FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

Corrective Action Unit (CAU) Number: 97, 99, 101, and 102
CAU Description: Yucca Flat/Climax Mine (97), Rainier Mesa/Shoshone Mountain (99), Central Pahute Mesa (101), and Western Pahute Mesa (102)
CAU Owner: Underground Test Area (UGTA) - Environmental Restoration (ER)

ROTC No. DOE/NV--1525-REV.1-ROTC 1 **Page** 1 of 13

Document Type Nevada National Security Site Integrated Groundwater Sampling Plan **Date** 02/05/2019

The following technical changes (including justification) are requested by:

Ken Rehfeldt — Requestor Name

Pahute Mesa CAU Lead / UGTA Project Manager, Navarro — Requestor Title

Description of Change:

1. Appendix A, Table A-1
   Remove: Table A-1
   Replace with: Table A-1 (attached)

Justification:

1. Justification for new table is as follows:
   - Table A-1: It has been determined that Wells U-19ad PS 1A, U-19q PS 1D, and U-19v PS1D do not need to be sampled on a regular basis and have been removed from Table A-1.
   - Well PM-3_p2 should be moved to the "Source/Plume Wells" category due to tritium results.
   - Hydrostratigraphic Unit (HSU) designations were updated for sample location IDs ER-EC-5_m1-3 (TMCM to ATWTA), ER-20-5-3_m1 (CHZCM to CHZCM/CHLFA5), ER-20-6-2_m1 (CHZCM to CHZCM/CHLFA3), U-20n PS 1D_o2 (CHZCM to CHZCM/CHLFA4), UE-20n 1_o2 (CHZCM to CHZCM/CHLFA4), and U-20 WW_m1 (CHZCM to CHZCM/CHLFA1/CHLFA4) to match the most current version of the hydrostratigraphic framework model.
   - The following Sample Location IDs changed to be consistent with industry standards: U-20n PS 1D_ m2 changed to U-20n PS 1D_o2; ER-EC-6_m4 changed to ER-EC-6_m4_a3; and ER-20-1_m1 changed to ER-20-1_p1.

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ROTC No. DOE/NV--1525-REV.1-ROTC 1 **Page** 2 of 13

Document Type Nevada National Security Site Integrated Groundwater Sampling Plan **Date** 02/05/2019

Description of Change:	**Justification:**
2. Appendix A, Table A-2 Remove: Table A-2 Replace with: Table A-2 (attached)	2. Table A-2: The following Sample Location IDs changed to be consistent with industry standards: ER-30-1_p1 changed to ER-30-1_m1; ER-12-4_p2 changed to ER-12-4_p1; ER-16-1_m1 changed to ER-16-1_p1; UE-18t_p1 changed to UE-18t_o1; U-12n.10 Vent Hole_m1 changed to U-12n.10 Vent Hole _o1; U-12n Vent Hole_2_m1 changed to U-12n Vent Hole_2_o1; ER-12-3_m1-2 changed to ER-12-3_m1; ER-19-1_p2 changed to ER-19-1_m3; and ER-19-1_p1 changed to ER-19-1_m2.
3. Appendix A, Table A-3 Remove: Table A-3 Replace with: Table A-3 (attached)	3. Table A-3: The following Sample Location IDs changed to be consistent with industry standards: TW-7_m1 changed to TW-7_o1; WW-3_m1 changed to WW-3_o1; UE-7nS_m1 changed to UE-7nS_m1_a1; and WW C-1_m1 changed to WW C-1_o1.
4. List of Acronyms and Abbreviations (pages viii and ix): Added "ATWTA = Ammonia Tanks welded-tuff aquifer" and CHLFA (1, 3, 4, 5) = Calico Hills lava flow aquifer" to list.	4. These acronyms were added to Table A-1, and therefore, added to the list.

Schedule Impacts:

No impacts to schedule.

ROTC applies to the following document(s):

- *Nevada National Security Site Integrated Groundwater Sampling Plan*, Rev. 1, March 2018, DOE/NV--1525-REV. 1

FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

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ROTC No. DOE/NV--1525-REV.1-ROTC 1 **Page** 3 **of** 13

Document Type Nevada National Security Site Integrated Groundwater Sampling Plan **Date** 02/05/2019

Approvals:

/s/ John Myers Date 2/13/19

John Myers
Activity Lead
Environmental Management (EM) Nevada Program

/s/ Wilhelm R. Wilborn Date 2/13/2019

Wilhelm R. Wilborn
Deputy Program Manager, Operations
Environmental Management (EM) Nevada Program

/s/ Chris Andres Date 2/14/19

Chris Andres
Chief, Bureau of Federal Facilities
Nevada Division of Environmental Protection (NDEP)

List of Acronyms and Abbreviations *(Continued)*

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

AA	Alluvial aquifer
ATCU	Argillic tuff confining unit
ATWTA	Ammonia Tanks welded-tuff aquifer
BA	Benham aquifer
BFCU	Bullfrog confining unit
BRA	Belted Range aquifer
BRCU	Belted Range confining unit
CFCM	Crater Flat composite unit
CFCU	Crater Flat confining unit
CHCU	Calico Hills confining unit
CHLFA	Calico Hills lava flow aquifer
CHZCM	Calico Hills zeolitic composite unit
CPA	Comb Peak aquifer
FCCM	Fortymile Canyon composite unit
FCCU	Fortymile Canyon confining unit
LCA	Lower carbonate aquifer
LCA3	Lower carbonate aquifer-upper plate
LPCU	Lower Paintbrush confining unit
LTCU	Lower tuff confining unit
LVTA	Lower vitric-tuff aquifer
MPCU	Middle Paintbrush confining unit
OSBCU	Oak Spring Butte confining unit
PBPCU	Post-Benham Paintbrush confining unit

List of Acronyms and Abbreviations *(Continued)*

PBRCM	Pre-Belted Range composite unit
PLFA	Paintbrush lava-flow aquifer
RMWTA	Rainier Mesa welded-tuff aquifer
RVA	Redrock Valley aquifer
SPA	Scrugham Peak aquifer
TCA	Tiva Canyon aquifer
TCVA	Thirsty Canyon volcanic aquifer
THCM	Tannenbaum Hill composite unit
TMCM	Timber Mountain composite unit
TMLVTA	Timber Mountain lower vitric-tuff aquifer
TMUWTA	Timber Mountain upper welded-tuff aquifer
TMWTA	Timber Mountain welded-tuff aquifer
TSA	Topopah Spring aquifer
UCCU	Upper clastic confining unit
UPCU	Upper Paintbrush confining unit

Appendix A

Sample Collection Location Information

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 1 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5426	ER-20-4	ER-20-4_m1	37.19503	-116.440272	CHZCM/CFCU	2,415	3,050	ES Pump
9712	ER-20-11	ER-20-11_m1	37.196125	-116.484182	FCCU/BA/UPCU	2,562	3,004	ES Pump
11810	ER-20-12	ER-20-12_p4	37.281104	-116.538352	TMWTA/TMLVTA	WL	2,287	Bailer
		ER-20-12_p3			CHZCM	2,510	2,947	LJ Pump
		ER-20-12_p1			BRA	3,725	3,343	LJ Pump
		ER-20-12_m1			PBRCM	3,916	4,543	ES Pump
4179	ER-EC-4	ER-EC-4_m2-3	37.158863	-116.631058	TCVA/FCCM/TMUWTA	952	2,295	ES Pump
4103	ER-EC-5	ER-EC-5_m1-3	37.084548	-116.564561	ATWTA	1,169 1,835 2,194	1,443 2,146 2,500	ES Pump
6770	ER-EC-11	ER-EC-11_p3	37.197547	-116.494759	FCCU/BA	WL	3,030	LJ Pump
		ER-EC-11_m2			UPCU/TCA	3,196	3,385	ES Pump
		ER-EC-11_p1			TSA/CHCU	3,590	4,148	LJ Pump
6772	ER-EC-12	ER-EC-12_m2	37.173291	-116.491991	THCM/TCA/LPCU	1,854	2,744	ES Pump
		ER-EC-12_p2			TSA/CHCU	3,188	3,770	LJ Pump
6773	ER-EC-13	ER-EC-13_m2	37.169369	-116.548301	FCCM	1,835	2,136	ES Pump
		ER-EC-13_p1			FCCM	2,240	2,680	LJ Pump
6774	ER-EC-14	ER-EC-14_m2	37.14018	-116.511485	RMWTA	1,295	1,704	ES Pump
		ER-EC-14_p1			RMWTA	1,889	2,378	LJ Pump
6775	ER-EC-15	ER-EC-15_m3	37.186141	-116.518152	FCCU/CPA/PBPCU	WL	1,769	ES Pump
		ER-EC-15_p2			TCA/LPCU	2,108	2,427	LJ Pump
		ER-EC-15_p1			TSA/CHCU	2,752	3,255	LJ Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 2 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Source/Plume Wells								
16	ER-20-5-1	ER-20-5-1_p1	37.220054	-116.477174	TSA/CHZCM	2,249	2,655	ES Pump
21	ER-20-5-3	ER-20-5-3_m1	37.219771	-116.477190	CHZCM/CHLFA5	3,348	3,914	ES Pump
19	ER-20-6-2 [a]	ER-20-6-2_m1	37.259935	-116.421166	CHZCM/CHLFA3	2,414	2,945	LJ Pump
6769	ER-20-7	ER-20-7_m1	37.213043	-116.479108	LPCU/TSA/CHZCM	2,292	2,936	ES Pump
6771	ER-20-8	ER-20-8_m2	37.193087	-116.473975	MPCU/TCA/LPCU	2,440	2,940	ES Pump
6963	ER-20-8-2	ER-20-8-2_m1	37.193024	-116.474129	BA/UPCU/SPA/MPCU	WL	2,339	ES Pump
3645	PM-3	PM-3_p2	37.239077	-116.560179	UPCU	1,473	1,687	LJ Pump
3533	U-20n PS 1DDh	U-20n PS 1D_o2	37.240273	-116.423325	CHZCM/CHLFA4	4,081	4,290	ES Pump [b] or LJ Pump
3534	UE-20n 1	UE-20n 1_o2	37.240308	-116.421934	CHZCM/CHLFA4	2,323	2,824	ES Pump
Early Detection Wells								
6771	ER-20-8	ER-20-8_p1	37.193087	-116.473975	LPCU/TSA/CHZCM	3,070	3,442	LJ Pump
4178	ER-EC-1	ER-EC-1_m1-3	37.206313	-116.529739	CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM	2,258 3,291 4,399	2,867 3,776 4,840	ES Pump
4180	ER-EC-6	ER-EC-6_m4_a3	37.188771	-116.496682	FCCU/BA	1.606	1,948	LJ Pump
3468	ER-20-1	ER-20-1_p1	37.222453	-116.491506	TCA	WL	2,065	LJ Pump
3645	PM-3	PM-3_p1	37.239077	-116.560179	TCA/LPCU	1,872	2,192	LJ Pump
3647	U-20 WW	U-20 WW_m1	37.251412	-116.429282	CHZCM/CHLFA1/ CHLFA4	2,271	3,268	ES Pump [b] or LJ Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 3 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Distal Wells								
5151	ER-EC-2A	ER-EC-2A_m3	37.144993	-116.567379	FCCM	1,635	2,236	ES Pump or LJ Pump
4104	ER-EC-8	ER-EC-8_m1-3	37.102846	-116.631282	FCCM/TMCM	632 1,388 1,626	1,050 1,558 2,000	ES Pump
3309	UE-18r	UE-18r_o1	37.134754	-116.444707	TMCM	1,629	5,004	LJ Pump or Bailer
Community Wells								
7067	Peacock Ranch	Peacock Ranch_s1	37.030830	-116.754700	NA	--	--	Scoop/Dipper
6531	Revert Springs	Revert Springs_s1	36.917500	-116.744722	NA	--	--	Scoop/Dipper
9521	Spicer Ranch	Spicer Ranch_s1	36.998800	-116.705500	NA	--	--	Scoop/Dipper
6761	Crystal Park [c]	Crystal Park	36.4905	-116.160944	NA	--	--	ES Pump
4936	U.S. Ecology	U.S. Ecology_m1	36.770639	-116.690278	NA	453	573	ES Pump
6768	Amargosa Valley RV Park	Amargosa Valley RV Park_m1	36.642167	-116.396639	NA	WL	1,280	ES Pump
4908	Cind-R-Lite Mine	Cind-R-Lite Mine_m1	36.685000	-116.507222	Valley Fill [d]	WL	460	ES Pump
4959	Beatty Wtr Swr-Well 3	Beatty Wtr Swr-Well 3_m1	36.904895	-116.757810	NA	NA	NA	ES Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 4 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	

[a] Wells ER-20-6-1 and ER-20-6-3 may substitute for ER-20-6-2.
[b] ES Pump needs to be repaired or replaced.
[c] Other wells in Crystal, Nevada, may substitute for Crystal Park.
[d] Aquifer, not HSU, is reported.

