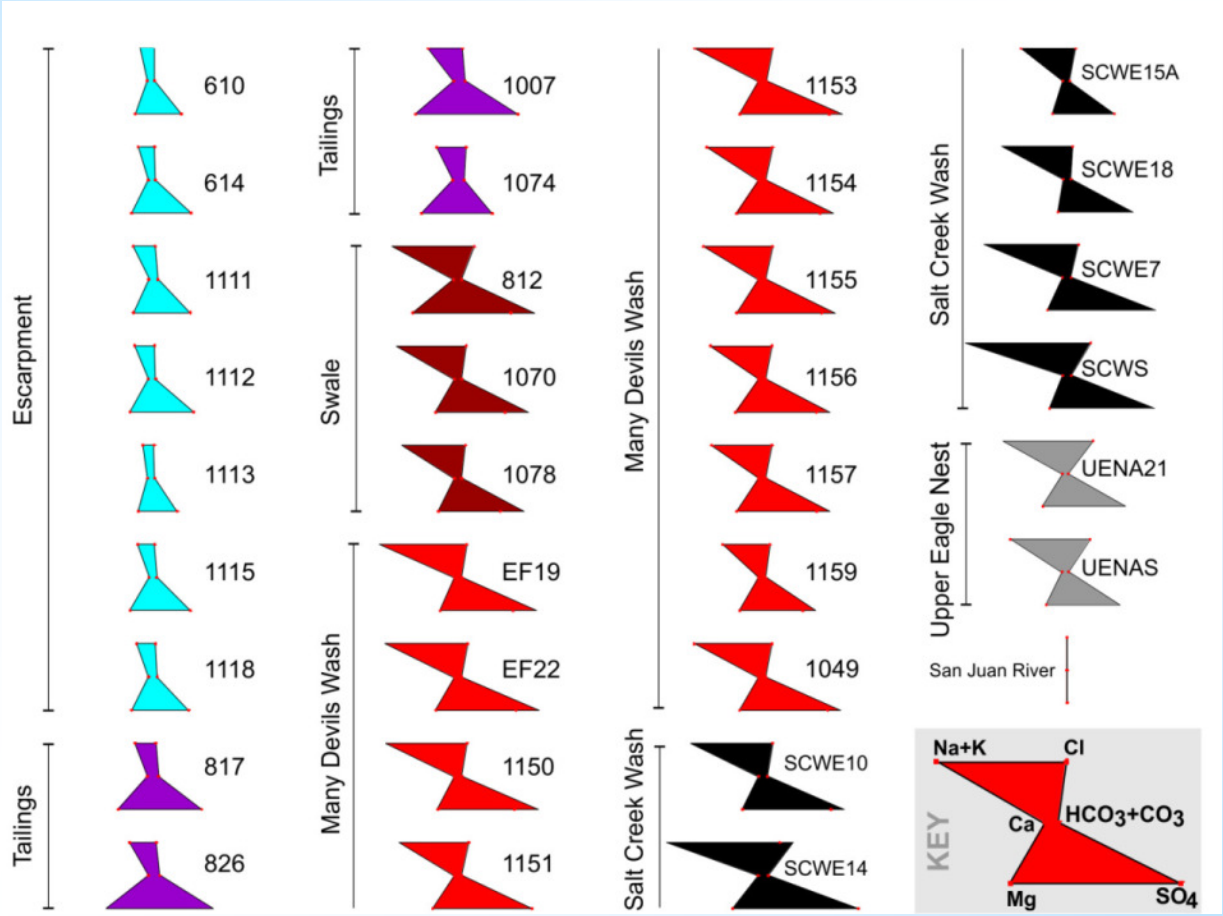
Uranium Concentrations and $^{234}U/^{238}U$ Activity Ratios



