ER-20-12: A Case Study of Corrective Action Investigation in a Challenging Environment

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Objective

To highlight actions taken by the U.S. Department of Energy’s (DOE) Environmental Management (EM) Program in Nevada as an exemplary approach to corrective action investigations under challenging conditions
Nevada National Security Site (NNSS)

- Historically used for nuclear testing (1951 – 1992)
- National Nuclear Security Administration is responsible for current national security missions along with overarching management of the NNSS
- DOE’s Office of EM is responsible for remediating historic locations on the NNSS and portions of the Nevada Test and Training Range
UGTA

- Underground Test Area Activity (UGTA) is the Nevada EM program charged with characterizing the groundwater to address impacts of 828 underground nuclear tests
  - NNSS is separated into groundwater characterization areas based on location and geology
Study Location

- Well ER-20-12 in the Pahute Mesa groundwater characterization area near the site of the underground nuclear test named Handley
Prior Conceptual Model

![Caldera Boundaries (DOE, 1992)](image1)

![Western Pahute Mesa Water Table Map (DOE, 1996)](image2)

Site of underground nuclear test
Groundwater characterization well
Phase I Characterization – 1999 to 2007

- Drilling, testing, and sampling 8 wells
- Geophysical surveys
- Geologic mapping/modeling
- Recharge studies
- Geochemical mixing models
- Radiochemical source term
- Tracer tests
- Colloid studies
- Laboratory based studies of matrix diffusion

Drilling at ER-EC-2a (Jan. 2000)
Phase 1 Modeling Results

Particle path lines (DOE, 2009)

Transport – 50 years (DOE, 2009)
Phase II Characterization – 2009 to Present

• Added a second phase to reduce uncertainty
• Drill, test, and sample 10 wells
• Updates to geologic model
• Refined water-level analysis
• Revised potentiometric surface
• Conducted 16 Interference tests
• Radiochemical source term analysis
• Fracture analysis
• Simplified 2-D water-balance model

Rainbows and Critters at ER-EC-14 (Oct. 2012)
Well PM-3 Tritium Results

Tritium Time Series from PM-3

Construction diagram
Well PM-3

Tritium (Bq/l)
Date

MDL: Minimum detectable level
GT MDL: Greater than minimum detectable level
DOE Communication of Sampling Results

- Verbal notification to Nevada Division of Environmental Protection (NDEP)
- Presentation to NSSAB
- Publication of results in the Annual Site Environmental Report
- Poster-style presentations of results at town-hall-style meetings

Groundwater issues being discussed at NSSAB Meeting
DOE Response – Documentation & Evaluation

• DOE ordered a complete review of the geochemistry
  – Frame recent monitoring results based on historical context
  – Identify potential sources of tritium
    ▪ A surprising number of alternatives
• DOE convened panel of subject matter experts: geologist, hydrogeologists, radiochemists, numerical modelers, and a representative of NDEP
  – Evaluate evidence to evaluate alternatives
  – Recommend course of action
Alternatives

Sources

- Site of underground nuclear test
- Groundwater characterization well

Fallout Plumes (BN, 1999) & Surface Water Runoff

Revised Water Table (USGS, 2010) & Fracture Orientation

Localized Infiltration
Consideration of Alternative Characterization Strategies

• Continued routine monitoring/expanded monitoring to include Chlorofluorocarbons and noble gases
• Shallow drilling in nearby ephemeral wash
• Drilling a single/multiple characterization well(s) upgradient
• Recommendation based on a pragmatic approach
  – General opinion that Handley was the likeliest source
    ▪ Consistent with tritium, Carbon-14, Chlorine-36, and revised potentiometric surface
    ▪ Advective transport via groundwater the only pathway subject to regulatory oversight
  – Drill single well upgradient – approach favored by state regulator
ER-20-12 Design

- Guidance committee reconvened to develop scientific criteria for the well (well objective, depth, target units, data, etc.)
- Well drilling, construction, and testing designed to accommodate multiple objectives under uncertain conditions. Decision tree developed to guide the process based on observations in the field.

Process that guides well completion under uncertain radiological conditions. Decision points are yellow.
ER-20-12 Construction

Opportunistic Data Collection

Wind and Tritiated Discharge

Impediments to Road and Pad Construction

Site of underground nuclear test
Groundwater characterization well
Hydrostratigraphic Cross-section

ER-20-12 Results

2,234 Bq/l

1,720 Bq/l

13.1 Bq/l

5.6 Bq/l

2,234 Bq/l
Results of Characterization Activities

- Depth dependent tritium profile within ER-20-12 can only be attributed to Handley
- Very likely that tritium in PM-3 is the leading edge of the plume
Summary of Challenges to Characterization Activities

- Tritium detected in PM-3 in 2010
- 3 km from edge of testing area and 7 km from potential source
- Challenges
  - Tritium detections were episodic and low-level
  - Site characterized by complex geology, great depth to water, remote, high elevation, rugged terrain, inclement weather, residual surface contamination
  - Competing hypothesis for source of tritium

Note: Cavity radius calculated from the minimum of the announced yield in NNSA/NFO (2015b) using the equations in Pawlowski (1999).
Exemplary Actions by DOE

- Flexibility in Federal Facility Agreement and Consent Order strategy
- Prompt and open communication with stakeholders
- Incorporated input from member of regulatory authority into Technical Guidance Committee
- Thorough evaluation of alternative conceptual models to explain the presence of elevated tritium in PM-3
- Thorough yet pragmatic evaluating of alternative characterization strategies
- Observational approach used during well drilling/construction
- Safety first
- Opportunistic data collection