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Management
Operations Activity

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Underground Test Area Calendar Year 2014 Annual Sampling Analysis Report Nevada National Security Site, Nevada

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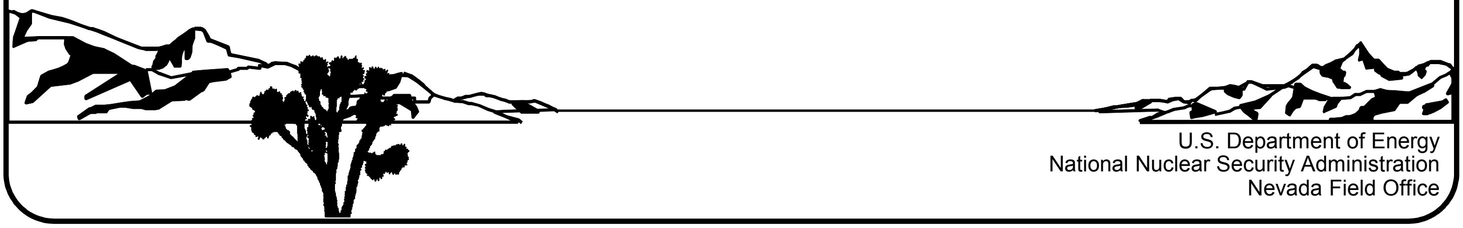

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UNDERGROUND TEST AREA
CALENDAR YEAR 2014
ANNUAL SAMPLING ANALYSIS REPORT
NEVADA NATIONAL SECURITY SITE, NEVADA

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

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ANNUAL SAMPLING ANALYSIS REPORT
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: ______________________ Date: 12/15/16

for/ Bill R. Wilborn
UGTA Activity Lead

Approved by: ______________________ Date: 12/15/16

/Robert F. Boehlecke
Environmental Management Operations Manager

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List of Acronyms and Abbreviations

General Acronyms and Abbreviations

AD	Absolute difference
AEC	Atomic Energy Commission
AMS	American Meteorological Society
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
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure report
CS	Carbon steel
CY	Calendar year
DOECAP	U.S. Department of Energy Consolidated Audit Program
DOE	U.S. Department of Energy
DRI	Desert Research Institute
EPA	U.S. Environmental Protection Agency
ES	Electric submersible
FFACO	*Federal Facility Agreement and Consent Order*
FMP	Fluid Management Plan
ft	Foot
FY	Fiscal year
gal	Gallon

List of Acronyms and Abbreviations *(Continued)*

gpm	Gallons per minute
HRMP	Hydrologic Radionuclide Monitoring Program
HSU	Hydrostratigraphic unit
in.	Inch
ISPID	Integrated Sampling Plan Identifier
IT	IT Corporation
LANL	Los Alamos National Laboratory
LCS	Laboratory control sample
LLNL	Lawrence Livermore National Laboratory
MB	Method blank
MCL	Maximum contaminant level
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
MDL	Minimum detection level
mg	Milligram
mg/L	Milligrams per liter
mi	Mile
M&O	Management and operating
mrem/yr	Millirem per year
MS	Matrix spike
N/A	Not applicable
NA	Not available
NAD	North American Datum
NDEP	Nevada Division of Environmental Protection
N-I	Navarro-Intera, LLC
NIST	National Institute of Standards and Technology
NNES	Navarro Nevada Environmental Services, LLC
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NSF	National Science Foundation

List of Acronyms and Abbreviations *(Continued)*

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
RCRA	*Resource Conservation and Recovery Act*
REECo	Reynolds Electrical & Engineering Co., Inc.
RL	Reporting limit
RN	Radionuclide
RNM	Radionuclide migration
RPD	Relative percent difference
RREMP	Routine Radiological Environmental Monitoring Plan
SDWA	*Safe Drinking Water Act*
SEC	Specific electrical conductance
SNJV	Stoller-Navarro Joint Venture
SS	Stainless steel
SU	Standard unit
T_0	Time zero
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
°C	Degrees Celsius

List of Acronyms and Abbreviations *(Continued)*

%meq/L	Percent milliequivalents per liter
‰	Per mil
µg/L	Micrograms per liter
µS/cm	Microsiemens per centimeter

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

AA	Alluvial aquifer
AA1	Alluvial aquifer 1
AA2	Alluvial aquifer 2
AA3	Alluvial aquifer 3
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
CHZCM	Calico Hills zeolitic composite unit
CPA	Comb Peak aquifer
FCCM	Fortymile Canyon composite unit
FCCU	Fluorspar Canyon confining unit
LCA	Lower carbonate aquifer
LCA3	Lower carbonate aquifer-thrust plate
LCCU	Lower clastic confining unit
LPCU	Lower Paintbrush confining unit
LTCU	Lower tuff confining unit

List of Acronyms and Abbreviations *(Continued)*

LVTA	Lower vitric-tuff aquifer
Mc	Chainman shale
MPCU	Middle Paintbrush confining unit
OAA	Older alluvial aquifer
OSBCU	Oak Spring Butte confining
PBPCU	Post-Benham Paintbrush confining unit
PBRCM	Pre-Belted Range composite unit
PCU2T	Playa confining unit 2
PLFA	Paintbrush lava-flow aquifer
Pz	Paleozoic sedimentary rocks
Qay	Young alluvial deposits/Quarternary alluvium
QTa	Quaternary and Tertiary alluvium
QTp	Older playa deposits
RMWTA	Rainier Mesa welded-tuff aquifer
RVA	Redrock Valley aquifer
SPA	Scrugham Peak aquifer
Tbgb	Grouse Canyon tuff, bedded
Tbgp	Crystal poor Grouse Canyon tuff
TCA	Tiva Canyon aquifer
Tcbs	Bullfrog tuff, Stockade Wash lobe
Tcg	Latite of Grimy Gulch
Tcpe	Rhyolite of ER-EC-1
Tcpk	Rhyolite of Kearsarge
Tcps	Rhyolite of Sled
TCVA	Thirsty Canyon volcanic aquifer
Tf	Volcanics of Fortymile Canyon, undifferentiated
Tfbr	Rhyolite of Chukar Canyon
Tfbw	Rhyolite of Beatty Wash
THCM	Tannenbaum Hill composite unit
THCU	Tannenbaum Hill confining unit

List of Acronyms and Abbreviations (Continued)

THLFA	Tannenbaum Hill lava-flow aquifer
Thp	Mafic-poor Calico Hills formation
Thr	Mafic-rich Calico Hills formation
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
Tml	Rhyolite of the Loop
TMLVTA	Timber Mountain lower vitric-tuff aquifer
Tmr	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
Tmt	Basalts of Tierra
TMWTA	Timber Mountain welded-tuff aquifer
To	Volcanics of Oak Spring Butte
To3	Volcanics of Oak Spring Butte, tunnel bed 3
Ton2	Tunnel bed 2
Tot	Tuff of Twin Peaks
Toy	Yucca Flat tuff
Tp	Paintbrush group, undivided
Tpb	Rhyolite of Benham
Tpc	Tiva Canyon tuff
Tpcm	Pahute Mesa lobe of Tiva Canyon tuff
Tpcx	Tiva Canyon, landslide or breccia
Tpcy	Crystal-poor tuff of Pinyon Pass
Tpd	Rhyolite of Delirium Canyon

List of Acronyms and Abbreviations *(Continued)*

Tpk	Rhyolite of Comb Peak
Tps	Rhyolite of Scrugham Peak
Tptm	Pahute Mesa lobe of Topopah Spring tuff
Tptx	Topopah Spring, landslide or breccia
Tpw	Rhyolite of Windy Wash
Tqh	Middle rhyolite of Quartz Mountain
TSA	Topopah Spring aquifer
Ttcl	Lower comendite of Ribbon Cliff
Ttcm	Middle comendite of Ribbon Cliff
Ttp	Pahute Mesa tuff
Ttr	Rocket Wash tuff
Ttt	Trail Ridge tuff
Ttwb	Basalt of Rocket Wash
Tyby	Basalt of Yucca Flat
UCCU	Upper clastic confining unit
UPCU	Upper Paintbrush confining unit

Symbols for Elements and Compounds

Ac	Actinium
Ag	Silver
Al	Aluminum
Am	Americium
Ar	Argon
As	Arsenic
Ba	Barium
Be	Beryllium
Bi	Bismuth
Br	Bromide
C	Carbon

List of Acronyms and Abbreviations *(Continued)*

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
Eu	Europium
F	Fluorine
Fe	Iron
H	Hydrogen
^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

List of Acronyms and Abbreviations *(Continued)*

Pb	Lead
Pu	Plutonium
S	Sulfur
Sb	Antimony
Se	Selenium
Si	Silicon
SO_4	Sulfate
Sr	Strontium
Tc	Technetium
TDIC	Total dissolved inorganic carbon
TDOC	Total dissolved organic carbon
Th	Thorium
Tl	Thallium
TOC	Total organic carbon
U	Uranium
Xe	Xenon
Y	Yttrium
$\delta^{2}H$	Delta deuterium
$\delta^{13}C$	Delta carbon-13
$\delta^{18}O$	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 Quality Assurance Plan (QAP) (NNSA/NSO, 2012) and the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended). The Sampling Plan is also designed to augment ongoing activities to ensure compliance with DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2013). 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 2014 fiscal year (FY) and calendar year (CY) (October 1, 2013, through December 31, 2014), and an evaluation of the data to ensure that the Sampling Plan's objectives are met. In addition to samples collected and analyzed for the Sampling Plan, some NNSS wells are monitored by NNSA/NFO to demonstrate compliance with State-issued water discharge permits; with protection of groundwater from ongoing radiological waste disposal activities (compliance wells); and to demonstrate that the onsite drinking water supply is below SDWA maximum contaminant levels (MCLs) (public water system [PWS] wells). While not all sampled locations are required by the Sampling Plan, these samples are relevant to its objectives and are therefore presented herein for completeness purposes. Special investigations that took place in 2014 that are relevant to the Sampling Plan are also presented.

This is the first annual report released to support Sampling Plan implementation. The original intent was that FY sampling results would be reported annually. It was later determined that CY year reporting was preferred. This report includes both FY and CY 2014 results; future reports will report only CY sampling results and special investigations.

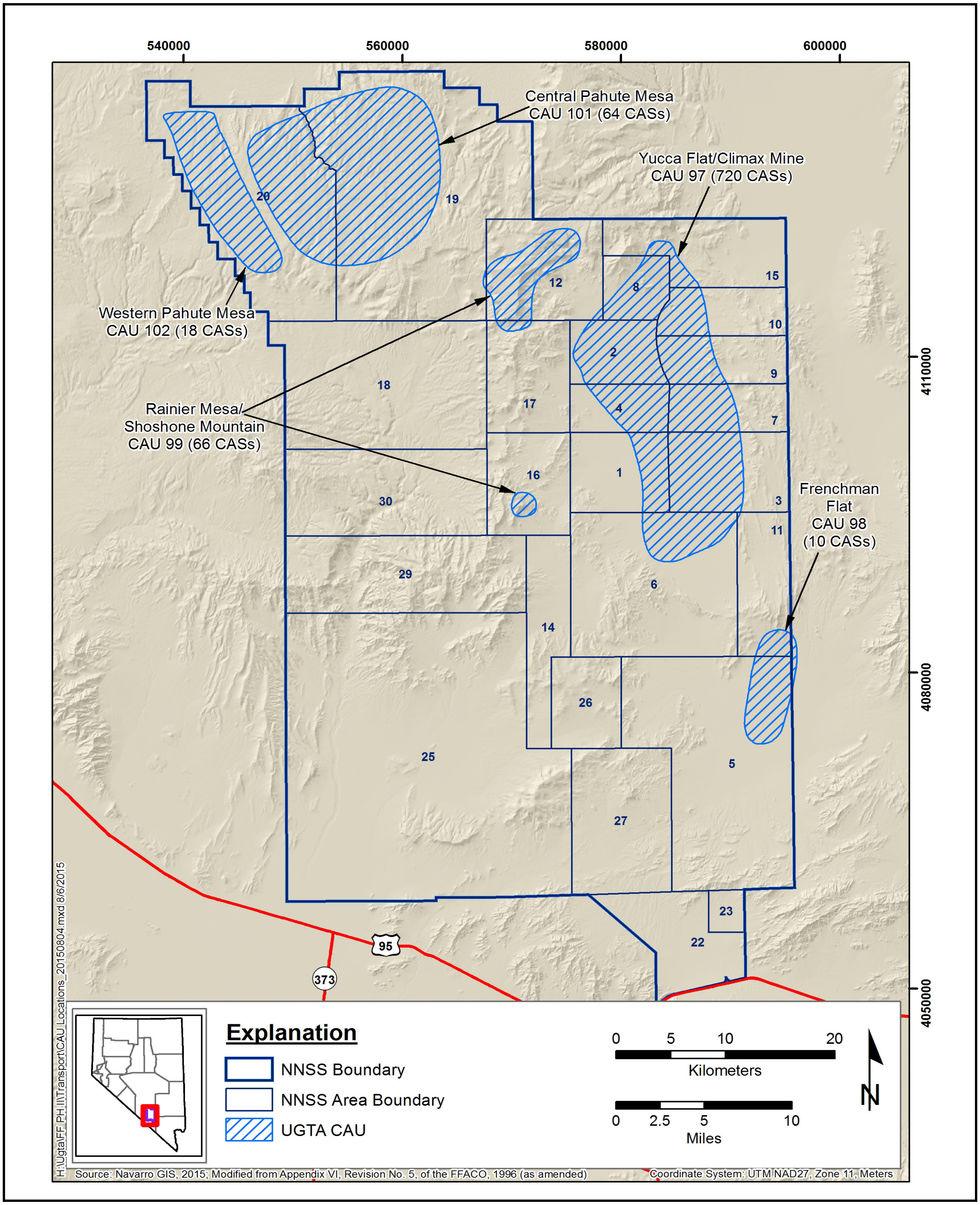
1.1 Background

A total of 907 underground nuclear detonations that are included in the UGTA Activity were conducted on the NNSS (formerly the Nevada Test Site) between 1951 and 1992, resulting in 878 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 (CAU 97), Frenchman Flat (CAU 98), Rainier Mesa/Shoshone Mountain (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 Rainier Mesa/Shoshone Mountain is fulfilled in four stages: the Corrective Action Investigation Plan (CAIP), Corrective Action Investigation (CAI), Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), and Closure Report (CR) (FFACO, 1996 as amended). The Rainier Mesa/Shoshone Mountain 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. With the exception of the Frenchman Flat CAU, all CAUs are currently 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 are categorized into six types based on the sampling objectives: characterization, source/plume, early detection, distal, community, and inactive. The six



Source: Navarro GIS, 2015; Modified from Appendix VI, Revision No. 5, of the FFACO, 1996 (as amended)

Coordinate System: UTM NAD27, Zone 11, Meters

Figure 1-1
UGTA CAU Locations

types are defined and the objectives identified for each type in Table 1-1. The type dictates the required analytical suite, associated detection limits, and sampling frequency (Table 1-1). The sampling locations and their types are shown in Figure 1-2. Relevant PWS and compliance wells are also shown on Figure 1-2.

Full implementation of the Sampling Plan is in progress and is expected to require several years. Some locations require pump replacement (e.g., ER-EC-2a, WW-C-1, U-4u PS 2A, U-20 WW, U-20n PS 1D), road repair (e.g., ER-EC-5, ER-16-1, UE-18r), or further evaluation because an obstruction or other sampling issue exists (e.g., ER-19-1, ER-20-6-1, ER-20-6-2, ER-20-6-3, UE-12t-6, UE-18t, U-19q PS 1D). Some locations (i.e., piezometers) were previously used for water-level measurements but can now be sampled because of new sampling technology (i.e., jack pump). Sampling priority is dependent on the sampling location type, CAU, and UGTA strategy stage; sampling technology availability; and well or road construction requirements. For instance, characterization locations in Pahute Mesa are given a high priority because this CAU is still in the early CAI stage; source/plume locations are a greater priority for Frenchman Flat because this CAU is in the beginning of the CR stage, and confidence in the COC and COPC list is a priority. Priority has been placed on answering Yucca Flat/Climax Mine external peer review panel questions to support advancement of this CAU to the CADD/CAP stage (N-I, 2015b).

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

- Piezometers are identified with an "_p" extension.
- Main completions are identified with an "_m" extension.
- Open boreholes are identified with an "_o" extension.
- 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.

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. • Identify groundwater flow paths. • Establish the presence or absence of groundwater COCs and COPCs. • 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. • Identify COCs. • Monitor contaminant migration. • 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. • 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. • 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

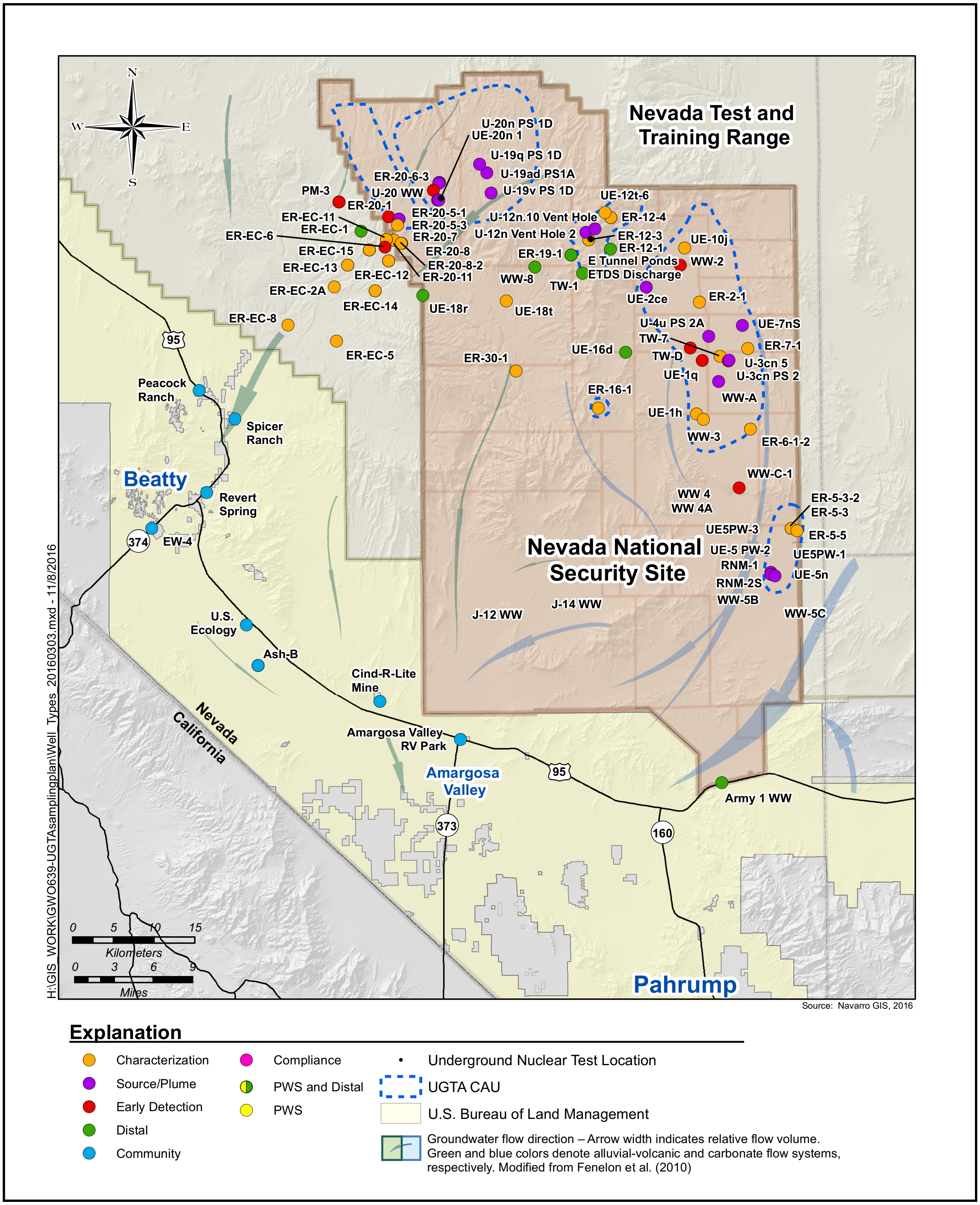
[a] Radioisotopes include ^{3}H (standard or enriched), ^{14}C, ^{26}Al, ^{36}Cl, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, $^{238/239/240}Pu$, ^{241}Am, and ^{243}Am.
[b] Characterization locations will transition to another type when a sufficient baseline (a minimum of three samples) is established to support categorization.
[c] Sampling frequency is every 2 years for Pahute Mesa CAUs and every 5 years for Frenchman Flat, Rainier Mesa/Shoshone Mountain, and Yucca Flat/Climax Mine CAUs.
[d] CFR, 2015

BLM = U.S. Bureau of Land Management
COC = Contaminant of concern
COPC = Contaminant of potential concern
MDC = Minimum detectable concentration

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



Source: Navarro GIS, 2016

Figure 1-2
Sampling Plan, Public Water Supply, and Compliance Well Locations

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 Contaminants of Concern and Contaminants of Potential Concern

The SDWA MCL (EPA, 2002) 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. 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 (Table 1-2). The MCL for beta and photon emitters is based on a calculated dose of 4 millirem per year (mrem/yr). 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 that will result in a 4-mrem/yr dose.

Table 1-2
Maximum Contaminant Levels
(Page 1 of 2)

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

Table 1-2
Maximum Contaminant Levels
(Page 2 of 2)

RN	MCL [a] (pCi/L)
$^{238/239/240}$Pu	15
$^{241/243}$Am	15

[a] Source: EPA, 2002

Notes:
(a) The MCL is based on the assumption that the radionuclide of interest is the only radionuclide present (i.e.,actual MCL is based on cumulative levels of RNs).
(b) The concentration equivalents leading to a 4-mrem/yr dose for ^{26}Al and ^{94}Nb have not been established by the EPA (EPA, 2002).

µg/L = Micrograms per liter

A COC is defined in the Sampling Plan as a 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 (Navarro, 2016b) 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.

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
Rainier Mesa/Shoshone Mountain	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and $^{238/239/240}$Pu
Yucca Flat/Climax Mine	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (and ^{90}Sr and ^{137}Cs in LCA samples)

LCA = Lower carbonate aquifer

A COPC is defined as a 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 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 current samples from each location (including each depth interval) identified in the Sampling Plan are presented in Table A-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 20,000 pCi/L MCL 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 (i.e., maximum ^{3}H concentrations for each depth interval) are in Table A-1.

MCL exceedances for RNs other than ^{3}H are presented in Figure 1-4. Only locations where ^{3}H has been previously detected are shown to improve decipherability of the specific locations. Test-related RNs are not present in NNSS groundwater without the simultaneous presence of ^{3}H, and therefore no exceedances exist where ^{3}H levels are not detectable. This is because of the high ^{3}H mobility and also because 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. Figure 1-4 and Table A-2 show that the SDWA MCL for RNs other than ^{3}H has been exceeded at six locations. These locations are all either a post-shot well that samples within the test cavity or chimney area (RNM-1, U-4u PS 2A, U-19ad PS1A, U-19v PS1D, U-20n PS 1D) or 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 (Table A-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-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, ^{14}C, and ^{137}Cs in the 2008 U-12n.10 vent hole sample are 0.99, 0.08, and 0.02,

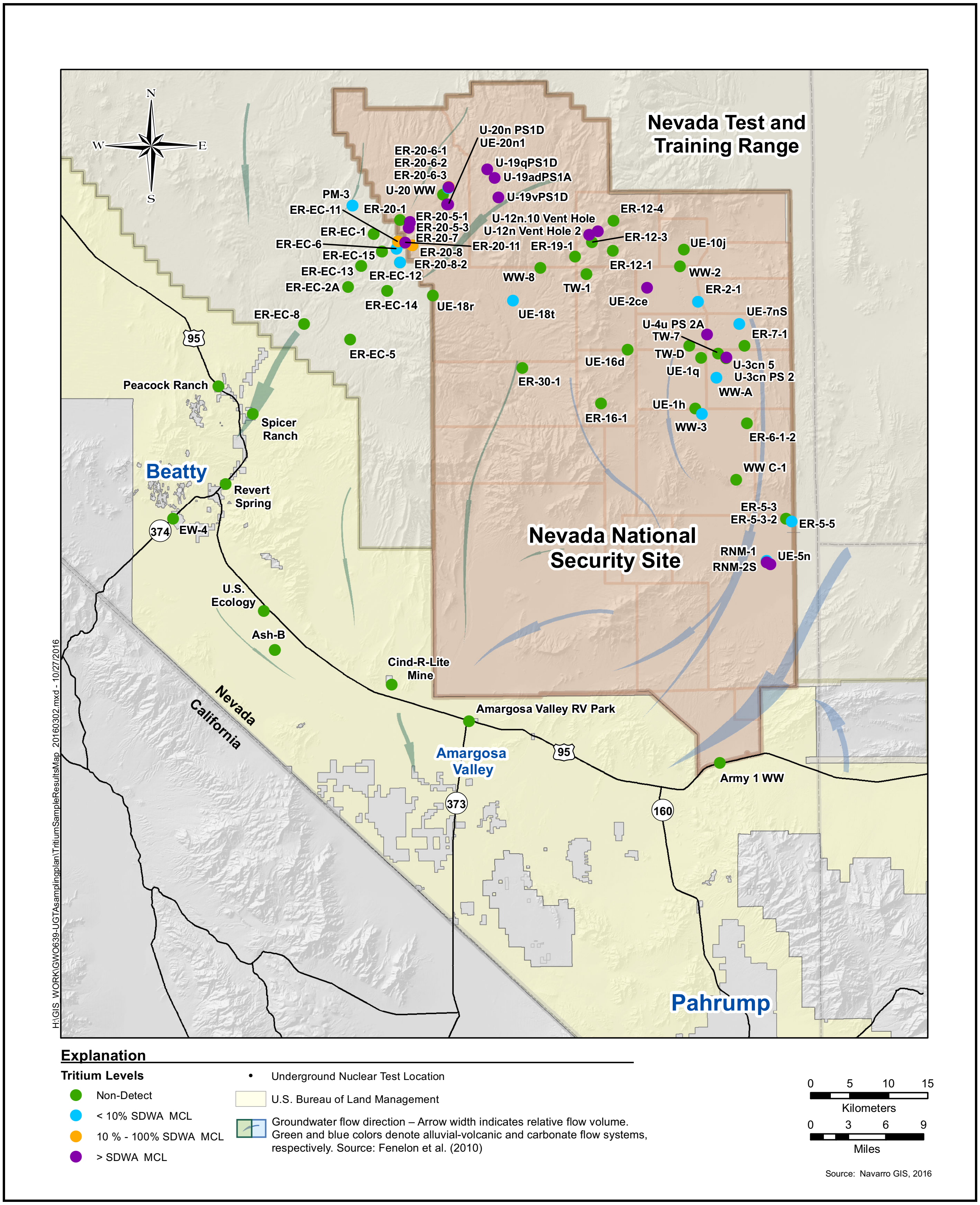
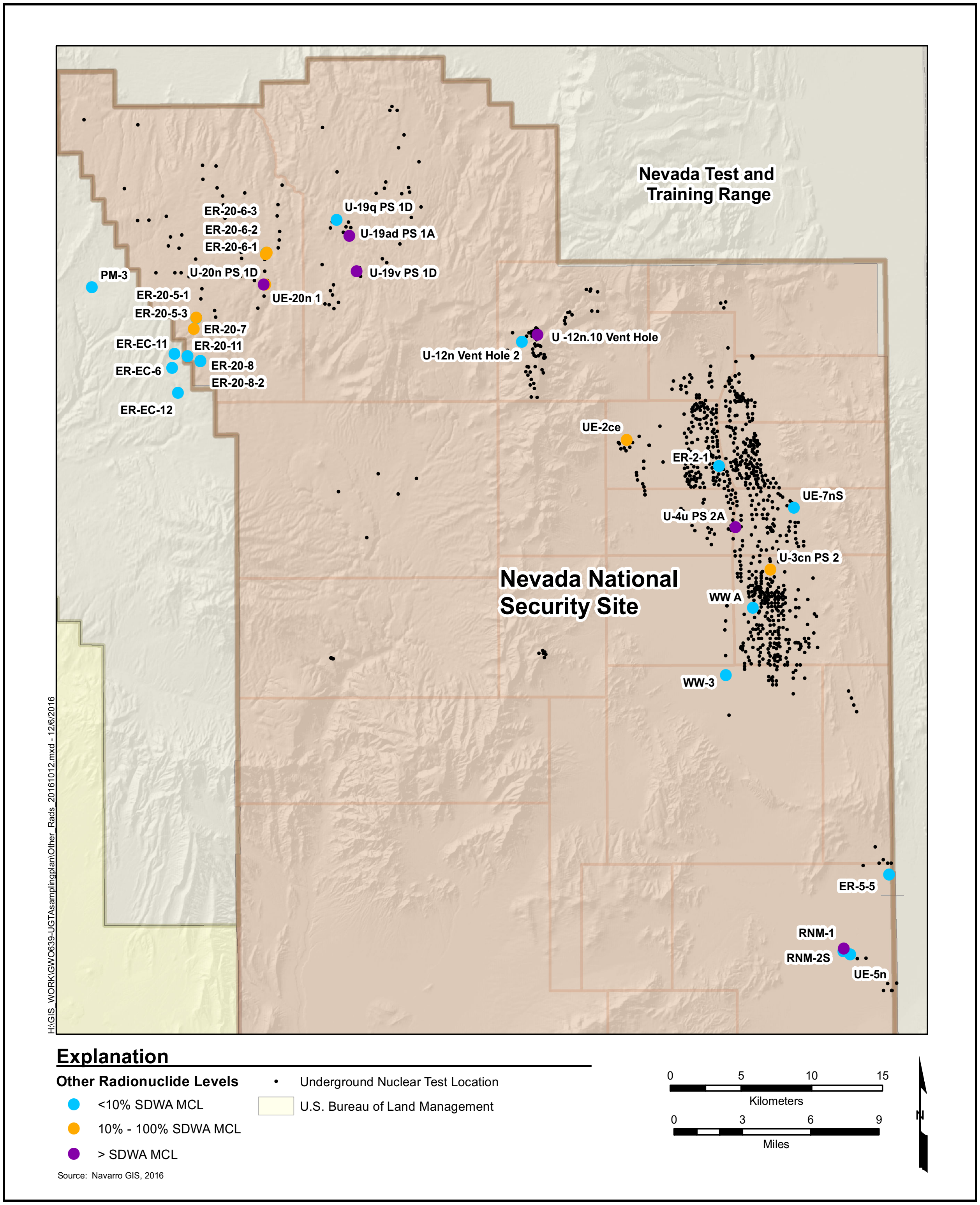


Figure 1-3
Maximum ^{3}H Concentrations



Source: Navarro GIS, 2016

Figure 1-4
MCL Exceedances for RNs Other Than ^3H

respectively; no ^{90}Sr data are available for this location. There are no exceedances for ^{14}C, ^{36}Cl, or ^{99}Tc in any of the samples.

There are seven locations that do not exceed the MCL but exceed 10 percent of the MCL for RNs other than ^{3}H (Figure 1-4 and Appendix A). These locations (ER-20-5-1, ER-20-6-1, ER-20-6-3, ER-20-7, UE-20n 1, UE-2ce, and U-3cn PS 2) are relatively close to an underground test cavity. The well furthest from a test cavity is ER-20-7. Groundwater contamination at ER-20-7 is at least partially attributed to the BENHAM cavity located approximately 1.3 miles (mi) from ER-20-7. While the ^{129}I concentration (0.14 pCi/L) is about 14 percent of the 1-pCi/L MCL, the ^{3}H concentration is 1.6×10^{7} pCi/L, which is nearly 800 times the 20,000 pCi/L MCL. One RN, ^{36}Cl, only exceeded 10 percent of its MCL and one RN, ^{99}Tc, did not exceed 10 percent of its MCL in any of the Sampling Plan locations, even in post-shot wells that sample the test cavity environment (Table 1-4).

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 PS1D
^{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	ER-20-5-1, UE-20n 1, U-3cn PS 2, and U-4u PS 2A
^{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-20n 1, 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

Two special investigations took place in 2014. The results are published in the following documents and summarized in the following subsections:

- *Underground Test Area Sampling Technologies Evaluation Report, Nevada National Security Site, Nye County, Nevada* (Navarro, 2015b)
- *Evaluation of PM-3 Chemistry Data and Possible Interpretations of ^{3}H Observations* (N-I, 2015a)

1.4.1 Sampling Technologies Evaluation

The goal of the sampling technologies evaluation was to identify sampling methods for each active well included in the Sampling Plan. The sampling method is dependent on the construction of the well and the objectives for each well type (characterization, source/plume, early detection, distal, and community). The investigation also sought to determine purging criteria for future sampling. Ultimately, the goal is to determine the most effective sampling technique to collect representative samples for the UGTA Activity. Currently, an electric submersible pump is most often used for sampling. This evaluation compared three technologies (bailer, electric submersible pump, and the jack pump) to determine whether they produce samples with similar ^{3}H activities.

Three wells located on Pahute Mesa (ER-20-8, ER-20-8-2, and ER-EC-11) and three sampling technologies were included in the evaluation. These wells were selected for testing because of their construction and proximity to known ^{3}H contamination. They were recently completed as large-diameter wells with accessible piezometer strings. ER-EC-11 and ER-20-8 have zones that were sealed off during drilling after encountering ^{3}H, and these zones were not developed or sampled since installation. The three ER-EC-11 piezometers (ER-EC-11_p1, ER-EC-11_p2, and ER-EC-11_p3) were sampled using a bailer and then a jack pump. The three ER-20-8 piezometers (ER-20-8_p1, ER-20-8_p2, and ER-20-8_p3) were sampled using a bailer, and the shallow main completion (ER-20-8_m2) was sampled using an electric submersible pump. The shallow ER-20-8-2 piezometer (ER-20-8-2_p1) was sampled using a bailer and a jack pump, and the main completion (ER-20-8-2_m1) was sampled using an electric submersible pump. Samples were analyzed for ^{3}H and major ions. In addition, time-series ^{3}H and water-quality samples were collected to determine how well water-quality parameters represent ^{3}H during purging, and to determine the number of purge volumes required for ^{3}H stabilization. The characterization analytical suite was also collected from each depth-interval as required by the Sampling Plan.

The study showed that depth-discrete bailer sample and purged sample ^{3}H concentrations are similar for the wells tested when the well had been previously developed. This indicates that depth-discrete bailer sampling may be used for collecting representative ^{3}H samples from these wells. This is particularly significant for sampling early detection, distal, and community wells for which ^{3}H is the only required analyte. The investigation also confirmed that the jack pump is an alternative method to collect samples in characterization wells. The relative cost (labor) of the jack pump is much greater than the bailer because of the required time and resources to set up and purge the interval. As experience is gained in using the jack pump, these costs may decrease considerably. Although the labor cost of moving the electric submersible pump in a multiple completion well was not determined in this study, these costs have historically been more than those determined for operating and moving the jack pump.

Stabilization of the water-quality-indicator parameters was shown to often require greater purge volumes than required to stabilize ^{3}H levels in the groundwater. In most cases, time-series ^{3}H results stabilized in less than one borehole volume. With the exception of turbidity and dissolved oxygen (DO), water-quality parameters also often stabilized after purging a single borehole volume. These findings led to the recommendation that stabilization criteria not include turbidity or DO when sampling for ^{3}H. Impacts on ambient hydrogeochemical conditions will be reduced by eliminating turbidity and DO as stabilization criteria. This recommendation has not yet been approved or implemented.

1.4.2 Evaluation of PM-3 Chemistry

Sampling performed under the Routine Radiological Environmental Monitoring Plan (RREMP) detected the presence of ^{3}H in depth-discrete bailed samples collected from PM-3 in 2010 and 2011. Similar results were observed in samples collected in 2011 by the UGTA Project (now UGTA Activity) (Table 1-5). A special investigation was performed to confirm the presence of ^{3}H measured in the bailed samples, and whether ^{3}H presence is confirmed to determine its source.