-- = Not applicable
NA = Not available

ft = Foot
ID = Identification
Lat = Latitude
Long = Longitude
NAD 27 = North American Datum of 1927
WL = Water level

AA = Alluvial aquifer
ATWTA = Ammonia Tanks welded-tuff aquifer
BA = Benham aquifer
BFCU = Bullfrog confining unit
BRA = Belted Range aquifer
CFCM = Crater Flat composite unit
CFCU = Crater Flat confining unit
CHCU = Calico Hills confining unit
CHLFA (1, 3, 4, 5) = Calico Hills lava flow aquifer
CHZCM = Calico Hills zeolitic composite unit
CPA = Comb Peak aquifer
FCCM = Fortymile Canyon composite unit
FCCU = Fortymile Canyon confining unit
LPCU = Lower Paintbrush confining unit
MPCU = Middle Paintbrush confining unit
PBPCU = Post-Benham Paintbrush confining unit
PBRCM = Pre-Belted Range composite unit
PLFA = Paintbrush lava-flow aquifer
RMWTA = Rainier Mesa welded-tuff aquifer
SPA = Scrugham Peak aquifer
TCA = Tiva Canyon aquifer
TCVA = Thirsty Canyon volcanic aquifer
THCM = Tannenbaum Hill composite unit
TMCM = Timber Mountain composite unit
TMLVTA = Timber Mountain lower vitric-tuff aquifer
TMUWTA = Timber Mountain upper welded-tuff aquifer
TMWTA = Timber Mountain welded-tuff aquifer
TSA = Topopah Spring aquifer
UPCU = Upper Paintbrush confining unit

Table A-2
Rainier Mesa/Shoshone Mountain Sample Collection Locations and Supporting Information
(Page 1 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
3809	ER-30-1	ER-30-1_m1	37.050258	-116.316190	FCCM	677	790	LJ Pump
5452	ER-12-3	ER-12-3_p1	37.195017	-116.214118	LTCU/OSBCU/ATCU	WL	2,200	LJ Pump
5453	ER-12-4	ER-12-4_p1	37.219627	-116.183146	LVTA/BRCU/ LTCU/OSBCU	WL	1,988	LJ Pump
5276	ER-16-1	ER-16-1_p1	37.008566	-116.203090	LCA	WL	4,566	LJ Pump
3311	UE-18t	UE-18t_o1	37.128145	-116.329146	TMCM	120	2,600	LJ Pump
Source/Plume Wells								
2921	E-Tunnel	E-Tunnel_mine1	37.188181	-116.194554	--	NA	NA	Grab
3043	U-12n.10 Vent Hole	U-12n.10 Vent Hole_o1	37.207719	-116.205506	LTCU	WL	1,240	Bailer
3069	U-12n Vent Hole 2	U-12n Vent Hole_2_o1	37.203559	-116.218060	LTCU	WL	1,252	Bailer
Early Detection Wells								
2876	ER-12-1	ER-12-1_m5	37.184905	-116.184217	UCCU	1,641	1,846	ES Pump
5452	ER-12-3	ER-12-3_m1	37.195017	-116.214118	LCA3	WL	4,908	ES Pump
5453	ER-12-4	ER-12-4_m1	37.219627	-116.183146	LCA3	WL	3,715	ES Pump
3317	ER-19-1	ER-19-1_m3	37.178521	-116.239147	OSBCU	1,301	1,422	LJ Pump or Bailer
		ER-19-1_m2			RVA/ATCU	2,550	2,738	LJ Pump or Bailer

Table A-2
Rainier Mesa/Shoshone Mountain Sample Collection Locations and Supporting Information
(Page 2 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Distal Wells								
3237	TW-1	TW-1_m1	37.158179	-116.222920	OSBCU/RVA/LTCU/ ATCU/LCA3	1,910	4,206	LJ Pump or Bailer
3235	UE-16d WW	UE-16d WW_m1	37.070112	-116.164283	UCCU	1,145	1,944	ES Pump
3316	WW-8	WW-8_m26	37.165586	-116.289152	BRA	WL	2,031	ES Pump

-- = Not applicable
NA = Not available

ATCU = Argillic tuff confining unit
BRCU = Belted Range confining unit
LCA3 = Lower carbonate aquifer-upper plate
LTCU = Lower tuff confining unit

LVTA = Lower vitric-tuff aquifer
OSBCU = Oak Spring Butte confining unit
RVA = Redrock Valley aquifer
UCCU = Upper clastic confining unit

Table A-3
Yucca Flat/Climax Mine Sample Collection Locations and Supporting Information

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5204	ER-2-1	ER-2-1_m1	37.125278	-116.061899	TMWTA/TMLVTA/LTCU	WL	2,177	ES Pump
11813	ER-3-3	ER-3-3_m1	37.063444	-116.038942	LTCU/ATCU/LCA	2,630	3,193	ES Pump
11812	ER-4-1	ER-4-1_m1	37.106606	-116.050159	LCA	2,812	3,035	ES Pump
1940	ER-6-1-1[a]	ER-6-1-1_p1	36.984313	-115.99283	LCA	1,835	2,085	LJ Pump
5199	ER-7-1	ER-7-1_m1	37.073318	-115.995265	LCA	WL	2,500	ES Pump
1747	TW-7	TW-7_o1	37.064863	-116.033776	LTCU	1,710	2,272	LJ Pump
69	UE-1h	UE-1h_o1	37.001333	-116.067373	LCA	WL	3,358	LJ Pump
1971	WW-3	WW-3_o1	36.995230	-116.057958	AA	WL	2,349	LJ Pump
Source/Plume Wells								
319	UE-2ce	UE-2ce_m1	37.142011	-116.135278	LCA3	WL	1,650	ES Pump
2059	UE-7nS	UE-7nS_m1_a1	37.098770	-116.002484	LCA	1,995	2,022	Bailer
Early Detection Wells								
549	WW-2	WW-2_m1	37.166234	-116.087622	LCA	2,563	3,422	ES Pump
1892	TW-D	TW-D_m1	37.074440	-116.075018	ATCU/LCA	1,772	1,950	Bailer or LJ Pump
22	UE-1q	UE-1q_o1	37.060342	-116.058332	LCA	2,459	2,600	Bailer or LJ Pump
1970	WW C-1	WW C-1_o1	36.918647	-116.009409	LCA	WL	1,650	ES Pump
1015	U-3cn 5	U-3cn 5_o1	37.059475	-116.022363	LCA	2,832	3,030	ES Pump

[a] Well ER-6-1-2 may substitute for ER-6-1-1.

Environmental
Management
Nevada Program

DOE/NV--1525-REV. 1

Nevada National Security Site Integrated Groundwater Sampling Plan

Revision No.: 1

March 2018

Approved for public release; further dissemination unlimited.

U.S. Department of Energy
Environmental Management Nevada Program

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NEVADA NATIONAL SECURITY SITE INTEGRATED GROUNDWATER SAMPLING PLAN

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

Revision No.: 1

March 2018

NEVADA NATIONAL SECURITY SITE
INTEGRATED GROUNDWATER SAMPLING PLAN

Approved by: /s/ Wilhelm R. Wilborn Date: 03/27/2018

Bill R. Wilborn
Deputy Program Manager, Operations
EM Nevada Program

Approved by: /s/ Robert F. Boehlecke Date: 03/27/2018

Robert F. Boehlecke
Program Manager
EM Nevada Program

Table of Contents

Table of Contents (Continued)

List of Figures

List of Tables

List of Acronyms and Abbreviations

General Acronyms and Abbreviations

AMS	Accelerator Mass Spectrometry
ASTM	ASTM International
BLM	Bureau of Land Management
CADD	Corrective action decision document
CAI	Corrective action investigation
CAIP	Corrective action investigation plan
CAP	Corrective action plan
CAU	Corrective action unit
CFR	*Code of Federal Regulations*
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure report
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DQI	Data quality indicator
DRI	Desert Research Institute
EDD	Electronic data deliverable
EERF	Eastern Environmental Radiation Facility
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
EPS	Environmental Program Services
ES	Electric submersible
FAWP	Field Activity Work Package
FFACO	*Federal Facility Agreement and Consent Order*

List of Acronyms and Abbreviations *(Continued)*

ft	Foot
HASL	Health and Safety Laboratory
HSU	Hydrostratigraphic unit
ICP-AES	Inductively coupled plasma-atomic emission spectrometry
ICP-MS	Inductively coupled plasma-mass spectrometry
ID	Identification
Lat	Latitude
LJ	Lift jack
LLNL	Lawrence Livermore National Laboratory
Long	Longitude
LQC	Laboratory quality control
MCL	Maximum contaminant level
mg/L	Milligrams per liter
M&O	Management and operating
mrem/yr	Millirem per year
N/A	Not applicable
NA	Not available
NAD 27	North American Datum of 1927
NDEP	Nevada Division of Environmental Protection
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NSF	National Science Foundation
NTTR	Nevada Test and Training Range
pCi/L	Picocuries per liter
PEP	Performance evaluation program

List of Acronyms and Abbreviations *(Continued)*

QA	Quality assurance
QAP	Quality Assurance Plan
QC	Quality control
ROTC	Record of Technical Change
RREMP	Routine Radiological Environmental Monitoring Plan
SDWA	*Safe Drinking Water Act*
SOP	Standard operating procedure
TDR	Technical Data Repository
UGTA	Underground Test Area
UIDMS	UGTA Information and Data Management System
USAF	U.S. Air Force
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WL	Water level
µg/L	Micrograms per liter
µmhos	Micromhos
µmhos/cm	Micromhos per centimeter

List of Acronyms and Abbreviations *(Continued)*

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

AA	Alluvial aquifer
ATCU	Argillic tuff confining unit
BA	Benham aquifer
BFCU	Bullfrog confining unit
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	Fortymile Canyon confining unit
LCA	Lower carbonate aquifer
LCA3	Lower carbonate aquifer-upper plate
LPCU	Lower Paintbrush confining unit
LTCU	Lower tuff confining unit
LVTA	Lower vitric-tuff aquifer
MPCU	Middle Paintbrush confining unit
OSBCU	Oak Spring Butte confining unit
PBPCU	Post-Benham Paintbrush confining unit
PBRCM	Pre-Belted Range composite unit
PLFA	Paintbrush lava-flow aquifer

List of Acronyms and Abbreviations (Continued)

RMWTA	Rainier Mesa welded-tuff aquifer
RVA	Redrock Valley aquifer
SPA	Scrugham Peak aquifer
TCA	Tiva Canyon aquifer
TCVA	Thirsty Canyon volcanic aquifer
THCM	Tannenbaum Hill composite unit
TMCM	Timber Mountain composite unit
TMLVTA	Timber Mountain lower vitric-tuff aquifer
TMUWTA	Timber Mountain upper welded-tuff aquifer
TMWTA	Timber Mountain welded-tuff aquifer
TSA	Topopah Spring aquifer
UCCU	Upper clastic confining unit
UPCU	Upper Paintbrush confining unit

List of Acronyms and Abbreviations *(Continued)*

Elements and Compounds

Ag	Silver
Al	Aluminum
Am	Americium
Ar	Argon
As	Arsenic
Ba	Barium
Br	Bromine
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cd	Cadmium
Cl	Chlorine
Cm	Curium
Cr	Chromium
Cs	Cesium
DIC	Dissolved inorganic carbon
DOC	Dissolved organic carbon
Eu	Europium
F	Fluorine
Fe	Iron
^{2}H	Deuterium
^{3}H	Tritium
H_2O	Water
He	Helium

List of Acronyms and Abbreviations *(Continued)*

Ho	Holmium
I	Iodine
K	Potassium
Kr	Krypton
Li	Lithium
Mg	Magnesium
Mn	Manganese
Na	Sodium
Nb	Niobium
Ne	Neon
Ni	Nickel
Np	Neptunium
O	Oxygen
Pb	Lead
Pd	Palladium
Pu	Plutonium
Ra	Radium
S	Sulfur
Se	Selenium
Si	Silicon
Sm	Samarium
Sn	Tin
SO_4	Sulfate
Sr	Strontium
Tc	Technetium

List of Acronyms and Abbreviations (Continued)

TDIC	Total dissolved inorganic carbon
TDOC	Total dissolved organic carbon
TIC	Total inorganic carbon
U	Uranium
Xe	Xenon
Zr	Zirconium

1.0 Introduction

1.1 Purpose and Scope

The purpose of the Nevada National Security Site (NNSS) Integrated Groundwater Sampling Plan (referred to herein as the Plan) is to provide a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet the needs and objectives of the U.S. Department of Energy (DOE), Environmental Management (EM) Nevada Program's Underground Test Area (UGTA) Activity. Implementation of this Plan will provide high-quality data required by the UGTA Activity for ensuring public protection in an efficient and cost-effective manner. The Plan is designed to ensure compliance with the UGTA Quality Assurance Plan (QAP) (NNSA/NFO, 2015); *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended); and DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2013).

The Plan's scope comprises sample collection and analysis requirements relevant to assessing both the extent of groundwater contamination from underground nuclear testing and impact of testing on water quality in downgradient communities. This Plan identifies locations to be sampled by corrective action unit (CAU) and location type, sampling frequencies, sample collection methodologies, and the constituents to be analyzed. In addition, the Plan defines data collection criteria such as well purging, detection levels, and accuracy requirements/recommendations; identifies reporting and data management requirements; and provides a process to ensure coordination between NNSS groundwater sampling programs for sampling analytes of interest to UGTA. Information used in the Plan development—including the rationale for selection of wells, sampling frequency, and the analytical suite—is discussed under separate cover (N-I, 2014) and is not reproduced herein.

