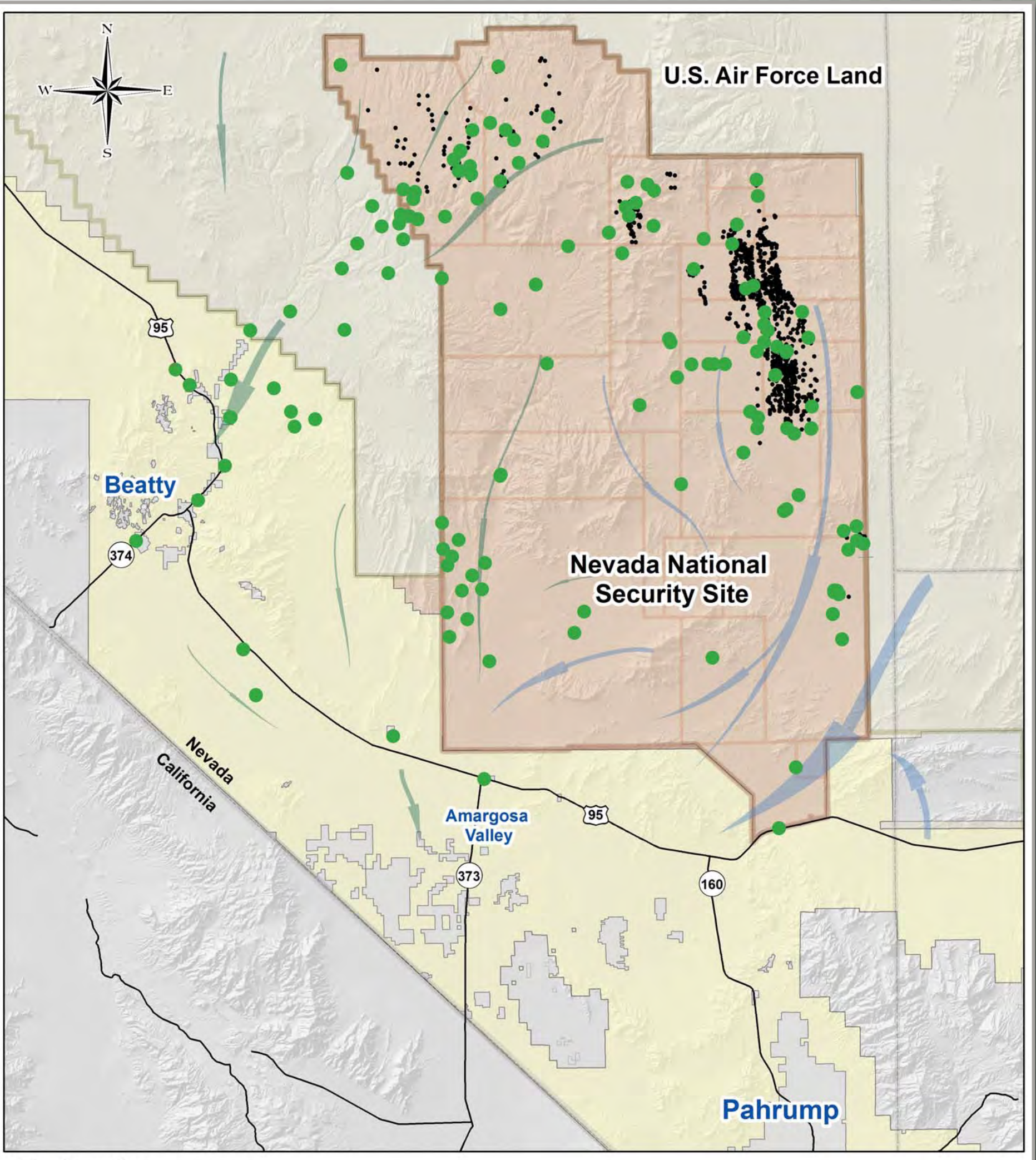
Wells Sampled On and Near the Nevada National Security Site

Nevada National Security Site



Explanation

- Well Location
- Underground Nuclear Test Location
- U.S. Bureau of Land Management
- Groundwater flow direction – Arrow width indicates relative flow volume. Green and blue colors denote alluvial-volcanic and carbonate flow systems, respectively. Source: Modified from USGS PP 1771 (2010)

0 5 10 15
Kilometers

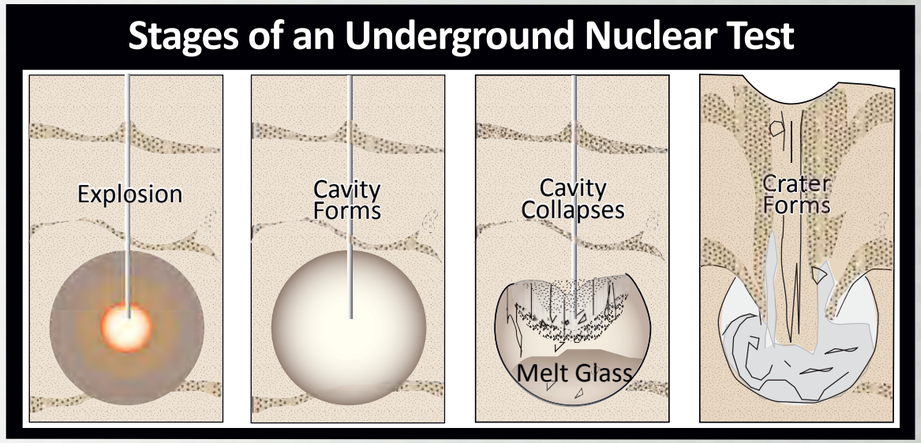
0 3 6 9
Miles

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office

Historic Underground Nuclear Testing and Groundwater at the Nevada National Security Site (NNSS)

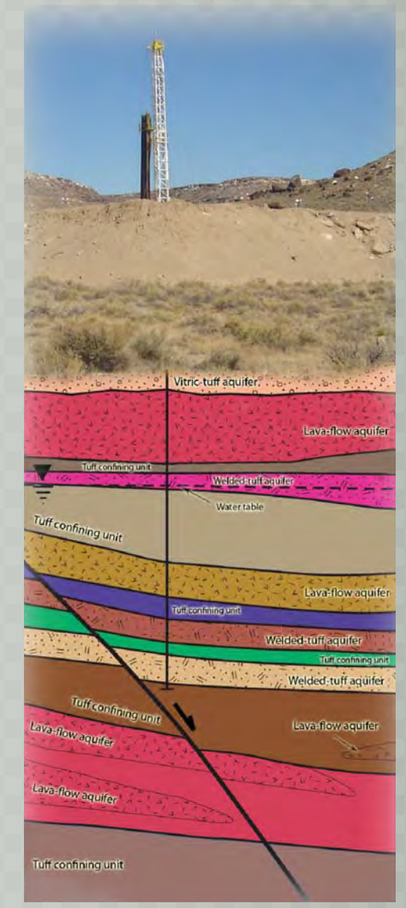
What Occurred

- 828 underground tests from 1951 to 1992
  - 90 to 4,800 feet below the ground surface
  - One-third near, below, or in the water table
  - Some groundwater under the NNSS and surrounding federal land contains radionuclides
  - Radionuclides are also in melt glass, underground rubble and in rocks surrounding the underground cavities



An underground nuclear explosion vaporizes the surrounding rock resulting in a cavity. As the remaining rock cools, melt glass forms and settles to the bottom of the cavity. This may lead to a collapse of the cavity which forms a depression on the surface, or a subsidence crater.