Table 1-5
PM-3 ^{3}H Results (pCi/L)

Year	Program	PM-3-1 (PM-3_p1)	PM-3-2 (PM-3_p2)
2010	RREMP	<27.8	48.3 | 46.8
2011	RREMP	<28 | 33.8	58.0 | 63.2
2011	UGTA	18.6 | 33.2	36.7 | 56.6
2012	RREMP	52.9 | 39.0	64.6 | 73.4
2013	UGTA	37.0 | 43.7	225 | 249

Note: The "|" denotes the sample | duplicate.

PM-3 is located in the Thirsty Canyon area of Nye County, Nevada, on the Nevada Test and Training Range (NTTR) and is approximately 2 mi west of operable Area 20 of the NNSS (Figure 1-2). PM-3 consists of an upper piezometer (PM-3-2) and lower piezometer (PM-3-1). The ISPID for PM-3-1 and PM-3-2 are PM-3_p1 and PM-3_p2, respectively. PM-3-2 accesses the Upper Paintbrush confining unit (UPCU), and PM-3-1 accesses the Tiva Canyon aquifer (TCA) and the upper portion of the Lower Paintbrush confining unit (LPCU) (see Appendix C).

In 2013, PM-3-1 and PM-3-2 were configured with a jack pump and pumped at 3 to 4 gallons per minute (gpm) until the water quality stabilized (after about 24,200 gallons [gal] from PM-3-1 and about 31,800 gal from PM-3-2). Well development and sampling activities were conducted to evaluate the groundwater chemistry at this location and compare the results to the previous depth-discrete bailer sample results. The development objectives included removing residual fluids from the two piezometers to improve the hydraulic connection to the formation and to restore the natural groundwater chemistry within the completion intervals. Samples were then collected and analyzed for the full characterization suite of geochemical and radiochemical parameters.

A range of possible hypotheses have been proffered to explain the observed ^{3}H at PM-3. These hypotheses included the following possibilities:

- Downward percolation of surface water or precipitation with a higher ^{3}H concentration
- Lateral groundwater flow and ^{3}H transport from upgradient ^{3}H sources such as the HANDLEY detonation

The downward percolation hypothesis relies on the possibility of vertical ^{3}H transport over the approximately 0.3 mi to the PM-3-2 open interval. Using average infiltration rates and average transport properties, it is not likely that anthropogenic ^{3}H would be transported this distance. However, it is possible that localized higher infiltration rates existed in areas where nearby ephemeral drainage channels intersect the permeable tuff aquifers. These areas of potentially higher infiltration could lead to more rapid vertical transport through the unsaturated zone. Information that generally supports the vertical transport hypothesis includes (1) higher ^{3}H and other mobile RN concentrations in PM-3-2 (i.e., shallow zone) than PM-3-1 (i.e., deeper zone); (2) an apparent vertical hydraulic gradient between PM-3-2 to PM-3-1, indicating the possibility of downward vertical flow; and (3) helium concentrations suggesting less than a 50-year travel time.

The second hypothesis relies on the possibility of lateral ^{3}H transport over the 4.5-mi distance from the HANDLEY, or possibly PURSE nuclear detonations, to PM-3 through aquifers and confining units between these locations. Information that generally supports the lateral transport hypothesis includes (1) a significant horizontal hydraulic gradient along the postulated groundwater flow path between HANDLEY and PM-3; (2) a similar groundwater geochemistry at HANDLEY (represented by UE-20j WW) and PM-3; (3) the presence of a potentially continuous fractured hydrostratigraphic unit (HSU) (i.e., the belted range aquifer [BRA]) that is penetrated by the HANDLEY chimney and PM-3; and (4) observed concentrations of mobile RNs (i.e., ^{3}H, ^{14}C, ^{36}Cl and ^{129}I) at PM-3-1 and PM-3-2 that have similar ratios to the HANDLEY cavity concentration when considering the effects of ^{3}H decay. Although there remains uncertainty in the definitive interpretation of the PM-3 ^{3}H, it is possible that the ^{3}H observed at PM-3 is the leading edge of the plume resulting from lateral transport downgradient from HANDLEY. If the lateral transport hypothesis is correct, one would expect that additional sampling of the two piezometers at this location over the next decades may show an increase of ^{3}H concentrations. It is important to recognize that the ^{3}H at this location and other locations along the possible transport path will also undergo decay, and that if the observed concentrations are the result of lateral transport from HANDLEY, PM-3 serves as an excellent monitoring location. To further evaluate the ^{3}H source, a well between HANDLEY and PM-3 will be drilled, developed, and sampled. Hydrologic testing at this well will provide additional data to improve the hydrogeologic understanding within this area.

2.0 Sampling and Analysis Methods

A total of 17 wells (27 depth intervals) were sampled in 2014 (Table 2-1). These comprised 9 characterization (17 depth intervals), 3 source/plume (3 depth intervals), 1 early detection (2 depth intervals), and 4 distal (5 depth intervals) locations. Some sampled wells are single-zone completions where samples are collected from one depth interval. Other wells are multiple-completion sampling multiple depth intervals (e.g., ER-20-8, ER-EC-11, ER-EC-14, ER-EC-15, and PM-3). The samples collected in 2014 and the collection method, purge volume, flow rate, depth intervals and HSUs associated with the sample are presented in Table 2-1. The 2014 sample and analysis methods and the corresponding results are presented in Sections 2.0 and 3.0, respectively.

Table 2-1
2014 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)							
Source/Plume	RNM-1	RNM-1_m3-5	04/08/2014	AA	ES Pump	1.7E+04	47
	RNM-2S	RNM-2S_m1	05/15/2014	AA	ES Pump	1.6E+05	580
	UE-5n	UE-5n_m1	06/12/2014	AA	ES Pump	2.2E+04	14
Pahute Mesa (CAUs 101 and 102)							
Characterization [a]	ER-20-7	ER-20-7_m1	11/21/2014	TSA	ES Pump	7.6E+05	20
	ER-20-8	ER-20-8_p1	09/03/2014 09/04/2014	LPCU/TSA/CHZCM	Bailer	N/A	N/A
		ER-20-8_p2	10/21/2014	LPCU/TSA/CHZCM	Bailer	N/A	N/A
		ER-20-8_p3	09/14/2014 09/15/2014 09/16/2014	UPCU/SPA	Bailer	N/A	N/A
	ER-20-8-2	ER-20-8-2_p1 [b]	10/06/2014 10/07/2014	BA/UPCU/SPA/MPCU	Jack Pump	2.3E+04 2.6E+04	2.3 2.3
		ER-20-8-2_m1 [b]	10/16/2014 10/17/2014		ES Pump	6.7E+04 1.0E+05	27 25
	ER-EC-11	ER-EC-11_p1	07/24/2014 07/25/2014	TSA/CHCU	Jack Pump	1.3E+04 1.6E+04	3.0 2.7
		ER-EC-11_p2	08/11/2014 08/12/2014	UPCU/TCA	Jack Pump	1.4E+04 1.7E+04	2.5 2.5
		ER-EC-11_p3	08/25/2014	FCCU/BA	Jack Pump	2.4E+04	2.5

Table 2-1
2014 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)
Pahute Mesa (CAUs 101 and 102) (continued)							
Characterization [a]	ER-EC-14	ER-EC-14_m1	05/11/2014	RMWTA	ES Pump	1.1E+07	265
		ER-EC-14_m2	04/05/2014	RMWTA	ES Pump	3.6E+06	153
	ER-EC-15	ER-EC-15_m1	02/16/2014 02/17/2014	TSA/CHCU	ES Pump	3.6E+06 3.6E+06	20 20
		ER-EC-15_m2	01/09/2014 01/10/2014	TCA/LPCU	ES Pump	1.1E+04 1.3E+04	13.5 11.9
		ER-EC-15_m3	11/05/2013 11/06/2013	FCCU/CPA/PBPCU	ES Pump	3.0E+06 3.1E+06	123
Early Detection	PM-3	PM-3_p1	06/11/2014	TCA/LPCU	Bailer	N/A	N/A
		PM-3_p2	06/11/2014	UPCU	Bailer	N/A	N/A
Community	Ash B	Ash-B_p1	04/21/2014	Volcanic rocks	Bailer	N/A	N/A
		Ash-B_p2	04/21/2014	Valley fill	Bailer	N/A	N/A
Rainier Mesa/Shoshone Mountain (CAU 99)							
Distal	WW-8	WW-8_m26	11/05/2013 01/14/2014 04/08/2014 07/22/2014 10/29/2014	OSBCU/RVA/ LTCU/ATCU	ES Pump	NA 9.0E+03 3.2E+03 6.6E+03 NA	NA
	UE-16d WW	UE-16d WW_m1	11/05/2013 01/14/2014	UCCU	ES Pump	NA 1.6E+04	NA
Yucca Flat/Climax Mine (CAU 97)							
Characterization [a]	ER-7-1	ER-7-1_m1	06/19/2014 06/20/2014	LCA	ES Pump	200 2.4E+04	23.5 23.8
	UE-1h	UE-1h_o1	06/03/2014	LCA	Bailer	N/A	N/A
	WW-3	WW-3_m1	06/03/2014	AA	Bailer	N/A	N/A
Distal	Army 1 WW	Army 1 WW_m1	11/05/2013 01/14/2014	LCA	ES Pump	NA 4.0E+03	NA 400

[a] Only pumped characterization samples—not bailer samples—are included when available. When characterization location samples are collected using a bailer the analytical suite is less extensive than provided in Table 1-1.
[b] ER-20-8-2_p1 and ER-20-2_m1 sample the same depth interval of ER-20-8-2.

AA = Alluvial aquifer
ATCU = Argillic tuff confining unit
BA = Benham aquifer
CHCU = Calico Hills confining unit
CHZCM = Calico Hills zeolitic composite unit
CPA = Comb Peak aquifer
FCCU = Fluorspar Canyon confining unit
LCA = Lower carbonate aquifer
LPCU = Lower Paintbrush confining unit
LTCU = Lower tuff confining unit
MPCU = Middle Paintbrush confining unit
OSBCU = Oak Spring Butte confining unit
PBPCU = Post-Benham Paintbrush confining unit
RMWTA = Rainier Mesa welded-tuff aquifer
RVA = Redrock Valley aquifer
SPA = Scrugham Peak aquifer
TCA = Tiva Canyon aquifer
TSA = Topopah Spring aquifer
UCCU = Upper clastic confining unit
UPCU = Upper Paintbrush confining unit
ES = Electric submersible
N/A = Not applicable
NA = Not available

Table 2-2 presents other sampling relevant to the UGTA Activity including PWS wells, compliance wells, and inactive wells (i.e., not routinely sampled for the Sampling Plan).

Table 2-2
PWS, Compliance, and Inactive Well Samples Collected in 2014

Location Type	Well Name	ISPID	Sample Date
PWS	J-12 WW	J-12 WW_m1	11/05/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/30/2014
	J-14 WW	J-14 WW_m1	11/19/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/30/2014
	WW-4	WW 4_m1	11/05/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/29/2014
	WW-4a	WW 4A_m1	11/05/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/29/2014
	WW-5b	WW 5B_m1	11/05/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/29/2014
	WW-8[a]	WW-8_m26	11/05/2013, 01/14/2014, 04/08/2014, 07/22/2014, 10/29/2014
Compliance	UE-5 PW-1	UE-5 PW-1_p1	03/11/2014, 08/12/2014
	UE-5 PW-2	UE-5 PW-2_p1	03/11/2014, 08/12/2014
	UE-5 PW-3	UE-5 PW-3_p1	03/11/2014, 08/12/2014
Inactive	ER-6-2	ER-6-2_o1	06/18/2014, 06/19/2014
	WW-5a	WW 5A_m1	07/02/2014
	ER-EC-6	ER-EC-6_m3	12/10/2014, 12/11/2014
		ER-EC-6_m2	12/18/2014, 12/19/2014

[a] WW-8 is also a distal well.

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 wire-line bailer or a portable pumping system. All water samples are collected in a manner that best ensures they represent ambient formation water following the sampling methods described in standard operating procedures. UGTA Activity sampling is performed in compliance with the “UGTA Sample Collection and Processing Procedure” (Navarro, 2016a), 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, 2016). 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). Documentation, sample handling, chain of custody, and quality control (QC) requirements associated with sample collection are performed in accordance with the UGTA QAP (NNSA/NSO, 2012). Chain of custody is implemented to provide traceability of sample possession from the time the samples are collected until disposition.

While the well is not purged when sampled using a bailer, purging of the well is required for collecting samples using a pump. The current standard operating procedures require that a minimum of three effective well volumes are purged and that water-quality parameters meet the following criteria: the pH has stabilized, and measurements remained constant within 0.1 standard unit (SU); specific conductance and temperature have stabilized and vary by no more than 10 percent for at least three consecutive readings; and the turbidity has stabilized below 10 nephelometric turbidity units (NTUs). These criteria were recently evaluated (Section 1.4.1). Stabilization of these water-quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the well-bore. The amount of groundwater purged before sample collection is presented in Table 2-1.

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 the State of Nevada. 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,

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			
δ^2H, δ^{18}O	SOP-UGTA-128	Analysis of ^{18}O and ^{2}H in Groundwater Samples	N/A
DIC, δ^{13}C	SOP-UGTA-116	Analysis of TDIC, TDOC, and ^{13}C in Groundwater Samples	0.01 mg/L (TDIC) N/A (δ^{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); 2.8E-06 ($^{3/4}$He); 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 SOP-UGTA-115	Determination of Inorganic Anions by Ion Chromatography Analysis of ^{36}Cl in Aqueous Samples	10E-06 pCi/L
$^{87/86}$Sr	SOP-UGTA-133 SOP-UGTA-134 SOP-UGTA-117	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS ^{87}Sr /^{86}Sr Analysis of Groundwater Samples	N/A
^{99}Tc	SOP-UGTA-133 SOP-UGTA-134 SOP-UGTA-111	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS 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 SOP-UGTA-134 SOP-UGTA-118	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS 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			
$^{34/32S}$	USGS-YM-GCP-44	Sulfur Isotope Analysis of Dissolved Sulfate in H2O	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
He = Helium
Kr = Krypton
Ne = Neon
O = Oxygen

S = Sulfur
TDIC = Total dissolved inorganic carbon
TDOC = Total dissolved organic carbon
U = Uranium
Xe = Xenon
δ^2H = Delta deuterium
δ^{13}C = Delta carbon-13
δ^{18}O = Delta oxygen-18

AMS = American Meteorological Society
mg/L = Milligrams per liter
NSF = National Science Foundation

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 Desert Research Institute (DRI) also perform or are responsible for specialized analyses (Table 2-3). These analyses support characterization of groundwater flow paths and travel time estimates.

3.0 Sampling and Analysis Results

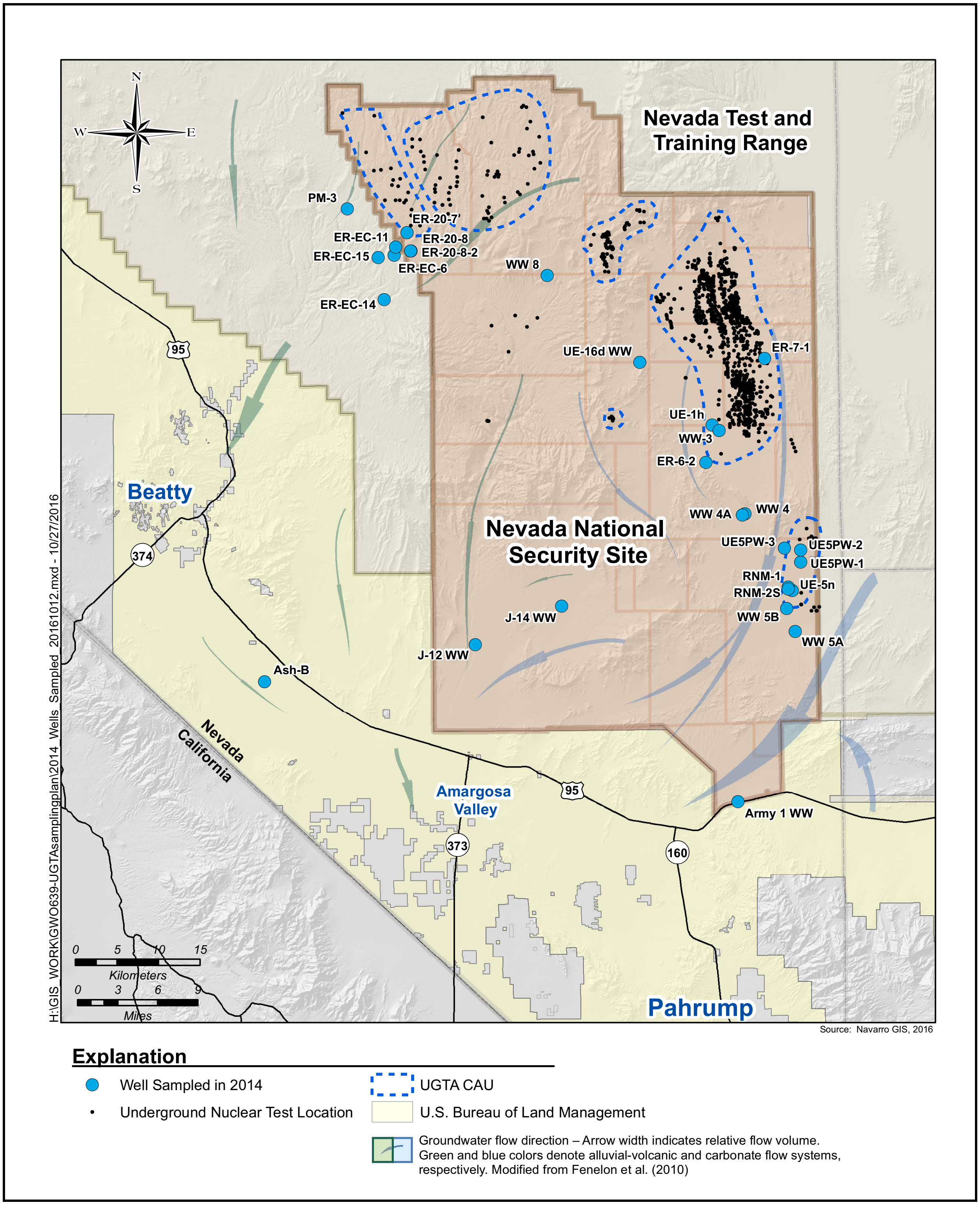
Sampling took place in all UGTA CAUs in 2014 (Table 2-1 and Figure 3-1). This section presents the sampling and the associated results within each CAU. The analytical results and information regarding the analyses (e.g., laboratory, data quality) are presented in Appendix B. The 2014 results along with the historical data reported within these sections are maintained within the UGTA Chemistry Database (Navarro, 2016b). 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.

3.1 Frenchman Flat

In 2014, three source/plume wells were sampled for Frenchman Flat-specific COPCs (Table 1-3) and other RNs (^{90}Sr, ^{237}Np, ^{234,235,238}U, and ^{238,239,240}Pu) included in the NNSS RN inventory (Finnegan et al., 2016). These additional RNs were analyzed at the CAU Lead's request to further validate the COPCs selected for this CAU as the CAU advances to the CR stage. In addition, one inactive well (WW-5a), three PWS wells (WW-4, WW-4a, and WW-5b), and three compliance wells (UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3) were sampled in Frenchman Flat or in its vicinity. Sampling at each of these wells and the corresponding analytical results are described in the following subsections.

3.1.1 Source/Plume Wells

Three source/plume wells associated with the CAMBRIC radionuclide migration (RNM) project (RNM-1, RNM-2S, UE-5n) were sampled in 2014. The RNM project was initiated in 1974 to evaluate RN migration away from the CAMBRIC underground nuclear test. RNM-1 was slant-drilled through the radioactive debris and cavity formed by the CAMBRIC test. RNM-2S was installed approximately 300 feet (ft) south of the CAMBRIC detonation point. Groundwater flow from the CAMBRIC test was induced by pumping well RNM-2S from October 1975 to August 1991 (Bryant, 1992). A total of 4.5×10^9 gal of RNM-2S groundwater was pumped into an unlined discharge ditch (CAMBRIC ditch). RNM-2S was pumped continuously over 75 days (April 26 to July 10, 2003) at an average rate of 595.5 gpm for a multiple-well aquifer test (SNJV, 2004). UE-5n was constructed in 1976, 1,865 ft southeast of the CAMBRIC cavity within the CAMBRIC ditch.



Source: Navarro GIS, 2016

Figure 3-1
2014 Sample Locations

3.1.1.1 RNM-1

RNM-1 penetrates the CAMBRIC nuclear test cavity and is currently open below the water table to about 272 ft of alluvium. The presence of packers and perforated casing allows for five discrete testing intervals (see Figure C-1). The intervals accessed for the 2014 sampling (RNM-1_m4-5) are defined by an external casing packer set at 1,002.07 ft below ground surface (bgs) for sampling within the chimney (RNM-1_m4) and chimney periphery (RNM-1_m5). The well is equipped with a dedicated electric submersible pump that is capable of pumping at a rate of 45 gpm. The static water level was measured on March 10, 2014, at a depth of 729.72 ft bgs and an elevation of 2,405.45 ft above mean seal level (amsl).

Groundwater samples were collected on April 8, 2014, after purging approximately 12,700 gal from the well (April 7 to April 8, 2014). This purge volume equates to approximately 3.7 well volumes (one purge volume is approximately 3,400 gal). Groundwater samples were collected from the sampling port on the wellhead manifold and analyzed by ALS Laboratory Group, ARS International, and LLNL. The results are presented in Tables B.1-1 and B.1-2. The commercial laboratory ^{3}H activities range from 550 to 620 pCi/L, and with the exception of the reported ^{90}Sr and ^{238}Pu activities, other RNs are below their analytical detection limits. As described in Section B.1.0, the reported ^{90}Sr and ^{238}Pu have a large degree of analytical uncertainty associated with them.

A groundwater sample and field duplicate for ^{3}H analysis were also collected on April 7, 2014, after purging 125 gal. This sample was collected to determine the difference in ^{3}H as a function of purge volume. The ^{3}H activities for these samples were reported as less than 320 pCi/L. Lower ^{3}H concentrations than those for the samples collected on April 8 confirm the need for well purging before sampling.

Figure 3-2 presents RN data from well RNM-1 (RNM-1_m4-5) collected since 1975. Although other RNs (gamma emitters, ^{14}C, Pu) were measured over this time period, they were not detected from this zone and are not shown in Figure 3-2. The ^{3}H activity has decreased from 10^{6} to 10^{2} pCi/L over this sampling period; the majority of the ^{3}H was removed during the 16-year pumping period ending in 1991. The reported ^{90}Sr activity in 1975 was as high as 340 pCi/L, well above the 8 pCi/L MCL, and had decreased below the MCL in 1985 (7 pCi/L). However, the ^{90}Sr activities have ranged from 1.8 to 11 pCi/L since 1985 (^{90}Sr in some samples has exceeded its MCL over this time period). The only

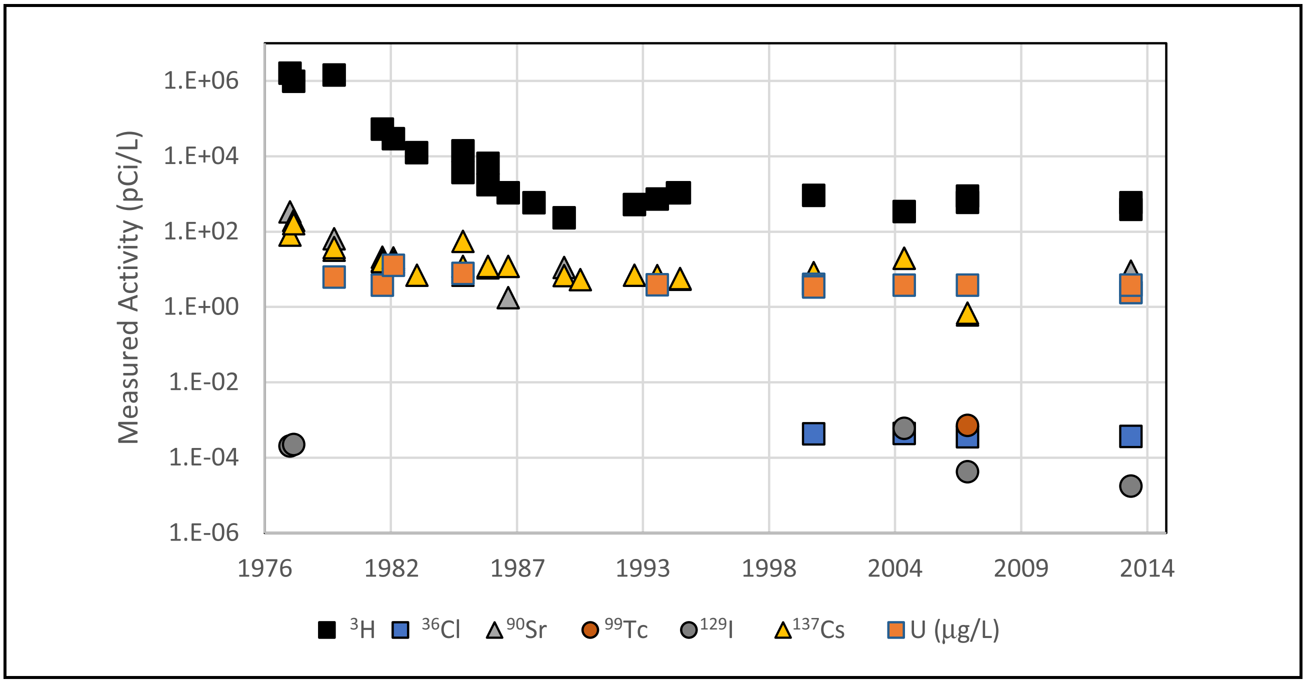


Figure 3-2
RN Concentrations in Groundwater at Well RNM-1 (RNM-1_m4-5)

detectable gamma emitters present in groundwater collected from RNM-1_m4-5 are ^{137}Cs and antimony-125 (^{125}Sb). The short half-life for ^{125}Sb, 2.75 years, precluded it from being included in the Finnegan et al. (2016) RN inventory. The highest ^{125}Sb activity was reported in 1979 as 0.1 pCi/L and has not been detected since 1985, when it was reported as 0.04 pCi/L (Navarro, 2016b). The ^{137}Cs activity peaked at 160 pCi/L (November 1977) and decreased to 0.7 pCi/L (March 2007). These activities are below the 200 pCi/L MCL for ^{137}Cs. The ^{36}Cl, ^{99}Tc, and ^{129}I have been below their MCLs (700, 900, and 1 pCi/L, respectively) the entire sampling period (Figure 3-2).

Several RNs were measured in samples collected in 1974 and 1975 from the five zones within RNM-1 (Table 3-1). No radioactivity was observed from the deepest zone located approximately 160 ft below the cavity region. The top two zones reported ^{3}H levels of 7.5×10^{7} pCi/L (RNM-1_m4) and 2.8×10^{7} pCi/L (RNM-1_m5). These activities are lower than those reported for samples collected from the lower (1.9×10^{9} and 5.3×10^{9} pCi/L) and upper (3.7×10^{9} pCi/L) cavity (Table 3-1).

Table 3-1
1974 and 1975 RNM-1 Radionuclide Activities (pCi/L)

Water Source	Sample Date(s) [a]	^{3}H	^{90}Sr	^{125}Sb	^{137}Cs	^{129}I	^{239}Pu
Below Cavity (RNM-1_m1)	07/10/1974	ND	No data	ND	ND	No data	ND
Lower Cavity (RNM-1_m2)	09/06/1974	1.9E+09 [c]	No data	2.2E+03 filtered [b]	5.9E+02 filtered [b]	5.3 [c,d]	6.3 [c,d]
	09/06/1974		4.0E+03 unfiltered	1.4E+03 unfiltered	6.1E+02 unfiltered		
	11/05/1974	5.3E+09	2.9E+03	4.2E+03	6.7E+02	8.1 [c]	1.3 [c]
Upper Cavity (RNM-1_m3)	04/29/1975	3.7E+09	2.6E+03	9.8E+02	1.5E+03	2.9 [c]	1.2 [c]
Chimney Area (RNM-1_m4)	08/07/1975–08/08/1975	7.5E+07	1.8E+03	ND [c]	3.7E+02	4.6E-03 [c]	ND [c]
Chimney Periphery (RNM-1_m5)	08/14/1975	2.8E+07	8.2E+01	ND [c]	8.2E+01	1.6E-03 [c]	ND [c]

[a] Data source is Hoffman et al. (1977) unless otherwise noted.
[b] Filtered through a 1-micrometer filter in the field (Hoffman et al., 1977).
[c] Information reported in Bryant (1992).
[d] Data from 09/06/1974 lower cavity sample not differentiated into filtered and unfiltered.

ND = No radioactivity above background detected.

3.1.1.2 RNM-2S

RNM-2S was constructed in 1974 to a depth of 1,156 ft bgs and is open below the water table to about 430 ft of alluvium. Two piezometers, west and east, were installed in the well annulus to a depth of 1,038 ft bgs and 954 ft bgs, respectively (see Figure C-2). The west piezometer is reported to be obstructed at approximately 994 ft bgs. A dedicated electric submersible pump was installed in the main completion on November 30, 1990, and is capable of pumping at a rate of 600 gpm. The static water level was measured on March 10, 2014, at 723.68 ft bgs and an elevation of 2,406.8 ft amsl.

Groundwater sampling was initiated on May 14, 2014, after purging approximately 85,000 gal from the main completion (May 13 to May 14, 2014). This purge volume equates to approximately 5.2 well volumes (one well volume is approximately 16,400 gal). Groundwater samples were collected from the sampling port on the wellhead manifold and analyzed by ALS Laboratory Group, ARS International, and LLNL. The results are presented in Tables B.1-1 and B.1-2. The commercial laboratory results for ^{3}H were reported as 46,900 and 48,200 pCi/L for the sample and its field duplicate, respectively. The ^{3}H results are reported as estimates (i.e., qualified with a “J”) because laboratory QC results did not meet the required control limits. LLNL reported a higher value of 66,087 pCi/L (see Table B.1-2). All other RNs analyzed by the commercial laboratory, except ^{90}Sr and U, are below the analytical detection limits. The total U in these samples (average of 2.6 µg/L) is well below the 30-µg/L MCL. The lack of ^{236}U indicates that the U is not test related (see Table B.1-2). As described in Section B.1.0, there is a high level of uncertainty associated with the ^{90}Sr result (2.58 pCi/L for the field duplicate sample), suggesting that the reporting value is a false detection. This will be verified during subsequent sampling events.

A groundwater sample and field duplicate for ^{3}H analysis were collected on May 14, 2014, after purging 745 gal. This sample was collected to determine the difference in ^{3}H as a function of purge volume. The ^{3}H activities for these samples were reported as 77,000 and 76,000 pCi/L for the sample and duplicate, respectively. Both values are reported as estimates because the associated QC results did not meet the required control limits. Nevertheless, these values are substantially greater than those for samples collected after 85,000 gal were purged.

Figure 3-3 presents RN data relative to their MCL for RNM-2S samples collected since 1975; RNs that exceed their MCL lie above the red dashed line. No RNs other than ^{3}H are present in RNM-2S groundwater above their MCL. The majority of these analyses were performed by LLNL and Los Alamos National Laboratory (LANL) because of their ability to measure low levels of these RNs. Other historically measured RNs (^{22}Na, ^{26}Al, ^{60}Co, ^{94}Nb, ^{125}Sb, ^{134}Cs, ^{154}Eu, ^{155}Eu, and ^{241}Am) were not observed above their detection limit in groundwater samples collected from RNM-2S. The maximum concentrations of the RNs ^{3}H, ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I, and ^{137}Cs are reported as 7.1×10^{6}, 0.83, 1.0, 0.17, 0.0028, and 0.035 pCi/L, respectively (Navarro, 2016b). $^{239/240}$Pu was reported as 1.8×10^{-4} pCi/L in 1982 but was not detected in subsequent analyses. In general, the RN concentrations are significantly lower than those observed in the CAMBRIC cavity (Table 3-1 and Figure 3-2). This indicates limited migration of these RNs in the groundwater over this period of time. Relatively high retardation is expected for Cs and Sr due to their strong affinities for mica, clay, and zeolite ion exchange sites. Pu is typically very insoluble in groundwater (Bryant, 1992).

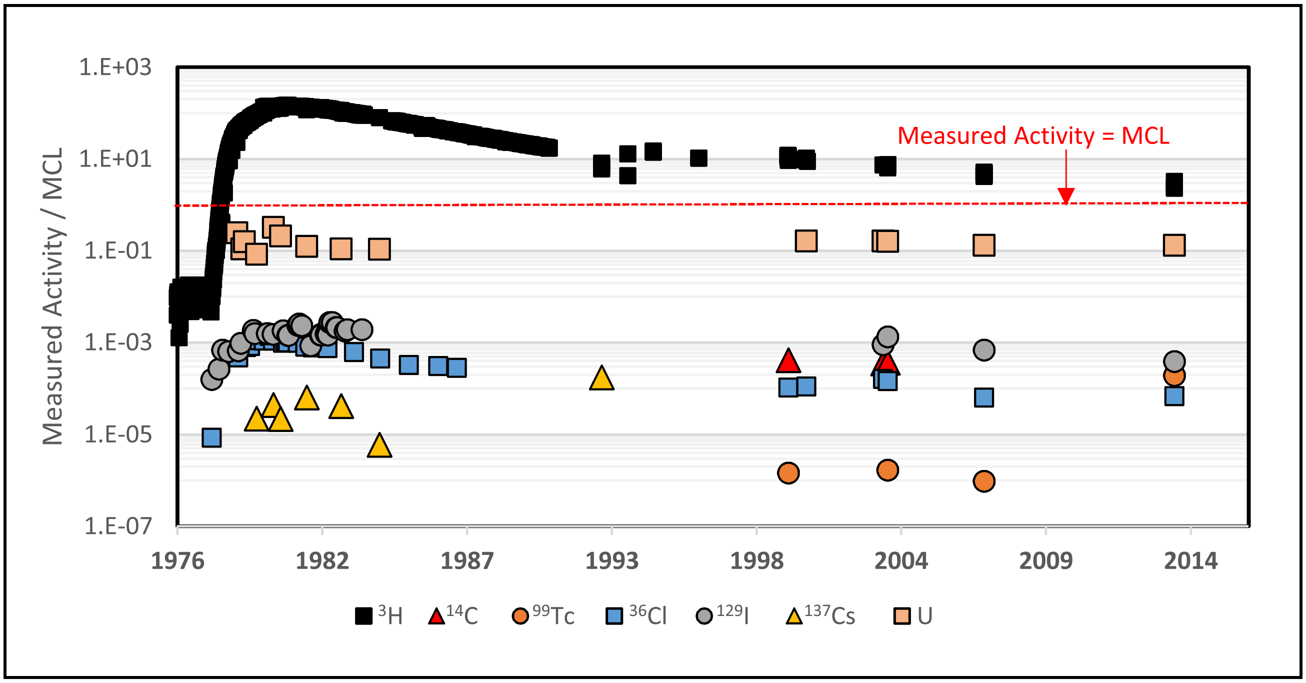


Figure 3-3
RN Concentrations Relative to their MCL in RNM-2S Samples

Maximum ^{3}H concentrations (7.1 × 10^{6} pCi/L) were observed at RNM-2S in 1980 and have decreased to the presently observed values (4.7 × 10^{4} to 6.6 × 10^{4} pCi/L). To determine whether the ^{3}H activity is decreasing because of migration following the natural groundwater gradient or simply as a result of decay, the measured ^{3}H activity and the ^{3}H activity decay corrected to the CAMBRIC detonation date (05/14/1965 - time zero [T_0]) in samples collected over the last 20 years are presented in Figure 3-4. The decay-corrected ^{3}H has remained relatively constant over this period, indicating that the ^{3}H decrease is primarily a result of decay rather than migration away from RNM-2S.