This Plan does not address compliance for those wells involved in a permitted activity. Sampling and analysis requirements associated with these wells are described in their respective permits and are discussed in NNSS environmental reports (see Section 5.2). In addition, sampling for UGTA CAUs that are in the Closure Report (CR) stage are not included in this Plan. Sampling requirements for these CAUs are described in the CR. Frenchman Flat is currently the only UGTA CAU in the CR stage. Sampling requirements for this CAU are described in *Underground Test Area (UGTA) Closure*

Report for Corrective Action Unit 98: Frenchman Flat Nevada National Security Site, Nevada (NNSA/NFO, 2016).

1.2 Planning and Scheduling

Successful implementation of this Plan requires integration between all organizations participating in activities relevant to the UGTA Activity. Integration will ensure that (1) adequate quality assurance (QA) protocols are followed; (2) sample collection and analysis criteria are consistent between organizations; (3) data needed for transition to each UGTA Corrective Action Strategy stage are collected and reported; and (4) sampling tasks are performed as efficiently as possible.

The Environmental Program Services (EPS) UGTA Integration Manager and CAU Leads will identify potential Plan activities for the next fiscal year as part of task planning with participating organizations. The EPS UGTA Integration Manager and EPS Closure Support Manager will then coordinate possible sampling activities; determine whether modifications (e.g., locations, sampling technology, analytes, detection limits) to the Plan activities are needed; and identify and coordinate required resources. The EPS UGTA Integration Manager will also coordinate potential sampling activities for the next fiscal year with the management and operating (M&O) contractor. Proposed sampling not included in the Plan must be consistent with the UGTA Corrective Action Strategy stage for the CAU. Proposed deviations from the Plan, including justification, will be documented and provided to DOE for approval.

Sampling by the EPS contractor is described in Field Activity Work Packages (FAWPs). A field planning meeting (EPS Closure Support Manager, field staff, CAU Lead, Analytical Services) will be held before sampling begins to communicate sampling and analysis requirements, including schedules. Lessons learned from previous sampling events and any deviations from routine sampling and analysis protocols will be discussed. The M&O contractor will inform the EPS UGTA Integration Manager and EPS Closure Support Manager of planned sampling that supports the Plan at the beginning of each fiscal year. Deviations from the Plan, including justification, will be documented in the Annual UGTA Sampling Report (see Section 5.1). The Nevada Division of Environmental Protection (NDEP) Bureau of Federal Facilities will be notified of the upcoming fiscal year sampling schedule.

1.3 Sampling Plan Revision

Data collected in accordance with this Plan will support the FFACO closure process for each CAU by ensuring that appropriate analytical data are available and standardized sampling processes are in place. Distribution and revision of this Plan will be controlled. As such, changes to the Plan require document revision, a Record of Technical Change (ROTC), or equivalent. Revision is not required if the change is a one-time deviation.

This Plan may be referenced in NDEP-approved FFACO documents (Corrective Action Investigation Plan [CAIP] or Corrective Action Decision Document [CADD]/Corrective Action Plan [CAP]), as appropriate. Plan sampling and analysis requirements do not supercede commitments in these documents. Revisions to FFACO documents that reference this Plan require NDEP approval and will be made in accordance with established FFACO protocols.

2.0 Groundwater Contaminants and Regulatory Levels

The UGTA Activity is conducted in compliance with the FFACO (1996, as amended). In turn, the FFACO regulatory requirements are based on *Safe Drinking Water Act* (SDWA) radiological maximum contaminant levels (MCLs) (CFR, 2017). The MCLs are regulatory standards established by the U.S. Environmental Protection Agency (EPA) for chemical and radioactive constituents in drinking water. The MCLs for radionuclides are presented in Table 2-1.

Table 2-1
Maximum Contaminant Levels

Radionuclide Category	MCL
Beta and photon emitters (combined)	4 mrem/yr
Gross alpha particles [a]	15 pCi/L
Radium-226/228 ($^{226/228}Ra$) (combined)	5 pCi/L
Uranium	30 µg/L

[a] Gross alpha MCL includes ^{226}Ra but excludes radon and uranium.

mrem/yr = Millirem per year
pCi/L = Picocuries per liter
µg/L = Micrograms per liter

The MCL for all alpha-emitting radionuclides collectively (i.e., summed together) is 15 pCi/L. Neptunium-237 (^{237}Np), plutonium-238 (^{238}Pu), ^{239}Pu, ^{240}Pu, ^{242}Pu, americium-241 (^{241}Am), ^{243}Am, and curium (^{244}Cm) are the alpha-emitting radionuclides included in the NNSS radionuclide inventory (Finnegan et al., 2016). The MCL for these radionuclides, combined, is therefore 15 pCi/L.

The MCL for beta and photon emitters is based on a calculated dose of 4 mrem/yr. This means that the combined dose from all beta and photon radionuclides present in a particular water source must be less than 4 mrem/yr. Each single radionuclide has a unique concentration of radioactivity (measured in pCi/L), which, when in isolation, equates to a 4-mrem/yr dose (EPA, 2002). The beta- and photon-emitting radionuclides included in the Finnegan et al. (2016) inventory of radionuclides produced by NNSS underground nuclear tests are presented in Table 2-2. The corresponding EPA-derived MCLs in the table indicate the concentration of that single radionuclide which, when in isolation, will result in a 4-mrem/yr dose. Thus, the concentrations of all radionuclides in a water

Table 2-2
Beta- and Photon-Emitter MCLs

Radionuclide	MCL (pCi/L)	Radionuclide	MCL (pCi/L)
Tritium (^{3}H)	20,000	Technetium-99 (^{99}Tc)	900
Carbon-14 (^{14}C)	2,000	Palladium-107 (^{107}Pd)	--
Aluminum-26 (^{26}Al)	--	Cadmium-113m (^{113m}Cd)	--
Chlorine-36 (^{36}Cl)	700	Tin-121m (^{121m}Sn)	--
Argon-39 (^{39}Ar)	--	Tin-126 (^{126}Sn)	--
Potassium-40 (^{40}K)	--	Iodine-129 (^{129}I)	1
Calcium-41 (^{41}Ca)	--	Cesium-135 (^{135}Cs)	900
Nickel-59 (^{59}Ni)	300	Cesium-137 (^{137}Cs)	200
Nickel-63 (^{63}Ni)	50	Europium-150 (^{150}Eu)	--
Krypton-85 (^{85}Kr)	--	Samarium-151 (^{151}Sm)	1,000
Strontium-90 (^{90}Sr)	8	Europium-152 (^{152}Eu)	200
Niobium-93m (^{93m}Nb)	1,000	Europium-154 (^{154}Eu)	60
Zirconium-93 (^{93}Zr)	2,000	Holmium-166 (^{166}Ho)	90
Niobium-94 (^{94}Nb)	--	Plutonium-241(^{241}Pu)	300

Source: EPA, 2002

-- = Not available

source must be considered to determine compliance with the 4-mrem/yr MCL. Note that the concentration equivalents leading to a 4-mrem/yr dose for some radionuclides included in the inventory have not been established by the EPA.

2.1 Contaminants of Concern and Contaminants of Potential Concern

A contaminant of concern (COC) is defined as a radionuclide that exceeds 50 percent of the associated MCL at sampling locations within the CAU other than in or near the underground nuclear test cavity (i.e., in sampling locations other than cavity, post-shot wells, or Rainier Mesa tunnels). At this time, ^{3}H is the only radionuclide that meets this criterion, and it meets this criterion for all UGTA CAUs (N-I, 2013). It is important to also note that ^{3}H is currently the only radionuclide known to exceed its MCL at sampling locations other than in or near the underground nuclear test cavity (N-I, 2013). Based on these data and the high mobility of ^{3}H in groundwater, ^{3}H has been identified as a COC for all CAUs.

A contaminant of potential concern (COPC) is defined as a radionuclide that has not been detected above 50 percent of the MCL in sampling locations other than in or near the underground nuclear test cavity, but may exceed this criterion in the future as a result of its migration away from the test cavity over time. The NNSS radionuclide inventory includes 43 radionuclides produced by NNSS underground nuclear tests (Finnegan et al., 2016). Many of these radionuclides are relatively immobile because portions of their inventory are bound within the melt glass produced during nuclear detonation and/or have chemical properties that cause them to bind strongly to solid particles in the aquifer. A smaller set of radionuclides that are more mobile in groundwater and produced in high abundance during nuclear detonation has the greatest potential for impacting groundwater quality. A COPC list has been developed based on the NNSS radionuclide inventory (Finnegan et al., 2016), previous sampling and analysis data, an understanding of relative mobility of the inventory radionuclides, and modeling results (Table 2-3).

Table 2-3
CAU-Specific COCs and COPCs

CAU	COC	COPC
Pahute Mesa (Western and Central)	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I
Rainier Mesa/Shoshone Mountain	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, $^{238/239/240}Pu$
Yucca Flat/Climax Mine	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (and ^{90}Sr and ^{137}Cs in lower carbonate aquifer [LCA] samples)

2.2 Radionuclide Threshold Levels

Four threshold levels (Investigation, Notification, Action Planning, and Action) have been established to ensure appropriate actions are taken and communicated when radionuclide concentrations deviate from previously established trends, approach MCLs, or reach or exceed MCLs. The threshold levels and associated responses are summarized in Table 2-4 and are described in the following subsections. These levels have been established to ensure appropriate actions are taken and communicated in a consistent, defined, and appropriate manner commensurate with the level of risk. For example, the radioactivity levels that trigger a response for non-potable wells on the Nevada Test and Training Range (NTTR) are higher because these wells are not water sources for human consumption. The purpose of these wells is to understand and forecast contaminant transport from underground nuclear testing, and the wells were drilled to be potentially downgradient of the

Table 2-4
Radionuclide Thresholds Levels and Responses

Threshold Levels	Analytical Result	Response
Investigation Level	• Result deviates from a previously established trend and/or the conceptual model of radionuclide migration for the UGTA CAUs. For example: - Initial confirmed detection of COC or COPC. - Increase in COC or COPC radioactivity (≥3 standard deviations from baseline value but less than Notification Level).	• Verify analytical results. • Investigate reason for result (i.e., underground nuclear test). • Change status to COC if COPC concentration is ≥50% of MCL. • Reassess reporting levels to ensure SDWA compliance for multiple radionuclides present.
Notification Level	• First-time detection of COC or COPC is ≥10% of its SDWA MCL for public, private, and BLM land sampling locations. • First-time detection of COC or COPC is ≥50% of its SDWA MCL for NTTR sampling locations.	• Verify analytical results. • Notify NDEP. • Notify USAF for NTTR sampling locations. • Notify land owner or permit holder of permit for public, private, and BLM land sampling locations. • Reassess reporting levels to ensure SDWA compliance for multiple radionuclides present.
Action Planning Level	• First-time detection of COC or COPC is ≥50% of its SDWA MCL for public, private, and BLM land sampling locations. • COC or COPC concentration is ≥ SDWA MCL for NTTR sampling locations.	• Verify analytical results. • Notify NDEP. • Notify USAF for NTTR sampling locations. • Notify land owner or permit holder for public, private, and BLM land sampling locations. • Implement measures to prevent consumption of water from the well. • Develop action plan to meet anticipated future FFACO and State requirements. • Reassess reporting levels to ensure SDWA compliance for multiple radionuclides present.
Action Level	• COC or COPC concentration is ≥ SDWA MCL for public, private, and BLM land sampling locations. • COC or COPC concentration reaches level identified in the Action Plan for NTTR sampling locations.	• Implement actions developed under Action Planning Level.

BLM = Bureau of Land Management
USAF = U.S. Air Force

nuclear testing. Therefore, it is expected that radionuclide contaminants will be detected in these wells long before, if ever, the groundwater travels off government land. The notification requirements are not mandated by the FFACO or NDEP regulation (Section 2.2). The conditions that require mandatory notification to NDEP during long-term groundwater monitoring are defined in CRs. The UGTA Federal Activity Lead will be notified as soon as possible if reporting thresholds with associated notifications are reached. There are no Notification, Action Planning, or Action thresholds associated with NNSS results; these results are addressed through feedback processes presented in Section 3.0 and are reported as described in Section 5.0.

2.2.1 Investigation Level

The **Investigation Level** is reached when the analytical results deviate from a previously established trend and/or the conceptual model of radionuclide migration for the UGTA CAUs. This would include a new detection of a COC or COPC that is not anticipated by the conceptual model, or an increase in COC or COPC radioactivity that is at or above three standard deviations of the baseline value but is still below the Notification Level defined below.

An investigation will be initiated to evaluate the reason for the deviation. The evaluation will begin by verifying the accuracy of the analytical result and may involve sample reanalysis, additional sample collection, and/or additional radioisotope analyses. If a radioisotope is detected at a concentration that is 50 percent of the MCL or greater at a sample location that is not in or near the underground nuclear test cavity, the radionuclide status will be changed to a COC. For sampling locations on the NNSS, the investigation may wait for the next scheduled sampling event to verify the accuracy of the analytical result. Threshold levels for the current and new COCs will be reassessed when multiple radionuclides are present. Formal notification to NDEP is not required at the Investigation Level.