Important Factors



- **The most current scientific data available indicates there is no imminent risk to the public**
- No practical technology for vast-scale contaminant removal
- Extremely complex underground hydrogeology
- Radionuclides are located deep underground
- Not all tests had equal potential to release radionuclides into groundwater

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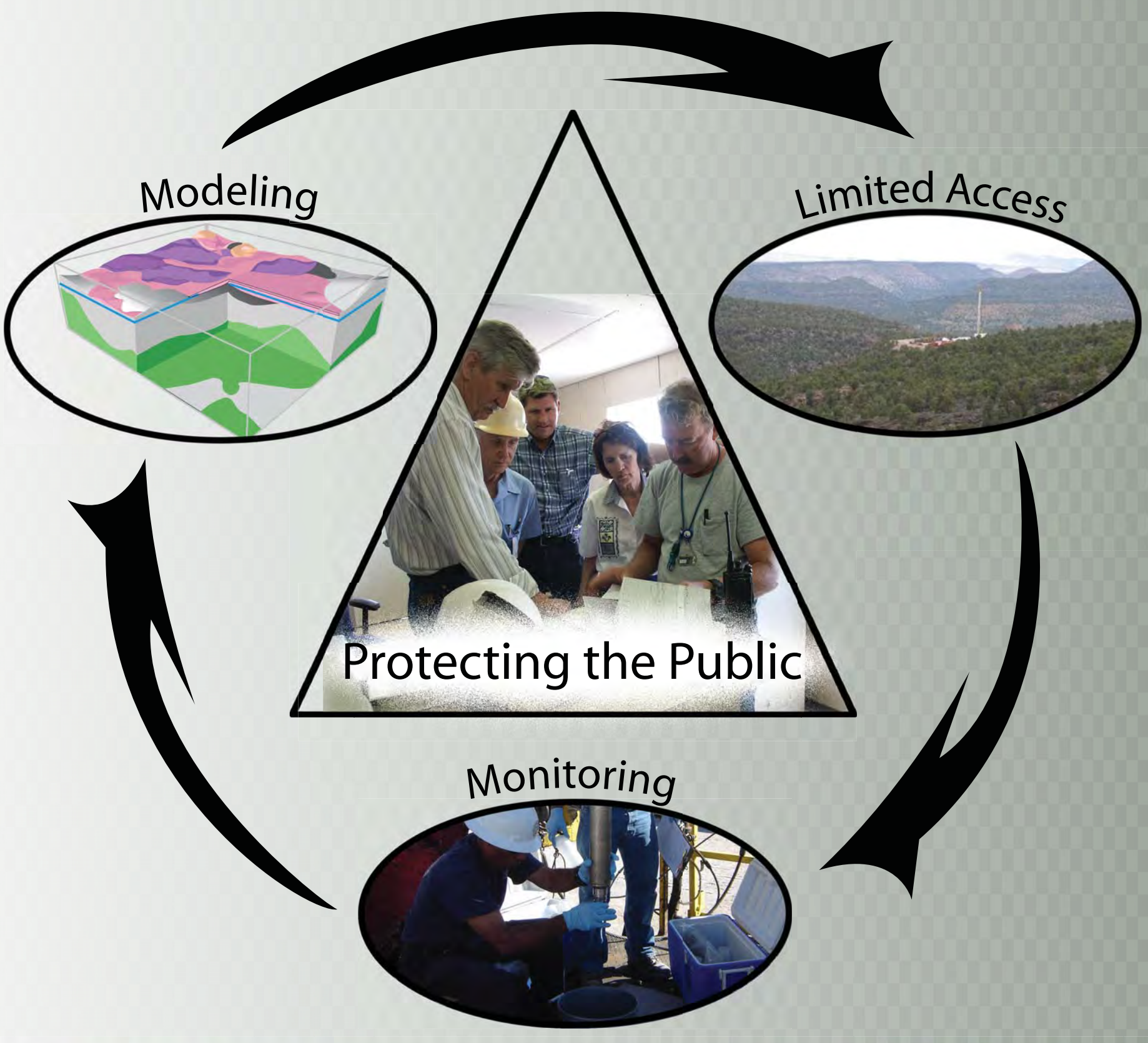
Protecting the Public

The U.S. Department of Energy developed a comprehensive groundwater program to address legacy contamination. The program:

- Incorporates an extensive network of monitoring wells on and off the Nevada National Security Site for early detection
- Continues to gather information to expand knowledge on the behavior of radionuclides in complex geology and enhance the monitoring network
- Integrates the following three principles for protecting the public:



Groundwater Monitoring

Routine On and Off-Site Monitoring

- Routine sampling of 60 wells, springs and surface water locations on and off the Nevada National Security Site (NNSS)
  - Purpose:
    - Verify groundwater continues to meet safety standards
    - Ensure NNSS drinking water is safe
    - Determine if facilities on the NNSS are compliant with permitted radionuclide limits

Results published in annual Nevada National Security Site Environmental Report at www.nv.energy.gov/enviroreport.aspx

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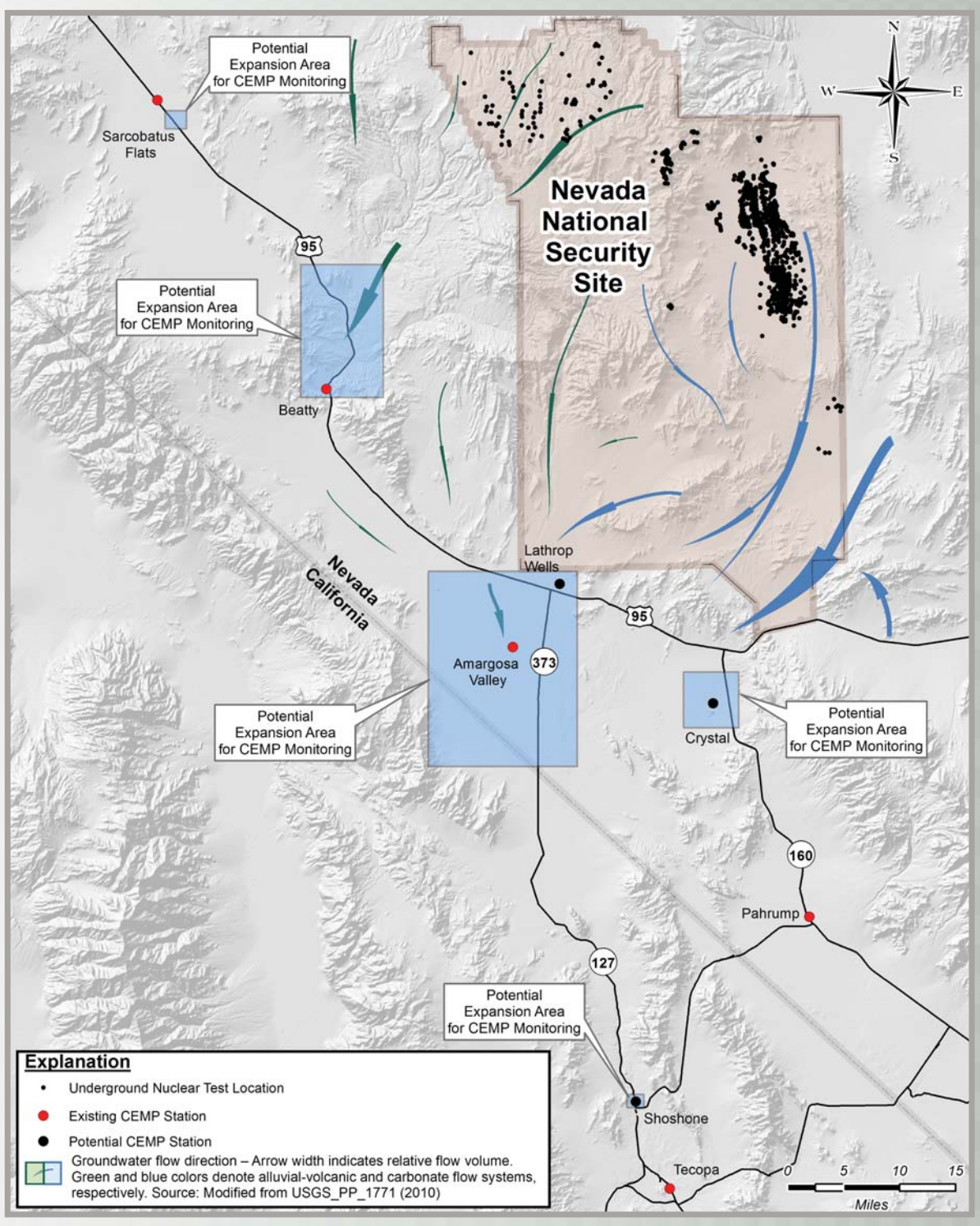
Log No. 2013-250

Community Environmental Monitoring Program (CEMP)