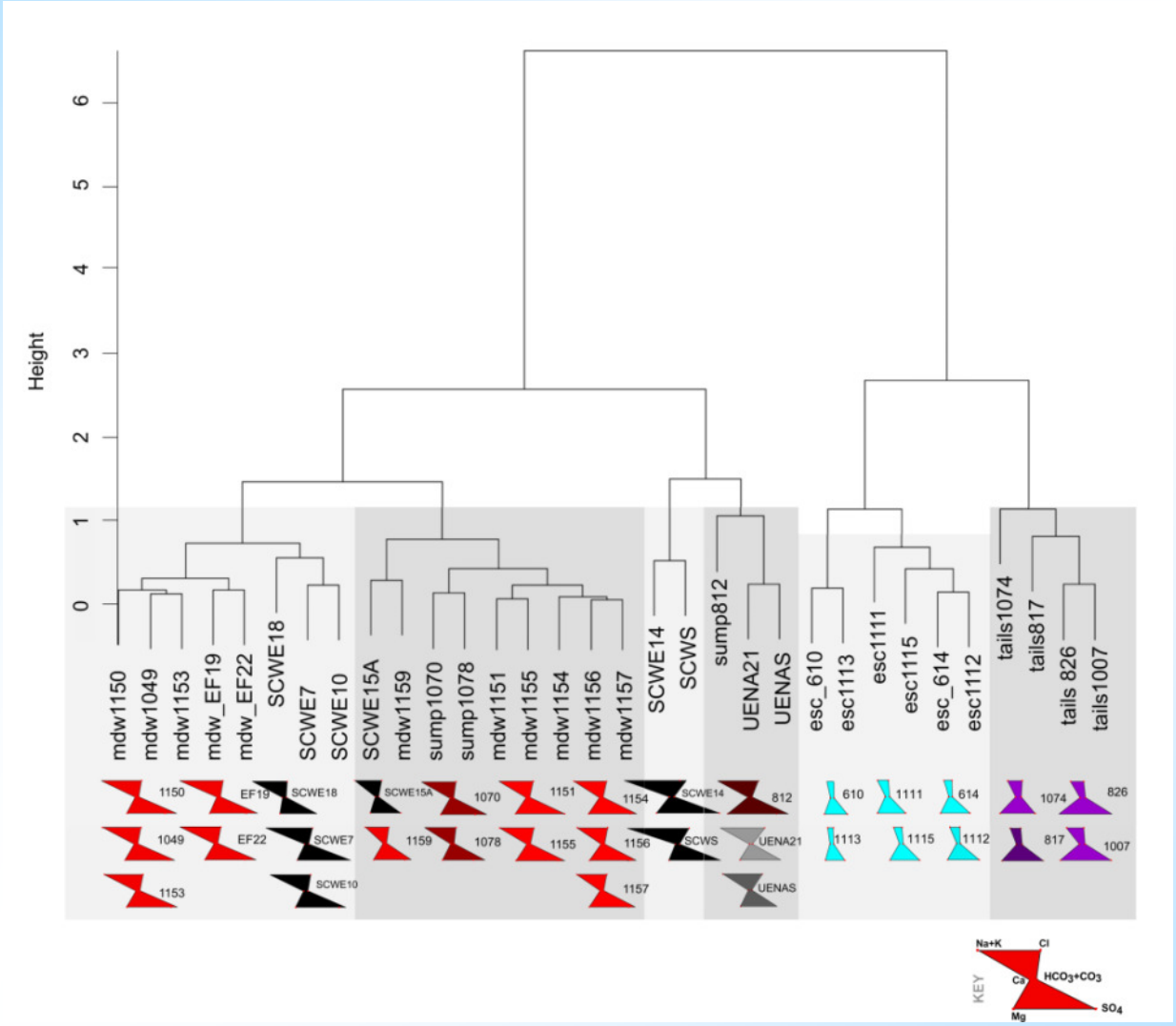
$^{234}U/^{238}U$ Activity Ratios



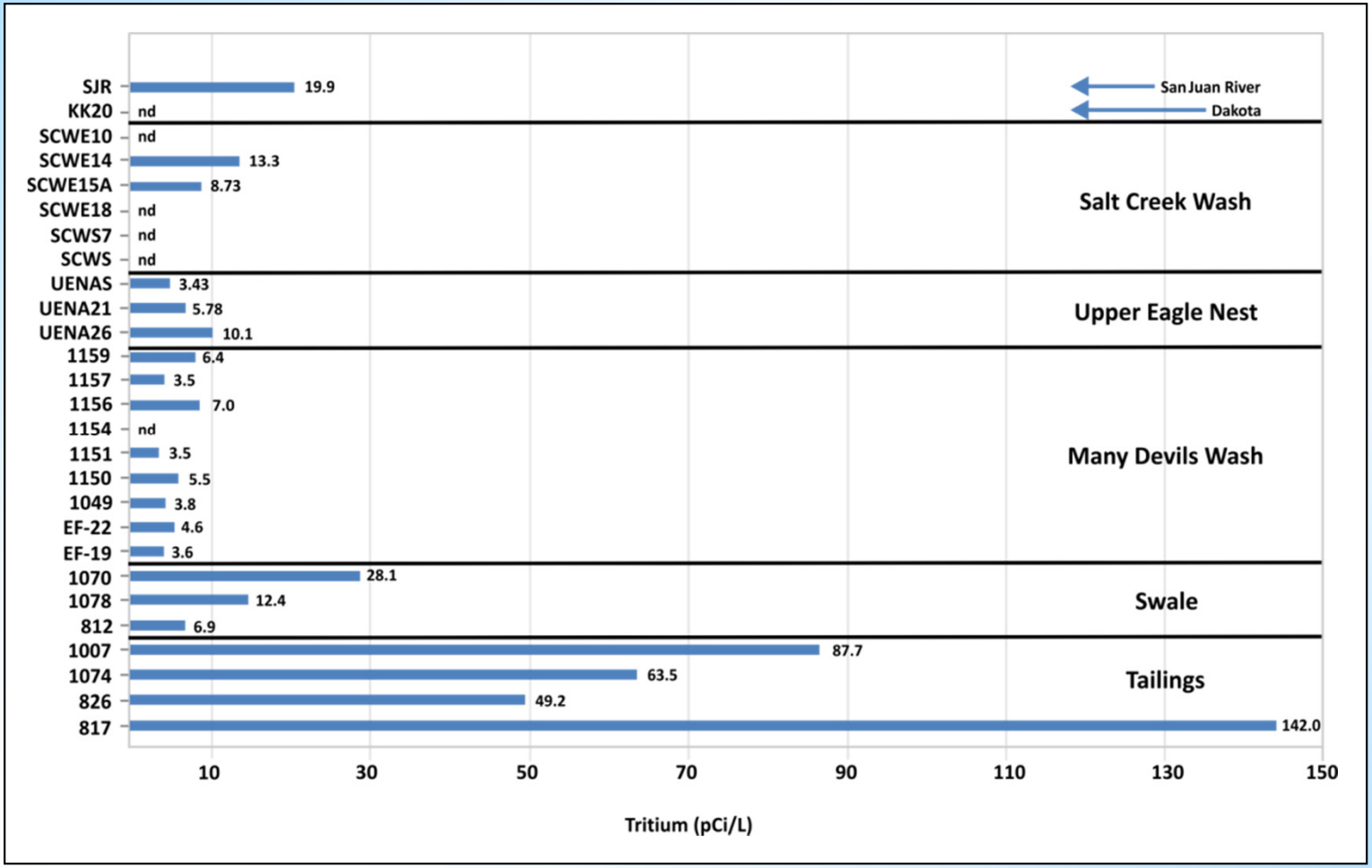
Geochemical Plotting (Stiff Diagrams): Two Basic Shapes:  & 



Cluster Analysis Dendrogram



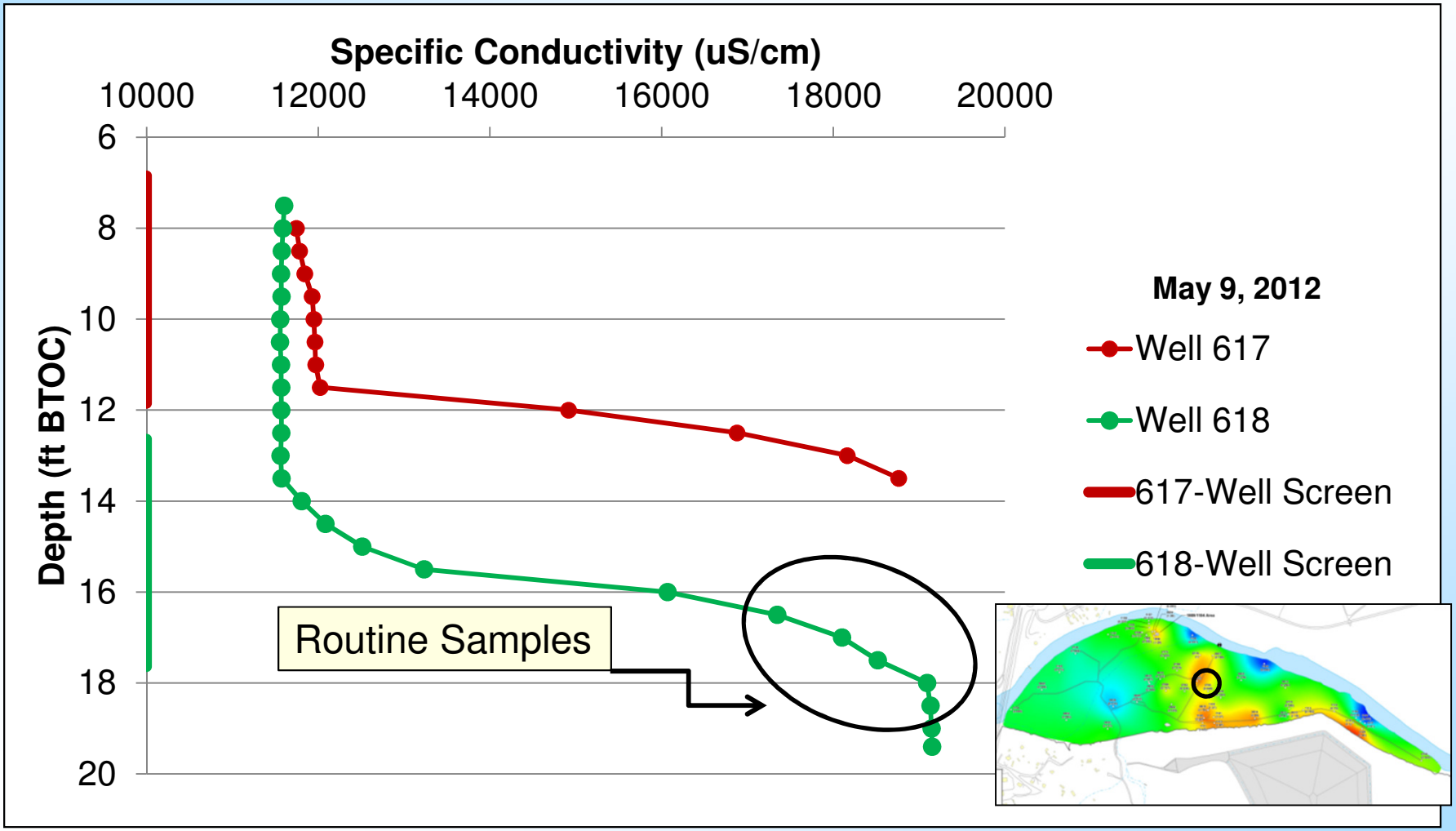
Tritium Results



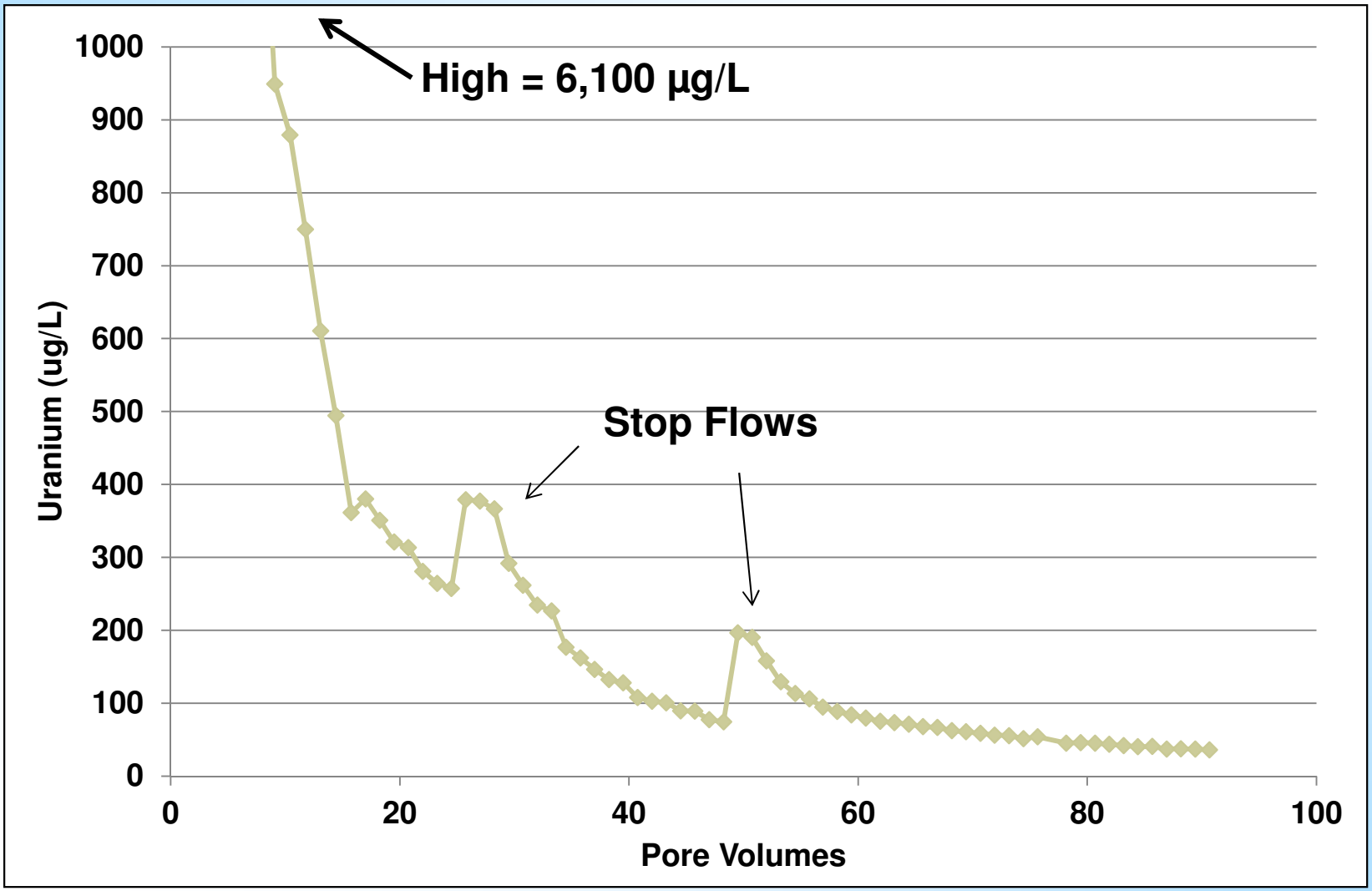
What Does It Mean?