2.2.2 Notification Level

The **Notification Level** is reached when a COC is detected for the first time at or above 50 percent of the MCL in a well on the NTTR, or at or above 10 percent of the MCL for wells on public/private or BLM land. The sample result will be verified, which may include additional sample collection and analysis of additional radioisotopes. NDEP will be formally notified once these respective limits are verified for both NTTR wells and wells on public/private or BLM land. No notifications are required for wells on the NNSS. Threshold levels for the current and new COCs will be reassessed when multiple radionuclides are present.

2.2.3 Action Planning Level

The **Action Planning Level** is reached when the COC is at or above the MCL in wells on the NTTR, or is at or above 50 percent of the MCL in wells on public/private or BLM land. For wells on the NTTR, NDEP and USAF will be notified, and measures will be put in place to ensure that personnel cannot use the wells as a source for drinking water. For wells on public/private lands, NDEP will be notified. The land owner, permit holder (if applicable), and other members of the public will be notified in accordance with DOE protocol. Threshold levels for the current and new COCs will be reassessed when multiple radionuclides are present.

For wells on the NTTR, DOE EM Nevada Program, in cooperation with NDEP, will determine action levels and monitoring will be continued until the action levels are reached. For wells on public/private lands, DOE EM Nevada Program—in cooperation with NDEP and the public water system or private land owner, as applicable—will formalize action plans to protect the public from any potential health risk associated with the consumption of water that could exceed the MCL. Future actions could include increasing sampling frequency, instituting modified institutional controls (such as limiting groundwater access), or providing an alternate water supply.

2.2.4 Action Level

The **Action Level** is reached when the COC or COPC is at or above its MCL on public/private or BLM lands, or when COC/COPC concentrations in NTTR or BLM wells reach a level described in the action plan. At this level, DOE EM Nevada Program will implement the actions previously developed (Section 2.2.3). Notifications will be made to the public in accordance with DOE protocols and applicable well permit requirements.

3.0 Sampling and Analysis

Sample locations are categorized into one of five types based on the sampling objectives: Characterization, Source/Plume, Early Detection, Distal, and Community. The type dictates the required analytical suite, associated detection limits, and sampling frequency for a given sampling location (Table 3-1). Required analyses are performed by a commercial lab certified by the State of Nevada. Additional optional analyses may be performed by Lawrence Livermore National Laboratory (LLNL), U.S. Geological Survey (USGS) and Desert Research Institute (DRI) (Table 3-2). The sample location type—and, subsequently, the sample analytes and analytical detection limits—may change over time for a given location based on analytical results (e.g., increase in radionuclide concentrations), modeling results (e.g., the well is not along a viable flow path), and/or other well-specific conditions (e.g., low groundwater velocity). A sample location is defined as a three-dimensional location within a completed well or open borehole. Wells with multiple completion intervals may have multiple sampling locations. The sampling locations may be categorized differently with different analytical requirements depending on the sampling objectives. For springs and tunnels, the location defines the specific sampling point.

Feedback loops shown in the decision diagrams in this section were established to ensure new data and/or observations are evaluated and used to continually ensure proper sampling frequencies and analytical requirements. These feedback loops allow COC identification and sample location types to evolve as new data are generated and as conditions change. Sample results will be evaluated for consistency with previous samples from the same well, wells from the same hydrostratigraphic unit (HSU), and/or with the conceptual model of groundwater flow and transport. If sufficient confidence exists to support a change in sample location type, the sample location will be recategorized by the CAU Lead. Confidence is established by evaluating measurement results over time and by qualitatively comparing the results to the conceptual model. Evaluation results and any corrective actions will be presented in the Annual UGTA Sampling Report (see Section 5.1).

Figure 3-1 illustrates the well locations and corresponding sample location type. Sample locations and the associated types are listed in Table A-1 (Pahute Mesa), Table A-2 (Rainier Mesa/Shoshone Mountain), and Table A-3 (Yucca Flat/Climax Mine).

Table 3-1
Sample Location Type Definitions and Objectives
(Page 1 of 2)

Location Type	Definition	Objective	Required Analytes [a]	Frequency
Characterization [b]	Used for system characterization or model evaluation	• Support flow and transport model development and/or evaluation. • Identify groundwater flow paths. • Establish COC and COPC presence or absence. • Estimate travel time of contaminants. • To be reclassified and sampled according to its new type when characterization objectives are met.	• Alkalinity, pH, specific conductance • Anions (Br, Cl, F, SO_4) • Total metals (Ag, Al, As, Ba, Ca, Cd, Cr, Fe, K, Li, Mg, Mn, Na, Pb, Se, Si, Sr, U) • Gross alpha and gross beta • Gamma emitters (^{26}Al, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, ^{241}Am, ^{243}Am) • ^{3}H (standard and/or low-level) [c] • ^{14}C, ^{36}Cl, ^{99}Tc, ^{90}Sr, ^{129}I, $^{238/239/240}$Pu Note: For bailed samples, analytes are alkalinity, pH, anions, total metals, ^{3}H (standard and/or low-level), and COPCs (if ^{3}H exceeds 5,000 pCi/L).[b]	3 years, or as needed
Source/Plume	Located within the plume from an underground nuclear test (i.e., test-related contamination present), and COCs detected above standard measurement levels (e.g., ^{3}H >300 pCi/L)	• Support flow and transport model development and/or evaluation. • Identify COC for downgradient wells. • Monitor contaminant migration. • Monitor natural attenuation.	• *Pahute Mesa:* ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I • *Rainier Mesa/Shoshone Mountain:* ^{3}H (standard), ^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and $^{238/239/240}$Pu • *Yucca Flat/Climax Mine:* ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (plus ^{90}Sr and ^{137}Cs in LCA samples)	4 years
Early Detection	Located downgradient of, or near, an underground test or Source/Plume well, and no COCs detected above standard measurement levels (i.e., ^{3}H ≤300 pCi/L)	• Support flow and transport model development and/or evaluation. • Detect plume edge.	• ^{3}H (low-level)	5 years

Table 3-1
Sample Location Type Definitions and Objectives
(Page 2 of 2)

Location Type	Definition	Objective	Required Analytes [a]	Frequency
Distal	Outside the Early Detection area [d]	• Support flow and transport model development and/or evaluation. • Monitor COC (i.e, ^{3}H) below SDWA 1,000-pCi/L detection limit [e].	• ^{3}H (standard)	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 [e].	• ^{3}H (standard)	5 years

[a] Required analyses performed by a commercial lab certified by the State of Nevada. See Section 4.2 for a discussion of laboratory analyses.
[b] A bailer will only be used to collect samples from a Characterization well if pumped samples cannot be collected.
[c] Standard ^{3}H analytical methods achieve a minimum detection limit of 300 pCi/L; low-level ^{3}H analytical methods achieve detection limits as low as 1 pCi/L.
[d] The Early Detection area is defined as the area near or directly downgradient of an underground nuclear test where COCs have not been detected above levels detectable using standard analytical methods.
[e] CFR, 2017.

Ag = Silver
As = Arsenic
Ba = Barium
Br = Bromide
Cr = Chromium
F = Fluorine
Fe = Iron
Li = Lithium
Mg = Magnesium
Mn = Manganese
Na = Sodium
Pb = Lead
Se = Selenium
Si = Silicon
SO_4 = Sulfate

Table 3-2
Optional Analyses for Characterization and Source/Plume Locations

<table>
<tr><th rowspan="2">CAU</th><th colspan="2">Characterization</th><th>Source/Plume</th></tr>
<tr><th>LLNL</th><th>Other</th><th>LLNL</th></tr>
<tr><td>Pahute Mesa</td><td rowspan="3">• ^{14}C and ^{36}Cl
• δD and $\delta^{18}O$
• TIC and $\delta^{13}C$
• Noble gases
• ^{3}H (low level) if ^{3}H <300 pCi/L
• ^{99}Tc, ^{129}I, and Pu if ^{3}H >5,000 pCi/L</td><td>• DRI: DOC $\delta^{13}C$, DOC ^{14}C [a]
• USGS: ^{34}S [a]</td><td>^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I</td></tr>
<tr><td>Rainier Mesa/
Shoshone Mountain</td><td>No additional analyses</td><td>^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I</td></tr>
<tr><td>Yucca Flat/
Climax Mine</td><td>No additional analyses</td><td>^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I</td></tr>
</table>

[a] Locations with ^{3}H >5,000 pCi/L will not be sampled for DOC $\delta^{13}C$ or DOC ^{14}C; and locations with ^{3}H >200,000 pCi/L will not be sampled for ^{34}S.

Note: Optional analyses are not performed for samples collected using a bailer. A bailer will be used only to collect samples from a Characterization or Source Plume well if pumped samples can not be collected.

DOC = Dissolved organic carbon
S = Sulfur
TIC = Total inorganic carbon
$\delta^{2}H$ = Delta deuterium
$\delta^{13}C$ = Delta carbon-13
$\delta^{18}O$ = Delta oxygen-18

3.1 Characterization Locations

Sample locations within new wells drilled to support the UGTA Activity, or existing wells for which insufficient baseline data exists, are categorized as Characterization locations. Figure 3-2 provides the decision diagram used to illustrate the process followed for sampling Characterization locations. Samples from these locations are collected at three-year intervals, or as needed, and may be analyzed for different sets of parameters when sampling with a bailer. New wells drilled during the corrective action investigation (CAI) stage will be sampled a minimum of three times in order to establish a baseline and to properly categorize the sampling locations within the well. The samples from each of the three sampling events will be analyzed for the parameters presented in Tables 3-1 and 3-2. Analyses may be expanded beyond those listed in Tables 3-1 and 3-2 and the results evaluated to determine whether the COPC/COC list should be revised.

3.2 Source/Plume Locations

Source/Plume sample locations have radionuclides at concentrations above standard measurement method detection limits that have been verified to originate from NNSS underground nuclear testing (Figure 3-3) (e.g., ^{3}H >300 pCi/L). Source/Plume sample locations range from those within the detonation cavity to those downgradient of the detonation at the plume edge. Wells within or near the