CEMP is currently refocusing its efforts on groundwater monitoring in areas down gradient from the Nevada National Security Site (NNSS)

In 2014, CEMP will begin sampling additional wells and springs for tritium (see blue boxes on map)

CEMP Facts

- CEMP is the off-site radiological monitoring program for communities surrounding the NNSS
- The U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office provides funding for the Desert Research Institute (DRI) to administer the program
- CEMP provides a hands-on role for public stakeholders
- Water sampling results are made available on the public website at **www.cemp.dri.edu** and posted on bulletin boards at local CEMP stations (see red dots on map)

Desert Research Institute

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Log No. 2013-250

Expanding Our Understanding of Groundwater

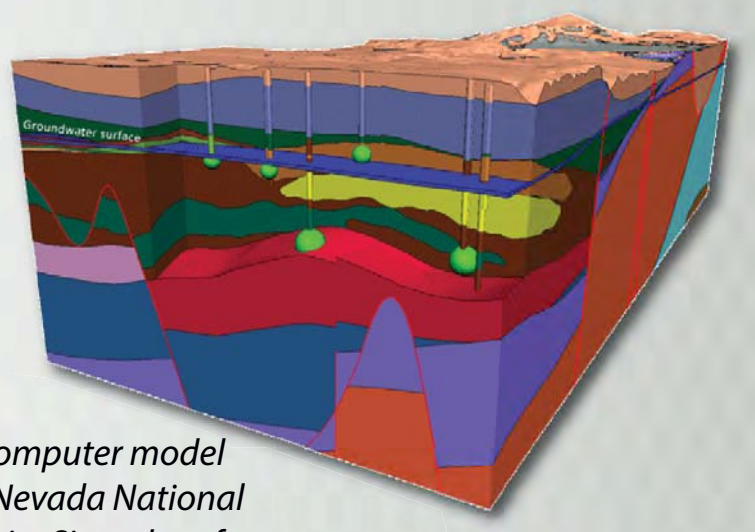
The Nevada Field Office is continuing to gather information to expand knowledge on the location, type, quantity, direction of movement, and flow rate of radionuclides in groundwater. Key steps involve:

Identifying Information

- Geology
- Hydrology
- Groundwater chemistry
- Amount of radionuclides in groundwater

Gathering Information

- Well drilling and construction
- Aquifer testing and water level monitoring
- Water sample collection



Computer model of Nevada National Security Site subsurface

Analyzing Information

- Computer simulations (modeling) of hydrogeology and groundwater flow and contaminant transport

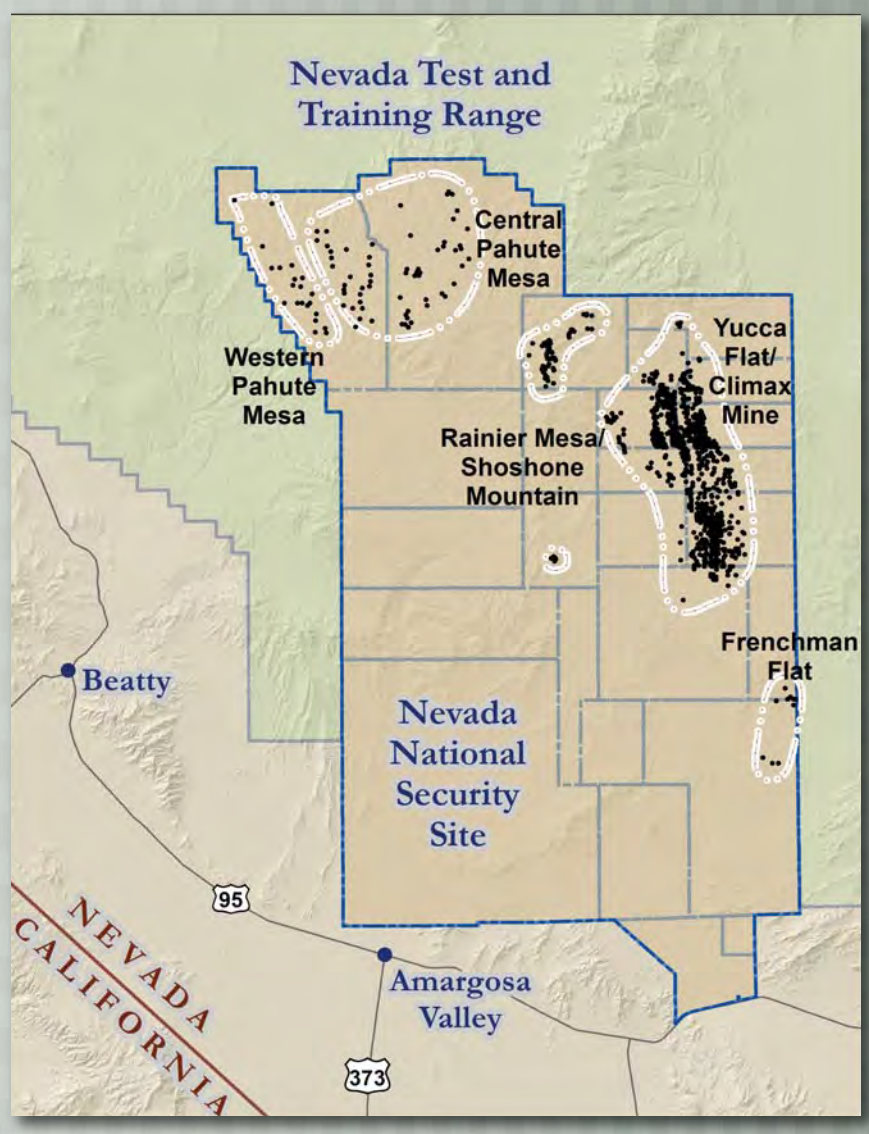
Federal Facility Agreement and Consent Order

Regulatory Strategy

Under a binding legal agreement, the State of Nevada Division of Environmental Protection must review and approve each stage of Nevada National Security Site groundwater characterization activities. Stages include:

Investigation Stage

- Gather new data to enhance models developed for each of the five (5) historic underground nuclear test areas (repeat as necessary)
- Review results: geology, hydrology, source term, groundwater and transport models, modeling approach (repeat as necessary)



Decision/Action Stage

- Develop a model evaluation plan to challenge and refine model forecasts
- Use model evaluation plan to identify locations for new wells

Closure Stage

- Negotiate use restrictions and regulatory boundary
- Establish institutional controls and requirements
- Develop long-term closure monitoring program

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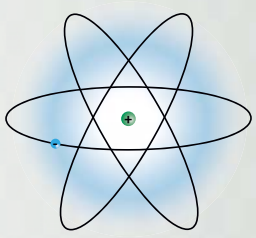
Log No. 2013-250

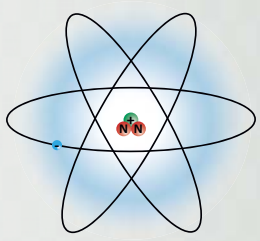
Understanding Tritium in Water

- Radioactive form of hydrogen with a half-life* of 12.3 years
- Naturally occurs in surface waters, such as Lake Mead, at 10 to 30 picocuries per liter
- Emits a weak form of radiation that cannot penetrate deeply into tissue or travel far in air
- Primarily enters the body when eating food or drinking water containing tritium
- Half of tritium is eliminated from the body about 10 days after exposure
- Regulatory standard for safe drinking water is 20,000 picocuries per liter



Hydrogen Atom

One proton
No neutrons
One electron



Tritium Atom

One proton
Two neutrons
One electron

Why Analyze for Tritium?

More than 95% of the radionuclide inventory (at the time of detonation) is tritium which will decay to nearly zero within 200 years. Since tritium is chemically similar to a water molecule, it can easily move in groundwater. Many of the longer-lived radionuclides, such as plutonium, are trapped in the melt glass or attached to rock surfaces which delays the movement of these radionuclides in groundwater. Until increased levels of tritium are observed, other longer-lived radionuclides will not be present.

In order to reach the allowable limit under the Safe Drinking Water Act, a person would need to drink 193 gallons of water per year containing 20,000 picocuries of tritium per liter...which is approximately the same dose of radiation you would get during a typical commercial flight between Los Angeles and New York City.