- Sites may have been contaminated naturally
- Remediation to maximum contaminant levels (MCL) is not warranted
- Supports an alternate concentration limit (ACL) approach
  - Risk analysis
  - Elevated background concentration as basis
  - Supported by monitoring data and modeling
  - Need multiple lines of evidence
  - More data
  - More types of data
  - Not your father's compliance data

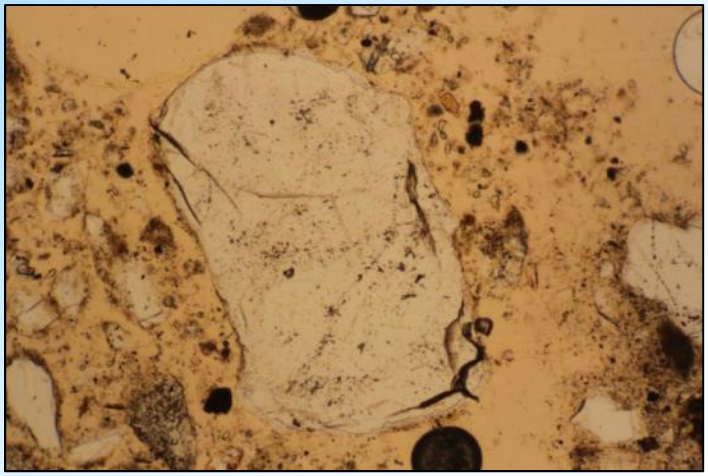
Variation Project: Well Profiles Shiprock Site

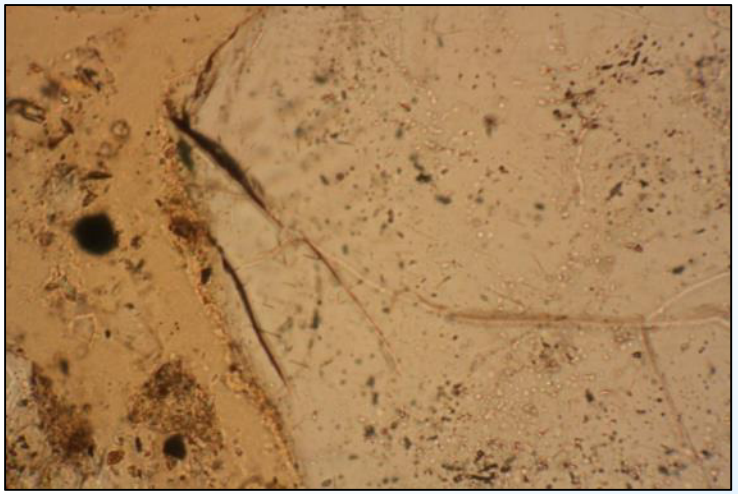


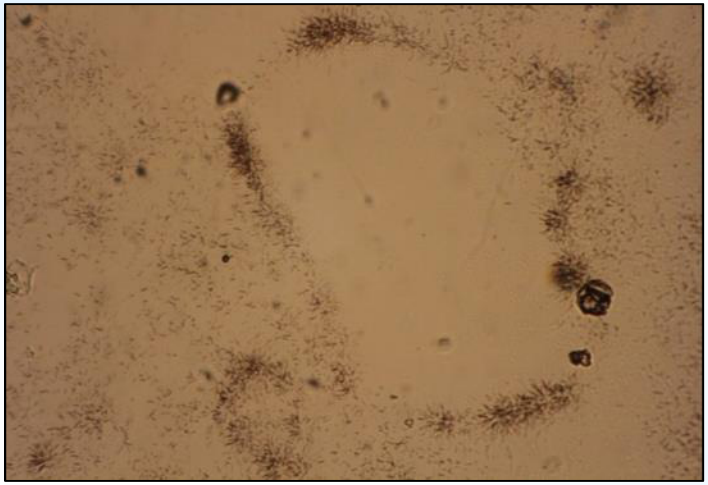
Plume Persistence: Column Data

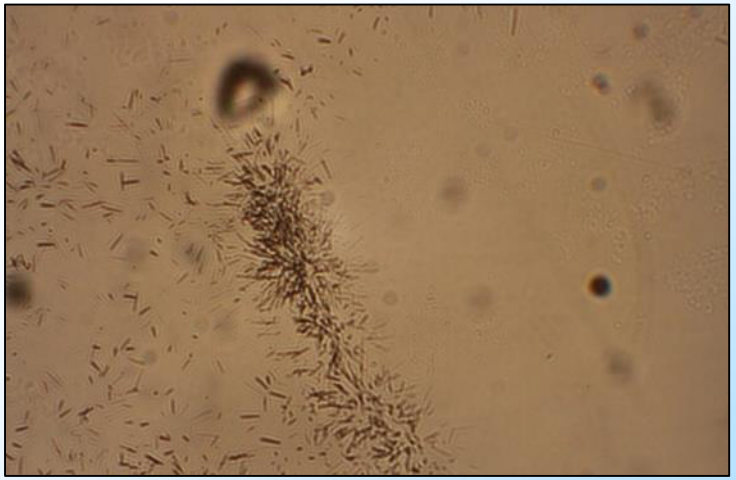


Plume Persistence: Fission Tracking







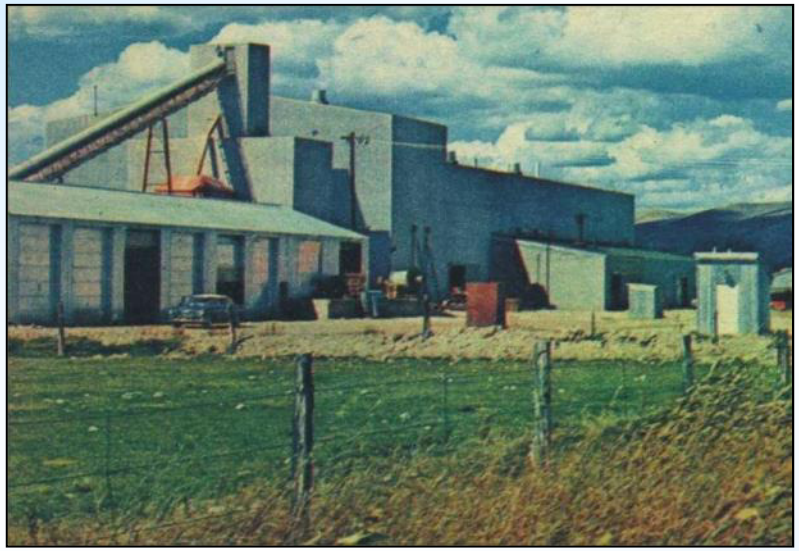


Geochemical Conundrum

- Oxyanions commonly in the environment
  - Soluble in reduced form, arsenic
  - Soluble in oxidized form, uranium
  - Many oxidation states, vandium
  - pH sensitivity varies with species, redox state, differently
- Despite many years of data collection
  - Multiple geochemical databases
  - Internally inconsistent
  - Inconsistent between
  - Many still unknown important species
  - Some proprietary databases