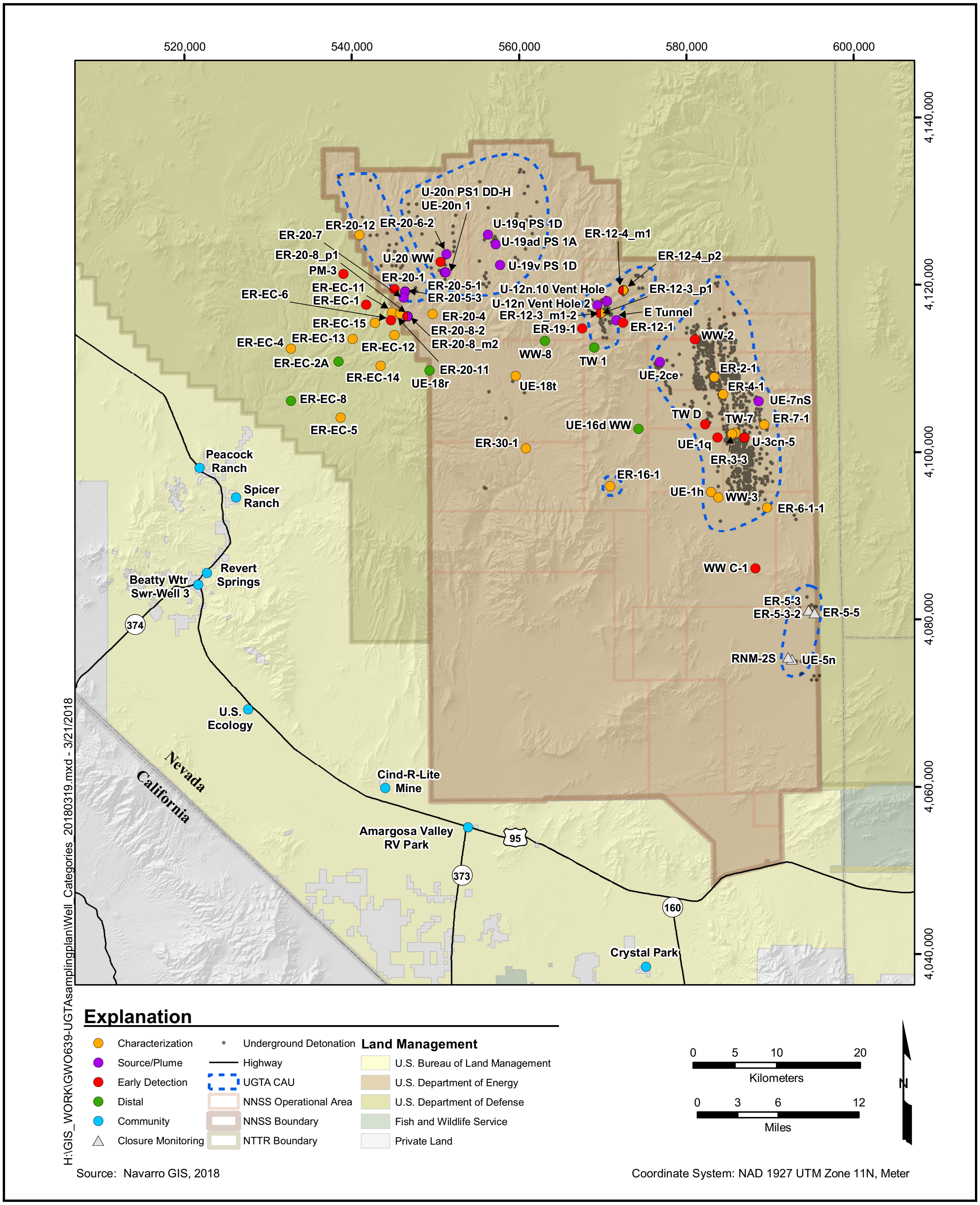

Figure 3-1
Wells and Sample Location Types

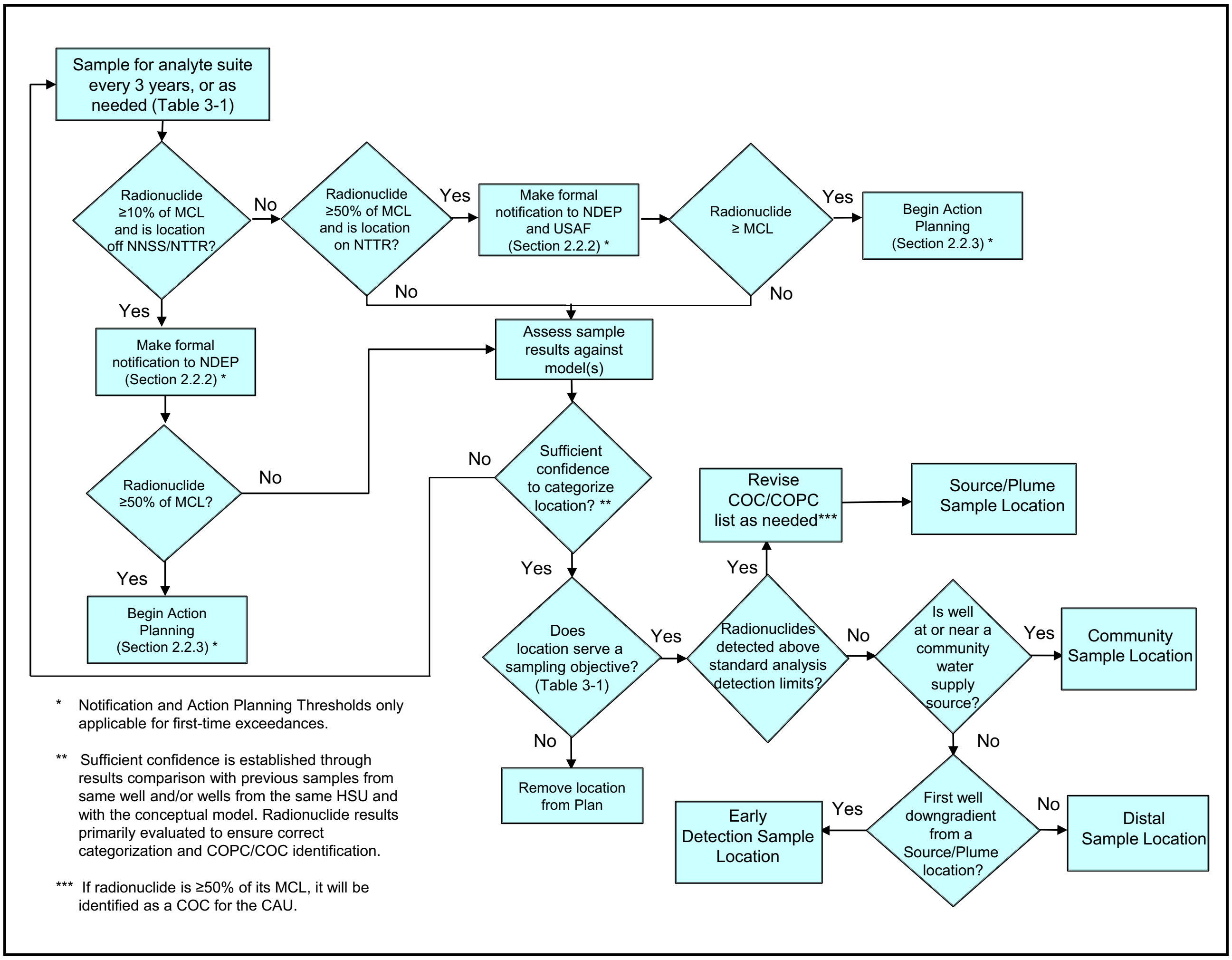

Figure 3-2
Characterization Sampling Flow Chart

detonation have historically been referred to as hot wells, post-shot holes, or near-field wells. Samples are collected every four years and analyzed for ^{3}H and the set of COPCs presented in Tables 3-1 and 3-2. Source/Plume sample location analytes include radionuclides that are likely to be detected and have the potential to exceed MCLs based on the radiological inventory published by Finnegan et al. (2016), historical and current radionuclide analyses, and/or modeling results. Analytical methods with low detection limits may be used to detect the presence of some radionuclides at very low levels (Table 3-2).

Source/Plume analytical results will be evaluated to determine whether additional radionuclides should be analyzed downgradient. A COPC increase could trigger additional analysis in a

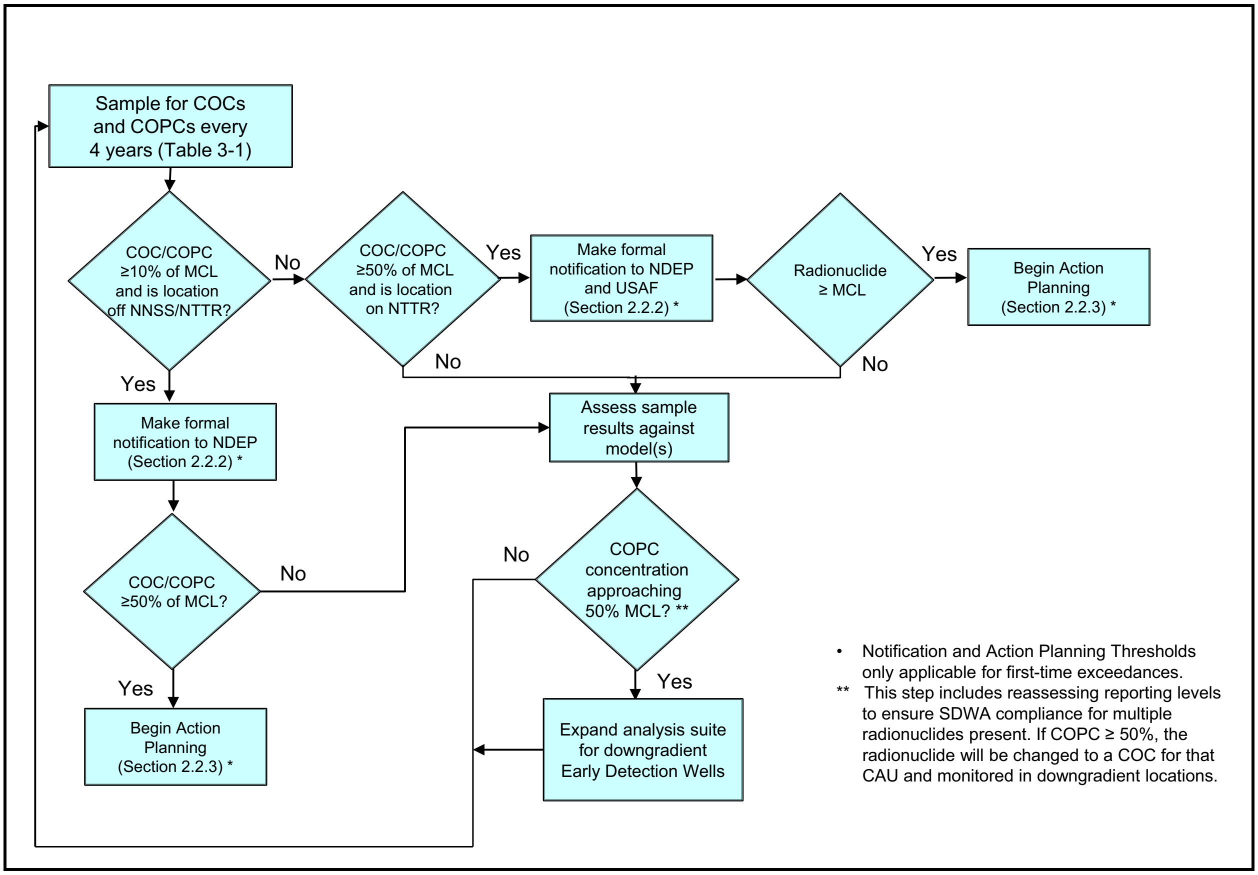

Figure 3-3
Source/Plume Sampling Flow Chart

downgradient Early Detection well. This decision may depend on the radionuclide concentration relative to its MCL.

3.3 Early Detection Locations

Early Detection sample locations do not contain the COC at concentrations above the minimum detection limit of the standard analytical measurement method (i.e., $^{3}H \leq 300$ pCi/L). Early Detection sample locations are downgradient of, or near, an underground nuclear test or Source/Plume sample location (Figure 3-4). These sample locations are sampled every five years and analyzed for low-level ^{3}H. The sampling frequency and low detection limit (≤ 10 pCi/L) are used to detect a plume front in a reasonable time frame to allow DOE to perform confirmation sampling, if necessary, and/or consider additional actions.

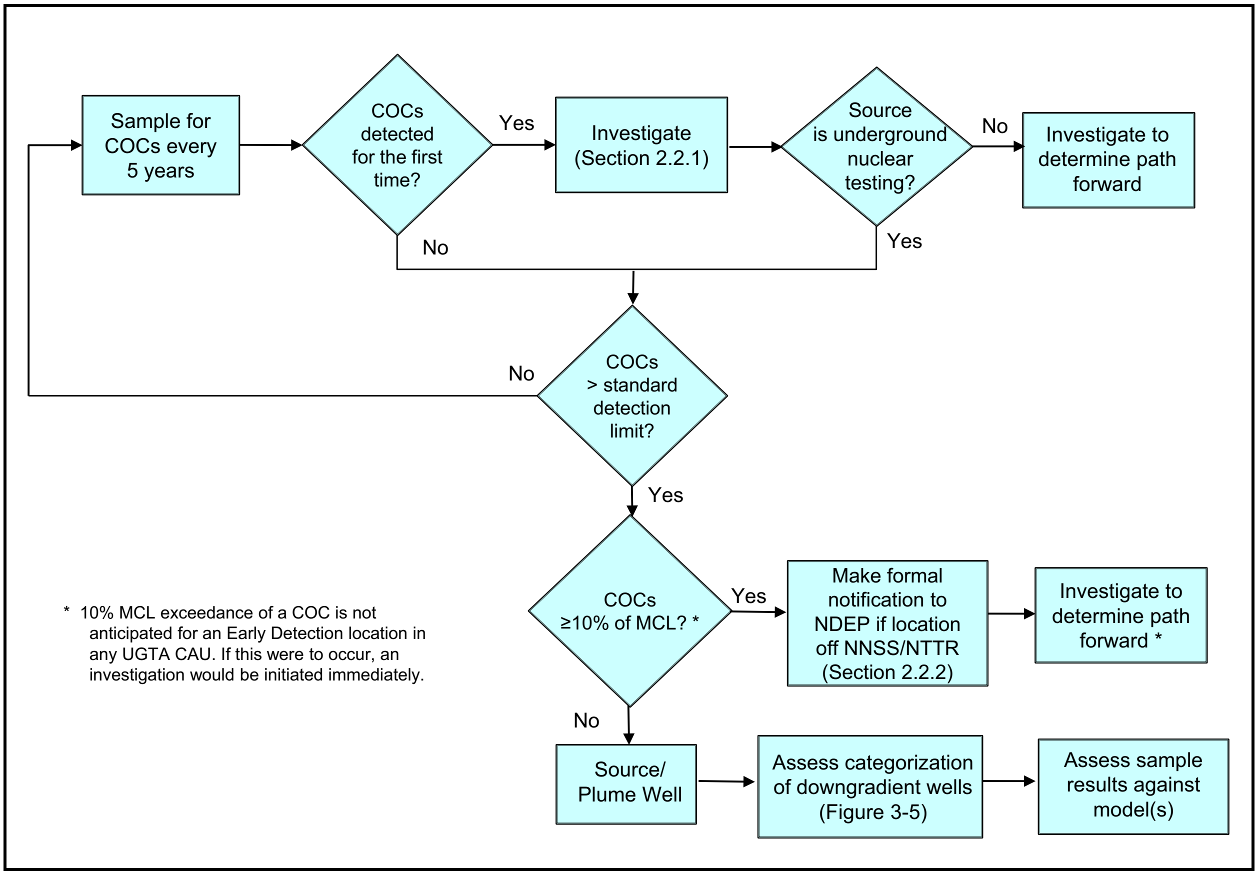

Figure 3-4
Early Detection Sampling Flow Chart

Once a COC is detected at an Early Detection sample location, an investigation is initiated to verify the presence of the COC and confirm that it resulted from an underground nuclear test. This investigation may consist of further well purging, resampling, and/or analyzing COPCs or other indicators (e.g., chlorofluorocarbons, sulfur hexafluoride). If the location is not a Community sample location (see Section 3.5) and is on government land, investigation activities may be deferred until the next scheduled sampling event to verify COC detection. Once the presence of a COC has been verified and it exceeds the detection limit using standard analytical measurements, the Early Detection location will be recategorized as a Source/Plume sample location. If the source is not verified as an underground test, the CAU Lead, in consultation with other subject matter experts, will identify future sampling objectives for the location. The suite of analytes and sampling frequency will depend on the sampling objective. The investigation will be described in the Annual UGTA Sampling Report (see Section 5.1). If the sampling location is changed from Early Detection to Source/Plume, an assessment of the downgradient Distal locations will take place to determine whether a Distal location should be changed to an Early Detection location (Figure 3-5).