3.1.1.3 UE-5n

UE-5n was constructed in 1976 to a depth of 1,687 ft bgs and is open below the water table to about 730 ft of alluvium. This well is perforated from 720 to 730 ft bgs (see Figure C-3). A dedicated electric submersible pump was installed in 2014 with the pump intake at 847.04 ft bgs. The static water level at UE-5n was measured on June 2, 2014, before groundwater sampling and pump

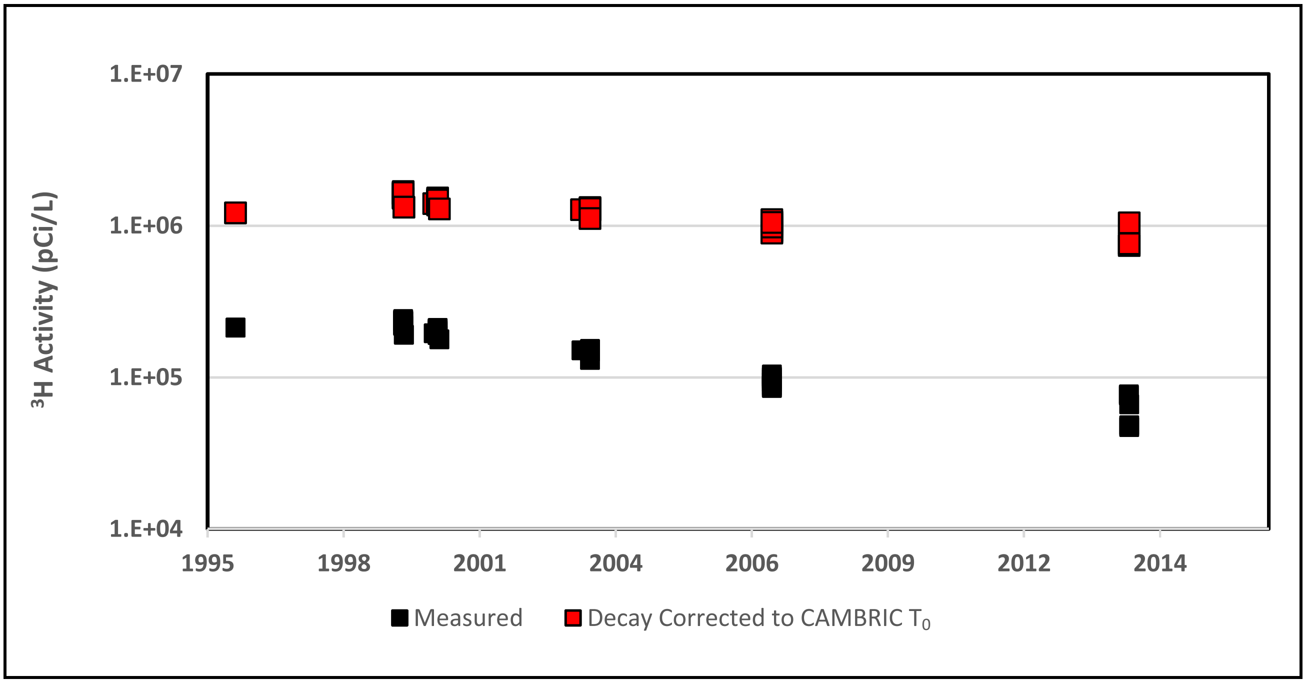


Figure 3-4
Measured and Decay Corrected ^{3}H Activities in RNM-2S Samples

installation, at a depth of 706.69 ft bgs and an elevation of 2,406.67 ft amsl. A bailed sample was also collected on this day. The ^{3}H activity was reported as 153,000 and 152,000 pCi/L by the commercial laboratory for the bailed sample and its field duplicate, respectively.

Groundwater sampling was initiated on June 12, 2014, after purging approximately 19,700 gal of groundwater (June 11 to June 12, 2014). Groundwater samples were collected from the sampling port on the wellhead manifold and were analyzed by ALS Laboratory Group and LLNL. The results are presented in Tables B.1-1 and B.1-2. The ^{3}H activity was reported as 153,000 and 151,000 pCi/L by the commercial laboratory for the sample and its field duplicate, respectively; and as 158,247 pCi/L by LLNL. With the exception of ^{137}Cs reported as 0.09 pCi/L in 1999, no gamma emitters have been detected in groundwater collected from UE-5n; ^{22}Na, ^{26}Al, ^{60}Co, ^{94}Nb, ^{125}Sb, ^{134}Cs, ^{154}Eu, ^{155}Eu, and ^{241}Am were not observed above their detection limit. All other RNs analyzed by the commercial laboratory, except ^{90}Sr reported in the field duplicate sample (1.22 pCi/L) only and U reported in the sample and field duplicate, are below the analytical detection limits. The total U in these samples (average of 3.1 µg/L) is well below the 30-µg/L MCL. The lack of ^{236}U indicates that the U is not test related (Table B.1-2). As previously mentioned, there is a high level of uncertainty associated with the ^{90}Sr results, indicating that the reported value is probably a false detection. This will be verified during subsequent sampling events. No ^{99}Tc, ^{237}Np, or ^{129}I were detected even with the low detection limits achieved by LLNL (Table B.1-2). Figure 3-5 presents the activities of detectable RNs since 1993. RNs detected are thought to reflect infiltration of water from the CAMBRIC ditch (Rose and Kersting, 2003). The dashed line in Figure 3-5 represents the ^{3}H activity that is decay corrected to the date of the CAMBRIC detonation (T_0). This trendline shows the mild increase that would be observed if ^{3}H were not decaying.

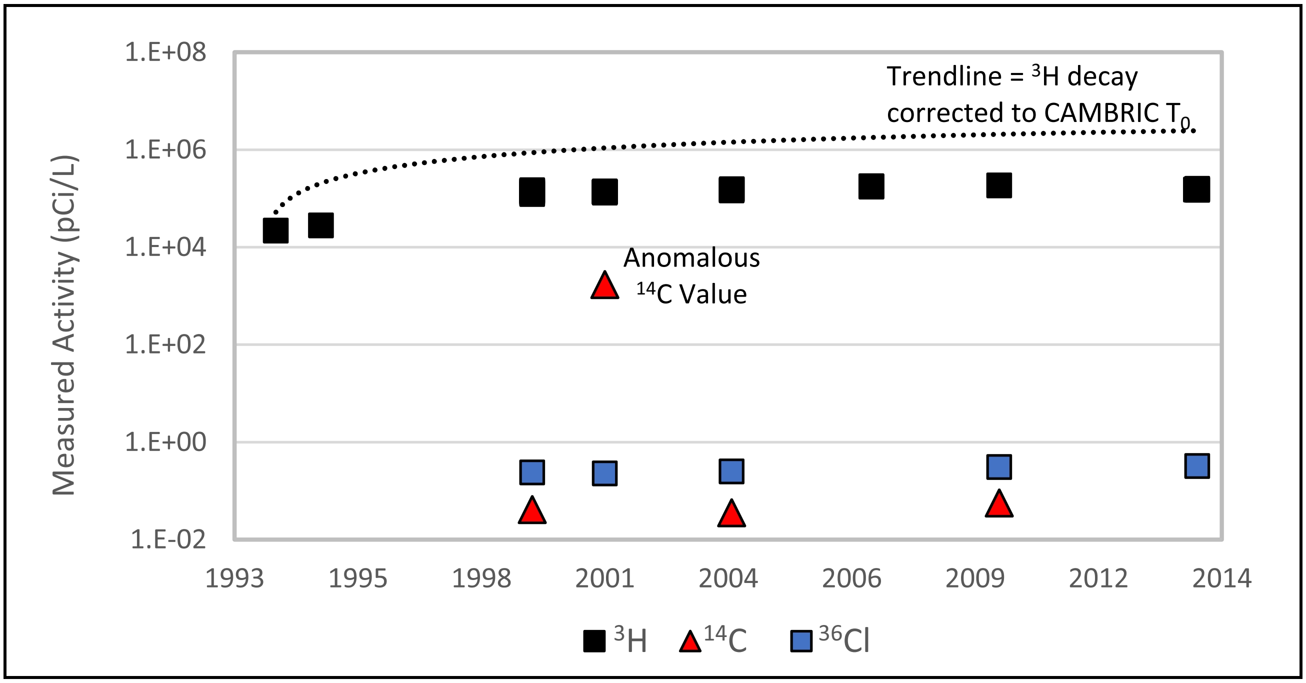


Figure 3-5
RN Concentrations in Groundwater at Well UE-5n

3.1.2 Inactive Wells

WW-5a was constructed in 1951 and is open below the water table to about 210 ft of alluvium. WW-5a was a supply well from 1954 to 1970 (see Figure C-4). In 1971, the pump was removed and the well was capped. In 1991, the well was recompleted, but a pump was not reinstalled. WW-5a was sampled on July 2, 2014, using a bailer at a depth of 880 ft bgs. Samples were analyzed for low-level ^{3}H by ARS International and LLNL. These analyses were performed because of a questionable ^{3}H result (1.5 pCi/L) reported for a sample collected in August 2000 (Navarro, 2016b). This value is questionable because no detection limit was reported for this sample, but other samples analyzed by the same laboratory at a similar time reported a detection limit of 1.5 pCi/L and also because of the unexpected presence of ^{3}H at this location based on the conceptual model of contaminant transport within the Frenchman Flat CAU. It is likely that the ^{3}H reported was not present at the 1.5-pCi/L detection limit, but this required verification. The commercial laboratory (see Table B.1-4) and LLNL (see Table B.1-2) reported nondetects, which confirms that ^{3}H is not present in groundwater of WW-5a at or above the MDCs or levels previously reported.

3.1.3 PWS Wells

Three PWS wells were sampled within or near the Frenchman Flat CAU (see Table B.1-3). No ^{3}H measurements were above their MDCs using the EPA standard analysis method (EPA, 1980). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in most 2014 samples and are believed to represent the presence of naturally occurring RNs. None of the samples had gross alpha measurements that exceeded the EPA MCL (15 pCi/L) or gross beta measurements that exceeded the EPA level of concern (50 pCi/L).

3.1.4 Compliance Wells

Wells UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 were sampled semi-annually to verify the performance of the Area 5 Mixed Waste Disposal Unit (Cell 18), which is operated under a *Resource Conservation and Recovery Act* (RCRA) permit. In 2014, all water samples, with the exception of the August field duplicate sample from UE-5 PW-2, had non-detectable levels of ^{3}H (see Table B.1-4), indicating that Cell 18 radioactive wastes have not contaminated local groundwater. The August UE-5 PW-2 field duplicate sample result for ^{3}H was considered to be anomalous, based on lack of any operational indication of a release, the values close proximity to the MDC, the current result being less than the MDC, and historical trends (Wills, 2015).

3.2 Central and Western Pahute Mesa

The nine Phase II wells within the Central and Western Pahute Mesa CAUs (ER-20-7, ER-20-8, ER-20-8-2, ER-20-11, ER-EC-11, ER-EC-12, ER-EC-13, ER-EC-14, and ER-EC-15) are characterization wells. The purpose of these wells is primarily to determine the RN contaminant extent, the geologic formations, groundwater geochemistry as an indicator of age and origin, and the water-bearing properties and hydraulic conditions that influence RN migration (NNSA/NSO, 2009). The primary HSUs through which contaminated groundwater is thought to migrate off of Pahute

Mesa are the Benham aquifer (BA) and the Topopah Spring aquifer (TSA) (N-I, 2015a). Groundwater flows from northwest to southeast in western Pahute Mesa, from northeast to southwest in eastern Pahute Mesa, and southwest in central Pahute Mesa. A comprehensive Phase II geochemical evaluation to support groundwater flow path and RN transport investigations is presently under way.

Six Pahute Mesa characterization wells (ER-20-7, ER-20-8, ER-20-8-2, ER-EC-11, ER-EC-14, and ER-EC-15) were sampled in 2014 for a total of 13 depth intervals (Table 2-1). In addition, one early detection well with two depth intervals (PM-3-1 and PM-3-2), one community location (Ash-B) with two piezometers, one inactive well with two depth intervals (ER-EC-6 deep intervals), and two PWS wells (J-12 WW and J-14 WW) were sampled within or potentially downgradient of the Pahute Mesa CAUs.

3.2.1 Characterization Wells

The characterization wells sampled in 2014 are ER-20-7, ER-20-8, ER-20-8-2, ER-EC-11, ER-EC-14, and ER-EC-15. Three of these wells (ER-20-8, ER-20-8-2, ER-EC-11) were sampled as part of the sampling technologies evaluation (Section 1.4.1). With the exception of ER-20-8, samples from these wells were analyzed for the characterization suite by the commercial laboratory. Samples were bailed from the three ER-20-8 piezometers and analyzed for a limited parameter suite (Table B.2-1). Commercial laboratory results are presented in Tables B.2-2 (ER-EC-11), B.2-3 (ER-EC-14 and ER-EC-15), and B.2-4 (ER-20-7 and ER-20-8-2). In addition, samples were collected from ER-EC-11, ER-EC-14, and ER-EC-15 for LLNL, DRI, and USGS specialized analyses (Table B.2-6); and from ER-20-7 and ER-20-8-2 for LLNL specialized analyses (Table B.2-5).

A Piper diagram, which illustrates the relative major-ion concentrations in groundwater the characterization wells sampled in 2014, is presented in Figure 3-6. 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 Piper diagram presents relative concentrations 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 relative concentrations of cations and anions are presented in the left and right triangles, respectively, and are projected onto the central diamond to present the combined major-ion chemistry (Figure 3-6).

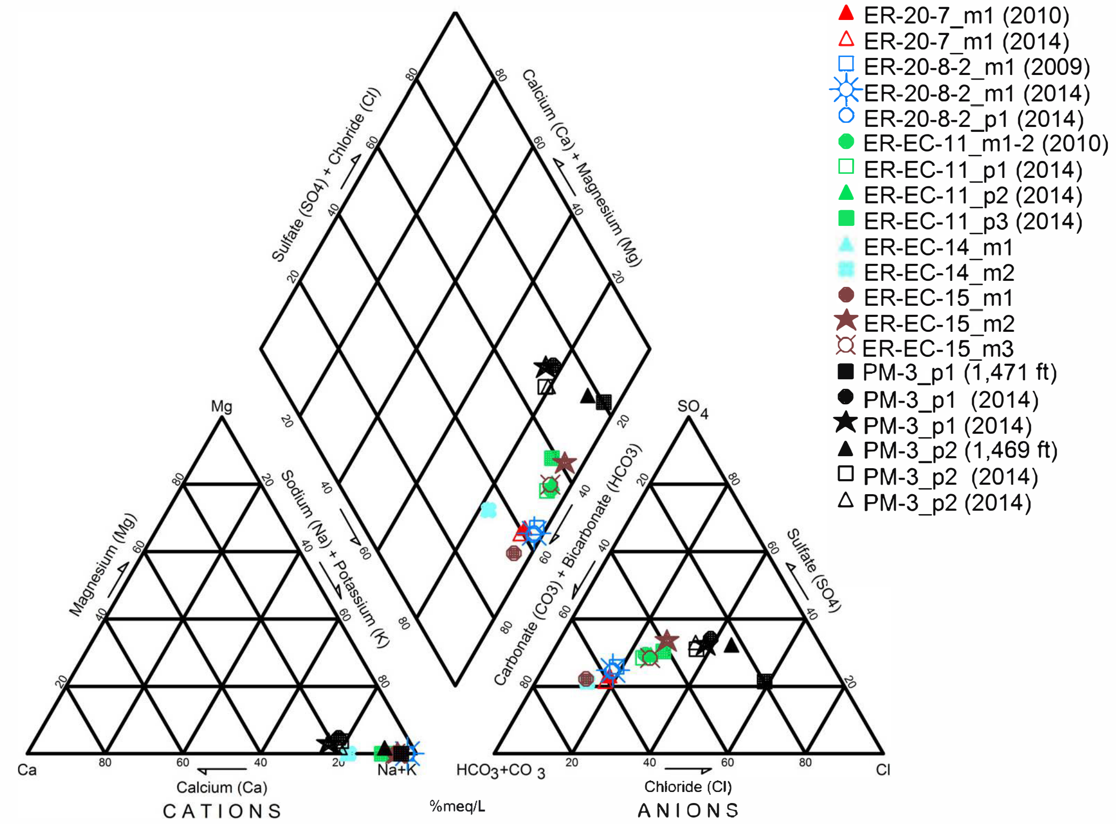


Figure 3-6
Piper Diagram Illustrating Groundwater Major-Ion Chemistry of Pahute Mesa Samples

The Piper diagram shows that Na+K dominates the cations in the groundwaters. The relative concentrations of anions are substantially more variable (Figure 3-6); the dominant anion in most samples is HCO_3^-, but significant relative concentrations of Cl^- and SO_4^{2-} also exist in some of the samples. The groundwaters vary from an $Na+K\text{-}HCO_3$ type (greater than 50 percent HCO_3^- as the dominant anion) to an $Na+K\text{-}HCO_3/SO_4/Cl$ type (relatively equal concentrations of the three anions are present). These groundwater types are characteristic of waters that have dissolved volcanic rhyolitic lava, ash-fall and ash-flow tuffs, and associated volcanic alluvium. Elevated levels of Cl^- and SO_4^{2-} are thought to result from interaction with hydrothermally altered zones; drill core and cuttings from wells in the area show evidence of hydrothermal alteration.

3.2.1.1 ER-20-7

ER-20-7 is constructed with one piezometer and a single open interval within the main completion (see Figure C-5). ER-20-7 was sampled in 2010 following development and testing (N-I, 2011) and again on November 21, 2014, after purging 760,000 gal. Figure 3-6 shows that both samples have very similar major-ion compositions and are a Na+K-HCO_3 type. The 2010 and 2014 samples plot nearly identically to each other and also plot nearly identically to the ER-20-8-2 samples on the Piper diagram. The ^3H activity decreased from 1.9×10^7 pCi/L to 1.6×10^7 pCi/L (2010 to 2014), which can be attributed to decay over the four-year period (one-third of the 12.3-year half-life) (Table 3-2). Table 3-2 also shows that the measured ^3H activities are quite similar between LLNL and the commercial laboratory.

Table 3-2
Summary of ^3H Activities

Location	2014 ^3H (pCi/L)		Previous ^3H (pCi/L)
	Commercial Laboratory	LLNL	
ER-EC-11_p1	7.99 | 6.01	11.8 | 9.9	31 [a]
ER-EC-11_p2	11.5 | 11.4	10.9 | 11.3	
ER-EC-11_p3	16,100 | 16,000	16,214 | 16,364	--
ER-20-7_m1	1.56E+07 | 1.51E+07	1.57E+07 | 1.56E+07	1.91E+07 | 1.89E+07 [b]
ER-20-8_p1	128 | 115	--	267 [c]
ER-20-8_p2	8,200 | 8,800	--	3,020 | 2,650 [d]
ER-20-8_p3	1,770 | 1,640	--	--
ER-20-8-2_m1	2,600 | 2,510	2,601 | 2,578	880 | 1,040 [e]
ER-20-8-2_p1	2,470 | 2,310	2,574 | 2,560	

-- = Not analyzed

[a] Sample was collected on 05/18/2010 from ER-EC-11_m1-2.
[b] Sample was collected on 09/24/2010 from ER-20-7_m1.
[c] Sample was collected on 08/08/2011 from ER-20-8_m1.
[d] Sample was collected on 06/27/2011 from ER-20-8_m2.
[e] Sample and field duplicate were collected on 12/18/2009 from ER-20-8-2_m1.

Note: The "|" denotes the sample | field duplicate.

The concentrations of the Pahute Mesa COPCs and $^{239/240}$Pu for the 2010 and 2014 samples are presented in Table 3-3. These analyses were performed by LLNL. The ^{14}C and ^{99}Tc activities are lower in the 2014 sample than the 2010 sample, but the other RN activities are quite similar. The ^{99}Tc measured in the 2010 sample was thought to be biased high as a result of an analytical interference or possibly post-sampling contamination. The lack of ^{99}Tc in the 2014 sample suggests that this may indeed have been the case. The reported Pu activity decreased over the four-year period. It is unclear at this time whether this is result of a decreasing trend or whether it is a sampling or analysis artifact. Continued sampling will answer this question. With the exception of ^{3}H, no MCL exceedances were observed at ER-20-7.

Table 3-3
Pahute Mesa COPC and Pu Concentrations (pCi/L) for ER-20-7 Samples

Date	^{14}C	^{36}Cl	^{99}Tc	^{129}I	$^{239/240}$Pu
09/24/2010	165	2.41	10.6	0.132	0.10
11/21/2014	118 | 117	2.47 | 2.52	< 7.0	0.135 | 0.128	0.04

Groundwater contamination at ER-20-7 is at least partially attributed to the BENHAM cavity located approximately 1.3 mi from ER-20-7. ER-20-7 is located south–southwest of the TYBO and BENHAM test cavities, along a path extending from the test cavities through ER-20-5 (Figure 3-7). The conceptual model is that thermally driven vertical flow migrated 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 3-7) generally follows the regional hydraulic gradient and shows that ^{3}H levels progressively decrease from north to south downgradient along the section (Figure 3-7). It is also clear that ^{3}H levels are greater in the more shallow HSUs (TSA and BA).

3.2.1.2 ER-20-8

ER-20-8 is constructed with three piezometers and two main completion zones (see Figure C-6). 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 shallow piezometer intersects the UPCU and Scrugham Peak aquifer (SPA) HSUs. The intermediate piezometer (ER-20-8_p2)

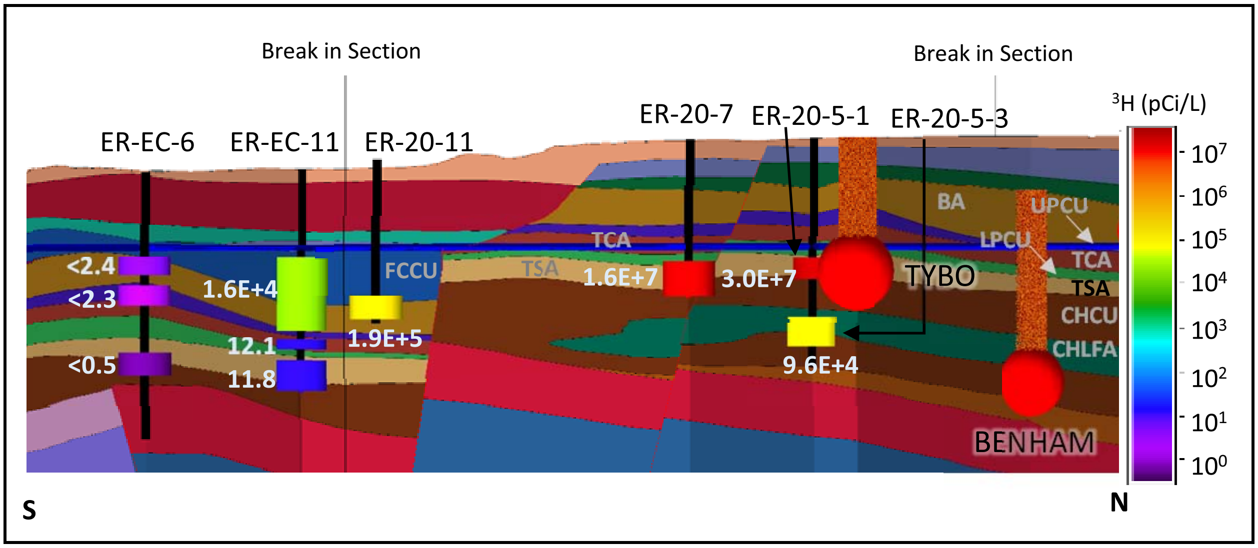


Figure 3-7
Cross Section from North to South with ^{3}H Values
Note: Cavity dimension based on maximum announced yield identified in NV-209-REV 16 (NNSA/NFO, 2015b) and Equation 1 in UCRL-ID-136003 (Pawloski, 1999).

intercepts the TCA, and there is a corresponding main completion zone (ER-20-8_m2) with a dedicated submersible pump installed. The deep piezometer (ER-20-8_p1) and corresponding main completion zone (ER-20-8_m1) intercept the TSA. Both main completion zones were developed and sampled in 2011 (N-I, 2012b).

In 2014, bailed samples were collected from ER-20-8_p1 (September 4, 2014), ER-20-8_p2 (September 4, 2014), and ER-20-8_p3 (September 15, 2014) in support of the technologies evaluation (Section 1.4.1). These samples were analyzed for ^{3}H and major ions by the commercial laboratories. No specialized analyses were performed for these samples. The ^{3}H was reported as 128 and 115 pCi/L for ER-20-8_p1; 8,200 and 8,800 for ER-20-8_p2; and 1,770 and 1,640 for the ER-20-8_p3 samples and field duplicates, respectively (see Table 3-2). The ER-20-8_p1 samples are relatively similar (within 50 percent) to the samples collected from the associated main completion in 2011 (Table 3-2). The ER-20-8_p2 samples are approximately three times greater than samples collected from the associated main completion in 2011 (Table 3-2). It is unclear at this time if this increase is a result of the sampling method (bailed vs. pumped) or if it is a result of contaminant migration. In 2015, a pumped sample was collected from the main completion (ER-20-8_m2). These results, presented in the 2015 Annual Report, will provide insight on the cause of the increase in ^{3}H activity observed for

ER-20-8_p2. ER-20-8_p3 has not been previously sampled. Alkalinity (HCO_3 and CO_3) was not measured in the 2014 samples, which precludes presentation on the Piper diagram.

A west-to-east cross section through Wells ER-20-8 and ER-20-8-2 is presented in Figure 3-8. This figure shows that greater ^3H levels are observed in the BA, SPA, and TCA HSUs.

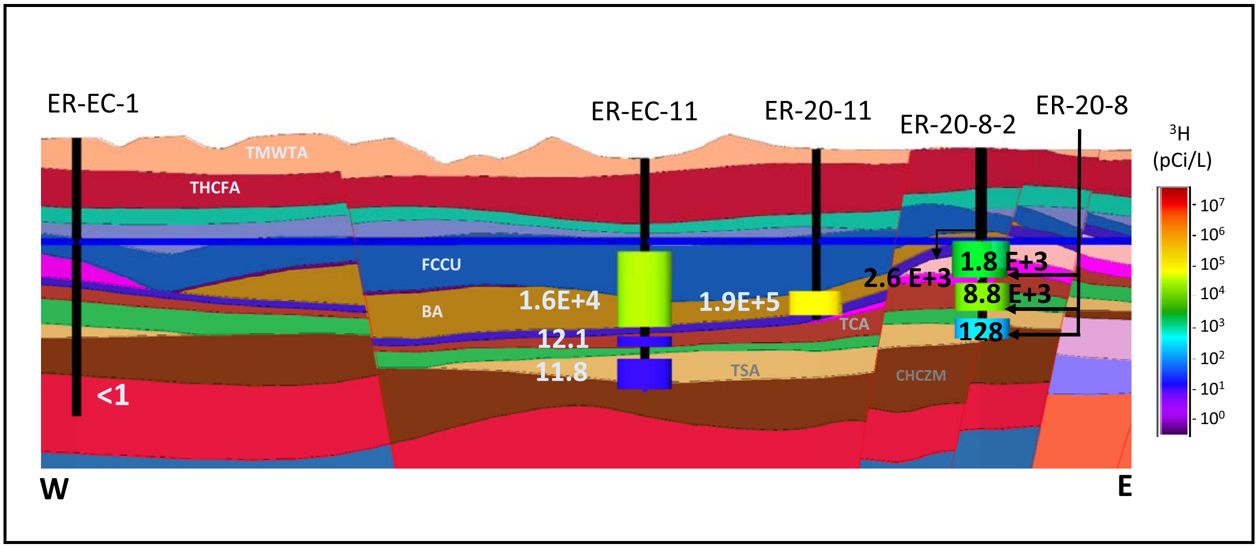


Figure 3-8
Cross Section from West to East with ^3H Values

3.2.1.3 ER-20-8-2

ER-20-8-2 is constructed with one piezometer (ER-20-8-2_p1) and a corresponding main completion zone (ER-20-8-2_m1) (see Figure C-7). Well ER-20-8-2 is approximately 50 ft away from ER-20-8 and accesses the BA and SPA. The main completion zone has a dedicated submersible pump installed, and the zone has been developed and sampled (N-I, 2011). In 2014, samples were collected from ER-20-8-2_m1 and ER-20-8-2_p1 using a bailer (ER-20-8-2_p1), jack pump (ER-20-8-2_p1), and electric submersible pump (ER-20-8-2_m1) in support of the technologies evaluation (Section 1.4.1). Figure 3-6 shows that both samples have very similar major-ion compositions and are an Na+K-HCO_3 type. Both plot nearly identically and also plot nearly identically with the ER-20-7 samples. This sample was analyzed for ^3H and major ions. The ^3H was reported as 2,670 and 2,440 pCi/L for the sample and field duplicate (see Table B.2-1), which is about two to three times greater than the activities reported in 2009 (Table 3-3).

3.2.1.4 ER-EC-11

ER-EC-11 is constructed with four piezometers and two main completion zones (see Figure C-8). The shallow piezometer (ER-EC-11_p4) is screened at the water table in the Timber Mountain welded-tuff aquifer (TMWTA). However, an obstruction is blocking this interval, and there is no corresponding main completion; therefore, this interval cannot be sampled. The upper piezometer (ER-EC-11_p3) intersects the BA and was sealed off from the lower completions during drilling because elevated ^{3}H was encountered; consequently, there is no corresponding main completion zone. The intermediate piezometer (ER-EC-11_p2) intercepts the TCA, and the deep piezometer (ER-EC-11_p1) intercepts the TSA; there are corresponding main completion zones (ER-EC-11_m2 and ER-EC-11_m1) for the intermediate and deep piezometers. A dedicated submersible pump is installed in the main upper completion zone (ER-EC-11_m2), and a bridge plug is installed to isolate the main completion intervals.

In 2014, samples were collected from three piezometers (ER-EC-11_p1, ER-EC-11_p2, and ER-EC-11_p3) using the jack pump and analyzed for the full characterization suite (see Tables B.2-2 and B.2-6). The commercial laboratory and LLNL ^{3}H results are quite similar (Table 3-3). As anticipated, the ^{3}H levels are significantly greater in the BA sampled by ER-EC-11_p3. No other RNs were detected by the commercial laboratory (see Table B.2-2). Similar increasing trends from the deep to shallow piezometers were observed for other RNs (^{36}Cl and ^{129}I) measured by LLNL (see Table B.2-6). In 2010, ER-EC-11 samples were collected from (ER-EC-11_m1-2): the reported ^{3}H (31 pC/L) was slightly higher than reported for either of the two piezometers in 2014 (N-I, 2011).

Figure 3-7 presents the ER-EC-11 ^{3}H activities on a north-to-south cross section extending from the TYBO and BENHAM cavities. It is clear from this figure that ^{3}H migration is primarily limited to the more shallow aquifers and that the ^{3}H activity is more than 1,000 times less in the shallow interval of ER-EC-11 than in the shallow interval sampling migration near the TYBO and BENHAM tests (ER-20-5-1). The west-to-east cross section (Figure 3-8) shows that the ^{3}H activity is greater in the BA sampled by ER-EC-11 and ER-20-11 than the SPA (ER-20-8 and ER-20-8-2) and TCA (ER-20-8 and ER-EC-11) HSUs.

The major-ion compositions for the three ER-EC-11 piezometer samples and the earlier sample collected from the main completion are presented in the Piper diagram (Figure 3-6). These groundwaters plot quite similarly and lie in the middle of a rough trend line connecting those dominated by Na-HCO_3 (ER-EC-14 and ER-EC-15) and those dominated by Na-HCO_3/Cl/SO_4 (PM-3). The sample from the shallow piezometer (ER-EC-11_p3) exhibits greater SO_4^{2-} and Cl^- and also has a higher total dissolved solid (TDS) concentration (see Table B.2-2).

3.2.1.5 ER-EC-14

ER-EC-14 is constructed with two piezometers (ER-EC-14_p1 and ER-EC-14_p2) and two main completion zones (ER-EC-14_m1 and ER-EC-14_m2) (see Figure C-9). ER-EC-14 is located 3.5 mi west of the NNSS boundary. Both completions sample the Rainier Mesa welded-tuff aquifer (RMWTA). Samples were collected following development and at the end of aquifer testing. They were collected from the shallow completion (ER-EC-14_m2) after pumping more than 3 million gal and from the deep completion (ER-EC-14_m1) after pumping approximately 6.5 million gal. Samples were analyzed for the full characterization suite by the commercial laboratories (see Table B.2-3), and specialized analyses were performed by DRI, LLNL, and USGS (see Table B.2-6). This was the first time pumped samples were collected from this well. A full evaluation of the analytical results is presented in Navarro (2015a).

With the exception of anomalous ^{90}Sr, ^{129}I, and ^{238}Pu detections reported (see discussion in Section B.2.0), no RNs were detected by the commercial laboratory. No ^{3}H was detected in ER-EC-14 samples even with the low-level methods (see Tables B.2-3 and B.2-6). The ^{129}I activities measured by LLNL ranged from 1.1×10^{-7} to 1.8×10^{-7} pCi/L and are consistent with background levels. This is similarly the case for ^{36}Cl activities, which range from 3.58×10^{-4} to 3.64×10^{-4} pCi/L; and ^{14}C activities, which range from 0.016 to 0.067 pCi/L. Other RNs analyzed by LLNL were not detected (see Table B.2-6).

The ER-EC-14 samples plot identically on the Piper diagram and are classified as Na+K-HCO_3 type waters. The samples plot similar to ER-EC-15_m1 but have lower relative Na+K. ER-EC-14 samples have lower relative Na+K and Cl^- and SO_4^{-2} than other ER-EC-15 (ER-EC-15_m2 and ER-EC-15_m3) and ER-EC-11 samples (Figure 3-6).

3.2.1.6 ER-EC-15

ER-EC-15 is located approximately 2.1 mi from the northwest boundary of the NNSS and approximately 3.2 mi northwest of ER-EC-14. ER-EC-15 is constructed with three piezometers (ER-EC-15_p1, ER-EC-15_p2, and ER-EC-15_p3) and three main completion zones (ER-EC-15_m1, ER-EC-15_m2, and ER-EC-15_m3) (see Figure C-10). The upper completions (ER-EC-15_m3 and ER-EC-15_p3) intersect the Fluorspar Canyon confining unit (FCCU), Comb Peak aquifer (CPA), and Post-Benham Paintbrush confining unit (PBPCU). The intermediate completions (ER-EC-15_m2 and ER-EC-15_p2) intercept the TCA and LPCU, and the deep completions (ER-EC-15_m1 and ER-EC-15_p1) intercept the TSA and Calico Hills confining unit (CHCU).

Samples were collected using a submersible pump following development and at the end of aquifer testing (January and February 2014). All of the samples are considered representative of the formation water, after pumping approximately 3 million gal from the shallow (ER-EC-15_m3), 400,000 gal from the intermediate (ER-EC-15_m2), and 14,000 gal from the deep (ER-EC-15_m1) zones. Samples were analyzed for the full characterization suite. A full evaluation of the analytical results is presented in N-I (2015a).

No ^{3}H or other RNs were detected by the commercial laboratories (see Table B.2-3). The ^{129}I activities measured by LLNL ranged from 1.2×10^{-6} to 7.1×10^{-6} pCi/L and are consistent with background levels. This is similarly the case for ^{36}Cl activities, which range from 5.3×10^{-4} to 1.1×10^{-3} pCi/L; and ^{14}C activities, which range from 0.007 to 0.078 pCi/L. Other RNs analyzed by LLNL were not detected (see Table B.2-6).