Site Profile
Gunnison, Colorado, Disposal and Processing Sites

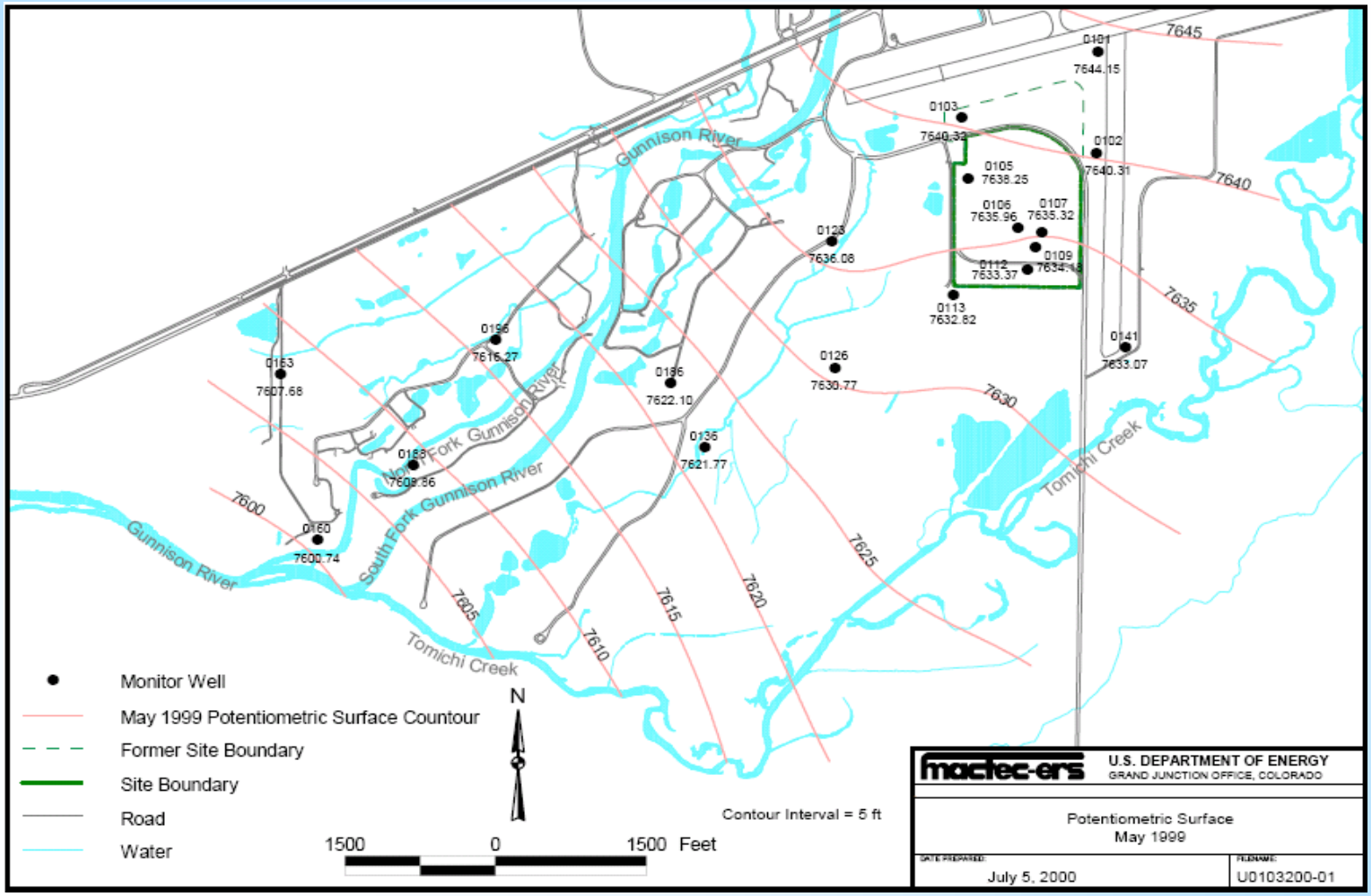
- UMTRCA Title I site
- Former uranium ore processing facility
- Cleanup took place from 1992 to 1995



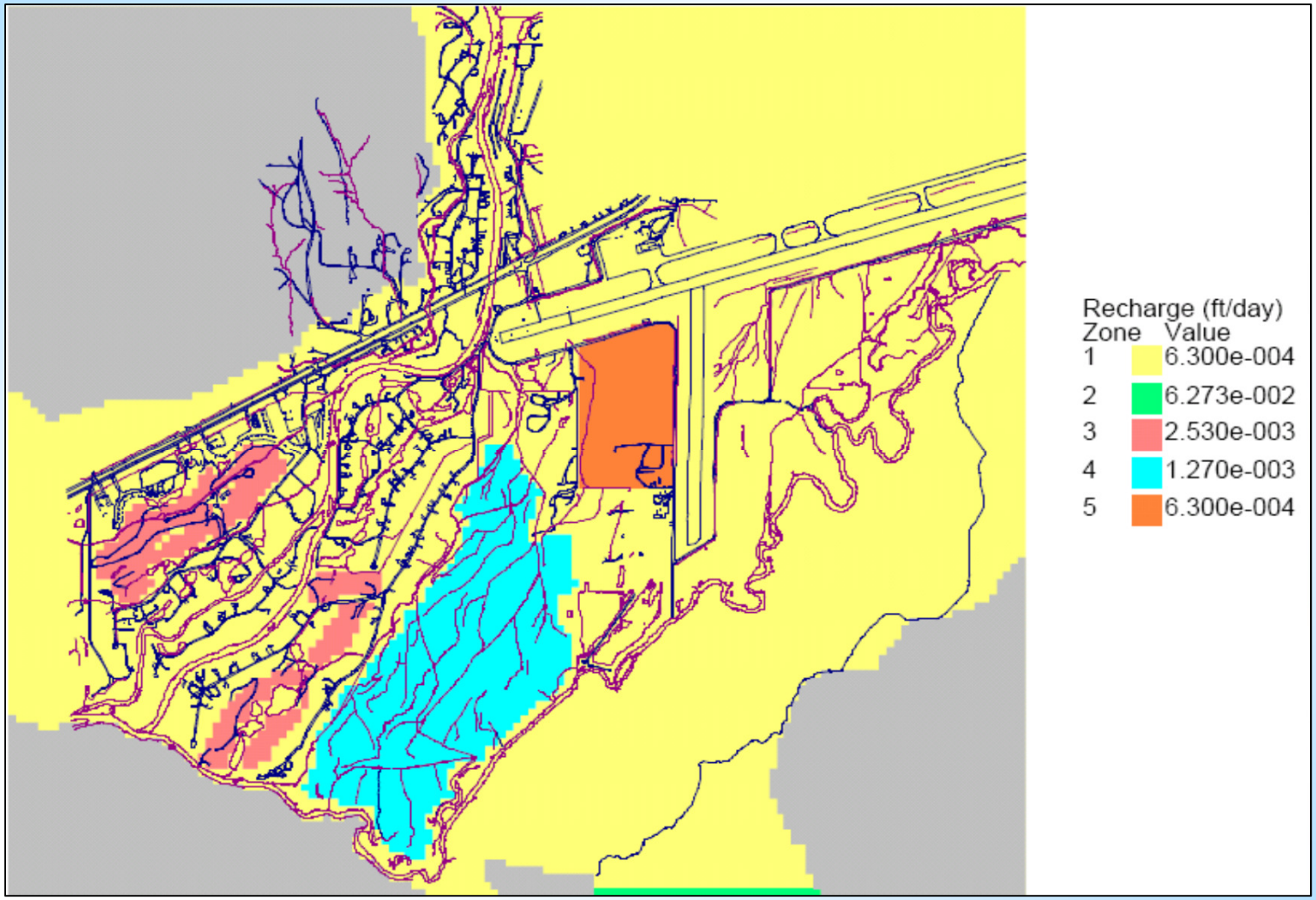
Gunnison uranium mill
operated from 1958 to 1962