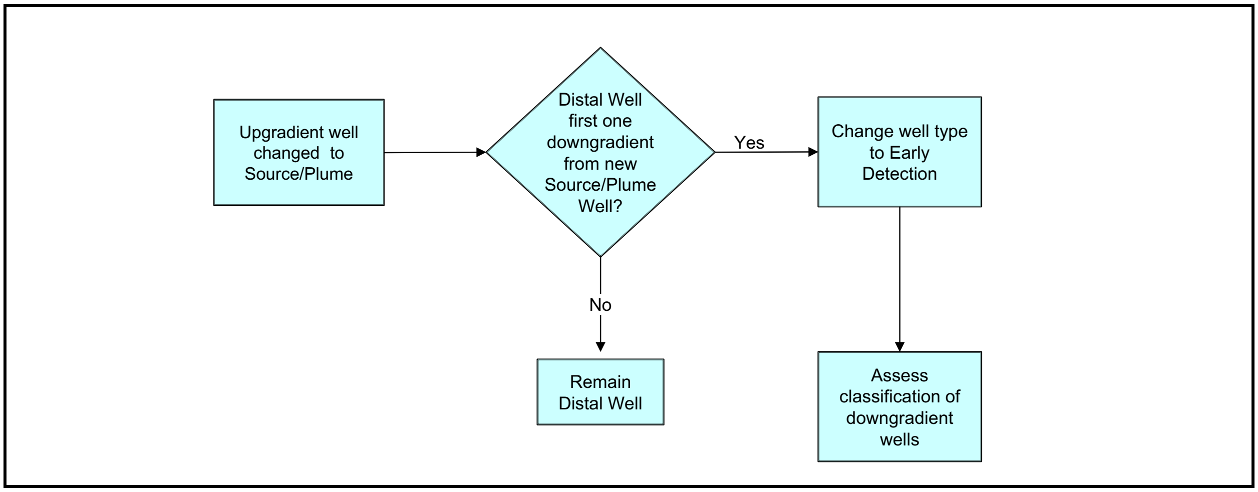

Figure 3-5
Flow Chart for Transition of a Distal to an Early Detection Sampling Location

3.4 Distal Locations

Wells that contain Distal sample locations are generally downgradient, but at some distance, from the contamination source or plume. Distal sample locations are analyzed for ^3H using a standard EPA method (see Table B-2) with a detection limit of 300 pCi/L. This provides for ^3H detection well below the 20,000 pCi/L MCL and below the SDWA required detection limit of 1,000 pCi/L for ^3H (CFR, 2017). Samples are collected at a five-year frequency (Figure 3-6). As illustrated in Figure 3-5, a Distal location may be recategorized as an Early Detection location if ^3H is detected in the upgradient Early Detection location. The detection limits for ^3H will be lowered.

3.5 Community Locations

Community sample locations may be in wells or springs that are either used as private, business, or community water supply sources or are located near such a source. Community locations are sampled at a five-year frequency (Figure 3-6) and analyzed for ^3H levels using a 300-pCi/L detection limit. This detection limit is well below the 20,000-pCi/L MCL and below the SDWA required detection limit of 1,000 pCi/L for ^3H (CFR, 2017).

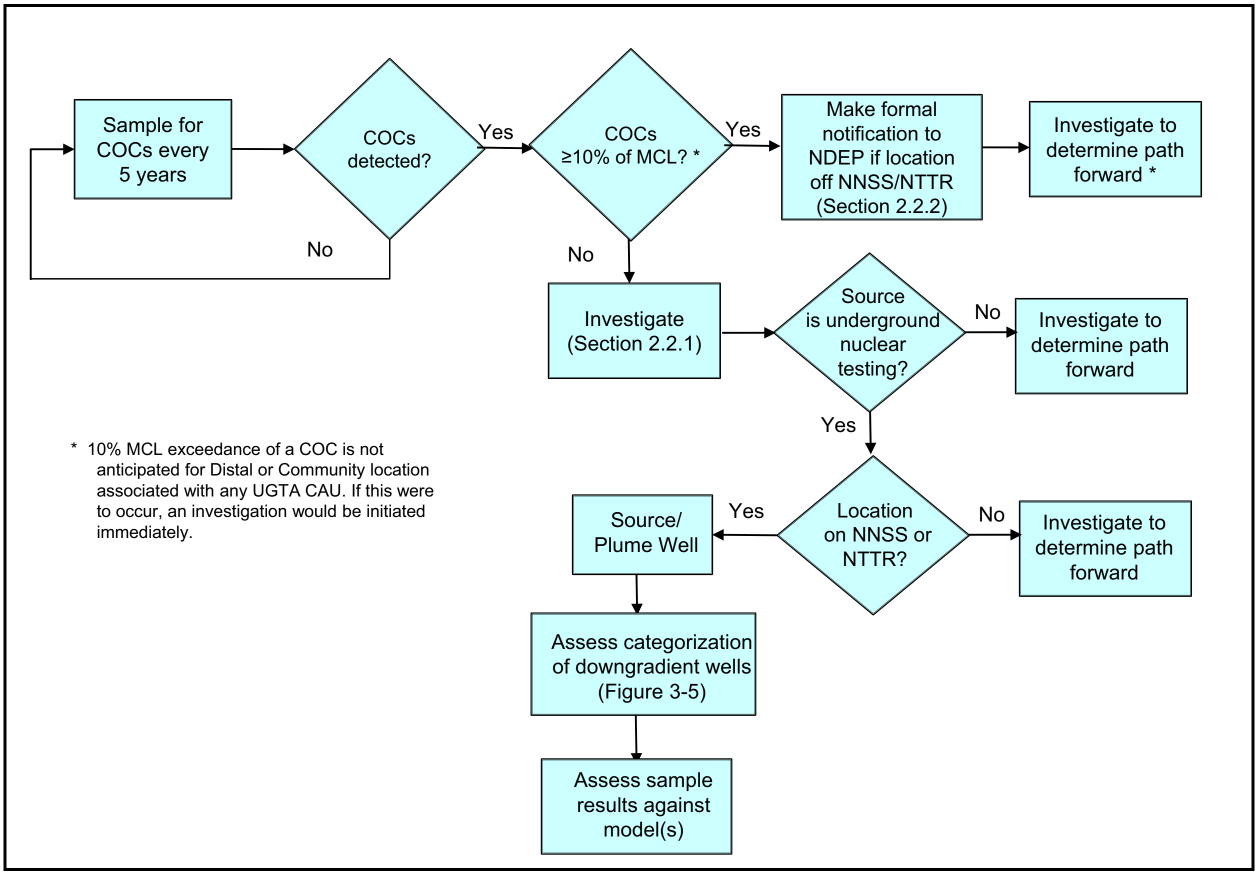

Figure 3-6
Distal and Community Sampling Flow Chart

4.0 Processes and Procedures

One of the Plan objectives is to ensure that data are collected in a consistent, scientifically defensible manner by all current and future DOE contractors. Data collection activities are therefore described in standard operating procedures (SOPs) that must comply with the UGTA Activity QAP (NNSA/NFO, 2015). Oversight assessments are performed to ensure compliance.

This section summarizes the processes and procedures used for sample collection and laboratory analysis. The current EPS and M&O contractor SOPs are presented in Appendix B. These SOPs are specific to the current contractors and will be updated as necessary in future Plan revisions.

4.1 Sample Collection

Sample collection procedures are shown in Table B-1. Samples are maintained under chain of custody protocols to provide the traceability of possession from the time the samples are collected until disposal. Field quality control (QC) samples are collected and analyzed to assess whether the sample-collection process meets the quality objectives. The rule of thumb for collection of field QC samples is collection of one QC sample for every 20 samples collected within the same CAU and/or collected using the same technology. The QC sample may be a blank or duplicate, depending on sampling needs. Blanks (rinsate/equipment or field) are used to assess potential contamination from the sample collection process. Blanks are implemented at specified frequencies, which vary according to the probability of contamination or cross-contamination. Field duplicates are used to assess sampling and analytical variability and may be collected when sample representativeness is a concern (e.g., bailed or low-volume purging). Duplicate collection should be evenly distributed throughout the sampling event.

Possible sample collection methods are presented in Appendix A (Tables A-1 through A-3). In general, wells or completion zones equipped with a permanently installed electric submersible (ES) pump will be sampled using the pump. Otherwise, the sample will be collected with a bailer, lift jack (LJ) pump, or newly installed ES pump, depending on a number of variables including the casing diameter, availability of a piezometer access tube, and number of completions/zones requiring sampling. Spring samples will be collected used a scoop or dipper.

If the well is sampled using a pump, a minimum of three effective well volumes will be withdrawn, and the well will be purged until water-quality parameters (e.g., pH, electrical conductivity, and temperature) have stabilized. Procedures for field measurement of water-quality parameters are listed in Table B-1. Bromide may also be measured if it was introduced to the groundwater during drilling, and trace amounts may be present due to varying levels of development. Water-quality parameter stabilization criteria should be based on established criteria such as that described by USGS (2013). The purging amount and rate will be balanced to minimize the potential for pump-induced contaminant migration while ensuring that the groundwater produced from the well represents ambient formation water. If the well is sampled using a wireline-deployed bailer, purging may not be feasible; therefore, the decision to purge will be determined on a case-by-case basis. Purging requirements will be documented in an SOP or the FAWP. All water produced during purging and/or sampling activities must be managed in accordance with the *Fluid Management Plan for the Underground Test Area Project* (NNSA/NSO, 2009).

4.2 Laboratory Analysis

An agreement between DOE and NDEP regarding the use of certified laboratories is documented in Boehlecke (2014) and Murphy (2014). Required analyses (Table 3-1) will be performed by a commercial laboratory that is certified through the NDEP Bureau of Safe Drinking Water, and that meets National Environmental Laboratory Accreditation Program requirements. Commercial laboratories also must participate in the U.S. Department of Energy Consolidated Audit Program (DOECAP).

Analyses listed in Table 3-2 (i.e., optional analyses) may be performed by non-certified laboratories, and will be identified and justified in the Annual UGTA QA Report (see Section 5.3). These laboratories provide state-of-the-art methods necessary to maximize analytical sensitivity or for analyzing unique parameters not available by a commercial laboratory. These laboratories will be assessed to ensure UGTA QAP compliance at a minimum of every three years.

Analytical methods for required analyses are presented in Table B-2 along with detection limits. Laboratory SOPs for optional analyses are presented in Table B-3. The required laboratory quality control (LQC) samples associated with each analysis are described within each SOP. LQC samples will include laboratory control samples, method blanks, laboratory replicates, and matrix spikes, as applicable. Analytical laboratories will participate in a performance evaluation program (PEP) for each analyte and/or method for which they are responsible. Some analytes and/or analytical methods do not have an available PEP, and alternative approaches can be applied. The approaches include interlaboratory comparisons between sample (duplicate, split, or prepared) results, blind samples (i.e., samples with a known or previously measured detectable quantity of analyte), or data evaluation. State-certified laboratories also require a demonstration of capability for their analysts. The PEP results are presented in the Annual UGTA QA Report.

5.0 Reporting

Results of activities associated with this Plan (laboratory analyses and any investigations that take place as a result of Plan implementation) will be presented in annual and/or special reports. These reports are submitted to NDEP and are publicly available. This section describes these reports and defines notification thresholds to be used in reporting groundwater sample results and other pertinent information obtained by Plan implementation.

5.1 Annual UGTA Sampling Report

The Annual UGTA Sampling Report documents all sampling activities and results for samples collected under this Plan during the previous calendar year. The report includes a description of investigations performed, laboratory results, and data evaluations and interpretations. Analytical results will be evaluated by the CAU Lead, or designee, with respect to the CAU conceptual model of flow and transport. Deviations from the Plan, along with their justification, will also be presented.

5.2 Annual NNSS Environmental Report

The annual NNSS environmental report summarizes data and the compliance status of the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) environmental protection and monitoring programs at the NNSS and other NNSA/NFO facilities. The report satisfies reporting requirements in DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2013), and is consistent with SDWA requirements for reporting water quality for public water supply wells. The Report also includes a summary of analytical data from recent sampling of the locations identified in this Plan.