ER-EC-15_m1 plots similar to both ER-EC-14 samples on the Piper diagram shown on Figure 3-6 but has greater relative Na+K. These groundwaters are classified as Na+K-HCO_3 type waters. These samples exhibit similar major-ion chemistry as samples from ER-EC-11. Samples collected from ER-EC-15 shallow and intermediate completions have similar major-ion compositions to ER-EC-11 and are classified as Na+K-HCO_3/Cl/SO_4 type waters (Figure 3-6).

3.2.2 Early Detection Wells

3.2.2.1 PM-3

PM-3 is located outside the NNSS boundary on the NTTR. PM-3 is completed with two piezometers: PM-3_p1 (deep) is screened across the TCA, and PM-3_p2 (shallow) is screened across the UPCU (see Figure C-11). PM-3 was the subject of an investigation to verify the presence of ^{3}H observed during annual monitoring. (Section 1.4.2). As part of this investigation, both piezometers were developed and sampled using a jack pump in 2013.

Discrete-bailed samples were collected on June 11, 2014 from two depths within each piezometer and analyzed for major and minor constituents and ^{3}H. These bailed samples were primarily collected for comparison to the pumped samples collected in 2013. The deep piezometer (PM-3_p1) was sampled at 1,471 and 1,983 ft bgs, and the ^{3}H activities were reported as 77.8 and 39.1 pCi/L, respectively. The shallow piezometer (PM-3_p2) was sampled at 1,469 and 1,560 ft bgs. The ^{3}H activity for the sample collected at 1,469 ft bgs was 130 pCi/L, and the ^{3}H activity for the sample and field duplicate collected at 1,560 ft bgs were 237 and 216 pCi/L. These results suggest that ^{3}H activities are quite dependent on the depth sampled when using a bailer. The pH and corresponding CO_3^{2-} concentration are much higher in the sample collected from the water table in PM-3_p1 (see Table B.2-7).

Figure 3-9 presents the reported ^{3}H activities since 2010 for PM-3_p1 and PM-3_p2 (^{3}H was not detected in 2010 samples collected from PM-3_p1). The samples collected in 2013 were pumped, and all other samples were bailed. PM-3 was recompleted in 1992, and 16,900 gal of water were swabbed from PM-3_p1 and 12,534 gal were swabbed from PM-3_p2; however, 105,000 gal of lithium-bromide water were used during the recompletion drilling (DOE/NV, 1996), so groundwater samples were not representative of formation waters. These two factors make it difficult to evaluate trends in ^{3}H activity. Nevertheless, it is noteworthy that the ^{3}H activities in samples collected using the depth-discrete bailer in 2014 were quite similar to those in samples collected using the jack pump in 2015. It is clear for this plot that ^{3}H MCL (20,000 pCi/L) exceedances are not anticipated in the near future and that continued sampling is necessary to establish the trend in RN activities at this well.

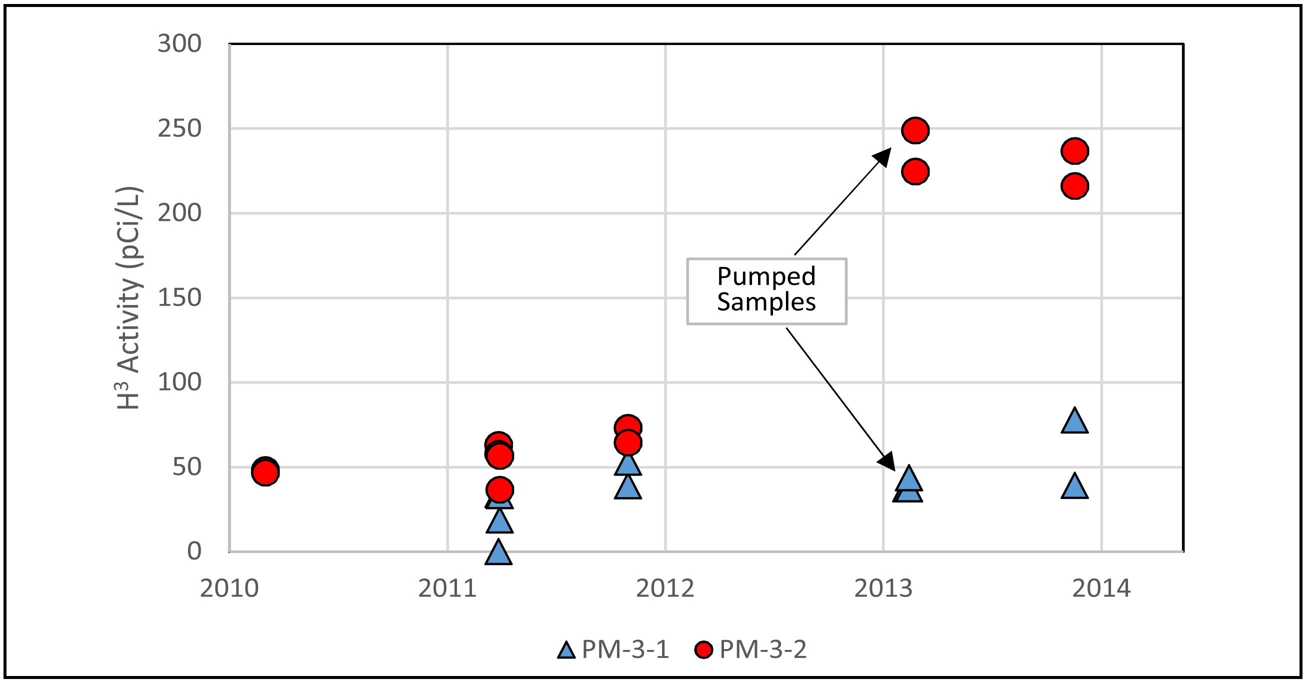


Figure 3-9
^{3}H Activities for PM-3 Samples

Note: ^{3}H activity (130 pCi/L) for the 2014 PM-3-2 sample collected from 1,469 ft bgs is not shown on this figure.

3.2.3 Community Wells

Ash B is a community well and is sampled for ^{3}H every five years. Sampling at a five-year frequency is sufficient because of the long flow paths to these locations, the low groundwater velocities, and the monitoring of upgradient early detection wells at a higher frequency (every two years). Ash B was sampled on April 21, 2014, and samples were analyzed for ^{3}H using the standard method. No ^{3}H was detected (see Table B.2-8).

3.2.4 Inactive Wells

ER-EC-6 is located outside the NNSS boundary on the NTTR. ER-EC-6 was recompleted in 2009 to allow monitoring of the three main completion zones; a fourth zone is isolated with a bridge plug (see Figure C-12). Previous samples collected at ER-EC-6 are composites collected across multiple open intervals in the main completion (ER-EC-6_m1-4 and ER-EC-6_m2-4). A packer is currently present between the top two main completion intervals (upper packer), and another is currently present between the two intermediate main completion intervals (lower packer). ER-EC-6 is completed with three open ended piezometers that access each zone through the packers.

ER-EC-6_m1 is screened across the CFCM and is currently unavailable for sampling. ER-EC-6_m2 (deep) is screened across the CHZCM and TSA; ER-EC-6_m3 is screened across the UPCU and TCA; and ER-EC-6_m4 is screened across the BA (see Figure C-12). The Sampling Plan defines the upper interval that samples the BA as an early detection location. The other intervals within this well are currently inactive.

Two zones within ER-EC-6 (ER-EC-6_m3 and ER-EC-6_m2) were sampled in 2014 to support an ongoing geochemistry evaluation for characterizing groundwater flow paths and estimating travel times in Pahute Mesa. ER-EC-6_m3 was sampled with a bailer from a depth of 2,440 ft bgs on December 10 and 11, 2014. ER-EC-6_m2 was sampled on December 18, 2014, after 11,120 gal of water were purged. The sample from ER-EC-6_m2 was analyzed for the full characterization suite, and the bailed sample from ER-EC-6_m3 was analyzed for major ions and ^{3}H (see Table B.2-10). As anticipated, no RNs in the samples were detected by the commercial laboratory.

3.2.5 PWS Wells

Two PWS wells (J-12 WW and J-14 WW) that are potentially downgradient of the Pahute Mesa CAUs were sampled in FY and CY 2014 (see Table B.2-9). Results from these water wells sampled quarterly in 2014 indicate that historical underground nuclear testing has not impacted the NNSS water supply network. No ^{3}H measurements were above their MDCs using the EPA standard analysis method (EPA, 1980). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in most 2014 samples and are believed to represent the presence of naturally occurring RNs. However, no water supply samples had gross alpha measurements that exceeded the EPA MCL (15 pCi/L) or gross beta measurements that exceeded the EPA level of concern (50 pCi/L).

3.3 Rainier Mesa/Shoshone Mountain

The Rainier Mesa/Shoshone Mountain CAU is in the latter part of the UGTA strategy CAI stage. Two distal wells were sampled in this CAU in 2014.

3.3.1 Distal Wells

3.3.1.1 WW-8

WW-8 is both a distal and PWS well, and is sampled quarterly by the M&O contractor (National Security Technologies, LLC [NSTec]). This well has been used for water supply since 1963. In FY and CY 2014, samples were analyzed for ^{3}H and gross alpha and gross beta (Table B.3-1). The first sample (November 5, 2013) was analyzed using the ^{3}H enrichment technique; subsequent analyses were performed using standard methods. No ^{3}H was detected above their MDCs (17.2 to 258 pCi/L). Gross alpha and gross beta radioactivity were found at concentrations slightly greater than their MDCs in most 2014 samples and are believed to represent the presence of naturally occurring RNs.

3.3.1.2 UE-16d WW

UE-16d WW has been used for water supply since 1981. A sample was collected from this well on January 14, 2014, and analyzed for ^{3}H using the standard methods. No ^{3}H was detected above the 258 pCi/L MDC (Table B.3-1).

3.4 Yucca Flat/Climax Mine

The Yucca Flat/Climax Mine 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, 2013). Sampling priorities in 2014 for this CAU were based on answering peer review questions (N-I, 2015b). Sampling included three characterization wells (ER-7-1, UE-1h, and WW-3), one distal well (Army 1 WW), and one inactive well (ER-6-2).

Although UE-1h and WW-3 are characterization wells, these wells were sampled using a bailer and analyzed for a limited suite of parameters. Bailing is a relatively inexpensive sampling technology (Navarro, 2015b) and was used to help prioritize future sampling using the jack pump. Sampling using the jack pump is much more costly and requires more time, which limits the number of wells that UGTA can sample using the jack pump within a given year.

3.4.1 Characterization Wells

3.4.1.1 ER-7-1

ER-7-1 was constructed in 2003 within a cluster of underground nuclear tests. The closest test, TORRIDO, is located 614 ft north of the well. The well has an open borehole with a screened interval from 2,181 to 2,479 ft bgs in the LCA (see Figure C-13). A dedicated low-volume electric submersible pump with the intake at 1,966.08 ft bgs was installed on July 29, 2003. The static water level at ER-7-1 was measured before groundwater purging on June 18, 2014, at 1,852.07 ft bgs and an elevation of 2,394.63 ft amsl.

Groundwater sampling was initiated on June 20, 2014, after purging approximately 24,000 gal of groundwater, which equates to approximately 5.5 well volumes (one well volume is approximately 4,333 gal). The groundwater samples were collected from the sampling port on the wellhead manifold and shipped to ALS Laboratory Group, ARS International, USGS, and LLNL for analyses. Samples were analyzed for the full characterization suite. No ^{3}H or other RNs were detected by the commercial laboratories or LLNL (see Tables B.4-1 and B.4-2) at detection limits as low as 1.1 pC/L. The ^{14}C activity (0.079 pCi/L) and ^{36}Cl activity (1.5×10^{-4} pCi/L) are consistent with background levels (see Table B.4-2).

A Piper diagram presenting the major-ion compositions of Yucca Flat samples collected in FY 2014 is shown in Figure 3-10. ER-7-1 samples exhibit similar major-ion chemistry as other samples collected within Yucca Flat and are also nearly identical to samples collected in 2004 (Figure 3-10). These groundwaters are classified as mixed Ca+Mg-Na+K-HCO_3 type waters typical of groundwaters of the carbonate aquifer.

3.4.1.2 UE-1h

UE-1h was constructed in 1968 with an open borehole in the LCA (see Figure C-14). The ^{3}H activity was reported as 6.08 pCi/L (collected at 2,136 ft bgs) and 10.9 pCi/L (collected at 1,978 ft bgs) in 1993. Detection limits were not reported with these data, and therefore the presence of ^{3}H required verification.

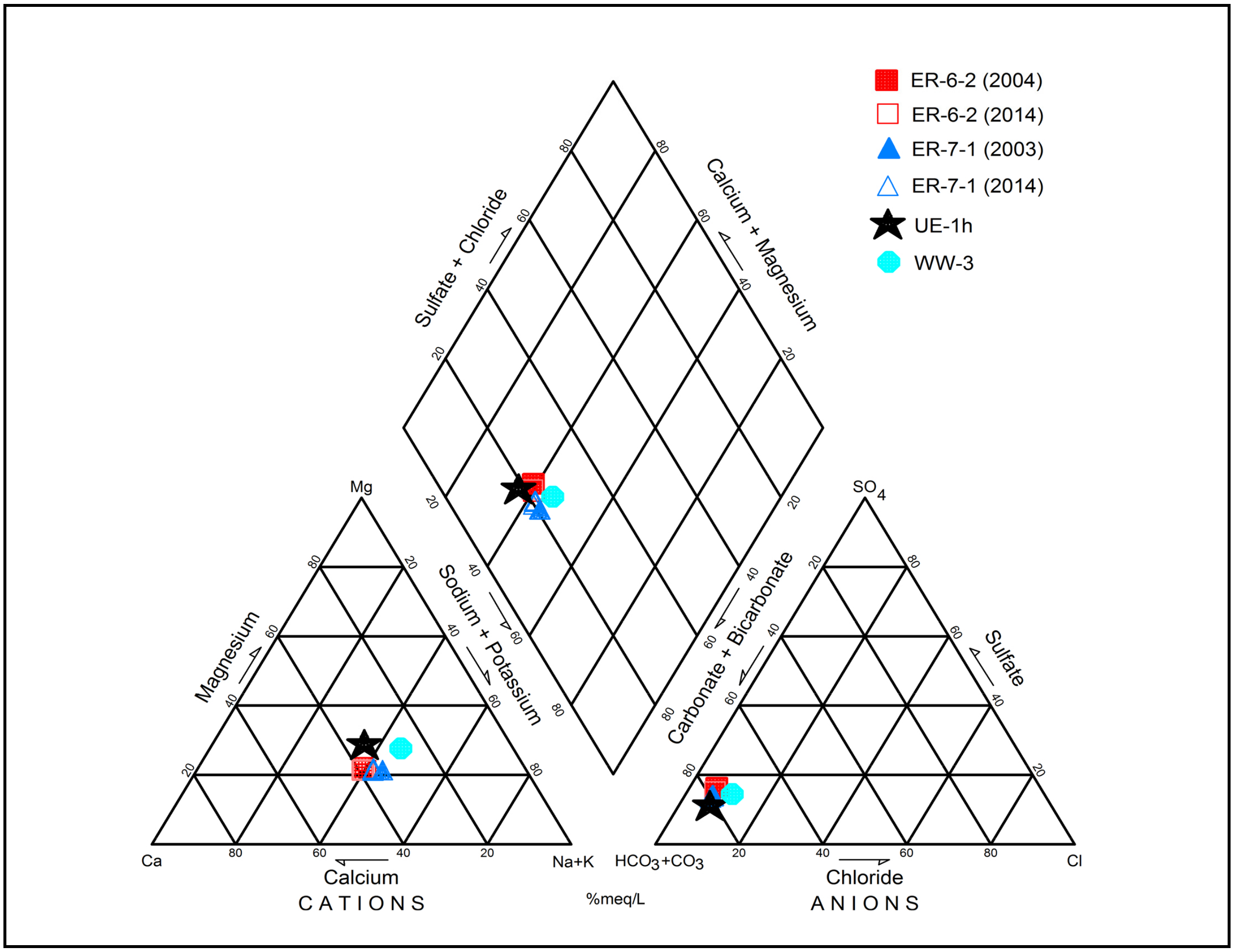


Figure 3-10
Piper Diagram Illustrating Groundwater Major-Ion Chemistry of Yucca Flat Samples

Samples were collected using a depth-discrete bailer from a depth of 2,410 ft bgs on June 3, 2014. Although this well is a characterization well, the bailed sample was analyzed only for major constituents and ^{3}H (see Table B.4-3). 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 2.0-pCi/L detection limit. This suggests that the earlier reported value (6.08 pCi/L) was actually a nondetect (i.e., a value reported below its MDC). The major ions are quite similar to those of other Yucca Flat wells completed in the LCA (Figure 3-10). These groundwaters are classified as mixed Ca+Mg-Na+K-HCO_3 type waters.

3.4.1.3 WW-3

WW-3 was constructed in 1950 to 1951, served as a PWS well from 1952 to 1970, and was later recompleted between November 1991 and March 1992. The tubing and pump that were removed were not reinstalled. WW-3 is open to approximately 770 ft of alluvium (see Figure C-15). This well was last sampled in 1972, and ^{3}H was reported as a non-detect; no detection limit was reported (Navarro, 2016b). WW-3 was sampled on June 3, 2014, using a depth-discrete bailer from a depth of 1,650 ft bgs. Although this well is a characterization well, the bailed sample was analyzed only for major constituents and ^{3}H (see Table B.4-3). This sample was collected to determine the level of ^{3}H and to help prioritize later sampling using the jack pump. The ^{3}H activity was reported as 7.3 pCi/L. 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 has infiltrated through the alluvium and is now detectable in the groundwater. The major ions are quite similar to those of the wells completed in the LCA (Figure 3-10). These groundwaters are classified as mixed Ca+Mg-Na+K-HCO_3 type waters.

3.4.2 Distal Wells

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. Army 1 WW was sampled on January 14, 2014. Tritium was not detected above the 257-pCi/L detection limit (see Table B.4-3).

3.4.3 Inactive Wells

ER-6-2 is located 6,846 ft southwest of the closest test, RUSSET, conducted in 1968. The open interval in the well is from 2,006 to 3,430 ft bgs and straddles the LCA and UCCU (see Figure C-16). Before groundwater sampling, the well was purged using a dedicated submersible pump. Approximately 25,725 gal of groundwater were purged before water samples were collected, and the water-quality parameter criteria had been met. Previous sampling (August 4, 2004) indicated a ^{3}H concentration of 92 pCi/L. This result was considered anomalous because this well does not lie along a flow path from underground nuclear testing and therefore the presence of ^{3}H is not expected. The full characterization suite along with many specialized analyses were performed to determine the ^{3}H source if, in fact, it is present in the groundwaters sampled by ER-6-2. No ^{3}H was detected by the commercial laboratory or LLNL (see Tables B.4-1 and B.4-2). All other measured RNs were reported as nondetects by the commercial laboratory. The ^{14}C (0.070 pCi/L) and ^{36}Cl (1.31×10^{-4} pCi/L) activities reported by LLNL are consistent with background levels (see Table B.4-2).

ER-6-2 groundwaters are classified as mixed Ca+Mg-Na+K-HCO_3 type waters typical of groundwaters of the carbonate aquifer (Figure 3-10). The samples plot identically to samples collected in 2004 and to other samples collected in Yucca Flat.

4.0 Quality Assurance/Quality Control

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/NSO, 2012). The QAP provides a systematic approach to evaluate analytical data that is essential to sustaining data quality.

NDEP Bureau of Safe Drinking Water certified laboratories were used for the analyses indicated in Table 1-3. 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 and ARS International) were certified by the State of Nevada. DRI, LLNL, and USGS provide analyses for specific parameters at lower detection limits not available from commercial laboratories and for analyses of parameters that are not offered by the commercial laboratories.

Data verification is a compliance and completeness review that ensures laboratory and field work documentation is complete. During this process, sampling documentation is reviewed (preservation, temperature, chain of custody, laboratory data package compliance to the statement of work). Additionally, data verification ensures that electronic data submitted to Navarro by the laboratories accurately represent the analyses performed. Data validation is an analyte and sample-specific process that determines analytical quality, and includes evaluation of instrument calibration, QC and sample results, standard reference material certifications, and their appropriateness of use. Data validation determines the validity of reported results and includes assignment of data qualifiers, if required.

Analytical methods routinely include laboratory QC samples such as duplicates, blanks, and spikes; and field QC samples such as field blanks, equipment rinsates, and field duplicates. In CY 2014, laboratory QC samples used to measure precision and accuracy were analyzed by the laboratories with each batch of samples submitted for analysis. When QC criteria were exceeded, qualifying flags were added to sample results. Documentation of data qualifications is retained in the Analytical Services and Geochemistry databases, and in the data packages located in Navarro Central Files and the

Technical Data Repository. The following subsections summarize the accuracy and precision associated with the laboratory data presented in Appendix B, as determined by laboratory and field QC results. An evaluation of blank sample results and other quality related issues associated with the laboratory results are also included.

4.1 Accuracy

Accuracy is defined as the nearness of a measurement to the true or accepted reference value. Laboratory control samples (LCSs) are analyzed by the laboratory 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 in 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 ^{3}H, ^{14}C, ^{90}Sr, and ^{129}I. Forty-seven percent of the ^{129}I results, 8 percent of standard ^{3}H, 6 percent of the ^{90}Sr, and 6 percent of ^{14}C results were estimated because associated LCSs were reported outside of the required control limits. For ^{129}I, the Navarro Analytical Services department reported the trend in exceedances to the laboratory, and a nonconformance report was initiated. The root cause analysis determined that the National Institute of Standards and Technology (NIST) standard used to spike the LCSs was defective. Seventeen percent of ^{14}C results were estimated because their associated MSs and/or tracer yields exceeded control criteria. Results determined to be estimated by the validation process are identified in the database and records packages with a “J” qualifier. Fifteen percent of the low-level ^{3}H data was qualified as estimated due to MS failures; the associated sample results were considered biased low (qualified with a “J-”) because the recoveries exceeded the lower control limit. All other sample results were reported with LCS and MS recoveries that were within the control limits.

Inorganic Chemistry

Five percent of chloride (Cl) and 4 percent of fluoride (F) results were estimated because their associated MSs exceeded control criteria. Two of the samples that exceeded MS criteria also exceeded temperature criteria when received at the laboratory. Results for these samples were therefore qualified as estimates. Five percent of mercury (Hg) results were estimated as a result of MS failures. In all cases, matrix interference was determined to be the result of the loss in recovery. Estimated data, as determined by the validation process, are identified in the database and records packages with a "J" qualifier. All other sample results had LCS and MS results that were within the control limits.

Additionally, calibration verification criteria were not met for several analyses. Associated data were estimated and were therefore flagged with a "J" qualifier.

4.2 Precision

Precision is a measure of the reproducibility of the measurement process. Field duplicate 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 field duplicate 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 lab). When results are greater than 10 times the MDCs or minimum detection levels (MDLs), RPD control limits are set at 25 percent; when this value is exceeded, it indicates the reported results do not meet quality assurance (QA) requirements and thus are considered for further evaluation.

A total of 170 groundwater samples were collected and submitted to commercial labs for analyses; of the 170, 78 were field duplicates. Thirty groundwater samples were collected and submitted to LLNL, 8 of which were field duplicates. Three groundwater samples were collected and submitted to USGS, 1 of which was a field duplicate. All field duplicate RPDs were within QC criteria with the exception of two calcium (Ca); two iron (Fe); and one each manganese (Mn), silicon (Si), and U measurements. 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.

Laboratory duplicate samples are used to evaluate overall precision of the sample preparation and measurement process. The RPD between the lab duplicate result and the corresponding field sample result should correspond more precisely than between field and field duplicate samples because they do not include variability from sampling. As a result, the control limits are more restrictive for laboratory duplicates than for field duplicates. The control limits are different depending on whether the analysis is for radiochemistry or inorganic chemistry.

Radiochemistry

Exceedances are dependent on the analyte level. 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 must be between -2 and 2. The normalized difference is calculated as the difference between two results divided by the square root of the sums of the squares of their total propagated uncertainties.

Six percent of bismuth-214 (^{214}Bi) and ^{214}Pb each, 8 percent ^{36}Cl, and 33 percent ^{238}U results were estimated for precision exceeding control criteria (Table 4-1). For ^{36}Cl, results one batch of samples were qualified for poor precision because the LCS and its corresponding laboratory QC sample duplicate failed to meet the control limit of 20 percent RPD. The other radionuclides duplicates were from split samples.

Inorganic Chemistry

Control limits are dependent on the level of the analyte with respect to its reporting limit (RL). 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). Fe, Se, and U were the only analytes where the duplicate precision resulted in data qualification. For Fe, the AD between the sample and its duplicate was greater than the required RL; minute particles of elemental Fe can result in sample splits that are not homogenous. All results that were estimated came from one batch of samples, which may indicate nonhomogeneous sample or poor sample handling and preparation in the laboratory.

Tables 4-1 and 4-2 present the percentage of estimated data, including results estimated for reasons other than those described in the aforementioned discussion. One-hundred percent of pH data was

Table 4-1
Percentage of Radiochemistry Results Flagged with Qualifiers
(Page 1 of 2)

Analyte	Total Measurements	Qualified Measurements	Percentage
^{228}Ac	34	0	0
^{26}Al	34	0	0
^{241}Am	34	0	0
^{125}Sb	34	0	0
^{7}Be	34	0	0
^{212}Bi	34	0	0
^{214}Bi	34	0	0
^{14}C	36	8	22
^{134}Cs	34	0	0
^{137}Cs	34	0	0
^{36}Cl	26	2	8
^{58}Co	34	0	0
^{60}Co	34	0	0
^{152}Eu	34	0	0
^{154}Eu	34	0	0
^{155}Eu	34	0	0
Gross Alpha	34	0	0
Gross Beta	34	0	0
^{129}I	30	17	57
^{212}Pb	34	0	0
^{214}Pb	34	2	6
^{237}Np	6	2	33
^{94}Nb	34	0	0
^{238}Pu	36	6	17
$^{239/240}$Pu	36	6	17
^{40}K	34	0	0
^{90}Sr	34	2	6

Table 4-1
Percentage of Radiochemistry Results Flagged with Qualifiers
(Page 2 of 2)

Analyte	Total Measurements	Qualified Measurements	Percentage
^{99}Tc	30	2	7
^{208}Tl	34	0	0
^{227}Th	34	0	0
^{234}Th	34	0	0
^{3}H	52	0	0
^{3}H (Low Level)	41	0	0
^{234}U	6	2	33
^{235}U	40	2	5
^{238}U	6	2	33

Table 4-2
Percentage of Inorganic Chemistry Results Flagged with Qualifiers
(Page 1 of 2)

Analyte	Total Measurements	Qualified Measurements	Percentage
Alkalinity as $CaCO_3$	41	2	5
Al	64	0	0
As	64	34	53
Ba	64	8	13
HCO_{3-} as $CaCO_3$	41	2	5
Br	56	2	4
Cd	64	0	0
Ca	80	5	6
CO^{2-}_3 as $CaCO_3$	41	2	5
Cl	56	3	5
Cr	64	0	0
F	56	4	7

Table 4-2
Percentage of Inorganic Chemistry Results Flagged with Qualifiers
(Page 2 of 2)

Analyte	Total Measurements	Qualified Measurements	Percentage
Fe	64	6	9
Pb	64	2	3
Li	58	37	64
Mg	80	0	0
Mn	64	6	9
Hg	62	8	13
pH	34	34	100
K	80	7	9
Se	64	12	19
Si	64	0	0
Ag	64	0	0
Na	80	0	0
Electrical Conductivity	34	2	6
Sr	58	22	38
SO^{2-}_4	56	3	5
S	30	6	20
U	60	6	10

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. One such example would be if certificates of calibration standards or tracers were not provided in the data package. These qualifiers are flags to the data users and the associated data are evaluated based on their intended use.

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 (1) equipment blanks (i.e., analyte-free media used to rinse sampling equipment), (2) field blanks (reagent water used to measure ambient sampling conditions), and (3) laboratory method blanks (MBs) or (4) preparation blanks. These QC samples are used to assess reporting false positive results. Tables 4-3 and 4-4 summarize the number of MB exceedances observed for commercial laboratory radiochemistry and inorganic chemistry results, respectively. 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 inorganic chemistry. Tables 4-3 and 4-4 present the exceedances relative to the total number of reported results. One exceedance (^{99}Tc) was observed for radiochemistry (Table 4-3). The associated data were qualified for laboratory blank contamination and flagged as nondetect ("U" qualifier) because similar concentrations were reported for the blank and the sample. Several exceedances were observed for inorganic chemistry. The associated data were qualified for laboratory blank contamination and the results flagged as nondetect ("U" qualifier) or biased low ("J-" qualifier) due to negative instrument responses in associated blank samples.

4.4 Other Quality-Related Issues

A series of ^{90}Sr detections was identified as a possible issue because of a known analytical interference that often results in false positive detections. Because there were no failures in laboratory QC for six detected ^{90}Sr results, there were no qualifiers assigned to the data during data validation. However, the data were flagged during data evaluation with a code that informs the user that the results are likely biased high due to the presence of other radionuclides or interferences. This will be prevented in the future by requiring that ^{90}Sr detections are verified using a more selective analysis (i.e., yttrium-90 [^{90}Y] ingrowth). This issue is summarized in Table A-2 of NNSA/NFO (2015a). The specific data are discussed in Appendix B.

Table 4-3
2014 Radiochemistry MB Exceedances

Analyte	Exceedances	Analyte	Exceedances
^{3}H (Standard)	0 / 23	^{137}Cs	0 / 16
^{3}H (Low Level)	0 / 13	^{154}Eu	0 / 16
Gross Alpha	0 / 22	^{152}Eu	0 / 16
Gross Beta	0 / 22	^{235}U	0 / 16
^{14}C	0 / 13	^{234}U	0 / 2
^{36}Cl	0 / 7	^{238}U	0 / 2
^{90}Sr	0 / 12	^{237}Np	0 / 2
^{94}Nb	0 / 16	$^{239/240}$Pu	0 / 13
^{99}Tc	1 / 10	^{241}Am	0 / 16
^{238}Pu	0 / 13	^{26}Al	0 / 16
^{129}I	0 / 10		

Note: Exceedances represent the number of blank results greater than the MDC plus the 2 sigma error relative to the total number of reported blank results.

Table 4-4
2014 Inorganic Chemistry MB Exceedances

Analyte	Exceedances	Analyte	Exceedances	Analyte	Exceedances
Br	2 / 17	Ca	0 / 17	K	0 / 17
Cl	0 / 17	Cd	0 / 19	Se	1 / 19
F	0 / 17	Cr	0 / 19	Si	0 / 14
SO_4	0 / 17	Fe	1 / 14	Ag	0 / 18
Al	0 / 14	Li	0 / 14	Na	0 / 17
As	6 / 19	Mg	0 / 17	Sr	0 / 14
Ba	3 / 19	Mn	2 / 14	U	0 / 14

Note: Exceedances represent the number of blank results greater than the MDL relative to the total number of reported blank results and/or the number or blank results that had negative instrument responses greater than the negative MDL.

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, it 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. This strategy letter also addresses any deviations or special requirements not included in the FMP.

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. PM-3 is an exception and has only one sump. 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).

5.1.1 FMP Sampling on Frenchman Flat

During pumping and sampling of RNM-1, a daily ^{3}H sample was collected under the far-field fluid management strategy. Tritium activities did not exceed the FMP criteria of 400,000 pCi/L. Groundwater produced from the well was directed into a surface infiltration area.

Groundwater samples were collected from RNM-2S for ^{3}H analysis during the initial discharge (after 4,130 gal); during pumping (collection of daily ^{3}H samples); and with the collection of groundwater and FMP samples. Because the groundwater produced at RNM-2S was discharged to a surface infiltration area, the FMP sample was collected from the wellhead sampling port. Tritium

Table 5-1
Discharge Volumes to Sump or Ground

Site	Sump No.	Volume (gal)	Lined	Date	FMP Sample
Frenchman Flat					
RNM-1	Ground	1.79E+04	No	04/18/2014	Yes
RNM-2S	Ground	1.61E+05	No	05/15/2014	Yes
UE-5n	Ground	2.16E+04	No	06/12/2014	Yes
Pahute Mesa (Central and Western)					
ER-20-8-2	1	1.77E+05	No	10/17/2014	Yes
ER-20-7	2	8.34E+04	Yes	11/21/2014	Yes
ER-EC-6	2	3.50E+04	Yes	12/18/2014	Yes
ER-EC-11	2	7.34E+04	Yes	08/25/2014	Yes
ER-EC-14	1	11.5E+07	No	05/11/2014	Yes
ER-EC-14	Ground	5.77E+06	No	05/11/2014	Yes
ER-EC-15	1	4.04E+06	No	02/17/2014	Yes
ER-EC-15	Ground	3.68E+06	No	02/17/2014	Yes
Yucca Flat/Climax Mine					
ER-6-2	1	31,395	Yes	06/19/2014	Yes
ER-7-1	1	32,026	No	06/20/2014	Yes

Note: PWS well discharge is to the ground.

activities for the daily RNM-2S samples ranged from 2,412 to 78,088 pCi/L, with the minimum detectable activity (MDA) ranging from 1,445 to 2,041 pCi/L. These results are well below action levels as described in the FMP (NNSA/NSO, 2009). The initial ^{3}H sample collected when purging began, 77,000 (duplicate 76,000) pCi/L, is similar to the FMP sample, 73,000 (duplicate 74,000) pCi/L, but approximately twice as high as the characterization sample, 46,900 (duplicate 48,200) pCi/L. This may result from mixing groundwater from an uncontaminated aquifer with that of the contaminated aquifer as large groundwater volumes are pumped with the submersible pump.

Groundwater produced from the purging UE-5n was directed to a surface infiltration area approximately 100 ft south of the wellhead. A total of 21,695 gal of groundwater was discharged to the infiltration area. Tritium grab samples were collected daily, and activities did not exceed the FMP criteria. At the end of sampling, FMP samples were sent to ALS Laboratory Group to be analyzed for total and dissolved metals as well as gross alpha/gross beta and ^{3}H. Tritium results were 153,000 pCi/L, and the duplicate results were 157,000 pCi/L.

WW-5A was sampled with a depth-discrete bailer, and there was no discharge to the surface.

5.1.2 FMP Sampling on Pahute Mesa

On Pahute Mesa, ER-EC-6, ER-EC-11, ER-EC-14, ER-EC-15, ER-20-7, and ER-20-8-2 were pumped and discharged to a sump and infiltration area. All the FMP sample results (metals, gross alpha, gross beta, and ^{3}H) were below the SDWA criteria. The highest ^{3}H concentration was ER-EC-11 with an average concentration of 14,350 pCi/L. Groundwater from PWS sampling (J-12 WW and J-14 WW) was discharged to the ground.

5.1.3 FMP Sampling on Yucca Flat

WW-3 and UE-1h were sampled with a bailer on the same day. There was no discharge from either well.

Groundwater produced from the purging of ER-6-2 was directed into a lined sump at the well site. A total of 31,359 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 ER-7-1 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 32,026 gal of groundwater produced from purging ER-7-1 was discharged to the unlined sump.

5.1.4 FMP Sampling on Rainier Mesa

The two Rainier Mesa wells sampled are both distal and PWS wells. Groundwater from sampling these wells was discharged to the ground.

6.0 Summary and Conclusions

The NNSS Integrated Groundwater Sampling Plan (NNSA/NFO, 2014) 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 QAP (NNSA/NSO, 2012), FFACO (1996, as amended), and DOE Order 458.1 (DOE, 2013).