Gunnison Disposal Site

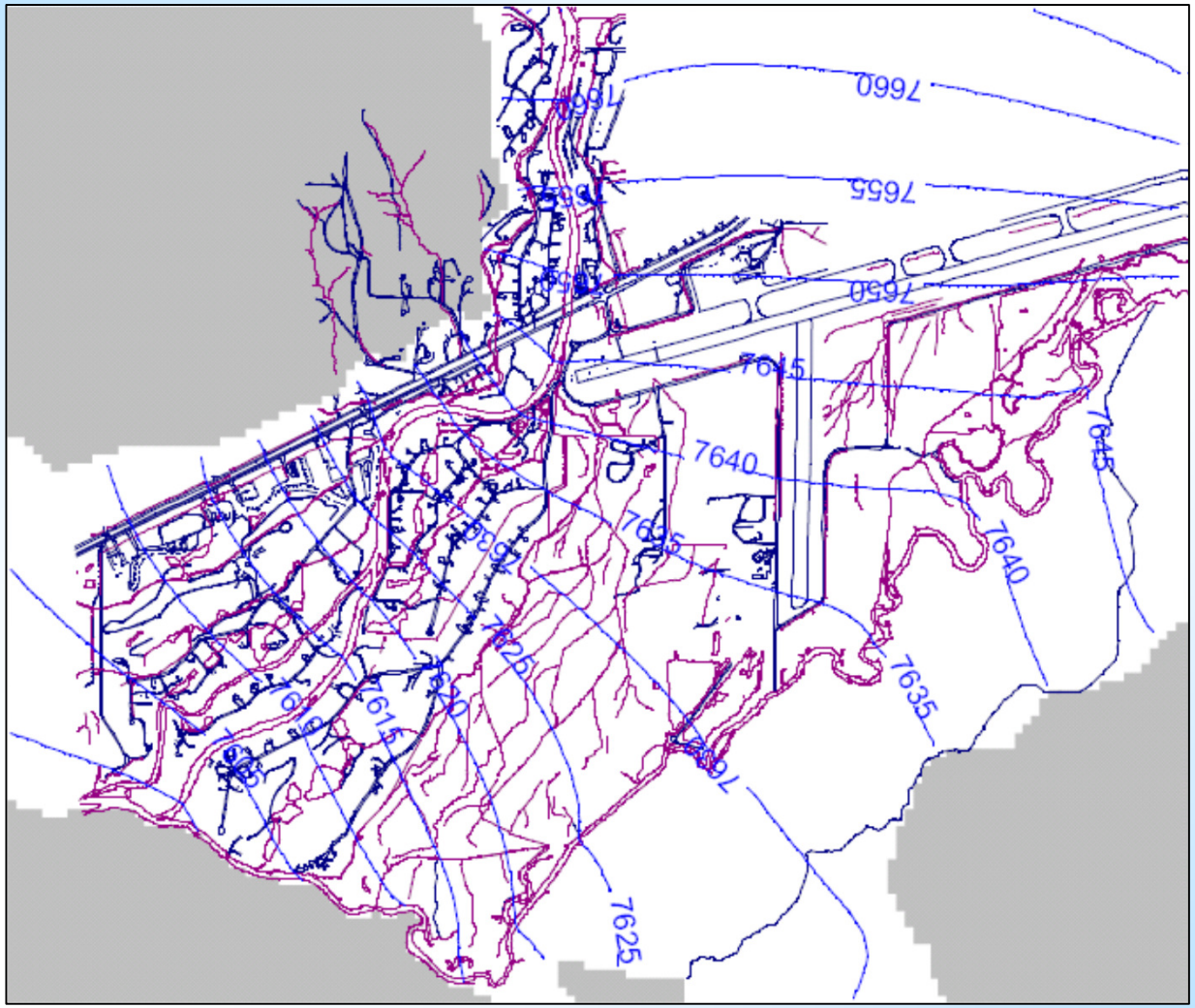
Potentiometric Surface Map



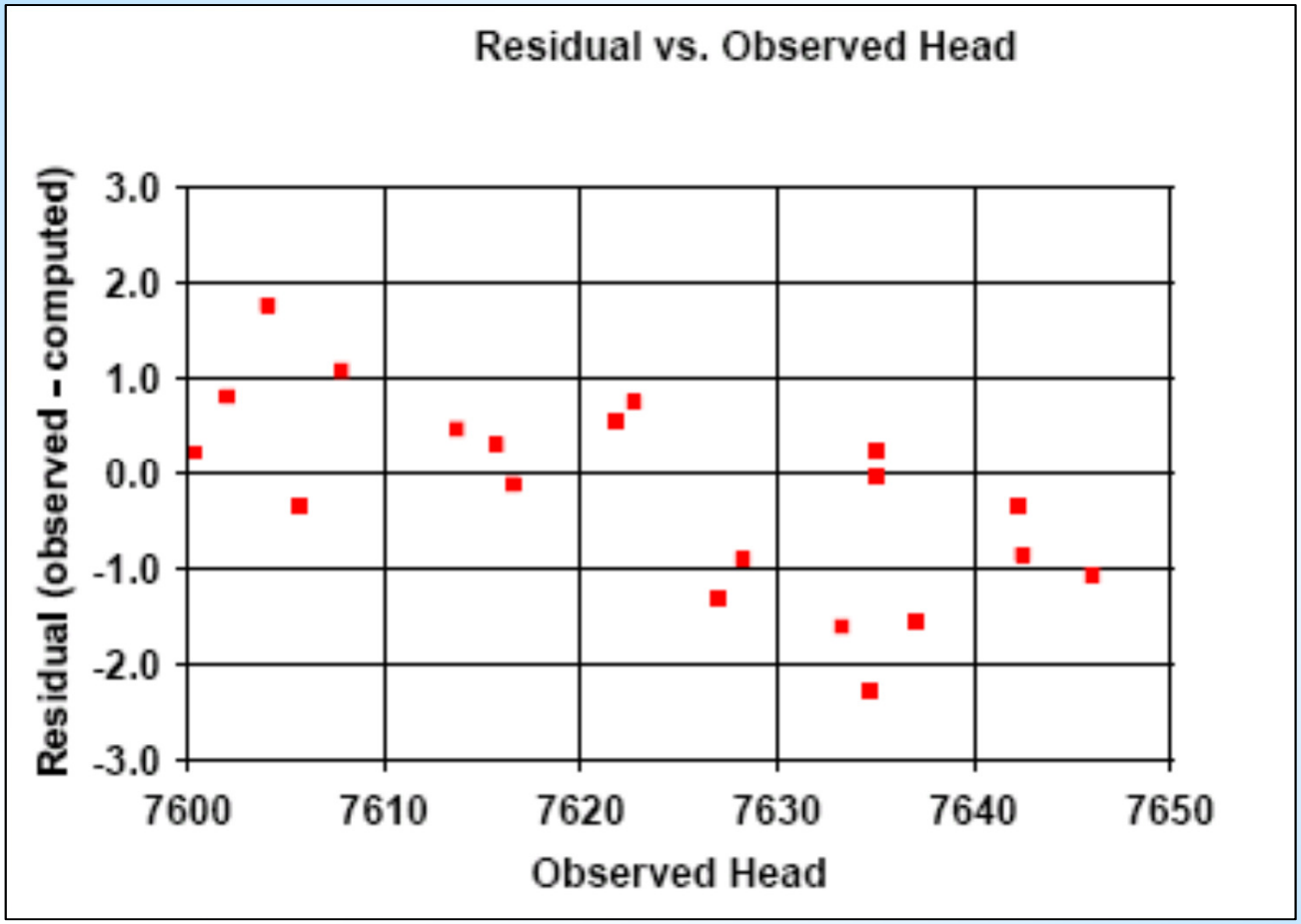
Recharge Zonation



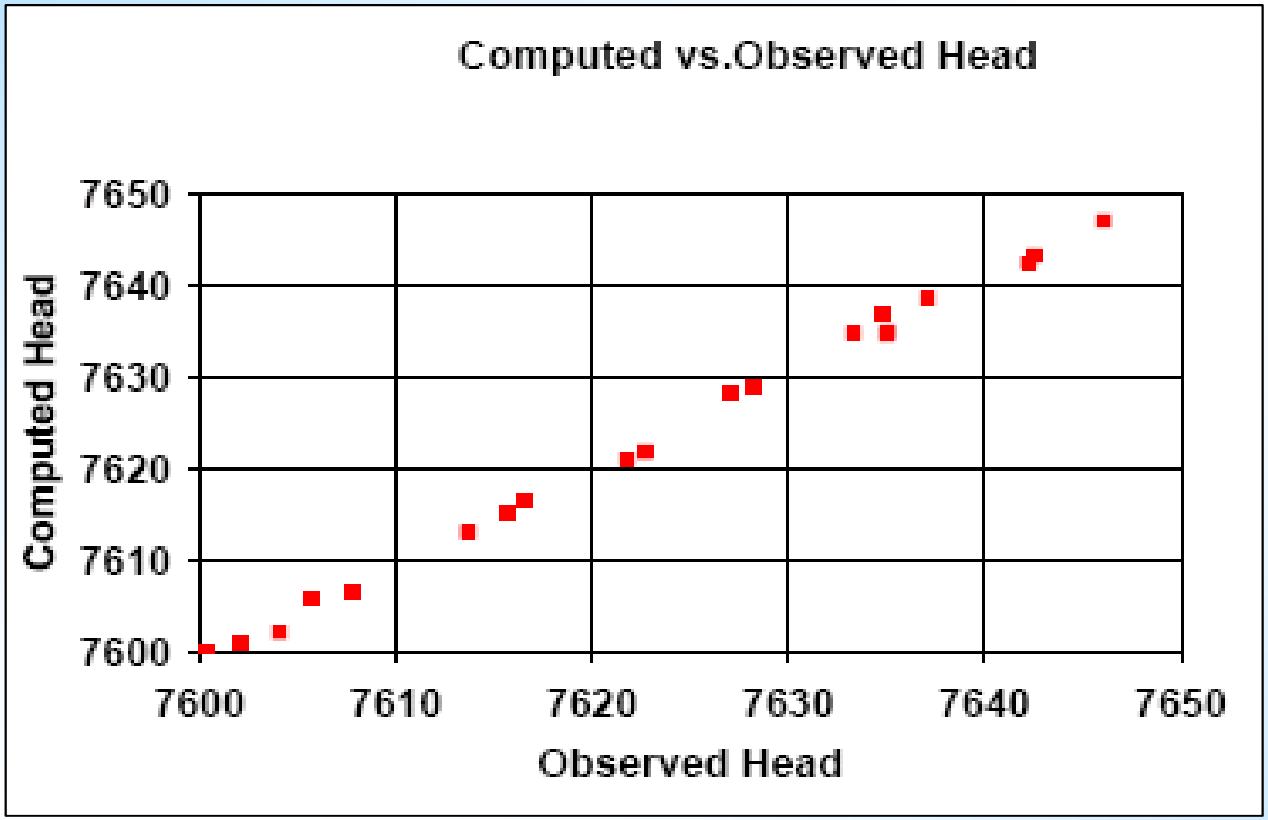
Model Results



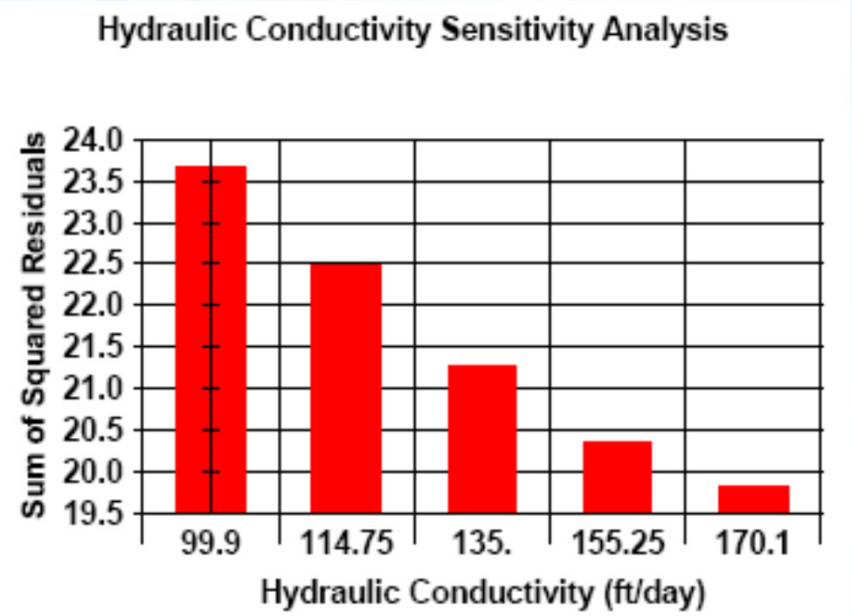
Model Residuals

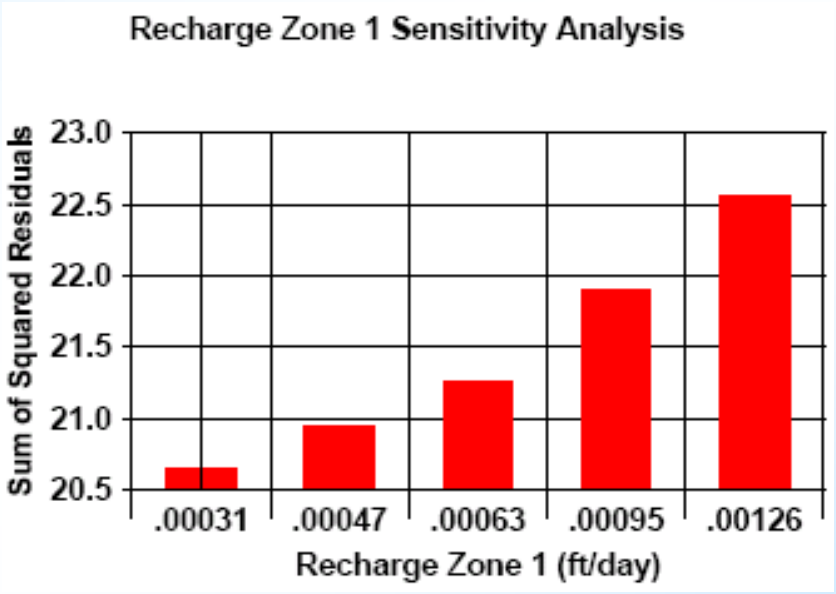


Model Correlation

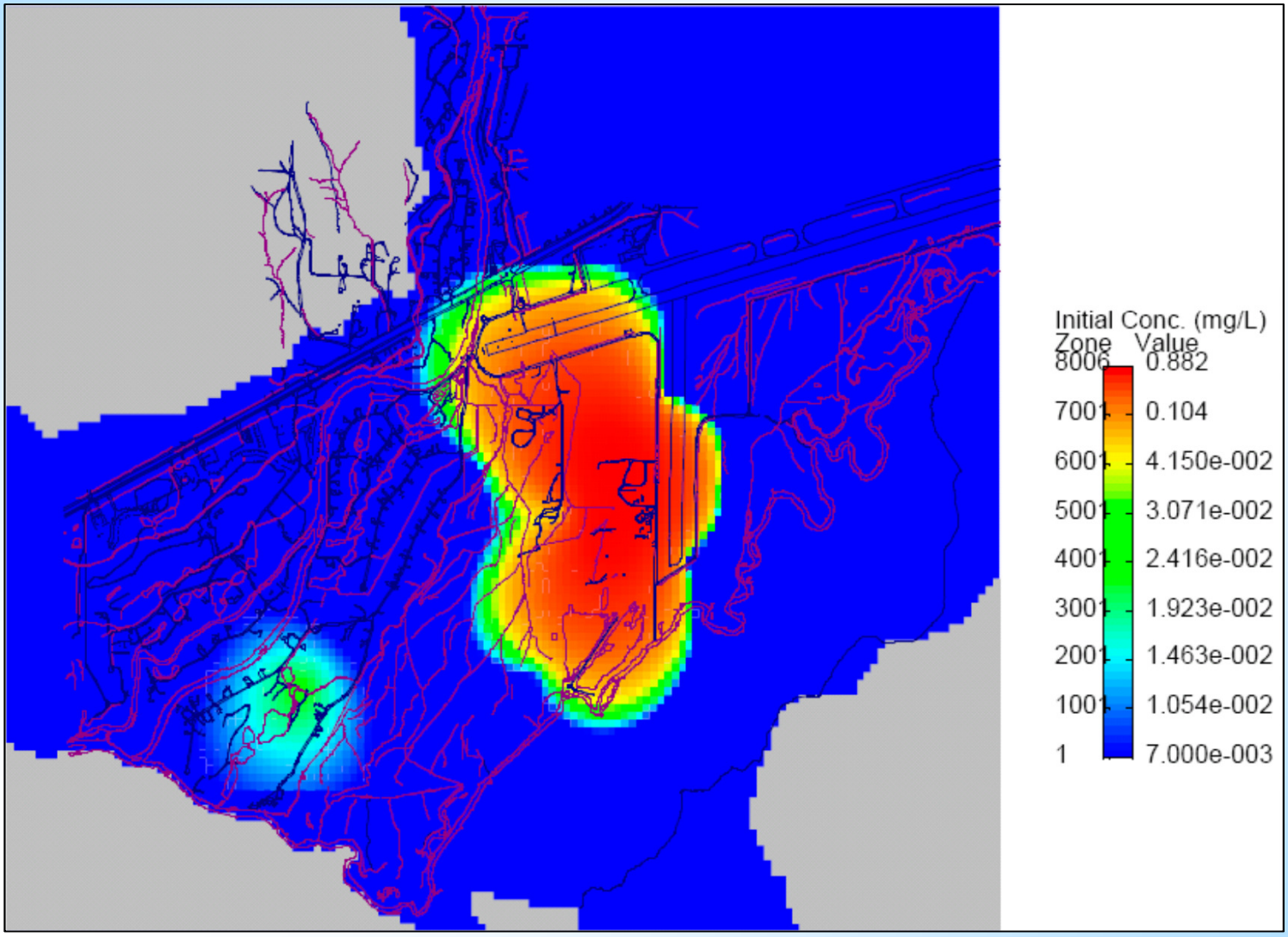


Sensitivity Analysis

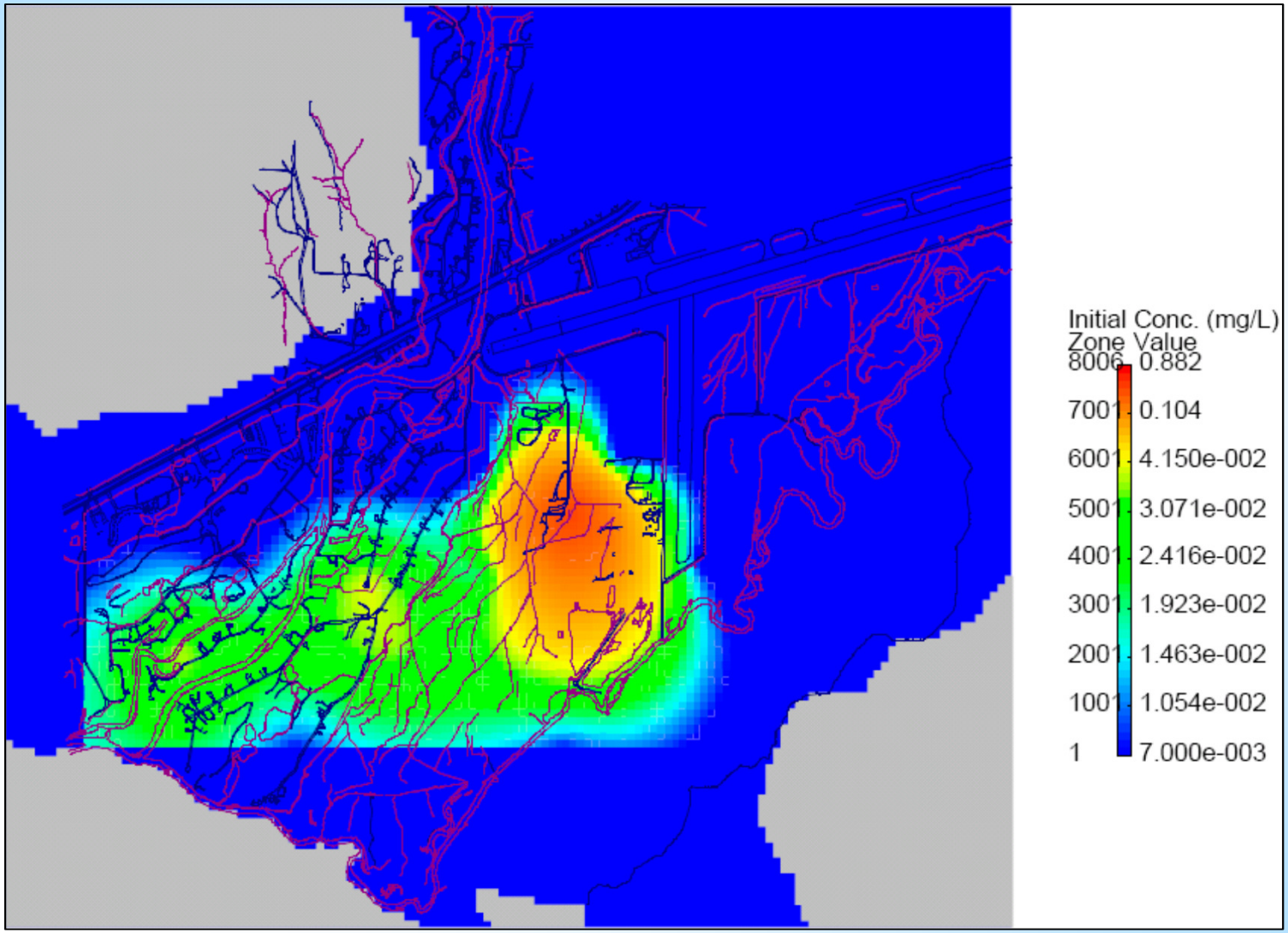




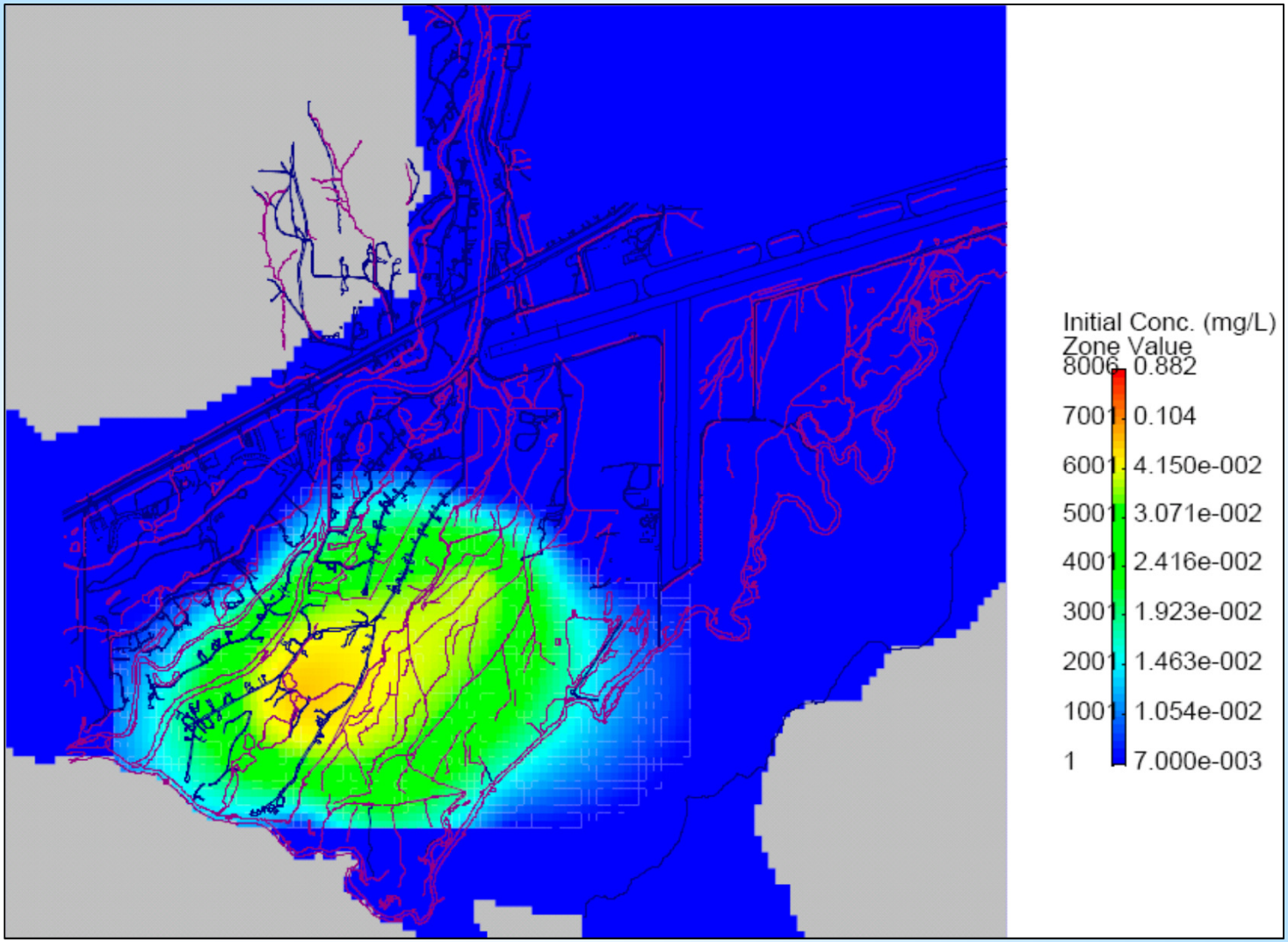
Shallow Uranium Contamination



Intermediate Uranium Contamination