5.3 Annual UGTA QA Report

The UGTA QAP (NNSA/NFO, 2015) requires DOE EM Nevada Program to issue an Annual UGTA QA Report to NDEP that contains QA activity results. QA activities include conducting assessments, identifying issues, evaluating laboratory performance, publishing documents, and participating in committees. At a minimum, the QA report will include PEP results and the identification and justification for optional analyses performed by non-certified laboratories, as discussed in

Section 4.2. Also, all UGTA assessments—including any findings and corrective actions, and closure dates—are presented, as discussed in Section 7.2

5.4 Special Reports

Data results that differ from previous analyses may require additional investigations. These investigations and associated results may be presented in special reports. Special reports may also be developed to describe other investigations relevant to this Plan (e.g., investigations of well sampling technologies, flow logs to identify optimal sampling depths, and historical analytical results).

5.5 Communications

All communications will follow the protocols established by DOE EM Nevada Program. DOE EM Nevada Program manages all external communications, including communications with NDEP and entities not affiliated with the project. Internal communications will follow processes established by the participant companies.

The notification requirements in this Plan are not mandated by the FFACO or NDEP regulation (Section 2.2). The CRs for each CAU will define the conditions that require mandatory notification to NDEP during long-term groundwater monitoring. The notifications described in this Plan are meant to ensure that NDEP and USAF are kept apprised of changing conditions in UGTA CAUs throughout the earlier stages of the FFACO process (CAIP, CAI, and CADD/CAP stages).

6.0 Records and Data Management

Records resulting from implementation of this Plan by the EPS contractor and UGTA participants will be controlled and maintained in the UGTA Document Center and Technical Data Repository (TDR). Entry into the TDR, which is a satellite electronic records location, is described in the "Technical Data Repository" (QA-1706) procedure within the "Quality Assurance" (QA-1700) subject area (Navarro, 2018a). Records associated with Plan implementation are described in the applicable SOPs (see Appendix B). The M&O contractor manages records in accordance with its procedures.

Requirements for documenting, verifying, and validating laboratory results are described in contract-specific SOPs. The SOPs used for implementing commercial laboratory verification, validation, and review requirements are presented in Table B-1. Requirements for verification and validation of other laboratory results (i.e., optional analyses) are presented in the analysis-specific SOPs (Table B-3). Laboratory data reports including electronic data deliverables (EDDs) will be submitted to the responsible contractor and stored as records in the TDR or equivalent record management system. Sample results, received as an EDD, will be entered into the EPS contractor UGTA Chemistry Database (Navarro, 2018b).

Field record reviews ensure forms have been filled out completely, are legible and in accordance with the UGTA QAP (NNSA/NFO, 2015) and associated SOPs, and that the recorded information accurately reflects the performed activities. Laboratory data package review ensures record sets are complete and legible, and analyses are consistent with chain-of-custody requests and compliant with the UGTA QAP. Data validation acceptance criteria will be based upon the intended use of the data and will include an evaluation of method compliance, data calculations, QC data quality indicators (DQIs), instrument calibrations, raw data, and data generation methods. Validation can include qualifying data that may restrict or limit data use; typical qualification codes are as follows:

- **U** Analyte was analyzed for but not detected at our above the reporting limit. The measured value is reported.
- **J** Reported result is estimated.
- **J+** Reported result is estimated with a positive bias.
- **J-** Reported result is estimated with a negative bias.

R Data rejected, not usable for decision-making purposes (will be made unavailable for use).

< Analyte was analyzed for but not detected. The detection limit is reported.

7.0 Quality Assurance

All UGTA activities presented within this Plan will be performed in compliance with the UGTA QAP (NNSA/NFO, 2015). The UGTA QAP provides requirements to ensure that analytical data are of sufficient known quality to withstand scientific and legal challenge considering the use for which the data were obtained. This section presents the methods used to ensure that QAP requirements are met and that analytical data are scientifically valid, defensible, and of known precision and accuracy.

7.1 Standard Operating Procedures

Implementation of UGTA QAP requirements is achieved through the use of SOPs by all participating organizations. The SOPs that support Plan activities are presented in Appendix B. These SOPS describe the required QC to establish DQI (precision, accuracy, representativeness, and comparability) goals for the described Plan activities. Sample collection and analysis requirements— including field and laboratory QC samples, and verification and validation of the resulting data—are established within the SOPs.

7.2 Assessments

Assessments play an integral role in assuring quality for UGTA data collection, analysis, and reporting activities. The UGTA QAP (NNSA/NFO, 2015) requires that annual assessments are performed. These assessments can be performed by the organization management or by an independent assessment team. DOE EM Nevada Program personnel, or their designees, will also perform oversight assessments periodically to verify compliance with applicable quality requirements, DOE policies, and procedures. These assessments will be conducted in accordance with NFO Order 226.X, *Line Oversight (LO) Program* (NNSA/NFO, 2016). Issues will be resolved and closure tracked in accordance with the "Issue Management" (PA-1503) procedure within the "Performance Assurance" (PA-1500) subject area (Navarro, 2018a). All UGTA assessments, including any findings and corrective actions, and closure dates are presented in the Annual UGTA QA Report (Section 5.3).

7.3 Lessons Learned

DOE EM Nevada Program has implemented a lessons learned system as a focal point for reporting and retrieving important information concerning experiences gained through previous activities. Continuous improvement can be fostered through incorporation of applicable lessons learned into work processes and planning activities, including work plan development, budget development, and strategic planning.

8.0 References

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EPA, see U.S. Environmental Agency.

FFACO, see *Federal Facility Agreement and Consent Order.*

Federal Facility Agreement and Consent Order. 1996 (as amended March 2010). Agreed to by the State of Nevada; U.S. Department of Energy, Environmental Management; U.S. Department of Defense; and U.S. Department of Energy, Legacy Management. Appendix VI, which contains the Underground Test Area Strategy, was last modified June 2014, Revision No. 5.

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N-I, see Navarro-Intera, LLC.

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Appendix A

Sample Collection Location Information

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 1 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5426	ER-20-4	ER-20-4_m1	37.19503	-116.440272	CHZCM/CFCU	2,415	3,050	ES Pump
9712	ER-20-11	ER-20-11_m1	37.196125	-116.484182	FCCU/BA/UPCU	2,562	3,004	ES Pump
11810	ER-20-12	ER-20-12_p4	37.281104	-116.538352	TMWTA/TMLVTA	WL	2,287	Bailer
		ER-20-12_p3			CHZCM	2,510	2,947	LJ Pump
		ER-20-12_p1			BRA	3,725	3,343	LJ Pump
		ER-20-12_m1			PBRCM	3,916	4,543	ES Pump
4179	ER-EC-4	ER-EC-4_m2-3	37.158863	-116.631058	TCVA/FCCM/TMUWTA	952	2,295	ES Pump
4103	ER-EC-5	ER-EC-5_m1-3	37.084548	-116.564561	TMCM	1,169 1,835 2,194	1,443 2,146 2,500	ES Pump
6770	ER-EC-11	ER-EC-11_p3	37.197547	-116.494759	FCCU/BA	WL	3,030	LJ Pump
		ER-EC-11_m2			UPCU/TCA	3,196	3,385	ES Pump
		ER-EC-11_p1			TSA/CHCU	3,590	4,148	LJ Pump
6772	ER-EC-12	ER-EC-12_m2	37.173291	-116.491991	THCM/TCA/LPCU	1,854	2,744	ES Pump
		ER-EC-12_p2			TSA/CHCU	3,188	3,770	LJ Pump
6773	ER-EC-13	ER-EC-13_m2	37.169369	-116.548301	FCCM	1,835	2,136	ES Pump
		ER-EC-13_p1			FCCM	2,240	2,680	LJ Pump
6774	ER-EC-14	ER-EC-14_m2	37.14018	-116.511485	RMWTA	1,295	1,704	ES Pump
		ER-EC-14_p1			RMWTA	1,889	2,378	LJ Pump
6775	ER-EC-15	ER-EC-15_m3	37.186141	-116.518152	FCCU/CPA/PBPCU	WL	1,769	ES Pump
		ER-EC-15_p2			TCA/LPCU	2,108	2,427	LJ Pump
		ER-EC-15_p1			TSA/CHCU	2,752	3,255	LJ Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 2 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Source/Plume Wells								
16	ER-20-5-1	ER-20-5-1_p1	37.220054	-116.477174	TSA/CHZCM	2,249	2,655	ES Pump
21	ER-20-5-3	ER-20-5-3_m1	37.219771	-116.477190	CHZCM	3,348	3,914	ES Pump
19	ER-20-6-2 [a]	ER-20-6-2_m1	37.259935	-116.421166	CHZCM	2,414	2,945	LJ Pump
6769	ER-20-7	ER-20-7_m1	37.213043	-116.479108	LPCU/TSA/CHZCM	2,292	2,936	ES Pump
6771	ER-20-8	ER-20-8_m2	37.193087	-116.473975	MPCU/TCA/LPCU	2,440	2,940	ES Pump
6963	ER-20-8-2	ER-20-8-2_m1	37.193024	-116.474129	BA/UPCU/SPA/MPCU	WL	2,339	ES Pump
5454	U-19ad PS 1A	U-19ad PS 1A_m1	37.270386	-116.354681	PLFA	WL	2,609	ES Pump
3390	U-19q PS 1D	U-19q PS 1D_m1	37.280413	-116.364905	NA	3,665	4,991	ES Pump [b] or LJ Pump
3399	U-19v PS1D	U-19v PS1D_m1	37.247966	-116.349120	BFCU	3,875	3,885	LJ Pump
3533	U-20n PS 1DDh	U-20n PS 1D_m2	37.240273	-116.423325	CHZCM	4,081	4,290	ES Pump [b] or LJ Pump
3534	UE-20n 1	UE-20n 1_o2	37.240308	-116.421934	CHZCM	2,323	2,824	ES Pump
Early Detection Wells								
6771	ER-20-8	ER-20-8_p1	37.193087	-116.473975	LPCU/TSA/CHZCM	3,070	3,442	LJ Pump
4178	ER-EC-1	ER-EC-1_m1-3	37.206313	-116.529739	CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM	2,258 3,291 4,399	2,867 3,776 4,840	ES Pump
4180	ER-EC-6	ER-EC-6_m4	37.188771	-116.496682	FCCU/BA	1,606	1,948	LJ Pump
3468	ER-20-1	ER-20-1_m1	37.222453	-116.491506	TCA	WL	2,065	LJ Pump
3645	PM-3	PM-3_p1	37.239077	-116.560179	TCA/LPCU	1,872	2,192	LJ Pump
		PM-3_p2			UPCU	1,473	1,687	LJ Pump
3647	U-20 WW	U-20 WW_m1	37.251412	-116.429282	CHZCM	2,271	3,268	ES Pump [b] or LJ Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 3 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Distal Wells								
5151	ER-EC-2A	ER-EC-2A_m3	37.144993	-116.567379	FCCM	1,635	2,236	ES Pump or LJ Pump
4104	ER-EC-8	ER-EC-8_m1-3	37.102846	-116.631282	FCCM/TMCM	632 1,388 1,626	1,050 1,558 2,000	ES Pump
3309	UE-18r	UE-18r_o1	37.134754	-116.444707	TMCM	1,629	5,004	LJ Pump or Bailer
Community Wells								
7067	Peacock Ranch	Peacock Ranch_s1	37.030830	-116.754700	NA	--	--	Scoop/Dipper
6531	Revert Springs	Revert Springs_s1	36.917500	-116.744722	NA	--	--	Scoop/Dipper
9521	Spicer Ranch	Spicer Ranch_s1	36.998800	-116.705500	NA	--	--	Scoop/Dipper
6761	Crystal Park [c]	Crystal Park	36.4905	-116.160944	NA	--	--	ES Pump
4936	U.S. Ecology	U.S. Ecology_m1	36.770639	-116.690278	NA	453	573	ES Pump
6768	Amargosa Valley RV Park	Amargosa Valley RV Park_m1	36.642167	-116.396639	NA	WL	1,280	ES Pump

Table A-1
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 4 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
4908	Cind-R-Lite Mine	Cind-R-Lite Mine_m1	36.685000	-116.507222	Valley Fill [d]	WL	460	ES Pump
4959	Beatty Wtr Swr-Well 3	Beatty Wtr Swr-Well 3_m1	36.904895	-116.757810	NA	NA	NA	ES Pump

[a] Wells ER-20-6-1 and ER-20-6-3 may substitute for ER-20-6-2.
[b] ES Pump needs to be repaired or replaced.
[c] Other wells in Crystal, Nevada, may substitute for Crystal Park.
[d] Aquifer, not HSU, is reported.

