Environmental
Management
Nevada Program

DOE/NV--1577

# Underground Test Area Calendar Year 2015 Annual Sampling Analysis Report Nevada National Security Site, Nevada

Revision No.: 0

September 2017

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# UNDERGROUND TEST AREA
# CALENDAR YEAR 2015
# ANNUAL SAMPLING ANALYSIS REPORT NEVADA
# NATIONAL SECURITY SITE, NEVADA

U.S. Department of Energy,
Environmental Management Nevada Program
Las Vegas, Nevada

Revision No.: 0

September 2017

**UNDERGROUND TEST AREA**
**CALENDAR YEAR 2015**
**ANNUAL SAMPLING ANALYSIS REPORT**
**NEVADA NATIONAL SECURITY SITE, NEVADA**

Approved by: /s/ Wilhelm R. Wilborn Date: 09/06/2017

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for Robert F. Boehlecke
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# List of Acronyms and Abbreviations

## General Acronyms and Abbreviations

| | |
|---|---|
| AD | Absolute difference |
| AEC | Atomic Energy Commission |
| AMS | Accelerator mass spectrometry |
| amsl | Above mean sea level |
| atoms/g | Atoms per gram |
| bgs | Below ground surface |
| BLM | U.S. Bureau of Land Management |
| CADD | Corrective action decision document |
| CAI | Corrective action investigation |
| CAIP | Corrective action investigation plan |
| CAP | Corrective action plan |
| CAS | Corrective action site |
| CAU | Corrective action unit |
| cm | Centimeter |
| COC | Contaminant of concern |
| COPC | Contaminant of potential concern |
| CR | Closure report |
| CS | Carbon steel |
| CY | Calendar year |
| DOE | U.S. Department of Energy |
| DOECAP | U.S. Department of Energy Consolidated Audit Program |
| DRI | Desert Research Institute |
| EPA | U.S. Environmental Protection Agency |
| ES | Electric submersible |
| FD | Field duplicate |
| FFACO | *Federal Facility Agreement and Consent Order* |
| FMP | Fluid Management Plan |
| ft | Foot |
| gal | Gallon |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| gpm | Gallons per minute |
| HSU | Hydrostratigraphic unit |
| in. | Inch |
| ISPID | Integrated Sampling Plan Identifier |
| IT | IT Corporation |
| LANL | Los Alamos National Laboratory |
| Lat | Latitude |
| LCS | Laboratory control sample |
| LLNL | Lawrence Livermore National Laboratory |
| Long | Longitude |
| m | Meter |
| MB | Method blank |
| MCL | Maximum contaminant level |
| MDC | Minimum detectable concentration |
| MDL | Minimum detection level |
| mg/L | Milligrams per liter |
| mi | Mile |
| M&O | Management and operating |
| mrem | Millirem |
| mrem/yr | Millirem per year |
| MS | Matrix spike |
| NA | Not available |
| N/A | Not applicable |
| NAD | North American Datum |
| NCR | Nonconformance report |
| ND | Normalized difference |
| NDEP | Nevada Division of Environmental Protection |
| NIST | National Institute of Standards and Technology |
| NNSA/NFO | U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office |
| NNSS | Nevada National Security Site |

# *List of Acronyms and Abbreviations* *(Continued)*

| | |
|---|---|
| NSF | National Science Foundation |
| NSPC | Nevada State Plane Coordinates |
| NSTec | National Security Technologies, LLC |
| NTTR | Nevada Test and Training Range |
| NTU | Nephelometric turbidity unit |
| pCi/L | Picocuries per liter |
| pmc | Percent modern carbon |
| PWS | Public water system |
| QA | Quality assurance |
| QAP | Quality Assurance Plan |
| QC | Quality control |
| REECo | Reynolds Electrical & Engineering Co., Inc. |
| RL | Reporting limit |
| RM/SM | Rainier Mesa/Shoshone Mountain |
| RN | Radionuclide |
| RPD | Relative percent difference |
| RREMP | Routine Radiological Environmental Monitoring Program |
| SDWA | *Safe Drinking Water Act* |
| SEC | Specific electrical conductance |
| SS | Stainless steel |
| SU | Standard unit |
| SWL | Static water level |
| TD | Total depth |
| TDS | Total dissolved solids |
| TSS | Total suspended solids |
| UDI | United Drilling, Inc. |
| UGTA | Underground test area |
| USGS | U.S. Geological Survey |
| UTM | Universal Transverse Mercator |
| YF/CM | Yucca Flat/Climax Mine |

# List of Acronyms and Abbreviations *(Continued)*

| | |
|---|---|
| °C | Degrees Celsius |
| %meq/L | Percent milliequivalents per liter |
| ‰ | Per mil |
| µg/L | Micrograms per liter |
| µmhos | Micromhos |
| µmhos/cm | Micromhos per centimeter |
| µS/cm | Microsiemens per centimeter |

## Stratigraphic, Hydrostratigraphic, Hydrogeologic, and Lithologic Unit Abbreviations and Symbols

*Note: Some well completion diagrams in Appendix C include terminology that has been redefined or replaced since the well was initially drilled. In these instances, both acronyms and/or definitions have been included on the following list.*

| | |
|---|---|
| AA | Alluvial aquifer |
| AA3 | Alluvial aquifer |
| ATCU | Argillic tuff confining unit |
| BA | Benham aquifer |
| BFCU | Bullfrog confining unit |
| BLFA | Basalt lava-flow aquifer |
| BRA | Belted Range aquifer |
| BRCU | Belted Range confining unit |
| CFCM | Crater Flat composite unit |
| CFCU | Crater Flat confining unit |
| CHCU | Calico Hills confining unit |
| CHVTA | Calico Hills vitric-tuff aquifer |
| CHZCM | Calico Hills zeolitic composite unit |
| CPA | Comb Peak aquifer |
| FCCM | Fortymile Canyon composite unit |
| FCCU | Fluorspar Canyon confining unit |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| LCA | Lower carbonate aquifer |
| LCA3 | Lower carbonate aquifer-upper plate |
| LCA3 | Lower carbonate aquifer 3 -Thrust plate |
| LCCU | Lower clastic confining unit |
| LPCU | Lower Paintbrush confining unit |
| LTCU | Lower tuff confining unit |
| LVTA | Lower vitric-tuff aquifer |
| LVTA1 | Lower vitric tuff aquifer 1 |
| Mc | Chainman Shale |
| MPCU | Middle Paintbrush confining unit |
| OAA | Older alluvial aquifer |
| OSBCU | Oak Spring Butte confining unit |
| PBPCU | Post-Benham Paintbrush confining unit |
| PBRCM | Pre-Belted Range Composite Unit |
| PCUT | Playa confining unit |
| PCU2T | Playa confining unit |
| PCU2T | Playa confining unit 2 |
| PLFA | Paintbrush lava-flow aquifer |
| Pz | Paleozoic Carbonate Rocks, undivided |
| Pz | Paleozoic Sedimentary Rocks |
| Qay | Younger alluvium |
| Qp | Playa deposits |
| QTa | Quaternary-Tertiary alluvium |
| QTa | Quaternary/Tertiary alluvium |
| RMWTA | Rainier Mesa welded-tuff aquifer |
| RVA | Redrock Valley aquifer |
| SPA | Scrugham Peak aquifer |
| Tbd | Dead Horse Flat Formation |
| Tbdc | Comendite of Chartreuse |
| Tbdk | Comendite of Kaw Station |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| Tbdl | Comendite of Lambs Canyon |
| Tbds | Comendite of Saucer Mesa |
| Tbg | Grouse Canyon Tuff |
| Tbgb | Bedded Grouse Canyon Tuff |
| Tbgr | Crystal-rich Grouse Canyon Tuff |
| Tbq | Comendite of Quartet Dome |
| Tc | Crater Flat Group, undivided |
| TCA | Tiva Canyon aquifer |
| Tcb | Bullfrog Tuff |
| Tcblp | Mafic-poor Bullfrog Tuff |
| Tcblr | Mafic-rich Bullfrog Tuff |
| Tcbs | Stockade Wash lobe of Bullfrog Tuff |
| Tcbx | Landslide or eruptive breccia |
| Tcg | Andesite of Grimy Gulch |
| Tcpe | Rhyolite of ER-EC-1 |
| Tcpk | Rhyolite of Kearsarge |
| Tct | Tram Tuff |
| Tcu | Tuff of Pool |
| TCVA | Thirsty Canyon volcanic aquifer |
| Tfbr | Rhyolite of Chukar Canyon |
| Tfbw | Rhyolite of Beatty Wash |
| Tftr | Post-Timber Mountain Group basalts |
| Th | Calico Hills Formation |
| THCM | Tannenbaum Hill composite unit |
| THLFA | Tannenbaum Hill lava-flow aquifer |
| Thp | Mafic-poor Calico Hills Formation |
| Thr | Mafic-rich Calico Hills Formation |
| Tlc/To | Nontuffaceous paleocolluvium/Volcanics of Oak Spring Butte |
| Tlc/To | Paleocolluvium and older tuffs |
| Tlt | Tuffaceous paleocolluvium |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| Tma | Ammonia Tanks Tuff |
| Tmab | Bedded Ammonia Tanks Tuff |
| Tmap | Mafic-poor Ammonia Tanks Tuff |
| Tmar | Mafic-rich Ammonia Tanks Tuff |
| Tmat | Rhyolite of Tannenbaum Hill |
| TMCM | Timber Mountain composite unit |
| TMLVTA | Timber Mountain lower vitric-tuff aquifer |
| Tmr | Rainier Mesa Tuff |
| Tmrb | Bedded Rainier Mesa Tuff |
| Tmrf | Rhyolite of Fluorspar Canyon |
| Tmrh | Tuff of Holmes Road |
| Tmrp | Mafic-poor Rainier Mesa Tuff |
| Tmrr | Mafic-rich Rainier Mesa Tuff |
| Tmr/Tmrh | Rainier Mesa Tuff/tuff of Holmes Road |
| TMUVTA | Timber Mountain upper vitric tuff aquifer |
| Tmw | Rhyolite of Windy Wash |
| TMWTA | Timber Mountain welded tuff aquifer |
| TMWTA | Timber Mountain welded-tuff aquifer |
| TM-WTA | Timber Mountain welded-tuff aquifer |
| Tn3A | Beds 3A Tunnel Formation |
| Tn3BC | Beds 3BC Tunnel Formation |
| Tn3bcd | Beds 3B - D Tunnel Formation |
| Tn3D | Beds 3D Tunnel Formation |
| Tn4abcde | Beds 4A - E Tunnel Formation |
| TN4AF | Beds 4A - F Tunnel Formation |
| Tn4f | Beds 4F Tunnel Formation |
| Tn4G | Beds 4G Tunnel Formation |
| Tn4H | Beds 4H Tunnel Formation |
| Tn4J | Beds 4J Tunnel Formation |
| Tn4K | Beds 4K Tunnel Formation |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| To | Volcanics of Oak Spring Butte |
| To2 | Volcanics of Oak Spring Butte, Tunnel bed 2 |
| To3 | Volcanics of Oak Spring Butte, Tunnel bed 3 |
| Ton1 | Tunnel bed 1 |
| Ton2 | Tunnel bed 2 |
| Tor | Redrock Valley Tuff |
| Tot | Tuff of Twin Peaks |
| Toy | Yucca Flat Tuff |
| Tp | Paintbrush Group, undivided |
| Tpb | Rhyolite of Benham |
| Tpcm | Pahute Mesa lobe of Tiva Canyon Tuff |
| Tpcm | Tiva Canyon Tuff, Pahute Mesa lobe |
| Tpcr | Crystal-rich Tiva Canyon Tuff |
| Tpcy | Tuff of Pinyon Pass |
| Tpcyp | Crystal-poor Tuff of Pinyon Pass |
| Tpd | Rhyolite of Delirium Canyon |
| Tps | Rhyolite of Scrugham Peak |
| Tpt | Topopah Spring Tuff |
| Tptb | Topopah Spring Tuff, bedded |
| Tptm | Pahute Mesa lobe of Topopah Spring Tuff |
| Tptm | Topopah Spring Tuff, Pahute Mesa lobe |
| Tpw | Rhyolite of Windy Wash |
| Tqj | Rhyolite of Handley |
| TSA | Topopah Spring aquifer |
| Ttc | Comendite of Ribbon Cliff |
| Ttp | Pahute Mesa Tuff |
| Ttr | Rocket Wash Tuff |
| Ttt | Trail Ridge Tuff |
| Tub | Tub Spring Tuff |
| Tw | Wahmonie Formation |

# *List of Acronyms and Abbreviations* *(Continued)*

| | |
|---|---|
| UCA | Upper carbonate aquifer |
| UCCU | Upper clastic confining unit |
| undiff | Undifferentiated |
| UPCU | Upper Paintbrush confining unit |
| UTCU | Upper tuff confining unit |
| UTCU1 | Upper tuff confining unit 1 |

## *Symbols for Elements and Compounds*

| | |
|---|---|
| Ag | Silver |
| Al | Aluminum |
| Am | Americium |
| Ar | Argon |
| As | Arsenic |
| Ba | Barium |
| Br | Bromide |
| C | Carbon |
| Ca | Calcium |
| $CaCO_3$ | Calcium carbonate |
| Cd | Cadmium |
| Cl | Chlorine |
| Co | Cobalt |
| $CO_3$ | Carbonate |
| Cr | Chromium |
| Cs | Cesium |
| DIC | Dissolved inorganic carbon |
| DO | Dissolved oxygen |
| DOC | Dissolved organic carbon |
| Eu | Europium |
| F | Fluorine |
| Fe | Iron |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| $H_2O$ | Water |
| $^2H$ | Deuterium |
| $^3H$ | Tritium |
| $HCO_3$ | Bicarbonate |
| He | Helium |
| Hg | Mercury |
| I | Iodine |
| K | Potassium |
| Kr | Krypton |
| Li | Lithium |
| Mg | Magnesium |
| Mn | Manganese |
| Na | Sodium |
| Nb | Niobium |
| Ne | Neon |
| Np | Neptunium |
| O | Oxygen |
| Pb | Lead |
| Pu | Plutonium |
| S | Sulfur |
| Sb | Antimony |
| Se | Selenium |
| $SO_4$ | Sulfate |
| Sr | Strontium |
| Tc | Technetium |
| TDIC | Total dissolved inorganic carbon |
| TDOC | Total dissolved organic carbon |
| TOC | Total organic carbon |
| U | Uranium |
| Xe | Xenon |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| $\delta^{13}C$ | Delta carbon-13 |
| $\delta^{2}H$ | Delta deuterium |
| $\delta^{18}O$ | Delta oxygen-18 |

# 1.0 Introduction

The Nevada National Security Site (NNSS) Integrated Groundwater Sampling Plan (NNSA/NFO, 2014) was designed to provide a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet the objectives of the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) Underground Test Area (UGTA) Activity. The Sampling Plan ensures routine sampling that is critical to understanding contaminant transport near and downgradient of the underground nuclear testing areas and is designed to ensure compliance with the UGTA Activity Quality Assurance Plan (QAP) (NNSA/NFO, 2015a) and the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended). The primary regulatory agreement governing the UGTA Activity is the FFACO (1996, as amended). The FFACO calls for the consequences of radionuclide (RN) exposure to be based on the *Safe Drinking Water Act* (SDWA) radiological standards (CFR, 2015).

This report presents the analytical data for the 2015 calendar year (CY) (January 1 through December 31, 2015) and an evaluation of the data to ensure that the Sampling Plan's objectives are met. Special investigations that took place in 2015 that are relevant to the Sampling Plan are also presented.

## 1.1 Background

A total of 907 underground nuclear detonations were conducted on the NNSS (formerly the Nevada Test Site) between 1957 and 1992 that resulted in 878 UGTA corrective action sites (CASs) (FFACO, 1996 as amended). The CASs are grouped into five corrective action units (CAUs) based primarily on geographically distinct areas of underground testing: Yucca Flat/Climax Mine (YF/CM) (CAU 97), Frenchman Flat (CAU 98), Rainier Mesa/Shoshone Mountain (RM/SM) (CAU 99), Central Pahute Mesa (CAU 101), and Western Pahute Mesa (CAU 102). The CAU locations are shown in Figure 1-1. The anticipated corrective action for each CAU is closure in place with monitoring and institutional controls because there is no reasonable method to remove or stabilize the RNs remaining from an underground nuclear test, and potential risks from these RNs are only realized with access to the groundwater (DOE, 2006). The corrective action strategy for all UGTA CAUs except RM/SM is fulfilled in four stages: the Corrective Action Investigation Plan (CAIP),

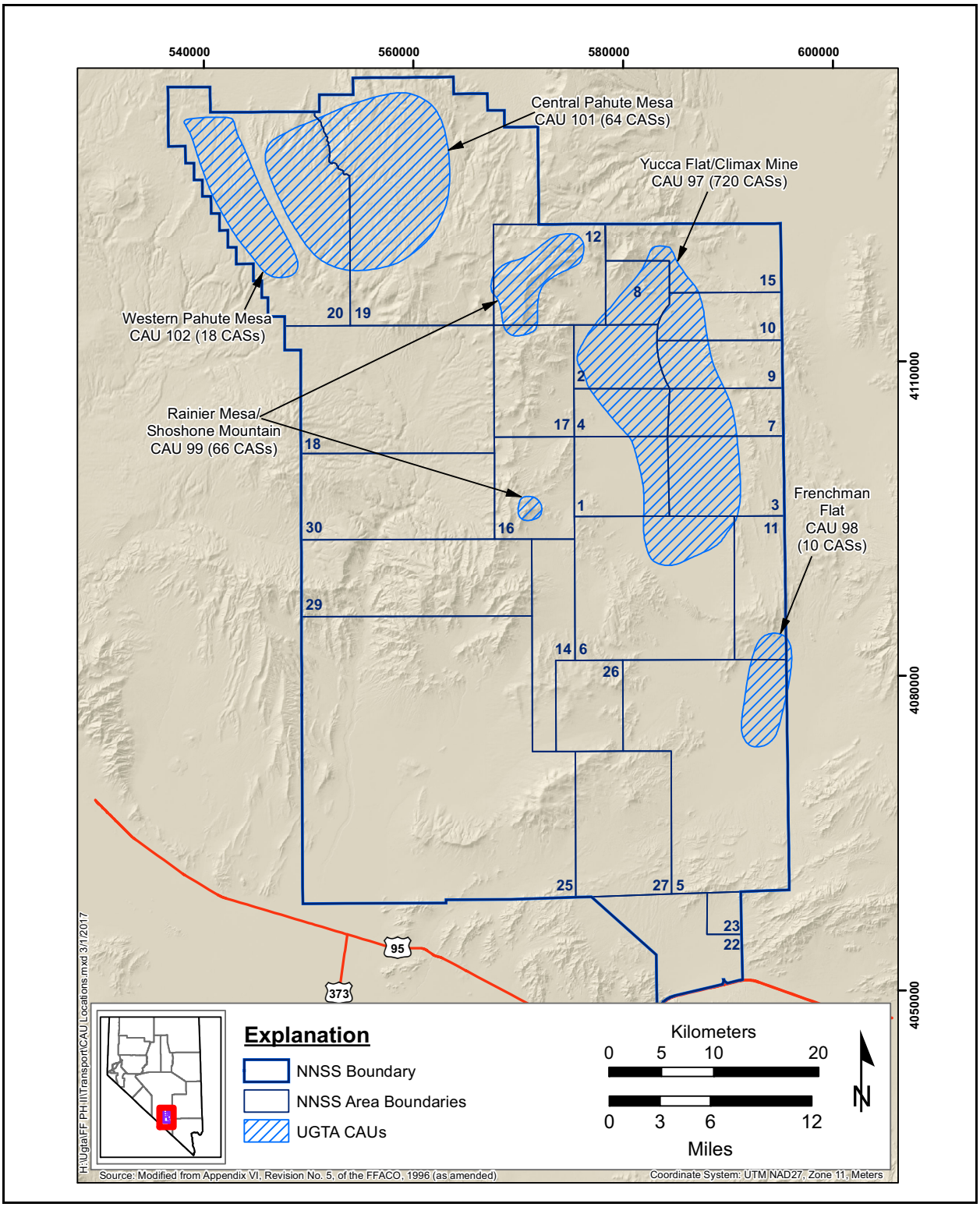



**Figure 1-1**
**UGTA CAU Locations**

Corrective Action Investigation (CAI), Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), and Closure Report (CR) (FFACO, 1996 as amended). The RM/SM CAU strategy was revised because of the complex hydrogeologic setting, its geographical isolation within the north–central portion in the NNSS interior, the low associated inventory (0.7 percent of the UGTA radiological inventory), and the high cost and low benefit of additional characterization and modeling (NNSA/NFO, 2013). Following CAI stage completion, this CAU will advance directly to the CR stage and monitoring and institutional controls rather than modeling will be emphasized. During CY15, with the exception of the Frenchman Flat CAU, all CAUs were in the CAI stage. Frenchman Flat is in the CR stage.

## *1.2 Sampling Plan Implementation*

Groundwater sampling is an integral part of the UGTA Activity, providing data to characterize the CAUs, and to develop and evaluate groundwater flow and contaminant transport conceptual and numerical models. The chemical and isotopic character of groundwater provides information on groundwater movement, and on the potential for and actual extent of contaminant transport. Locations sampled for the Sampling Plan (NNSA/NFO, 2014) are categorized into six types based on the sampling objectives: characterization, source/plume, early detection, distal, community, and inactive. The six types are defined and the objectives identified for each type in Table 1-1. The type dictates the analytical suite, associated detection limits, and sampling frequency (Table 1-1). The sampling locations and their types are shown in Figure 1-2.

An Integrated Sampling Plan Identifier (ISPID) nomenclature has been developed to identify the specific well configuration at the time of sampling. The nomenclature is summarized as follows:

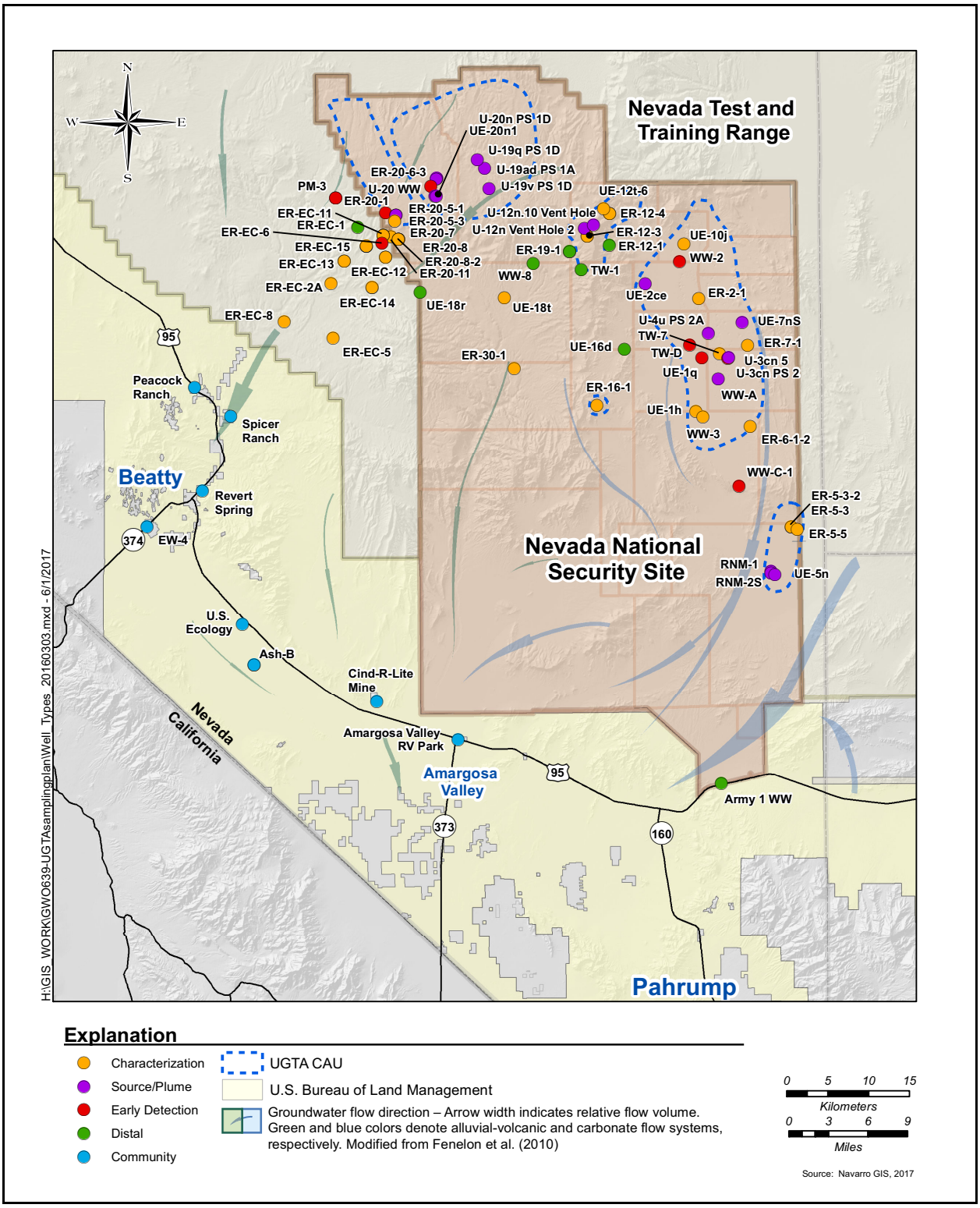
- Piezometers are identified with a "_p" extension
- Main completions are identified with an "_m" extension
- Open boreholes are identified with an "_o" extension
- Access tubes are identified with an "_a" extension

# Table 1-1
# Type Definitions and Objectives for Water Sample Locations

| Location Type | Definition | Objective | Analytes | Frequency |
|---|---|---|---|---|
| Characterization | Used for system characterization or model evaluation. | • Support flow and transport model development and/or evaluation.<br>• Identify groundwater flow paths.<br>• Establish the presence or absence of groundwater COCs and COPCs.<br>• Estimate travel time of contaminants. | General chemistry, metals, age and migration parameters, gross alpha, gross beta, and select radioisotopes [a] | 2–3 years, as needed [b] |
| Source/Plume | Located within the plume from an underground nuclear test (i.e., test-related contamination present). | • Support flow and transport model development and/or evaluation.<br>• Identify COCs.<br>• Monitor contaminant migration.<br>• Monitor natural attenuation. | COCs and CAU-specific COPCs (see Table 1-3) | 4 years |
| Early Detection | Located downgradient of an underground test, and no radioisotopes detected above the MDC for standard analysis. | • Support flow and transport model development and/or evaluation.<br>• Detect and monitor plume edge. | $^{3}$H (enriched analysis) | 2–5 years [c] |
| Distal | Downgradient of the Early Detection area. | • Support flow and transport model development and/or evaluation.<br>• Monitor COC ($^{3}$H) below SDWA 1,000-pCi/L detection limit [d]. | $^{3}$H (standard analysis) | 5 years |
| Community | Located on BLM or private land; used as a water supply source or is located near one. | • Monitor COC (i.e., $^{3}$H) below SDWA 1,000-pCi/L detection limit [d]. | $^{3}$H (standard analysis) | 5 years |
| Inactive | Locations not routinely sampled but available for sampling. | • Defined as needed. | As necessary | As necessary |

[a] Radioisotopes include $^{3}$H (standard or enriched), $^{14}$C, $^{26}$Al, $^{36}$Cl, $^{90}$Sr, $^{94}$Nb, $^{99}$Tc, $^{129}$I, $^{137}$Cs, $^{152}$Eu, $^{154}$Eu, $^{235}$U, $^{238/239/240}$Pu, $^{241}$Am, and $^{243}$Am.
[b] Characterization locations will transition to another type when a sufficient baseline (a minimum of three samples) is established to support categorization.
[c] Sampling frequency is every two years for Pahute Mesa CAUs and every five years for Frenchman Flat, RM/SM, and YF/CM CAUs (NNSA/NFO, 2014).
[d] CFR, 2015

BLM = U.S. Bureau of Land Management
COC = Contaminant of concern
COPC = Contaminant of potential concern
MDC = Minimum detectable concentration
pCi/L = Picocuries per liter
Al = Aluminum
Am = Americium
C = Carbon
Cl =Chlorine
Cs = Cesium
Eu = Europium
$^{3}$H = Tritium
I = Iodine
Nb = Niobium
Pu = Plutonium
Sr = Strontium
Tc = Technetium
U = Uranium




**Explanation**

- Characterization
- Source/Plume
- Early Detection
- Distal
- Community
- UGTA CAU
- 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. Modified from Fenelon et al. (2010)

0 5 10 15
Kilometers
0 3 6 9
Miles

Source: Navarro GIS, 2017

**Figure 1-2**
**Sampling Plan Well Locations**

- Piezometer and main completion intervals are numbered with a "1" for the deepest, "2" for the next deepest, and so on.

- Open borehole intervals are numbered according to the time of sample collection as drilling progresses with a "1" for the first sample, "2" for the next greatest depth, and so on. Generally, this results in the lowest numbers associated with the most shallow depths.

For example, the ISPID associated with a sample collected from the deepest piezometer at ER-EC-11 is identified as ER-EC-11_p1 and from the deepest open interval within the main completion is identified as ER-EC-11_m1. The ISPID associated with the first sample collected from the ER-EC-11 open borehole (before it was completed) is identified as ER-EC-11_o1.

### *1.3 Contaminant of Concern and Contaminant of Potential Concern*

The SDWA maximum contaminant level (MCL) for RNs included in the Sampling Plan are presented in Table 1-2. The MCL for all alpha-emitting RNs collectively (i.e., summed together) is 15 pCi/L (CFR, 2015). Neptunium-237 ($^{237}$Np), $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{242}$Pu, $^{241}$Am, and $^{243}$Am are alpha-emitting RNs; and the MCL for these combined RNs is 15 pCi/L. The MCL for beta and photon emitters is based on a calculated dose of 4 millirem per year (mrem/yr) (CFR, 2015). This means that the combined dose from all beta and photon emitting RNs present in a particular water source must be less than 4 mrem/yr. Each single RN has a unique concentration of radioactivity (measured in pCi/L), which equates to a 4-mrem/yr dose (EPA, 2002). The corresponding U.S. Environmental Protection Agency (EPA)-derived MCLs in Table 1-2 indicate the concentration of that single RN which will result in a 4-mrem/yr dose.

A COC is defined in the Sampling Plan as an RN that exceeds 10 percent of its MCL at sampling locations other than in or near the underground nuclear test cavity (i.e., in sampling locations other than wells drilled directly into the nuclear test cavity, near-field satellite wells, or Rainier Mesa tunnels). Tritium is the only radioisotope that meets this criterion (NNSA/NFO, 2014) and has been identified as the COC for all CAUs (Table 1-3). At this time, $^{3}$H is the only COC for sampling locations both on and off the NNSS.

A COPC is defined as an RN that has not been detected above 10 percent of its MCL in sampling locations other than in or near the underground nuclear test cavity, but has some likelihood of exceeding this criterion in the future. A COPC list, specific to each CAU, has been developed based

**Table 1-2**
**Maximum Contaminant Levels**

| RN | MCL (pCi/L) |
|---|---|
| $^{241/243}$Am | 15 |
| $^{14}$C | 2,000 |
| $^{137}$Cs | 200 |
| $^{36}$Cl | 700 |
| $^{152}$Eu | 200 |
| $^{154}$Eu | 60 |
| $^{3}$H | 20,000 |
| $^{129}$I | 1 |
| $^{237}$Np | 15 |
| $^{238/239/240}$Pu | 15 |
| $^{90}$Sr | 8 |
| $^{99}$Tc | 900 |
| $^{234/235/236/238}$U | 30 µg/L |

Note: The MCL is 15 pCi/L (cumulative) for alpha-emitting RNs, 4 mrem/yr (cumulative) for beta and photon emitters, and 30 µg/L (cumulative) for U (CFR, 2015). EPA (2002) provides the conversion from dose (4 mrem/yr) to activity (pCi/L) for beta and photon emitters.

µg/L = Micrograms per liter

**Table 1-3**
**CAU-Specific COCs and COPCs**

| CAU | COC | COPC |
|---|---|---|
| Frenchman Flat | $^{3}$H | $^{14}$C, $^{36}$Cl, $^{99}$Tc, and $^{129}$I |
| Pahute Mesa (Central and Western) | $^{3}$H | $^{14}$C, $^{36}$Cl, $^{99}$Tc, and $^{129}$I |
| RM/SM | $^{3}$H | $^{14}$C, $^{36}$Cl, $^{90}$Sr, $^{99}$Tc, $^{129}$I, and $^{238/239/240}$Pu |
| YF/CM | $^{3}$H | $^{14}$C, $^{36}$Cl, $^{99}$Tc, $^{129}$I (and $^{90}$Sr and $^{137}$Cs in LCA samples) |

LCA = Lower carbonate aquifer

on the NNSS RN inventory (Finnegan et al., 2016), an understanding of relative mobility of the inventory RNs, previous sampling and analysis data, and modeling results (Table 1-3).

The maximum $^{3}$H concentrations for the most recent samples from each Sampling Plan location are presented in Table A.1-1 (see Appendix A). When $^{3}$H was not detected, the value is reported as less

than the sample's MDC (i.e., <MDC). A map view of the maximum $^{3}$H concentrations relative to the SDWA MCL (20,000 pCi/L) is presented in Figure 1-3. The greatest concentrations of $^{3}$H for each sampling location is shown in Figure 1-3 (e.g., shallow interval for ER-EC-11 and ER-20-8), and detailed results (maximum $^{3}$H concentrations for the different sampled depth intervals) are in Table A.1-1.

MCL exceedances for RNs other than $^{3}$H are presented in Table 1-4. Only locations where $^{3}$H has been previously detected are shown on Figure 1-4. Test-related RNs are not present in NNSS groundwater without the simultaneous presence of $^{3}$H, because $^{3}$H is highly mobile and it is the RN produced at the greatest concentration by the nuclear tests (Finnegan et al., 2016). The maximum concentrations of the COPCs for the most current samples for characterization and source/plume locations are presented in Appendix A.