Deep Uranium Contamination



Conclusions

- Steady State model to match observations
- Stochastic model to determine uncertainty
- Transport based on advection, sorption
- 100 years of flushing adequate

What Does That All Mean?

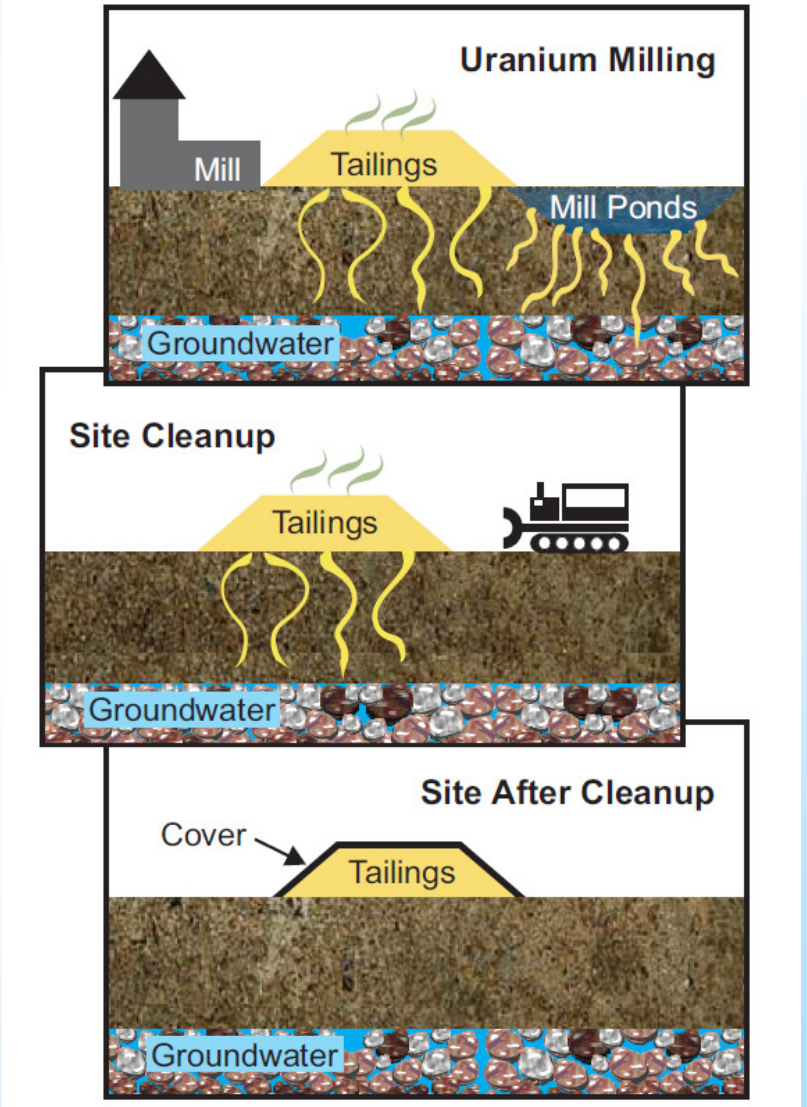
- Traditional Kd approach to modeling
  - Many unknowns
  - Many assumptions needed
  - Unstated assumptions inherent
  - Empirical in nature
  - Sampling of soils for Kd – what is representative?
  - Use real site water or simulated?
  - Ignores other processes
    - Biological
      - Bacteria, viruses, mold, yeast, fungi, benthic organisms
      - Sterilization changes the chemistry
    - Geochemical not really linked to hydrologic yet, emerging

From Science to Compliance

- State-of-the-art modeling – science
  - STOMP
  - TOUGH2
  - Coupled geochemical-hydrologic
  - Others?
  - Rely on supercomputing time, DOE excels
  - Lab proprietary
  - ASCEM
- Regulatory acceptance – compliance
  - Modflow or GMS – hydrologic
  - PHREEQC – geochemical
  - MT3D – transport

Where Are We Going?