*Half-life refers to the amount of time it takes for a radioactive substance to lose half of its radioactivity.

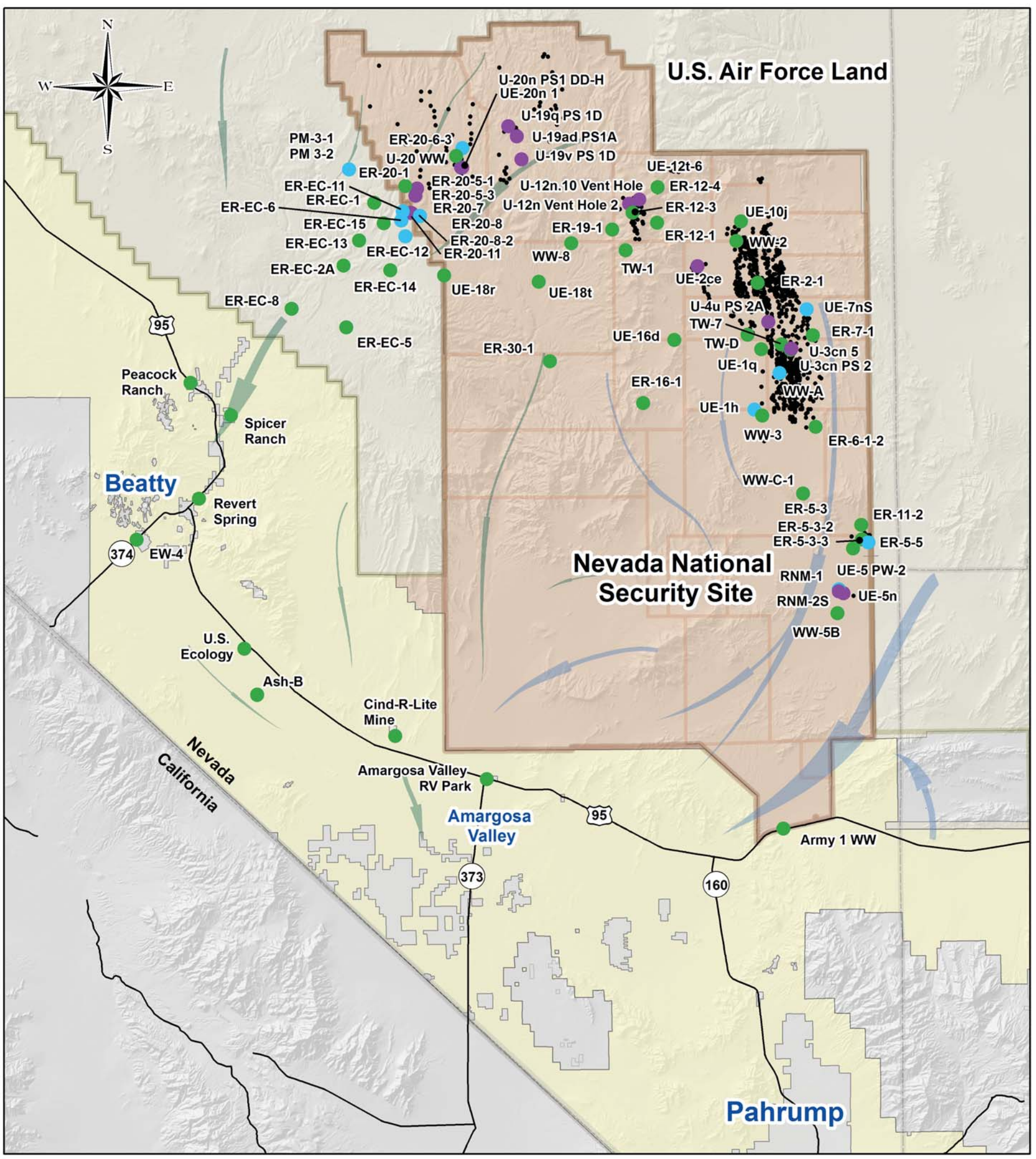
U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office

Log No. 2013-250

Results of Wells Sampled for Tritium

Nevada National Security Site

Calculations show tritium in the groundwater from underground nuclear tests will decay to nearly zero in 200 years



Explanation

Tritium Levels

- Non-Detect
- Below Safe Drinking Water Limit
- At or Above Safe Drinking Water Limit

- Underground Nuclear Test Location
- U.S. Bureau of Land Management
- Groundwater flow direction – Arrow width indicates relative flow volume. Green and blue colors denote alluvial-volcanic and carbonate flow systems, respectively. Source: Modified from USGS_PP_1771 (2010)

0 5 10 15 Kilometers

0 3 6 9 Miles

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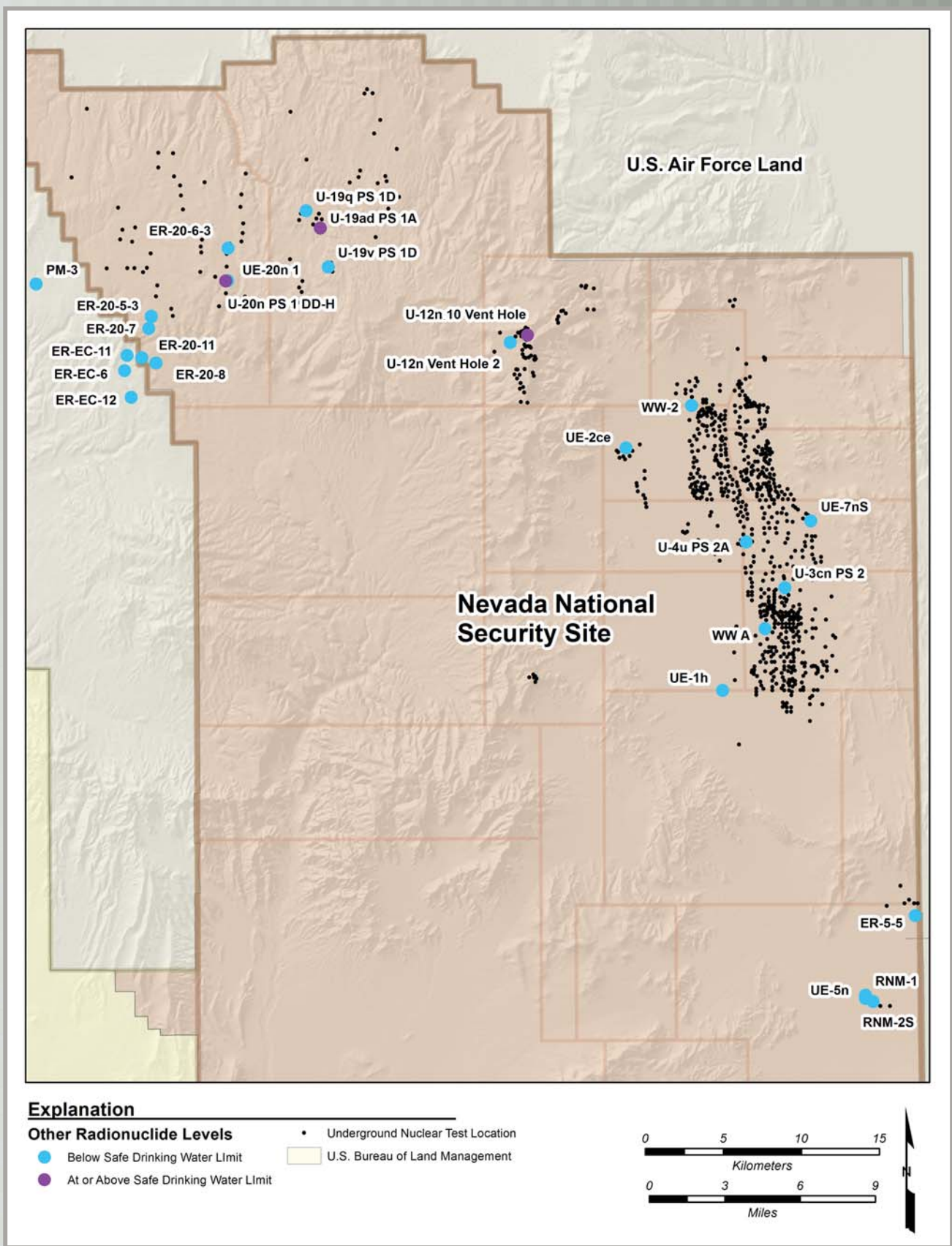
Log No. 2013-250