The MCLs for RNs other than $^{3}$H have been exceeded at six locations (Figure 1-4). These locations are either (1) a post-shot well that samples within the test cavity or chimney area (RNM-1, U-4u PS 2A, U-19ad PS 1A, U-19v PS 1D, U-20n PS 1D); or (2) an access point that samples from a tunnel used for nuclear testing (U-12n.10 vent hole). Several RNs ($^{90}$Sr, $^{129}$I, $^{137}$Cs, and $^{239/240}$Pu) exceeded their MCLs in samples collected from U-19ad PS 1A (see Table A.1-2). Groundwater from this well contains some of the highest concentrations of these RNs observed in any NNSS test cavity; this is the only Sampling Plan well that exceeds the Pu MCL. This may be an indication that the residual radioactivity from the test is still largely contained within the cavity environment. At locations other than U-19ad PS 1A, the RNs that contribute to the MCL exceedances are $^{90}$Sr, $^{129}$I, and $^{137}$Cs (Table 1-4). Although no single RN exceeded its MCL at U-4u PS 2A and U-12n.10 vent hole, the combined concentrations of multiple RNs exceeded the 4-millirem (mrem) MCL. The fractional contribution for $^{129}$I, $^{14}$C, $^{90}$Sr, and $^{137}$Cs toward the 4-mrem dose are 0.15, 0.16, 0.39, and 0.46, respectively, for U-4u PS 2A. The fractional contribution for $^{129}$I, $^{36}$Cl, and $^{239/240}$Pu toward the 4-mrem dose in the 2008 U-12n.10 vent hole sample are 0.99, 0.14, and 0.11, respectively; no $^{90}$Sr data are available for this location. There are no MCL exceedances for four COPCs ($^{14}$C, $^{36}$Cl, $^{99}$Tc, and $^{238}$Pu) in any samples collected from Sampling Plan locations.

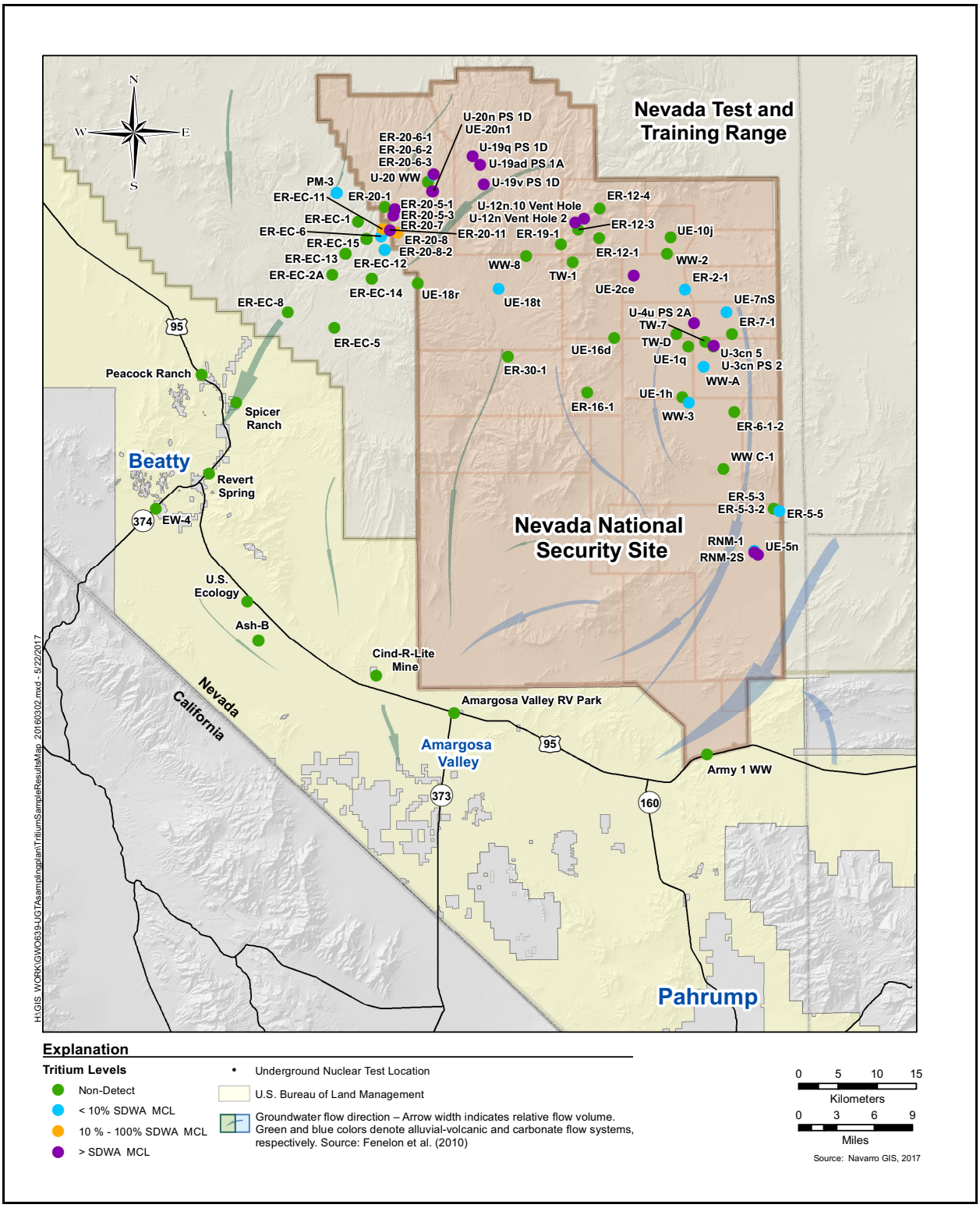



**Figure 1-3**
**Maximum $^{3}H$ Concentrations**

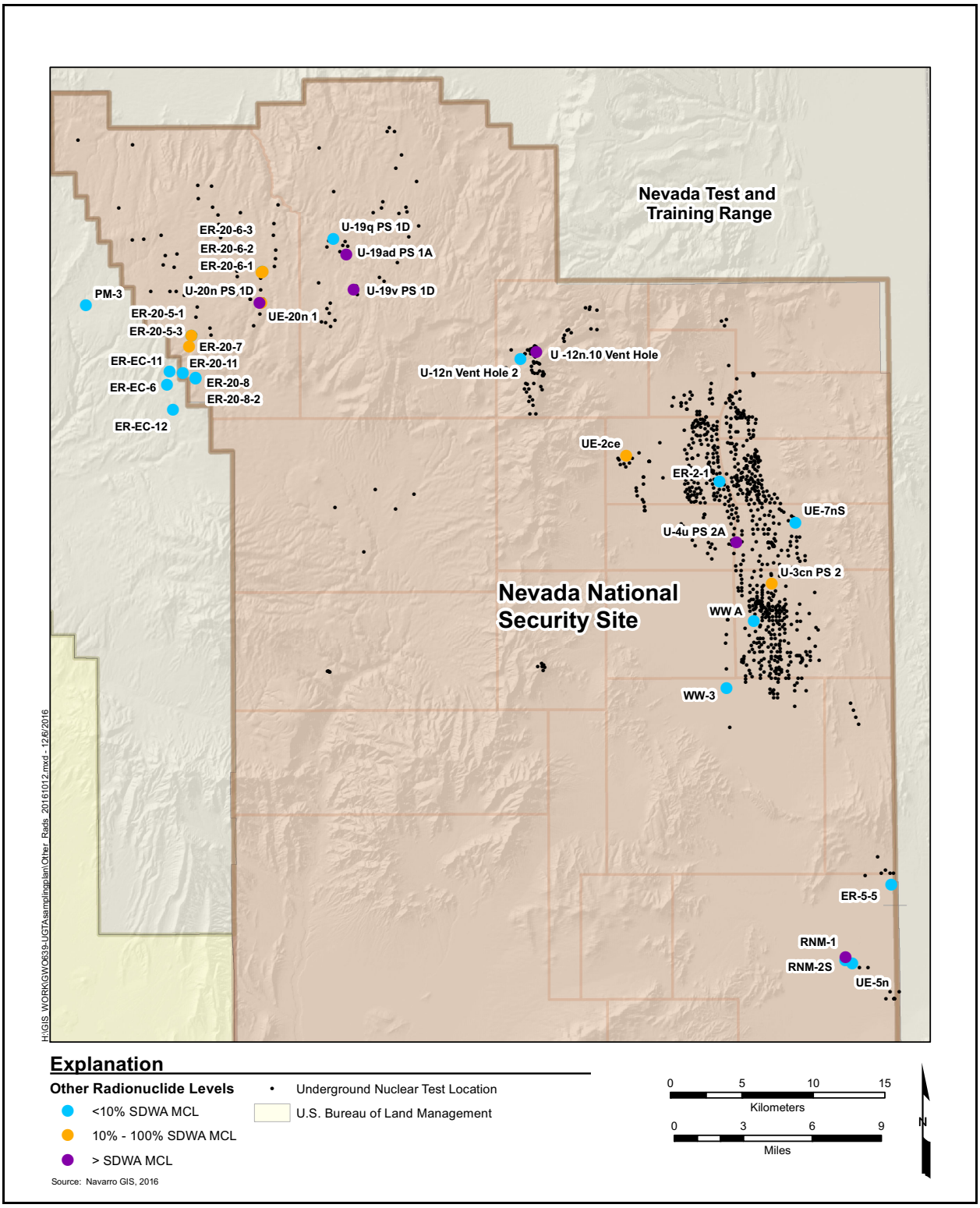



**Figure 1-4**
**MCL Exceedances for RNs Other Than $^{3}H$**

**Table 1-4**
**Locations and Specific COPC Exceedances**

| COPC | Sampling Locations |
|---|---|
| **MCL Exceeded** | |
| $^{90}Sr$ | RNM-1, U-19ad PS 1A, and U-20n PS 1D |
| $^{129}I$ | U-19ad PS 1A and U-19v PS 1D |
| $^{137}Cs$ | U-19ad PS 1A and U-20n PS 1D |
| $^{239/240}Pu$ | U-19ad PS 1A |
| **Less than MCL but Greater than 10% MCL** | |
| $^{14}C$ | UE-20n1, U-3cn PS 2, U-4u PS 2A, and U-19q PS 1D |
| $^{36}Cl$ | U-12n.10 vent hole |
| $^{90}Sr$ | ER-20-6-1, ER-20-6-3, UE-2ce, U-3cn PS 2, and U-4u PS 2A |
| $^{129}I$ | ER-20-5-1, ER-20-7, U-12n.10 vent hole, UE-20n1, U-20n PS 1D, U-3cn PS 2, and U-4u PS 2A |
| $^{137}Cs$ | U-4u PS 2A |
| $^{238}Pu$ | U-19ad PS 1A |
| $^{239/240}Pu$ | U-12n.10 vent hole |

## *1.4 Special Investigations*

In 2015, special investigations took place in Yucca Flat and Pahute Mesa to assess groundwater sampling conditions for wells that had never been sampled or that had not been sampled in more than 20 years. Five wells in Yucca Flat (TW-B, UE-6d, UE-6e, U-2gg PSE 3A, and U-10L 1) were investigated by Desert Research Institute (DRI) (Pohlmann et al., 2017). Three of those wells (TW-B, UE-6d, and UE-6e) were sampled in response to YF/CM External Peer Review Committee recommendations (Navarro, 2016). For wells TW-B, UE-6d, and UE-6e, the investigation focused on determining possible sources of low-level $^{3}H$ detections historically reported but inconsistent with the groundwater flow and transport model results. The $^{3}H$ activity in groundwater samples collected in 1994 and 1995 were 710 and 670 pCi/L, respectively for UE-6d and 13.5 and 16 pCi/L, respectively for UE-6e (Navarro, 2017b). The $^{3}H$ activity in groundwater samples collected from TW-B declined steadily from approximately 260 to 100 pCi/L between 1976 and 1981, increased to 150 to 200 pCi/L by 1984, and declined from 1984 to 1998 (Pohlmann et al., 2017). On June 22, 1998, $^{3}H$ was reported as 44 pCi/L.

**Table 1-5**
**Yucca Flat Special Investigation Sampling Results**

| Well | Sample Date | Sample Depth (ft) | $^{3}$H (pCi/L) |
|---|---|---|---|
| TW-B | 05/20/2015 | 1,625 | U 2.84 |
| UE-6d | 05/18/2015 | 2,950 | <2.44 \| <2.22 |
| UE-6e | 05/19/2015 | 2,142 | <102.5 [a] |
| U-2gg PSE 3A | 12/14/2015 | 1,956 | 3,649 \| 3,507 |
| U-10L 1 | Not sampled | -- | -- |

[a] High suspended solids content prevented the low detection limits usually achieved for the analysis (i.e., sample dilution was required before analysis).

ft = Foot

U = Result was below the detection limit (2.32 pCi/L) plus error (1.67 pCi/L) and is considered a non-detect.
-- = Not applicable

Groundwater samples were collected for $^{3}$H analysis using a bailer; sampling dates, depths, and $^{3}$H results are presented in Table 1-5. No $^{3}$H was detected in the 2015 samples from these three wells (Table 1-5). The UE-6d and UE-6e historical $^{3}$H detections were therefore attributed to cross-contamination transferred between wells by sampling equipment; and the TW-B detections were attributed to possible infiltration into cracks that periodically develop in the playa, during periods in the 1960s when atmospheric $^{3}$H levels were at their highest (thousands of pCi/L) (Lyles, 1990). Most importantly, the lack of $^{3}$H in these samples indicated that the previously reported low-level $^{3}$H detections were not a precursor to a contaminant plume of regulatory concern.

U-2gg PSE 3A and U-10L 1 were evaluated to determine whether these wells can be used as additional sampling points in Yucca Flat. U-2gg PSE 3A is a slant hole drilled in 1994 to within 100 ft of the INGOT detonation cavity in bedded tuffs (Elliot and Fenelon, 2016). Evaluation of this slanted hole indicated an obstruction within the casing at a borehole depth of 1,966 ft, approximately 94 ft above the slotted interval in the casing. Samples were collected at 1,956 ft below ground surface (bgs) within the casing above the obstruction (Pohlmann et al., 2017). The mean $^{3}$H concentration was 3,579 pCi/L (Table 1-5) as compared to 5,970 pCi/L for samples collected in the slotted interval in 1994 (Smith et al., 1998). Tritium activities are higher than the expected decay-corrected values, suggesting some interaction with surrounding groundwater (Pohlmann et al., 2017). Unfortunately,

low visibility caused by the drilling fluid prevents useful evaluation by video logging. Purging the well of drilling fluids may allow further evaluation through video and chemtool logging, and dramatically improve conditions for sampling, although it is also likely to significantly disrupt RN distributions in the vicinity of the well and INGOT cavity (Pohlmann et al., 2017). U-10L 1 was constructed in 1964 with 217 ft of uncased borehole in the LCA, making it a potentially ideal monitoring well in Yucca Flat. Water samples could not be collected from U-10L 1 because of an obstruction in the casing above the most recently measured water level (Pohlmann et al., 2017).

In Pahute Mesa, post-shot wells U-19e PS 2D, U-20f PS 1D, and U-20m PS 1D were evaluated to support hydrologic source term development for the Pahute Mesa groundwater flow and transport models. These holes were selected to evaluate the hydrological and radiochemical environment near the MUENSTER (U-19e PS 2D), FONTINA (U-20f PS 1D), and HANDLEY (U-20m PS 1D) detonations. U-19e PS 2D is 2,185 ft southeast of U-19e (MUENSTER emplacement hole); U-20f PS 1D is 1,400 ft southeast of U-20f (FONTINA emplacement hole); and U-20m PS 1D is 1,347 ft southeast of U-20m (HANDLEY emplacement hole). Well construction diagrams for U-19e PS 2D, U-20f PS 1D, and U-20m PS 1D are presented in Figure C-6, Figure C-7, and Figure C-8, respectively.

Well evaluations included collecting physical attributes and conducting temperature and pressure logs in the wells. The results will determine whether each well should be developed and sampled with a pump. In addition, samples were collected using a depth-discrete bailer and analyzed for $^{3}H$, metals, gamma emitters and gross alpha/gross beta. Temperature, pH, specific electrical conductance (SEC), dissolved oxygen (DO), and turbidity measurements were also performed in the field (Table 1-6). The RN results are presented in Table 1-6. While the $^{3}H$ concentrations ranged from 2.1 million to 22.7 million pCi/L, no gamma emitters were observed above the analytical detection limits (Table 1-6). Samples from two of the post-shot holes (U-19e PS 2D and U-20m PS 1D) do not exceed the SDWA MCL (15 pCi/L) for gross alpha or the EPA level of concern (50 pCi/L) for gross beta (CFR, 2015). Pressure and temperature logging by DRI is scheduled for 2017. The full results of the evaluations will be provided in future reports.

# Table 1-6
# Pahute Mesa Special Investigation Sampling Results

| Analyte | U-19e PS 2D | | U-20f PS 1D | | U-20m PS 1D | |
|---|---|---|---|---|---|---|
| **Sampling Information** | | | | | | |
| Date | 08/27/2015 | 08/28/2015 | 08/20/2015 | 08/24/2015 | 07/21/2015 | 07/22/2015 |
| Depth (ft) | 2,143 | 2,383 | 2,020 | 2,274 | 1,361 | 1,361 |
| **Field Measurements** | | | | | | |
| Temperature (°C) | 26.1 | 25.8 | 26.8 | 32.95 | 29.3 | 29.3 |
| pH (SU) | 9.6 | 9.6 | 8.78 | 8.67 | 10.2 | 10.2 |
| SEC (µS/cm) | 617 | 618 | 607 | 600 | 914 | 914 |
| DO (mg/L) | 5.9 | 6.2 | 9.5 | 7.5 | 6.7 | 6.6 |
| Turbidity (NTU) | -- | -- | 168 | 109 | 198 | 198 |
| **Laboratory Analyses (pCi/L)** | | | | | | |
| Gross Alpha | 5.3 \| 4.9 | 3.9 | 44.9 \| 40.7 | 48.9 | <2.7 | <2.6 |
| Gross Beta | 5.8 \| 6.5 | 6.0 | 135 \| 108 | 106 | 4.9 | U 4.4 |
| $^{3}$H | 2.16E+06 \| 2.20E+06 | 2.11E+06 | 2.27E+07 \| 1.90E+07 | 2.06E+07 | 8.9E+06 | 8.8E+06 |
| $^{26}$Al | <6.3 \| <6.8 | <5.9 | <8.0 \| <8.3 | <7.0 | <6.6 | <7.5 |
| $^{94}$Nb | <5.5 \| <5.3 | <5.0 | <5.7 \| <6.6 | <6.1 | <6.2 | <5.9 |
| $^{137}$Cs | <5.2 \| <5.5 | <4.7 | <4.2 \| U 7.7 | U 4.8 | <6.2 | <5.5 |
| $^{152}$Eu | <28 \| <33 | <26 | <31 \| <35 | <29 | <29 | <29 |
| $^{154}$Eu | <41 \| <31 | <27 | <33 \| <37 | <33 | <33 | <32 |
| $^{235}$U | <39 \| <24 | U 17.8 | <36 \| <51 | <33 | <199 | <20 |
| $^{241}$Am | <6.2 \| <30 | <5.6 | <33 \| <52 | <210 | <210 | <6.3 |

mg/L = Milligrams per liter
NTU = Nephelometric turbidity unit
SU = Standard unit
°C = Degrees Celsius
µS/cm = Microsiemens per centimeter

U = Result is below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Notes:
(a) A sample was collected from U-20m PS 1D (2,100 ft) on July 22, 2015, for $^{3}$H analysis only. The $^{3}$H result was 8.1E+06 pCi/L, which was qualified with a "J-" because significant dilution was performed by the laboratory.
(b) Values reported with a "|" indicate results of duplicate samples.
(c) No gamma emitters were detected in these samples; only those candidates for inclusion into the source-term inventory (Finnegan et al., 2016) are included in this table.

# 2.0 Sampling and Analysis Methods

A total of 23 wells (23 intervals) were sampled in 2015 (Tables 2-1 and 2-2). The samples collected in 2015 and the collection method, purge volume, flow rate, depth intervals (ISPID), and hydrostratigraphic units (HSUs) associated with the sample are presented in Table 2-1. Sample and analysis methods for 2015 and the corresponding results are presented in this section and in Section 3.0, respectively. Some wells sampled in 2015 are single-zone completions where samples are collected from one depth interval. Other wells are multiple-completions sampling several depth intervals. Sampling information for special investigation samples are presented in Table 2-2. These sampling locations, and the sampling and analytical methods, are described within this section.

**Table 2-1**
**2015 Sample Collection Summary**
**NNSS Integrated Sampling Plan Locations**
(Page 1 of 2)

| Location Type | Well Name | ISPID | Sample Date | HSU | Collection Method | Purge Volume (gal) | Flow Rate (gpm) |
|---|---|---|---|---|---|---|---|
| **Frenchman Flat (CAU 98)** | | | | | | | |
| No sampling in support of the Sampling Plan took place in 2015. | | | | | | | |
| **Pahute Mesa (CAUs 101 and 102)** | | | | | | | |
| Characterization | ER-20-8 | ER-20-8_m2 | 03/07/2015<br>03/08/2015 | LPCU/TSA/CHZCM | ES Pump | 7.8E+04<br>1.1E+05 | 25<br>25 |
| Source/Plume | ER-20-5-3 | ER-20-5-3_m1 | 03/13/2015 | CHZCM | ES Pump | 3.1E+04 | 20 |
| | ER-20-5-1 | ER-20-5-1_m1 | 04/02/2015 | TSA | ES Pump | 4.2E+04 | 31 |
| Early Detection | ER-EC-6 | ER-EC-6_m4 | 01/12/2015<br>01/13/2015 | FCCU/BA | Jack Pump | 1.6E+04<br>2.0E+04 | 2.5<br>2.5 |
| | ER-20-1 | ER-20-1_o1 | 02/23/2015<br>02/24/2015 | TCA | Jack Pump | 2.2E+04<br>2.6E+04 | 3.2<br>3.2 |
| **RM/SM (CAU 99)** | | | | | | | |
| Characterization | ER-12-3 | ER-12-3_m1 | 05/01/2015 | LCA | ES Pump | 5.9E+04 | 20 |
| | ER-12-4 | ER-12-4_m1 | 05/09/2015 | LCA | ES Pump | 2.1E+04 | 3.7 |
| Distal | ER-12-1 | ER-12-1_m5 | 04/15/2015 | UCCU | ES Pump | NA | NA |
| | UE-16d WW | UE-16d WW_m1 | 01/21/2015 | UCA | ES Pump | 1,600 | 160 |
| | WW-8 | WW-8_m26 | 01/21/2015<br>04/28/2015<br>07/14/2015<br>11/03/2015 | BRA | ES Pump | 4.0E+03<br>2.9E+05<br>9.0E+03<br>4.0E+03 | 200<br>200<br>200<br>200 |

## Table 2-1
## 2015 Sample Collection Summary
## NNSS Integrated Sampling Plan Locations
(Page 2 of 2)

| Location Type | Well Name | ISPID | Sample Date | HSU | Collection Method | Purge Volume (gal) | Flow Rate (gpm) |
|---|---|---|---|---|---|---|---|
| **YF/CM (CAU 97)** | | | | | | | |
| Characterization | ER-2-1 | ER-2-1_m1 | 03/26/2015 | LTCU/TMLVTA/TMWTA | Jack Pump | 9.3E+03 [a]<br>9.5E+03 [b] | 3.4 [a]<br>3.0 [b] |
| | TW-7 | TW-7_m1 | 05/21/2015 | LTCU | Bailer | N/A | N/A |
| | WW-3 | WW-3_m1 | 06/09/2015 | AA | Jack Pump | 8.3E+03 | 6.2 |
| Source/Plume | UE-7nS | UE-7nS_m1 | 06/10/2015 | LCA | Bailer | N/A | N/A |
| Early Detection | WW-2 | WW-2_m1 | 04/22/2015 | LCA | ES Pump | 7.3E+04 | 29 |
| Distal | Army 1 WW | Army 1 WW_m1 | 01/21/2015 | LCA | ES Pump | 4,500 | 450 |

[a] Purge volume and flow rate associated with sample analyzed by the commercial laboratories.
[b] Purge volume and flow rate associated with sample analyzed by LLNL.

AA = Alluvial aquifer
BA = Benham aquifer
BRA = Belted Range aquifer
CHZCM = Calico Hills zeolitic composite unit
FCCU = Fluorspar Canyon confining unit
LPCU = Lower Paintbrush confining unit
LTCU = Lower tuff confining unit
TCA = Tiva Canyon aquifer
TMLVTA = Timber mountain lower vitric-tuff aquifer
TMWTA = Timber mountain welded tuff aquifer
TSA = Topopah Spring aquifer
UCA = Upper carbonate aquifer
UCCU = Upper clastic confining unit
ES = Electric submersible
gal = Gallon
gpm = Gallons per minute
NA = Not available
N/A = Not applicable

## Table 2-2
## Special Investigation Samples Collected in 2015

| Well Name | ISPID | Collection Method | Sample Date |
|---|---|---|---|
| TW-B | TW-B_m1 | Bailer | 05/20/2015 |
| UE-6d | UE-6d_o1 | Bailer | 05/18/2015, 05/19/2015 |
| UE-6e | UE-6e_o1 | Bailer | 05/19/2015 |
| U-2gg PSE 3A | U-2gg PSE 3A_m1 | Bailer | 12/14/2015 |
| U-19e PS 2D | U-19e PS 2D_o1 | Bailer | 08/27/2015, 08/28/2015 |
| U-20f PS 1D | U-20f PS 1D_o1 | Bailer | 08/20/2015, 08/24/2015 |
| U-20m PS 1D | U-20m PS 1D_m1 | Bailer | 07/21/2015, 07/22/2015 |

## 2.1 Sample Collection Methods

Sample collection methods are based, in part, on the characteristics and configurations of the well. Some wells are equipped with dedicated pumps and are sampled from the associated plumbing (e.g., spigots) at the wellhead, while wells without pumps may be sampled via a wireline bailer or a portable pumping system. All water samples are generally collected in a manner that best ensures they represent ambient formation water following the sampling methods described in standard operating procedures. While the well is not purged when sampled using a bailer, purging of the well is required for collecting samples using a pump. Currently purging is considered adequate once a minimum of three effective well volumes are purged and the water-quality parameters meet the following criteria: (1) the pH has stabilized, and measurements remained constant within 0.1 SU; (2) SEC and temperature have stabilized, and vary by no more than 10 percent for at least three consecutive readings; and (3) the turbidity has stabilized below 10 NTUs. Stabilization of these water-quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the wellbore. The amount of groundwater purged before sample collection is presented in Table 2-1.

Documentation, sample handling, chain of custody, and quality control (QC) requirements associated with sample collection are performed in accordance with the UGTA Activity QAP (NNSA/NFO, 2015a). Chain of custody is implemented to provide traceability of sample possession from the time the samples are collected until disposition. UGTA Activity sampling is performed in compliance with the UGTA "Sample Collection and Processing" procedure (Navarro, 2015b), and sampling performed by the management and operating (M&O) contractor is in compliance with SOP-P420.104: "Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Water Locations" (NSTec, 2015). Water-quality monitoring was conducted in accordance with the *Field Instruction for the Underground Test Area Activity Well Development, Hydraulic Testing, and Groundwater Sampling* (N-I, 2012a). Fluids produced during well purging were managed according to the UGTA Waste Management Plan (NNSA/NSO, 2009) and the associated fluid management strategy letter.

## 2.2 Analytical Methods

Analyses specified in the Sampling Plan (i.e., required analyses) are performed by a commercial laboratory that is certified through the Nevada Division of Environmental Protection (NDEP) Bureau of Safe Drinking Water, and that meets National Environmental Laboratory Accreditation Program or equivalent requirements for those analytes not currently NDEP certified. Commercial laboratories also must participate in the U.S. Department of Energy Consolidated Audit Program (DOECAP) or equivalent. Standard analytical methods are used by the commercial laboratories. Other analytes require specialized methodology and cannot be analyzed by a commercial laboratory certified by NDEP. These analyses are not required by the Sampling Plan (i.e., optional analyses) and may be performed by non-certified laboratories. These laboratories provide state-of-the-art methods necessary to maximize analytical sensitivity to obtain reduced detection limits, or for analyzing unique parameters not available by a commercial laboratory (Table 2-3). These analytes support groundwater source, flow path, and groundwater mixing evaluations. As shown in Table 2-3, Lawrence Livermore National Laboratory (LLNL) provides specialized laboratory analyses with much lower MDCs than the commercial laboratory. The majority of the radioisotopes are reported as nondetects by the commercial laboratory. While this is satisfactory for ensuring RNs do not exceed the MCLs, it is insufficient for quantitatively evaluating contaminant migration. Confidence in the results is also gained by using different methods by the two labs. The U.S. Geologic Survey (USGS) and DRI also perform or are responsible for specialized analyses (Table 2-3). These analyses support characterization of groundwater flow paths and travel time estimates. Analyses performed by laboratories that are not NDEP certified are identified and justified in the Annual UGTA Quality Assurance (QA) Report (NNSA/NFO, 2016).

# Table 2-3
# Non-certified Laboratory Analytical Procedures

| Analytes | Procedure | Title | Detection Limit |
|---|---|---|---|
| **Desert Research Institute** | | | |
| $^{14}C$ (DOC) | Accelerator Mass Spectrometry | NSF-Arizona AMS Facility Quality Assurance Manual | N/A |
| **Lawrence Livermore National Laboratory** | | | |
| $\delta^{2}H$, $\delta^{18}O$ | SOP-UGTA-128 | Analysis of $^{18}O$ and $^{2}H$ in Groundwater Samples | N/A |
| DIC, $\delta^{13}C$ | SOP-UGTA-116 | Analysis of TDIC, TDOC, and $^{13}C$ in Groundwater Samples | 0.01 mg/L (TDIC)<br>N/A ($\delta^{13}C$) |
| Noble Gases (Ar, Kr, Ne, Xe, $^{3}He$, $^{4}He$,$^{3/4}He$, $^{3/4}He$ [$R/R_a$]) | SOP-NGMS-122 | Collection and Analysis of Groundwater for Determination of Noble Gas Abundance and Helium Isotopic Composition | 1.4E-15 – 1.0E-05 $cm^3$ STP/g (Ar, Kr, Ne, Xe, $^{3}He$, $^{4}He$);<br>2.8E-06 ($^{3/4}He$);<br>0.02 ($^{3/4}He$ [$R/R_a$]) |
| $^{3}H$ (Low Level) | SOP-NGMS-121 | Collection and Analysis of Groundwater for Determination of Tritium by Helium-3 Accumulation | 1 pCi/L |
| $^{3}H$ | SOP-UGTA-131 | Liquid Scintillation Counting Method for Analyses of $^{3}H$ in Groundwater Sample Using a $^{3}H$ Column | 300 pCi/L |
| $^{14}C$ | SOP-UGTA-136 | Extraction and Analysis of $^{14}C$ in Groundwater Samples | 10E-03 pCi/L |
| $^{36}Cl$ | SOP-UGTA-120<br>SOP-UGTA-115 | Determination of Inorganic Anions by Ion Chromatography<br>Analysis of $^{36}Cl$ in Aqueous Samples | 10E-06 pCi/L |
| $^{87/86}Sr$ | SOP-UGTA-133<br>SOP-UGTA-134<br>SOP-UGTA-117 | ICP/MS Sample Preparation<br>Sample Analysis by Quadrupole ICPMS<br>$^{87}Sr$ /$^{86}Sr$ Analysis of Groundwater Samples | N/A |
| $^{99}Tc$ | SOP-UGTA-133<br>SOP-UGTA-134<br>SOP-UGTA-111 | ICP/MS Sample Preparation<br>Sample Analysis by Quadrupole ICPMS<br>Analysis of $^{99}Tc$ Samples | 10E-03 pCi/L |
| $^{129}I$ | SOP-UGTA-123 | Analysis of I-129 in Aqueous Samples | 10E-07 pCi/L |
| $^{234}U$, $^{235}U$, $^{236}U$, $^{238}U$ | SOP-UGTA-133<br>SOP-UGTA-134<br>SOP-UGTA-118 | ICP/MS Sample Preparation<br>Sample Analysis by Quadrupole ICPMS<br>Uranium Isotopic Analysis of Groundwater Samples | N/A |
| $^{238/239/240}Pu$ | SOP-UGTA-135 | Analysis of Plutonium in Groundwater Samples by MC-ICP-MS | 10E-03 pCi/L |
| **U.S. Geologic Survey** | | | |
| $^{34/32}S$ | USGS-YM-GCP-44 | Sulfur Isotope Analysis of Dissolved Sulfate in $H_2O$ | N/A |

$cm^3$ STP/g = Cubic centimeters of gas at standard temperature and pressure per gram.
MC-ICP-MS = Multicollector-inductively coupled plasma-mass spectrometry.
$R/R_a$ = Ratio in sample relative to ratio in air.

Ar = Argon
DIC = Dissolved inorganic carbon
DOC = Dissolved organic carbon
$^{2}H$ = Deuterium
$H_2O$ = Water
He = Helium
Kr = Krypton
Ne = Neon
O = Oxygen
S = Sulfur
TDIC = Total dissolved inorganic carbon
TDOC = Total dissolved organic carbon
Xe = Xenon
$\delta^{2}H$ = Delta deuterium
$\delta^{13}C$ = Delta carbon-13
$\delta^{18}O$ = Delta oxygen-18

AMS = Accelerator mass spectrometry
NSF = National Science Foundation

# 3.0 Sampling and Analysis Results

Sampling in 2015 took place in four of the five UGTA CAUs (Table 2-1 and Figure 3-1). Sampling and the associated results within each CAU are described within this section, and the analytical results are presented in Appendix B. The 2015 results along with historical data reported within these sections are maintained within the UGTA Chemistry Database (Navarro, 2017b). The database is a repository for historical and current analytical chemistry data associated with the Sampling Plan locations and additional locations used for CAU investigations.

This section includes comparisons of the 2015 sample results to the results of previous samples from the same location. The objective is to evaluate trends in the radioisotope data and to evaluate consistency of other chemical parameters. For characterization samples and other samples for which major ions were analyzed, Piper diagrams are presented to facilitate these comparisons. The Piper diagram presents relative concentrations of major ions in percent milliequivalents per liter (%meq/L) and is used to classify various groundwater chemistry types, or facies, and illustrate the relationships that may exist between water samples. The major ions consist of calcium ($Ca^{2+}$), potassium ($K^{+}$), magnesium ($Mg^{2+}$), sodium ($Na^{+}$), chloride ($Cl^{-}$), sulfate ($SO_4^{2-}$), bicarbonate ($HCO_3^{-}$), and carbonate ($CO_3^{2-}$).