- The regs … don't really matter!
  - UMTRCA, CERCLA, Offsites
  - Same problems regardless
  - Surface largely addressed
  - We will have these sites forever
  - Groundwater – legacy plumes

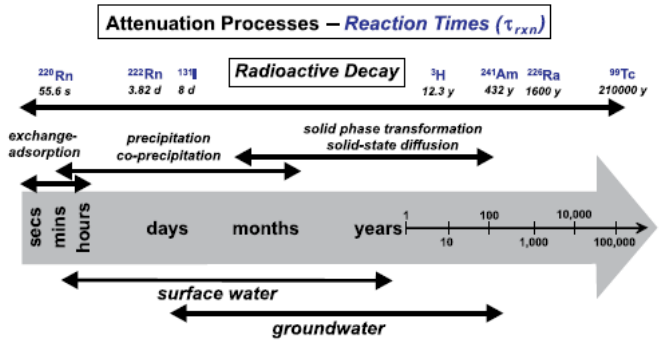


It's Not Just Us…

EPA United States Environmental Protection Agency

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



Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites

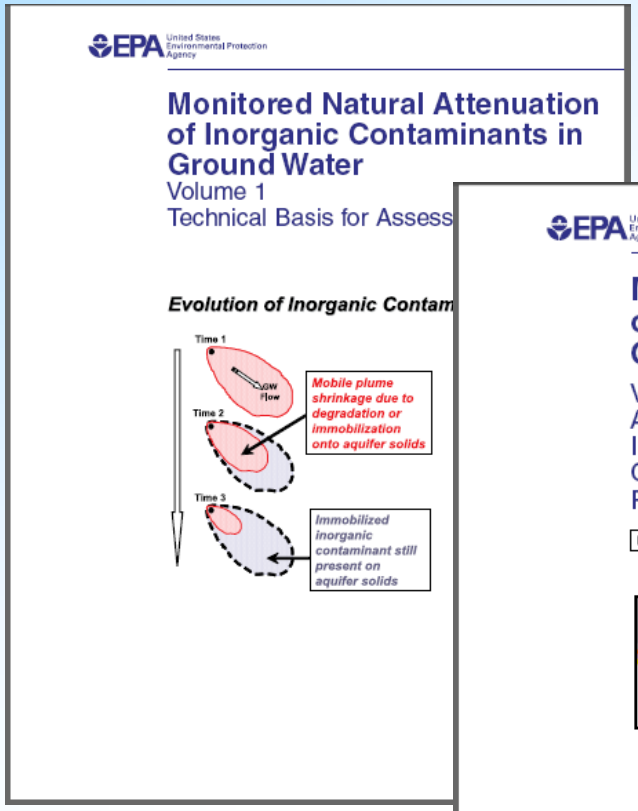
Committee on Future Options for Management in the Nation's Subsurface Remediation Effort

Water Science and Technology Board

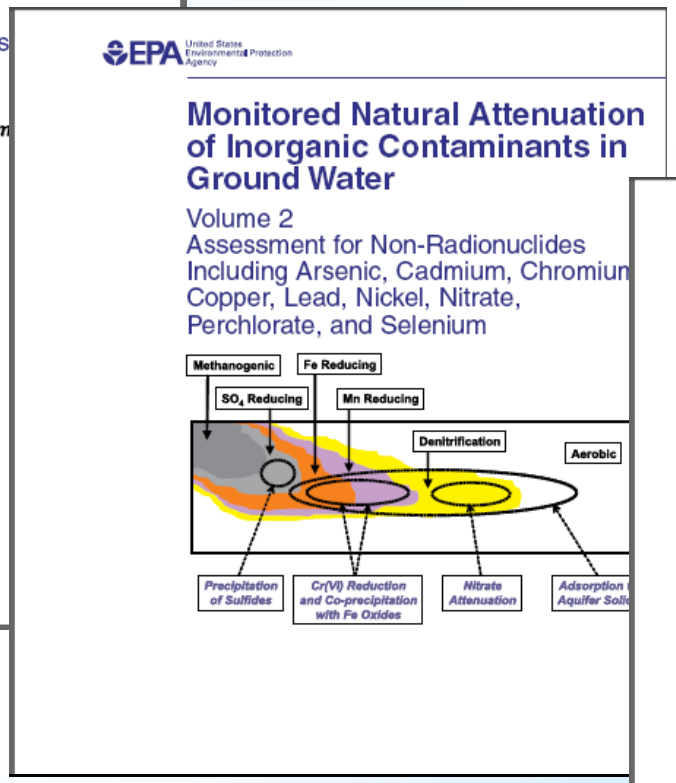
Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Recent EPA Guidance for MNA of Metals and Radionuclides



http://www.epa.gov/ada/download/reports/600R07139/600R07139-01.pdf



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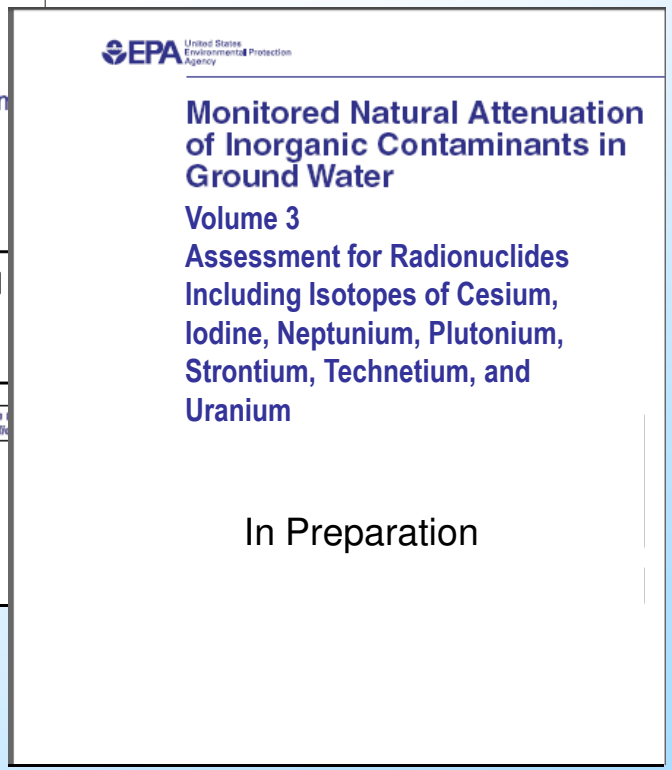
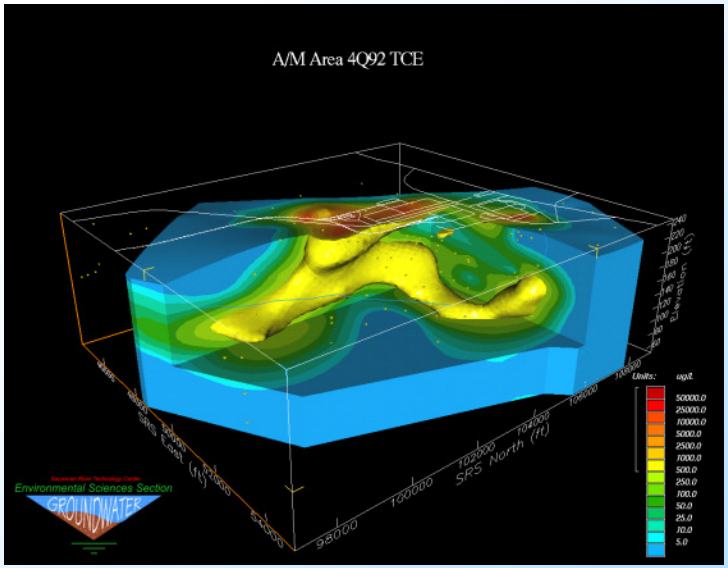


In Preparation

U.S. DEPARTMENT OF ENERGY | Legacy Management

DOE Groundwater Remediation Challenges

- National Academy of Science 2009 Review
  - Contaminant behavior in the subsurface is poorly understood
  - Contaminant and hydrogeological site characteristics may limit usefulness of baseline remediation technologies
  - Long-term performance of caps, liners, and reactive barriers cannot be assessed with current knowledge



Interactive Monitoring and Modeling

- Monitoring
  - Well sampling
  - Mostly compliance driven, incomplete for modeling
- SOARS
  - Over 1 million data points to date
  - Purpose not modeling
  - Sorting it out
  - Water level, conductivity, temp, Eh, pH
  - Data repository
- GEMS
  - 25 years of data

The Verdict – Monitoring

- LM has years of data
- Ongoing collection
- Continuous and discrete
- Focus on compliance
- Reworking characterization
- Reliability of data
- Data density
  - Spatial
  - Temporal
- Data types
  - Compliance versus full suite

The Verdict – Modeling

- It's possible, but is it accepted in regulatory world?
- From science to compliance
- It relies on state-of-the-art in modeling
- Requires unique capabilities
  - Supercomputing
  - Codes
- Data intensive
  - Unusual data
  - High density