Sampling Results for Other Radionuclides

- **Other than tritium, no other radionuclides from underground nuclear testing have been detected in wells sampled off the Nevada National Security Site**
- **No radionuclides from underground nuclear testing have been detected beyond U.S. Air Force controlled land**

43 radionuclides produced during nuclear tests considered a potential risk

- 29 radionuclides are trapped in the melt glass formed by the detonation of the underground nuclear device
- Tritium, carbon, iodine, chlorine, technetium are mobile in all subsurface environments
- Cesium and strontium are mobile in a carbonate aquifer system
- Plutonium is transported a limited distance on small particles
- Samples are analyzed for other radionuclides once tritium has been detected



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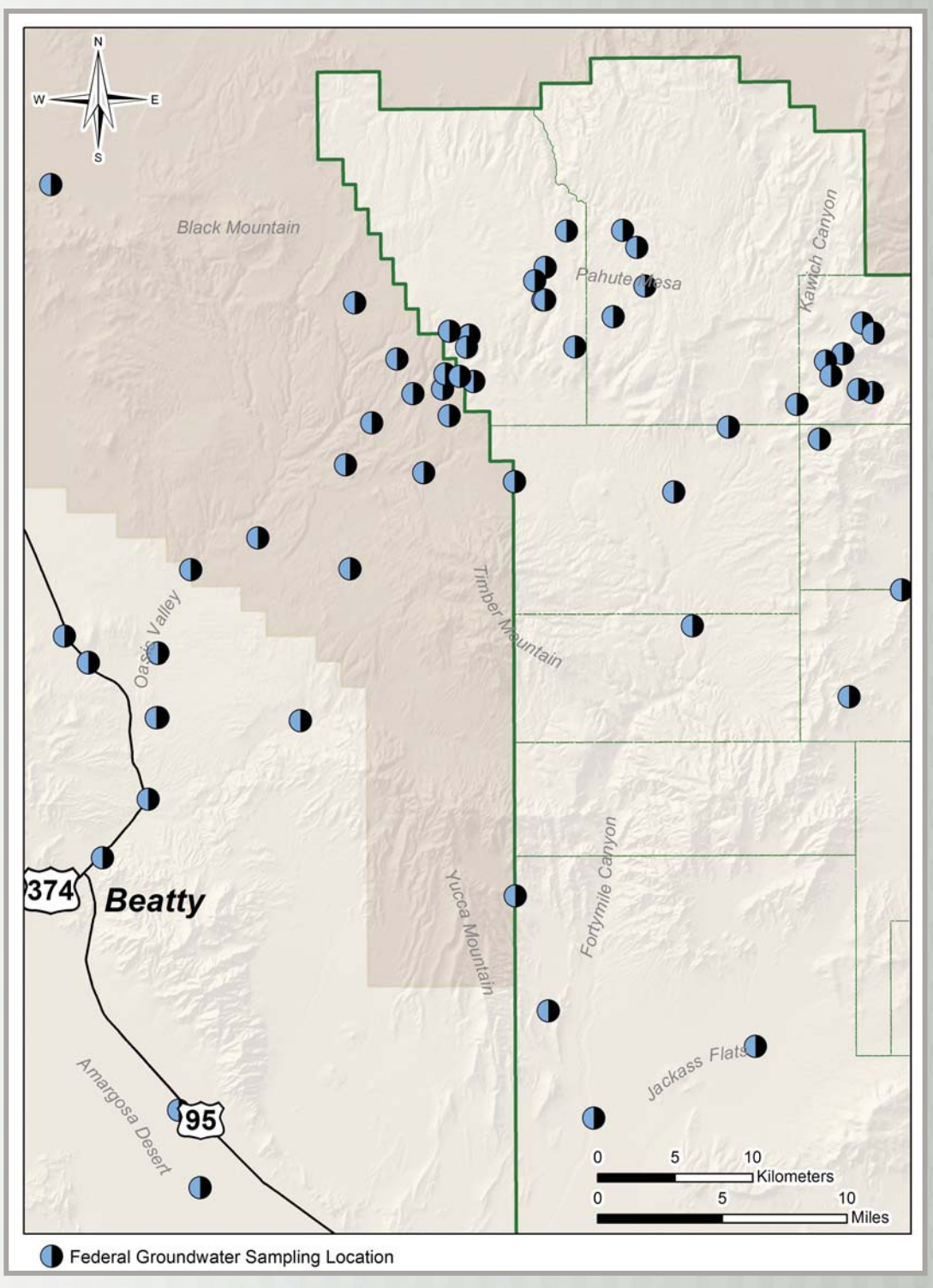
Log No. 2013-250

Putting Results into Perspective



- **Based on conservative, scientific calculations and sampling results, it will take at least 100 years for tritium to reach the closest public land boundary**
  - **In approximately 100 years, the concentration of tritium is estimated to be less than Safe Drinking Water Act limits at the closest public land boundary**
  - **In approximately 200 years, the concentration of tritium will be nearly zero at the closest public land boundary**

Protecting the Public

- No public access to contaminated groundwater
  - Large area of federally-controlled land provides buffer zone
- Evolving and conservative computer models provide forecasts to identify potential areas of concern in advance of sampling detection
- Ongoing monitoring serves as a means for early detection

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Log No. 2013-250

Communicating Sampling Results

Groundwater samples are analyzed for various radionuclides at certified laboratories. Based on validated results, notifications are made as appropriate. Results are published annually in the Nevada National Security Site Environmental Report.

Wells on surrounding U.S. Air Force land

- Notify State of Nevada if 50% of Safe Drinking Water Act (SDWA)* limits
- Public notifications if above SDWA limits

Wells on public, private or BLM lands

- Notify State of Nevada if 10% of SDWA limits
- Public notifications if greater than 50% SDWA limits

Ongoing Reporting

In 2014, the Nevada Site Specific Advisory Board will recommend when and how to communicate results.

Nevada National Security Site Environmental Report available online at: *www.nv.energy.gov/enviroreport.aspx*

***SDWA is a law that protects the quality of drinking water in the United States**

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Log No. 2013-250

Current and Upcoming Activities

Scientists continue to collect and analyze data to gain a greater understanding of the complex subsurface environment. This work strengthens public protection.

Pahute Mesa
(investigation stage)

- Analyze data and develop additional computer simulations to forecast groundwater flow and contamination transport

Rainier Mesa
(investigation stage)