-- = Not applicable
NA = Not available

ft = Foot
ID = Identification
Lat = Latitude
Long = Longitude
NAD 27 = North American Datum of 1927
WL = Water level

AA = Alluvial aquifer
BA = Benham aquifer
BFCU = Bullfrog confining unit
BRA = Belted Range aquifer
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 = Fortymile Canyon confining unit
LPCU = Lower Paintbrush confining unit
MPCU = Middle Paintbrush confining unit
PBPCU = Post-Benham Paintbrush confining unit
PBRCM = Pre-Belted Range composite unit
PLFA = Paintbrush lava-flow aquifer
RMWTA = Rainier Mesa welded-tuff aquifer
SPA = Scrugham Peak aquifer
TCA = Tiva Canyon aquifer
TCVA = Thirsty Canyon volcanic aquifer
THCM = Tannenbaum Hill composite unit
TMCM = Timber Mountain composite unit
TMLVTA = Timber Mountain lower vitric-tuff aquifer
TMUWTA = Timber Mountain upper welded-tuff aquifer
TMWTA = Timber Mountain welded-tuff aquifer
TSA = Topopah Spring aquifer
UPCU = Upper Paintbrush confining unit

Table A-2
Rainier Mesa/Shoshone Mountain Sample Collection Locations and Supporting Information
(Page 1 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
3809	ER-30-1	ER-30-1_p1	37.050258	-116.316190	FCCM	677	790	LJ Pump
5452	ER-12-3	ER-12-3_p1	37.195017	-116.214118	LTCU/OSBCU/ATCU	WL	2,200	LJ Pump
5453	ER-12-4	ER-12-4_p2	37.219627	-116.183146	LVTA/BRCU/ LTCU/OSBCU	WL	1,988	LJ Pump
5276	ER-16-1	ER-16-1_m1	37.008566	-116.203090	LCA	WL	4,566	LJ Pump
3311	UE-18t	UE-18t_p1	37.128145	-116.329146	TMCM	120	2,600	LJ Pump
Source/Plume Wells								
2921	E-Tunnel	E-Tunnel_mine1	37.188181	-116.194554	--	NA	NA	Grab
3043	U-12n.10 Vent Hole	U-12n.10 Vent Hole_m1	37.207719	-116.205506	LTCU	WL	1,240	Bailer
3069	U-12n Vent Hole 2	U-12n Vent Hole_2_m1	37.203559	-116.218060	LTCU	WL	1,252	Bailer
Early Detection Wells								
2876	ER-12-1	ER-12-1_m5	37.184905	-116.184217	UCCU	1,641	1,846	ES Pump
5452	ER-12-3	ER-12-3_m1-2	37.195017	-116.214118	LCA3	WL	4,908	ES Pump
5453	ER-12-4	ER-12-4_m1	37.219627	-116.183146	LCA3	WL	3,715	ES Pump
3317	ER-19-1	ER-19-1_p2	37.178521	-116.239147	OSBCU	1,301	1,422	LJ Pump or Bailer
		ER-19-1_p1			RVA/ATCU	2,550	2,738	LJ Pump or Bailer

Table A-2
Rainier Mesa/Shoshone Mountain Sample Collection Locations and Supporting Information
(Page 2 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Distal Wells								
3237	TW-1	TW-1_m1	37.158179	-116.222920	OSBCU/RVA/LTCU/ ATCU/LCA3	1,910	4,206	LJ Pump or Bailer
3235	UE-16d WW	UE-16d WW_m1	37.070112	-116.164283	UCCU	1,145	1,944	ES Pump
3316	WW-8	WW-8_m26	37.165586	-116.289152	BRA	WL	2,031	ES Pump

-- = Not applicable
NA = Not available

ATCU = Argillic tuff confining unit
BRCU = Belted Range confining unit
LCA3 = Lower carbonate aquifer-upper plate
LTCU = Lower tuff confining unit
LVTA = Lower vitric-tuff aquifer
OSBCU = Oak Spring Butte confining unit
RVA = Redrock Valley aquifer
UCCU = Upper clastic confining unit

Table A-3
Yucca Flat/Climax Mine Sample Collection Locations and Supporting Information

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5204	ER-2-1	ER-2-1_m1	37.125278	-116.061899	TMWTA/TMLVTA/LTCU	WL	2,177	ES Pump
11813	ER-3-3	ER-3-3_m1	37.063444	-116.038942	LTCU/ATCU/LCA	2,630	3,193	ES Pump
11812	ER-4-1	ER-4-1_m1	37.106606	-116.050159	LCA	2,812	3,035	ES Pump
1940	ER-6-1-1[a]	ER-6-1-1_p1	36.984313	-115.99283	LCA	1,835	2,085	LJ Pump
5199	ER-7-1	ER-7-1_m1	37.073318	-115.995265	LCA	WL	2,500	ES Pump
1747	TW-7	TW-7_m1	37.064863	-116.033776	LTCU	1,710	2,272	LJ Pump
69	UE-1h	UE-1h_o1	37.001333	-116.067373	LCA	WL	3,358	LJ Pump
1971	WW-3	WW-3_m1	36.995230	-116.057958	AA	WL	2,349	LJ Pump
Source/Plume Wells								
319	UE-2ce	UE-2ce_m1	37.142011	-116.135278	LCA3	WL	1,650	ES Pump
2059	UE-7nS	UE-7nS_m1	37.098770	-116.002484	LCA	1,995	2,022	Bailer
Early Detection Wells								
549	WW-2	WW-2_m1	37.166234	-116.087622	LCA	2,563	3,422	ES Pump
1892	TW-D	TW-D_m1	37.074440	-116.075018	ATCU/LCA	1,772	1,950	Bailer or LJ Pump
22	UE-1q	UE-1q_o1	37.060342	-116.058332	LCA	2,459	2,600	Bailer or LJ Pump
1970	WW C-1	WW C-1_m1	36.918647	-116.009409	LCA	WL	1,650	ES Pump
1015	U-3cn 5	U-3cn 5_o1	37.059475	-116.022363	LCA	2,832	3,030	ES Pump

[a] Well ER-6-1-2 may substitute for ER-6-1-1.

Appendix B

Procedures

B.1.0 Introduction

This section presents the SOPs used by each organization for sample collection, water-quality measurements, and analytical data verification/validation (Table B-1); laboratory analyses (Tables B-2 and B-3); and technical data storage and issue management (Table B-4).

Table B-1
Sample Collection, Water-Quality Measurement, and Analytical Data Verification/Validation Procedures

Responsible Organization	Procedure
Sample Collection	
EPS contractor	Field Operations (FO-1202) • Decontamination of Field Sampling Equipment (DI-FO-02) • Field Quality Control Samples (DI-FO-06) • Fluid Sample Collection and Field Filtration (DI-FO-08) • Sample Handling and Shipping (DI-FO-11) • Water-Level and Flow Monitoring Operations (DI-FO-14)
M&O contractor	• SOP-P420.104: Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Groundwater Wells
Water-Quality Measurements	
EPS contractor	Field Operations (FO-1202) • Field Screening for Lead in Fluid Samples (DI-FO-07) • Water Quality Monitoring and Analysis (DI-FO-15)
	• Radiation Services (DI-RP-01) Note: Section 2.1.3 covers TriCarb.
Analytical Data Verification and Validation	
EPS contractor	Analytical Data Validation (QA-1701) • Tier I Data Verification (DI-QA-01) • Tier II Chemical Data Validation (DI-QA-02) • Tier II Radiological Data Validation (DI-QA-03)
M&O contractor	• Verification, Validation and Data Review of Environmental Monitoring Program Data (OP-P420.117)
	• Radioanalytical Data Verification, Data Validation, and Data Review (OP-P420.457)
	• Inorganic Data Verification and Validation (OP-P420.459)

Table B-2
Analytical Procedures for Required Analyses

Analyte	Preferred Analytical Method [a]	Title	Reporting Limit
General Chemistry			
Alkalinity	EPA 310.2 [b]	Alkalinity (Colorimetric, Automated, Methyl Orange)	20 mg/L as $CaCO_3$
pH	EPA 150.1 [b]	pH (Electrometric)	0.01
Specific Conductance	EPA 120.1 [b]	Conductance (Specific Conductance, µmhos at 25 °C)	1.0 µmhos/cm
Br, Cl, F, SO_4	EPA 300.0 [c]	Determination of Inorganic Anions in Drinking Water by Ion Chromatography	0.25–1 mg/L
Metals			
Ag, Al, As, Ba, Ca, Cd, Cr, Fe, K, Li, Mg, Mn, Na, Pb, Se, Si, Sr	EPA 6010 [d]	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	0.001–1.0 mg/L
U	EPA 6020 [d]	Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)	0.0001 mg/L
Radioisotopes			
Gamma Emitters (^{26}Al, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, ^{241}Am, ^{243}Am)	EPA 901.1 [e]	Gamma-Emitting Radionuclides in Drinking Water	10 pCi/L ^{137}Cs
Gross Alpha and Gross Beta	EPA 900.0 [e]	Gross Alpha/Beta Radioactivity in Drinking Water	3 pCi/L (Gross Alpha)
^{3}H (Low Level)	HASL 300 3H-01-RC (prep) [f] EPA 906.0 [e] (analysis)	Tritium Assay in Water Samples using Electrolytic Enrichment; Tritium (^{3}H) in Drinking Water	3 pCi/L
^{3}H	EPA 906.0 [e]	Tritium (^{3}H) in Drinking Water	300 pCi/L
^{90}Sr	EPA 905.0 [e]	Radioactive Strontium-90 (^{90}Sr) in Drinking Water	1 pCi/L
^{14}C	EERF C-01 [g] or equivalent	Radiochemical Determination of Carbon-14 (^{14}C) in Aqueous Samples	500 pCi/L
^{36}Cl	Laboratory specific	Chlorine-36 (^{36}Cl)	4 pCi/L
^{99}Tc	HASL 300 TC-01-RC [f] or equivalent	Technetium-99 (^{99}Tc) in Water	10 pCi/L
^{129}I	EPA 902.0 [e]	Radioactive Iodine in Drinking Water	<1 pCi/L
$^{238/239/240}$Pu	HASL 300 Pu-10-RC [f] or ASTM D3865-09 [h] or equivalent	Isotopic Plutonium (Pu) in Water	0.1 pCi/L

[a] Equivalent methods promulgated in 40 CFR 141 (CFR, 2017) or as certified by the State of Nevada are also allowed.
[b] EPA, 1983
[c] EPA, 1993
[d] EPA, 2018
[e] EPA, 1980
[f] DOE, 1997
[g] EPA, 1984
[h] ASTM, 2015

ASTM = ASTM International
$CaCO_3$ = Calcium carbonate
CFR = *Code of Federal Regulations*
EERF = Eastern Environmental Radiation Facility
HASL = Health and Safety Laboratory
ICP-AES = Inductively coupled plasma-atomic emission spectrometry
ICP-MS = Inductively coupled plasma-mass spectrometry
mg/L = Milligrams per liter
µmhos = Micromhos
µmhos/cm = Micromhos per centimeter

Table B-3
Analytes, Analytical Procedures, and Detection Limits for Optional Analyses

Analytes	Procedure	Title	Detection Limit [a]
DRI			
$\delta^{13}C$, ^{14}C (DOC)	Accelerator Mass Spectrometry	NSF-Arizona AMS Facility Quality Assurance Manual	N/A
LLNL			
$\delta^{2}H$, $\delta^{18}O$	SOP-UGTA-128	Analysis of ^{18}O and ^{2}H in Groundwater Samples	N/A
DIC, $\delta^{13}C$	SOP-UGTA-116	Analysis of TDIC, TDOC, and ^{13}C in Groundwater Samples	0.01 mg/L (TDIC) N/A ($\delta^{13}C$)
Noble Gases (Ar, Kr, Ne, Xe, ^{3}He, ^{4}He, $^{3/4}He$, $^{3/4}He$ [R/R_a])	SOP-NGMS-122	Collection and Analysis of Groundwater for Determination of Noble Gas Abundance and Helium Isotopic Composition	1.4E-15 – 1.0E-05 cm^3 STP/g (Ar, Kr, Ne, Xe, ^{3}He, ^{4}He); 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	1E-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	1E-06 pCi/L
^{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	1E-03 pCi/L
^{129}I	SOP-UGTA-123	Analysis of I-129 in Aqueous Samples	1E-07 pCi/L
$^{238/239/240}Pu$	SOP-UGTA-135	Analysis of Plutonium in Groundwater Samples by MC-ICP-MS	1E-03 pCi/L
USGS			
$^{34/32}S$	USGS-YM-GCP-44	Sulfur Isotope Analysis of Dissolved Sulfate in H_2O	N/A

[a] Approximate detection limits.

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.

DIC = Dissolved inorganic carbon
DOC = Dissolved organic carbon
^{2}H = Deuterium
H_2O = Water
He = Helium
Ne = Neon
O = Oxygen
TDIC = Total dissolved inorganic carbon
TDOC = Total dissolved organic carbon
Xe = Xenon

AMS = Accelerator Mass Spectrometry
N/A = Not applicable
NSF = National Science Foundation

Table B-4
Additional Procedures

Procedure	Comments
Technical Data Repository (QA-1706)	Describes the process for receiving, reviewing, and placing contributions from UGTA participants into the UGTA UIDMS. Includes processes for information and data management; development, verification, review, and documentation of software and models; and preparation, review, and issuance of UGTA documents. Processes for handling both shared and published information and data are included.
Issue Management (PA-1503)	Describes the processes for entering, administrating, and closing UGTA issues within the issue tracking system.

UIDMS = UGTA Information and Data Management System

B.2.0 References

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CFR, see *Code of Federal Regulations.*

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DOE, see U.S. Department of Energy.

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