The dissolved constituents in groundwater provide a record of the minerals encountered as water moves through an aquifer; therefore, the major-ion characteristics of groundwater can provide insight on groundwater source areas and flow directions.

Two ongoing geochemical evaluations are in progress. A Phase II Pahute Mesa geochemical evaluation is in progress to update the Phase I evaluations presented in Thomas et al. (2002), Kwicklis et al. (2005), and Rose et al. (2006). In addition, an evaluation is under way regarding noble gas data measured by LLNL over the last 15 years at the NNSS and surrounding area. This report will therefore defer noble gas and Pahute Mesa geochemistry evaluations to future reports focusing specifically on these data.

## 3.1 Frenchman Flat

No UGTA Activity samples were collected in the Frenchman Flat CAU or in its vicinity during 2015.

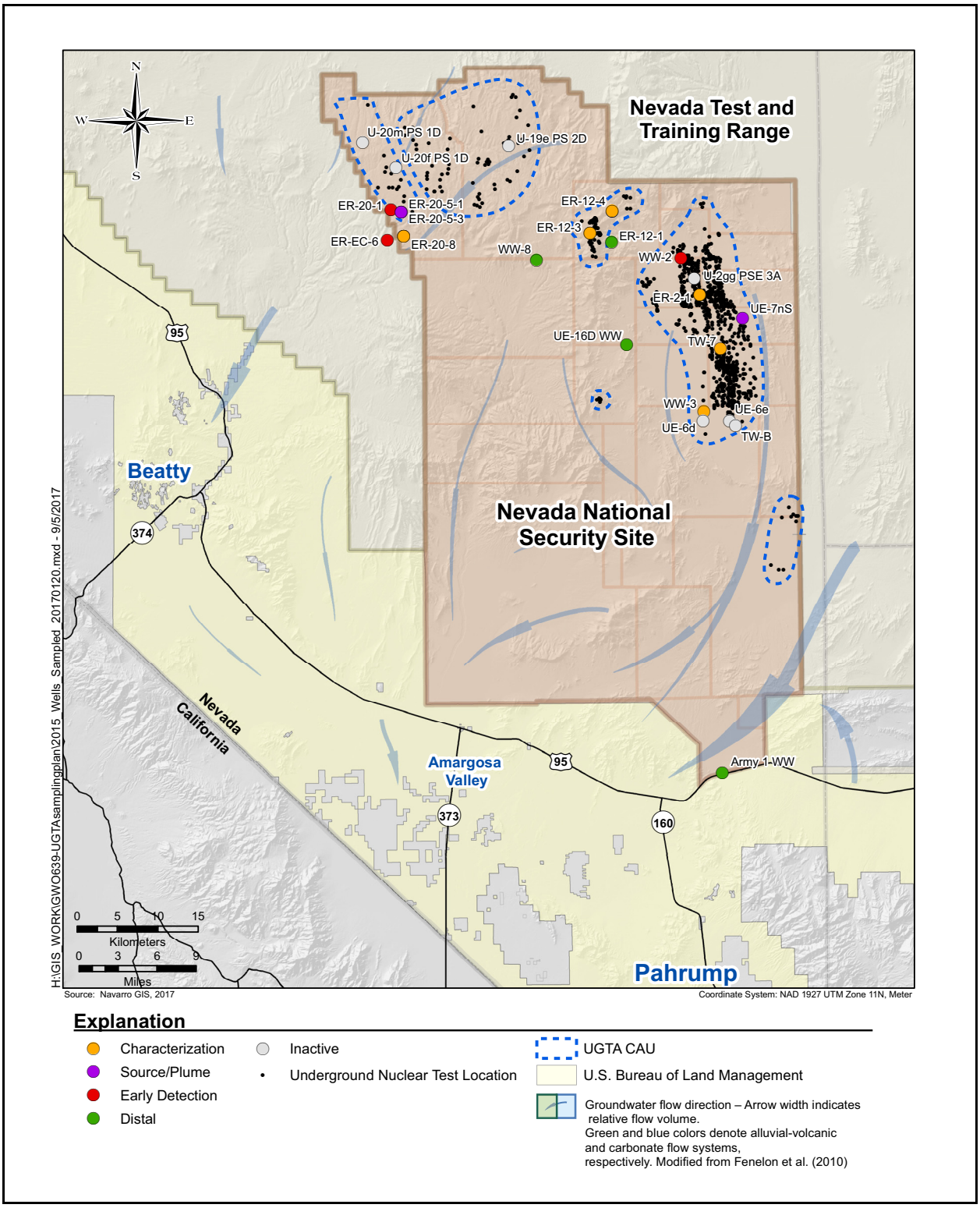



**Figure 3-1**
**Samples Collected in 2015**

## 3.2 Central and Western Pahute Mesa

Five wells were sampled in the Western Pahute Mesa CAUs in 2015: one characterization well, ER-20-8 (Section 3.2.1); two source/plume wells, ER-20-5-1 (Section 3.2.2) and ER-20-5-3 (Section 3.2.3); and two early detection wells, ER-EC-6 (Section 3.2.4) and ER-20-1 (Section 3.2.5). The analytical results for these samples are reported in Section B.2.0 of Appendix B.

### 3.2.1 ER-20-8

ER-20-8 is a characterization location. This well is constructed with three piezometers and two main completion zones (see Figure C-3). The shallow piezometer (ER-20-8_p3) was sealed off during drilling because elevated $^{3}H$ was observed; consequently, there is no corresponding main completion zone. The remaining two piezometers, ER-20-8_p1 and ER-20-8_p2, access the same depth intervals as the main completion zones, ER-20-8_m1 and ER-20-8_m2. Well development and testing were completed at this well in 2011. Samples were collected at the end of the hydraulic testing after purging more than 1 million gal of groundwater from each main completions zone (N-I, 2012b). In addition, samples from the three piezometers and one main completion were collected in support of a sampling technologies evaluation performed in 2014 that compared $^{3}H$ activities in samples collected using three technologies (bailer, jack pump, and electric submersible pump) (Navarro, 2015a).

Samples were collected from ER-20-8_m2 in 2015 using an electric submersible pump. ER-20-8_m2 accesses the TCA. A sample and duplicate were collected on March 7, 2015, and analyzed for the full characterization suite by the commercial laboratory (see Table B.2-1). A sample and duplicate were collected on March 8, 2015, and analyzed for a large suite of analytes by LLNL (see Table B.2-2). The purge volumes and field water-quality data are reported in Table 3-1.

**Table 3-1**
**Purge Volumes and Field Water-Quality Data for ER-20-8_m2**

| Date | Purge Volume (gal) | Temperature (°C) | $Br^-$ (mg/L) | DO (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| 03/07/2015 | 77,684 | 38.5 | 0.24 | 5.2 | 8.46 | 381 | 27.2 |
| 03/08/2015 | 108,931 | 38.3 | 0.32 | 4.8 | 8.46 | 376 | 17.9 |

$Br^-$ = Bromide

The only RN detected in the samples by the commercial laboratory was $^{3}H$ (Table B.2-1). The five RNs sampled for LLNL were detected using their specialized methods (Table B.2-2). Table 3-2 presents the current and historical results of the RNs detected in samples collected from ER-20-8_m2 and ER-20-8_p2 using an electric submersible pump and a bailer, respectively. LLNL only analyzed samples from ER-20-8_m2, and therefore detectable RNs (other than $^{3}H$) for the bailed ER-20-8_p2 samples are not available.

As shown in Table 3-2, the 2015 $^{3}H$ results were similar between the commercial laboratory (4,560 and 4,590 pCi/L) and LLNL (4,019 and 4,056 pCi/L), although LLNL results were about 12 percent lower on average. The $^{3}H$ activity in the 2015 samples is approximately 40 percent less than the 2014 bailed samples from ER-20-8_p2 (8,200 and 8,800 pCi/L) suggesting that the sampling technique impacts the $^{3}H$ levels at this location. All RN levels increased over time when comparing samples collected from the same well completion and the same sampling technology (Table 3-2). No MCL exceedances are observed for these samples.

**Table 3-2**
**Historical RN Data for ER-20-8_m2 and ER-20-8_p2**

| Year Sampled | $^{3}H$[a] (pCi/L) | $^{3}H$[b] (pCi/L) | $^{14}C$[b] (pCi/L) | $^{36}Cl$[b] (pCi/L) | $^{129}I$[b] (pCi/L) | $^{239/240}Pu$[b] (pCi/L) |
|---|---|---|---|---|---|---|
| 2011 | 2,070 \| 2,110 [c] | -- | -- | -- | -- | -- |
| | 3,020 \| 2,650 | 2,810 | 0.197 | 3.4E-03 | 2.1E-04 | -- |
| 2014 | 8,800 \| 8,200 [c] | -- | -- | -- | -- | -- |
| 2015 | 4,560 \| 4,590 | 4,019 \| 4,056 | J- 0.337 | 5.4E-03 \| 5.5E-03 | 3.6E-04 \| 3.8E-04 | J 4E-04 \| J 3E-04 |

[a] Sample was analyzed by the commercial laboratory.
[b] Sample was analyzed by LLNL.
[c] Sample was collected from ER-20-8_p2 at a depth of 2,800 ft using a depth discrete bailer. All other samples were collected from ER-20-8_m2 (2,440 to 2,940 ft) using an electric submersible pump after water-quality parameters stabilized.

J = Result is estimated
J- = Result is estimated and is biased low.
-- = Not analyzed

Note: Values reported with a "|" indicate sample | duplicate results.

A Piper diagram illustrating the major-ion results for the 2011 and 2015 samples is presented in Figure 3-3. Unfortunately, alkalinity ($HCO_3/CO_3$) data are not available for the 2014 ER-20-8_p2 sample, so these samples could not be included in the diagram. The ER-20-8 groundwater samples plot very close to one another on this diagram; all groundwaters are a mixed Na-$HCO_3/SO_4$ type. The

samples are dominated by Na+K (cations) and both $HCO_3$ and $SO_4$ (anions). This hydrochemical facies is observed in western Pahute Mesa and Oasis Valley (Thomas et al., 2002). The increased concentrations of sulfate are attributed to the interaction with hydrothermal mineralization and are supported by the presence of sulfide minerals in boreholes on western Pahute Mesa (Blankennagel and Weir, 1973; IT, 1998).

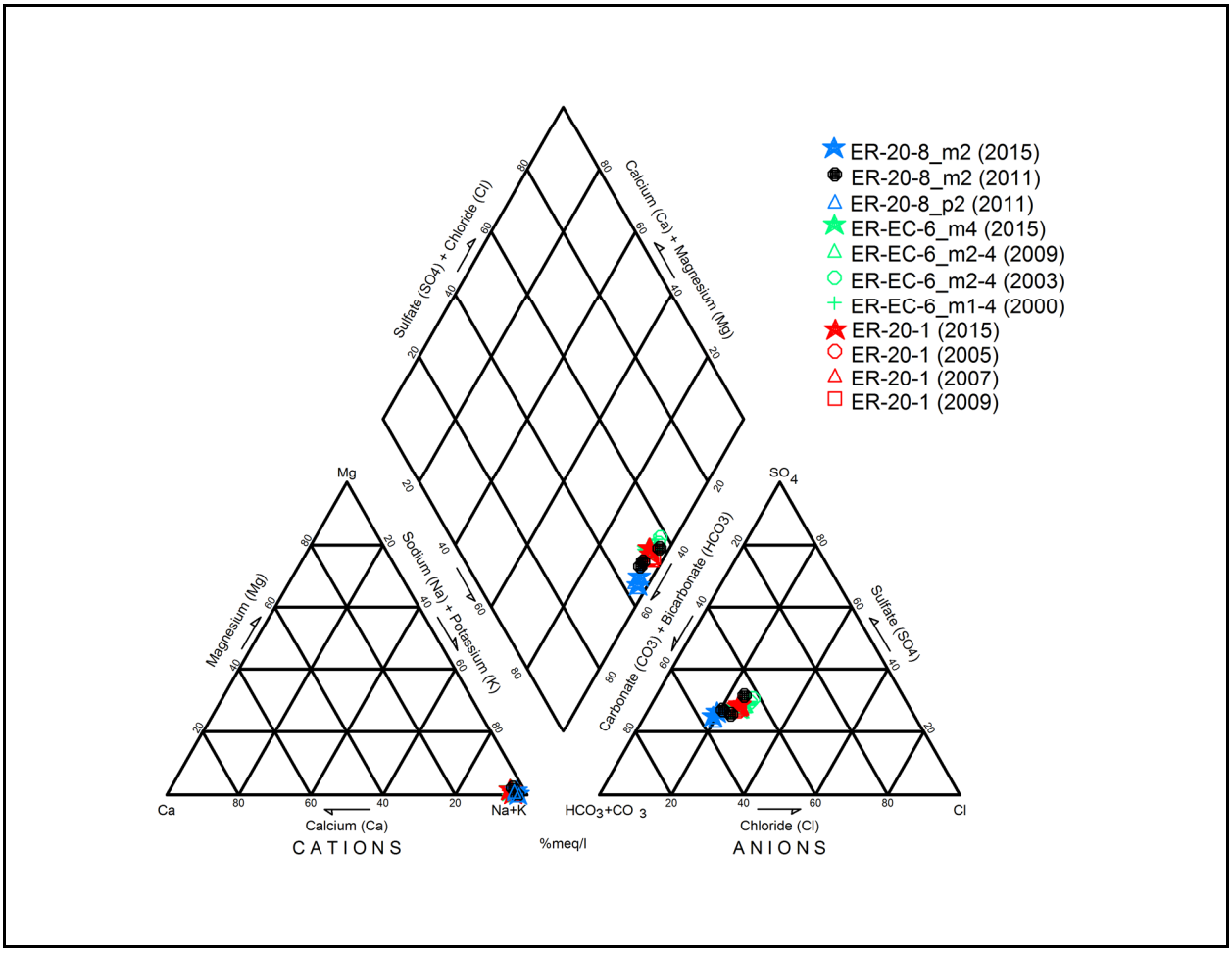



**Figure 3-2**
**Piper Diagram Illustrating Groundwater**
**Major-Ion Chemistry of Pahute Mesa Samples**

### *3.2.2 ER-20-5-1*

ER-20-5-1 is a source/plume location. This well was drilled in 1995 to a depth of 2,823 ft and accesses the TSA (see Figure C-2). A sample and duplicate were collected on April 2, 2015, and analyzed for COPCs (Table 1-3), $^{238}$Pu, $^{239/240}$Pu, and gamma emitters by the commercial laboratory

(Table B.2-3); and COPCs, $^{239/240}$Pu, and environmental tracers by LLNL (Table B.2-4). The purge volumes and field water-quality data are reported in Table 3-3.

**Table 3-3**
**Purge Volumes and Field Water-Quality Data for ER-20-5-1 and ER-20-5-3**

| Location | Date | Purge Volume (gal) | Temperature (°C) | DO (mg/L) | $Br^-$ (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| ER-20-5-1 | 04/02/2015 | 42,075 | 33.6 | 3.5 | -- | 8.4 | 478 | 16.2 |
| ER-20-5-3 | 03/13/2015 | 30,977 | 38.1 | 4.2 | 0.35 | 8.8 | 386 | 23.7 |

-- = Not analyzed

The RNs detected by the commercial laboratory are $^{3}$H (2.48 E+07), $^{36}$Cl (5.7 pCi/L), and $^{239/240}$Pu (0.287 and 0.400 pCi/L). LLNL detected all COPCs ($^{14}$C, $^{36}$Cl, $^{99}$Tc and $^{129}$I) (Table B.2-4). Historical results show $^{3}$H activity has declined from approximately 6.85E+07 pCi/L in 1996 to 2.5E+07 pCi/L in 2015, which is the result of decay represented by the orange line in Figure 3-3. Table 3-4 presents the historical results for the COPCs and $^{239/240}$Pu.

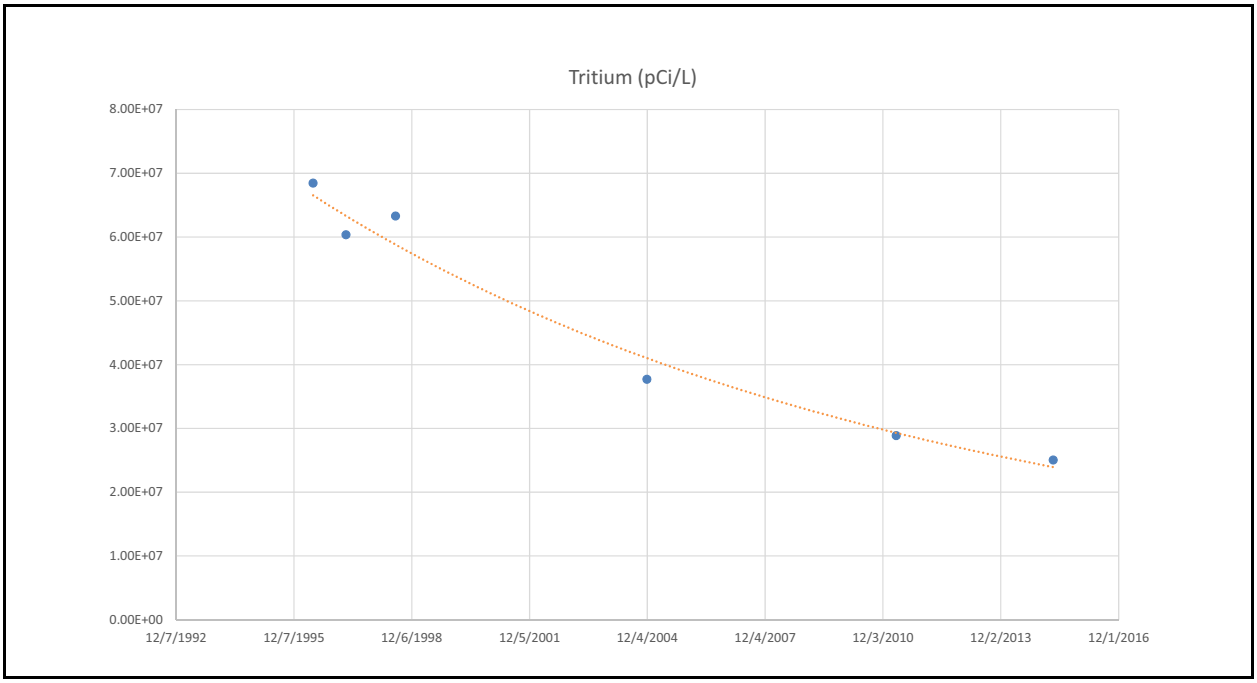



**Figure 3-3**
**ER-20-5-1 Average Historical $^{3}$H Results**

**Table 3-4**
**Historical RN Data for ER-20-5-1_m1 and ER-20-5-3_m1**

| Year Sampled | $^{14}C$ (pCi/L) | $^{36}Cl$ (pCi/L) | $^{99}Tc$ (pCi/L) | $^{129}I$ (pCi/L) | $^{239/240}Pu$ (pCi/L) |
|---|---|---|---|---|---|
| **ER-20-5-1** | | | | | |
| 1996 | 63.2 | 3.43 | <2.3 | -- | 0.52 |
| 1997 | 75.1 | 2.89 | <1.0 | <6.1 | 0.59 |
| 1998 | 179 | 3.32 | 0.27 | 0.27 | 0.58 |
| 2004 | 224 | 3.57 | 0.35 | 0.19 | 0.42 |
| 2011 | 472 | 3.60 | 0.38 | 0.19 | -- |
| 2015 | 150 | 3.7 | 0.43 | 0.19 | 0.32 |
| **ER-20-5-3** | | | | | |
| 1996 | 1.89 | 1.0E-02 | <4.9 | -- | 0.02 |
| 1997 | 1.89 | 9.4E-03 | <0.83 | <3.3 | 0.05 |
| 1998 | 1.73 | 1.1E-02 | <0.03 | -- | <0.31 |
| 2001 | 2.08 | 2.2E-02 | -- | 1.2E-03 | <0.04 |
| 2004 | 2.73 | 1.3E-02 | 1.7E-02 | 1.4E-03 | <0.04 |
| 2011 | 2.72 | 1.3E-02 | 4.0E-03 | 4.4E-04 | -- |
| 2015 | 2.60 | 1.4E-02 | 8.7E-03 | 3.8E-04 | 0.01 |

-- = Not analyzed

Kersting et al. (1999) used the $^{240}Pu/^{239}Pu$ isotope ratio to "fingerprint" the source of Pu in the ER-20-5-1 groundwaters to the BENHAM test. The presence of $^{3}H$, cobalt-60 ($^{60}Co$), $^{137}Cs$, $^{152/\ 154/\ 155}Eu$, and $^{239/240}Pu$ was observed in ER-20-5-1 groundwaters; and lower levels of these RNs, with the exception of $^{152/\ 154/\ 155}Eu$, were observed in ER-20-5-3. No Eu was detected in ER-20-5-3 groundwaters. The study found that Pu, Eu, Co, and Cs are transported as colloidal material (Kersting et al., 1999). The conceptual model is that thermally driven vertical flow migrates contaminants upward in the BENHAM chimney to the relatively permeable lava flow aquifers, including the TSA and FCCM. Horizontal transport then occurs through these aquifers down the regional hydraulic gradient.

A cross section along the line extending from the TYBO/BENHAM test cavities to ER-EC-6 (Figure 3-4) generally follows the regional hydraulic gradient and shows that $^{3}H$ levels progressively decrease from north to south downgradient along the section (Figure 3-4). It is also clear that $^{3}H$ levels are greater in the more shallow HSUs (TSA and BA).

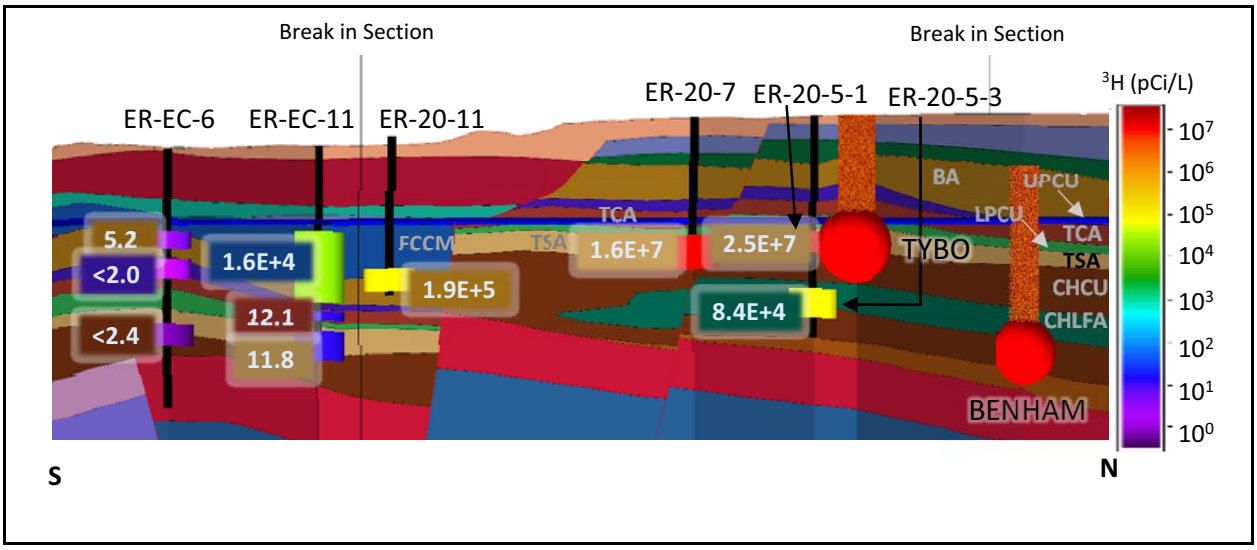



**Figure 3-4**
**Cross Section from North to South of $^3$H Values**
Note: Cavity radius based on maximum yield range identified in NNSA/NFO (2015b) and Pawloski (1999).

### *3.2.3 ER-20-5-3*

ER-20-5-3 is a source/plume location. This well was constructed in 1995 to a depth of 4,294 ft to intersect a deeper lava-flow aquifer (CHZCM) (see Figure C-1). A sample and duplicate were collected on March 13, 2015, and analyzed for COPCs (Table 1-3), $^{238}$Pu, $^{239/240}$Pu, and gamma emitters by the commercial laboratory; and COPCs and environmental tracers by LLNL. The purge volumes and field water-quality data are reported in Table 3-3.

Results for the COPCs (Table 1-3) and other specific RNs from the commercial laboratory are presented in Table B.2-3. Analyses conducted by LLNL are presented in Table B.2-4. The $^3$H activity from the commercial laboratory is 8.4E+04 pCi/L for the sample and its duplicate. The $^3$H activities from LLNL range from 8.1E+04 to 8.2E+04 pCi/L. No other RN was detected by the commercial laboratory. LLNL detected $^{14}$C, $^{36}$Cl, $^{99}$Tc and $^{129}$I at levels well below the MCL. Averages of historical $^3$H results show that $^3$H activity in ER-20-5-3 groundwater is declining as shown in Figure 3-5. The orange line is $^3$H decay, assuming an initial activity of 2.17E+05 pCi/L in 1997.

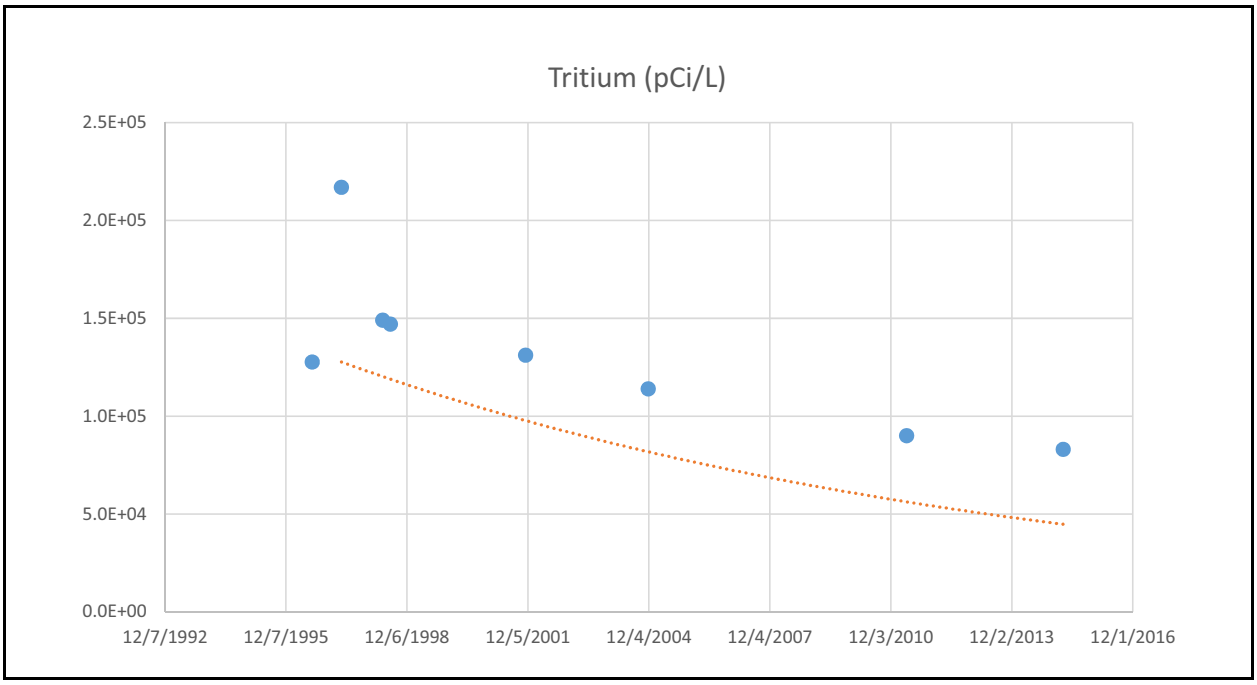



**Figure 3-5**
**ER-20-5-3 Average Historical $^{3}H$ Results**

### *3.2.4 ER-EC-6*

The upper interval of well ER-EC-6 (ER-EC-6_m4) is an early detection location located outside the NNSS boundary on the Nevada Test and Training Range (NTTR). The well was recompleted in 2009 to allow monitoring of the three main completion zones, and the fourth zone is isolated with a bridge plug (ER-EC-6_m1). Previous samples collected at ER-EC-6 are composites collected across the three open intervals in the main completion. ER-EC-6 is completed with three open-ended piezometers that access each zone through straddle packers. ER-EC-6_m1 is screened across the Crater Flat composite unit (CFCM) and is currently unavailable, ER-EC-6_m2 (deep) is screened across the CHZCM and TSA, ER-EC-6_m3 (intermediate) is screened across the Upper Paintbrush confining unit (UPCU) and TCA, and ER-EC-6_m4 (shallow) is screened across the BA (see Figure C-4). Previous samples collected in the composite interval (ER-EC-6_m2-4) show $^{3}H$ activity in 2009 at 1.7 pCi/L by LLNL. On January 13, 2015, the shallow zone (ER-EC-6_m4) was sampled after purging 20,295 gal. The purge volumes and field water-quality data are reported in Table 3-5.

**Table 3-5**
**Purge Volumes and Field Water-Quality Data for ER-EC-6 and ER-20-1**

| Location | Date | Purge Volume (gal) | Temperature (°C) | DO (mg/L) | $Br^-$ (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| ER-EC-6 | 01/12/2015 | 16,039 | 27.2 | 3.0 | 0.61 | 8.3 | 565 | 17.5 |
| | 01/13/2015 | 20,295 | 26.6 | 3.2 | 0.60 | 8.4 | 570 | 12.5 |
| ER-20-1 | 02/23/2015 | 21,965 | 25.9 | 2.7 | 0.46 | 8.2 | 616 | 16.5 |
| | 02/24/2015 | 26,345 | 24.9 | 3.3 | 0.63 | 8.3 | 611 | 19.1 |

These samples were analyzed for the full groundwater characterization suite to provide baseline chemistry from the individual zones and specialized analyses by LLNL. Low-level $^{3}H$ analyses from the commercial laboratory showed activity of 5.18 and 4.42 pCi/L, and LLNL results show 4.2 pCi/L (see Tables B.2-5 and B.2-6). LLNL ran additional analysis for COPCs, noble gases, and environmental tracers presented in Table B.2-6.

ER-EC-6 samples collected from the different completions are presented on the Piper diagram in Figure 3-2. The major ion compositions are similar to one another over time as well as to the 2015 samples within Pahute Mesa.

### *3.2.5 ER-20-1*

ER-20-1 was drilled in 1992 to a depth of 2,065 ft bgs. The well was designed to be completed to a depth of 5,500 ft bgs; however, construction was suspended after setting casing to a depth of 1,937 ft bgs and is an open borehole to a TD of 2,065 ft bgs (see Figure C-5). The well was not developed at the time of construction. On February 24, 2015, samples were collected after purging 26,345 gal from the well. The purge volumes and field water-quality data are reported in Table 3-5. This was the first time the well had been pumped, so the groundwater characterization suite of analytes was collected (see Tables B.2-5 and B.2-6). No $^{3}H$ was detected above the 2.12 pCi/L MDC (see Table B.2-5). Other RNs were not detected by the commercial laboratory (see Table B.2-5). LLNL ran additional analysis for environmental tracers, noble gases, and selected RNs as presented in Table B.2-6 and detected natural levels of $^{36}Cl$ and $^{14}C$.

These samples plot very similarly to the historical samples as well as in Pahute Mesa on the Piper diagram (Figure 3-2), indicating similar relative major ion composition.

## 3.3 Rainier Mesa/Shoshone Mountain

Five wells were sampled in the RM/SM CAU: two characterization wells, ER-12-3 (Section 3.3.1) and ER-12-4 (Section 3.3.2); and three distal wells, ER-12-1 (Section 3.3.3), UE-16d WW (Section 3.3.4), and WW-8 (Section 3.3.5). The analytical results for these samples are presented in Section B.3.0 of Appendix B.

### 3.3.1 ER-12-3

ER-12-3 is completed to a depth of 4,908 ft bgs; the lower section of the well from 2,622 to the total depth (TD) is open to the Paleozoic carbonates (LCA) (see Figure C-9). Groundwater samples have been previously collected from ER-12-3_m1 in 2005 and 2008. Groundwater samples were again collected on May 1, 2015, and analyzed for the characterization suite by the commercial laboratory (see Table B.3-1); and additional analyses for environmental tracers and noble gases were conducted by LLNL (see Table B.3-2). The purge volumes and field water-quality data are reported in Table 3-6.

**Table 3-6**
**Purge Volumes and Field Water-Quality Data for ER-12-3 and ER-12-4**

| Location | Date | Purge Volume (gal) | Temperature (°C) | DO (mg/L) | $Br^-$ (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|
| ER-12-3 | 05/01/2015 | 59,447 | 28.7 | 1.7 | 0.05 | 7.6 | 270 | 12.8 |
| ER-12-4 | 05/09/2015 | 20,644 | 26.0 | 3.9 | 0.27 | 8.6 | 186 | 14.6 |

No $^{3}H$ was detected above the 2.19 pCi/L MDC by the commercial laboratory. LLNL reports detections at 0.5 and 0.4 pCi/L with corresponding MDCs of 0.2 and 0.3 pCi/L respectively. These values are near the MDC and are considered uncertain. No other RNs were detected, with the exception of natural levels of $^{36}Cl$ and $^{14}C$. The Piper diagram presented in Figure 3-6 illustrates the similarity between the 2015 samples and all other samples previously collected from ER-12-3_m1. The groundwater is a Ca-Mg-Na-$HCO_3$ hydrochemical facies, typical of other NNSS groundwaters from the lower carbonate aquifer (SNJV, 2006).

ER-12-3_m1 has now been sampled three times as a characterization well as required by the Sampling Plan and a sufficient baseline for this well has been established. ER-12-3_m1 will now be recategorized as an early detection well for the RM/SM CAU.