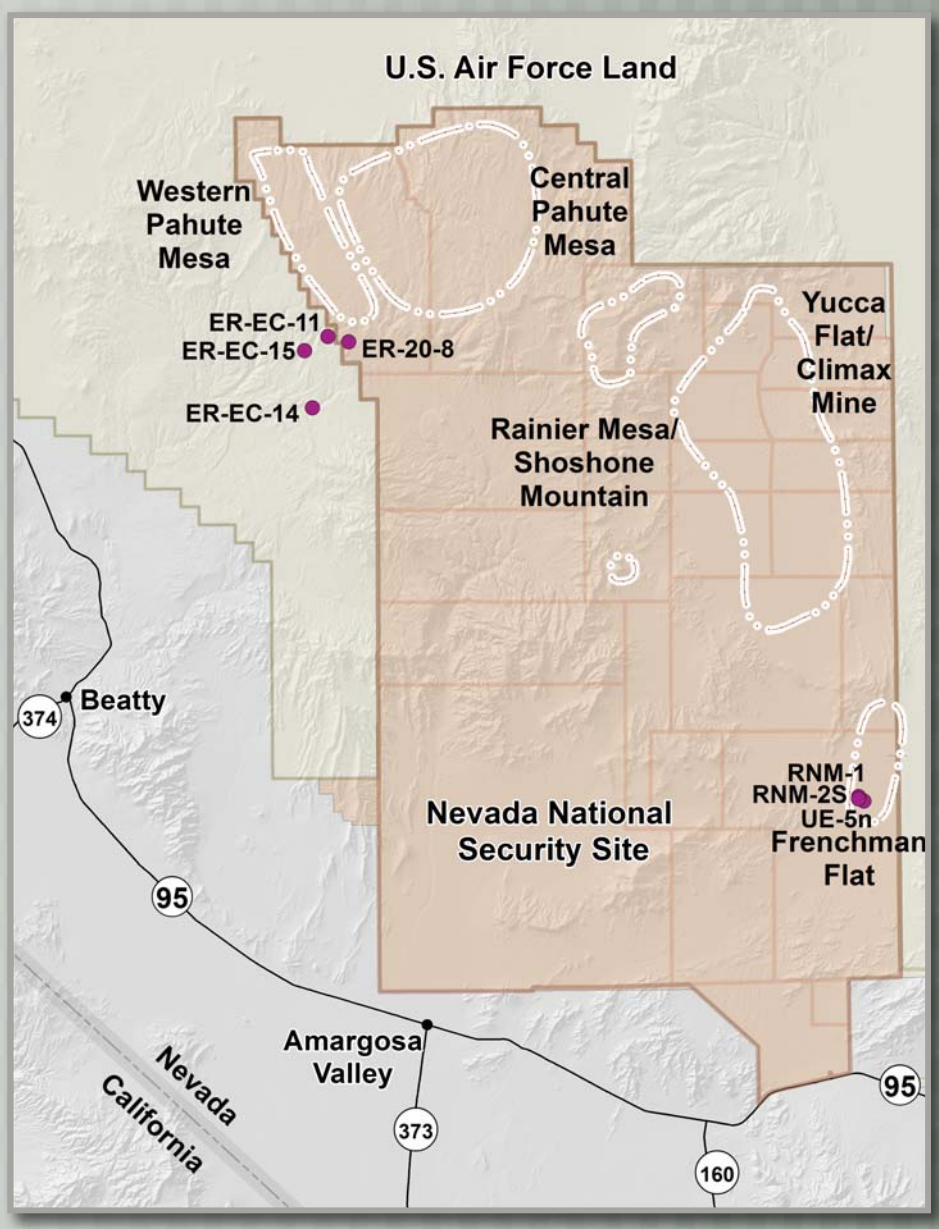
- Update conceptual model

Yucca Flat
(investigation stage)

- Finalize fluid transport model
- Conduct independent peer review

Frenchman Flat
(decision/action stage)

- Complete evaluation of model



Groundwater Sampling in Frenchman Flat

Continue Sampling and Water Level Monitoring

Pahute Mesa

– Water level monitoring at various wells

– Groundwater sampling

- Well ER-EC-15 (Fall and Winter)
- Well ER-EC-14 (Spring)
- Well ER-EC-11 (Spring and Summer)
- Well ER-20-8 (Spring and Summer)

Frenchman Flat

– Groundwater sampling

- Well UE-5n (Spring)
- Well RNM-2s (Spring)
- Well RNM-1 (Spring)

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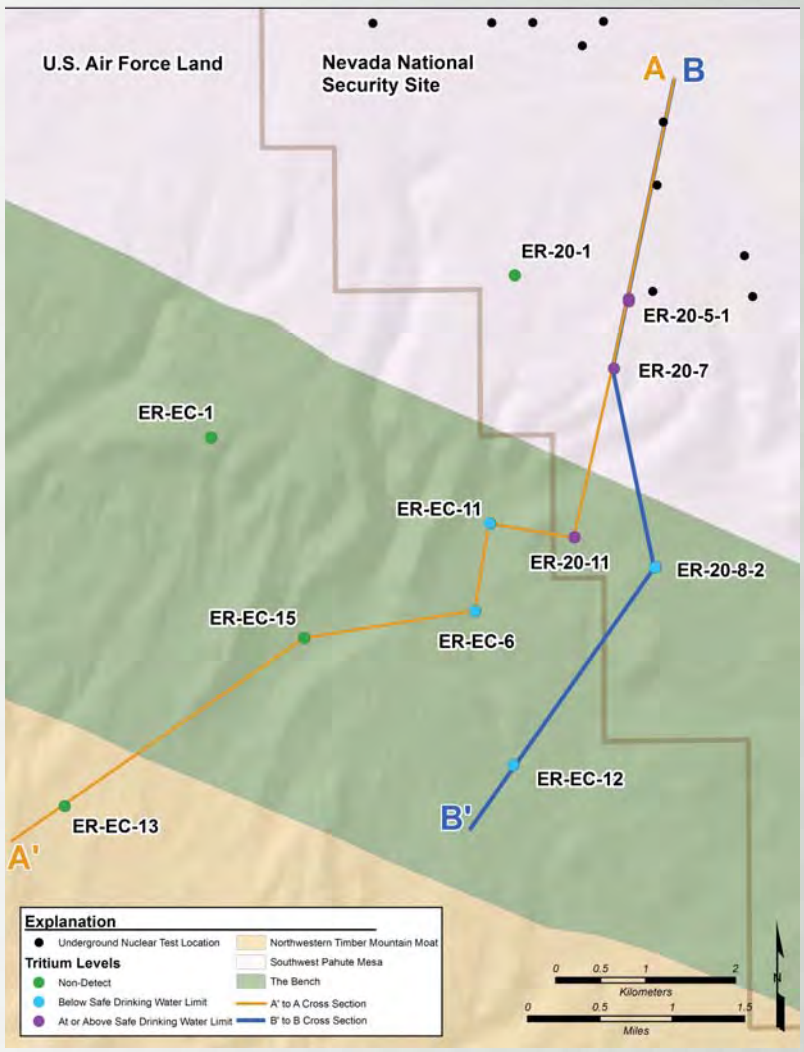
Log No. 2013-250

Expanding Knowledge of the Complicated Subsurface



- Complex subsurface geology
- Area dominated by rhyolitic volcanic rocks
- Geologic units form aquifers, through which water can flow easily (blue units in figure below) or confining units, through which water does not move easily (brown units in figure below)
- Faults (red lines in figure below) add complexity and may disrupt or connect aquifer units
- Area characterized by data from drill holes
- Groundwater flow is generally toward the southwest

Hydrogeologic Cross Sections Across the Bench Area South of Pahute Mesa

Sections are roughly along the general groundwater flow direction (see map above) and denote locations of underground nuclear tests (red spheres)

Cavity size based on maximum of yield range identified in DOE/NV- 209 (Pawloski, 1999)

*** Low tritium detection in the deep interval of ER-EC-12 has not been confirmed to be underground test related**

Why Computer Modeling?

Nevada National Security Site

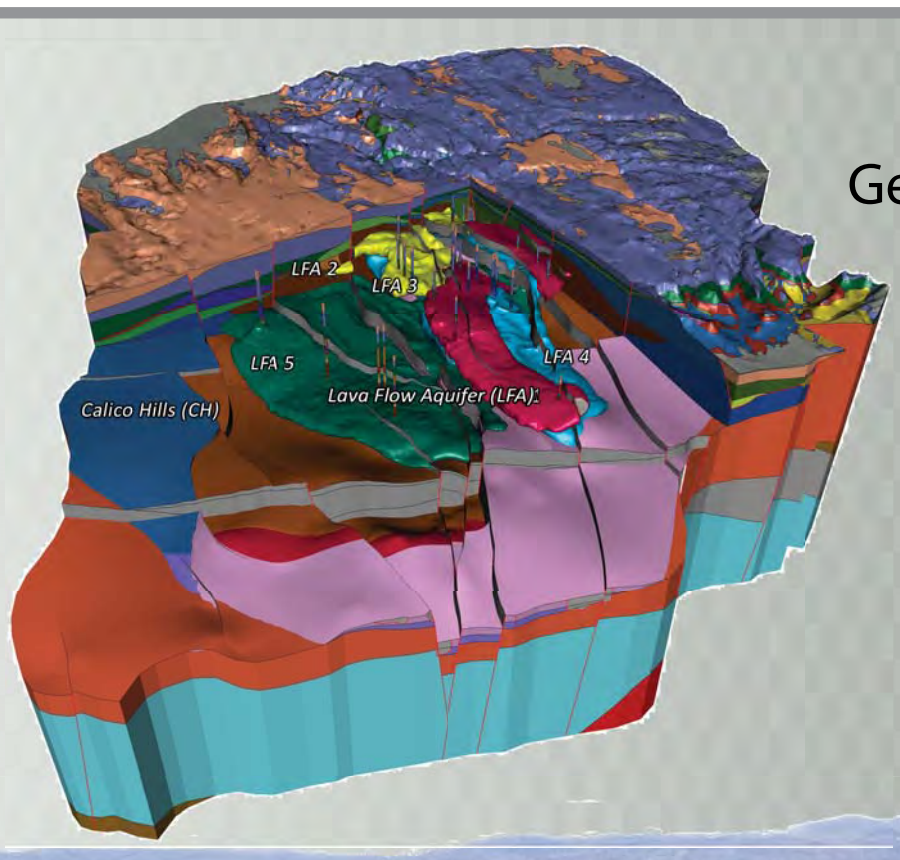
Creates three-dimensional representations of otherwise inaccessible subsurface