The maximum ^{3}H concentrations for the most recent 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 number of ^{3}H measurements for each location type, the number of detections that exceeded the MDC, and the number where ^{3}H has exceeded the 20,000 pCi/L 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	21	10	5	2	9
	>MDC	10	10	3	0	0
	>MCL	2	8	0	0	0
Rainier Mesa [a]	n	8	2	0	6	0
	>MDC	1	2	0	0	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 17 wells (27 depth intervals) were sampled in 2014 (Table 2-1). These comprised 9 characterization (17 depth intervals), 3 source/plume (3 depth intervals), 1 early detection (2 depth intervals), and 4 distal (5 depth intervals) locations. The analytical results for all of these samples are presented in Appendix B. Although samples were collected from all UGTA CAUs, the greatest number of samples were collected from the Pahute Mesa (CAUs 101 and 102) in 2014.

Nine characterization locations (17 depth intervals) were sampled in 2014: 6 (13 depth intervals) in Pahute Mesa and 3 (3 depth intervals) in Yucca Flat. Three of these locations (ER-20-8, UE-1h, and WW-3) were sampled for ^{3}H and major ions using a bailer. The remaining characterization locations were sampled for the full suite of characterization analytes. Wells ER-20-8, ER-20-8-2, and ER-EC-11 were sampled as part of the sampling technologies evaluation (Section 1.4.1). An evaluation of the chemistry data for two multiple-completion wells (ER-EC-14 and ER-EC-15) is presented in the UGTA Geochemistry Database (Navarro, 2015c). The ER-EC-14 and ER-EC-15 samples were collected after well development and aquifer testing and therefore have been sampled only one time. Results from the other characterization samples were consistent with previously collected samples.

All source/plume sampling in 2014 took place in Frenchman Flat. Tritium exceeded the MCL for two of the three locations. The ^{3}H concentrations were impacted by the purge volume. The ^{3}H activities for samples collected after purging 125 gal at RNM-1 were reported as less than 320 pCi/L, and those for samples collected after purging 12,700 gal ranged from 550 to 620 pCi/L. For RNM-2S, the ^{3}H activities were reported as 77,000 to 76,000 pCi/L for samples collected after purging 745 gal, and as 46,900 to 48,200 pCi/L after purging 85,000 gal. The ^{3}H activity for bailed (153,000 and 152,000 pCi/L) and pumped (153,000 and 151,000 pCi/L) samples from UE-5n were identical. All other RNs analyzed by the commercial laboratory, except ^{90}Sr and U, are below the analytical detection limits for the UE-5n samples. The total U in these samples is well below the 30-µg/L MCL. The lack of ^{236}U indicates that the U is not test related. There is a high level of uncertainty associated with the ^{90}Sr results (see Section B.1.0), which will be verified during subsequent sampling events.

Two early detection locations (PM-3-1_p1 and PM-3-1_p2) were sampled in 2014. These samples were bailed, and the results are consistent with those previously reported for pumped samples (Figure 3-9), although additional sampling is required to establish trends.

Five distal well locations and no community wells were sampled in 2014. Distal wells are located potentially downgradient of testing in Pahute Mesa, Rainier Mesa, and Yucca Flat. No ^{3}H was detected in the samples.

Three inactive wells (ER-EC-6 [deep intervals], WW-5a, and ER-6-2) were sampled in 2014. The deep intervals of ER-EC-6 were sampled to support characterization activities in Pahute Mesa, and the other two were sampled to determine whether previously reported ^{3}H in these wells was falsely reported. No ^{3}H was detected by the commercial laboratory (ARS International) or by LLNL in these samples. In addition, six PWS wells and three compliance wells were sampled. No RNs were detected in these samples. These results continue to indicate that historical underground nuclear testing has not impacted the NNSS water supply network to date.

Two investigations took place in 2014. The first investigation focused on evaluating sampling methods and purging criteria for future sampling. The study showed that depth-discrete bailer sample and purged sample ^{3}H concentrations are similar for the wells tested. It was also shown that the bailer may not provide representative samples for the entire characterization suite and that the jack pump is an alternative method to collect samples in characterization wells. The investigation showed that greater purge volumes were generally required to reach stabilization of the water-quality-indicator parameters than required to stabilize ^{3}H levels in the groundwater. In most cases time-series ^{3}H results stabilized in less than one borehole volume. With the exception of turbidity and DO, water-quality parameters also often stabilized after purging a single borehole volume.

The second investigation focused on determining the source of ^{3}H observed in depth-discrete bailed samples collected from PM-3 in 2010 and 2011. Although there remains uncertainty in the definitive interpretation of the PM-3 ^{3}H, it is possible that the ^{3}H observed at PM-3 is the leading edge of the plume resulting from lateral transport downgradient from HANDLEY. To further evaluate the ^{3}H source, a well between HANDLEY and PM-3 will be drilled, developed, and sampled. Hydrologic testing at this well will provide additional data to improve the hydrogeologic understanding within this area.

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Appendix A

COC and COPC Concentrations for NNSS Integrated Sampling Plan Locations

Table A-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_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
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	2011	30,100,000
	ER-20-5-3	ER-20-5-3_m1	CHZCM	2011	96,200
	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	2012	<24
	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_m2-4	FCCU/BA	2009	1.7
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
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]
Rainier Mesa/Shoshone Mountain					
Characterization	ER-12-3	ER-12-3_p1	LTCU/OSBCU/ATCU	--	--
		ER-12-3_m1	LCA3	2008	<0.5 [f]
	ER-12-4	ER-12-4_p1	LVTA/BRCU/ LTCU/OSBCU	--	--
		ER-12-4_m1	LCA3	2008	<0.5 [f]
	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	2013	<366
	TW-1	TW-1_m1	OSBCU/RVA/ LTCU/ATCU/LCA3	2013	<21
	UE-16d WW	UE-16d WW_m1	UCCU	**2014**	<258
	WW-8	WW-8_m22	BRA	**2014**	<258
Yucca Flat/Climax Mine					
Characterization	ER-2-1	ER-2-1_m1	TMWTA/ TMLVTA/LTCU	2003	228
	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	1994	<5.5
	UE-1h	UE-1h_o1	LCA	**2014**	<2.0
	UE-10j	UE-10j_m3	LCA	1997	<210
	WW-3	WW-3_m1	AA	**2014**	7.3
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	2012	94.2

Table A-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	2006	<12
	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	**2014**	<257

AA = 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
CHCU = Calico Hills confining unit
CHZCM = Calico Hills zeolitic composite unit
CPA = Comb Peak aquifer
FCCM = Fortymile Canyon composite unit
FCCU = Fluorspar Canyon confining unit
LCA = Lower carbonate aquifer
LCA3 = Lower carbonate aquifer-upper plate
LCCU = Lower clastic confining unit
LPCU = Lower Paintbrush confining unit
LTCU = Lower tuff 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
TCA = Tiva Canyon aquifer
TMCM = Timber Mountain composite unit
TMLVTA = Timber Mountain lower vitric-tuff aquifer
TMWTA = Timber Mountain welded-tuff aquifer
TSA = Topopah Spring aquifer
UCCU = Upper clastic confining unit
UPCU = Upper Paintbrush confining unit

NA = Not available
-- = 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 FY 2014 and CY 2014 are in bold type.
(2) Values highlighted in blue exceed the 20,000 pCi/L SDWA MCL.

Table A-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 [e]	2011	0.20	3.4E-03	<0.46	<7.2	2.1E-04	0.17	<0.02	<0.001
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-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	2011	472	3.6	UJ 1.35	0.38	0.19	9.2	--	0.42
ER-20-5-3	ER-20-5-3_m1	2011	2.72	0.013	U 0.71 [f]	0.004	4.4E-04	0.4	<0.31 [f]	<0.04 [g]
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 PS 1A_m1	2008	158	7.2	1,780 [g]	25.4	1.3	28,900	3.76	47
U-19q PS 1D	U-19q PS 1D_m1	2003	293	0.018	<0.75 [f]	0.08 [f]	2.0E-03	11.9	<10.8	<0.02
U-19v PS 1D	U-19v PS 1D_m1	2009	76.4	33	--	2.89	2.7	0.57 [h]	--	<0.004
U-20n PS1D	U-20n PS 1D_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
Early Detection										
PM-3	PM-3_p1 [e]	2013	0.12	1.9E-03	<0.39	<5.7	1.6E-05	<7.2	<0.02	<0.02
	PM-3_p2 [e]		0.15	2.1E-03	<0.51	<5.7	8.8E-05	<7.2	<0.03	<0.03
ER-EC-6	ER-EC-6_m2-4	2009	0.033	8.8E-04	<0.43	<8.2	<0.91 [d]	<8.1	<0.006	<0.02

Table A-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
Rainier Mesa/Shoshone Mountain										
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	2008	<350	5.3E-05	<0.33	<8.7	<8.6E-08 [j]	<6.7	<0.005	<0.02
	ER-12-3_p1	--	--	--	--	--	--	--	--	--
ER-12-4	ER-12-4_m1	2008	0.045	1.8E-04	<0.31	<8.2	<3.5	<6	<0.01	<0.005
	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	<145
U-12n.10 Vent Hole	U-12n.10 Vent Hole_m1	2008	150	1.0E+02	--	0.19	0.99	3.3	--	1.6
Yucca Flat/Climax Mine										
Characterization										
ER-2-1	ER-2-1_m1	2003	0.04	1.0E-04	<0.7	U 7.9	<3.2	<6.6	<0.01	<0.02
ER-5-3-2	ER-5-3-2_m1	2001	<460	2.9E-04	<0.57	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**	--	--	--	--	--	--	--	--

Table A-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
UE-10j	UE-10j_m3	1997	--	1.8E-04	--	--	--	--	--	--
WW-3	WW-3_m1	1962	--	--	<0.4	--	--	--	--	--
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	UE-7nS_m1	2012	<235	2.4E-04	<0.52	<7.64	4.1E-05	<5.64	<0.03	<0.04
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] Bailed samples collected from ER-20-8_p1, ER-20-8_p2, ER-20-8_p3, PM-3_p1, PM-3_p2, and UE-1h_o1 were not analyzed for COPCs.
[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.

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 FY 2014 and CY 2014 are in bold type.
(2) Values highlighted in blue exceed the SDWA MCL.

Appendix B

2014 Analytical Results

B.1.0 Frenchman Flat

Groundwater samples were collected from three source/plume wells in Frenchman Flat and analyzed by the commercial laboratory (Table B.1-1) and LLNL (Table B.1-2). All RNM-2S and UE-5n samples were analyzed by ALS Laboratory Group. For RNM-1, ^{3}H and ^{90}Sr were analyzed by ALS Laboratory Group, and all other RNs were analyzed by ARS International. With the exception of low-level ^{3}H, which is analyzed by ARS International, UGTA commercial laboratory analyses have typically been performed solely by ALS Laboratory Group. Select samples were sent to ARS International in 2014 to increase the laboratories available for UGTA analysis.

Table B.1-1
Commercial Laboratory Results (pCi/L) for Frenchman Flat Source/Plume Samples

Analyte	RNM-1 04/08/2014		RNM-2S 05/15/2014		UE-5n 06/12/2014	
^{3}H	620	550	J 46,900	J 48,200	153,000	151,000
^{14}C	J <8.39 [a]	J <8.26 [a]	J <420	J <460	<430	<420
^{36}Cl	--	--	J <3.4	J <3.4	<4.3	<3.3
^{90}Sr	7.4 [b]	8.9 [b]	U 0.72 [b]	2.58 [b]	<0.41	1.22 [b]
^{99}Tc	J <15 [a]	J <15 [a]	<6.2	<5.8	<7.3	<7.2
^{129}I	J <1.85 [a]	J <1.89 [a]	J <0.64	J <0.67	<0.69	<0.79
^{237}Np	J <0.58 [a]	J <0.42 [a]	<0.085	<0.063	<0.039	<0.028
^{238}Pu	J 0.17 [a]	J <0.10 [a]	<0.018	<0.037	<0.021	<0.034
$^{239/240}$Pu	J <0.11 [a]	J <0.10 [a]	<0.027	<0.037	<0.009	<0.02
^{234}U	J 3.41 [a]	J 3.13 [a]	3.24	2.70	3.30	3.32
^{235}U	J <0.11 [a]	J <0.05 [a]	0.095	0.085	U 0.085	0.098
^{238}U	J 1.34 [a]	J 1.34 [a]	1.35	1.22	1.50	1.55

[a] Samples were analyzed by ARS International; all others were analyzed by ALS Laboratory Group.

[b] The presence of interferences likely caused positive bias in the target analyte's measured and reported concentration.

J = Result is estimated; QC sample results exceeded the control limits. For RNM-1 samples, calibration verification did not meet criteria. For ^{238}U, duplicate precision also exceeded the control limit.
U = The reported result is less than the MDC plus 2-sigma error.
-- = Not analyzed

Notes:
(1) Nondetects are reported as "<" MDC.
(2) ^{3}H was reported as "<320 pCi/L" for a sample and field duplicate collected from RNM-1 on 04/07/2014 (after purging 125 gal).
(3) ^{3}H was estimated as 77,000 and 76,000 pCi/L for a sample and field duplicate, respectively collected from RNM-2S on 05/04/2014 (after purging approximately 745 gal).
(4) ^{3}H was reported as 153,000 and 152,000 pCi/L for a bailed sample and field duplicate, respectively collected from UE-5n on 06/02/2014.

Table B.1-2
LLNL Results (pCi/L) for Frenchman Flat Samples

Analyte	RNM-1 04/08/2014	RNM-2S 05/15/2014	UE-5n 06/12/2014	WW-5a 07/02/2014
^{3}H	U 389	66,087	158,247	<1 | <1
^{36}Cl	3.64E-04	0.0481	0.325	--
^{99}Tc	<4.5E-04	0.174	<4.5E-04	--
^{129}I	1.76E-05	3.89E-04	8.63E-06	--
^{234}U	3.12	3.34	3.28	--
^{235}U	0.058	0.067	0.074	--
^{236}U	<1.23E-05	<1.42E-05	<1.56E-05	--
^{238}U	1.27	1.46	1.60	--
^{237}Np	<1.6E-03	<1.6E-03	<1.6E-03	--

-- = Not analyzed
U = Result is less than the MDC plus 2-sigma error.

Note: The “|” denotes the sample | field duplicate.

The ARS International results are all flagged with a “J” qualifier to indicate they are estimated (Table B.1-1). The qualifier was required because various QA/QC requirements were not achieved (Section 4.0). In addition, the concentration of ^{90}Sr is highly uncertain because of a known analytical interference that often results in false positive detections. This was reported as an issue and is prevented in the future by requiring that ^{90}Sr detections are verified using a more selective analysis (i.e., ^{90}Y ingrowth) (Table A-2; NNSA/NFO, 2015). The reported ^{238}Pu in the RNM-1 sample is also most likely to be a false detection because (1) $^{239/240}$Pu was not detected in the RNM-1 sample, and ^{238}Pu has never been detected in NNSS groundwater without the simultaneous presence of $^{239/240}$Pu in greater concentrations; and (2) no ^{238}Pu was measured in the field duplicate sample.

LLNL provides more sensitive analytical techniques to detect the presence of test-related RNs at very low levels (Table B.1-2). They do not measure ^{90}Sr or Pu in these samples; therefore, the commercial laboratory’s analytical issues could not be refuted based on LLNL results. Detectable levels of ^{36}Cl, ^{129}I, ^{99}Tc (RNM-2S_m1), ^{234}U, ^{235}U, and ^{238}U were measured by LLNL. While most of the measured RNs were below the commercial laboratory’s detection limits, the concentrations for those that were detected (^{234}U, ^{235}U, and ^{238}U) were quite similar to those reported by LLNL.

Table B.1-3 presents the results of PWS (WW-4, WW-4a, and WW-5b), and Table B.1-4 presents the compliance (UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3) samples collected in 2014. These samples were collected by the M&O contractor (NSTec) and analyzed by a commercial laboratory. An inactive well (WW-5a) sample was analyzed by LLNL (Table B.1-2) and the commercial laboratory, ARS International (Table B.1-3). The compliance samples were enriched for ^{3}H analysis, providing a detection limit approximately an order of magnitude lower than the standard ^{3}H analysis used for the PWS samples. ARS International also used a ^{3}H enrichment technique that provides a detection limit of approximately 2 pCi/L for analyzing the WW-5a sample (Table B.1-3). The detection limit (1 pCi/L) was slightly lower using LLNL's helium accumulation method. No ^{3}H was detected in the WW-5a sample using either method.

Table B.1-3
Frenchman Flat PWS Sample Results (pCi/L)

Analyte	Sample Date	WW-4	WW-4a	WW-5b
Gross Alpha	11/05/2013	6.9	8.4	6.8
	01/14/2014	7.14	6.60	4.21
	04/08/2014	6.39	6.35	3.9 | 3.41
	07/22/2014	7.46 | 7.69	8.82	6.3
	10/29/2014	6.55	8.14	5.68
Gross Beta	11/05/2013	5.3	4.6	9.6
	01/14/2014	4.04	3.85	8.37
	04/08/2014	2.59	3.90	6.72 | 7.43
	07/22/2014	4.56 | 2.65	3.58	8.12
	10/29/2014	5.01	3.23	8.56
^{3}H	11/05/2013	<16.9	<16.9	<16.9
	01/14/2014	<261	<261	<254
	04/08/2014	<189	<215	<215 | <208
	07/22/2014	<195 | <194	<193	<197
	10/29/2014	<191	<201	<204

-- = Not analyzed

Note: The "|" denotes the sample | field duplicate.

Table B.1-4
Frenchman Flat Compliance and Inactive Well ^3H Results (pCi/L)

Sample Date	WW-5a	UE-5 PW-1	UE-5 PW-2	UE-5 PW-3
03/11/2014	--	<35 | <36	<37 | <35	<36 | <35
07/02/2014	<2.39 | <2.21	--	--	--
08/12/2014	--	<23 | <22	<20 | 36	<22 | <22

-- = Not analyzed

Note: The “|” denotes the sample | field duplicate.

B.2.0 Pahute Mesa

Groundwater samples were collected from six characterization wells (13 separate depths) in Pahute Mesa. ER-20-8 samples were collected using a bailer to support the sampling technologies evaluation task (Section 1.4.1). These samples were analyzed for a reduced set of analytes by the commercial laboratory. For the remaining characterization samples, a sample and a field duplicate were analyzed by the commercial laboratory for the full characterization suite. Both filtered (dissolved constituents) and unfiltered (total constituents) samples were analyzed for major cations and trace constituents for these locations. Samples and field duplicates were collected from the main completion and the piezometer at ER-20-8-2. The commercial laboratory results are presented in Tables B.2-1 (ER-20-8), B.2-2 (ER-EC-11), B.2-3 (ER-EC-14 and ER-EC-15), and B.2-4 (ER-20-7 and ER-20-8-2).

Table B.2-1
ER-20-8 Commercial Laboratory Results

Analyte	ER-20-8_p1 09/03/2014 and 09/04/2014		ER-20-8_p2 10/21/2014		ER-20-8_p3 09/10/2014, 09/15/2014, 09/16/2014	
Major Constituents (mg/L)						
Br	J 0.16	J 0.14	J 0.16	J 0.18	J 0.14	--
Cl	25	24	29	30	29	--
F	4.4	4.5	3.8	3.8	5.4	--
SO_4	43	44	52	52	44	--
Ca	28	35	3.1	3.5	13	--
Mg	2.1	3.7	0.87	1.1	0.44	--
K	J 3.0	J 2.6	2.9	2.9	J 3.6	--
Na	84	87	96	98	87	--
RNs (pCi/L)						
^3H	128	115	8,200	8,800	1,770	1,640

J = Result is estimated.
-- = Not analyzed

Note: Two columns for each ISPID report the sample and field duplicate results.

All commercial laboratory low-level ^3H measurements were made by ARS International. The majority of the remaining commercial laboratory analyses were performed by ALS Laboratory Group. The only exceptions are that ^{14}C, ^{99}Tc, ^{129}I, and $^{238/239/240}Pu$ analyses for ER-EC-14_m2

Table B.2-2
ER-EC-11 Commercial Laboratory Results
(Page 1 of 2)

Analyte	**ER-EC-11_p1 07/24/2014**		**ER-EC-11_p2 08/11/2014**		**ER-EC-11_p3 08/25/2014**	
Major and Minor Constituents (mg/L)						
Alkalinity as $CaCO_3$	140	130	120	120	150	150
HCO_3 [a]	146.3	146.3	134.1	134.1	158.5	146.3
CO_3 [a]	<12	<12	<12	<12	<12	15
Br	J 0.19	J 0.18	0.22	0.21	0.25	0.26
Cl	43	43	44	44	61	60
F	2.9	2.9	3.1	3.1	3.1	3.1
SO_4	69	69	69	69	88	88
Ca	5.0 | 4.8	4.9 | 4.8	4.8 | 4.7	4.7 | 4.8	25 | 4.7	7.9 | 4.7
Mg	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | U 1
K	1 | U 1	U 1 | U 1	1.2 | 1.1	1.1 | 1.1	4.1 | 3.8	4 | 3.8
Na	99 | 98	99 | 99	100 | 100	100 | 100	120 | 120	130 | 120
Al	U 0.2 | U 0.2	U 0.2 | U 0.2	U 0.2 | <0.015	U 0.2 | U 0.2	1.3 | <0.015	U 0.2 | <0.015
Fe	2.0 | 1.8	2.0 | 1.8	3.4 | 2.3	2.7 | 2.4	180 | 1.6	25 | 1.5
Silica [b]	40.6 | 38.5	38.5 | 38.5	40.6 | 40.6	40.6 | 40.6	72.7 | 44.9	51.3 | 44.9
Sulfide	J <2	J <2	J <2	J <2	<2	<2
SEC [c]	540	540	550	550	670	660
TDS	J- 340	J- 350	J- 360	J- 340	J- 440	J- 460
TOC	<1	<1	<1	<1	<1	<1
TSS	J <20	J <20	J <20	J <20	J- 25	J <20
Trace Constituents (µg/L)						
As	<3.9 | U 10	<3.9 | U 10	J 5.1 | UJ 10	UJ 10 | J <3.9	J+ 19 | <3.9	<3.9 | <3.9
Ba	U 100 | U 100	U 100 | U 100	UJ 100 | UJ 100	UJ 100 | UJ 100	200 | U 100	U 100 | U 100
Cd	<0.33 | <0.33	<0.33 | <0.33	<0.33 | <0.33	<0.33 | <0.33	J- 1.7 | <0.33	<0.33 | <0.33
Cr	0.52 |<0.51	<0.51 | <0.51	U 10 | <0.51	J- 1.4 | <0.51	200 | <0.51	35 | <0.51
Pb	J- 2.3 | <1.3	<1.3 | J- 1.5	2.2 | <1.3	<1.3 | <1.3	20 | <1.3	U 3 | <1.3
Li	J 170 | J 170	J 170 | J 170	J 170 | J 170	J 170 | J 170	140 | 130	130 | 130
Mn	88 | 76	87 | 84	110 | 98	100 | 99	1,400 | 62	280 | 62
Hg	J <0.0029 | J <0.0029	J <0.0029 | UJ 0.2	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029
Se	<2.7 | <2.7	<2.7 | <2.7	<2.7 | <2.7	<2.7 | <2.7	13 | 5.1	<2.7 | <2.7
Ag	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1
Sr	J 33 | J 32	J 33 | J 32	J 41 | J 41	J 41 | J 41	53 | J- 5.9	13 | J- 5.7
U	0.07 | 0.07	0.07 | 0.05	0.14 | 0.11	0.13 | 0.1	4.9 | 0.59	1.2 | 0.45

Table B.2-2
ER-EC-11 Commercial Laboratory Results
(Page 2 of 2)

Analyte	**ER-EC-11_p1 07/24/2014**		**ER-EC-11_p2 08/11/2014**		**ER-EC-11_p3 08/25/2014**	
RNs (pCi/L)						
Gross Alpha	U 1.37	<1.8	<1.25	<1.8	4.8	U 1.38
Gross Beta	<1.8	<2.9	<1.57	<2.2	5.6	U 2.5
^{3}H	<410	<400	<340	<350	16,100	16,000
^{3}H (Low Level)	J 7.99	J 6.01	11.5	11.41	--	--
^{14}C	<480	<480	<400	<400	<380	<380
^{26}Al	<9.7	<9.2	<9.6	<8.6	<8.5	<8.4
^{36}Cl	<3.3	<3.7	<3.2	<3.5	<3.9	<3.8
^{60}Co	<8.8	<7.9	<7.7	<7.1	<8.4	<7.3
^{90}Sr	<0.28	<0.28	<0.35	<0.37	<0.30	<0.29
^{94}Nb	<8.5	<8.6	<7.3	<7.2	<7.0	<6.1
^{99}Tc	<6.7	<7.9	<6.7	<6.8	<6.9	<6.6
^{125}Sb	<20	<19	<17.4	<16.2	<18	<14.9
^{129}I	J <0.67	J <0.74	<0.64	<0.77	<0.8	<0.71
^{134}Cs	<8.4	<8.0	<7.7	<7.6	<7.7	<6.9
^{137}Cs	<7.8	<7.5	<7.3	<7.5	<6.8	<7.0
^{152}Eu	<38	<41	<39	<34	<43	<34
^{154}Eu	<46	<51	<42	<41	<44	<42
^{155}Eu	<33	<11.6	<21	<26	<22	<19
^{235}U	<53	<29	<32	<40	<32	<24
^{238}Pu	<0.016	<0.032	<0.029	<0.031	<0.049	<0.024
$^{239/240}$Pu	<0.039	<0.032	<0.041	<0.027	<0.043	<0.019
^{241}Am	<240	<8.8	<62	<172	<64	<7.2

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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 by 2.139 mg silica / mg silicon.

[c] Units are μS/cm.

$CaCO_3$ = Calcium carbonate
Hg = Mercury
mg = Milligram

TOC = Total organic carbon
TSS = Total suspended solids
μS/cm = Microsiemens per centimeter

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) 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) Two columns for each ISPID report the sample and field duplicate results.

Table B.2-3
ER-EC-14 and ER-EC-15 Commercial Laboratory Results
(Page 1 of 3)

Analyte	ER-EC-15_m1 (TSA)		ER-EC-15_m2 (TCA)		ER-EC-15_m3 (CPA)		ER-EC-14_m1 (RMWTA)		ER-EC-14_m2 (RMWTA)	
	02/16/2014		01/09/2014		11/06/2013		05/11/2014		04/05/2014	
Major and Minor Constituents (mg/L)										
Alkalinity as CaCO$_3$	270	260	160	160	160	160	140	140	140	140
HCO$_3$ [a]	329.1	316.9	158.5	134.1	195	195	170.7	170.7	170.7	170.7
CO$_3$ [a]	<12	<12	18.0	30.6	<12	<12	<12	<12	<12	<12
Br	J 0.14	J 0.15	0.27	0.28	0.31	0.32	J 0.12	J 0.12	J 0.11	J 0.13
Cl	36	36	60	61	63	65	20	20	20	20
F	14	13	6.2	6.1	6.1	6.3	6.6	6.6	6.2	6.2
SO$_4$	87	86	97	100	94	97	44	44	44	44
Ca	7.2 | 6.9	7.1 | 6.9	6.3 | 6.1	6.4 | 6.2	6.9 | 6.7	6.9 | 6.8	15 | 15	16 | 15	14 | 14	14 | 14
Mg	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | U 1	<0.013 | <0.013	<0.013 | <0.013	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | U 1
K	4.8 | 4.7	4.8 | 4.7	2.5 | 2.5	2.6 | 2.6	3.6 | 3.2	3.3| 3.2	2.7 | 2.7	2.7 | 2.7	2.1 | 2.1	2.1 |2.1
Na	160 | 160	170 | 170	140 | 140	140 | 140	140 | 130	140 | 130	78 | 80	79 | 78	77 | 75	74 | 74
Al	U 0.2 | U 0.2	U 0.2 | U 0.2	U 0.2 | U 0.2	U 0.2 | U 0.2	U 0.2 | U 0.2	U 0.2 | U 0.2	0.025 | <0.015	0.020 | <0.015	<0.029 | <0.029	0.039 | <0.029
Fe	0.23 | J- 0.075	0.12 | J- 0.072	2.1 | 0.29	0.95 | 0.32	<0.0049 | J- 0.0057	<0.0049 | <0.0049	J 0.16 | J 0.16	UJ 0.1 | UJ 0.1	<0.0067 | <0.0067	<0.0067 | <0.0067
Silica [b]	49.2 | 47.1	49.2 | 47.1	44.9 | 44.9	44.9 | 44.9	55.6 | 55.6	55.6 | 55.6	49.2 | 49.2	49.2 | 49.2	42.8 | 42.8	42.8 | 42.8
Sulfide	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
SEC [c]	830	830	730	730	750	750	440	450	450	450
TDS	540	520	450	460	490	480	280	290	310	300
TOC	<1	<1	3.0	2.9	<1	<1	<1	<1	<1	<1
TSS	J <20	J <20	<20	<20	<20	<20	<20	<20	<20	<20

Table B.2-3
ER-EC-14 and ER-EC-15 Commercial Laboratory Results
(Page 2 of 3)

Analyte	ER-EC-15_m1 (TSA)		ER-EC-15_m2 (TCA)		ER-EC-15_m3 (CPA)		ER-EC-14_m1 (RMWTA)		ER-EC-14_m2 (RMWTA)	
	02/16/2014		01/09/2014		11/06/2013		05/11/2014		04/05/2014	
Trace Constituents (µg/L)										
As	29 | 28	21 | 24	J 14 | J 17	J 12 | J 14	9.6 | 7.9	10 | 6.3	J 13 | J 6.2	J <3.9 | J <3.9	U 10 | 13	10 | U 10
Ba	J- 6.7 | J- 5.9	J- 6.3 | J- 6	J- 4.7 | J- 2.5	J- 3.8 | J- 2.6	U 100 | U 100	U 100 | U 100	<0.19 | <0.19	<0.19 | <0.19	1.6 | 1.7	1.9 | 1.5
Cd	<0.33 | <0.33	<0.33 | <0.33	<0.33 | <0.33	J- 0.42 | <0.33	<0.33 | <0.33	<0.33 | <0.33	<0.33 | <0.33	<0.33 | J- 0.36	<0.21 | <0.21	<0.21 | <0.21
Cr	<0.51 | <0.51	J- 1.5 | <0.51	J- 1.8 | <0.51	J- 0.65 | <0.51	<0.51 | <0.51	<0.51 | <0.51	<0.51 | <0.51	<0.51 | <0.51	<0.73 | <0.73	<0.73 | <0.73
Pb	3.7 | <1.3	4.0 | <1.3	4.8 | U 3	3.9 | <1.3	<1.3 | J 1.7	<1.3 | J 1.4	<1.3 | <1.3	<1.3 | <1.3	<1.8 | 2.4	<1.8 | <1.8
Li	J 530 | J 520	J 540 | J 530	J 270 | J 280	J 280 | J 280	J 260 | J 240	J 250 | J 240	J 110 | J 110	J 120 | J 110	110 | 100	100 | 100
Mn	48 | 43	45 | 43	69 | 26	40 | 26	J- 7.9 | J- 7.9	J- 7.8 | J- 7.5	J- 0.17 | J- 0.47	<0.11 | <0.11	1.9 | 1.9	2.0 | 1.9
Hg	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029	J <0.0029 | J <0.0029	J <0.0029 | J <0.0029	0.0098 | 0.0083	0.01 | 0.0097	U 0.2 | U 0.2	U 0.2 | U 0.2
Se	8.2 | <2.7	5.8 | <2.7	5.2 | U 5	U 5 | <2.7	J <2.7 | J- 2.9	J <2.7 | J <2.7	<2.7 | <2.7	<2.7 | <2.7	<3 | <3	<3 | <3
Ag	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<1.1 | <1.1	<0.42 | U 10	U 10 | U 10
Sr	140 | 140	140 | 140	40 | 38	40 | 39	J 21 | J 20	J 21 | J 20	J 41 | J 40	J 42 | J 41	45 | 44	44 | 44
U	1.4 | 1.4	1.4 | 1.3	1.1 | 0.97	1.0 | 0.97	4.3 | 4.3	4.2 | 4.3	2.0 | 2.0	2.2 | 2.0	2.1 | 2.0	2.0 | 2.0
RNs (pCi/L)										
Gross Alpha	<2.3	<1.6	<1.51	<1.55	5.3	4.0	U 2.6	2.8	U 2.5	U 2.3
Gross Beta	4.3	4.6	<2.2	<2.2	3.1	4.0	<2.1	3.6	<3.3	U 3.1
^{3}H	<340	<340	<360	<360	<360	<360	<310	<320	<320	<320
^{3}H (Low Level)	<1.9	<1.9	J <2.09	J <2.12	<2.20	<2.08	<1.81	<2.01	<1.59	<2.16
^{14}C	J <14.4	J <16.9	--	--	--	--	<480	<480	<8.36	<7.24
^{26}Al	<10.7	<7.7	<9.2	<6.9	<9.2	<13.4	<9.9	<9.3	<12.7	<11.7
^{36}Cl	<16.5	<20.5	--	--	--	--	<3.2	<3.3	--	--
^{60}Co	<9.1	<9.1	<8	<7.5	<9.1	<9.6	<8.1	<7.9	<11.5	<10.4
^{90}Sr	<0.37	<0.37	<0.33	U 0.47	<0.37	<0.37	0.77 [d]	1.1 [d]	<0.32	<0.43
^{94}Nb	<8.1	<7.7	<8.2	<7.6	<9.0	<9.8	<8.5	<7.1	<9.7	<9.4

Table B.2-3
ER-EC-14 and ER-EC-15 Commercial Laboratory Results
(Page 3 of 3)

Analyte	ER-EC-15_m1 (TSA)		ER-EC-15_m2 (TCA)		ER-EC-15_m3 (CPA)		ER-EC-14_m1 (RMWTA)		ER-EC-14_m2 (RMWTA)	
	02/16/2014		01/09/2014		11/06/2013		05/11/2014		04/05/2014	
^{99}Tc	UJ 7.1	UJ 5.7	--	--	--	--	<6.1	<5.8	<14	<15
^{125}Sb	<19	<16	<21	<19	<19	<21	<19	<16	<22	<20
^{129}I	J <1.21	J <1.87	--	--	--	--	UJ 0.79 [d]	J+ 1.47 [d]	J <1.85	J <1.74
^{134}Cs	<51	<7.5	<8.9	<10.1	<7.1	<12.2	<7.6	<7.3	<13.9	<8.6
^{137}Cs	<7.7	<7.6	<7.7	<6.6	<8.9	<9.7	<8.2	<7.3	<9.8	<8.7
^{152}Eu	<45	<45	<40	<43	<48	<54	<47	<38	<61	<50
^{154}Eu	<44	<44	<48	<41	<49	<47	<50	<43	<54	<53
^{155}Eu	<20	<19	<27	<43	<17	<21	<12	<17	<23	<14.6
^{235}U	<31	<26	<58	<49	<35	<36	<35	U 27	<51	<30
^{238}Pu	J <0.13	J <0.20	--	--	--	--	<0.044	<0.023	J <0.05	J <0.48
$^{239/240}$Pu	J <0.10	J <0.12	--	--	--	--	<0.044	<0.023	J <0.14	J <0.10
^{241}Am	<43	<9.5	<190	<250	<9.8	<62	<9.2	<36	<50	<10.3

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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 by 2.139 mg silica / mg silicon.
[c] Units are µS/cm.
[d] The presence of interferences likely caused positive bias in the target analyte's measured and reported concentration.

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) 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) Two columns for each ISPID report the sample and field duplicate results.