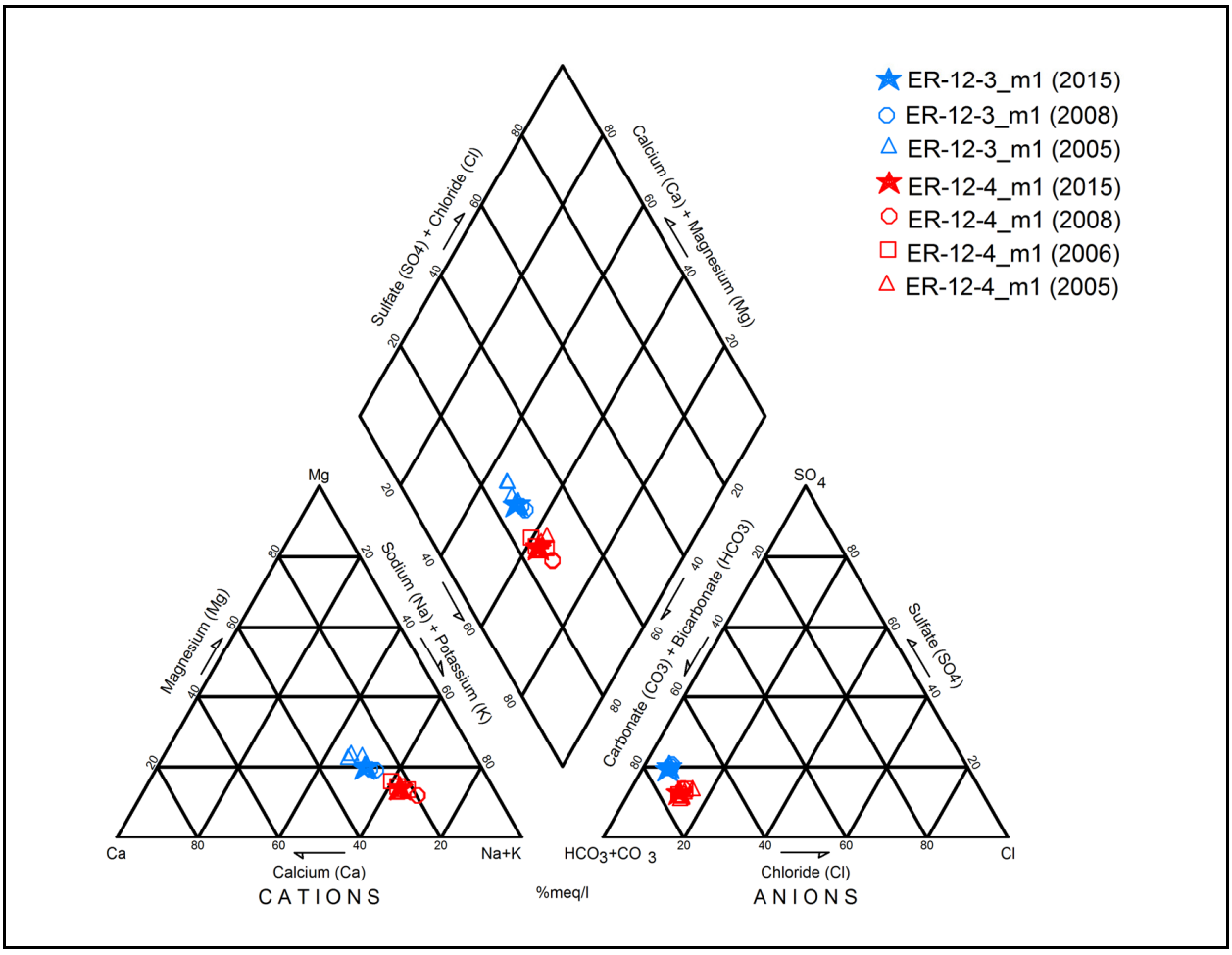



**Figure 3-6**
**Piper Diagram Illustrating Groundwater**
**Major-Ion Chemistry of ER-12-3 and ER-12-4 Samples**

### *3.3.2 ER-12-4*

ER-12-4 was drilled and completed to a depth of 3,715 ft bgs in the Paleozoic carbonates (LCA) (see Figure C-10). The main completion of this well (ER-12-4_m1) was sampled on May 9, 2015. The purge volumes and field water-quality data are reported in Table 3-6. The field alkalinity was reported as 66 mg/L as calcium carbonate ($CaCO_3$), and field $CO_3$ and $HCO_3$ were reported as 1.2 mg/L and 78.0 mg/L, respectively. The samples were analyzed for the full characterization suite (see Table B.3-1), and additional analyses were conducted by LLNL (see Table B.3-2). No $^3H$ was detected above the 1.74 pCi/L MDC by the commercial laboratory nor the 1.0 and 0.2 pCi/L MDCs by LLNL.

The Piper diagram presented in Figure 3-6 illustrates the similarity between the 2015 samples and all other samples previously collected from ER-12-4. The groundwater is a Ca-Mg-Na-$HCO_3$ hydrochemical facies, typical of other NNSS groundwaters from the lower carbonate aquifer (SNJV, 2006).

ER-12-4_m1 has now been sampled three times as a characterization well as required by the Sampling Plan, and a sufficient baseline for this well has been established. ER-12-4_m1 will now be recategorized as an early detection well for the RM/SM CAU.

### *3.3.3 ER-12-1*

Well ER-12 -1 is a distal well located 1.3 miles (mi) east–southeast of the E-Tunnel complex within Rainier Mesa and 1,509.2 ft east of the E-Tunnel effluent ponds. The unlined ponds contain tritiated water accumulated from the discharge of perched groundwater draining from the E-Tunnel complex. ER-12-1 was drilled in 1991 to TD of 3,588 ft. The completion consists of a 5.5-inch [in.] casing with five sliding sleeves nested inside a 7.625-in. slotted casing cemented and gravel packed inside a 31.12-cm 12.25-in. borehole. Currently, only the uppermost of five completion zones are accessible (ER-12-1_m5) for sampling (see Figure C-11). ER-12-1 is monitored at least every five years for $^3H$ as a distal well. However, every two years, well ER-12-1 is sampled under an NDEP permit (Murphy, 2003). On April 15, 2015, groundwater samples were collected from the wellhead and no $^3H$ was detected above the 348 pCi/L MDC (see Table B.3-3). Gross alpha and gross beta radioactivity were found at concentrations above their MDCs and are believed to represent the presence of naturally occurring RNs.

### *3.3.4 UE-16d WW*

UE-16d WW is both a distal location and also has been a water supply well since 1981. It is currently used for construction water supply and is monitored annually by the M&O contractor (National Security Technologies, LLC [NSTec]). A sample was collected from this well on January 21, 2015, and analyzed for $^3H$ using the standard method. No $^3H$ was detected above the 223 pCi/L MDC (see Table B.3-3).

### 3.3.5 WW-8

WW-8 is both a distal and public water supply well, and is sampled quarterly by NSTec. This well has been used for water supply since 1963. In 2015, samples were analyzed for $^{3}H$ and gross alpha and gross beta (see Table B.3-3). No $^{3}H$ was detected above their MDCs (185 to 229 pCi/L). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in a few of the 2015 samples and are believed to represent the presence of naturally occurring RNs.

## 3.4 Yucca Flat/Climax Mine

The YF/CM CAU is currently at the end of the CAI stage of the UGTA strategy; the flow and transport model was completed and reviewed by an external peer review committee (N-I, 2014). Sampling priorities in 2015 for this CAU were based on responding to external peer review comments (N-I, 2015). Sampling included three characterization wells, ER-2-1 (Section 3.4.1), TW-7 (Section 3.4.2) and WW-3 (Section 3.4.3); one source/plume well, UE-7nS (Section 3.4.4); one early detection well, WW-2 (Section 3.4.5); and one distal well, Army 1 WW (Section 3.4.6). The analytical results for these samples are presented in Section B.4.0 in Appendix B.

### 3.4.1 ER-2-1

More than two dozen underground nuclear tests (mostly of yields in the 20- to 200-kiloton range) were conducted near the Well ER-2-1 site. The four closest tests were PANAMINT, CHIBERTA, REBLOCHON, and STARWORT. The site of Well ER-2-1 is approximately 328 ft west of the PANAMINT surface ground zero. CHIBERTA is 870 ft north of ER-2-1; REBLOCHON is 840 ft southwest of ER-2-1; and STARWORT is 1,277 ft southwest of ER-2-1. STARWORT was conducted in 1973, CHIBERTA in 1975, and REBLOCHON in 1975 (NNSA/NFO, 2015b). PANAMINT, the most recent test in the area, was conducted in 1986. PANAMINT was conducted above the water table, and the other tests were conducted below the water table.

ER-2-1 has a main completion interval from 1,641 to 2,079 (ER-2-1_m1) ft bgs in the TMLVTA (see Figure C-12). A piezometer is completed across the LTCU from 2,495 to 2,558 ft bgs (ER-2-1_p1). The static water level (SWL) at ER-2-1 was measured at 1,725 ft bgs. In 2003, LLNL provided low-level $^{3}H$ analysis, and $^{3}H$ was detected at 228 pCi/L.

Groundwater sampling was initiated on March 26, 2015, after purging approximately 9,049 gal of groundwater, which equates to approximately 4.5 well volumes (one well volume is approximately 2,022 gal). The field water-quality data are reported in Table 3-7. Samples were analyzed for the full characterization suite by the commercial laboratory (see Table B.4-1). Additional analyses for environmental tracers and noble gases were conducted by LLNL (see Table B.4-2). The commercial laboratory detected $^{3}H$ at an average of 920 pCi/L and LLNL detected $^{3}H$ at an average of 739 pCi/L (see Tables B.4-2 and B.4-3). The $^{14}C$ activity and $^{36}Cl$ activity are consistent with background levels (see Table B.4-3).

**Table 3-7**
**Field Water-Quality Data for ER-2-1**

| Date | Temperature (°C) | DO (mg/L) | $Br^-$ (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|
| 03/26/2015 | 24.4 | 2.3 | 0.11 | 7.5 | 312 | 66 |

A Piper diagram presenting the major-ion compositions of the ER-2-1 samples collected in 2003 and 2015 is shown in Figure 3-7. ER-2-1 samples (2003 and 2015) exhibit similar major-ion chemistry and all exhibit an Na-K-$HCO_3$ hydrochemical facies, similar to other groundwaters of volcanic aquifers in Yucca Flat (SNJV, 2006).

### *3.4.2 TW-7*

TW-7 is a characterization well that was constructed in 1954 with 600 ft of open borehole in the LTCU (see Figure C-13). Samples were collected using a depth-discrete bailer from a depth of 1,950 ft bgs on May 21, 2015. TW-7 is within 1 mi of 22 tests that were conducted below the water table. DRI bailed a sample from TW-7 for $^{3}H$ analysis. This sample was collected to determine the level of $^{3}H$ and to help prioritize later sampling using the jack pump. No $^{3}H$ activity was detected above the 2.47-pCi/L detection limit.

### *3.4.3 WW-3*

WW-3 is a characterization well. This well was constructed in 1950 to 1952, served as a public water system (PWS) well from 1952 to 1970, and was sampled multiple times during this time period. The well was recompleted between November 1991 and March 1992, and the tubing and pump that were

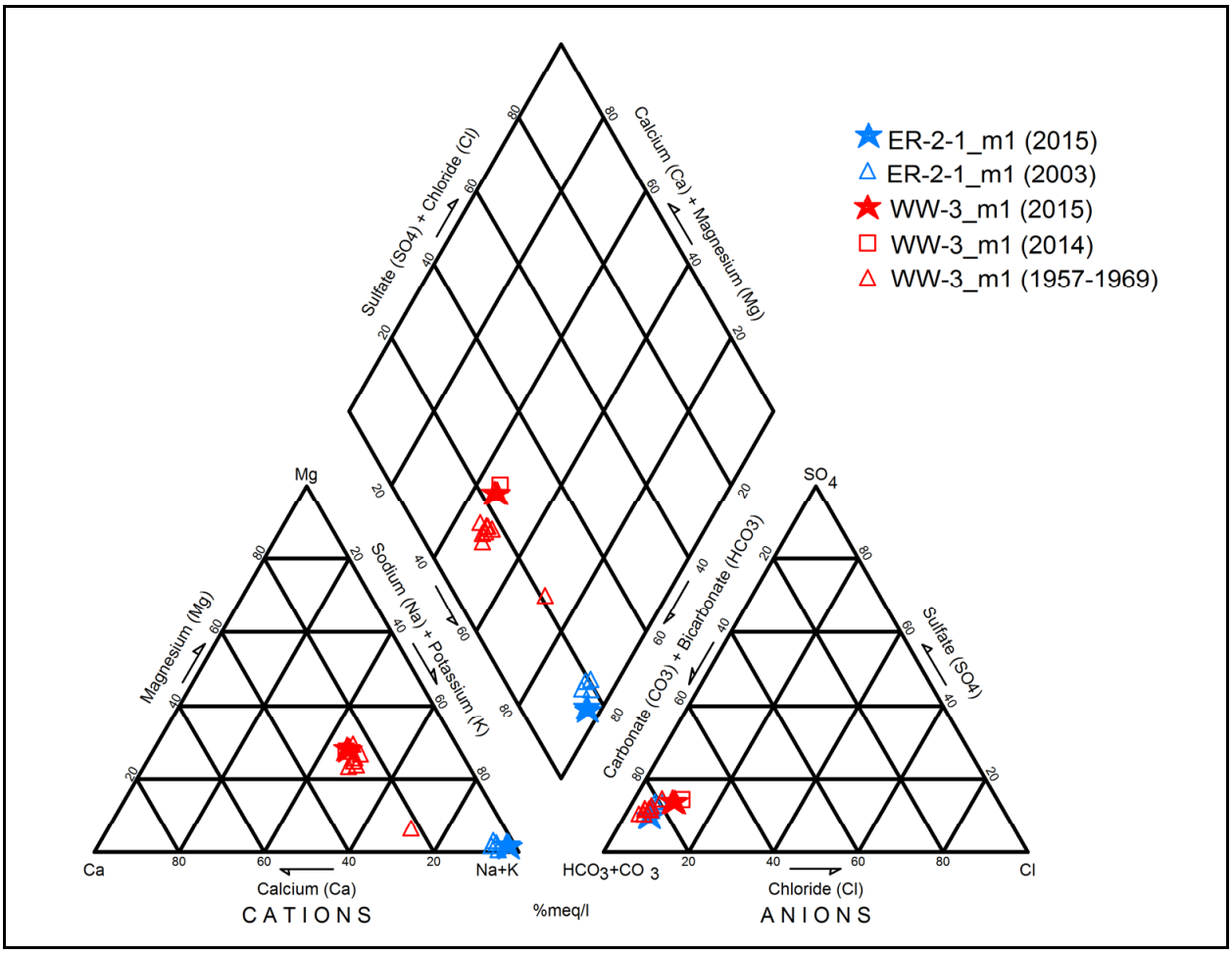



**Figure 3-7**
**Piper Diagram Illustrating Groundwater Major-Ion Chemistry of Yucca Flat Samples**

removed were not reinstalled. WW-3 is open to approximately 770 ft of alluvium (see Figure C-14). This well was last sampled with a bailer in 2014, and $^{3}H$ was reported as 7.3 pCi/L (Navarro, 2017b). WW-3 was sampled on June 9, 2015, using a jack pump after purging 8,311 gal of water. Samples were collected and analyzed for the full characterization suite, with additional analyses by LLNL (see Tables B.4-1 and B.4-2). Low-level $^{3}H$ activity was measured at 6.27 and 5.63 pCi/L from the sample and duplicate, respectively, by the commercial laboratory. LLNL low-level $^{3}H$ activity was measured at 6.0 and 6.1 pCi/L. The $^{3}H$ activity in WW-3 has been hypothesized to be due to a small amount of $^{3}H$ associated with surface water formerly contained within the WW-3 pond that infiltrated through the alluvium and is now detectable in the groundwater (Navarro, 2016).

A Piper diagram presenting the major-ion compositions of WW-3 samples is shown in Figure 3-7. WW-3 samples exhibit similar major-ion chemistry to the 2015 sample and exhibit a Ca-Mg-Na-$HCO_3$ hydrochemical facies, similar to other groundwaters of carbonate aquifers in Yucca Flat (SNJV, 2006).

### *3.4.4 UE-7nS*

UE-7nS was completed on July 15, 1976, as an exploratory hole to determine the geologic and geophysical characteristics of the area. The well has been extensively pumped and sampled over its history. The nearest underground test is BOURBON (U-7n), located 450 ft to the northwest. Samples collected in 2011 and 2012 by RREMP had reported $^3$H activities of 94.2, 63.8 and 71.3 pCi/L. The well was drilled to a depth of 2,205 ft and has a main completion interval from 1,995 to 2,199 ft bgs in the LCA (see Figure C-17). Two perforated access tubing strings are installed in the main completion zone. A bailer sample was collected on June 10, 2015, from the 2.875-in. tubing in UE-7nS_m1. Field measurements at the time of sampling are presented in Table 3-8. No $^3$H measurements were above their MDCs using the EPA standard analysis method (EPA, 1980). Tritium activities were reported by the commercial laboratories as 45.16 pCi/L. The value was reported with a "J" qualifier, indicating that the result is an estimation (the laboratory control sample [LCS] recovery exceeded the control limits). LLNL reported a $^3$H activity of 53.3 pCi/L (see Table B.4-3). No samples were collected using the rod pump due to technical difficulties. NSTec originally set the intake of the rod pump at 1,971 ft bgs, 3 ft below the SWL, but after three hours, no water was produced. The pump string was moved down past a tight spot to a depth of 1,978 ft bgs and 10 ft below the SWL but not pumped. The decision was made to try to pull the 2.875-in. tubing and lower the perforated interval 100 ft below the SWL. The 2.875-in. tubing was not able to be removed and remains in the well in its original configuration.

**Table 3-8**
**Field Water-Quality Data for UE-7nS**

| Temperature (°C) | DO (mg/L) | $Br^-$ (mg/L) | pH (SU) | SEC (µS/cm) | Turbidity (NTU) |
|---|---|---|---|---|---|
| 33.5 | 5.1 | 1.29 | 6.8 | 382 | 62.4 |

### 3.4.5 WW-2

WW-2 is an early detection well. This well was completed in 1962 and was recompleted in June 1992. The well is open to about 300 ft of the LCA with perforations in the liner from 2,700 to 2,950 ft bgs and 3,166 to 3,414 ft bgs (see Figure C-18). WW-2 was sampled on April 22, 2015, after purging 73,168 gal of groundwater. Samples were collected and analyzed for the full characterization suite, with additional analyses by LLNL (see Tables B.4-1 and B.4-2). Tritium was not detected above the 2.17-pCi/L MDC by the commercial laboratory and above the 0.2-pCi/L MDC by LLNL.

### 3.4.6 Army 1 WW

Army 1 WW is open to about 370 ft of the LCA and was a PWS well for Nevada Test Site operations between 1962 and 2005. Army 1 WW is now a distal well and is analyzed for $^{3}H$ using the standard EPA method (EPA, 1980). Samples are collected at a five-year frequency to demonstrate that $^{3}H$ is not present downgradient of underground nuclear testing at levels above the SDWA-required MDC of 1,000 pCi/L (CFR, 2015). Army 1 WW was sampled on January 21, 2015. Tritium was not detected above the 229-pCi/L detection limit (see Table B.4-4).

# 4.0 Quality Assurance/Quality Control

This section summarizes QA/QC results associated with 2015 Sampling Plan implementation. The data verification and validation process, QC sample results, and nonconformances are presented. Sampling and analysis methods associated with Sampling Plan implementation are described in Section 2.0, and the associated requirements are identified in the UGTA QAP (NNSA/NFO, 2015a). The QAP provides a systematic approach to evaluate analytical data that are essential to sustaining data quality.

Data verification reviews for compliance and completeness of commercial laboratory data packages were performed on all UGTA packages to ensure documentation was complete. Sampling information was reviewed (e.g., preservation, temperature, chain-of-custody documentation and analytical hold-time compliance). Upon completion of data verification, data validation was performed to determine analytical quality. This included evaluations of instrument calibrations, QC and sample results, standard reference material certifications, and their appropriateness of use. UGTA 2015 analytical data were acceptable for use. Several data points were estimated and annotated with qualifying flags; explanations are described within the text below. No data were rejected.

NDEP Bureau of Safe Drinking Water certified laboratories were used for the analyses required by the Sampling Plan (Table 1-1). These certifications meet National Environmental Laboratory Accreditation Program credentials. For analyses/analytes not certified by NDEP, the Navarro Analytical Services department reviews laboratories' performance evaluation program results, demonstrations of capability, and procedures for the analytes of concern for acceptability of use. Additional analyses may be performed by non-certified laboratories. Commercial laboratories (ALS Laboratory Group; GEL Laboratories, LLC; and American Radiation Services, Inc.) are certified by the State of Nevada. DRI, LLNL, and USGS provide analytical data not available from commercial laboratories.

Analytical processes routinely include laboratory QC samples such as duplicates, blanks, and spikes; and field QC samples such as field blanks, equipment rinsates, and field duplicates (FDs). Laboratory QC samples used to measure precision and accuracy are analyzed with each batch of samples submitted for analysis. When QC criteria are exceeded, associated sample results are considered to be

estimated. Estimated data, as determined by the validation process, are identified in the database and records packages with a "J" qualifier. Documentation of data qualifications are retained in the Navarro Analytical Services and Geochemistry databases (Navarro, 2017a and c) and in the data packages located in Navarro's Central Files and the Technical Data Repositories.

## 4.1 Accuracy

Accuracy is defined as the nearness of a measurement to the true or accepted reference value. LCSs are analyzed by the laboratories to evaluate method accuracy; matrix spikes (MSs) are analyzed to evaluate the effect of the sample matrix on method accuracy; and tracers are used to determine accuracy for certain radiochemical analytes. In all cases (LCSs, MSs, and tracers), samples are spiked with known concentrations, prepared, and analyzed; then results are expressed as a recovery percentage or chemical yield.

***Radiochemistry***

LCS results were acceptable with the exception of three analytes (low-level $^{3}H$, $^{14}C$, and $^{129}I$). Six percent of the low-level $^{3}H$, 8 percent of the $^{14}C$, and 44 percent of the $^{129}I$ results were qualified for accuracy because the LCSs were reported outside of the required control limits. The previous reporting year, the Navarro Analytical Services department reported a trend for the failing $^{129}I$ to the laboratory, and a nonconformance report (NCR) was initiated for $^{129}I$. The root cause analysis determined that the National Institute of Standards and Technology (NIST) standard used to spike the LCSs was defective. While there were a significant amount of results qualified for $^{129}I$ LCS failures, the occurrences took place in the first quarter of the year; thereafter, LCS recoveries were acceptable, indicating that the corrective action taken by the laboratory was sufficient.

Eight percent of $^{14}C$ results were estimated because their associated MSs exceeded control criteria, and 4 percent of $^{238}Pu$ and $^{239/240}Pu$ were qualified because tracer yields exceeded control criteria.

One result for standard $^{3}H$ was qualified as estimated because the sample was diluted significantly due to high content of $^{3}H$; the result was considered biased low (qualified with a "J-") as a result of the dilution. All other sample results were reported with LCS, MS, and tracer recoveries within the control limits.

***Inorganic Chemistry***

Twenty-two percent of $Cl^-$ results were estimated because their associated MSs exceeded control criteria. Two of the samples that exceeded MS criteria also exceeded temperature requirements because the laboratory stored them improperly (Section 4.4). Results for these samples were therefore qualified as estimates with biased low results (qualified with a "J-") because the MS results recovered low and the potential loss of analyte due to improper storage. All other sample results had LCS and MS results that were within the control limits.

Additionally, calibration verification and/or quantitation limit check standard criteria were not met for arsenic (As), chromium (Cr), lithium (Li), and selenium (Se) analyses. Associated data were estimated and flagged with a "J" qualifier. Control limits associated with serial dilutions were exceeded for barium (Ba), calcium (Ca), lithium (Li), manganese (Mn), and potassium (K). The associated sample results were qualified as estimates because of the potential for a matrix effect.

## *4.2 Precision*

Precision is a measure of the reproducibility of the measurement process. FD samples were used to evaluate overall precision of the measurement process, including variability resulting from sampling, sample preparation, and analysis. The relative percent difference (RPD) between the FD result and the corresponding sample result is a measure of the variability in the process caused by the sampling uncertainty (e.g., matrix heterogeneity, collection variables) and measurement uncertainty (field and laboratory). When results are greater than 10 times the MDCs or minimum detection limits (MDLs), RPD control limits are set at 25 percent; when this value is exceeded, it indicates the reported results do not meet QA requirements and thus are considered for further evaluation. Ninety-six groundwater samples were collected and submitted to commercial laboratories for analyses; of the 96, 39 were FDs. Twenty-six samples (half of which were FDs) were collected and submitted to UGTA participating laboratories (USGS, LLNL, DRI).

Laboratory duplicate samples are used to evaluate overall precision of the sample preparation and measurement process. The RPD between the laboratory duplicate result and the corresponding field sample result should correspond more precisely than between field and FD samples because they do not include variability from sampling. As a result, the control limits are more restrictive for laboratory

duplicates than for FDs. The control limits are different depending on whether the analysis is for radiochemistry or inorganic chemistry.

***Radiochemistry***

Control limits for laboratory duplicates (split samples) are dependent on the level of the analyte for radiochemistry. If the analyte is present at greater than or equal to five times the MDC, the RPD must agree within 20 percent (control limit); and if the analyte is present at less than five times the MDC, the normalized difference (ND) must be between -2 and 2. The ND is calculated as the difference between two results divided by the square root of the sums of the squares of their total propagated uncertainties. All laboratory and FD NDs and RPDs were within QC criteria.

***Inorganic Chemistry***

Control limits for laboratory duplicates (split samples) are dependent on the level of the analyte with respect to its reporting limit (RL) for inorganic chemistry. The RL is the concentration that the laboratory must be able to detect in a sample and is generally less than 10 percent of the analyte's MCL. If the analyte is present at greater than or equal to five times the RL, the RPD must not exceed 20 percent; and if the analyte is present at less than five times the RL, the absolute difference (AD) must not be above the RL (this criterion is used because increased uncertainty occurs when results are reported at levels at or near instrument and method sensitivity levels). All laboratory duplicate RPDs were within QC criteria.

FD RPDs were within QC criteria with the exception of one As, four iron (Fe), and one Mn result. Elemental Fe contains minute particles that can result in duplicate samples that are not homogenous. Relative to the amount of data measurement by the laboratories, these low numbers of exceedences indicate that quality data are being produced for the majority of the parameters used to support the UGTA Activity.

## 4.3 Blank Samples

Blank samples have not been exposed to sample streams and are analyzed to monitor contamination that might be introduced during sampling, transport, storage, or analysis. Blanks establish background values and are sometimes used to adjust or correct analytical results. The four types of blanks used are as follows:

- Equipment blanks (i.e., analyte-free media used to rinse sampling equipment)
- Field blanks (reagent water used to measure ambient sampling conditions)
- Laboratory method blanks (MBs)
- Preparation blanks.

These QC samples are used to assess reporting false positive results. Exceedances are defined as the number of blank samples with analytes detected above the MDC plus the 2 sigma (σ) error for radiochemistry and the number of blank samples with analytes detected above the MDL for general chemistry. For radiochemistry, there were no RNs detected above the blank control criteria.

For general chemistry, contamination was observed in some laboratory blanks for As, Ba, Fe, Mn, aluminum (Al), cadmium (Cd), chromium (Cr), lead (Pb), magnesium (Mg), mercury (Hg), selenium (Se), silver (Ag), and strontium (Sr). Depending on the measured concentration of the analyte in the sample and the blank, the associated sample results were qualified as nondetect ("U" flag) or biased low ("J-" flag) due to negative instrument responses in associated blank samples.

## 4.4 Other Quality-Related Issues

One sample batch containing two samples requiring 6 °C as thermal preservation were mistakenly left unrefrigerated in the pre-screening station of the laboratory overnight. When the temperatures were checked in the morning, the samples were ambient. Effected analytical results were qualified for alkalinity, $Br^-$, $Cl^-$, $F^-$, $SO_4^{2-}$, and SEC. An NCR and CAP were generated to prevent reoccurrence.

Seventeen percent of Hg results were qualified for samples being analyzed outside of the required holding time. The laboratory issued an NCR for staffing issues and the corrective action was to obtain a new analyst.

There are other reasons for estimating results than those described in the aforementioned discussion. One-hundred percent of pH data was estimated because the samples were received at the laboratory after the required holding time. The holding time for pH is 24 hours, and all shipments are to offsite laboratories, so missing the holding time is unavoidable. Although data may be qualified, that does not necessarily mean that the data are inaccurate; instead, it may mean that some form of documentation or associated QC does not meet requirements. These qualifiers are flags to the data users, so that the associated data are evaluated based on their intended use.

# 5.0 Regulatory Requirements

## 5.1 Environmental Compliance

A Well-Specific Fluid Management Strategy Letter is required by the Fluid Management Plan (FMP) (NNSA/NSO, 2009) and approved by NDEP. Typically, the letter provides the site layout, specifies the number and kind of containment to be constructed to support fluid management, and dictates onsite monitoring requirements and transition contingencies. Deviations or special requirements not included in the FMP are also addressed by the strategy letter.

As specified in the Well Specific Fluid Management Strategy for each well, all fluids generated during sampling operations with $^{3}H$ activity less than 400,000 pCi/L were contained in the onsite unlined sumps or discharged to designated infiltration areas. Each well pad has two unlined sumps with one of the sumps incorporating an overflow pipe to allow for discharge to the ground surface. During the pumping phase at each well site, fluids were pumped through the main discharge line or the bypass discharge line. Both lines were routed to the sump that incorporates the overflow pipe. The total volume of fluid discharged to each sump was documented, and an FMP sample was collected from the sump at the end of discharge.

In accordance with the FMP, $^{3}H$ monitoring samples were collected from the discharge line during fluid-generating activities. The results of onsite $^{3}H$ monitoring were compared to the FMP discharge criteria on a daily basis (Table 5-1).

Depth-discrete bailer samples do not produce discharge. Bailed samples are collected and shipped off to the labs. No waste is generated during this activity.

### 5.1.1 FMP Sampling on Frenchman Flat

No UGTA Activity samples were collected in Frenchman Flat or in its vicinity during 2015.

**Table 5-1**
**Discharge Volumes to Sump or Ground**

| Site | CAU | Sump No. | Volume (gal) | Lined | Date | FMP Sample |
|---|---|---|---|---|---|---|
| ER-EC-6 | Pahute Mesa | 2 | 16,039 | Yes | 01/13/2015 | Yes |
| ER-20-1 | | 1 | 30,144 | Yes | 02/24/2015 | Yes |
| ER-20-8 | | 1 | 108,931 | No | 03/08/2015 | Yes |
| ER-20-5-3 | | 1 | 36,105 | Yes | 03/13/2015 | Yes |
| ER-20-5-1 | | 1 | 48,009 | Yes | 04/02/2015 | Yes |
| ER-12-3 | RM/SM | 1 | 63,171 | No | 05/01/2015 | Yes |
| ER-12-4 | | 2 | 21,475 | No | 05/09/2015 | Yes |
| ER-12-1 | | 1 | 11,964 | Partial | 04/15/2015 | Yes |
| ER-2-1 | YF/CM | 1 | 9,871 | Yes | 03/26/2015 | Yes |
| WW-2 | | Infiltration Area | 80,300 | No | 04/22/2015 | Yes |
| WW-3 | | 1 | 8,311 | No | 06/09/2015 | Yes |

### *5.1.2 FMP Sampling on Pahute Mesa*

On Pahute Mesa, wells ER-20-5-3, ER-20-5-1, ER-20-8, ER-EC-6, and ER-20-1 were pumped and discharged to a sump. All the FMP sample results (metals, gross alpha, gross beta and $^{3}H$) met the criteria. The highest $^{3}H$ result was from ER-20-5-1, with an average concentration of 24.8 million pCi/L. The average gross alpha measurement from ER-20-5-3 is 30.25 pCi/L and the average gross beta is 31 pCi/L. Other FMP samples were below the criteria.

### *5.1.3 FMP Sampling on Rainier Mesa*

On Rainier Mesa, two characterization wells (ER-12-3 and ER-12-4) were pumped and discharged to the sump. Groundwater from distal wells (UE-16d WW and WW-8) sampling was discharged to the ground. ER-12-1 is sampled as part of a permit issued by NDEP (Murphy, 2013) to allow discharge of fluids from the E-Tunnel Complex.

Groundwater produced from the purging of ER-12-3 was directed into an unlined sump at the well site. A total of 63,171 gal of groundwater was discharged to the sump. Daily $^{3}H$ and wellhead sampling port results did not exceed FMP criteria.

Sampling activities at ER-12-4 included collection of the initial discharge $^{3}H$, groundwater, and FMP samples. Samples were collected after 8,311 gal of groundwater was purged from the well. Daily $^{3}H$ and wellhead sampling port results did not exceed FMP criteria.

On April 15, 2015, the pump at ER-12-1 was turned on, and 11,964 gal of groundwater was purged into the partially lined sump. All the sample analytical results were below the criteria in the *Water Pollution Control Permit NEV 96021* (Murphy, 2013).

### *5.1.4 FMP Sampling on Yucca Flat*

At Yucca Flat, wells ER-2-1, WW-2, WW-3 were discharged to a sump. TW-7 and UE-7nS were sampled with a bailer, so there was no discharge from either well.

Groundwater produced from the purging of ER-2-1 was directed into a lined sump at the well site. A total of 9,871 gal of groundwater was discharged to the lined sump. FMP daily $^{3}H$ and wellhead sampling port results did not exceed FMP criteria.

Groundwater samples were collected from WW-2 for $^{3}H$ analysis from the initial discharge (when the dedicated submersible pump was started), during purging with the collection of daily $^{3}H$ samples, and with the collection of groundwater characterization and FMP samples. Tritium activities were below detection limits. A total of 80,300 gal of groundwater was produced from WW-2 and was discharged to the unlined sump. FMP daily $^{3}H$ and wellhead sampling port results did not exceed FMP criteria.

Sampling activities at WW-3 included collection of the initial discharge $^{3}H$, groundwater characterization, and FMP samples. Samples were collected after 8,311 gal of groundwater was purged from the well. FMP daily $^{3}H$ and wellhead sampling port results did not exceed FMP criteria.