Helps forecast where contamination is moving and how fast

Provides flexibility for integrating available data

Allows for uncertainty and sensitivity analysis

Provides basis for regulatory compliance and risk decisions



Geologic Model

Groundwater "Ant Farm" Demonstration

- The principles of groundwater flow and transport can be demonstrated visually in the Ant Farm
- The Ant Farm, although not truly representative of the hydrogeologic setting of the Nevada National Security Site, does provide a sense of how groundwater behaves in nature

Groundwater is water that has infiltrated from surface sources (rain/snow) and accumulated in the subsurface

- It moves through pore spaces and fractures in geologic layers, like volcanic rock and soil
- These different types of geologic layers cause groundwater to move at different speeds and in different directions because of differing pressures

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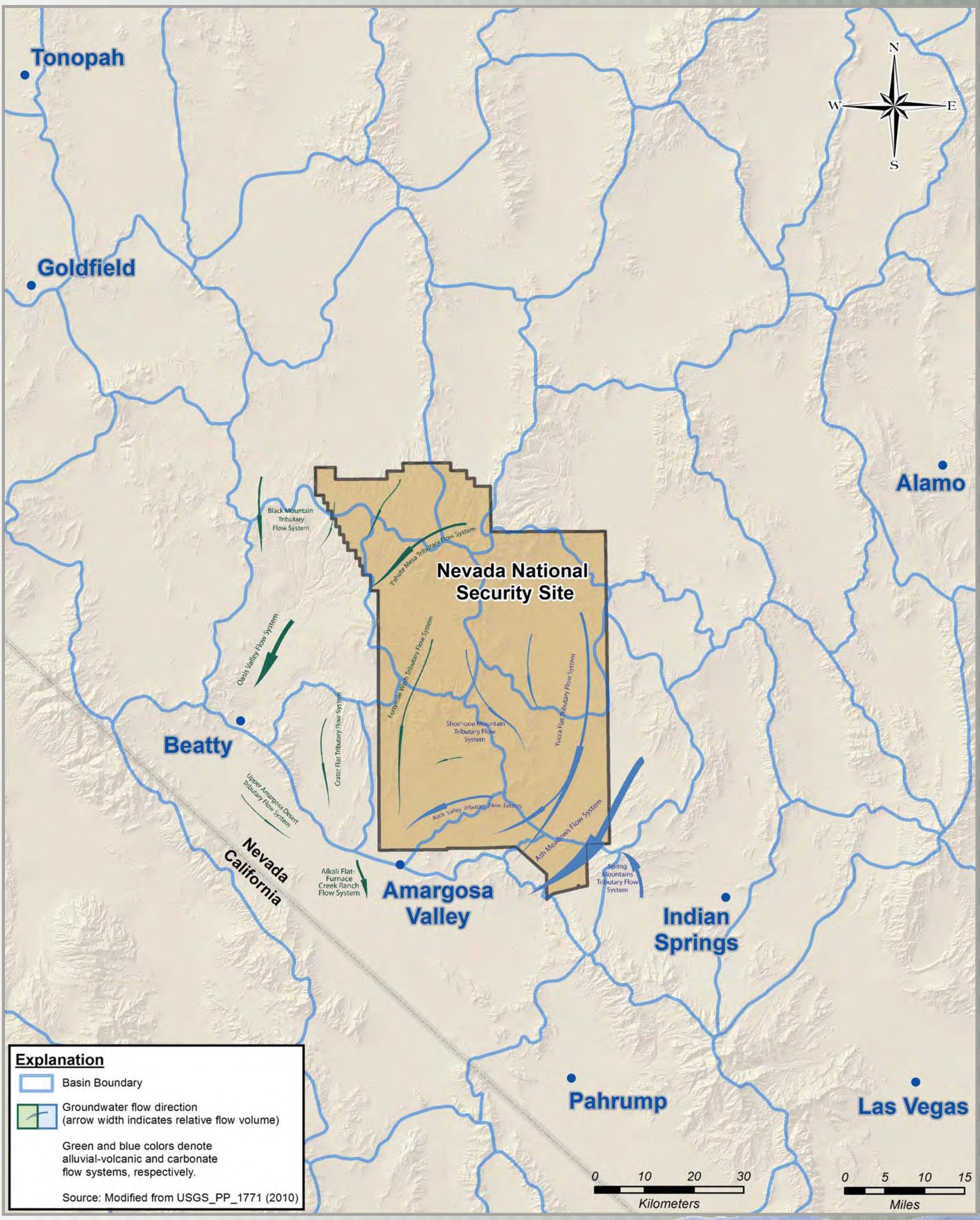
Regional Groundwater Flow and Hydrographic Basins

Nevada National Security Site



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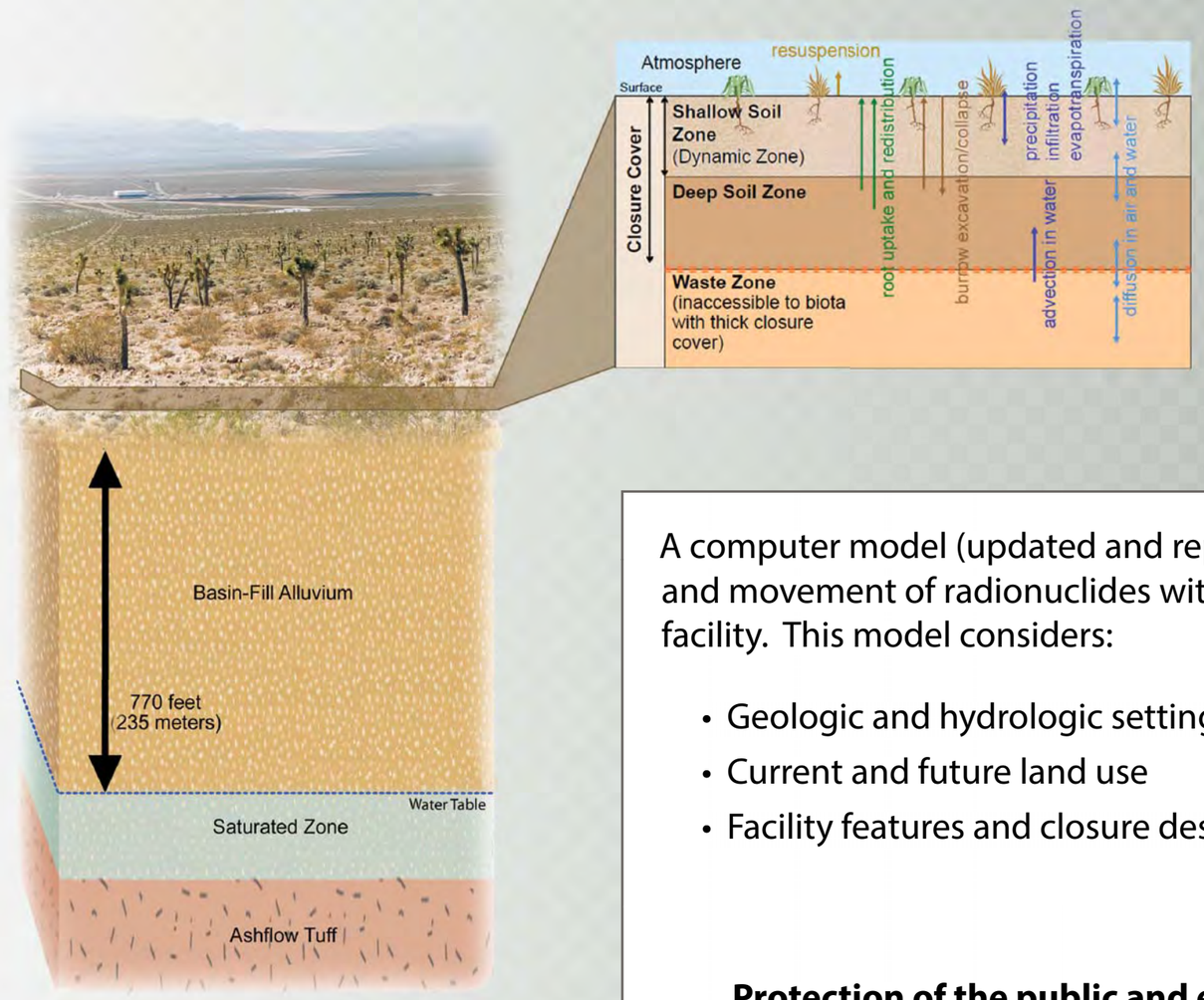
Groundwater Protection at the Area 5 Radioactive Waste Management Site