Table B.2-4
ER-20-7 and ER-20-8-2 Commercial Laboratory Results
(Page 1 of 3)

Analyte	ER-20-7_m1		ER-20-8-2_m1		ER-20-8-2_p1	
	11/21/2014		10/16/2014		10/06/2014	
Major And Minor Constituents (mg/L)						
Alkalinity as $CaCO_3$	150	150	120	120	120	120
HCO_3 [a]	182.85	182.85	146.28	146.28	146.28	146.28
CO_3 [a]	<12	<12	<12	<12	<12	<12
Br	J 0.15	J 0.15	J 0.14	J 0.16	J 0.15	J 0.16
Cl	31	31	27	27	27	26
F	6.7	6.9	J+ 5.1	J+ 5.2	4.9	5.1
SO_4	51	51	49	51	49	49
Ca	5.4 | 5.4	5.4 | 5.2	J 1.8 | J 1.7	J 1.8 | J 1.8	1.9 | 1.8	1.8 | 1.8
Mg	0.19 | 0.18	0.18 | 0.17	U 1 | U 1	U 1 | U 1	U 1 | U 1	U 1 | <0.03
K	4.8 | 4.8	4.8 | 4.7	2.2 | 2.3	2.2 | 2.3	2.3 | 2.4	2.4 | 2.4
Na	100 | 100	100 | 100	86 | 87	86 | 88	91 | 91	92 | 92
Al	1.3 | 0.89	1.3 | 0.72	0.041 | 0.061	0.068 | 0.063	U 0.2 | U 0.2	U 0.2 | U 0.2
Fe	0.29 | J- 0.076	0.22 | J- 0.071	U 0.1 | U 0.1	U 0.1 | U 0.1	5.8 | 2.7	5 | 2.7
Silica [b]	66.3 | 66.3	66.3 | 64.2	44.9 | 44.9	44.9 | 44.9	44.9 | 42.8	44.9 | 44.9
Sulfide	<2	<2	<2	<2	<2	<2
SEC [c]	510	510	440	440	440	440
TDS	370	370	J- 300	J- 290	290	290
TOC	<1	<1	<1	<1	<1	<1
TSS	<20	<20	J<20	J<20	J<20	J<20
Trace Constituents (μg/L)						
Ag	<1.1 | <1.1	<1.1 | <1.1	<0.42 | <0.42	<0.42 | <0.42	<0.42 | <0.42	<0.42 | <0.42
As	J<3.9 | J<3.9	J 4.7 | J<3.9	J- 7.3 | J- 4.8	J- 5.6 | J- 4.6	J- 4.1 | J- 7.6	J- 3.9 | J<2
Ba	J- 2.3 | J- 1.5	J- 2.2 | J- 1	1.3 | 1.3	0.94 | 1	U 100 | U 100	U 100 | U 100
Cd	<0.33 | <0.33	<0.33 | <0.33	U 5 | U 5	U 5 | U 5	U 5 | U 5	U 5 | U 5
Cr	<0.51 | <0.51	<0.51 | <0.51	<0.73 | <0.73	<0.73 | <0.73	10 | <0.73	U 10 | U 10

Table B.2-4
ER-20-7 and ER-20-8-2 Commercial Laboratory Results
(Page 2 of 3)

Analyte	ER-20-7_m1		ER-20-8-2_m1		ER-20-8-2_p1	
	11/21/2014		10/16/2014		10/06/2014	
Hg	0.0056 | <0.0029	0.0072 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029	<0.0029 | <0.0029
Li	J 95 | J 96	J 94 | J 95	100 | 100	100 | 110	110 | 110	110 | 110
Mn	J- 8.7 | J- 5.1	J- 7.4 | J- 4.7	1.2 | U 10	1 | 1.3	150 | 100	130 | 100
Pb	<1.3 | J- 1.5	<1.3 | <1.3	<1.8 | U 3	U 3 | U 3	3.5 | 2.8	<1.8 | 3.2
Se	<2.7 | <2.7	<2.7 | <2.7	<3 | <3	<3 | <3	<3 | <3	<3 | <3
Sr	7.3 | 6.7	7.2 | 6.3	1.6 | 1.6	1.6 | 1.6	U 10 | U 10	U 10 | U 10
U	8 | 8.1	8.4 | 8.6	2.4 | 2.3	2.4 | 2.3	0.38 | 0.19	0.37 | 0.18
RNs (pCi/L)						
Gross Alpha	9.1	7.7	U 3.2	U 2.4	<1.05	<1.32
Gross Beta	9	10.6	U 3.9	<2.2	U 2.23	U 2.2
^{3}H	1.51E+07	1.56E+07	2,600	2,510	2,470	2,310
^{14}C	R	R	J <470	J <470	<380	<380
^{26}Al	<6.4	<6.6	<9.6	<13.2	<11.1	<9.6
^{60}Co	<6	<7	<10.5	<10.2	<11.2	<8.7
^{36}Cl	<2.8	<2.6	<2.5	<2.2	<3.1	<3
^{90}Sr	<0.51	<0.5	<0.48	<0.48	<0.5	<0.51
^{94}Nb	<6.3	<5.5	<8	<8.7	<8.6	<7.3
^{99}Tc	<7.6	<7	<7.3	<6.9	<7.2	<7.4
^{125}Sb	<17.5	<14.5	<18	<20	<20	<19
^{129}I	<0.67	<0.68	J <0.71	J <0.75	J <0.73	J <0.69
^{134}Cs	<6.5	<6.2	<8.8	<11.7	<12.9	<8.5
^{137}Cs	<6.2	<6.2	<7.8	<8	<8.7	<8.5
^{152}Eu	<32	<36	<37	<41	<54	<38
^{154}Eu	<35	<35	<43	<56	<55	<44
^{155}Eu	<26	<9.3	<30	<24	<22	<11.5
^{235}U	<34	<33	<61	<36	<41	<38
^{238}Pu	<0.052	<0.011	<0.02	<0.031	<0.045	<0.012

Table B.2-4
ER-20-7 and ER-20-8-2 Commercial Laboratory Results
(Page 3 of 3)

Analyte	ER-20-7_m1		ER-20-8-2_m1		ER-20-8-2_p1	
	11/21/2014		10/16/2014		10/06/2014	
$^{239/240}$Pu	U 0.041	U 0.042	<0.02	<0.031	<0.029	<0.033
^{241}Am	<220	<6.8	<190	<68	<53	<8.3

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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 by 2.139 mg silica/ mg silicon.
[c] Units are µS/cm.
[d] The presence of interferences likely caused positive bias in the target analyte's measured and reported concentration.

J = Result is estimated.
J- = Result is estimated and is biased low.
J+ = Result is estimated and is biased high.
R = Result is rejected.
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) Two columns for each ISPID report the sample and field duplicate results.

(04/05/2014) and ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I, and $^{238/239/240}$Pu analyses for ER-EC-15_m1 (02/16/2014) were performed by ARS International. Several issues were identified for ER-EC-14 sample analyses. Several results are reported as estimates (qualified with a "J") because certain QC requirements were not satisfied. For instance, ^{129}I was reported as estimated with a positive bias for one ER-EC-14 samples because the LCS recovery exceeded the control limits. The laboratory also exceeded the 1-pCi/L detection limit requirement for ^{129}I for two ER-EC-14 samples (Table B.2-3). In addition, a ^{238}Pu detection was reported as an estimate (Table B.2-3); in this case, the calibration verification was unacceptable. The reported ^{238}Pu is most likely a false detection because (1) $^{239/240}$Pu was not detected in the samples, and ^{238}Pu has never been detected in NNSS groundwater without the simultaneous presence of $^{239/240}$Pu in greater concentrations; and (2) no ^{238}Pu was measured in the field duplicate sample. ^{90}Sr was also reported for the sample and field duplicate from ER-EC-14_m1. As previously stated, the concentration of ^{90}Sr is highly uncertain because of a known analytical interference that often results in false positive detections. This was reported as an issue and is prevented in the future by requiring that ^{90}Sr detections are verified using a more selective analysis (i.e., ^{90}Y ingrowth) (Table

A-2; NNSA/NFO, 2015). The ^{14}C reported by the commercial laboratory for ER-20-7 samples was rejected because spectral problems prevented accurate quantitation.

In addition to the required commercial laboratory analyses, a number of specialized analyses were performed by LLNL for ER-20-7 and ER-20-8-2 (Table B.2-5) and performed by DRI, LLNL, and USGS for ER-EC-11, ER-EC-14, and ER-EC-15 (Table B.2-6). These analyses include environmental tracers (e.g., stable isotopes, noble gases) and low-level RNs.

Table B.2-5
LLNL Results for ER-20-7 and ER-20-8-2
(Page 1 of 2)

Analyte	ER-20-7_m1	ER-20-8-2_m1	ER-20-8-2_p1
	11/21/2014	10/17/2014	10/07/2014
Environmental Tracers			
C-13/12 (‰)	-2.77 | -2.7	-3.52 | -3.48	-3.47 | -3.83
H-2/1 (‰)	-115.1 | -114.8	-114.4 | -114.4	-114 | -114.4
O-18/16 (‰)	-14.78 | -14.88	-14.99 | -15.03	-14.9 | -15.01
Sr-87/86 (‰)	2.42 | 2.44	0.76 | 0.7	-0.64 | -0.65
^{14}C (pmc)	--	--	J- 104.5 | J- 110.38
^{36}Cl/Cl (ratio)	2.49E-09 | 2.51E-09	3.76E-12 | 3.84E-12	3.78E-12 | 3.8E-12
^{129}I/^{127}I (ratio)	6.50E-05 | 6.10E-05	1.2E-07 | 1.2E-07	1.1E-07 | 1.1E-07
^{87}Sr/^{86}Sr (ratio)	0.710917 | 0.710931	0.709737 | 0.709698	0.708743 | 0.70874
^{234}U/^{235}U (ratio)	0.0229 | 0.0229	0.0295 | 0.0295	0.02942 | 0.02912
^{234}U/^{238}U (ratio)	1.66E-04 | 1.66E-04	2.14E-04 | 2.14E-04	2.12E-04 | 2.11E-04
^{234}U/^{238}U (Activity ratio)	3.029 | 3.0285	3.886 | 3.895	3.862 | 3.838
^{235}U/^{238}U (ratio)	0.007255 | 0.0072549	0.0072471 | 0.0072486	0.007213 | 0.007241
^{236}U/^{235}U (ratio)	<8.5E-06 | <8.5E-06	<8.5E-06 | <8.5E-06	<7.0E-06 | <7.0E-06
Noble Gases (atoms/g)			
Ar	--	--	6.62E+15 | 9.97E+15
^{40}Ar	--	--	6.59E+15 | 9.93E+15
^{3}He	--	--	1.09E+08 | 1.26E+08
^{4}He	--	--	1.15E+13 | 1.49E+13
^{3}He/^{4}He (R/Ra) [a]	--	--	6.84 | 6.17
Kr	--	--	1.44E+12 | 1.84E+12
Ne	--	--	4.70E+12 | 1.12E+13

Table B.2-5
LLNL Results for ER-20-7 and ER-20-8-2
(Page 2 of 2)

Analyte	ER-20-7_m1	ER-20-8-2_m1	ER-20-8-2_p1
	11/21/2014	10/17/2014	10/07/2014
^{20}Ne	--	--	4.25E+12 | 1.02E+13
Xe	--	--	2.05E+11 | 2.27E+11
^{130}Xe	--	--	8.39E+09 | 9.31E+09
RNs (pCi/L)			
^{3}H	1.57E+07 | 1.56E+07	2,601 | 2,578	2,574 | 2,560
^{14}C	--	--	J- 0.1903 | J- 0.2004
^{36}Cl	2.47 | 2.52	0.00332 | 0.00339	0.00336 | 0.00334
^{99}Tc	--	0.0672 | 0.063	J 0.00732 | J 0.00582
^{129}I	0.135 | 0.128	0.000237 | 0.000227	0.000208 | 0.00021
^{234}U	8.741 | 8.748	3.176 | 3.209	0.272 | 0.270
^{235}U	0.13291 | 0.13306	0.037601 | 0.037916	0.00322 | 0.00324
^{236}U	<3.397E-05 | <3.401E-05	<9.61E-06 | <9.69E-06	<6.78E-07 | <6.81E-07
^{238}U	2.89 | 2.89	0.82 | 0.82	0.07 | 0.07

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

atoms/g = Atoms per gram
pmc = Percent modern carbon

-- = Not analyzed

The results for samples collected from the early detection (PM-3) and community (Ash-B) wells are presented in B.2-7 and B.2-8, respectively. Table B.2-9 presents the results of PWS (J-12 WW and J-14 WW) samples collected by the M&O contractor (NSTec) and analyzed by a commercial laboratory. Two intervals of ER-EC-6 that are not included in the Sampling Plan (NNSA/NFO, 2014) were sampled and analyzed by the commercial laboratory (Table B.2-10).

Table B.2-6
DRI, LLNL, and USGS Results for ER-EC-11, ER-EC-14, and ER-EC-15
(Page 1 of 2)

Analyte	**ER-EC-11_p1**	**ER-EC-11_p2**	**ER-EC-11_p3**	**ER-EC-14_m1**	**ER-EC-14_m2**	**ER-EC-15_m1**	**ER-EC-15_m2**	**ER-EC-15_m3**
	07/24/2014, 07/25/2014	**08/11/2014, 08/12/2014**	**08/25/2014**	**05/11/2014, 05/12/2014**	**04/05/2014, 04/06/2014**	**02/17/2014**	**01/09/2014, 01/10/2014**	**11/05/2013, 11/06/2013**
LLNL								
Environmental Tracers								
C-13/12 (‰)	-3.17 | -3.40	-3.32 | -3.32	-2.78 | -3.46	-2.59	-2.13	0.2	-2.4	-1.9
H-2/1 (‰)	-114.8 | -114.7	-115.0 | -115.3	-115.0 | -115.3	-115.3	-115.1	-115.7	-116.6	-116.2
O-18/16 (‰)	-14.91 | -14.95	-14.93 | -15.04	-14.83 | -14.91	-14.37	-14.31	-14.93	-14.74	-14.81
Sr-87/86 (‰)	0.70 | 0.71	0.50 | 0.50	0.16 | 0.16	0.43	0.34	0.41	0.71	0.71
^{14}C (pmc)	36.3 | 44.2	30.9 | 42.8	J- 292 | J- 274	31.28	7.23	1.72	9.04	32.24
^{36}Cl/Cl (ratio)	5.57E-13 | 5.64E-13	1.11E-12 | 1.10E-12	3.96E-12 | 3.99E-12	5.54E-13	5.39E-13	4.44E-13	5.17E-13	5.33E-13
^{129}I/^{127}I (ratio)	5.06E-10 | 4.75E-10	8.99E-08 | 9.00E-08	1.15E-07 | 1.09E-07	9.41E-11	5.97E-11	5.03E-10	1.96E-09	3.34E-10
^{87}Sr/^{86}Sr (ratio)	0.709698 | 0.709702	0.709554 | 0.709553	0.709313 | 0.709315	0.709502	0.709441	0.709849	0.709706	0.709703
^{234}U/^{235}U (ratio)	0.02922 | 0.02819	0.03067 | 0.02905	0.02345 | 0.02339	0.04884	0.04923	0.0315	0.03171	0.0279
^{234}U/^{238}U (ratio)	2.15E-04 | 2.10E-04	2.21E-04 | 2.10E-04	1.70E-04 | 1.70E-04	3.54E-04	3.57E-04	2.29E-04	2.30E-04	2.02E-04
^{234}U/^{238}U (Activity ratio)	3.906 | 3.826	4.020 | 3.804	3.096 | 3.090	6.452	6.501	4.161	4.186	3.678
^{235}U/^{238}U (ratio)	7.34E-03 | 7.46E-03	7.20E-03 | 7.19E-03	7.26E-03 | 7.26E-03	7.26E-03	7.26E-03	7.26E-03	7.25E-03	7.25E-03
^{236}U/^{235}U (ratio)	2.52E-04 | 1.90E-04	<7.0E-06 | <7.0E-06	<7.0E-06 | <7.0E-06	<7.0E-06	<7.0E-06	<7.0E-06	<7.0E-06	<7.0E-06
Noble Gases (atoms/g)								
Ar	6.60E+15 | 6.62E+15	6.62E+15 | 6.58E+15	--	6.04E+15	6.39E+15	1.11E+16	1.24E+16	7.38E+15
^{40}Ar	6.57E+15 | 6.59E+15	6.60E+15 | 6.55E+15	--	6.02E+15	6.36E+15	1.11E+16	1.24E+16	7.35E+15
^{3}He	1.09E+07 | 1.19E+07	1.30E+07 | 1.12E+07	--	8.00E+06	8.37E+06	1.77E+08	3.34E+07	5.74E+07
^{4}He	1.22E+13 | 1.31E+13	1.39E+13 | 1.27E+13	--	5.45E+12	5.71E+12	1.37E+14	2.62E+13	4.32E+13
^{3}He/^{4}He (R/Ra) [a]	0.645 | 0.656	0.676 | 0.644	--	1.06	1.06	0.935	0.924	0.962
Kr	1.48E+12 | 1.49E+12	1.52E+12 | 1.53E+12	--	1.25E+12	1.30E+12	2.13E+12	2.15E+12	1.57E+12
Ne	4.32E+12 | 4.35E+12	4.40E+12 | 4.48E+12	--	5.32E+12	5.27E+12	9.95E+12	1.30E+13	6.53E+12
^{20}Ne	3.91E+12 | 3.94E+12	3.98E+12 | 4.06E+12	--	4.81E+12	4.77E+12	9.00E+12	1.17E+13	5.91E+12
Xe	2.12E+11 | 2.12E+11	2.20E+11 | 2.23E+11	--	1.65E+11	1.83E+11	2.75E+11	3.08E+11	2.04E+11
^{130}Xe	8.71E+09 | 8.71E+09	9.02E+09 | 9.13E+09	--	6.77E+09	7.49E+09	1.13E+10	1.26E+10	8.38E+09

Table B.2-6
DRI, LLNL, and USGS Results for ER-EC-11, ER-EC-14, and ER-EC-15
(Page 2 of 2)

Analyte	ER-EC-11_p1	ER-EC-11_p2	ER-EC-11_p3	ER-EC-14_m1	ER-EC-14_m2	ER-EC-15_m1	ER-EC-15_m2	ER-EC-15_m3
	07/24/2014, 07/25/2014	08/11/2014, 08/12/2014	08/25/2014	05/11/2014, 05/12/2014	04/05/2014, 04/06/2014	02/17/2014	01/09/2014, 01/10/2014	11/05/2013, 11/06/2013
RNs (pCi/L)								
^{3}H	9.9 | 11.8	11.3 | 10.9	16,364 | 16,214	<0.3	<0.4	<1	<0.4	<0.3
^{14}C	0.0707 | 0.0857	0.0599 | 0.0819	J- 0.626 | J- 0.590	0.067	0.0157	0.0067	0.0209	0.0782
^{36}Cl	7.9E-04 | 8.0E-04	1.6E-03 | 1.6E-03	7.8E-03 | 7.8E-03	3.6E-04	3.6E-04	5.3E-04	1.0E-03	1.1E-03
^{99}Tc	<4.5E-04 | <4.5E-04	<4.5E-04 | <4.5E-04	<4.5E-04 | <4.5E-04	<4.5E-04	J 6.1E-03	<0.34	J 1.9E-03	<4.0E-04
^{129}I	1.31E-06 | 1.23E-06	2.33E-04 | 2.33E-04	3.75E-04 | 3.56E-04	1.77E-07	1.10E-07	1.54E-06	7.07E-06	1.20E-06
^{234}U	0.0755 | 0.0714	0.1556 | 0.1446	0.4431 | 0.4404	4.54	4.53	1.499	1.397	5.67
^{235}U	9.0E-04 | 8.8E-04	1.77E-03 | 1.74E-03	6.59E-03 | 6.57E-03	0.0324	0.0321	0.0166	0.0154	0.071
^{236}U	6.83E-06 | 5.05E-06	<3.72E-07 | <3.66E-07	<1.39E-06 | <1.38E-06	<6.83E-06	<6.76E-06	<3.49E-06	<3.23E-06	<1.49E-05
^{238}U	0.0194 | 0.0187	0.0387 | 0.0380	0.143 | 0.142	0.704	0.697	0.36	0.3336	1.54
DRI								
Alkalinity as $CaCO_3$ (mg/L)	--	--	--	72.4	123	240	142	124
CO_3 (mg/L)	--	--	--	ND	ND	ND	4.8	ND
HCO_3 (mg/L)	--	--	--	88.3	149.9	292.6	163.3	151.2
DOC	--	--	--	0.24	0.23	0.86	1.31	0.30
C-13/12 DOC (‰)	--	--	--	-24.0	-25.7	-29.7	-28.6	-20.2
^{14}C DOC (pmc)	--	--	--	91.9	74.3	19.7 | 22.2	27.5	88.3
USGS								
S-34/32 (‰)	18.7 | 18.8	--	--	16.5	16.9	17.5	18.3	19.5

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

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

Note: Values reported with a “|” indicate Sample | field duplicate results.

Table B.2-7
Pahute Mesa Early Detection Results

Analyte	PM-3-1 06/11/2014		PM-3-2 06/11/2014		
	1,471 ft	1,983 ft	1,469 ft	1,560 ft	1,560 ft
Field Measurements					
Temp (°C)	31.4	32.8	35.1	30.7	29.1
pH (SU)	9.6	8.0	8.6	7.9	7.6
SEC (µS/cm)	688	797	629	810	798
Turbidity (NTU)	53.6	130	14.3	11.9	9.4
Major Constituents (mg/L)					
HCO_3	57.3	121.9	75.6	146.3	146.3
CO_3	33.6	<12	<12	<12	<12
Alkalinity	100	100	62	120	120
SO_4	49	120	84	110	110
F	3	2.7	4.5	3.1	3.3
Cl	99	100	86	95	96
Br	0.53	0.50	0.74	0.67	0.66
Na	130	130	100	120	120
K	11	11	15	16	17
Ca	4.8	27	7.6	25	25
Mg	U 1	4.4	1.1	3.0	3.5
Charge Balance	3.2%	0.3%	-2.0%	-1.7%	-1.4%
RNs (pCi/L)					
^3H	77.8	39.0	130.4	236.9	216.2

°C = Degrees Celsius

Table B.2-8
Pahute Mesa Community Well Results

Analyte	Ash-B_p1	Ash-B_p2
	04/21/2014	
Field Measurements		
Temp (°C)	26.6	25.8
pH (SU)	10.8	7.95
SEC (µS/cm)	499	1,004
Turbidity (NTU)	6.15	8.71
RNs (pCi/L)		
^3H	<183	<177

-- = Not analyzed

Table B.2-9
Pahute Mesa PWS Laboratory Results

Location	Date	Gross Alpha	Gross Beta	^3H
J-12 WW	11/05/2013	<1.4	4.0	<17
	01/14/2014	<1.4	3.1	<261
	04/08/2014	1.4	3.7	<215
	07/22/2014	1.9	3.4	<196
	10/30/2014	<1.2	3.2	<201
J-14 WW	11/19/2013	4.2	8.2	<17
	01/14/2014	3.8 | 3.7	7.3 | 7.2	<268 | <268
	04/08/2014	3.3	8.5	<213
	07/22/2014	5.3	7.6	<196
	10/30/2014	2.2 | 3.6	6.8 | 6.6	<200 | <203

Note: The “|” denotes the sample | field duplicate.

Table B.2-10
Inactive Well Samples and Field Duplicates
(Page 1 of 3)

Analyte	ER-EC-6_m2		ER-EC-6_m3	
	12/18/2014		12/11/2014	
Major and Minor Constituents (mg/L)				
Alkalinity as $CaCO_3$ [a]	110	110	--	--
CO_3[a]	<12	<12	--	--
HCO_3[a]	134.09	119.46	--	--
Br	0.25	0.26	J 0.11	J 0.11
Cl	26	26	13	13
F	4.3	4.4	8.7	8.9
SO_4	55	55	J- 27	28
Ca	4.0 | 3.9	3.9 | 3.8	5.4 | --	5.2 | --
K	1.7 | 1.7	1.7 | 1.7	1.4 | --	1.3 | --
Na	79 | 80	78 | 78	84 | --	76 | --
Mg	0.025 | 0.033	0.021 | 0.02	U 1 | --	0.27 | --
Al	<0.015 | <0.015	<0.015 | <0.015	--	--
Fe	17 | 0.55	19 | 0.54	--	--
Silica [b]	32.085 | 29.946	32.085 | 29.946	--	--
Sulfide	J<2	J<2	--	--
SEC [c]	420	420	--	--
TDS	J- 280	J- 280	--	--
TOC	<1	<1	--	--
TSS	J<20	J<20	--	--
Trace Constituents (μg/L)				
Ag	<1.1 | <1.1	<1.1 | <1.1	--	--
As	U 10 | U 10	11 | U 10	--	--
Ba	J- 12 | J- 16	J- 12 | J- 10	--	--
Cd	<0.33 | <0.33	<0.33 | <0.33	--	--
Cr	37 | <0.51	42 | <0.51	--	--
Hg	<0.0029 | <0.0029	<0.0029 | <0.0029	--	--

Table B.2-10
Inactive Well Samples and Field Duplicates
(Page 2 of 3)

Analyte	ER-EC-6_m2		ER-EC-6_m3	
	12/18/2014		12/11/2014	
Li	J 85 | J 86	J 84 | J 84	--	--
Mn	240 | 52	250 | 50	--	--
Pb	J- 1.7 | <1.3	<1.3 | <1.3	--	--
Se	J 21 | J 25	J 23 | J 18	--	--
Sr	J 40 | J 39	J 39 | J 38	--	--
U	J 1.4 | J 0.38	J 1.4 | J 0.29	--	--
RNs (pCi/L)				
Gross Alpha	<2.4	<2.2	--	--
Gross Beta	U 3.9	<2.4	--	--
^{3}H	<2.35	<2.33	<2.41	<2.01
^{26}Al	<10.3	<9.3	--	--
^{14}C	J <330	J <320	--	--
^{36}Cl	<2.7	<3.1	--	--
^{60}Co	<7.9	<8.8	--	--
^{90}Sr	J <0.44	J <0.47	--	--
^{94}Nb	<6.5	<6.8	--	--
^{99}Tc	<6.8	<6.8	--	--
^{125}Sb	<15.6	<16.1	--	--
^{129}I	J <0.62	J <0.68	--	--
^{134}Cs	<9.9	<10.3	--	--
^{137}Cs	<6.6	<6.6	--	--
^{152}Eu	<39	<41	--	--
^{154}Eu	<42	<40	--	--
^{155}Eu	<16	<26	--	--
^{235}U	<45	<44	--	--
^{238}Pu	<0.031	<0.032	--	--

Table B.2-10
Inactive Well Samples and Field Duplicates
(Page 3 of 3)

Analyte	ER-EC-6_m2		ER-EC-6_m3	
	12/18/2014		12/11/2014	
$^{239/240}$Pu	<0.035	<0.026	--	--
^{241}Am	<39	<40	--	--

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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 by 2.139 mg silica/ mg silicon.
[c] Units are µS/cm.

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) 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) Two columns for each ISPID report the sample and field duplicate results.

B.3.0 Rainier Mesa

Groundwater samples were collected from two distal wells (UE-16d WW and WW-8) in Rainier Mesa by the M&O contractor (NSTec) and were analyzed by the commercial laboratory (Table B.3-1). UE-16d WW was analyzed for ^{3}H using a standard methods with a resulting detection limit of 258 pCi/L. WW-8 is also a PWS well and is therefore sampled quarterly. The sample collected on November 5, 2013, was analyzed using the ^{3}H enrichment technique, and subsequent analyses were performed using standard methods.

Table B.3-1
Rainier Mesa Distal Well Results

Analyte	UE-16d WW		WW-8				
	11/05/2013	01/14/2014	11/05/2013	01/14/2014	04/08/2014	07/22/2014	10/29/2014
Field Measurements							
Temp (°C)	22.5	22.7	22.8	24.3	25.7	28.8	25.7
pH (SU)	7.22	7.06	7.21	7.20	7.32	7.64	7.28
SEC (µS/cm)	669	674	202	479	202	199	197
Turbidity (NTU)	0.54	0.47	0.89	1.47	2.34	0.7	0.68
RNs (pCi/L)							
Gross Alpha	--	--	<1.3	<1.1	<1.34	1.77	<1.95
Gross Beta	--	--	<1.8	1.27	2.13	2.13	2.3
^{3}H	<17	<258	<17.2	<258	<213	<198	<204

-- = Not analyzed

B.4.0 Yucca Flat

Groundwater samples were collected from three characterization well (ER-7-1, WW-3, UE-1h), one distal well (Army 1 WW), and one inactive well (ER-6-2) in Yucca Flat. ER-6-2 and ER-7-1 samples were analyzed for the characterization suite by commercial laboratories (Table B.4-1); ^{3}H was analyzed by ARS International, and all other analyses were performed by ALS Laboratory Group. ER-6-2 and ER-7-1 samples were also analytes for a large suite of parameters by LLNL (Table B.4-2) The sample collected from Army 1 WW, a distal well, was analyzed for ^{3}H using the enrichment method on November 5, 2013, and using the standard analytical method on January 14, 2014 (Table B.4-3). The two wells, WW-3 and UE-1h, were sampled by the M&O contractor (NSTec), and the samples were analyzed for ^{3}H by ARS International and for major ions by ALS Laboratory Group (Table B.4-3).

Table B.4-1
ER-6-2 and ER-7-1 Commercial Laboratory Results
(Page 1 of 3)

Analyte	ER-6-2		ER-7-1	
	06/19/2014		06/20/2014	
Major and Minor Constituents (mg/L)				
Alkalinity as $CaCO_3$	J- 300	J- 300	210	200
HCO_3 [a]	J- 365.7	J- 365.7	255.99	243.8
CO_3 [a]	J <12	J <12	<12	<12
Br	J- 0.13	J- 0.12	J 0.075	J 0.087
Cl	J- 18	J- 18	12	12
F	J- 1.5	J- 1.6	0.86	0.83
SO_4	J- 56	J- 56	34	34
Ca	56	60	37	36
Mg	19	20	13	13
K	11	12	J 8.1	J 8
Na	61	63	44	43
Al	U 0.2	U 0.2	U 0.2	U 0.2
Fe	0.39	0.37	J 0.26	J 0.39
Silica [b]	29.9	32.1	38.5	38.502

Table B.4-1
ER-6-2 and ER-7-1 Commercial Laboratory Results
(Page 2 of 3)

Analyte	ER-6-2		ER-7-1	
	06/19/2014		06/20/2014	
SEC[c]	J- 700	J- 700	480	480
TDS	--	--	300	310
TSS	--	--	<20	<20
Trace Constituents (µg/L)				
As	J 14	UJ 10	UJ 10	J <3.9
Ba	110	120	210	210
Cd	<0.33	<0.33	U 5	U 5
Cr	U 10	U 10	<0.51	U 10
Pb	<1.3	J- 1.7	<1.3	<1.3
Li	J 190	J 200	58	57
Mn	J 19	J 20	16	18
Hg	--	--	<0.0029	<0.0029
Se	J <2.7	J <2.7	J <2.7	J <2.7
Ag	<1.1	<1.1	<1.1	<1.1
Sr	370	390	260	260
U	2.1	2.2	2.2	2.2
RNs (pCi/L)				
Gross Alpha	3.6	3.1	6.2	5.6
Gross Beta	10.0	10.5	8.0	8.1
^{3}H	<330	<330	<340	<340
^{3}H (Low Level)	<1.76	<2.22	<2.26	<2.17
^{14}C	<470	<470	<470	<470
^{26}Al	<10.3	<6.0	<9.1	<6.2
^{36}Cl	<2.7	<3.6	<3.1	<4.0
^{60}Co	<8.8	<6.0	<6.6	<7.4
^{90}Sr	<0.47	<0.4	<0.52	<0.59
^{94}Nb	<8.5	<6.2	<6.7	<6.9
^{99}Tc	<7.0	<7.0	<6.7	<7.1

Table B.4-1
ER-6-2 and ER-7-1 Commercial Laboratory Results
(Page 3 of 3)

Analyte	ER-6-2		ER-7-1	
	06/19/2014		06/20/2014	
^{125}Sb	<17.7	<15.5	<16.7	<18.0
^{129}I	J <0.68	J <0.78	<0.75	<0.74
^{134}Cs	<7.9	<6.2	<6.9	<7.6
^{137}Cs	<8.6	<6.4	<6.7	<7.1
^{152}Eu	<39	<31	<34	<26
^{154}Eu	<45	<35	<43	<37
^{155}Eu	<18	<25	<10	<23
^{235}U	<31	<32	<39	<36
^{238}Pu	<0.015	<0.007	<0.017	<0.026
$^{239/240}$Pu	<0.015	<0.02	<0.021	<0.023
^{241}Am	<40	<210	<7.5	<170

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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 by 2.139 mg silica/ mg silicon.
[c] Units are µS/cm.

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: Two columns for each sampling location report the sample and field duplicate results.

Table B.4-2
ER-6-2 and ER-7-1 LLNL Results

Analyte	ER-6-2_o1	ER-7-1_m1
	06/19/2014	06/20/2014
Environmental Tracers		
H-2/1 (‰)	-105.2	-105.6
O-18/16 (‰)	-13.7	-13.46
C-13/12 (‰)	-2.15	-4.14
^{14}C (pmc)	14.3	24.4
^{36}Cl/Cl (ratio)	2.34E-13	3.93E-13
Noble Gases (atoms/g)		
Ar	5.14E+15	1.43E+16
^{40}Ar	5.12E+15	1.43E+16
^{3}He	5.90E+06	5.04E+07
^{3}He/^{4}He (R/Ra) [a]	0.676	0.596
^{4}He	6.32E+12	6.13E+13
Kr	1.11E+12	2.67E+12
Ne	4.74E+12	1.47E+13
^{20}Ne	4.29E+12	1.33E+13
Xe	1.68E+11	3.47E+11
^{130}Xe	6.9E+09	1.42E+10
RNs (pCi/L)		
^{3}H	<1.1	<1.1
^{14}C	0.0696	0.0789
^{36}Cl	0.000131	0.000146

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

-- = Not analyzed

Table B.4-3
Army 1 WW, UE-1h, and WW-3 Results

Analyte	Army 1 WW 11/05/2013, 01/14/2014		UE-1h 06/03/2014	WW-3 06/03/2014
Major Constituents (mg/L)				
Alkalinity as $CaCO_3$	--	--	270	150
CO_3 [a]	--	--	<12	<12
HCO_3 [a]	--	--	329.13	182.85
Br	--	--	J 0.085	J 0.16
Cl	--	--	J 18	16
F	--	--	0.62	0.79
SO_4	--	--	34	28
Ca	--	--	45	24
Mg	--	--	22	15
K	--	--	J 9.4	J 8.1
Na	--	--	48	42
RNs (pCi/L)				
^3H	<17.1	<257	<2.04	7.28

J = Result is estimated.
-- = Not analyzed

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 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.5.0 References

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office.