# 6.0 Summary and Conclusions

The NNSS Integrated Groundwater Sampling Plan ensures routine sampling that is critical to understanding contaminant transport near and downgradient of the underground nuclear testing areas. Analytical data are generated in compliance with the UGTA Activity QAP (NNSA/NSO, 2012), FFACO (1996, as amended), and DOE Order 458.1 (DOE, 2013).

The maximum $^{3}H$ concentrations for the most current samples from each Sampling Plan location are presented in Appendix A. These data are summarized for each location type and CAU in Table 6-1. Table 6-1 identifies the location type in each CAU, the number (n) of $^{3}H$ detections for each location type (>MDC), and the number of locations where $^{3}H$ has exceeded the 20,000 pCi/L MCL (>MCL). It is important to note that while in some cases (e.g., Frenchman Flat), there are currently no early detection or distal locations; the characterization locations will likely be transitioned into these types once a baseline has been established.

**Table 6-1**
**Number of $^{3}H$ Measurements (n), Detections (>MDC), and MCL Exceedances (>MCL) for Each Location Type and CAU**

| CAU | Criteria | Characterization | Source/Plume | Early Detection | Distal | Community |
|---|---|---|---|---|---|---|
| Frenchman Flat | n | 2 | 3 | 0 | 0 | 0 |
| | >MDC | 0 | 3 | 0 | 0 | 0 |
| | >MCL | 0 | 2 | 0 | 0 | 0 |
| Pahute Mesa | n | 22 | 10 | 7 | 2 | 9 |
| | >MDC | 11 | 10 | 3 | 0 | 0 |
| | >MCL | 2 | 8 | 0 | 0 | 0 |
| Rainier Mesa [a] | n | 8 | 2 | 0 | 6 | 0 |
| | >MDC | 2 | 2 | 0 | 1 | 0 |
| | >MCL | 0 | 2 | 0 | 0 | 0 |
| Yucca Flat | n | 8 | 5 | 5 | 1 | 0 |
| | >MDC | 2 | 5 | 0 | 0 | 0 |
| | >MCL | 0 | 3 | 0 | 0 | 0 |

[a] No $^{3}H$ data are available for three characterization and one distal location.

A total of 16 wells (16 separate intervals) (Table 2-1) were sampled in 2015 to directly support the Sampling Plan. The analytical results for all of these samples are presented in Appendix B. Samples were collected from four UGTA CAUs; no samples were collected in Frenchman Flat (CAU 98).

Six characterization locations were sampled in 2015: one in Pahute Mesa, three in Yucca Flat, and two in Rainier Mesa. Of these locations, one was sampled for $^{3}H$ using a bailer (TW-7). Five were sampled using a pump for the full characterization suite. Results from the characterization samples were consistent with previously collected samples as shown in the piper diagrams for each CAU. Wells ER-12-3_m1 and ER-12-4_m1 in RM/SM have provided a base line of groundwater characterization data and these wells will be recategorized to early detection wells.

Two source/plume wells were sampled in Pahute Mesa and one in Yucca Flat in 2015. Tritium exceeded the MCL for both locations on Pahute Mesa but had decreased since 2011. Most of the other RNs analyzed by the commercial laboratory and LLNL, except gross alpha and beta, are below the analytical detection limits for the ER-20-5-3 samples. At ER-20-5-1, $^{36}Cl$ and $^{239/240}Pu$ were detected by the commercial laboratory at 5.7 and 0.4 pCi/L, respectively. In Yucca Flat, the source/plume well (UE-7nS) was only bailed for a $^{3}H$ analysis by the commercial laboratory and LLNL. Low-level $^{3}H$ results report 53.3 pCi/L.

Three early detection locations (ER-EC-6, ER-20-1, and WW-2) were sampled in 2015. These samples were pumped from the wells, and no $^{3}H$ was detected other than at ER-EC-6, where $^{3}H$ results have increased from 1.7 pCi/L (2009) to 4.6 pCi/L (2015).

Four distal well locations and no community wells were sampled in 2015. Distal wells are located potentially downgradient of testing, and no $^{3}H$ was detected in the samples.

# 7.0 References

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# Appendix A

# COC and COPC Concentrations for NNSS Integrated Sampling Plan Locations

# Table A.1-1
# Maximum $^{3}H$ Concentrations for Most Recent Year Sampled COC
(Page 1 of 4)

| Type | Sampling Locations | ISPID | HSU | Sample Year | Maximum $^{3}H$ Concentration (pCi/L) [a] |
|---|---|---|---|---|---|
| **Frenchman Flat** | | | | | |
| Characterization | ER-5-3 | ER-5-3_p2 | BLFA/OAA | 2001 | <1.5 [b] |
| | ER-5-5 | ER-5-5_m1 | BLFA/OAA | 2013 | 1.1 [c] |
| Source/Plume | RNM-1 | RNM-1_m5 | AA | 2014 | 620 |
| | RNM-2S | RNM-2S_m1 | AA | 2014 | 77,000 [d] |
| | UE-5n | UE-5n_m1 | AA | 2014 | 153,000 |
| **Pahute Mesa (Central and Western)** | | | | | |
| Characterization | ER-20-7 | ER-20-7_m1 | LPCU/TSA/CHZCM | 2014 | 15,600,000 |
| | ER-20-8 | ER-20-8_p3 | UPCU/SPA | 2014 | 1,770 |
| | | ER-20-8_p2 | MPCU/TCA/LPCU | 2014 | 8,800 |
| | | ER-20-8_m2 | MPCU/TCA/LPCU | **2015** | **4,590** |
| | | ER-20-8_p1 | LPCU/TSA/CHZCM | 2014 | 128 |
| | ER-20-8-2 | ER-20-8-2_m1 | BA/UPCU/SPA/MPCU | 2014 | 2,600 |
| | ER-20-11 | ER-20-11_m1 | FCCU/BA/UPCU | 2013 | 191,000 |
| | ER-EC-2A | ER-EC-2A_m3 | FCCM | 2010 | <270 [e] |
| | ER-EC-5 | ER-EC-5_m1-3 | TMCM | 2003 | <320 [e] |
| | ER-EC-8 | ER-EC-8_m1-3 | FCCM/TMCM | 2010 | <340 [e] |
| | ER-EC-11 | ER-EC-11_p3 | FCCU/BA | 2014 | 16,100 |
| | | ER-EC-11_p2 | UPCU/TCA | 2014 | 12.1 |
| | | ER-EC-11_p1 | TSA/CHCU | 2014 | 11.8 |
| | ER-EC-12 | ER-EC-12_m2 | THCM/TCA/LPCU | 2011 | <2.1 |
| | | ER-EC-12_m1 | TSA/CHCU | 2012 | 4.2 |
| | ER-EC-13 | ER-EC-13_m2 | FCCM | 2012 | <2.5 |
| | | ER-EC-13_m1 | FCCM | 2013 | <3.0 |
| | ER-EC-14 | ER-EC-14_m2 | RMWTA | 2014 | <2.2 |
| | | ER-EC-14_m1 | RMWTA | 2014 | <2.0 |
| | ER-EC-15 | ER-EC-15_m3 | FCCU/CPA/PBPCU | 2013 | <2.2 |
| | | ER-EC-15_m2 | TCA/LPCU | 2014 | <2.1 |
| | | ER-EC-15_m1 | TSA/CHCU | 2014 | <2.0 |

## Table A.1-1
## Maximum $^{3}H$ Concentrations for Most Recent Year Sampled COC
(Page 2 of 4)

| Type | Sampling Locations | ISPID | HSU | Sample Year | Maximum $^{3}H$ Concentration (pCi/L) [a] |
|---|---|---|---|---|---|
| Source/Plume | ER-20-5-1 | ER-20-5-1_m1 | TSA/CHZCM | **2015** | **24,800,000** |
| | ER-20-5-3 | ER-20-5-3_m1 | CHZCM | **2015** | **84,000** |
| | ER-20-6-1 | ER-20-6-1_m1 | CHZCM | 1998 | 3,200 |
| | ER-20-6-2 | ER-20-6-2_m1 | CHZCM | 1997 | 71,000 |
| | ER-20-6-3 | ER-20-6-3_m1 | CHZCM | 1998 | 1,110 |
| | U-19ad PS 1A | U-19ad PS1A_m1 | PLFA | 2008 | 12,900,000 |
| | U-19q PS 1D | U-19q PS1D_m1 | NA | 2003 | 11,000,000 |
| | U-19v PS 1D | U-19v PS1D_m1 | BFCU | 2009 | 84,900,000 |
| | U-20n PS 1D | U-20n PS1D_m2 | CHZCM | 2005 | 33,300,000 |
| | UE-20n1 | UE-20n1_o2 | CHZCM | 2012 | 55,500,000 |
| Early Detection | ER-20-1 | ER-20-1_o1 | TMLVTA/PBPCU/BA/ UPCU/TCA | **2015** | **<2.12** |
| | U-20 WW | U-20 WW_m1 | CHZCM | 1999 | <29 |
| | PM-3 | PM-3_p1 | TCA/LPCU | 2014 | 78 |
| | | PM-3_p2 | UPCU | 2014 | 237 |
| | ER-EC-6 | ER-EC-6_m2 | TSA/CHZCM | 2014 | <2.35 |
| | ER-EC-6 | ER-EC-6_m3 | UPCU/TCA | 2014 | <2.01 |
| | ER-EC-6 | ER-EC-6_m4 | FCCU/BA | **2015** | **5.18** |
| Distal | ER-EC-1 | ER-EC-1_m1-3 | CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM | 2009 | <1 |
| | UE-18r | UE-18r_o1 | TMCM | 2007 | <22 |
| Community | Ash-B | Ash-B_p1 | Volcanic rocks | 2014 | <183 |
| | | Ash-B_p2 | Valley fill | 2014 | <177 |
| | U.S. Ecology | U.S. Ecology_m1 | NA | 2012 | <22 |
| | Cind-R-Lite Mine | Cind-R-Lite Mine_m1 | Valley fill | 2012 | <24 |
| | Peacock Ranch | Peacock Ranch_s1 | NA | 2012 | <21 |
| | Revert Spring | Revert Spring_s1 | NA | 2012 | <22 |
| | Spicer Ranch | Spicer Ranch_s1 | NA | 2012 | <21 |
| | Amargosa Valley RV Park | Amargosa Valley RV Park_m1 | NA | 2012 | <24 |
| | EW-4 | EW-4 m1 | NA | 2011 | <30 |

## Table A.1-1
## Maximum $^{3}H$ Concentrations for Most Recent Year Sampled COC
(Page 3 of 4)

| Type | Sampling Locations | ISPID | HSU | Sample Year | Maximum $^{3}H$ Concentration (pCi/L) [a] |
|---|---|---|---|---|---|
| **RM/SM** | | | | | |
| Characterization | ER-12-3 | ER-12-3_p1 | LTCU/OSBCU/ATCU | -- | -- |
| | | ER-12-3_m1 | LCA3 | **2015** | **0.5** |
| | ER-12-4 | ER-12-4_p1 | LVTA/BRCU/ LTCU/OSBCU | -- | -- |
| | | ER-12-4_m1 | LCA3 | **2015** | **<0.2** |
| | UE-12t-6 | UE-12t-6_o1 | LTCU/OSBCU/LCCU | -- | -- |
| | ER-16-1 | ER-16-1_m1 | LCA | 2008 | <340 |
| | UE-18t | UE-18t_p1 | TMCM | 1999 | 144 |
| | ER-30-1 | ER-30-1_p1 | FCCM | 1996 | <215 |
| Source/Plume | U-12n.10 Vent Hole | U-12n.10 Vent_m1 Hole_m1 | LTCU | 2008 | 6,260,000 |
| | U-12n Vent Hole 2 | U-12n Vent Hole_2_m1 | LTCU | 2011 | 1,030,000 |
| Distal | ER-19-1 | ER-19-1_p2 | OSBCU | -- | -- |
| | | ER-19-1_p1 | RVA/ATCU | 2013 | <30 |
| | ER-12-1 | ER-12-1_m5 | UCCU | **2015** | **18.4** |
| | TW-1 | TW-1_m1 | OSBCU/RVA/ LTCU/ATCU/LCA3 | 2013 | <21 |
| | UE-16d WW | UE-16d WW_m1 | UCCU | **2015** | **<223** |
| | WW-8 | WW-8_m26 | BRA | **2015** | **<229** |
| **YF/CM** | | | | | |
| Characterization | ER-2-1 | ER-2-1_m1 | TMWTA/ TMLVTA/LTCU | **2015** | **1,013** |
| | ER-5-3-2 | ER-5-3-2_m1 | LCA | 2001 | <1.5 |
| | ER-6-1-2 | ER-6-1-2_o1 | LCA | 2004 | <370 |
| | ER-7-1 | ER-7-1_m1 | LCA | 2014 | <3.8 [g] |
| | TW-7 | TW-7_m1 | LTCU | **2015** | **<2.5** |
| | UE-1h | UE-1h_o1 | LCA | 2014 | <2.0 |
| | UE-10j | UE-10j_m3 | LCA | 1997 | <210 |
| | WW-3 | WW-3_m1 | AA | **2015** | **6.3** |
| Source/Plume | UE-2ce | UE-2ce_m1 | LCA3 | 2008 | 265,000 |
| | U-3cn PS 2 | U-3cn PS 2_m1 | LTCU | 2007 | 7,680,000 |
| | WW-A | WW-A_m1 | AA | 2012 | 355 |
| | U-4u PS 2A | U-4u PS 2A_p1 | LTCU | 2008 | 24,100,000 |
| | UE-7nS | UE-7nS_m1 | LCA | **2015** | **53.3** |

# Table A.1-1
# Maximum $^{3}H$ Concentrations for Most Recent Year Sampled COC
(Page 4 of 4)

| Type | Sampling Locations | ISPID | HSU | Sample Year | Maximum $^{3}H$ Concentration (pCi/L) [a] |
|---|---|---|---|---|---|
| Early Detection | UE-1q | UE-1q_o1 | LCA | 2013 | <26 |
| | WW-2 | WW-2_m1 | LCA | **2015** | **<2.18** |
| | U-3cn 5 | U-3cn 5_o1 | LCA | 2011 | <6.5 |
| | TW-D | TW-D_m1 | ATCU/LCA | 2013 | <27 |
| | WW C-1 | WW C-1_m1 | LCA | 2012 | <27 |
| Distal | Army 1 WW | Army 1 WW_m1 | LCA | **2015** | **<229** |

BFCU = Bullfrog confining unit
BLFA = Basalt lava-flow aquifer
BRCU = Belted Range confining unit
CHCU = Calico Hills confining unit
CPA = Comb Peak aquifer
FCCM = Fortymile Canyon composite unit
LCA3 = Lower carbonate aquifer-upper plate
LCCU = Lower clastic confining unit
LPCU = Lower Paintbrush confining unit
LVTA = Lower vitric-tuff aquifer
MPCU = Middle Paintbrush confining unit
OAA = Older alluvial aquifer
OSBCU = Oak Spring Butte confining unit
PBPCU = Post-Benham Paintbrush confining unit
PLFA = Paintbrush lava-flow aquifer
RMWTA = Rainier Mesa welded-tuff aquifer
RVA = Redrock Valley aquifer
SPA = Scrugham Peak aquifer
TMCM = Timber Mountain composite unit

-- = Location has never been sampled.

[a] The largest $^{3}H$ concentration for the most recent year sampled is reported. Commercial laboratory values for standard analyses (MDC approximately 300 pCi/L) are reported when available. Values below the detection limit are reported as "<MDC."
[b] The reported value is for a sample from ER-5-3_m1-2.
[c] The reported activity is near the MDC (0.8 pCi/L) and therefore has a high level of associated uncertainty.
[d] The analysis for this sample did not meet certain QC requirements and is therefore considered an estimate.
[e] $^{3}H$ was reported as 77 pCi/L (ER-EC-2a), 7.3 pCi/L (ER-EC-5), and 5.4 pCi/L (ER-EC-8) in 2003. This detection is suspected to have resulted from post-sampling contamination. Samples were stored near other samples that contained high levels of $^{3}H$. Low-level $^{3}H$ analyses have not been performed since 2003.
[f] Reported values were less than the typical MDC for the analytical method (0.5 pCi/L).
[g] $^{3}H$ is considered a nondetect (<3.8 pCi/L) and is reported as less than the MDC (2.2 pCi/L) plus the error (1.6 pCi/L).

Notes:
(1) Locations sampled in CY 2015 are in bold type.
(2) Values highlighted in blue exceed the 20,000 pCi/L SDWA MCL (EPA, 2002).

# Table A.1-2
## Maximum Most Recent COPC Concentrations (pCi/L) for Select Sampling Locations (Locations with Detectable $^{3}H$ and Characterization Locations)

(Page 1 of 4)

| Location | ISPID | Sampled Year | $^{14}C$ | $^{36}Cl$ | $^{90}Sr$ | $^{99}Tc$ | $^{129}I$ | $^{137}Cs$ | $^{238}Pu$ | $^{239/240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **Frenchman Flat** | | | | | | | | | | |
| **Characterization** | | | | | | | | | | |
| ER-5-3 | ER-5-3_m2 | 2001 | <460 | 4.3E-04 [a] | <0.56 | <4.7 | <4.7 | <7.9 | <0.07 | <0.02 |
| ER-5-5 | ER-5-5_m1 | 2013 | 0.13 | 3.4E-04 | 1.22 [b] | <8.6E-04 | 2.5E-06 | <6.4 | <0.02 | <0.05 |
| **Source/Plume** | | | | | | | | | | |
| RNM-1 | RNM-1_m4-5 | 2014 | J <8.3 | 3.6E-04 | 8.90 [b] | <4.5E-04 | 1.8E-05 | 0.68 [c] | J <0.1 | J <0.1 |
| RNM-2S | RNM-2S_m1 | 2014 | J <420 | 4.8E-02 | 2.58 [b] | 0.174 | 3.9E-04 | <3.6 [d] | <0.02 | <0.03 |
| UE-5n | UE-5n_m1 | 2014 | <420 | 0.32 | 1.22 [b] | <4.5E-04 | 8.6E-06 | <8.3 [c] | <0.02 | <0.01 |
| **Pahute Mesa** | | | | | | | | | | |
| **Characterization** | | | | | | | | | | |
| ER-20-7 | ER-20-7_m1 | 2014 | 118 | 2.52 | <0.5 | <7.0 | 0.14 | <6.2 | <0.01 | U 0.04 |
| ER-20-8 | ER-20-8_m1 [e] | 2011 | 0.06 | 9.2E-04 | <0.47 | <7.1 | 3.5E-05 | <0.05 | <0.02 | <0.001 |
| | ER-20-8_m2 | **2015** | **J- 0.34** | **5.4E-03** | **<0.46** | **<7.2** | **3.76E-04** | **<6.9** | **<0.03** | **<0.024** |
| ER-20-8-2 | ER-20-8-2_m1 | 2014 | J- 0.22 | 3.4E-03 | <0.48 | 0.067 | 2.4E-04 | <7.8 | <0.02 | <0.02 |
| ER-20-11 | ER-20-11_m1 | 2013 | 3.84 | 7.3E-02 | <0.39 | 0.953 | 4.4E-03 | 6.2 | <0.02 | <0.02 |
| ER-EC-2A | ER-EC-2A_m3 | 2010 | <390 | 9.2E-04 [d] | <0.55 | <7.9 | <3.9 | <7.7 | <0.01 | <0.02 |
| ER-EC-5 | ER-EC-5_m1-3 | 2003 | <340 | 3.0E-04 | <0.55 | <5.2 | <3.5 | <8.0 | <0.03 | <0.03 |
| ER-EC-8 | ER-EC-8_m1-3 | 2010 | <400 | 7.7E-04 [d] | <0.37 | <6.1 | <2.9 | <9.1 | <0.02 | <0.03 |
| ER-EC-11 | ER-EC-11_p1 | 2014 | 0.09 | 8.0E-04 | <0.28 | <4.5E-04 | 1.3E-06 | <7.5 | <0.02 | <0.03 |
| | ER-EC-11_p2 | 2014 | 0.08 | 1.6E-03 | <0.35 | <4.5E-04 | 2.3E-04 | <7.3 | <0.03 | <0.03 |
| | ER-EC-11_p3 | 2014 | J- 0.63 | 7.8E-03 | <0.29 | <4.5E-04 | 3.8E-04 | <6.8 | <0.02 | <0.02 |
| ER-EC-12 | ER-EC-12_m1 | 2012 | 0.14 | 4.6E-03 | U 0.67 | <5.8 | 3.7E-04 | <0.02 | <0.03 | <0.04 |
| | ER-EC-12_m2 | 2011 | 0.03 | 2.9E-04 | <0.45 | <7.4 | 1.1E-06 | <0.04 | <0.02 | <0.02 |

# Table A.1-2
## Maximum Most Recent COPC Concentrations (pCi/L) for Select Sampling Locations (Locations with Detectable $^{3}H$ and Characterization Locations)
(Page 2 of 4)

| Location | ISPID | Sampled Year | $^{14}C$ | $^{36}Cl$ | $^{90}Sr$ | $^{99}Tc$ | $^{129}I$ | $^{137}Cs$ | $^{238}Pu$ | $^{239/240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ER-EC-13 | ER-EC-13_m1 | 2013 | 0.14 | 9.8E-04 | <0.42 | <6.2 | 1.8E-07 | <0.06 | <0.02 | <0.03 |
| | ER-EC-13_m2 | 2012 | 0.03 | 1.0E-03 | <0.28 | J <6.5 | 1.3E-07 | <0.08 | <0.01 | <0.02 |
| ER-EC-14 | ER-EC-14_m1 | 2014 | 0.07 | 3.6E-04 | 1.10 [b] | <4.5E-04 | 1.8E-07 | <7.3 | <0.02 | <0.004 |
| | ER-EC-14_m2 | 2014 | 0.02 | 3.6E-04 | <0.32 | J 0.006 | 1.1E-07 | <8.7 | J <0.05 | <0.004 |
| ER-EC-15 | ER-EC-15_m1 | 2014 | 0.01 | 5.3E-04 | <0.37 | <0.34 | 1.5E-06 | <7.6 | J <0.13 | <0.004 |
| | ER-EC-15_m2 | 2014 | 0.02 | 1.0E-03 | <0.33 | J 0.002 | 7.1E-06 | <6.6 | -- | <0.004 |
| | ER-EC-15_m3 | 2013 | 0.08 | 1.1E-03 | <0.37 | <4.2E-04 | 1.2E-06 | <8.9 | -- | <0.004 |
| **Source/Plume** | | | | | | | | | | |
| ER-20-5-1 | ER-20-5-1_m1 | **2015** | **165** | **5.7** | **<0.55** | **0.428** | **0.195** | **<6.7** | **<0.033** | **0.4** |
| ER-20-5-3 | ER-20-5-3_m1 | **2015** | **2.74** | **1.4E-02** | **<0.54** | **0.009** | **4.0E-04** | **<6.1** | **<0.039** | **<0.052** |
| ER-20-6-1 | ER-20-6-1_m1 | 1998 | 0.04 | 6.0E-04 | 2.19 [h] | <0.03 | <1.3 [i] | UJ 17.2 | <0.03 [i] | <0.03 [i] |
| ER-20-6-2 | ER-20-6-2_m1 | 1997 | 0.07 | 6.9E-04 | <0.57 [h] | <3.7 | <3.6 | <3.9 | 0.02 | <0.05 |
| ER-20-6-3 | ER-20-6-3_m1 | 1998 | 0.02 | 3.3E-04 | 4.21 [h] | <0.008 | <3.7 [i] | UJ 16.2 | <0.03 [i] | <0.05 [i] |
| U-19ad PS 1A | U-19ad PS1A_m1 | 2008 | 158 | 7.2 | 1,780 [g] | 25.4 | 1.3 | 28,900 | 3.76 | 47 |
| U-19q PS 1D | U-19q PS1D_m1 | 2003 | 293 | 1.8E-02 | <0.75 [f] | 0.08 [f] | 2.0E-03 | 11.9 | <10.8 | <0.02 |
| U-19v PS 1D | U-19v PS1D_m1 | 2009 | 76.4 | 33 | -- | 2.89 | 2.7 | 0.57 [h] | -- | <0.004 |
| U-20n PS 1D | U-20n PS1D_m2 | 2005 | 183 [e] | 0.48 | J 202 | 0.93 | 0.14 | 1,970 [e] | <1.21 [e] | 0.46 |
| UE-20n 1 | UE-20n 1_o2 | 2012 | 218 | 0.89 | -- | 49.2 | 0.32 | 0.003 | -- | <0.004 |
| **RM/SM** | | | | | | | | | | |
| **Characterization** | | | | | | | | | | |
| ER-30-1 | ER-30-1_p2 | 1996 | -- | -- | <0.42 | <2.27 | -- | 7.88 | <0.06 | <0.06 |
| UE-12t-6 | UE-12t-6_o1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| ER-12-3 | ER-12-3_m1 | **2015** | **J+ 0.012** | **1.2E-04** | **<0.33** | **<7.0** | **<0.62** | **<7.6** | **<0.028** | **<0.022** |
| | ER-12-3_p1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

# Table A.1-2
## Maximum Most Recent COPC Concentrations (pCi/L) for Select Sampling Locations (Locations with Detectable $^{3}H$ and Characterization Locations)

(Page 3 of 4)

| Location | ISPID | Sampled Year | $^{14}C$ | $^{36}Cl$ | $^{90}Sr$ | $^{99}Tc$ | $^{129}I$ | $^{137}Cs$ | $^{238}Pu$ | $^{239/240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|---|
| ER-12-4 | ER-12-4_m1 | **2015** | **J+ 0.014** | **1.8E-04** | **<0.34** | **<6.9** | **<0.71** | **<6.4** | **<0.018** | **<0.018** |
| | ER-12-4_p1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| ER-16-1 | ER-16-1_m1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| UE-18t | UE-18t_p1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **Source/Plume** | | | | | | | | | | |
| U-12n Vent Hole 2 | U-12n Vent Hole 2_m1 | 2011 | 6.57 | 2.2 | <0.28 | 0.005 | <0.60 | 1.2 | <109 | 1.2 |
| U-12n.10 Vent Hole | U-12n.10 Vent Hole_m1 | 2008 | 150 | 1.0E+02 | -- | 0.19 | 0.99 | 3.3 | -- | 1.6 |
| **YF/CM** | | | | | | | | | | |
| **Characterization** | | | | | | | | | | |
| **ER-2-1** | **ER-2-1_m1** | **2015** | **J+ 0.06** | **2.1E-04** | **<0.58** | **<7.3** | **<0.87** | **<7.3** | **<0.084** | **<0.067** |
| ER-5-3-2 | ER-5-3-2_m1 | 2001 | <460 | 2.9E-04 | <0.5 | J <3.5 | <1.3 | <7.9 | <0.04 | <0.03 |
| ER-6-1-2 | ER-6-1-2_m1 | 2003 | 0.01 | 2.1E-04 | -- | -- | -- | -- | -- | -- |
| ER-7-1 | ER-7-1_m1 | 2014 | 0.08 | 1.5E-04 | <0.52 | <6.7 | <0.74 | <6.7 | <0.02 | <0.02 |
| TW-7 | TW-7_m1 | 1958 | -- | -- | <6 | -- | -- | -- | -- | -- |
| TW-D | TW-D_m1 | 2012 | J <235 | -- | J <0.52 | <7.6 | -- | <2.9 | <0.03 | <0.03 |
| UE-1h [e] | UE-1h_o1 | 2014 | -- | -- | -- | -- | -- | -- | -- | -- |
| UE-10j | UE-10j_m3 | 1997 | -- | 1.8E-04 | -- | -- | -- | -- | -- | -- |
| **WW-3** | **WW-3_m1** | **2015** | **J+ 0.01** | **2.7E-04** | **<0.42** | **<6.7** | **J <0.73** | **<7.1** | **<0.014** | **<0.014** |
| **Source/Plume** | | | | | | | | | | |
| U-3cn PS 2 | U-3cn PS 2_m1 | 2007 | 258 | 24 | 2.35 [i] | 35.7 | 0.19 | 1.0 | <0.08 [i] | 0.06 |
| U-4u PS 2A | U-4u PS 2A_p1 | 2008 | 326 [e] | 19 | 3.11 [i] | 26.5 | 0.15 | 92 | 0.03 [f] | 0.44 |
| UE-2ce | UE-2ce_m1 | 2008 | 1.95 | 1.3 | 2.32 [l] | 0.0023 | 0.011 | 1.2 | -- | <0.01 |
| UE-7nS [m] | UE-7nS_m1 | 2012 | <235 | 2.4E-04 | <0.52 | <7.64 | 4.1E-05 | <5.64 | <0.03 | <0.04 |

# Table A.1-2
## Maximum Most Recent COPC Concentrations (pCi/L) for Select Sampling Locations (Locations with Detectable $^{3}H$ and Characterization Locations)
(Page 4 of 4)

| Location | ISPID | Sampled Year | $^{14}C$ | $^{36}Cl$ | $^{90}Sr$ | $^{99}Tc$ | $^{129}I$ | $^{137}Cs$ | $^{238}Pu$ | $^{239/240}Pu$ |
|---|---|---|---|---|---|---|---|---|---|---|
| WW-A | WW A_m1 | 2012 | <235 | -- | <0.52 [k] | <7.69 [k] | -- | <3.35 | <0.03 | <0.03 |

-- = Not available

[a] No $^{36}Cl$ data are available for ER-5-3_m2. The reported data are for a sample collected from ER-5-3_m1-2.
[b] The presence of other RNs or interferences may cause positive bias in the target analyte's measured and reported concentration.
[c] These data are not available for this sample. This result is associated with a sample collected in 2007.
[d] These data are not available for this sample. This result is associated with a sample collected in 2003.
[e] UE-1h_o1 was not analyzed for COPCs in 2014.
[f] These data are not available for this sample. This result is associated with a sample collected in 1998.
[g] These data are not available for this sample. This result is associated with a sample collected in 2004.
[h] These data are not available for this sample. This result is associated with a sample collected in 1996.
[i] These data are not available for this sample. This result is associated with a sample collected in 1997.
[j] These data are not available for this sample. This result is associated with a sample collected in 2005.
[k] These data are not available for this sample. This result is associated with a sample collected in 2011.
[l] These data are not available for this sample. This result is associated with a sample collected in 1984.
[m] This location was only sampled for $^{3}H$ in 2015.

J = Result is estimated.
J- = Result is estimated and is biased low.
J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Notes:
(1) Locations sampled in 2015 are in bold type.
(2) Values highlighted in blue exceed the SDWA MCL (EPA, 2002).

## A.1.0 References

EPA, see U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 2002. *Radionuclides in Drinking Water: A Small Entity Compliance Guide,* EPA 815-R-02-001. Washington, DC: Office of Ground Water and Drinking Water.

# Appendix B

# 2015 Analytical Results

# B.1.0 Frenchman Flat

No UGTA Activity groundwater samples were collected from wells in Frenchman Flat in 2015.

# B.2.0 Pahute Mesa

This section presents the commercial (see Tables B.2-1, B.2-3, and B.2-5) laboratory and LLNL (see Tables B.2-2, B.2-4, and B.2-6) results for one characterization (Tables B.2-1 and B.2-2), two source/plume (Tables B.2-3 and B.2-4), and two early detection wells (Tables B.2-5 and B.2-6) in the Pahute Mesa CAUs.

**Table B.2-1**
**Commercial Laboratory Results for**
**Pahute Mesa Characterization Samples**
(Page 1 of 2)

| Analyte | ER-20-8_m2<br>03/07/2015 | |
|---|---|---|
| **Miscellaneous** | | |
| pH (SU) | J- 8.5 | J- 8.6 |
| SEC (µS/cm) | 440 | 430 |
| **Major and Minor Constituents (mg/L)** | | |
| Alkalinity as $CaCO_3$ | 110 | 120 |
| $HCO_3$ [a] | 134.1 | 146.3 |
| $CO_3$ [a] | <12 | <12 |
| Br | J 0.15 | J 0.14 |
| Cl | 28 | 29 |
| F | 4.0 | 4.1 |
| $SO_4$ [b] | 51 | 51 |
| Ca | 2.0 \| 2.0 | 2.0 \| 2.0 |
| Mg | J 0.025 \| U 1 | <0.013 \| J 0.021 |
| K | 2.2 \| 2.2 | 2.2 \| 2.2 |
| Na | 86 \| 87 | 87 \| 88 |
| Al | U 0.2 \| U 0.2 | U 0.2 \| U 0.2 |
| Fe | 0.17 \| J- 0.078 | J- 0.072 \| J- 9.6E-3 |
| Silica [b] | 114.4 \| 114.4 | 114.4 \| 114.4 |
| **Trace Constituents (µg/L)** | | |
| Ag | <1.1 \| <1.1 | <1.1 \| <1.1 |
| As | J- 8.6 \| <3.9 | <3.9 \| <3.9 |
| Ba | J- 0.31 \| <0.19 | <0.19 \| <0.19 |
| Cd | <0.33 \| <0.33 | <0.33 \| <0.33 |
| Cr | <0.51 \| <0.51 | <0.51 \| <0.51 |
| Li | J 90 \| J 89 | J 91 \| J 91 |

# Table B.2-1
# Commercial Laboratory Results for
# Pahute Mesa Characterization Samples
(Page 2 of 2)

| Analyte | ER-20-8_m2 03/07/2015 | |
|---|---|---|
| Mn | J- 2.6 \| J- 1.2 | J- 1.2 \| J- 0.78 |
| Pb | J- 2.1 \| <1.3 | J- 1.6 \| <1.3 |
| Se | J 2.9 \| J <2.7 | J <2.7 \| J <2.7 |
| Sr | <0.078 \| <0.078 | <0.078 \| <0.078 |
| $^{238}$U | 2.5 \| 2.5 | 2.6 \| 2.5 |
| **RNs (pCi/L)** | | |
| Gross Alpha | U 3.1 | 3.6 |
| Gross Beta | <2.6 | U 3.5 |
| $^{3}$H | 4,560 | 4,590 |
| $^{14}$C | <420 | <400 |
| $^{26}$Al | <7.7 | <8.6 |
| $^{36}$Cl | <2.5 | <2.8 |
| $^{90}$Sr | <0.46 | <0.45 |
| $^{94}$Nb | <6.1 | <7.3 |
| $^{99}$Tc | <7.7 | <7.2 |
| $^{129}$I | J <0.81 | J <0.84 |
| $^{137}$Cs | <6.2 | <6.9 |
| $^{152}$Eu | <33 | <37 |
| $^{154}$Eu | <35 | <38 |
| $^{235}$U | <22 | <47 |
| $^{238}$Pu | <0.041 | <0.03 |
| $^{239/240}$Pu | <0.032 | <0.024 |
| $^{241}$Am | <7.4 | <34 |

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L $HCO_3$/mg/L $CaCO_3$ ($HCO_3$) and 0.6 mg/L $CO_3$/mg/L $CaCO_3$ ($CO_3$).
[b] Values converted from laboratory reported (silicon) by multiplying times 2.139 mg silica/mg silicon.