Arid conditions and natural features provide for the safe isolation of permanently disposed low-level radioactive waste.



Site Hydrologic Conditions

- Located far above regional groundwater levels
- Arid environment (high evaporation rates)
- Very low precipitation (about 5 inches/year)
- Limited pathways to move contamination from buried waste
- No pathway to saturated zone

A computer model (updated and reported annually) forecasts the potential release and movement of radionuclides within 1,000 years after closure of the disposal facility. This model considers:

- Geologic and hydrologic setting
- Current and future land use
- Facility features and closure design
- Processes that could release radioactive waste
- Effects of nature, such as flooding or earthquakes
- Anticipated waste inventories

Protection of the public and environment must be demonstrated to operate the disposal facility.

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Monitoring Groundwater at the Area 5 Radioactive Waste Management Site

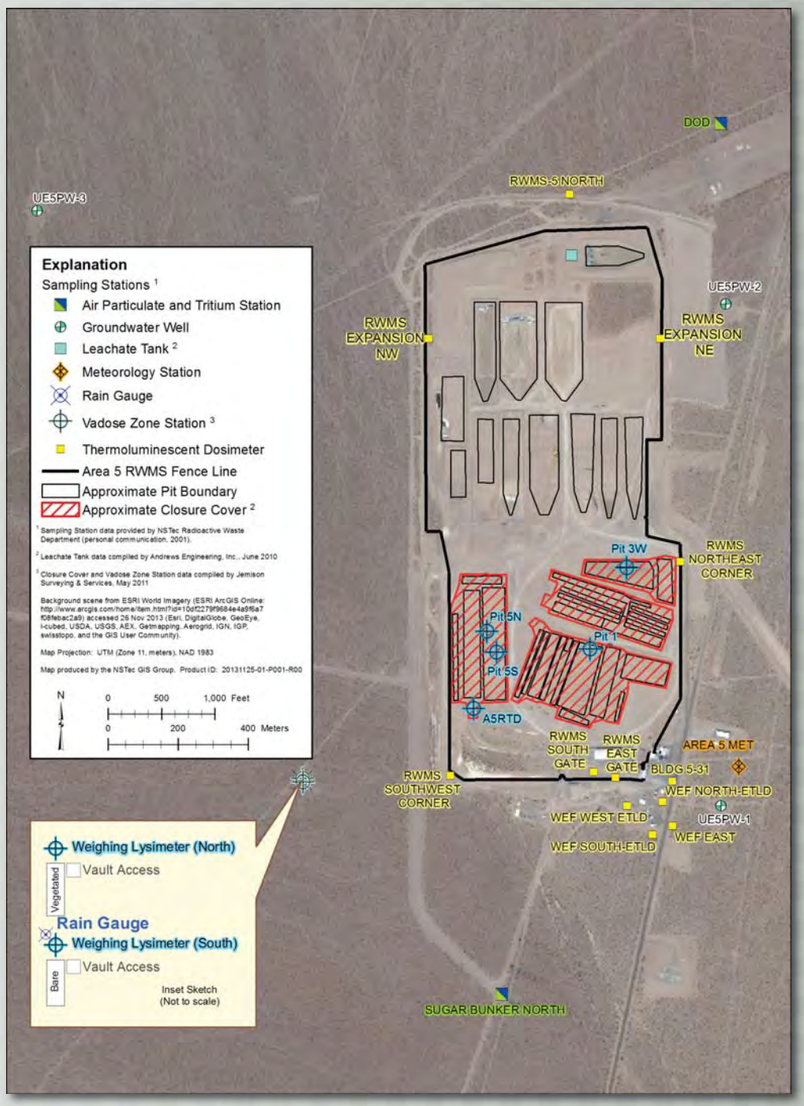
Groundwater Sampling

- Three wells in alluvium sampled quarterly
- Results indicate no contamination from radioactive waste disposal activities
- Additional wells sampled as part of groundwater characterization that addresses contamination from historic underground nuclear testing

Soil Moisture

- Seven (7) monitoring stations
- Automated sampling for precipitation, transpiration, evaporation, etc.
- Moisture content changes not detected below buried waste

Measuring bare-soil cell



Meteorology

- Hourly and daily measurements of temperature, relative humidity, precipitation, wind speed, etc.
- Potential loss of water through evapotranspiration is estimated at 12 times annual precipitation

Meteorology Monitoring Station

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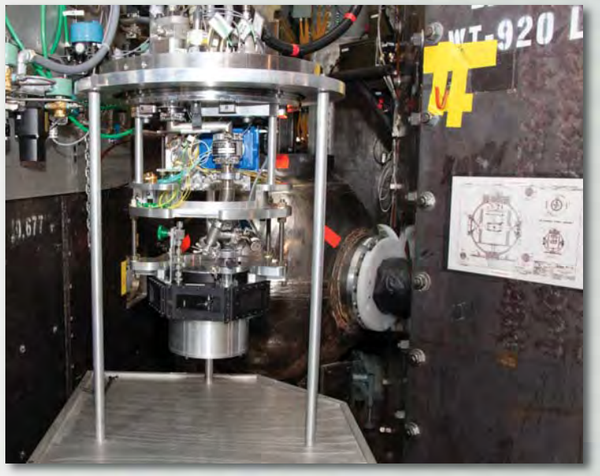
Nevada National Security Site

With a 2013 budget of $570.7M, the Nevada National Security Site provides over 3,300 jobs.



Subcritical experiment

Site Overview

The Nevada National Security Site is a large, geographically diverse outdoor laboratory used for national security programs and other research and development efforts; historically used for nuclear research, development and testing.

- Big - 1,360 square miles
- Secure - Access to the site is controlled
- Remote - Surrounded by federally-owned land

Defense Experimentation and Stockpile Stewardship

Ensures the nation's nuclear weapons remain safe, secure, and reliable by conducting a wide range of experiments using advanced diagnostic technologies, many of which were developed at the Nevada National Security Site

Homeland Security and Defense Applications

Train first responders to confront a radiological or nuclear emergency, detect and locate "dirty bombs," "loose nukes," and radiological sources

National Center for Nuclear Security

Proving ground for technologies used for treaty verification that must perform more accurately, reliably, and at stand-off distances

Environmental Management

Address the environmental legacy from historic nuclear weapons-related activities, while ensuring the health and safety of workers, the public, and the environment

Radiological/Nuclear Countermeasures Test and Evaluation Complex

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Points of Interest on the Nevada National Security Site

Nevada National Security Site

N
W
E
S

U.S. Air Force Land

Nevada National Security Site

Beatty

Amargosa Valley

Mercury

Nevada

California

20
19
12
8
15
10
Sedan Crater
2
9
17
18
BEEF
4
7
Icecap
T-1 Training Area
1
Apple-2 Houses
3
Huron King Test Chamber
U1a Complex
30
16
29
News Nob
Control Point
6
11
Device Assembly Facility
14
Area 5 RWMC
Historic Nuclear Rocket Research Area
26
NPTEC
Frenchman Flat
25
5
JASPER Facility
27
23
22

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Log No. 2013-250