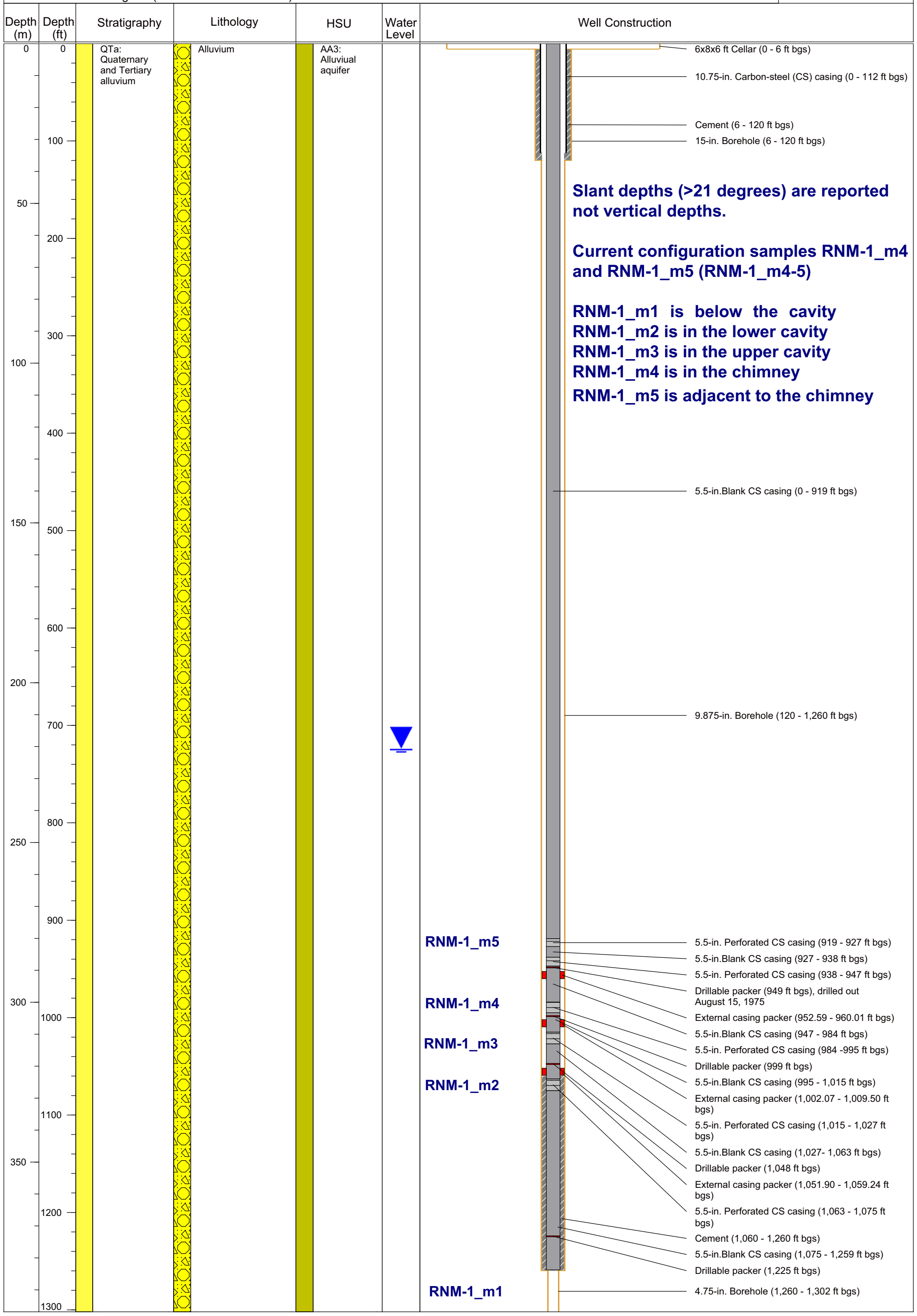
U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014. *Nevada National Security Site Integrated Groundwater Sampling Plan, Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1525. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2015. *Underground Test Area Fiscal Year 2014 Annual Quality Assurance Report, Nevada National Security Site, Nevada,* Rev. 0, DOE/NV--1531. Las Vegas, NV.

Appendix C

Well Completion Diagrams

Well ID: RNM-1		UTM NAD 27	Northing: 4,075,699.19 m	Easting: 592,142.37 m
Start Date: 05/01/1974	Stop Date: 05/10/1974	NSPC NAD 83	Northing: 6,230,376.29 m	Easting: 562,354.14 m
Drilling Program: Radionuclide Migration		Lat/Long NAD 83	Deg N: 36.824455	Deg W: 115.967689
Environmental Contractor: Fenix & Scission, Inc.		Surface Elevation	3,135.17 ft amsl	955.60 m amsl
Drilling Contractor: REECo		Drill Method:	Reverse Circulation	Drilled Depth: 1,302 ft bgs
Well Construction Diagram (Current as of 03/24/2014)				



Slant depths (>21 degrees) are reported not vertical depths.

Current configuration samples RNM-1_m4 and RNM-1_m5 (RNM-1_m4-5)

RNM-1_m1 is below the cavity
RNM-1_m2 is in the lower cavity
RNM-1_m3 is in the upper cavity
RNM-1_m4 is in the chimney
RNM-1_m5 is adjacent to the chimney

Figure C-1
Well Completion Diagram for RNM-1

Well ID: RNM-2S	UTM NAD 27	Northing: 4,075,483.95 m	Easting: 592,136.58 m
Start Date: 03/22/1974 Stop Date: 04/01/1974	NSPC NAD 83	Northing: 6,230,161.02 m	Easting: 562,347.59 m
Drilling Program: Hydrologic Test Hole	Lat/Long NAD 83	Deg N: 36.822515	Deg W: 115.967780
Environmental Contractor: Fenix & Scission, Inc.	Surface Elevation	3,130.45 ft amsl	954.2 m amsl
Drilling Contractor: REECo	Drill Method:	Reverse Circulation	Drilled Depth: 1,156 ft bgs
Well Construction Diagram (Current as of 05/21/2013)			

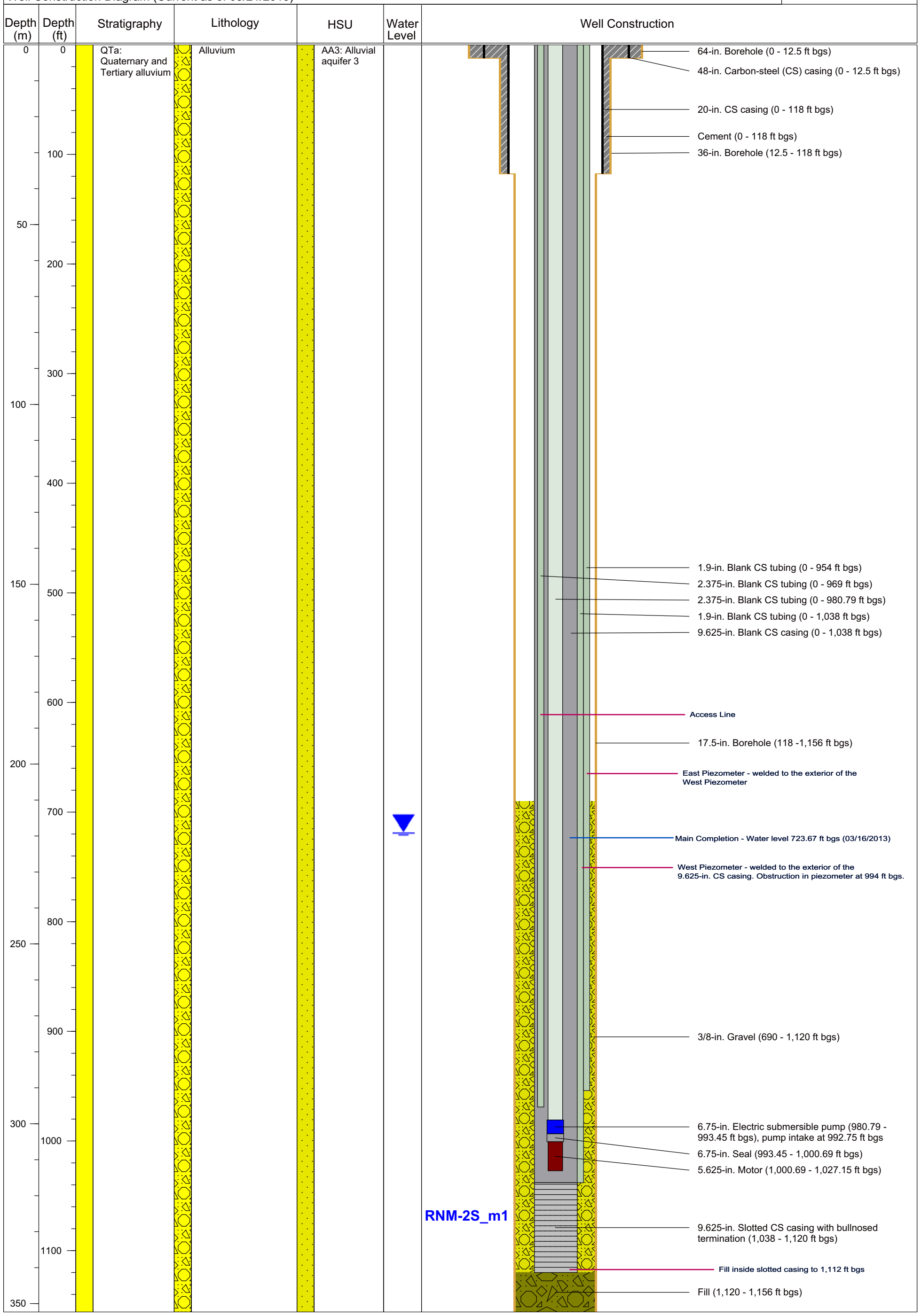


Figure C-2
Well Completion Diagram for RNM-2S

Well ID: UE-5n		UTM NAD 27	Northing: 4,075,284.87 m	Easting: 592,626.39 m
Start Date: 02/09/1976	Stop Date: 03/01/1976	NSPC NAD 83	Northing: 6,229,960.18 m	Easting: 562,836.83 m
Drilling Program: Exploratory Borehole		Lat/Long NAD 83	Deg N: 36.820673	Deg W: 115.96231
Environmental Contractor: Fenix & Scission, Inc.		Surface Elevation	3,113.36 ft amsl	948.95 m amsl
Drilling Contractor: REECo		Drill Method:	Reverse Circulation	Drilled Depth: 1,687 ft bgs
Well Construction Diagram (Current as of 07/08/2014)				

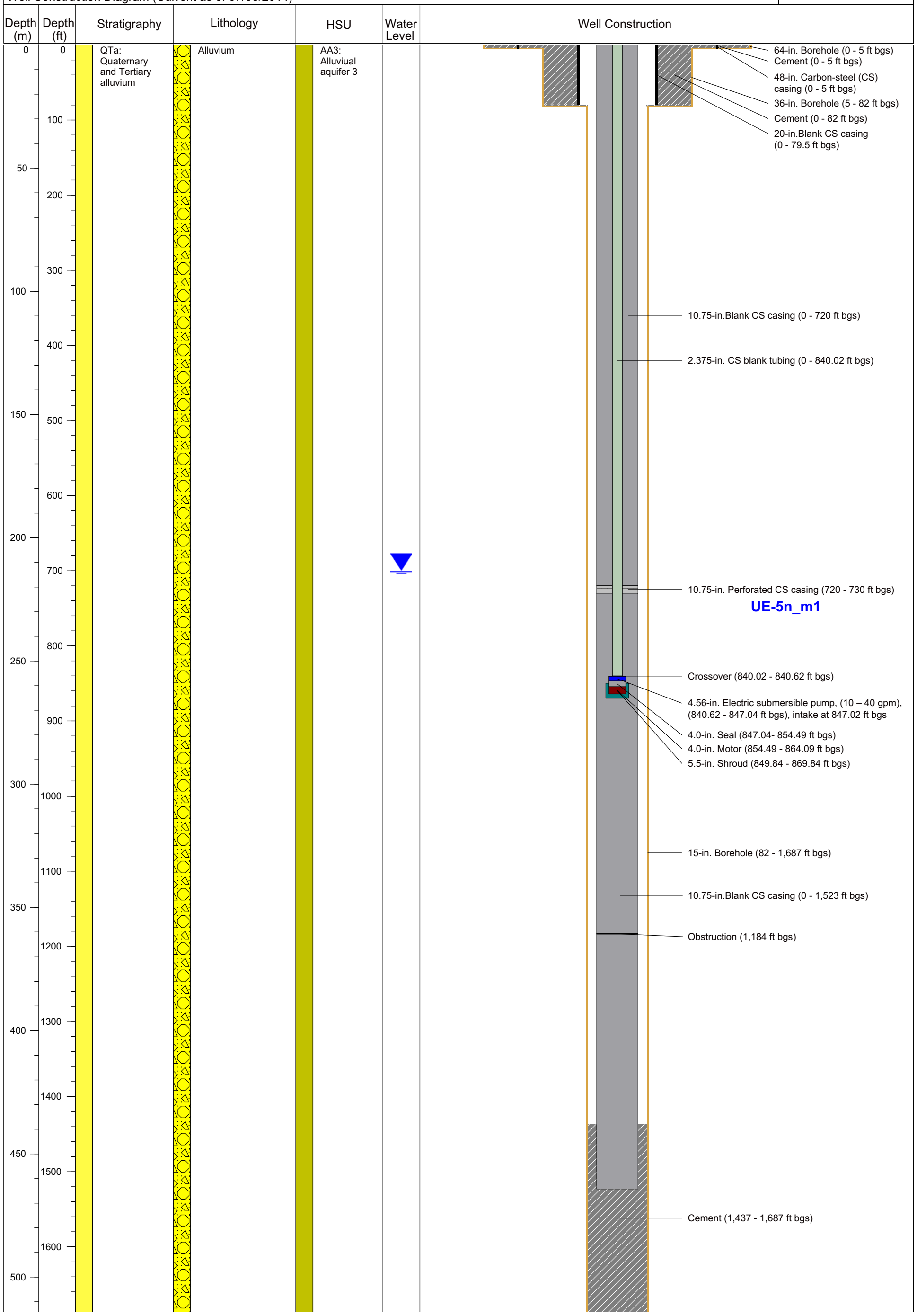


Figure C-3
Well Completion Diagram for UE-5n

Well ID: WW-5a		UTM NAD 27	Northing: 4,070,378.46 m	Easting: 592,980.20 m
Start Date: Unknown	Stop Date: 03/23/1951	NSPC NAD 83	Northing: 6,225,051.29 m	Easting: 563,173.60 m
Drilling Program: Water Well		Lat/Long NAD 83	Deg N: 36.776415	Deg W: 115.958945
Environmental Contractor: AEC		Surface Elevation	3,092.61 ft amsl	942.63 m amsl
Drilling Contractor: S.R. Mckinney Inc.		Drill Method:	Cable Tool	Drilled Depth: 910 ft bgs
Well Construction Diagram (Current as of 06/25/2014)				

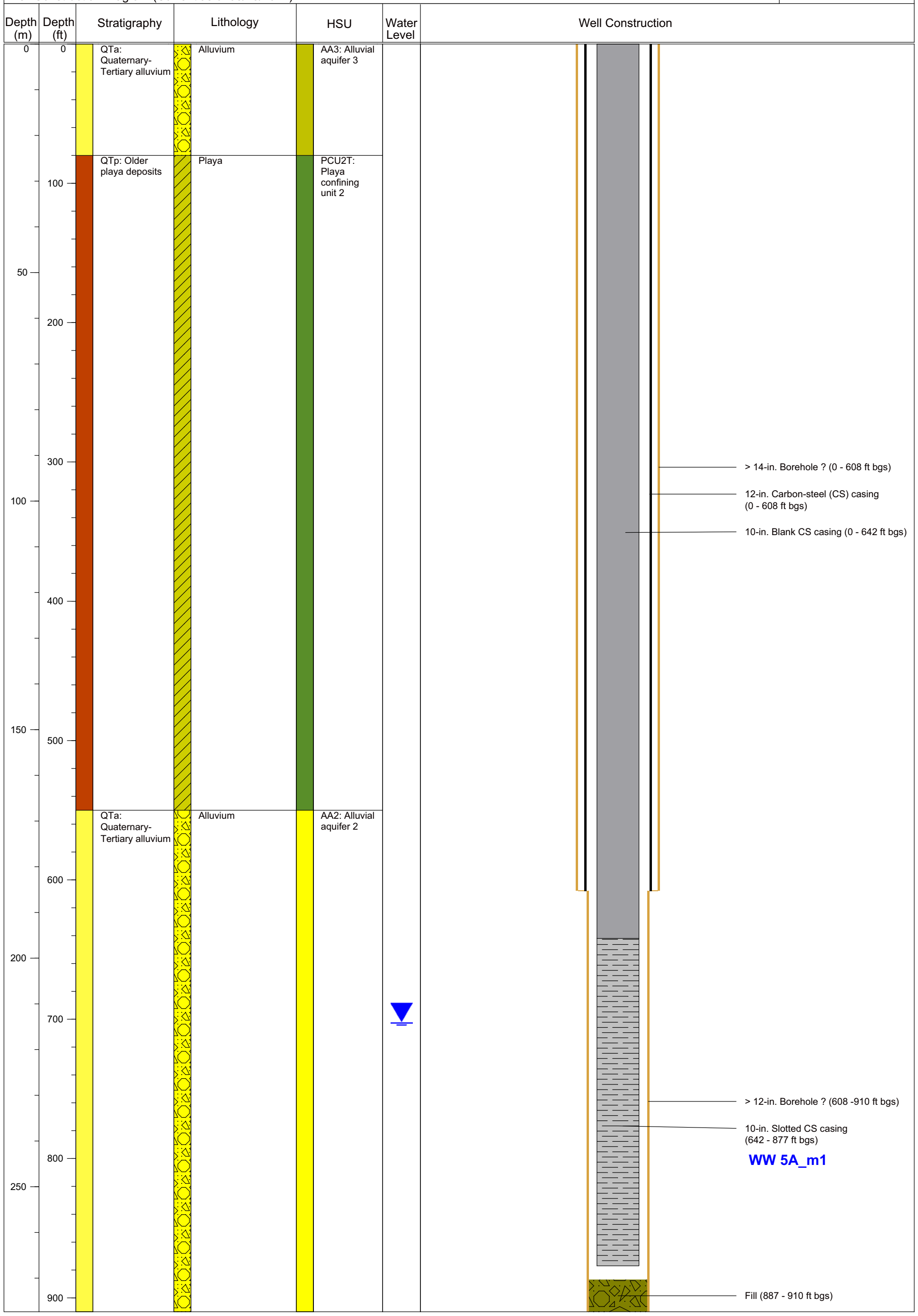


Figure C-4
Well Completion Diagram for WW-5a

Well ID: ER-20-7	UTM NAD 27	Northing: 4,118,429.7 m	Easting: 546,218.4 m
Start Date: 06/06/2009 Stop Date: 07/07/2009	NSPC NAD 83	Northing: 6,273,279.1 m	Easting: 516,567.3 m
Drilling Program: Pahute Mesa Phase II	Lat/Long NAD 83	Deg N: 37.212989	Deg W: 116.480002
Environmental Contractor: UGTA/N-I	Surface Elevation	6,208.9 ft amsl	1,892.5 m amsl
Drilling Contractor: United Drilling Inc.	Drill Method:	Rotary Air Foam	Drilled Depth: 2,936.24 ft bgs
Well Construction Diagram (Current as of 11/27/2013)			

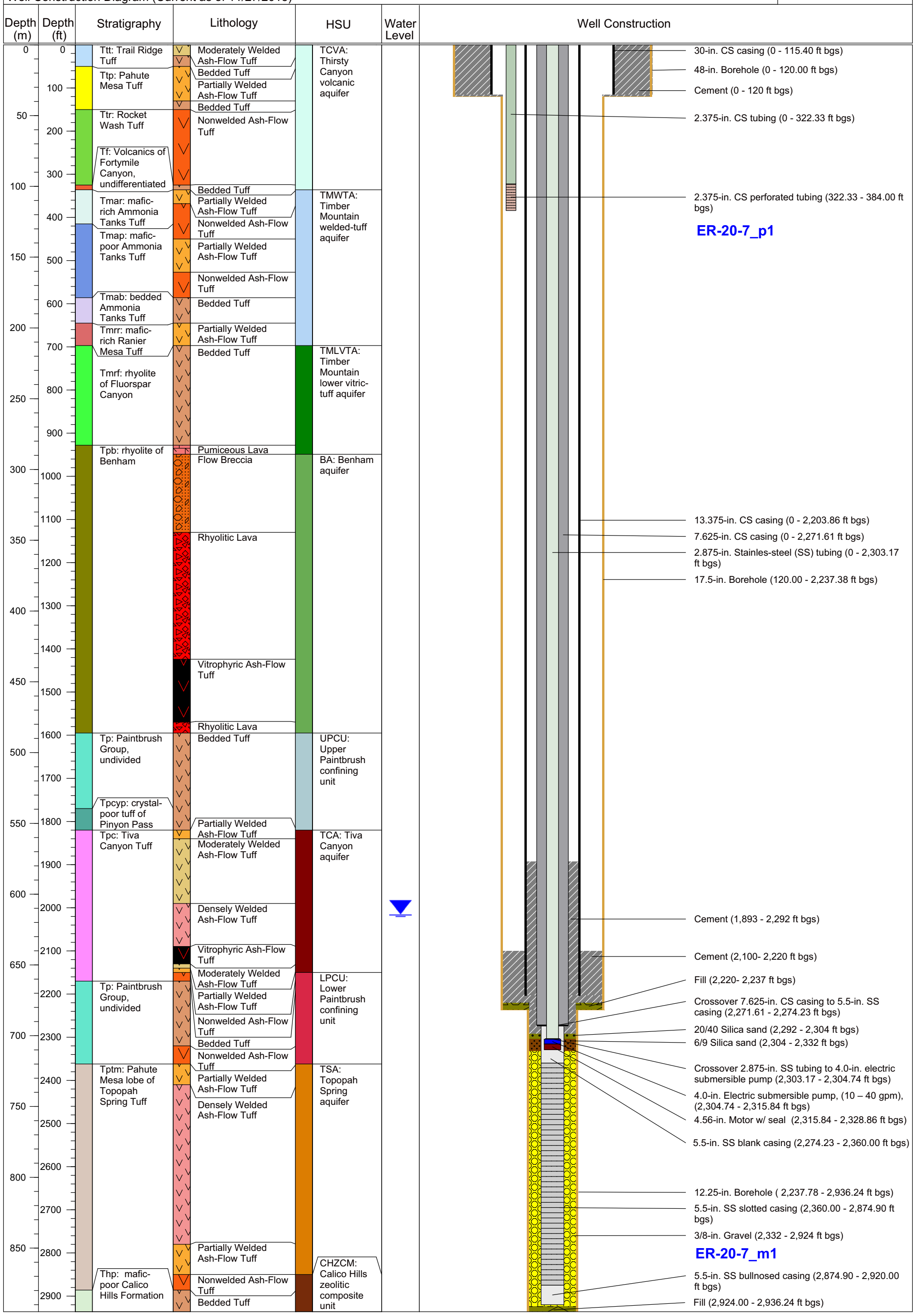


Figure C-5
Well Completion Diagram for ER-20-7

Well ID: ER-20-8		UTM NAD 27	Northing: 4,116,218.33 m	Easting: 546,686.35 m
Start Date: 07/12/2009	Stop Date: 08/15/2009	NSPC NAD 83	Northing: 6,271,065.35 m	Easting: 517,027.54 m
Drilling Program: Pahute Mesa Phase II		Lat/Long NAD 83	Deg N: 37.193032	Deg W: 116.474866
Environmental Contractor: UGTA/SNJV		Surface Elevation	5,848.3 ft amsl	1,782.56 m amsl
Drilling Contractor: United Drilling Inc.	Drill Method: Rotary Air Foam	Drilled Depth: 3,442.25 ft bgs		
Well Construction Diagram (Current as of 11/19/2014)				

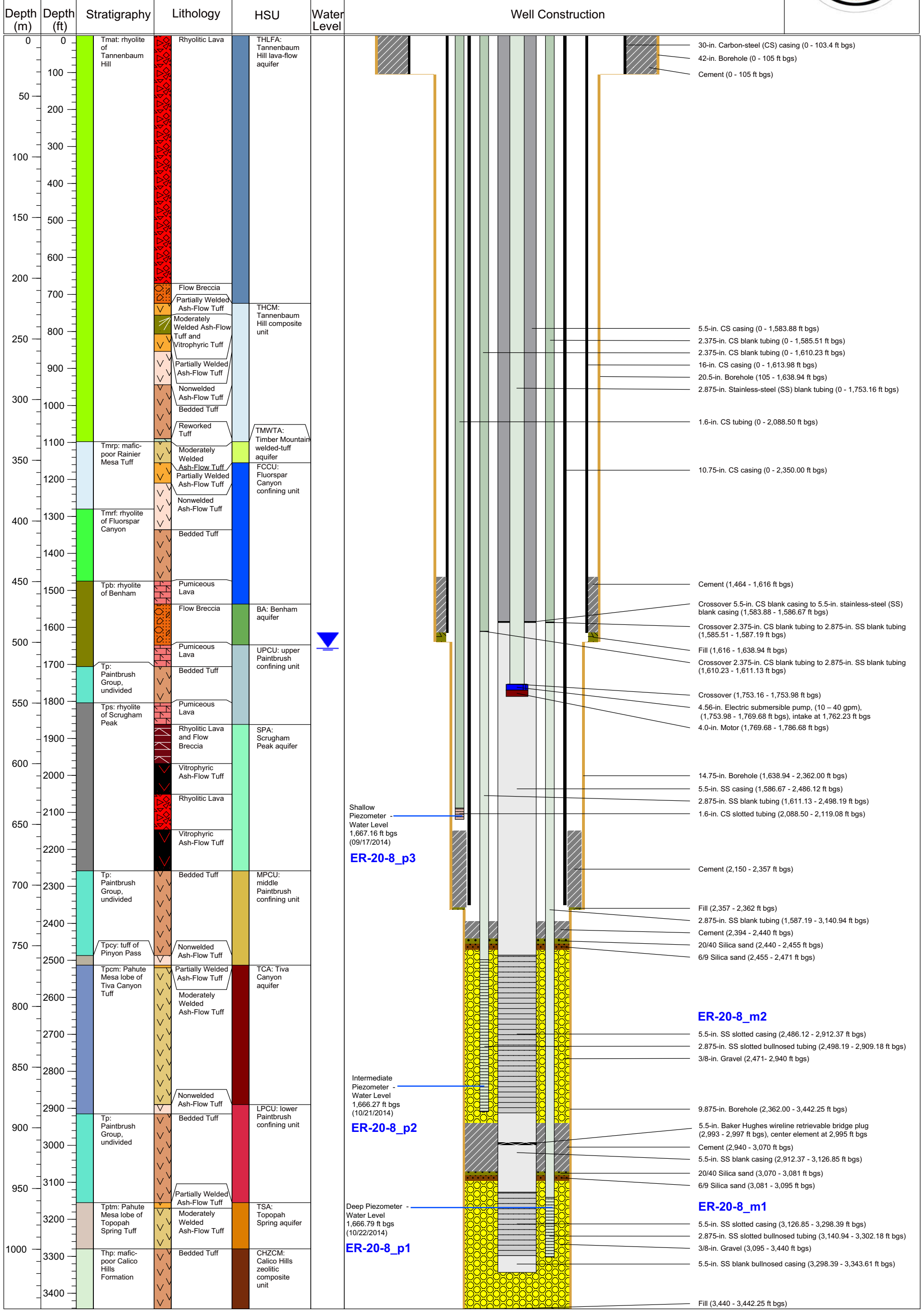


Figure C-6
Well Completion Diagram for ER-20-8

Well ID: ER-20-8-2	UTM NAD 27	Northing: 4,116,211.30 m	Easting: 546,672.68 m
Start Date: 08/17/2009 Stop Date: 08/30/2009	NSPC NAD 83	Northing: 6,271,058.37 m	Easting: 517,013.84 m
Drilling Program: Pahute Mesa Phase II	Lat/Long NAD 83	Deg N: 37.192969	Deg W: 116.475021
Environmental Contractor: UGTA/SNJV	Surface Elevation	5,848.8 ft amsl	1,782.71 m amsl
Drilling Contractor: United Drilling Inc.	Drill Method: Air Rotary Foam	Drilled Depth: 2,338.62 ft bgs	
Well Construction Diagram (Current as of 06/04/2012)			

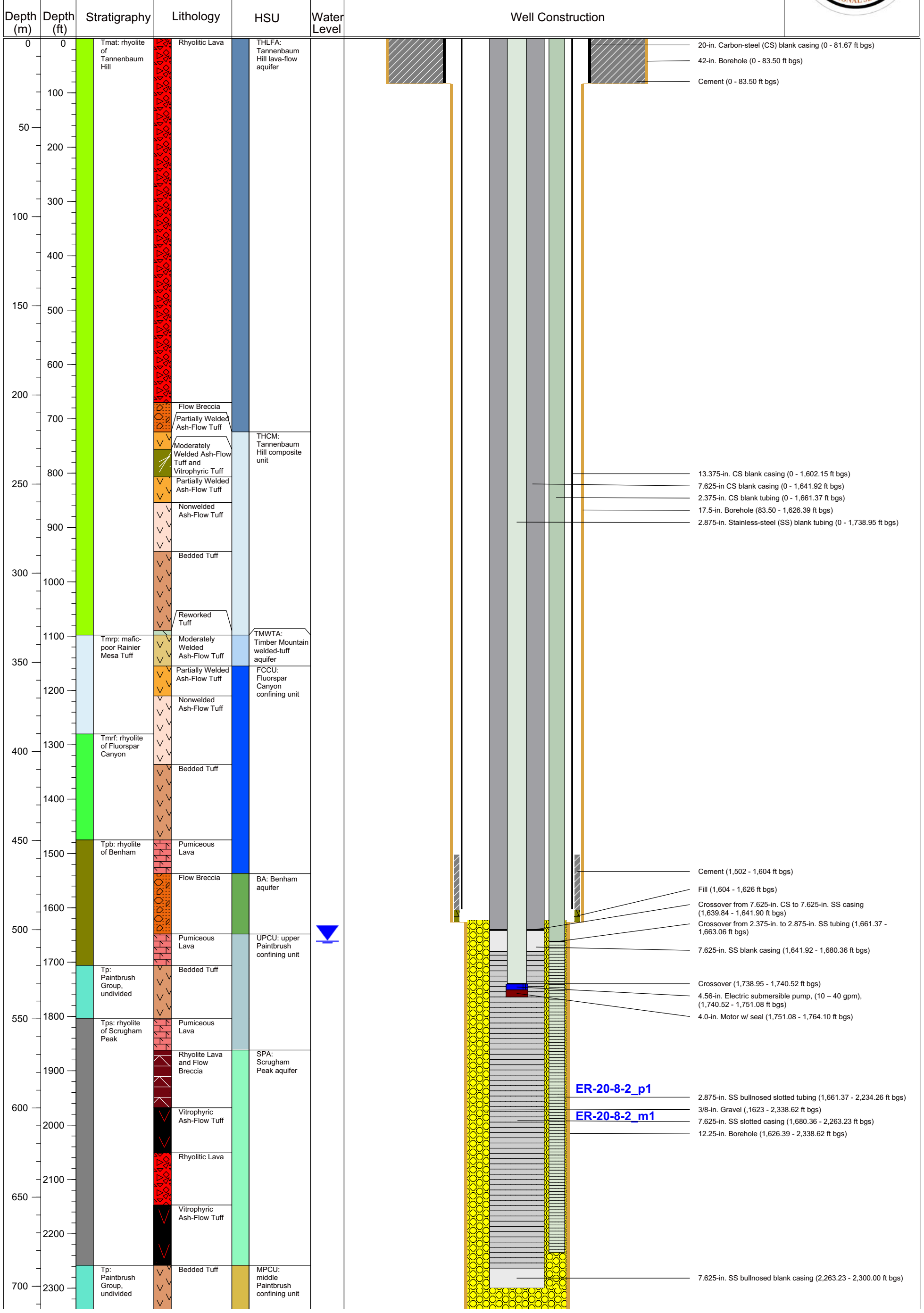


Figure C-7
Well Completion Diagram for ER-20-8-2

Well ID: ER-EC-11		UTM NAD 27	Northing: 4,116,703.12 m	Easting: 544,838.93 m
Start Date: 9/12/09	Stop Date: 10/21/09	NSPC NAD 83	Northing: 890,930.38 ft	Easting: 550,068.29 ft
Drilling Program: Pahute Mesa Phase II		Lat/Long NAD 83	Deg N: 37.197492	Deg W: 116.495653
Environmental Contractor: UGTA/NNES		Surface Elevation	5,656.26 ft amsl	1,724.03 m amsl
Drilling Contractor: United Drilling Inc.		Drill Method:	Rotary Air Foam	Drilled Depth: 4,148.80 ft bgs

Well Construction Diagram (Current as of 11/27/2013)

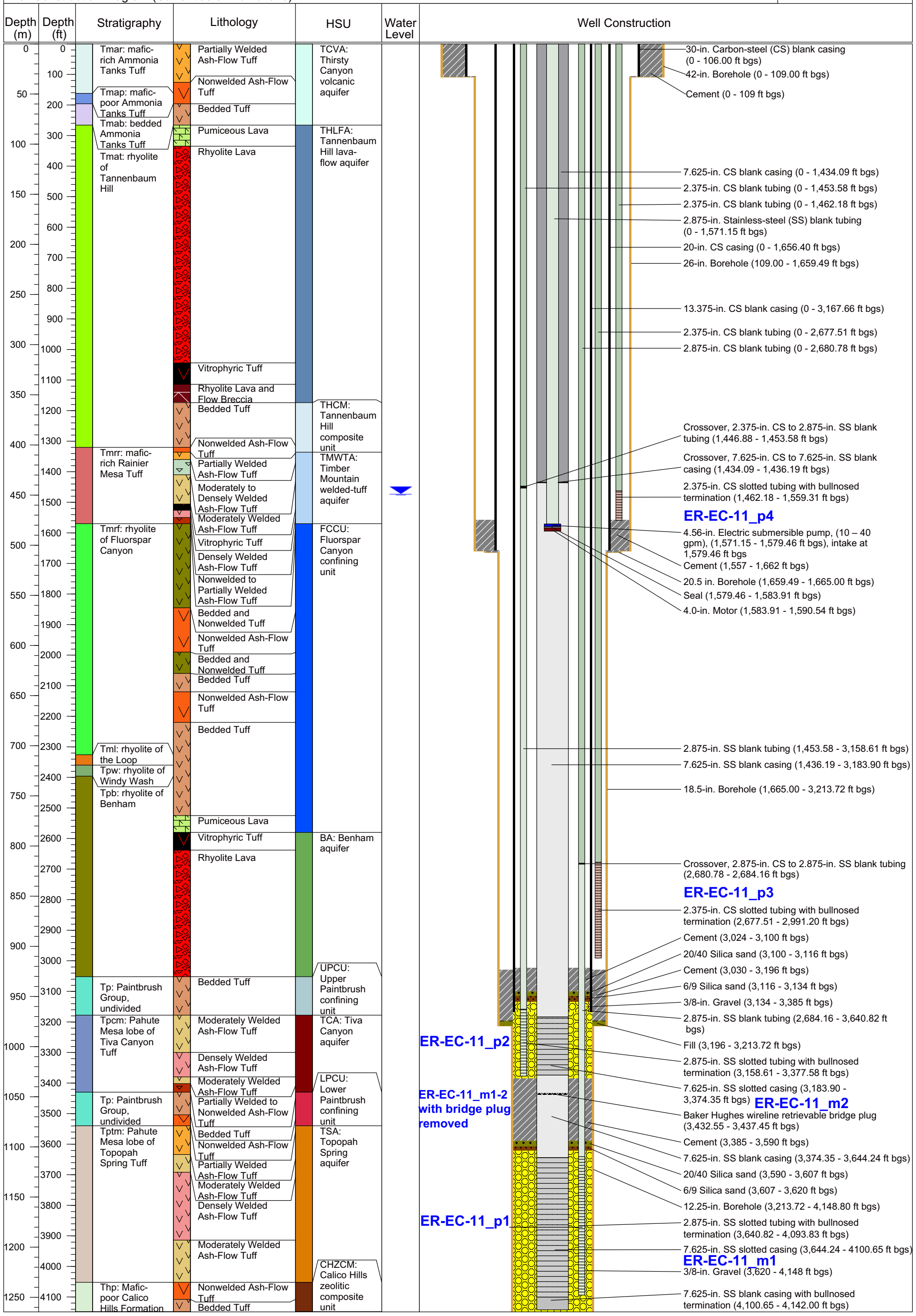


Figure C-8
Well Completion Diagram for ER-EC-11

Well ID: ER-EC-14	UTM NAD 27	Northing: 4,110,337.86 m	Easting: 543,466.54 m
Start Date: 09/27/2012 Stop Date: 10/17/2012	NSPC NAD 83	Northing: 6,265,194.50 m	Easting: 513,786.14 m
Drilling Program: Pahute Mesa Phase II	Lat/Long NAD 83	Deg N: 37.140180	Deg W: 116.511485
Environmental Contractor: UGTA/N-I	Surface Elevation	5,185.9 ft amsl	1,580.7 m amsl
Drilling Contractor: UDI	Drill Method:	Rotary Air Foam	Drilled Depth: 2,378.2 ft bgs