F = Fluorine

J = Result is estimated.
J- = Result is estimated and is biased low.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.

Notes:
(1) Values reported with a "|" indicate unfiltered | filtered sample results. Only filtered samples were collected and reported when a single metal result is shown. Unfiltered samples were analyzed for RNs.
(2) Nondetects are reported as "<Detection Limit."

# Table B.2-2
# LLNL Results for Pahute Mesa Characterization Samples

| Analyte | ER-20-8_m2 03/08/2015 | |
|---|---|---|
| **Major and Minor Constituents (mg/L)** | | |
| Br | 0.599 | 0.597 |
| Cl | 27.19 | 27.32 |
| F | 4.41 | 4.37 |
| $SO_4$ | 48.41 | 48.76 |
| Ca | 1.98 | 1.97 |
| Mg | 0.0201 | 0.0194 |
| K | 2.09 | 2.08 |
| Na | 90 | 90 |
| Al | 0.05 | 0.049 |
| Fe | 0.019 | 0.0196 |
| **Trace Constituents (μg/L)** | | |
| As | 6.72 | 6.6 |
| Ba | 1.18 | 1.17 |
| Cd | <0.015 | <0.015 |
| Cr | 0.49 | 0.53 |
| Pb | 0.075 | 0.059 |
| Mn | 1.48 | 1.41 |
| Se | <4,500 | <2,100 |
| Ag | <0.018 | <0.009 |
| Sr | 1.7 | 1.65 |
| U | 2.71 | 2.67 |
| **RNs (pCi/L)** | | |
| $^{3}H$ | 4,019 | 4,056 |
| $^{14}C$ | J- 0.34 | -- |
| $^{36}Cl$ | 5.35E-03 | 5.49E-03 |
| $^{129}I$ | 3.6E-04 | 3.8E-04 |
| $^{239/240}Pu$ | J 4.0E-04 | J 3.0E-04 |

J- = Result is estimated and is biased low.
-- = Not analyzed

Note: Nondetects are reported as "<MDC".

# Table B.2-3
# Commercial Laboratory Results (pCi/L) for Pahute Mesa Source/Plume Samples

| Analyte | ER-20-5-3_m1 03/13/2015 | | ER-20-5-1_m1 04/02/2015 | |
|---|---|---|---|---|
| Gross Alpha | 37.4 | 33.2 | 16.4 | 15.7 |
| Gross Beta | 33.2 | 37.2 | 14.2 | 13.9 |
| $^{3}H$ | 8.4E+04 | 8.4E+04 | 2.48E+07 | 2.48E+07 |
| $^{14}C$ | <430 | <420 | <430 | <420 |
| $^{26}Al$ | <12.2 | <7.0 | <10.9 | <9.8 |
| $^{36}Cl$ | <4.2 | <3.5 | U 3.1 | 5.7 |
| $^{94}Nb$ | <8.4 | <5.7 | <9.2 | <8.2 |
| $^{99}Tc$ | <7.3 | <8.8 | U 13.7 | U 9.1 |
| $^{129}I$ | J <7.8 | J <8.1 | -- | -- |
| $^{137}Cs$ | <8.7 | <6.1 | <6.7 | <8.0 |
| $^{152}Eu$ | <47 | <32 | <52 | <40 |
| $^{154}Eu$ | <44 | <35 | <49 | <43 |
| $^{235}U$ | <38 | <45 | <56 | <77 |
| $^{238}Pu$ | <0.021 | <0.039 | U 0.039 | <0.033 |
| $^{239/240}Pu$ | <0.021 | <0.052 | 0.287 | 0.400 |
| $^{241}Am$ | <50 | <220 | <75 | <270 |

J = Result is estimated; QC sample results exceeded the control limits.
U = Result is less than the MDC plus 2-sigma error.
-- = Not analyzed

Notes: Nondetects are reported as “<MDC.”

# Table B.2-4
# LLNL Results for Pahute Mesa Source/Plume Samples

| Analyte | ER-20-5-3_m1 03/13/2015 | | ER-20-5-1_m1 04/02/2015 | |
|---|---|---|---|---|
| **Environmental Tracers** | | | | |
| C-13/12 (‰) | -4.48 | -4.56 | -1.75 | -1.66 |
| $^{14}C$ (pmc) | 1,806 | 1,631 | 65,904 | 54,371 |
| $^{36}Cl/Cl$ (ratio) | 2.41E-11 | 2.57E-11 | 4.91E-09 | 4.73E-09 |
| $^{129}I/^{127}I$ (ratio) | 3.8E-07 | 3.4E-07 | 1.4E-04 | 1.2E-04 |
| **RNs (pCi/L)** | | | | |
| $^{3}H$ | 8.2E+04 | 8.1E+04 | 2.57E+07 | 2.49E+07 |
| $^{14}C$ | 2.74 | 2.47 | 165 | 136 |
| $^{36}Cl$ | 0.0133 | 0.0142 | 3.79 | 3.63 |
| $^{99}Tc$ | -- | 0.00871 | 0.428 | 0.428 |
| $^{129}I$ | 4.04E-04 | 3.55E-04 | 0.195 | 0.176 |
| $^{239/240}Pu$ | 0.005 | 0.006 | 0.322 | 0.326 |

pmc = Percent modern carbon ‰ = Per mil

-- = Not analyzed

# Table B.2-5
# Commercial Laboratory Results for
# Pahute Mesa Early Detection Samples

| Analyte | ER-EC-6_m4 | | ER-20-1_o1 | |
|---|---|---|---|---|
| | 01/12/2015 | | 02/23/2015 | |
| **Major and Minor Constituents (mg/L)** | | | | |
| Alkalinity as $CaCO_3$ | 140 | 140 | 150 | 150 |
| $HCO_3$ [a] | 170.66 | 170.66 | 182.85 | 182.85 |
| $CO_3$ [a] | <12 | <12 | <12 | <12 |
| Cl | 53 | 52 | 56 | 56 |
| $SO_4$ | 78 | 76 | 88 | 87 |
| F | 2.7 | 2.7 | 3.1 | 3.1 |
| Br | 0.27 | 0.26 | 0.39 | 0.37 |
| Na | 120 \| 120 | 120 \| 120 | 130 \| 140 | 130 \| 130 |
| K | 2.6 \| 2.6 | 2.6 \| 2.6 | 3.7 \| 3.9 | 3.7 \| 3.7 |
| Ca | 4.5 \| 4.4 | 4.4 \| 4.4 | 5 \| 5 | 5 \| 4.9 |
| Mg | U 1 \| U 1 | U 1 \| U 1 | U 1 \| U 1 | U 1 \| U 1 |
| Al | <0.015 \| <0.015 | <0.015 \| <0.015 | 0.32 \| U 0.2 | U 0.2 \| U 0.2 |
| **RNs (pCi/L)** | | | | |
| Gross Alpha | U 2.8 | U 2.7 | 2.33 | 2.7 |
| Gross Beta | 4.4 | U 3.5 | U 2.2 | 5.2 |
| $^{3}H$ | -- | -- | <340 | <330 |
| $^{3}H$ (Low Level) | 5.18 | 4.42 | <2.12 | <2.23 |
| $^{14}C$ | J <330 | J <330 | <400 | <400 |
| $^{26}Al$ | <6.5 | <8.7 | <11.9 | <8.8 |
| $^{36}Cl$ | <3.1 | <3.2 | <2.6 | <2.7 |
| $^{90}Sr$ | <0.42 | <0.43 | U 0.69 | U 0.68 |
| $^{94}Nb$ | <6.3 | <7.2 | <8.6 | <8.1 |
| $^{99}Tc$ | <6.8 | <7.0 | J <7.6 | J <7.7 |
| $^{129}I$ | J <0.66 | J <0.68 | J <0.79 | J <0.83 |
| $^{137}Cs$ | <6.3 | <8.1 | <8.0 | <7.8 |
| $^{152}Eu$ | <30 | <39 | <43 | <45 |
| $^{154}Eu$ | <32 | <45 | <51 | <41 |
| $^{235}U$ | <48 | <32 | <47 | <25 |
| $^{238}Pu$ | <0.016 | <0.031 | <0.034 | <0.056 |
| $^{239/240}Pu$ | <0.04 | <0.017 | <0.028 | <0.045 |
| $^{241}Am$ | <220 | <106 | <55 | <9.8 |

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L $HCO_3$/mg/L $CaCO_3$ ($HCO_3$) and 0.6 mg/L $CO_3$/mg/L $CaCO_3$ ($CO_3$).

J = Result is estimated.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Note: Values reported with a "|" indicate unfiltered | filtered sample results. Unfiltered samples were analyzed for RNs.

# Table B.2-6
# LLNL Results for Pahute Mesa
# Early Detection Samples
(Page 1 of 2)

| Analyte | ER-EC-6_m4 | ER-20-1_m1 | |
|---|---|---|---|
| | 01/13/2015 | 02/23 & 02/24/2015 | |
| **Environmental Tracers** | | | |
| C-13/12 (‰) | -2.93 | -3.55 | -3.55 |
| H-2/1 (‰) | -115 | -115.3 | -115.2 |
| O-18/16 (‰) | -14.98 | -14.74 | -14.7 |
| S-34/32 (‰) [a] | -- | 19.1 | 19.1 |
| Sr-87/86 (‰) | 1.54 | 1.04 | 1.04 |
| $^{14}C$ (pmc) | J+ 23.86 | J+ 15.82 | J+ 16.61 |
| $^{36}Cl/Cl$ (ratio) | 5.27E-13 | 5.18E-13 | 5.12E-13 |
| $^{129}I/^{127}I$ (ratio) | <9.7E-13 | <9.7E-13 | 3.3E-10 |
| $^{87}Sr/^{86}Sr$ (ratio) | 0.7103 | 0.7099 | 0.71 |
| $^{234}U/^{235}U$ (ratio) | 0.0274 | 0.02115 | 0.211 |
| $^{234}U/^{238}U$ (ratio) | 1.9E-04 | 1.53E-04 | 1.53E-04 |
| $^{234}U/^{238}U$ (Activity ratio) | 3.624 | 2.79 | 2.79 |
| $^{235}U/^{238}U$ (ratio) | 7.25E-03 | 7.25E-03 | 7.27E-03 |
| $^{236}U/^{235}U$ (ratio) | <8.5E-06 | <8.5E-06 | 1.17E-05 |
| **Noble Gases (atoms/g)** | | | |
| Ar | -- | 7.34E+15 | 9.86E+15 |
| $^{40}Ar$ | -- | 7.31E+15 | 9.82E+15 |
| $^{3}He$ | -- | 1.31E+07 | 1.38E+07 |
| $^{4}He$ | -- | 1.13E+13 | 1.19E+13 |
| $^{3}He/^{4}He$ (R/Ra) [b] | -- | 0.841 | 0.844 |
| Kr | -- | 1.49E+12 | 1.8E+12 |
| Ne | -- | 6.68E+12 | 1.13E+13 |
| $^{20}Ne$ | -- | 6.05E+12 | 1.03E+13 |
| Xe | -- | 2.06E+11 | 2.3E+11 |
| $^{130}Xe$ | -- | 8.45E+09 | 9.45+09 |

# Table B.2-6
# LLNL Results for Pahute Mesa
# Early Detection Samples
(Page 2 of 2)

| Analyte | ER-EC-6_m4 | ER-20-1_m1 | |
|---|---|---|---|
| | 01/13/2015 | 02/23 & 02/24/2015 | |
| **RNs (pCi/L)** | | | |
| $^{3}H$ | U 1,262 | <320 | <320 |
| $^{3}H$ (Low Level) | 4.2 | <0.3 | <0.3 |
| $^{14}C$ | J+ 0.0492 | J+ 0.0378 | J+ 0.397 |
| $^{36}Cl$ | 9.0E-04 | 9.5E-04 | 9.38E-04 |
| $^{129}I$ | <1.7E-09 | <1.7E-09 | 8.73E-07 |
| $^{234}U$ | 1.97 | 0.987 | 0.978 |
| $^{235}U$ | 0.0250 | 0.0163 | 0.0162 |
| $^{236}U$ | <6.39E-06 | <4.16E-06 | 5.7E-06 |
| $^{238}U$ | 0.544 | 0.354 | 0.350 |

[a] USGS analysis
[b] Reported as ratio, not atoms/g.

atoms/g = Atoms per gram

J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

# B.3.0 Rainier Mesa/Shoshone Mountain

This section presents the commercial (see Tables B.3-1 and B.3-3) laboratory and LLNL (Table B.3-2) results for two characterization (Tables B.3-1 and B.3-2) and three distal (Table B.3-3) wells in the RM/SM CAU.

**Table B.3-1**
**Commercial Laboratory Results for RM/SM Characterization Samples**
(Page 1 of 2)

| Analyte | ER-12-3_m1 | | ER-12-4_m1 | |
|---|---|---|---|---|
| | 05/01/2015 | | 05/09/2015 | |
| **Major and Minor Constituents (mg/L)** | | | | |
| Alkalinity as $CaCO_3$ | 97 | 98 | 75 | 76 |
| $HCO_3$ [a] | 118.2 | 119.5 | 91.4 | 92.6 |
| $CO_3$ [a] | <12 | <12 | <12 | <12 |
| $SO_4$ | 25 | 24 | 12 | 12 |
| F | 1.9 | 1.9 | 0.79 | 0.83 |
| Cl | 6.0 | 6.0 | 9.0 | 9.0 |
| Br | <0.06 | <0.06 | J 0.084 | J 0.086 |
| Na | 30 | 31 | 27 | 26 |
| K | 2.3 | 2.4 | 3.7 | 3.6 |
| Ca | 15 | 16 | 9.4 | 9.0 |
| Mg | 6.3 | 6.5 | 3.4 | 3.2 |
| Al | <0.029 | <0.029 | J 0.068 | J 0.042 |
| **RNs (pCi/L)** | | | | |
| Gross Alpha | <2 | U 2.2 | <1.9 | <1.67 |
| Gross Beta | 4.2 | 4.4 | <2.3 | U 2.3 |
| $^{3}H$ | <390 | <400 | <280 | <280 |
| $^{3}H$ (Low Level) | <2.19 | <2.19 | <1.74 | <2.11 |
| $^{14}C$ | <480 | <480 | <480 | <480 |
| $^{26}Al$ | <9.9 | <13.9 | <8.6 | <8.5 |
| $^{36}Cl$ | <2.6 | <2.8 | <2.9 | <2.9 |
| $^{90}Sr$ | <0.33 | <0.37 | <0.36 | <0.34 |
| $^{94}Nb$ | <7.8 | <9.8 | <6.7 | <7 |
| $^{99}Tc$ | <7 | <7 | <6.9 | <7 |
| $^{129}I$ | <0.62 | <0.69 | <0.71 | <0.76 |

## Table B.3-1
## Commercial Laboratory Results for RM/SM Characterization Samples
(Page 2 of 2)

| Analyte | ER-12-3_m1 | | ER-12-4_m1 | |
|---|---|---|---|---|
| | 05/01/2015 | | 05/09/2015 | |
| $^{137}$Cs | <7.6 | <9.4 | <6.4 | <7.1 |
| $^{152}$Eu | <45 | <60 | <39 | <38 |
| $^{154}$Eu | <40 | <62 | <32 | <38 |
| $^{235}$U | <52 | <58 | <26 | <39 |
| $^{238}$Pu | <0.028 | <0.028 | <0.018 | <0.025 |
| $^{239/240}$Pu | <0.022 | <0.022 | <0.018 | <0.032 |
| $^{241}$Am | <60 | <46 | <35 | <180 |
| **Trace Constituents (μg/L)** | | | | |
| As | U 10 | U 10 | J 2.3 | J 5 |
| Ba | J 30 | J 31 | J 16 | J- 15 |
| Cd | <0.21 | <0.21 | <0.21 | <0.21 |
| Cr | <0.73 | <0.73 | <0.73 | <0.73 |
| Pb | <1.8 | <1.8 | <1.8 | <1.8 |
| Li | J- 25 | J- 26 | J- 17 | J- 14 |
| Mn | J 2.6 | J 2.9 | J 29 | J 27 |
| Se | <3 | <3 | <3 | <3 |
| Ag | <0.42 | J- 0.71 | <0.42 | J- 0.79 |
| Sr | 160 | 160 | 54 | 53 |
| $^{238}$U | 1.7 | 1.9 | 0.42 | 0.39 |

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L $HCO_3$/mg/L $CaCO_3$ ($HCO_3$) and 0.6 mg/L $CO_3$/mg/L $CaCO_3$ ($CO_3$).

J- = Result is estimated and is biased low.
J = Result is estimated.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

# Table B.3-2
# LLNL Results for RM/SM Characterization Samples

| Analyte | ER-12-3_m1 | | ER-12-4_m1 | |
|---|---|---|---|---|
| | 05/01/2015 | | 05/09/2015 | |
| **Environmental Tracers** | | | | |
| H-2/1 (‰) | -106.9 | -107.3 | -101.2 | -101.1 |
| C-13/12 (‰) | -4.16 | -4.52 | -6.23 | -6.29 |
| O-18/16 (‰) | -14.39 | -14.36 | -13.42 | -13.44 |
| $^{14}$C (pmc) | J+ 7.43 | J+ 6.72 | J+ 12.69 | J+ 12.02 |
| $^{36}$Cl/Cl (ratio) | 6.29E-13 | 6.27E-13 | 5.95E-13 | 5.69E-13 |
| **Noble Gases** (atoms/g) | | | | |
| Ar | 8.45E+15 | 9.06E+15 | 7.17E+15 | 7.16E+15 |
| $^{40}$Ar | 8.42E+15 | 9.02E+15 | 7.14+15 | 7.13+15 |
| $^{3}$He | 2.53E+06 | 2.87E+06 | 1.69E+06 | 1.62E+06 |
| $^{4}$He | 2.21E+13 | 2.48+E13 | 2.16E+12 | 2.15E+12 |
| $^{3}$He/$^{4}$He (R/Ra) | 0.0829 | 0.084 | 0.567 | 0.546 |
| Kr | 1.85E+12 | 1.88E+12 | 1.63E+12 | 1.65E+12 |
| Ne | 6.25E+12 | 7.29E+12 | 4.7E+12 | 4.6E+12 |
| $^{20}$Ne | 5.65E+12 | 6.59E12 | 4.26E+12 | 4.17E+12 |
| Xe | 2.74E+11 | 2.74E+11 | 2.76E+11 | 2.83E+11 |
| $^{130}$Xe | 1.13E+10 | 1.12E+10 | 1.13E+10 | 1.16E+10 |
| **RNs (pCi/L)** | | | | |
| $^{3}$H | <277 | <277 | <281 | <279 |
| $^{3}$H (Low Level) | 0.5 | 0.4 | <1 | <0.2 |
| $^{14}$C | J+ 0.0119 | J+ 0.0107 | J+ 0.0144 | J+ 0.0138 |
| $^{36}$Cl | 1.19E-04 | 1.20E-04 | 1.75E-04 | 1.69E-04 |

J+ = Result is estimated and is biased high.
-- = Not analyzed

## Table B.3-3
## Commercial Laboratory Results for RM/SM Distal Well Samples

| Location | Date | $^{3}H$ (pCi/L) | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|---|---|
| ER-12-1 | 04/15/2015 | <348 \| <348 | 13.9 \| 14.4 | 6.9 \| 7.1 |
| UE-16D WW | 01/21/2015 | <223 | -- | -- |
| WW-8 | 01/21/2015 | <229 \| <226 | <1.6 | 2.3 |
| | 04/28/2015 | <185 | <1.1 | 2.5 |
| | 07/14/2015 | <226 | <0.9 | 0.9 |
| | 11/03/2015 | <227 | <1.8 | 2.1 |

-- = Not analyzed

Note: Values reported with a "|" indicate sample | FD results.

# B.4.0 Yucca Flat/Climax Mine

This section presents the commercial (see Tables B.4-1 and B.4-3) laboratory and LLNL (see Tables B.4-2 and B.4-4) results for two characterization (Tables B.4-1 and B.4-2), one early detection (Tables B.4-1 and B.4-2), one source/plume (Tables B.4-3 and B.4-4), and one distal (Table B.4-4) wells in the YF/CM CAU. Only $^{3}H$ was measured for one characterization location in 2015 (TW-7); the $^{3}H$ activity for this bailed sample was reported as <281 pCi/L and <2.47 pCi/L (Low Level).

**Table B.4-1**
**Commercial Laboratory Results for YF/CM Characterization (ER-2-1 and WW-3) and Early Detection (WW-2) Samples**
(Page 1 of 3)

| Analyte | ER-2-1 | | WW-2 | | WW-3 | |
|---|---|---|---|---|---|---|
| | 03/26/2015 | | 04/22/2015 | | 06/09/2015 | |
| **Major and Minor Constituents (mg/L)** | | | | | | |
| Alkalinity as $CaCO_3$ | 160 | 160 | J- 160 | J- 160 | 160 | 160 |
| $HCO_3$ [a] | 195.04 | 195.04 | J- 195.04 | J- 195.04 | 195.04 | 195.04 |
| $CO_3$ [a] | <12 | <12 | J <12 | J <12 | <12 | <12 |
| Br | <0.06 | J 0.088 | J <0.06 | J <0.06 | J 0.15 | J 0.15 |
| Cl | 8.4 | 8.1 | J- 6.9 | J- 6.8 | 15 | 14 |
| F | 3.9 | 3.8 | J- 0.35 | J- 0.34 | 1.1 | 1.1 |
| $SO_4$ | 17 | 17 | J- 22 | J- 22 | 27 | 27 |
| Ca | 2.1 \| J 0.84 | 1.9 \| J 0.78 | J 30 | J 30 | 22 | 22 |
| Mg | 1.2 \| J 0.1 | 1 \| J 0.084 | 13 | 13 | 14 | 14 |
| K | 6.7 \| 4.3 | 6.4 \| 4.2 | 6 | 6 | 7.6 | 7.4 |
| Na | 79 \| 81 | 81 \| 79 | 24 | 25 | 40 | -- |
| Al | 5.8 \| J- 0.035 | 5.1 \| J- 0.022 | U 0.2 | U 0.2 | U 0.2 | U 0.2 |
| Fe | 13 \| J- 0.064 | 10 \| J- 0.04 | 0.43 | 0.43 | 11 | 16 |
| Silica | 94.116 \| 57.753 | 91.977 \| 57.753 | 44.919 | 44.919 | 64.17 | 64.17 |
| SEC[b] | 360 | 360 | J- 370 | J- 370 | 420 | 430 |

# Table B.4-1
## Commercial Laboratory Results for YF/CM Characterization (ER-2-1 and WW-3) and Early Detection (WW-2) Samples
(Page 2 of 3)

| Analyte | ER-2-1 | | WW-2 | | WW-3 | |
|---|---|---|---|---|---|---|
| | 03/26/2015 | | 04/22/2015 | | 06/09/2015 | |
| **Trace Constituents (μg/L)** | | | | | | |
| As | <3.9 \| <3.9 | <3.9 \| <3.9 | J 6 | <3.9 | J <3.9 | J <3.9 |
| Ba | J- 16 \| <0.19 | J- 13 \| <0.19 | UJ 100 | UJ 100 | J- 11 | J- 11 |
| Cd | <0.33 \| <0.33 | <0.33 \| <0.33 | U 5 | U 5 | <0.33 | U 5 |
| Cr | 11 \| <0.51 | J- 3.7 \| <0.51 | <0.51 | <0.51 | 13 | 16 |
| Pb | 4 \| <1.3 | 3.1 \| <1.3 | <1.3 | U 3 | 3.7 | 5.7 |
| Li | 54 \| 47 | 55 \| 46 | J 22 | J 22 | 44 | 43 |
| Mn | J 180 \| J 33 | J 140 \| J 31 | J 94 | J 94 | 370 | 390 |
| Se | <2.7 \| J 4.2 | <2.7 \| <2.7 | <2.7 | <2.7 | <2.7 | U 5 |
| Ag | <1.1 \| <1.1 | <1.1 \| <1.1 | <1.1 | <1.1 | <1.1 | <1.1 |
| Sr | J- 7.3 \| <0.078 | J- 5.5 \| <0.078 | 80 | 80 | 330 | 320 |
| $^{238}$U | 3.7 \| 2 | 3.7 \| 2.1 | 1.1 | 1.0 | 3.61 \| -- | 3.61 \| -- |
| **RNs (pCi/L)** | | | | | | |
| Gross Alpha | 3.6 | U 2.8 | U 2.3 | U 1.7 | 4.5 | 4.9 |
| Gross Beta | U 3.7 | 6.5 | 5 | 7.3 | 6.7 | 6.8 |
| $^{3}$H | 840 \| 920 | 1,013 \| 908.83 | <370 | <370 | <330 | <370 |
| $^{3}$H (Low Level) | -- | -- | <2.18 | <2.17 | 6.27 | 5.63 |
| $^{14}$C | <440 | <420 | <480 | <480 | <350 | <350 |
| $^{26}$Al | <8.3 | <7.9 | <9 | <11.4 | <9 | <9.9 |
| $^{36}$Cl | <2.6 | <2.9 | <2.6 | <2.7 | <2.9 | <2.8 |
| $^{90}$Sr | <0.58 | <0.65 | <0.34 | <0.38 | <0.42 | <0.45 |
| $^{94}$Nb | <7.7 | <7 | <7.6 | <9.1 | <8 | <8.8 |
| $^{99}$Tc | <7.6 | <7.3 | <8.6 | <7 | <6.7 | <6.9 |
| $^{129}$I | <0.87 | <0.95 | <0.61 | <0.69 | J <0.77 | J <0.73 |
| $^{137}$Cs | <7.3 | <7.5 | <7.6 | <9.2 | <7.1 | <8.3 |
| $^{152}$Eu | <40 | <35 | <48 | <48 | <43 | <44 |
| $^{154}$Eu | <44 | <41 | <44 | <44 | <45 | <48 |

## Table B.4-1
## Commercial Laboratory Results for YF/CM
## Characterization (ER-2-1 and WW-3) and Early Detection (WW-2) Samples
(Page 3 of 3)

| Analyte | ER-2-1 | | WW-2 | | WW-3 | |
|---|---|---|---|---|---|---|
| | 03/26/2015 | | 04/22/2015 | | 06/09/2015 | |
| $^{235}U$ | <32 | <56 | <41 | <46 | <44 | <38 |
| $^{238}Pu$ | <0.102 | <0.084 | <0.024 | <0.023 | <0.014 | <0.031 |
| $^{239/240}Pu$ | <0.088 | <0.067 | <0.024 | <0.027 | <0.031 | <0.014 |
| $^{241}Am$ | <64 | <170 | <260 | <49 | <12.1 | <47 |

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L $HCO_3$/mg/L $CaCO_3$ ($HCO_3$) and 0.6 mg/L $CO_3$/mg/L $CaCO_3$ ($CO_3$).
[b] Units are µS/cm.

Sb = Antimony

J = Result is estimated.
J- = Result is estimated and is biased low.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Note: The $^{3}H$ activity for the TW-7 sample bailed on May 21, 2015, was reported as <281 pCi/L and <2.47 pCi/L (Low Level).

## Table B.4-2
## LLNL Results for YF/CM
## Characterization (ER-2-1 and WW-3) and Early Detection (WW-2) Samples
(Page 1 of 2)

| Analyte | ER-2-1 | WW-2 | WW-3 |
|---|---|---|---|
| | 03/26/2015 | 04/22/2015 | 06/09/2015 |
| **Environmental Tracers** | | | |
| C-13/12 (‰) | -7.55 \| -7.63 | -.9.39 \| -9.36 | -6.08 \| -6.12 |
| H-2/1 (‰) | -109.3 \| -109.3 | -103.6 \| -103.4 | -103.2 \| -103.2 |
| O-18/16 (‰) | -14.28 \| -14.47 | -13.61 \| -13.46 | -12.98 \| -13.34 |
| $^{14}C$ (pmc) | J+ 23.64 \| J+ 23.46 | J+ 15.79 \| J+ 16.52 | J+ 6.39 \| J+ 6.42 |
| $^{36}Cl/Cl$ (ratio) | 8.4 E-13 \| 8.35 E-13 | 6.35 E-13 \| 6.73 E-13 | 5.72 E-13 \| 5.92 E-13 |
| **Noble Gases (atoms/g)** | | | |
| Ar | -- | 6.98E+15 | 9.32E+15 |
| $^{40}Ar$ | -- | 6.95E+15 | 9.29E+15 |
| $^{3}He$ | -- | 4.43E+06 | 1.72E+06 |

## Table B.4-2
## LLNL Results for YF/CM
## Characterization (ER-2-1 and WW-3) and Early Detection (WW-2) Samples
(Page 2 of 2)

| Analyte | ER-2-1 | WW-2 | WW-3 |
|---|---|---|---|
| | 03/26/2015 | 04/22/2015 | 06/09/2015 |
| $^{3}He/^{4}He$ (R/Ra) | -- | 0.217 | 0.917 |
| $^{4}He$ | -- | 1.48E+13 | 1.36E+12 |
| Kr | -- | 1.57E+12 | 2.09E+12 |
| Ne | -- | 4.49E+12 | 5.53E+12 |
| $^{20}Ne$ | -- | 4.07E+12 | 5.00E+12 |
| Xe | -- | 2.28E+11 | 2.75E+11 |
| $^{130}Xe$ | -- | 9.35E+09 | 1.13E+10 |
| **RNs (pCi/L)** | | | |
| $^{3}H$ | 682 \| 795 | <367 \| <278 | <283 \| <286 |
| $^{3}H$ (Low Level) | -- | <0.2 \| <0.2 | 6 \| 6.1 |
| $^{14}C$ | J+ 0.06 \| J+ 0.06 | J+ 0.0421 \| J+ 0.0441 | J+ 0.0147 \| J+ 0.0149 |
| $^{36}Cl$ | 2.14E-04 \| 2.13E-04 | 1.3E-03 \| 1.38E-03 | 2.59E-04 \| 2.67E-04 |

J = Result is estimated.
J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Notes:
(1) Values reported with a "|" indicate unfiltered | filtered sample results. Only filtered samples were collected and reported when a single metal result is shown. Unfiltered samples were analyzed for RNs.
(2) Unfiltered samples were analyzed for RNs.

## Table B.4-3
## Commercial Laboratory Results for YF/CM Source/Plume and Distal Samples

| Analyte | UE-7nS_m1<br>06/10/2015 | | Army 1 WW_m1<br>01/21/2015 |
|---|---|---|---|
| **RNs (pCi/L)** | | | |
| $^{3}H$ | <279.73 | <370 | <229 |
| $^{3}H$ (Low Level) | J 45.16 | -- | -- |

J = Result is estimated; QC sample results exceeded the control limits.
-- = Not analyzed

## Table B.4-4
## LLNL Results for YF/CM Source/Plume Samples

| Analyte | UE-7nS_m1 06/10/2015 |
|---|---|
| $^{3}H$ | <289 |
| $^{3}H$ (Low Level) | 53.3 |

# Appendix C

# Well Completion Diagrams

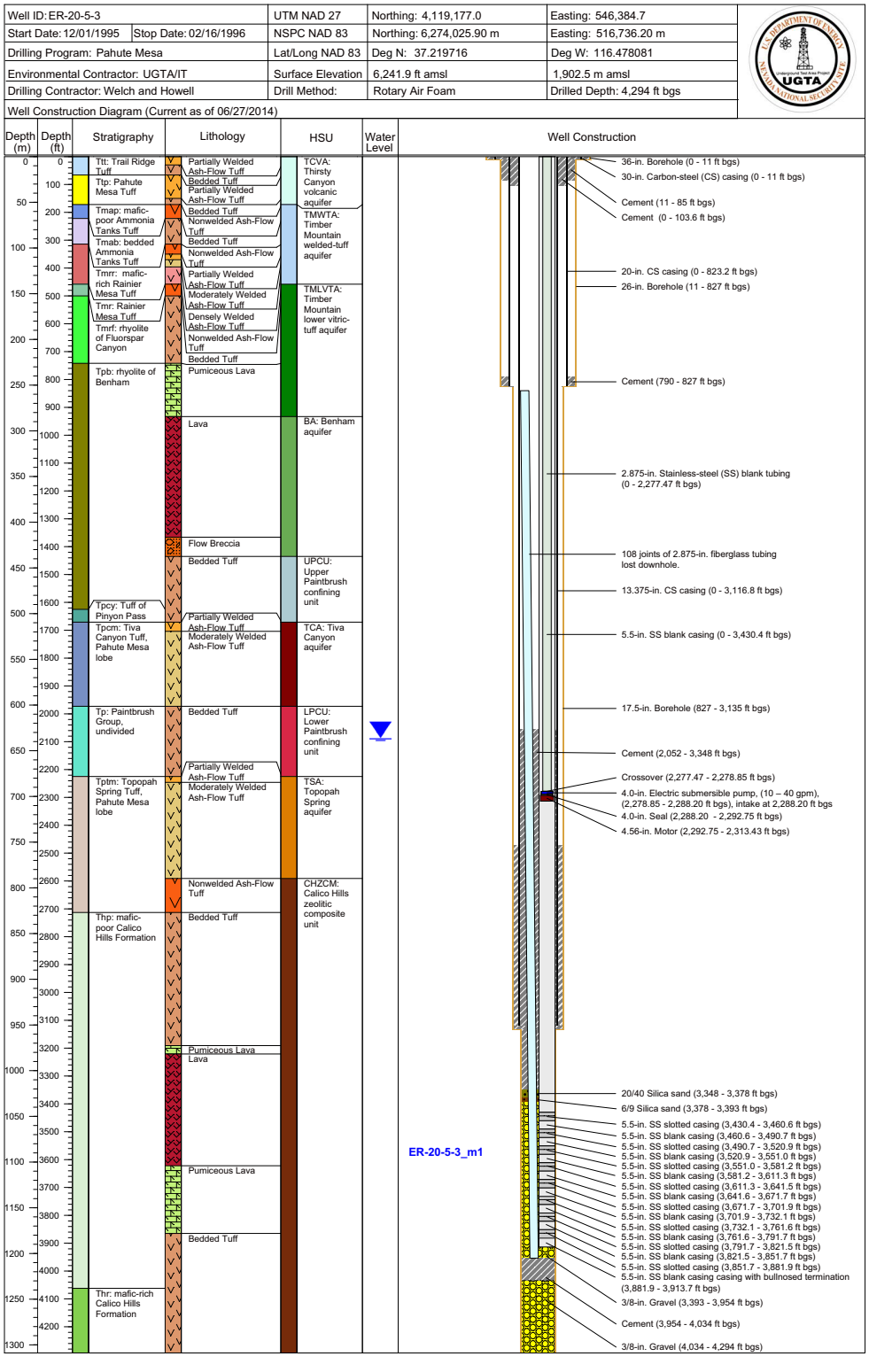


**Figure C-1**
**Well Completion Diagram for ER-20-5-3**

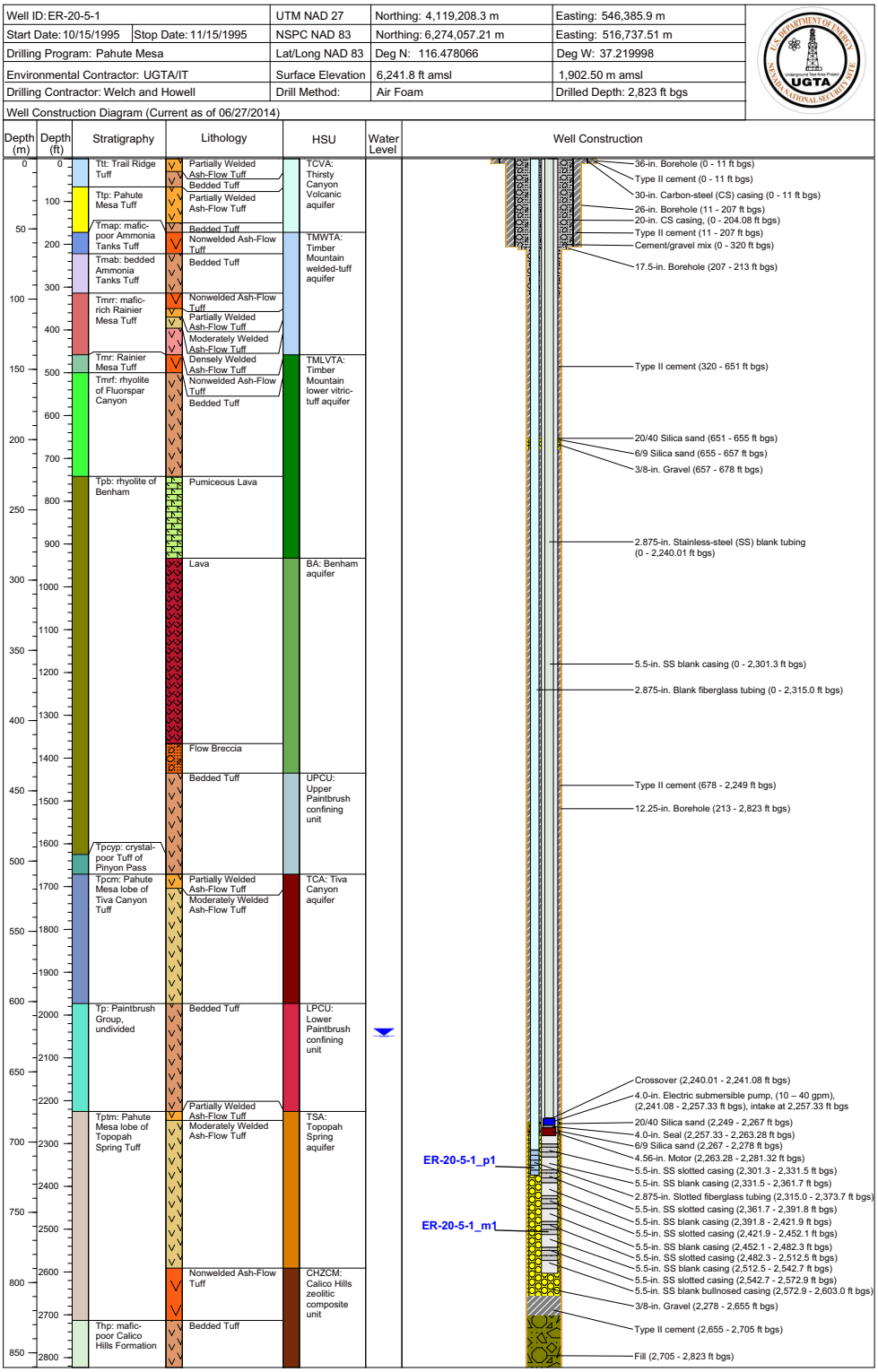


**Figure C-2**
**Well Completion Diagram for ER-20-5-1**

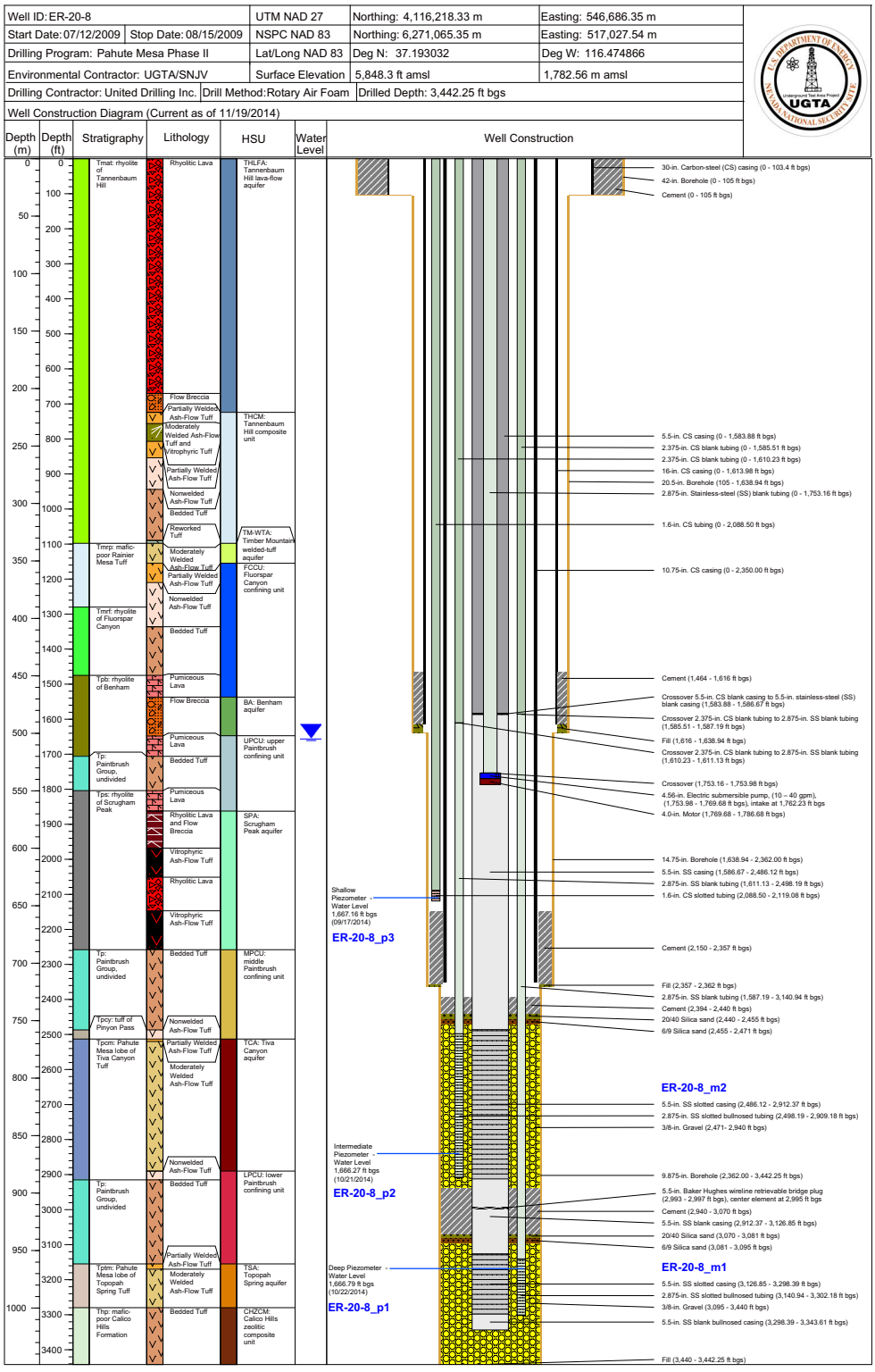


**Figure C-3**
**Well Completion Diagram for ER-20-8**

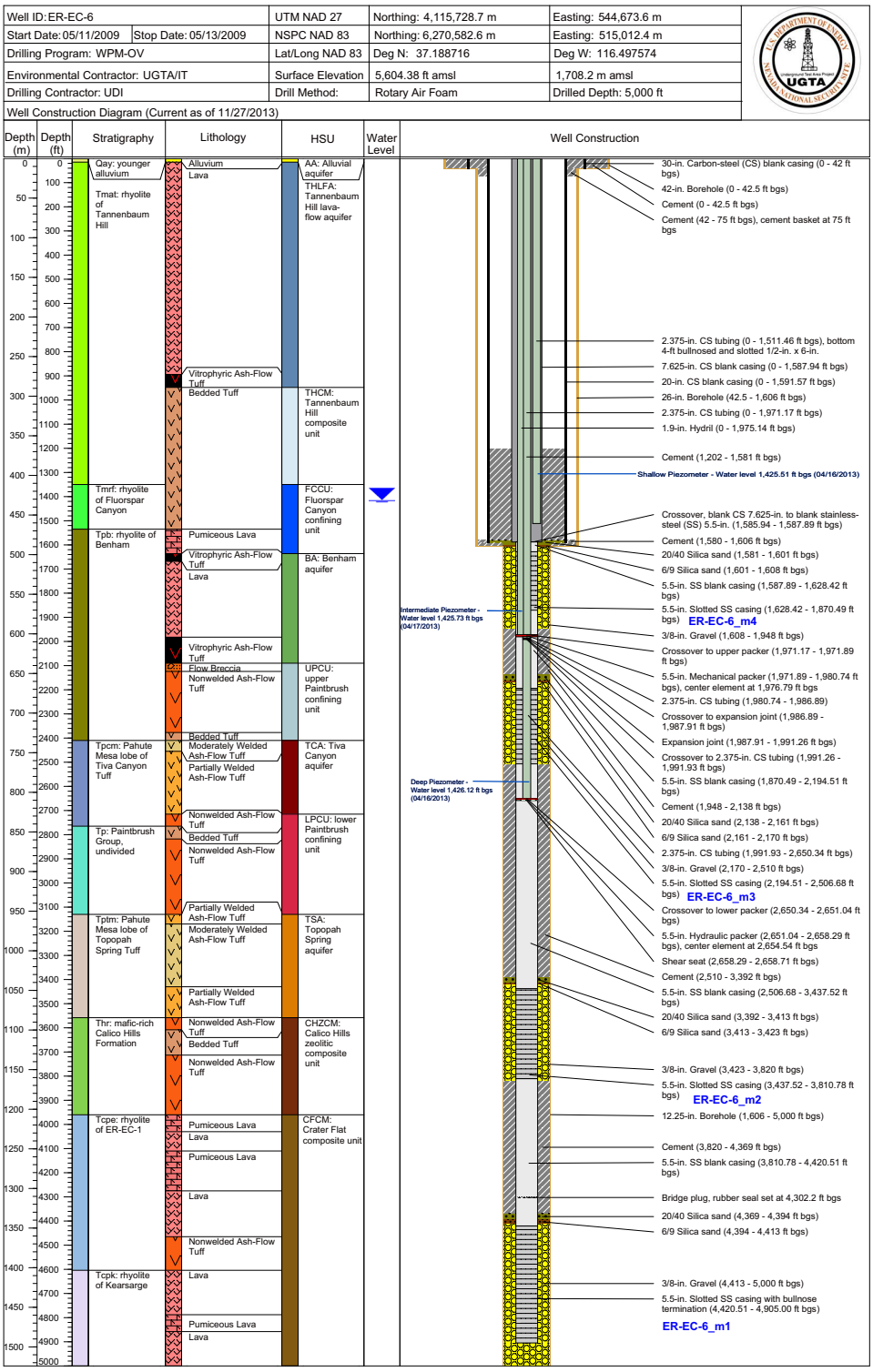


**Figure C-4**
**Well Completion Diagram for ER-EC-6**

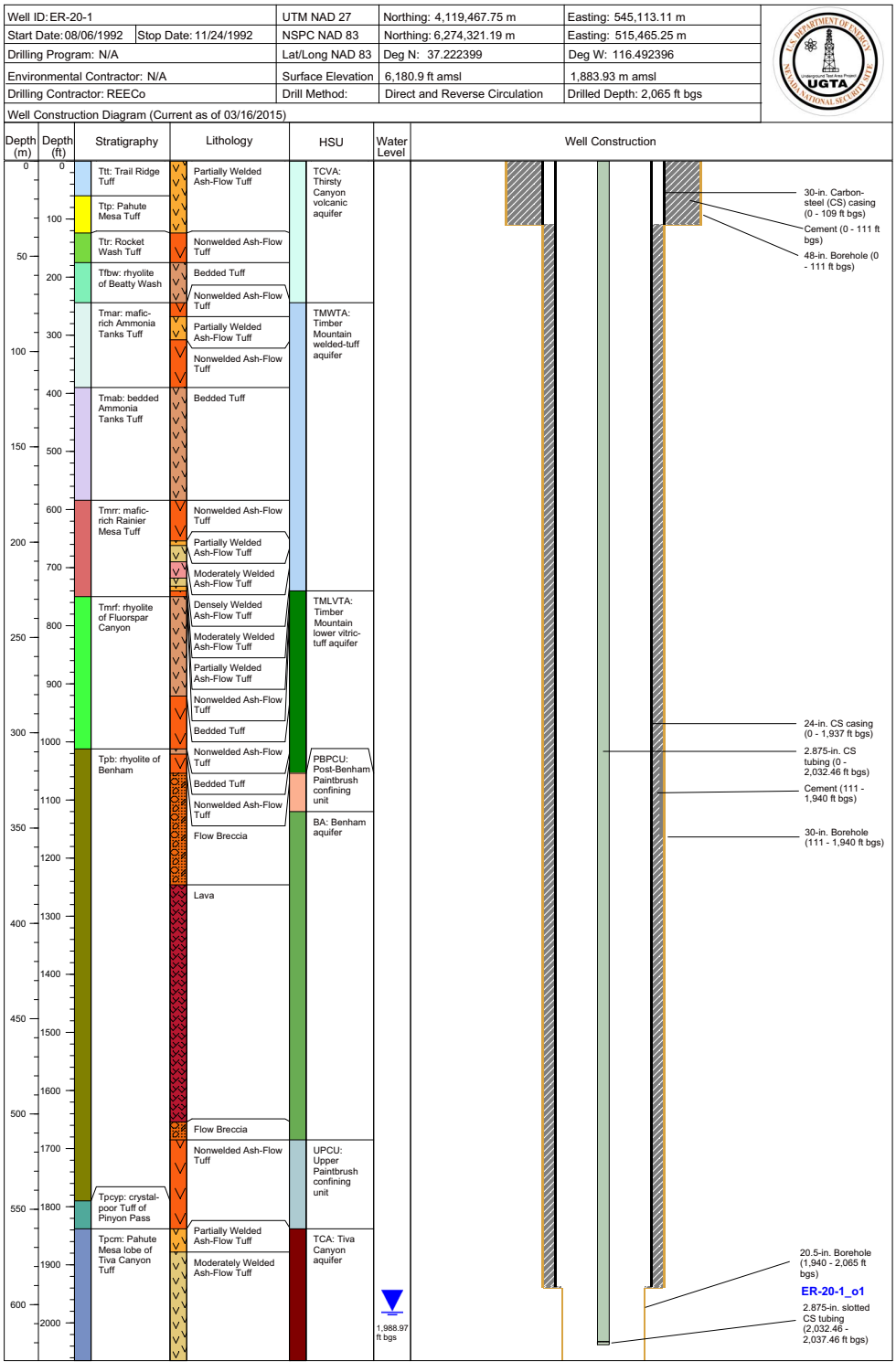


**Figure C-5**
**Well Completion Diagram for ER-20-1**

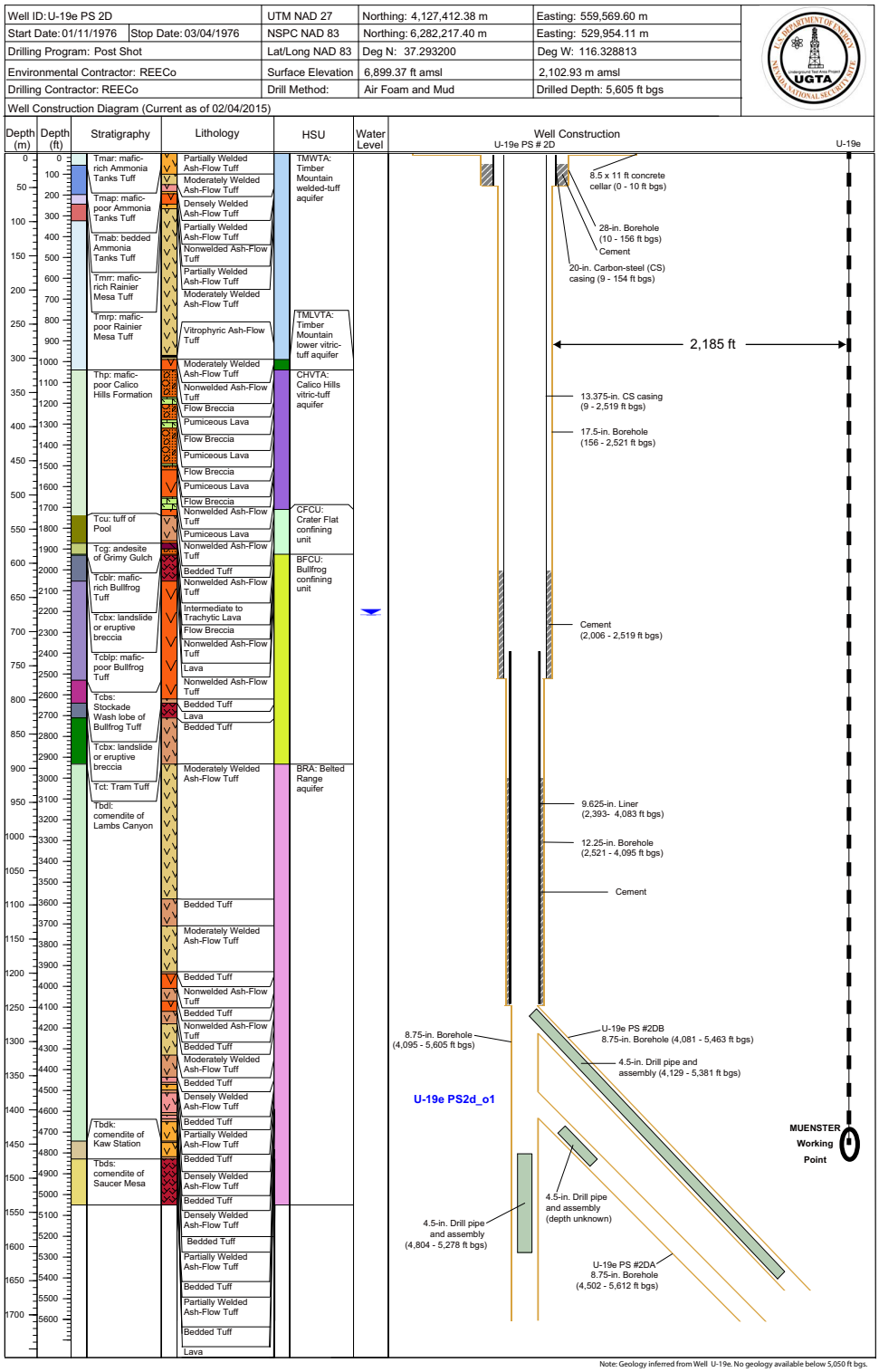


**Figure C-6**
**Well Completion Diagram for U-19e PS 2D**

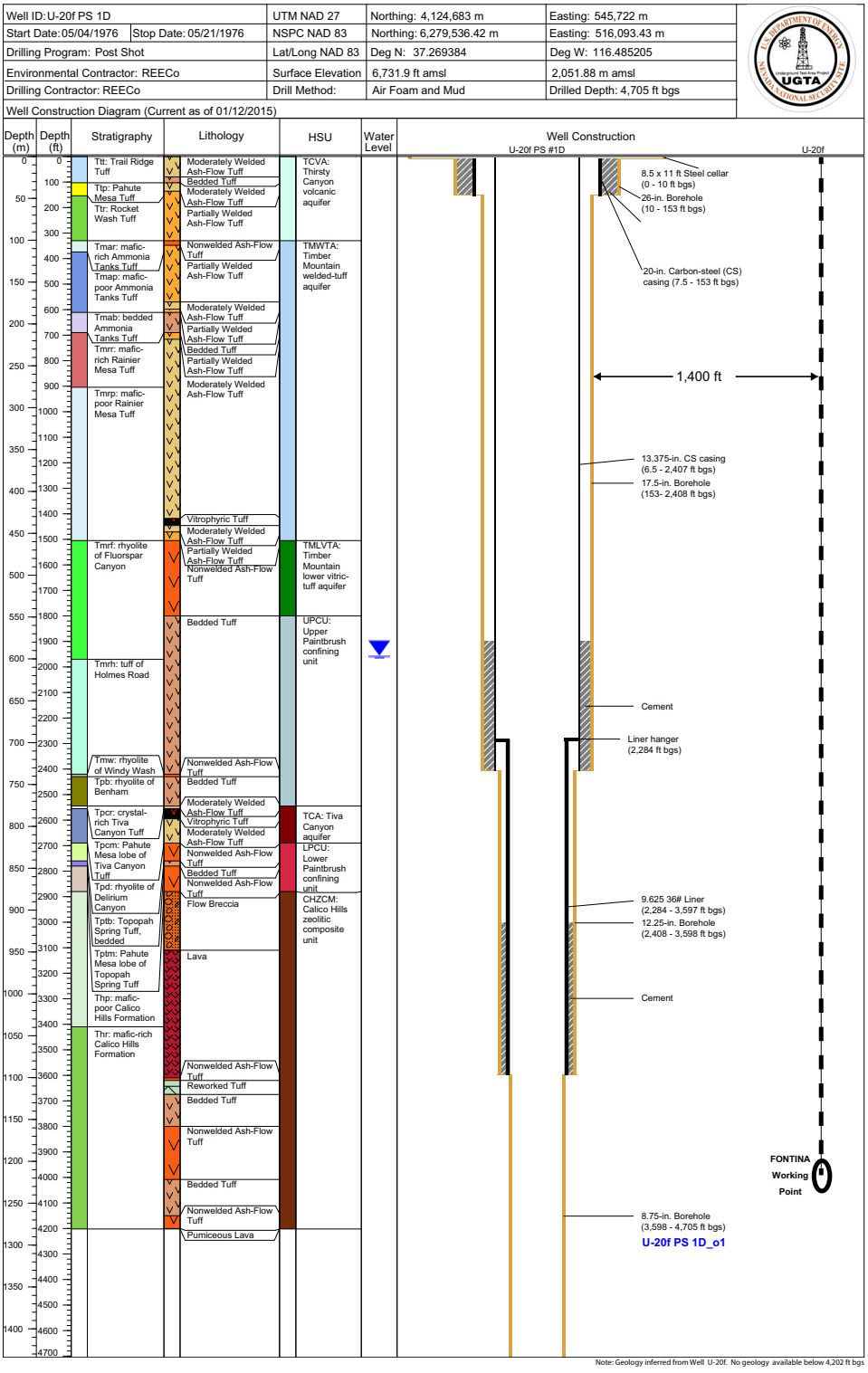


**Figure C-7**
**Well Completion Diagram for U-20f PS 1D**

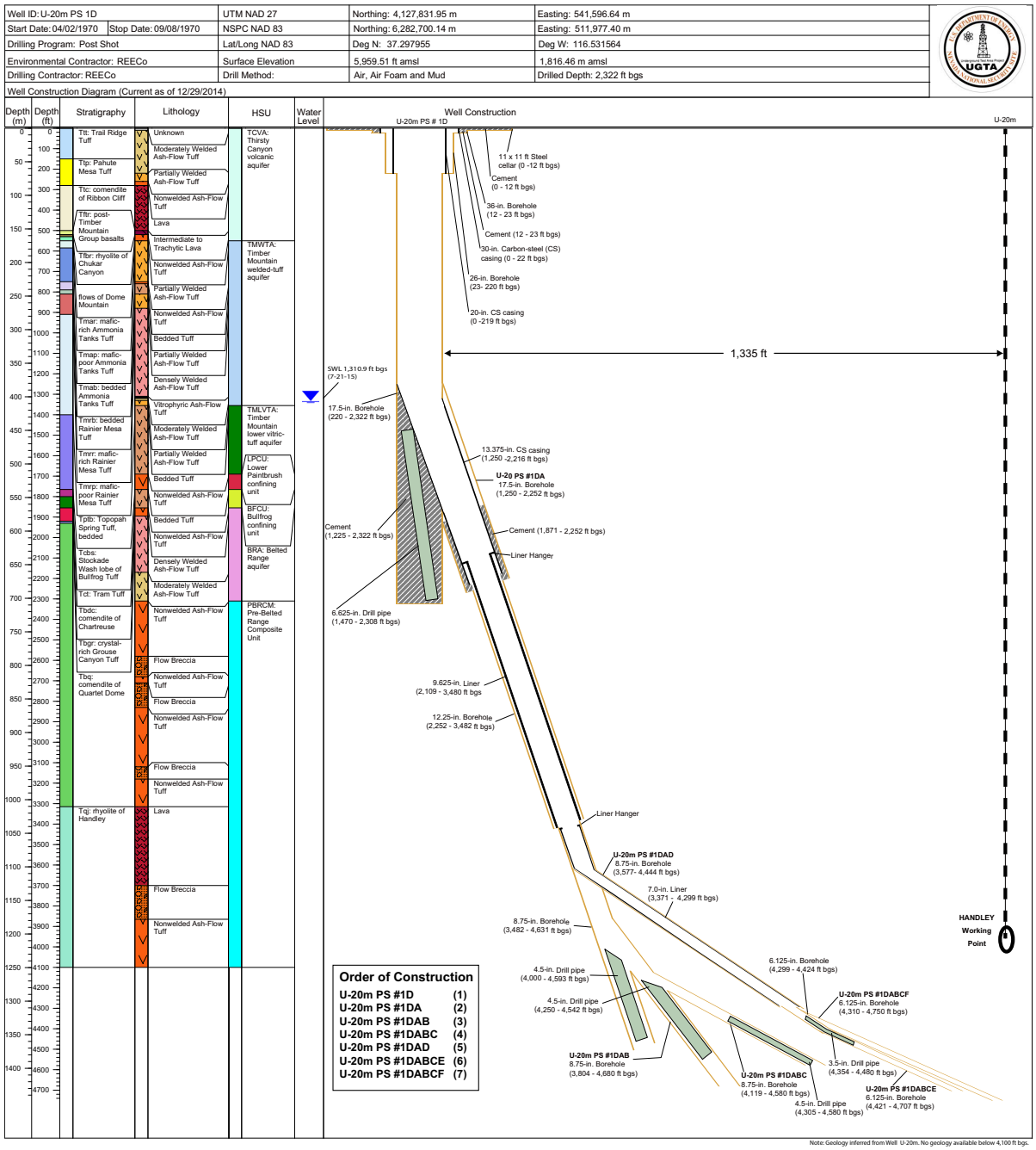


**Figure C-8**
**Well Completion Diagram for U-20m PS 1D**

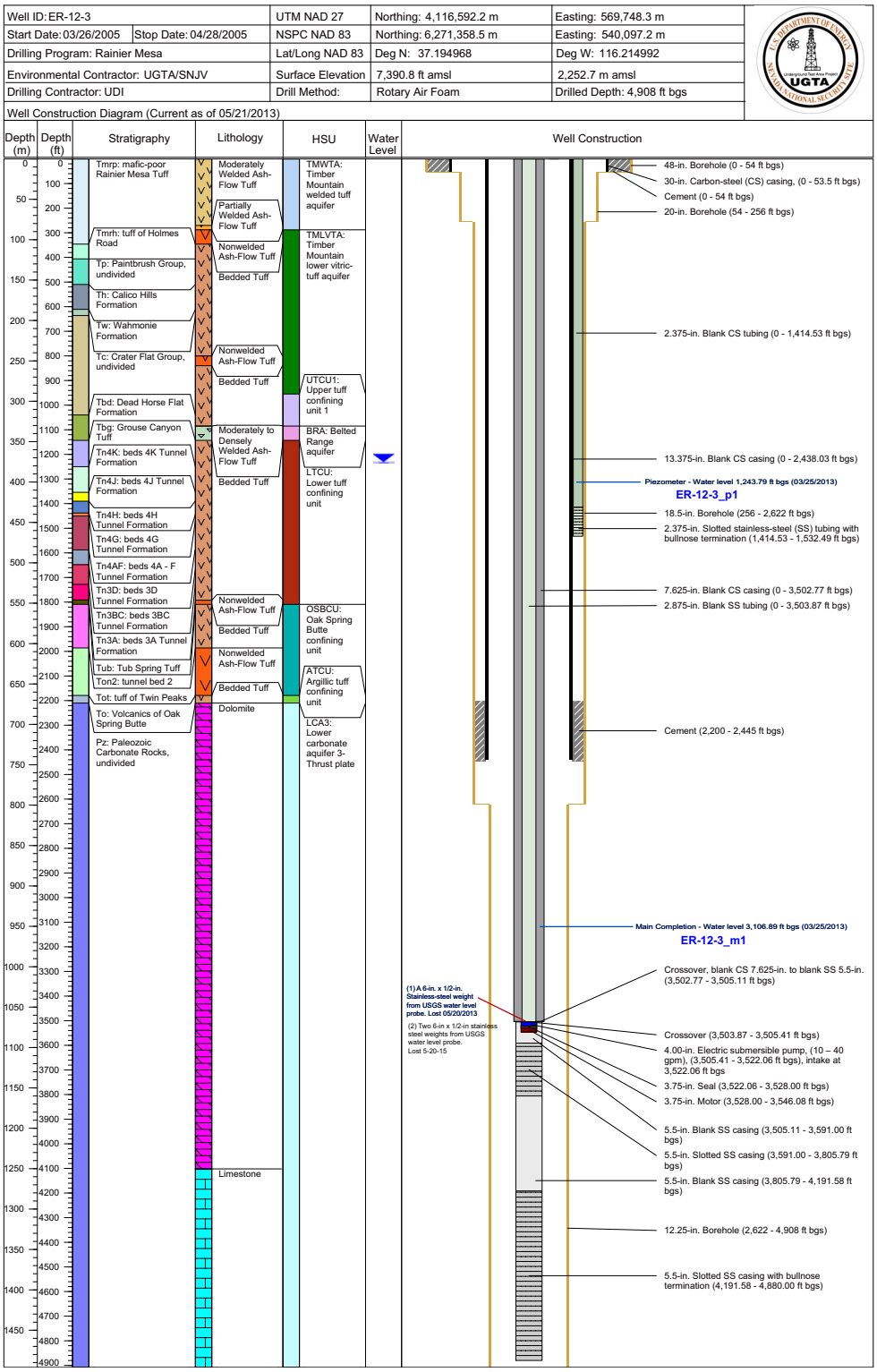


**Figure C-9**
**Well Completion Diagram for ER-12-3**

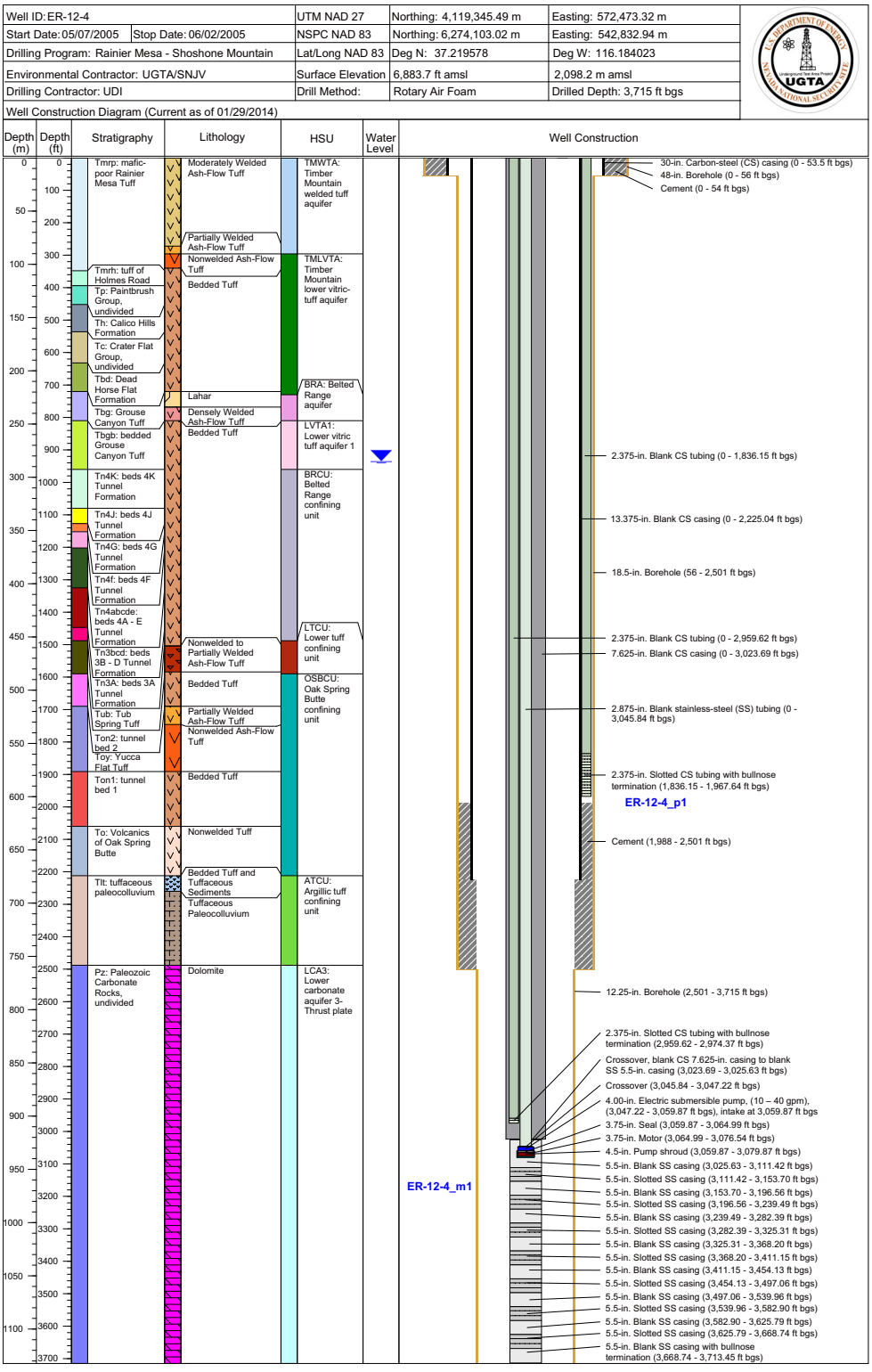


**Figure C-10**
**Well Completion Diagram for ER-12-4**

| | | | | |
|---|---|---|---|---|
| Well ID: ER-12-1 | | UTM NAD 27 | Northing: 4,115,492.84 | Easting: 572,411.67 |
| Start Date: 07/19/1991 | Stop Date: 10/17/1991 | NSPC NAD 83 | Northing: 6,270,249.54 m | Easting: 542,757.71 m |
| Drilling Program: Groundwater Charecterization Program | | Lat/Long NAD 83 | Deg N: 37.184857 | Deg W: 116.185091 |
| Environmental Contractor: Fenix & Scission, Inc. | | Surface Elevation | 5,817.12 ft amsl | 1,773.06 m amsl |
| Drilling Contractor: REECo | | Drill Method: Conventional, Air hammer, Rotary and Reverse Air | | Drilled Depth: 3,588 ft bgs |
| Well Construction Diagram (Current as of 02/03/2017) | | | | |