Well Construction Diagram (Current as of 12/10/2013)

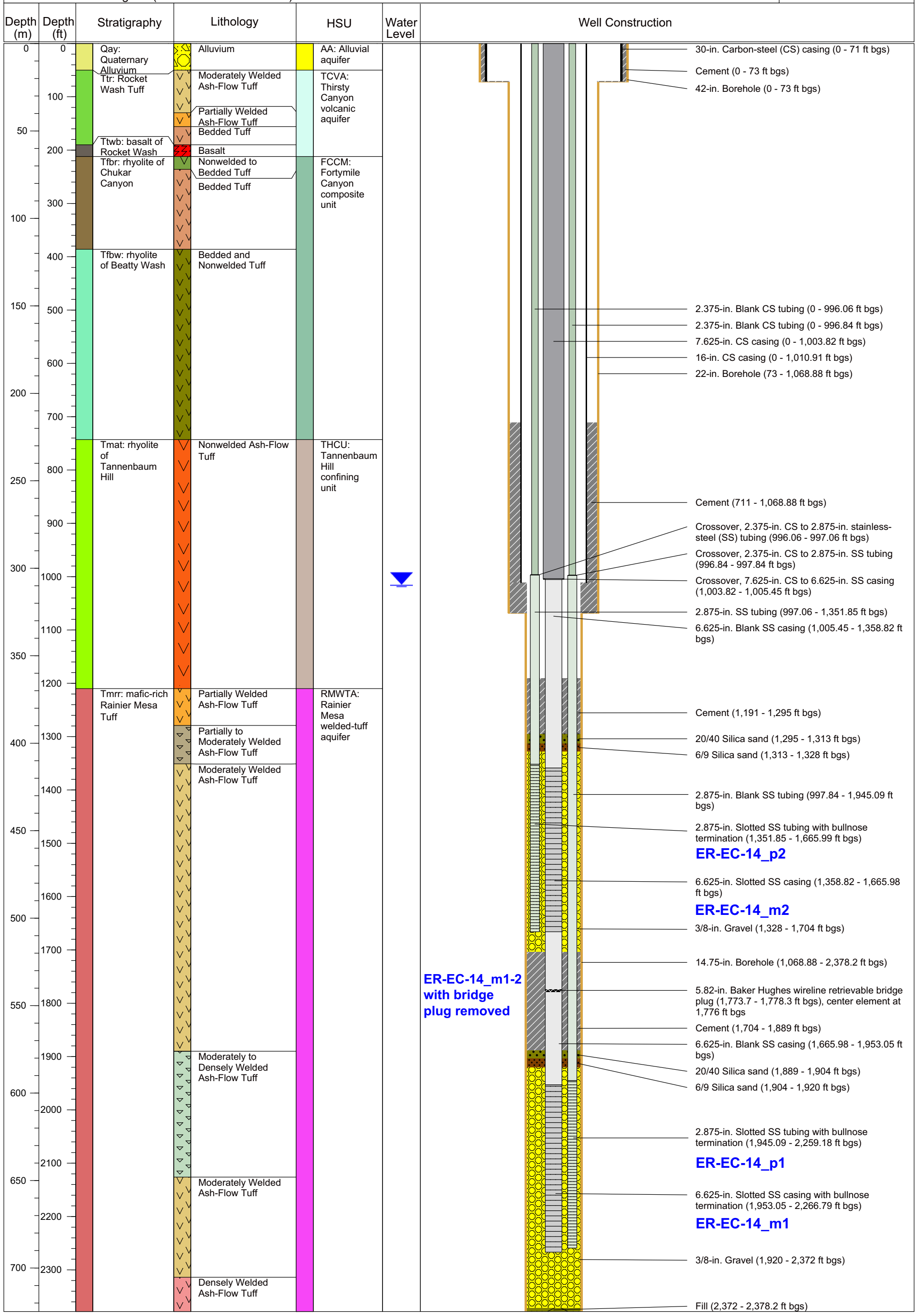


Figure C-9
Well Completion Diagram for ER-EC-14

Well ID: ER-EC-15	UTM NAD 27	Northing: 4,115,426.88 m	Easting: 542,769.42 m
Start Date: 11/05/2010 Stop Date: 12/01/2010	NSPC NAD 83	Northing: 6,270,287.39 m	Easting: 513,106.69 m
Drilling Program: Pahute Mesa Phase II	Lat/Long NAD 83	Deg N: 37.187865	Deg W: 116.519045
Environmental Contractor: UGTA/N-I	Surface Elevation	5,365.00 ft amsl	1,635.25 m amsl
Drilling Contractor: UDI	Drill Method:	Rotary Air Foam	Drilled Depth: 3,254.54 ft bgs

Well Construction Diagram (Current as of 03/04/2014)

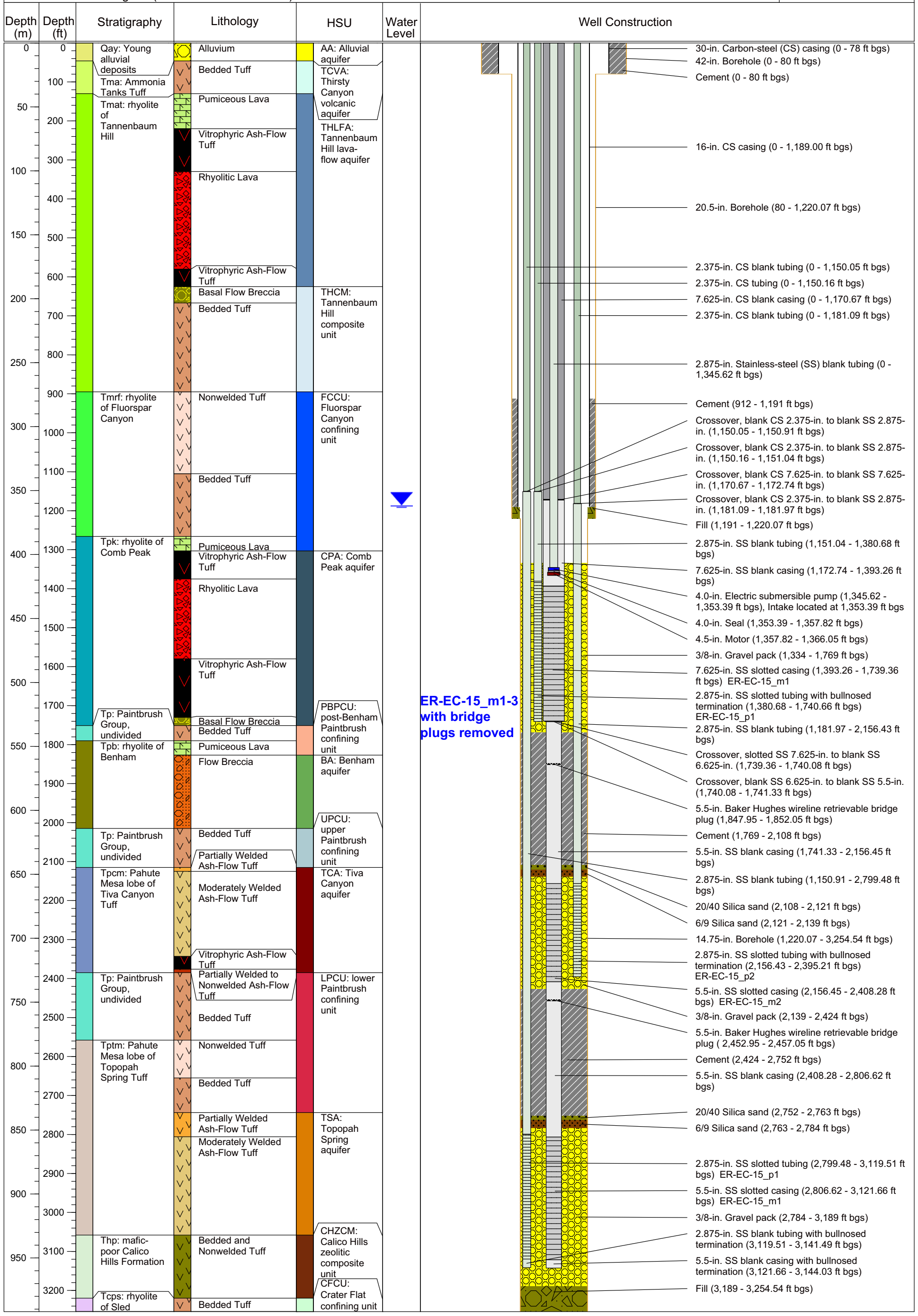


Figure C-10
Well Completion Diagram for ER-EC-15

Well ID: Pahute Mesa 3 (PM-3)		UTM NAD 27	Northing: 4,121,281.28 m	Easting: 539,011.77 m
Start Date: 09/01/1988	Stop Date: 11/03/1988	NSPC NAD 83	Northing: 6,276,156.56 m	Easting: 509,368.57 m
Drilling Program: HRMP		Lat/Long NAD 83	Deg N: 37.239019	Deg W: 116.561074
Environmental Contractor: UGTA		Surface Elevation	5,823.00 ft amsl	1,774.85 m amsl
Drilling Contractor: REECo		Drill Method:	Air Foam	Drilled Depth: 3,019 ft bgs
Well Construction Diagram (Current as of 09/25/2014)				

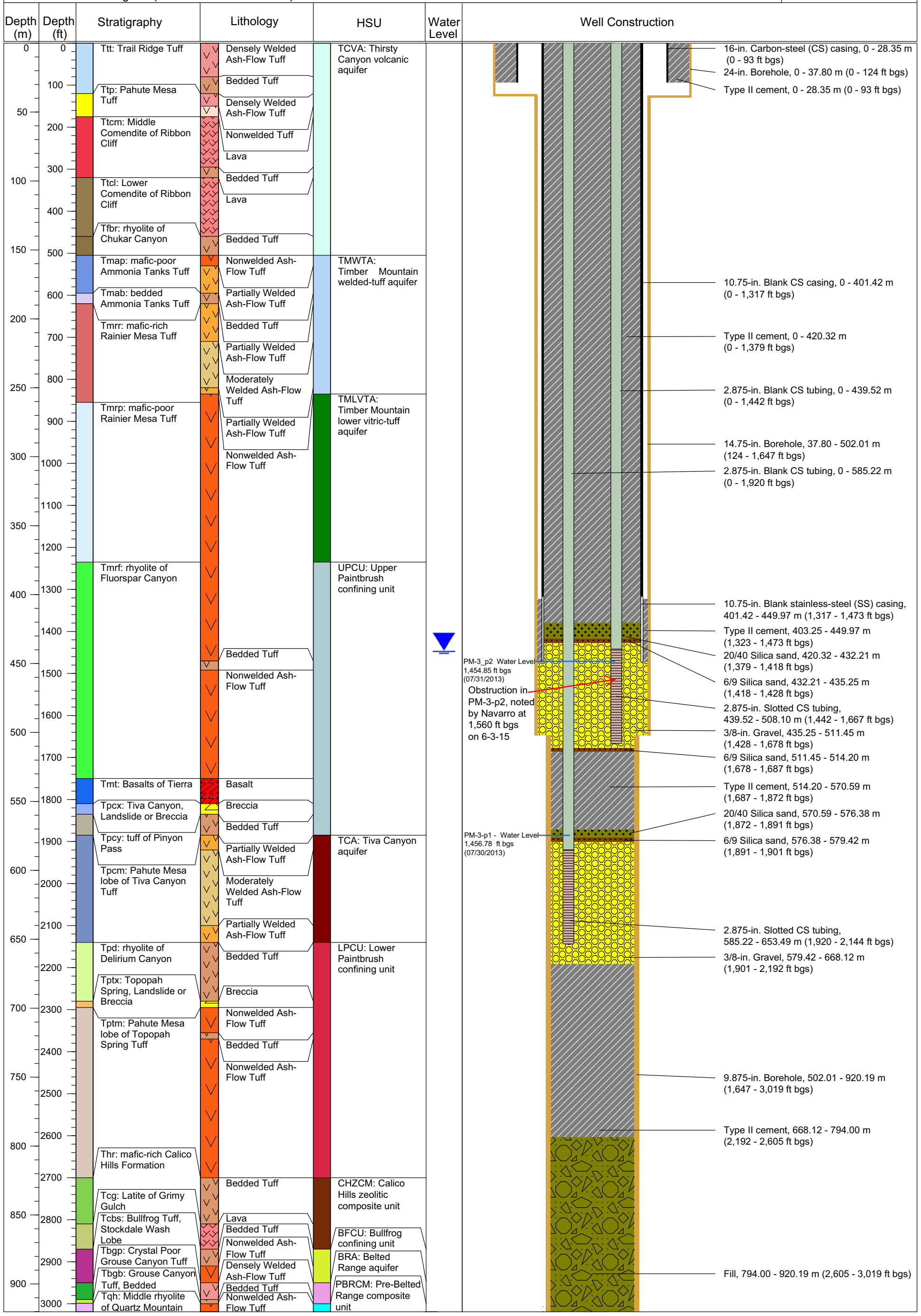
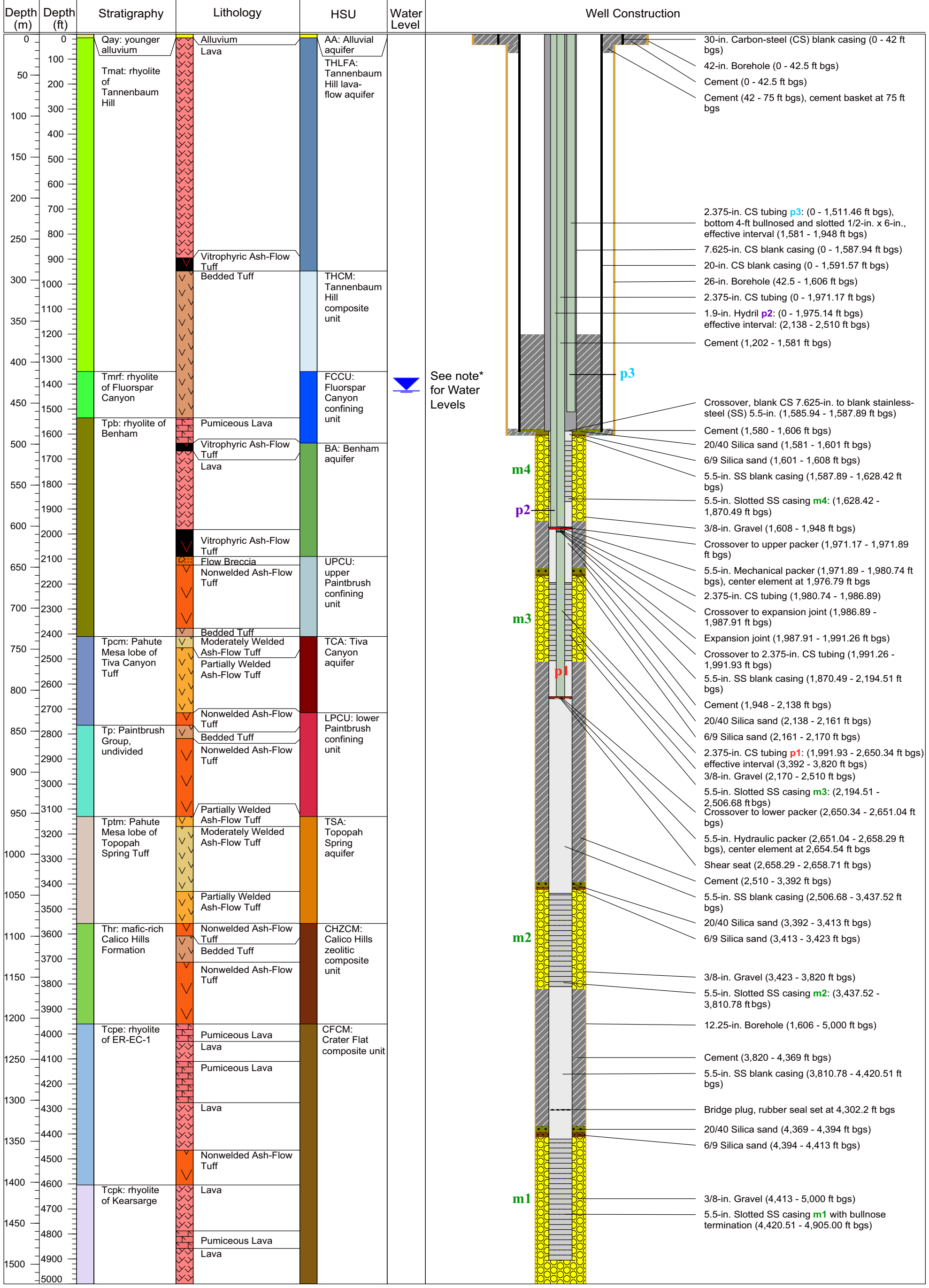


Figure C-11
Well Completion Diagram for PM-3

Well ID: ER-EC-6	UTM NAD 27	Northing: 4,115,728.7 m	Easting: 544,673.6 m
Start Date: 05/11/2009 Stop Date: 05/13/2009	NSPC NAD 83	Northing: 6,270,582.6 m	Easting: 515,012.4 m
Drilling Program: WPM-OV	Lat/Long NAD 83	Deg N: 37.188716	Deg W: 116.497574
Environmental Contractor: UGTA/IT	Surface Elevation	5,604.38 ft amsl	1,708.2 m amsl
Drilling Contractor: UDI	Drill Method:	Rotary Air Foam	Drilled Depth: 5,000 ft
Well Construction Diagram (Current as of 11/01/2016)			



Note: On 01/22/2015, the Water Level in p1 was 1,427.09 ft bgs, and p2 was 1,425.73 ft bgs; and on 01/15/2015, p3 was 1,425.71 ft bgs.

Figure C-12
Well Completion Diagram for ER-EC-6

Well ID: ER-7-1	UTM NAD 27	Northing: 4,103,274.60 m	Easting: 589,314.94 m
Start Date: 01/27/2003 Stop Date: 02/07/2003	NSPC NAD 83	Northing: 6,257,968.72 m	Easting: 559,622.52 m
Drilling Program: Yucca Flat	Lat/Long NAD 83	Deg N: 37.073271	Deg W: 115.996132
Environmental Contractor: UGTA/SHAW	Surface Elevation	4,246.7 ft amsl	1,294.4 m amsl
Drilling Contractor: United Drilling Inc.	Drill Method:	Rotary Air Foam	Drilled Depth: 2,500 ft bgs

Well Construction Diagram (Current as of 05/19/2014)

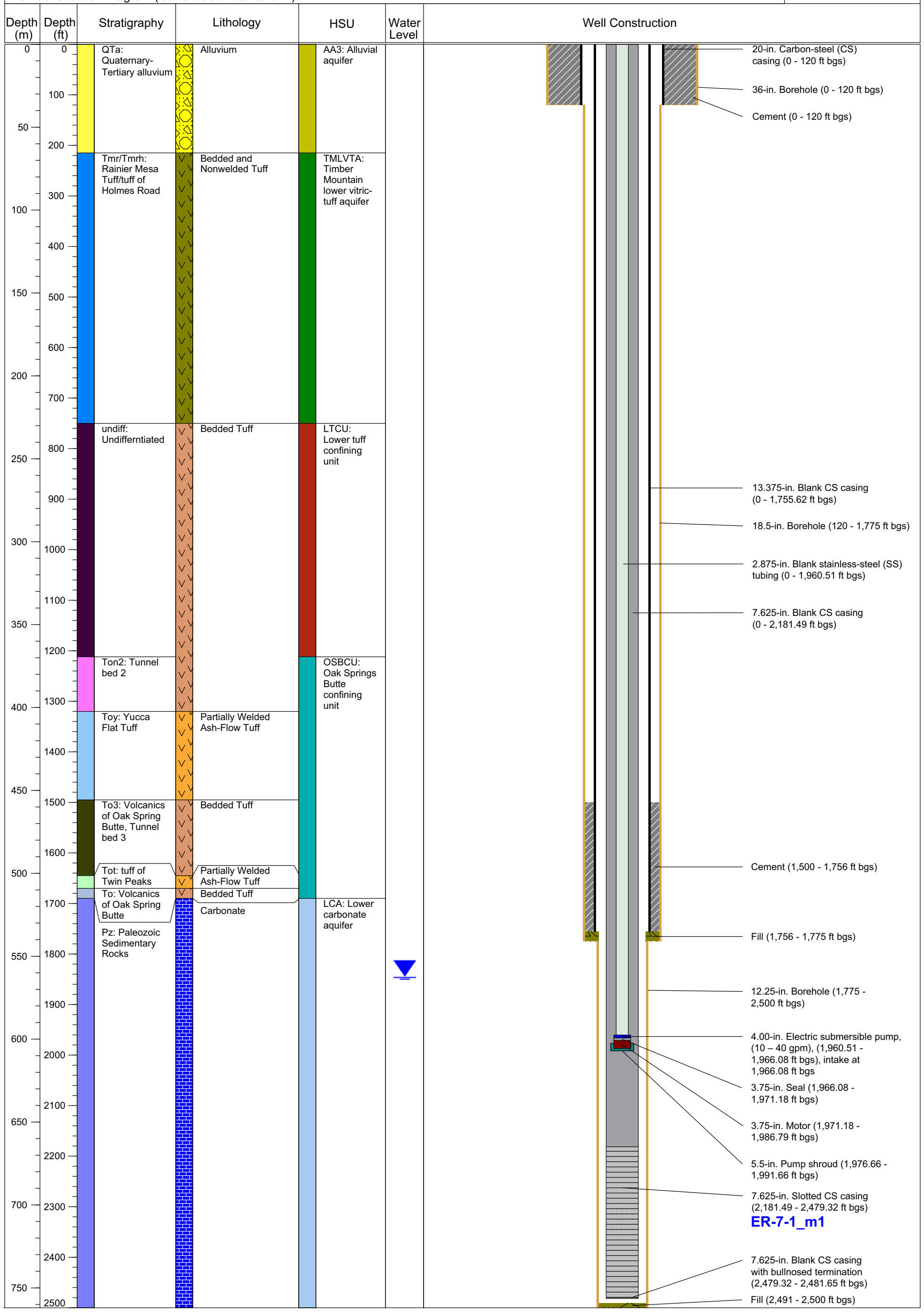


Figure C-13
Well Completion Diagram for ER-7-1

Well ID: UE-1h		UTM NAD 27	Northing: 4,095,222.94 m	Easting: 582,983.75 m
Start Date: 04/02/1968	Stop Date: 07/16/1968	NSPC NAD 83	Northing: 6,249,937.10 m	Easting: 553,261.44 m
Drilling Program: Underground Exploratory		Lat/Long NAD 83	Deg N: 37.001280	Deg W: 116.068235
Environmental Contractor: Fenix & Scission, Inc.		Surface Elevation	3,995 ft amsl	1,217.68 m amsl
Drilling Contractor: REECo		Drill Method:	Air and Foam	Drilled Depth: 3,358 ft bgs
Well Construction Diagram (Current as of 05/28/2014)				

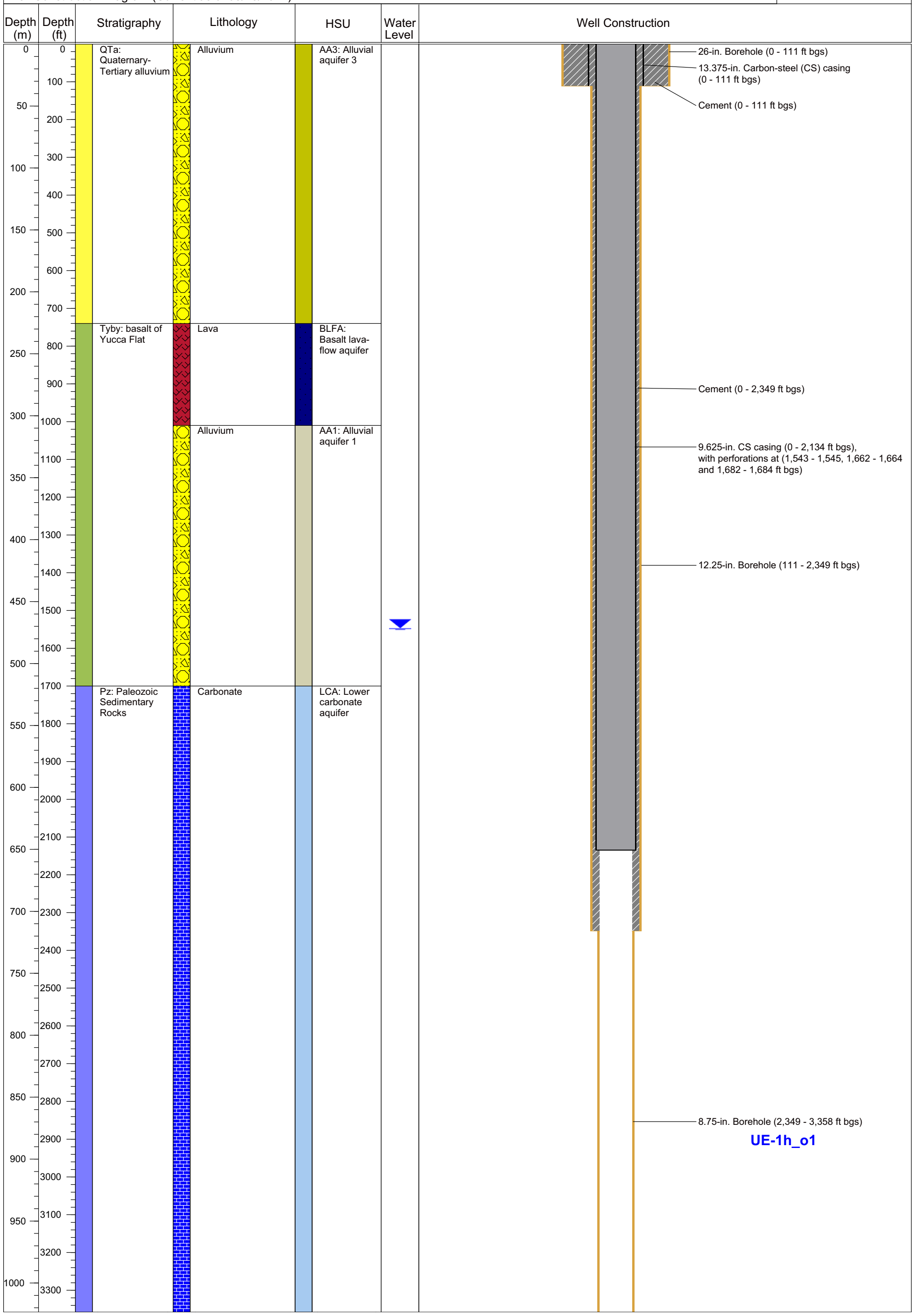


Figure C-14
Well Completion Diagram for UE-1h

Well ID: WW-3		UTM NAD 27	Northing: 4,094,553.97 m	Easting: 583,827.75 m
Start Date: 11/15/1950	Stop Date: 03/05/1952	NSPC NAD 83	Northing: 6,249,265.01 m	Easting: 554,103.32 m
Drilling Program: Water Test		Lat/Long NAD 83	Deg N: 36.995175	Deg W: 116.058825
Environmental Contractor: AEC		Surface Elevation	3,969 ft amsl	1,209.75 m amsl
Drilling Contractor: McKinney and Son		Drill Method:	Cable Tool	Drilled Depth: 1,800 ft bgs
Well Construction Diagram (Current as of 05/28/2014)				

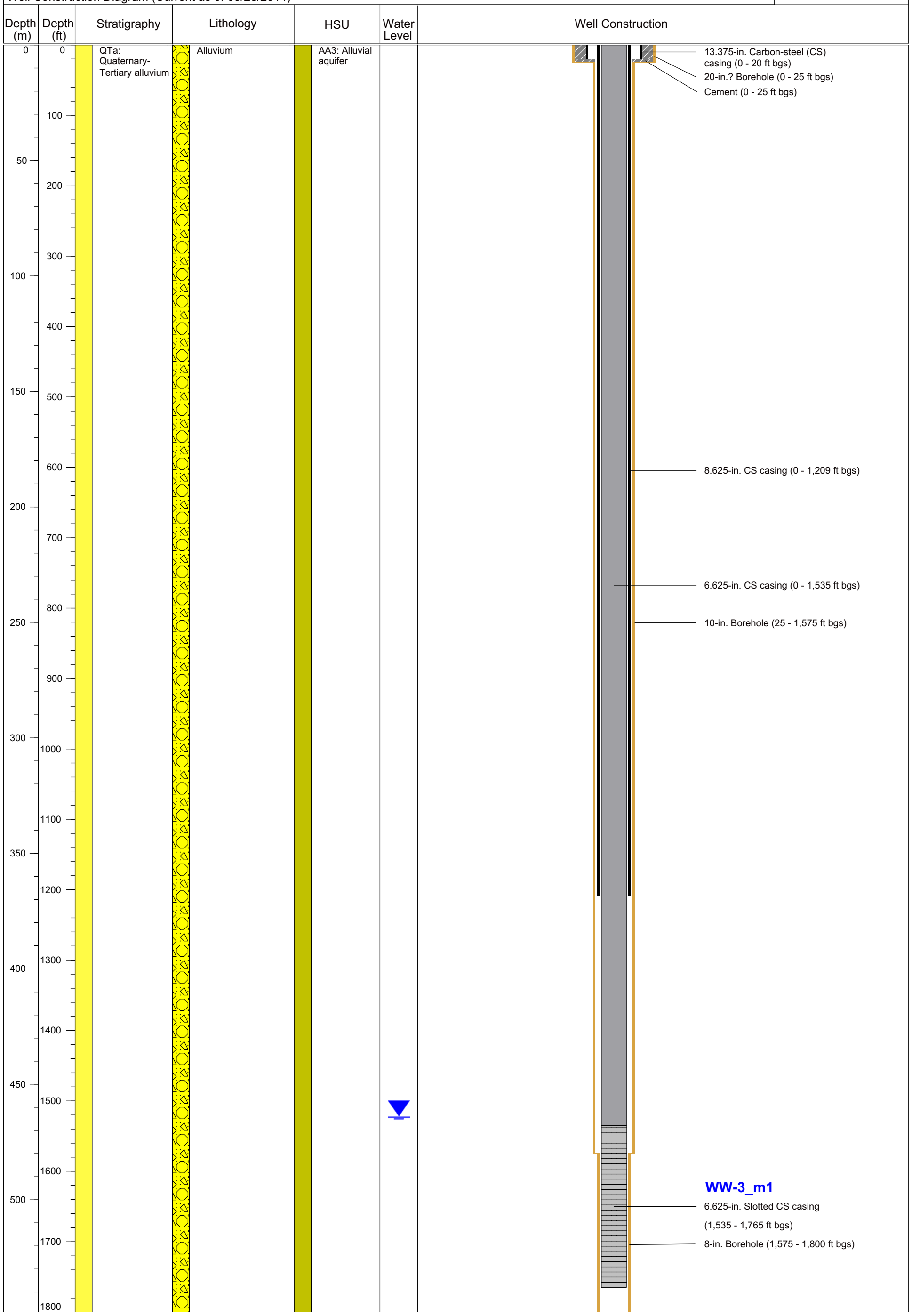


Figure C-15
Well Completion Diagram for WW-3

Well ID: ER-6-2		UTM NAD 27	Northing: 4,090,745.00 m	Easting: 582,235.73 m
Start Date: 11/20/1992	Stop Date: 7/21/1994	NSPC NAD 83	Northing: 6,245,460.61 m	Easting: 552,497.53
Drilling Program: Yucca Flat		Lat/Long NAD 83	Deg N: 36.960984	Deg W: 116.077129
Environmental Contractor: UGTA/IT		Surface Elevation	4,231.3 ft amsl	1,289.69 m amsl
Drilling Contractor: REECo		Drill Method:	Air Foam	Drilled Depth: 3,430 ft bgs
Well Construction Diagram (Current as of 04/17/2014)				

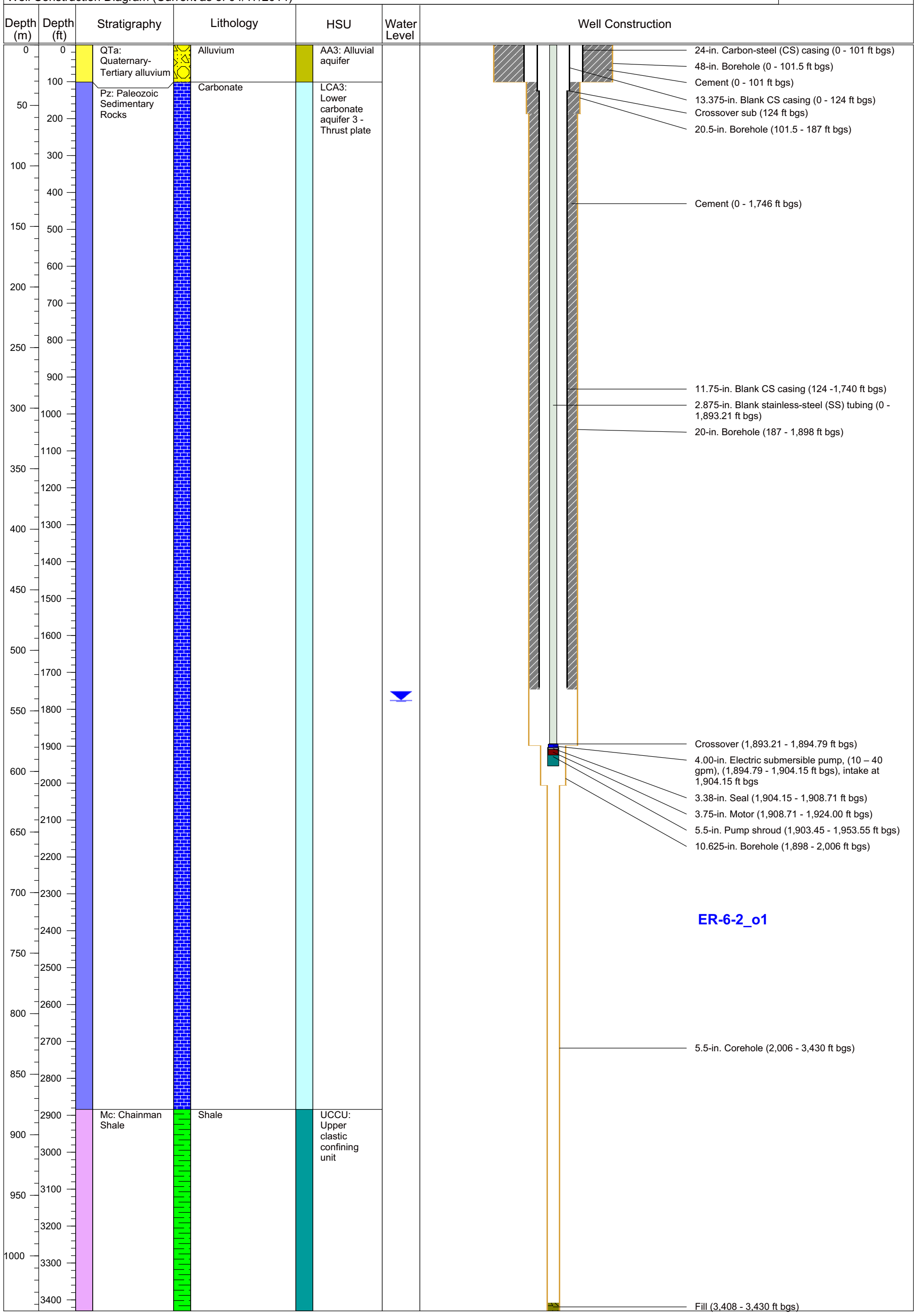


Figure C-16
Well Completion Diagram for ER-6-2

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