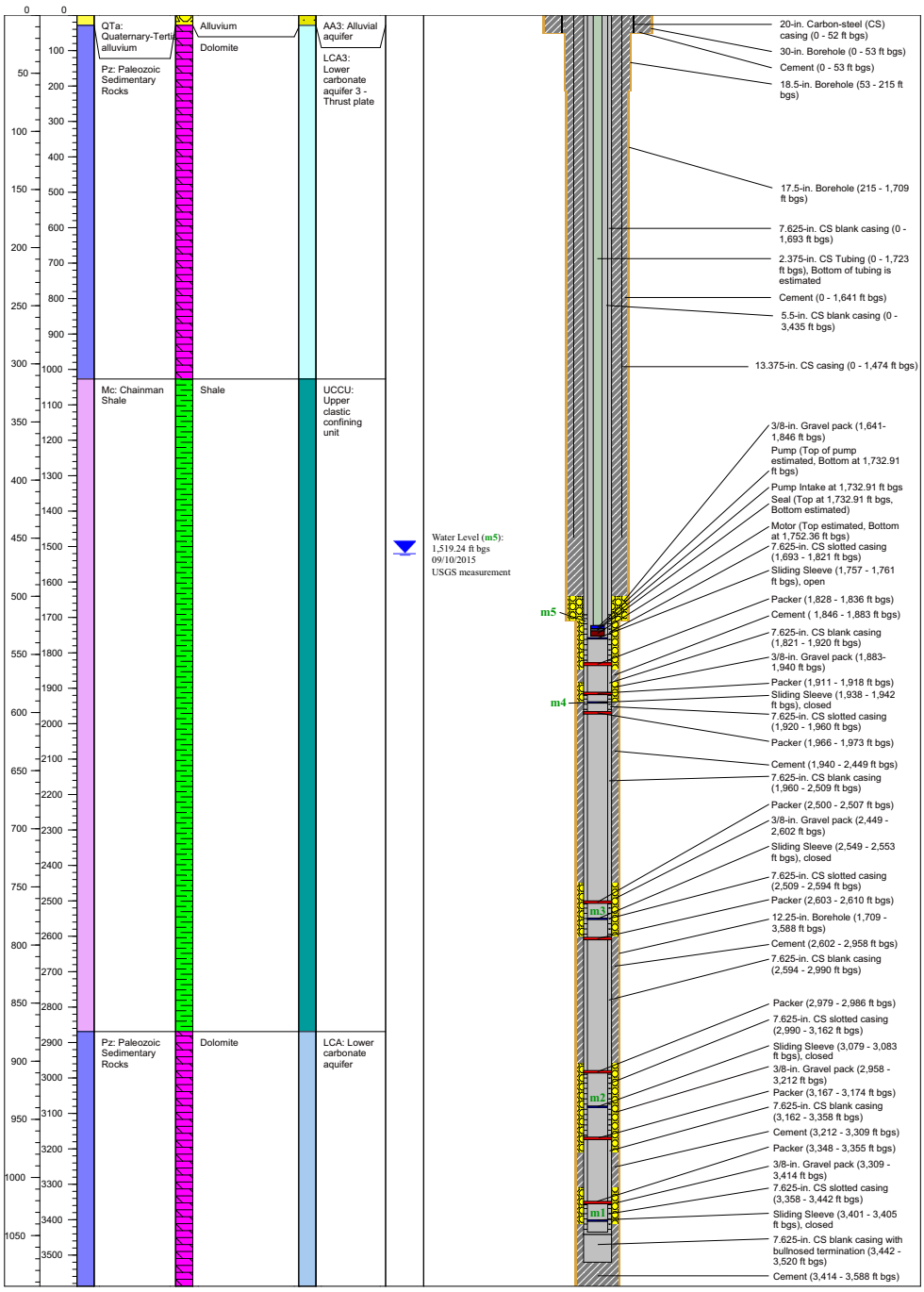


**Figure C-11**
**Well Completion Diagram for ER-12-1**

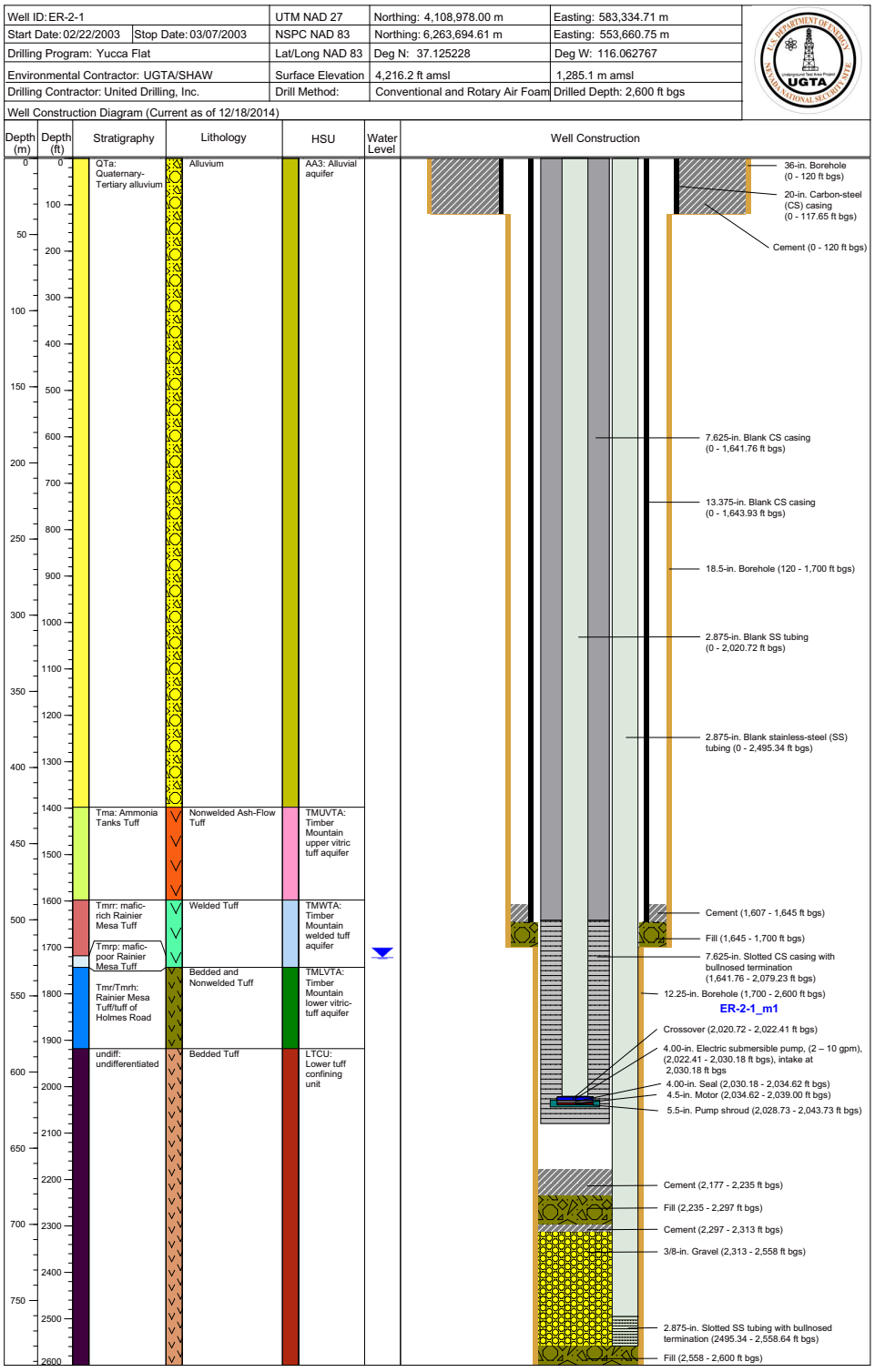


**Figure C-12**
**Well Completion Diagram for ER-2-1**

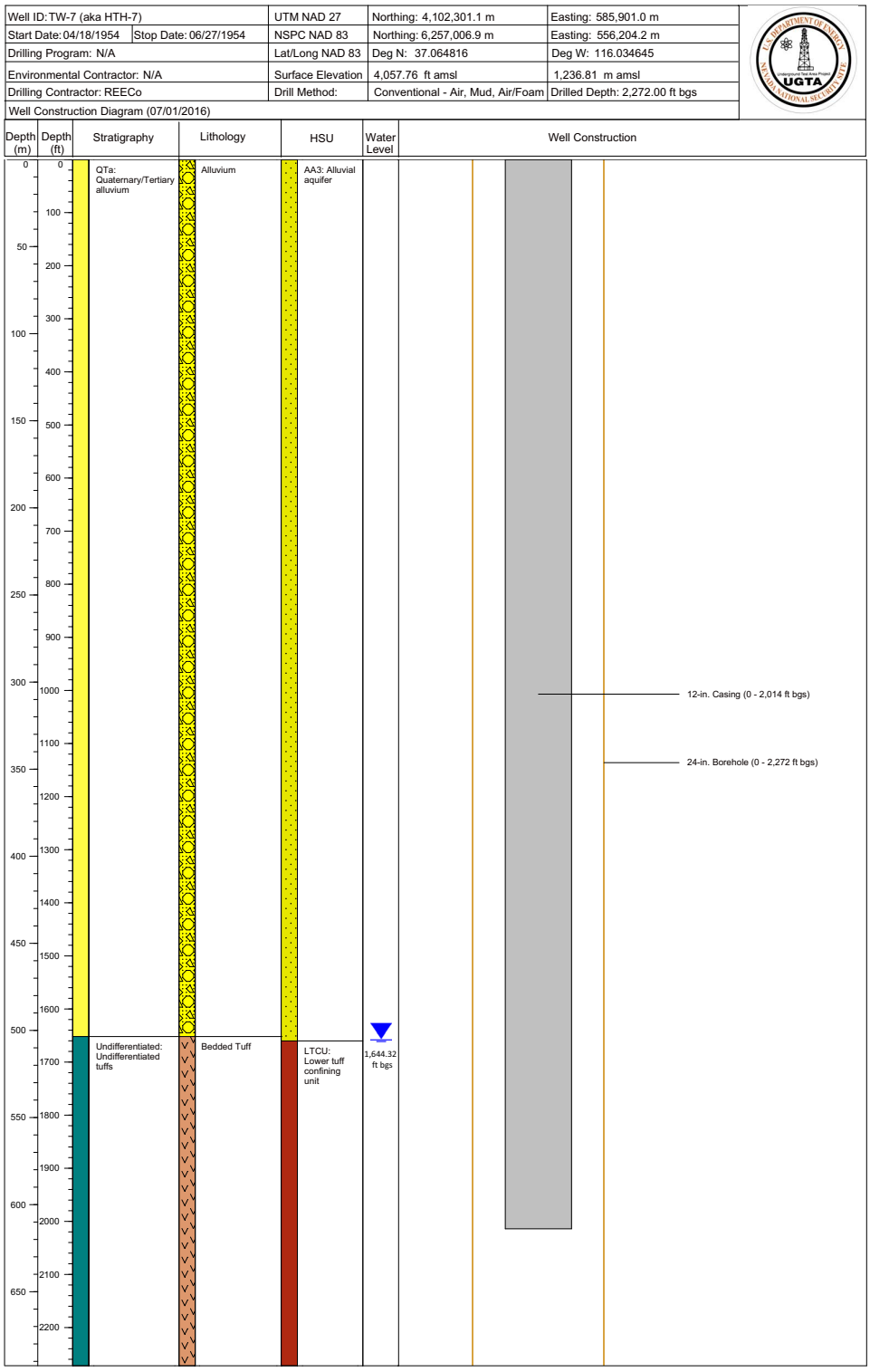


**Figure C-13**
**Well Completion Diagram for TW-7**

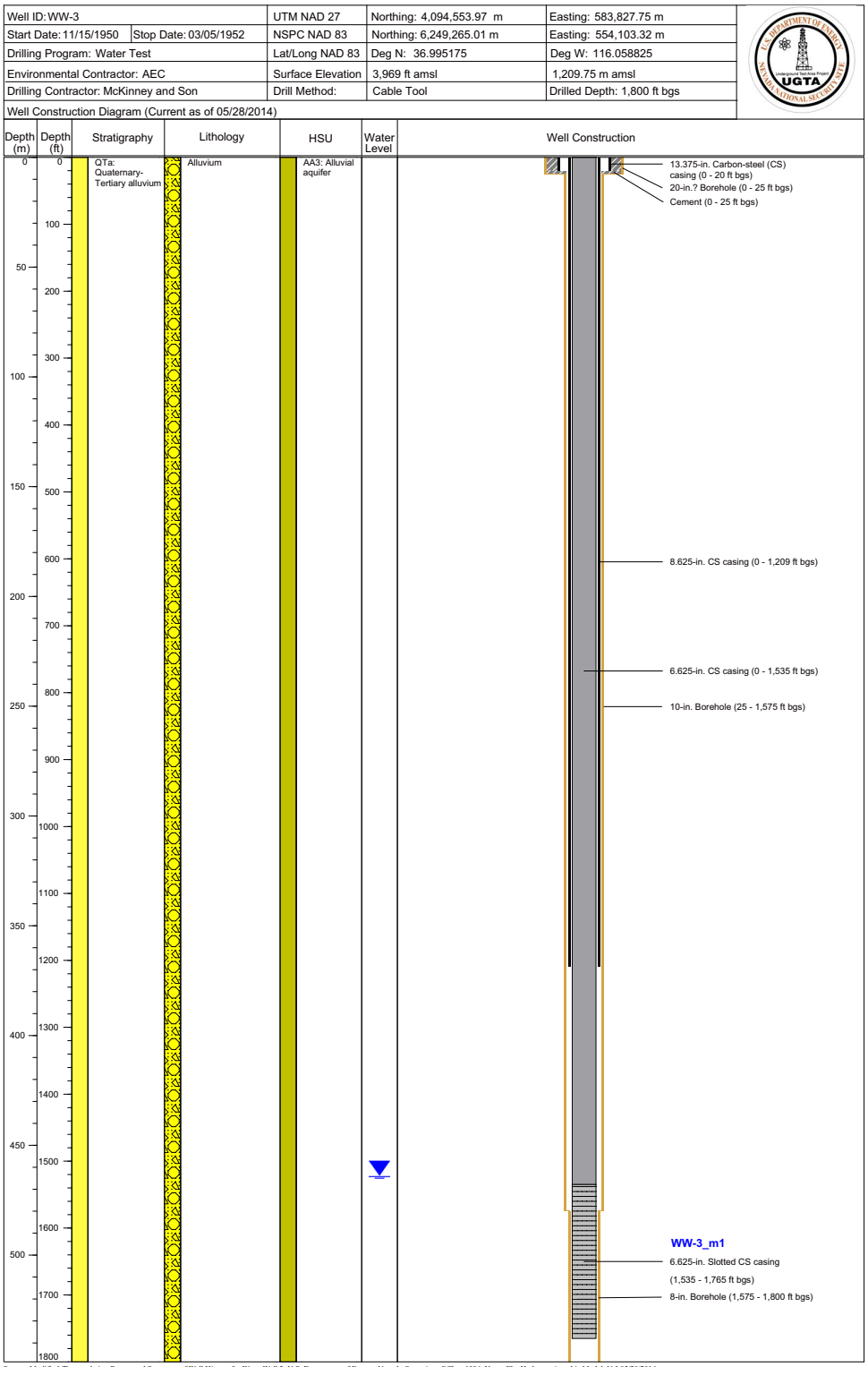


**Figure C-14**
**Well Completion Diagram for WW-3**

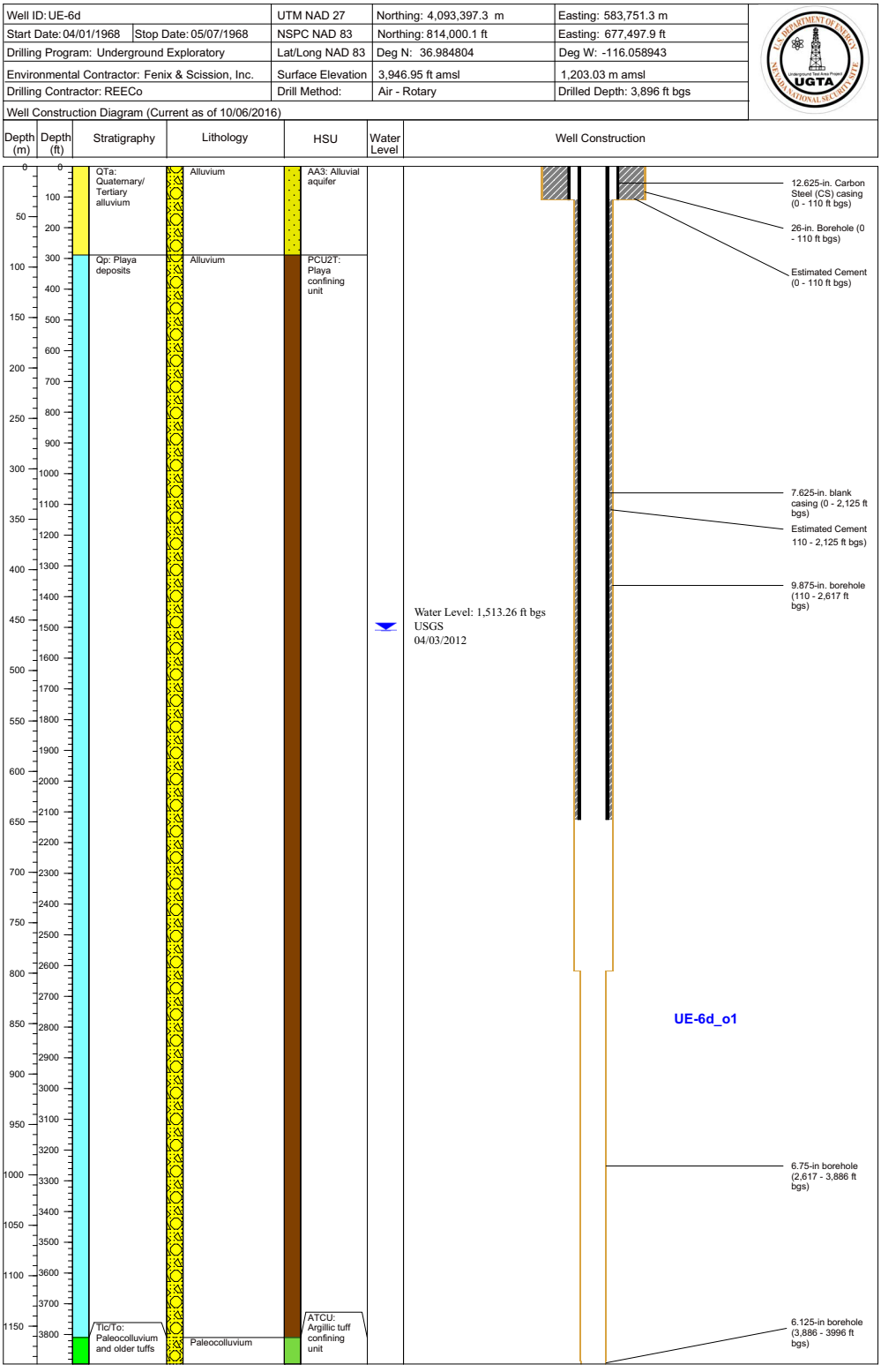


**Figure C-15**
**Well Completion Diagram for UE-6d**

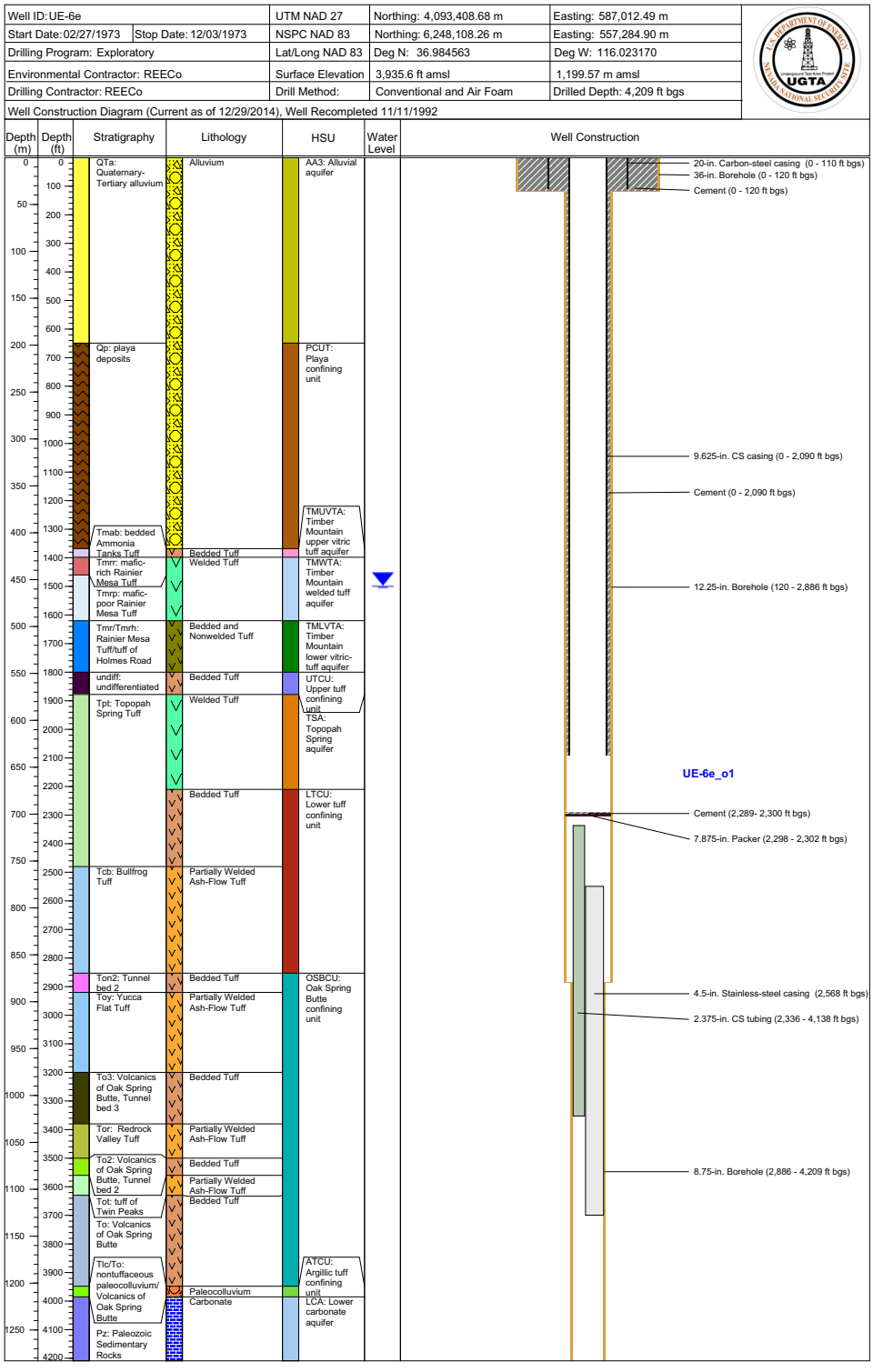


**Figure C-16**
**Well Completion Diagram for UE-6e**

| | | | | |
|---|---|---|---|---|
| Well ID: UE-7nS | | UTM NAD 27 | Northing: 4,106,091.4 m | Easting: 588,643.5 m |
| Start Date: 06/03/1976 | Stop Date: 07/15/1976 | NSPC NAD 83 | Northing: 6,260,788.6 m | Easting: 558,960.8 m |
| Drilling Program: NMO/ARPA | | Lat/Long NAD 83 | Deg N: 37.098723 | Deg W: 116.003352 |
| Environmental Contractor: LLNL | | Surface Elevation | 4,369.79 ft amsl | 1,331.91 m amsl |
| Drilling Contractor: REECo | | Drill Method: | Rotary/Air-foam | Drilled Depth: 2,205 ft bgs |
| Well Construction Diagram (Current as of 02/09/2017) | | | | |

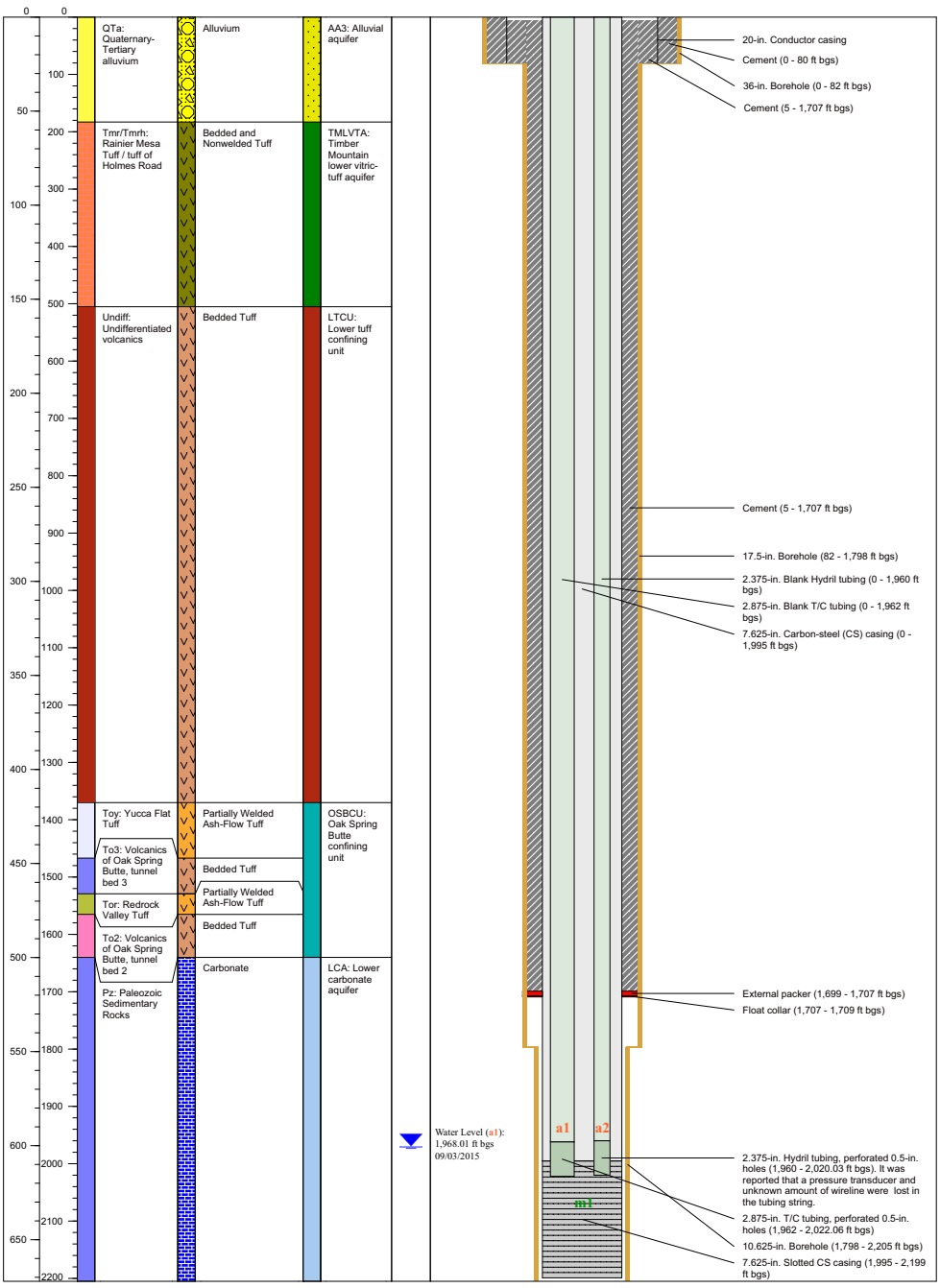


**Figure C-17**
**Well Completion Diagram for UE-7nS**

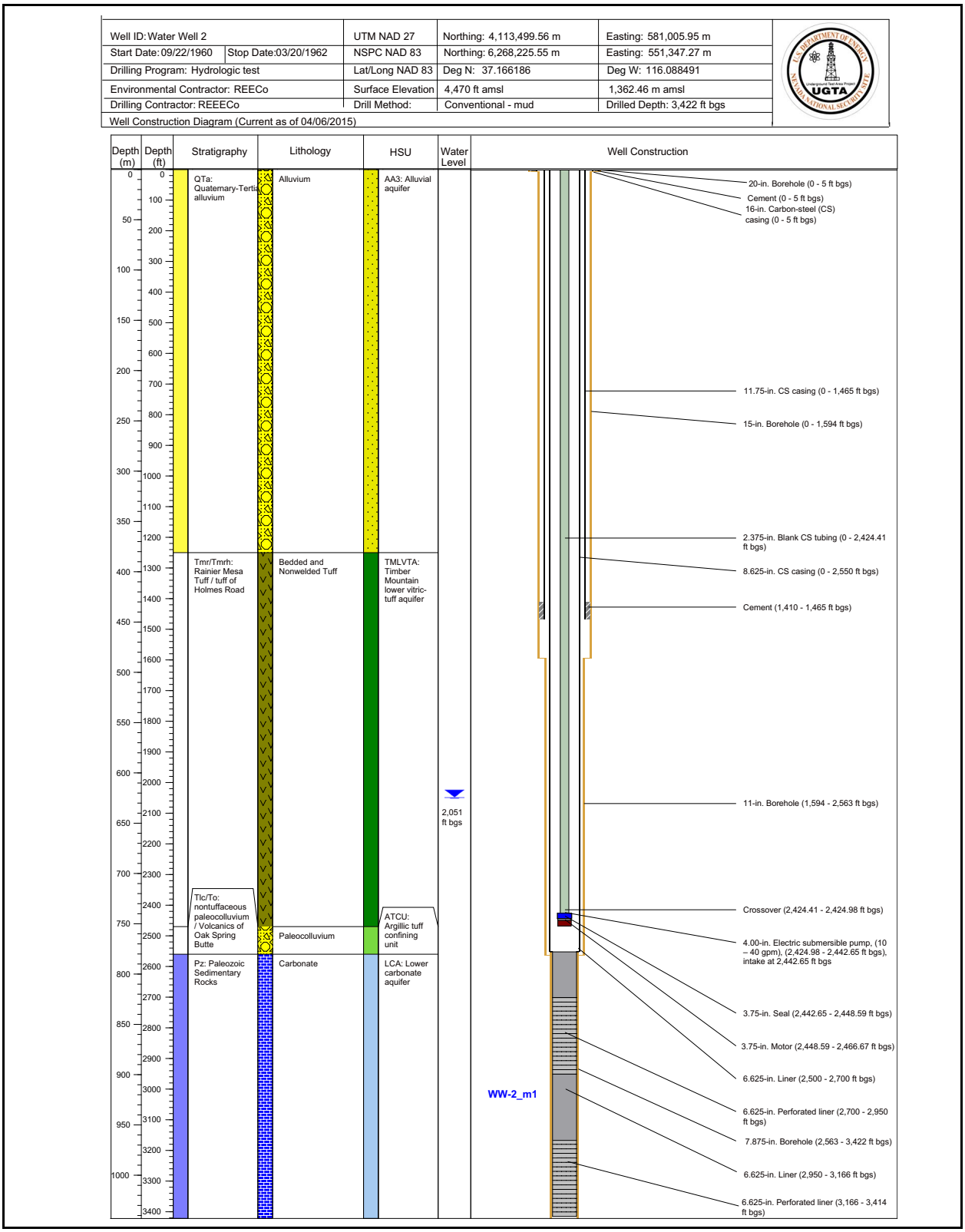


**Figure C-18**
**Well Completion Diagram for WW-2**

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